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APPENDICES

STRUCTURE PLAN

Lots 705 & 707 Armadale Road, Treeby

JANUARY 2020

APPENDICES

1. Environmental Assessment Report (360 Environmental)
2. Bushfire Management Plan (Bushfire Safety Consulting)
3. Landscape Strategy (EPCAD)
4. Local Water Management Strategy (JDA Consulting Hydrologists)
5. Transport Impact Assessment (Transcore)
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APPENDIX ONE

Environmental Assessment Report (360 Environmental)

360 environmental

Lots 705 and 707 Armadale Road, Treeby

Environmental Assessment Report

In support of the Local Structure Plan

Prepared for:

Perron Treeby Pty Ltd

December 2019

people • planet • professional

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Executive Summary

Perron Treeby Pty Ltd (Perron) proposes to develop Lots 705 and 707 Armadale Road, Treeby ('the site') for urban residential purposes. This Environmental Assessment Report (EAR) has been prepared to support the local structure planning (LSP) phase of planning approvals for the proposed residential development.

The site is approximately 62.3 ha and is located within the City of Cockburn. The area of the site proposed for residential development has been rezoned from 'Rural – Water Protection' to 'Urban' under the Metropolitan Region Scheme (MRS).

A large part of the site has been used for sand mining and for the manufacture of bricks and consequently it has been cleared of native vegetation and then partially rehabilitated. It is this cleared part of the site that is proposed for residential development. Consequently, the development footprint is environmentally degraded and contains little of environmental value. The remainder of the site, while owned by Perron, will remain undeveloped and part of Bush Forever site 390.

The proposed Concept Plan for the development includes:

- Low and medium density residential development
- A high school and oval
- Public open space.
- A connecting road to the north.

The Concept Plan has been designed to avoid impacts to remnant native vegetation within the Bush Forever areas adjacent. Native vegetation within the existing Bush Forever boundary will be retained, aside for a small area in the north-western corner of the lot to accommodate a connector road into the development Supporting documentation includes a Bushfire Management Plan which concludes that there is no requirement to clear bushland to meet bushfire management requirements. The Landscape Management Plan that supports the LSP recognises that the interface between the retained bushland and the proposed development needs special focus and proposes that this linear space be developed as a buffer and serve to educate people about the bushland.

The key environmental considerations for the proposed development are as follows:

- The interface of the development with Bush Forever 390
- Declared Rare Flora
- Residual contamination issues from previous land uses
- Groundwater and surface water management.

The environmental features of the Bush Forever area have been documented via formal biological surveys and the results of these surveys have been considered in the local structure planning process. Regionally significant vegetation and the declared rare flora

orchid species, *Caladenia huegelii* have been identified within Bush Forever 390 and will be retained.

Contaminated land issues that are a consequence of the past use of the site as a brickworks have been resolved for most of the site. This has involved assessing and remediating the land to make it suitable for the proposed residential land use. The result is that most of the site has been classified as Decontaminated by the Department of Water and Environmental Regulation under the *Contaminated Sites Act 2003* meaning that it is suitable for residential development without any further environmental management. One area containing fill remains classified as Possibly Contaminated Investigation Required and the resolution of this issue will be addressed under the *Contaminated Sites Act 2003* in parallel with the planning approval process.

A Local Water Management Strategy (LWMS) was prepared in conjunction with this EAR which deals with the management of groundwater and surface water in the context of the development. The LWMS provides a framework for the application of total water cycle management in order to demonstrate that the development is capable of meeting appropriate water management outcomes. The protection of groundwater that is used for drinking water purposes is a focus of the LWMS given that the proposed development will be within a Priority 3 Public Drinking Water Source Area. Stormwater is collected and disposed of within the development area and thus there are no hydrological impacts on the wetland and bushland within the site.

The proposed development plan for the site has been assessed and it is concluded that the development will not have a significant impact on environmental values that cannot be managed. Environmental matters related to the construction phase, such as acid sulfate soil management, can be adequately managed and will be addressed at later stages in the planning approval process.

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1 Introduction

1.1 Background

360 Environmental Pty Ltd was commissioned by Perron Treeby Pty Ltd (Perron) to prepare an environmental assessment report (EAR) for Lot 705 and 707 (previously Lot 4 and 2, respectively) Armadale Road, Treeby ('the site').

The purpose of this EAR is to inform local structure planning for future urban residential development for a portion of the site. This EAR has been prepared to inform the Western Australian Planning Commission (WAPC) and City of Cockburn on the key environmental characteristics of the site, and to demonstrate compliance with regulatory objectives by detailing proposed avoidance, minimization and mitigation measures to reduce the potential environmental impact of the proposed development.

The site is composed of two lots, Lot 705 and 707, is approximately 62.3 ha and is located approximately 19 km southeast of Perth's Central Business District (Figure 1). The site is situated within the City of Cockburn local government area. The site underwent an MRS Amendment and is currently zoned Urban under the Perth Metropolitan Region Scheme (MRS).

1.2 Environmental Assessment Objectives

The objectives of this EAR are to describe how the existing environmental attributes of the site have been considered in the local structure planning process and demonstrate that the potential environmental issues have been adequately managed through the design of the development.

2 Key Environmental Legislation and Policies

2.1 Commonwealth Legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the central piece of environmental legislation which protects Matters of National Environmental Significant (MNES) and broadly, to conserve Australia's biodiversity.

The Project was referred to the (then) Commonwealth Department of the Environment (DoE) in 2013 and received a 'Not Controlled' action under the EPBC Act (EPBC 2013/7049)

2.2 State Legislation

2.2.1 Environmental Protection Act 1986

The *Environmental Protection Act 1986* (EP Act) is the key legislative tool for environmental protection in Western Australia. It is administered by the EPA and the Minister for the Environment and Energy. Under Part IV of the EP Act, the EPA undertakes environmental impact assessment of proposals and schemes to provide advice on environmental acceptability of developments. The environment impact assessment process provides an orderly and systematic evaluation of a proposal and its potential impact on the environment. A critical component of the assessment is the consideration of ways in which the implemented proposal could avoid or reduce any potential impact on the environment.

2.2.2 Relevant Legislation and Regulations

All future subdivision and development will be required to comply with the requirements of other relevant state legislation and regulations. Table 1 provides a summary of the key state legislation and regulations relevant to the proposed residential development.

Table 1: Key State Legislation

Key Legislation	Responsible Government Agency	Aspect
Aboriginal Heritage Act 1972	Department of Planning, Lands and Heritage	Archaeological and ethnographic heritage
Aboriginal Heritage Regulations 1974	Department of Planning, Lands and Heritage	Archaeological and ethnographic heritage

KEY LEGISLATION	RESPONSIBLE GOVERNMENT AGENCY	ASPECT
Agricultural and Related Resources Protection Act 1976	Department of Primary Industries and Regional Development	Weeds and feral animals
Biosecurity and Agriculture Management Act 2007	Department of Primary Industries and Regional Development	Weeds / pests / diseases
Bush Fires Act 1954	Department of Fires and Emergency Services	Bush fire control
Conservation and Land Management Act 1984	Department of Biodiversity Conservation and Attractions Department of Agriculture	Flora and fauna / habitat / weeds / pests / diseases
Conservation and Land Management Regulations 2002	Department of Biodiversity Conservation and Attractions Department of Agriculture	Flora and fauna / habitat / weeds / pests / diseases
Contaminated Sites Act 2003	Department of Water and Environmental Regulation	Management of contaminated soils and water
Environmental Protection Act 1986	Environmental Protection Authority Department of Water and Environmental Regulation	Part IV – Environmental Impact Assessment Clearing of native vegetation
Environmental Protection (Clearing of Native Vegetation) Regulations 2004	Department of Water and Environmental Regulation	Clearing of native vegetation
Planning and Development Act 2005	Department of Planning, Lands and Heritage	Structure planning and subdivision approval
Rights in Water and Irrigation Act 1914	Department of Water and Environmental Regulation	Governs management of the use, service and health of water and watercourses (including beds and banks). Water licensing is required in all proclaimed areas and for all artesian groundwater wells throughout the state.

KEY LEGISLATION	RESPONSIBLE GOVERNMENT AGENCY	ASPECT
Biodiversity Conservation Act 2016 (partially proclaimed)	Department of Biodiversity, Conservation and Attractions	Wildlife and biodiversity conservation and protection

2.2.3 Relevant Standards, Guidelines and Policies

Future subdivision and development is subject to compliance with applicable standards, guidelines and policies developed by the State's regulators to assist proponents in understanding the minimum requirements for environmental protection. The following table details the key standards, guidelines and State Planning Policies relevant to future residential development of the site (Table 2).

Table 2: Relevant Standards, Guidelines and Policies

DOCUMENT	DESCRIPTION
EPA Policies and Guidance	
Guidance Statement No. 3: *Separation Distances between Industrial and Sensitive Land Uses* (EPA 2005)	Provides guidance on the generic separation (buffer) distances between Industrial and Sensitive land uses to avoid conflicts between these land uses.
Guidance Statement No. 33: *Environmental Guidance for Planning and Development* (EPA 2008)	Provides information and advice to assist land use planning and development processes to protect, conserve and enhance the environment. Describes the processes the EPA may apply under the EP Act to land use planning and development in Western Australia, and the environmental impact assessment process applied by the EPA to schemes.
WA Environmental Offsets Policy (EPA 2011)	Seeks to protect and conserve environmental and biodiversity values for present and future generations. The policy ensures that economic and social development may occur while supporting long term environmental and conservation values.
State Planning Policies	
State Planning Policy 2.3: Jandakot Groundwater Protection (WAPC 2017)	Provides guidance regarding planning requirements within the Jandakot Groundwater Protection Area to ensure development is compatible with maximising the long term protection and management of groundwater.
State Planning Policy 2.7: Public	Policy aims to protect and manage public drinking water

DOCUMENT	DESCRIPTION
Drinking Water Source (WAPC 2003)	source areas from incompatible land uses and pollution in order to maintain the quality of the drinking water.
State Planning Policy 2.8: Bushland Policy for the Perth Metropolitan Region (WAPC 2010)	Recognition of regionally significant bushland that is constrained by existing commitments, approvals and policies. Development approvals should seek to achieve a reasonable balance through conservation and development.
State Planning Policy 2.9 Water Resources (DoP 2006)	Provides guidance in planning, protection and management of surface and groundwater catchments, including consideration of availability of water and management.
State Planning Policy 3.7: *Planning in Bushfire Prone Areas* (WAPC 2015)	Provides guidance on the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure.
Department of Water and Environmental Regulation (DWER) Guidelines	
Assessment and management of contaminated sites Guideline (DER 2014)	Provides guidance on the assessment and management of contaminated sites in Western Australian within legislative framework of the Contaminated Sites Act 2003 and the Contaminated Sites Regulations 2006.
Identification and investigation of acid sulfate soils and acidic landscapes (DER 2013)	Provides guidance to assist with the identification, assessment and management of acid sulfate soils in Western Australia.
Better Urban Water Management (WAPC 2008)	Provides guidance on the implementation of SPP 2.9 and is designed to facilitate better management and use of urban water resources.
Water Quality Protection Note 25: Land Use Compatibility Tables for public drinking water source areas (DoP 2017)	Provides guidance for land use planning within onshore PDWSAs and sets out guidelines on appropriate land uses and activities within PDWSAs that represent best management practice to protect water quality and public health.

3 Planning Context

3.1.1 Metropolitan Region Scheme

The area of the site proposed for residential development has been rezoned from 'Rural – Water Protection' to 'Urban' under the Metropolitan Region Scheme (MRS) in accordance with Metropolitan Regional Scheme Amendment 1345/57. This Scheme Amendment was referred to the Environmental Protection Authority and it was resolved that the scheme not be assessed under Part IV of the EP Act. The remainder of the site remains as Rural – Water Protection in the MRS.

3.1.2 Adopted Treeby District Structure Plan

The adopted Treeby District Structure Plan (Treeby DSP) is a strategic planning document intended to guide and coordinated future detailed planning for individual sites within the District Structure Plan area for Treeby. The Treeby DSP covers an area of approximately 460 ha of which the site is located within. The Treeby DSP outlined the land use arrangements, district level infrastructure and movement networks to inform the City's response for future rezoning and LSP requests within the DSP area (CLE 2017).

As under the Treeby DSP, future LSPs should generally conform with the layout of the DSP and be accompanied by, but not limited to, the following documents:

- A Local Water Management Strategy (LWMS) consistent with the approved District Water Management Strategy (DWMS)
- An EAR
- A Bushfire Hazard Assessment
- A Noise Impact Assessment.

The majority of the site has been identified under the Treeby DSP for residential purposes and includes a school and district level public open space, and local public open space aligning with the Bush Forever boundary which has been identified as having regional conservation values (CLE 2017).

3.1.3 Perth and Peel @3.5 Million Sub-regional Planning Framework

The Perth and Peel@3.5 million suite of strategic land use planning documents aim to accommodate 3.5 million people by the year 2050. The document promotes more efficient and reuse of land and infrastructure, with a target of 47% of new lots by infill. It is anticipated that residential development within the site and wider DSP area would contribute to these targets whilst protecting significant environmental features.

4 Proposed Development

4.1 Concept Local Structure Plan

The proposed Concept Plan for the development is presented in Appendix A of this document. The Concept Plan illustrates local level detail of the urban structure for the area. The proposed development of the site will consist of residential lots, a high school, district level POS with a senior sized oval and local POS. The proposed development yield and elements will be subject to further refinement and modification at subdivision design stage. The key characteristics of the Local Structure Plan and the Concept Plan are outlined in Table 3:

Table 3: Key Characteristics of the Proposed Development

ASPECT	DESCRIPTION
Local Structure Plan and Concept Plan	• Lot yield of 650 residential lots with a highly accessible and well serviced "infill" location • Solar orientation of lots with a focus on sustainability • Strong integration with surrounding land context, particularly with emerging and future urban residential land uses • Roads create a boundary between residential areas and retained bushland • Linear POS interfacing retained bushland in places to act as a buffer between land uses • Use of existing artificially created water bodies in a key landscape area.

4.2 Water Management

A Local Water Management Strategy (LWMS) has been prepared to support the local structure planning process (JDA 2019). It includes measures to ensure the site's hydrology is not altered during or post development of the site in a manner that would impact on surrounding sensitive areas. Stormwater will be collected and disposed of within the development area and thus there are no hydrological impacts on the wetland and bushland within the site. Appendix B shows the proposed stormwater management systems for the proposed development. See Section 6.3 for further details.

4.3 Bushfire

A Bushfire Management Plan (BMP) has been prepared to support the proposed Local Structure Plan (Bushfire Safety Consulting, 2019). It concludes that all areas within 150 metres of the site boundary of the proposed development have been assessed, including that which interfaces proposed retained bushland, for vegetation classification and BAL contours. It has been determined that all proposed future dwellings arising from the LSP will be exposed to BAL-29 or lower and will fall within the acceptable level of risk. Consequently, there is no requirement to clear bushland to meet bushfire management requirements.

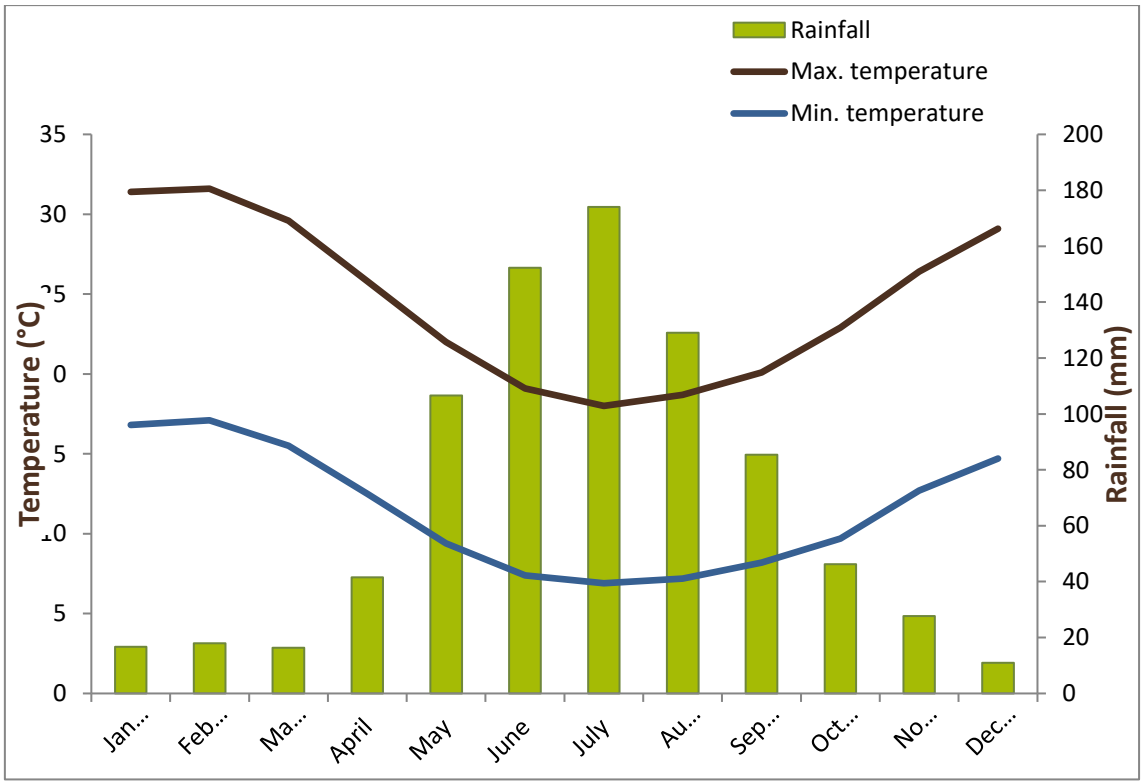
4.4 Landscape Management Plan

A Landscape Management Plan (LMP) has been prepared for the development in support of the Local Structure Plan (EPCAD, 2019). This LMP recognises that the interface between the retained bushland and the proposed development needs special focus. It proposes that this linear space be developed as a buffer and include outdoor classroom elements that serve to educate people about the bushland. It will include walking tracks, conservation fencing, and signage. It will also be managed in line with the BMP.

5 Site Environmental Features

5.1 Climate

The climate of the site is described as warm Mediterranean with warm summers and cool winters. Weather data over 29 years was collected from the Jandakot Aero Station located approximately 3.6 km northwest of the site (Graph 1). The annual mean maximum temperature is 18.0 and the annual mean minimum temperature is 6.9. The annual average rainfall is 823.7 mm (BoM 2018).



Graph 1: Climate Statistics for Jandakot Aero Station 1989 – 2018 (BoM 2018)

5.2 Topography

A large portion of the site has been used for mineral extraction resulting in the topography of the impacted areas to be reduced approximately 5 m lower than the surrounding natural area. Topographic mapping shows a mixture of undulating and steep rises with elevations ranging between 26 m and 42 m Australian Height Datum (AHD) (Figure 2). The mined areas have been levelled out following completion of extraction.

5.3 Regional Geology and Soils

Surface geology profile mapping at 1:250,000 indicates the geology of the site is typically Bassendean Sand: basal conglomerate overlain by dune quartz with heavy mineral concentrations (GSWA 2008).

Soil Landscape and Land System mapping has identified that the site is within the Bassendean System, characterised as sand dunes and sandplains with pale deep sand, semi-wet and wet soil (DAFWA 2012).

Soil subsystem mapping undertaken by the (then) Department of Agricultura and Food WA (DAFWA), has identified the site is mostly within the following soil subsystems:

- 212Bs_B1 - Bassendean B1 Phase: Extremely low to very low relief dunes, undulating sandplain and discrete sand rises. Deep, bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m
- 212Bs_B4 - Bassendean B4 Phase: Broad poorly drained sandplain. Deep siliceous grey sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan (DAFWA 2008) (Figure 3).

5.4 Hydrogeology

5.4.1 Groundwater

Data from the Perth Groundwater Map indicates that groundwater depths across the site range between 2.0 m below ground level (mbgl) from the eastern portion to up to 15.8 mbgl in the central portion (DWER 2018a).

5.4.1.1 Public Drinking Water Source Areas

The site is located within a Public Drinking Water Source Area (PDWSA) as part of the Jandakot Underground Water Pollution Control Area (UWPCA) (DWER 2018a). The site is subject to the provisions of the Statement of Planning Policy 2.3 – *Jandakot Groundwater Protection Policy* (SPP 2.3) and Water Quality Protection Note 25: *Land use compatibility tables for public drinking water source areas* (WQPN 25) (DoW 2016).

The WQPN 25 sets out the following Priority system for PDWSAs:

- Priority 1 (P1) areas are defined and managed to ensure there is no degradation of the quality of the drinking water source with the objective of risk avoidance. P1 areas occur within PDWSAs where existing land uses have low risks to PDWSAs.
- Priority 2 (P2) areas are defined and managed to maintain or improve the quality of the drinking water source with the objective of risk minimisation. P2 areas occur within PDWSAs where the land is zoned Rural and the risks need to be minimised.

- **Priority 3 (P3)** areas are defied and managed to maintain the quality of the drinking water source for as long as possible with the objective of risk management. P3 areas occur within PDWSAs where the land is zoned Urban for commercial or light industrial uses (DoW 2016).

At the time of writing this EAR the Department of Water and Environmental Regulation was in the process of changing the site from P2 to P3 to reflect the Urban zoning of the site under the MRS, as approved by the WAPC.

5.4.2 Surface Water

Review of available surface water feature mapping did not identify any known watercourses, rivers, creeks or streams that intersect the site (DWER 2018b). The site is not within a mapped 100 Year ARI Floodplain area (DWER 2018c) (Figure 5).

Two artificial water bodies occur within the site as a result of sand mining (Figure 5). The two artificial water bodies were previously used as effluent ponds when the site was used for brick manufacture.

5.4.3 Wetlands

A wetland is defined in Schedule 5 of the *Environmental Protection Act 1986* as a 'an area of seasonally, intermittently or permanently waterlogged or inundated land, whether natural or otherwise, and includes a lake, swamp, marsh, spring, dampland, tidal flat or estuary' (Hill *et al.* 1996). Wetlands of the Swan Coastal Plain have been described and mapped by Hill *et al.* (1996) and assigned a management category reflecting their condition.

Wetland categories and their management objectives are described within Table 4 below:

Table 4: Wetland Categories and Management Objectives (WAPC 2005)

CATEGORY	CATEGORY DESCRIPTION	MANAGEMENT OBJECTIVES
Conservation Category	High conservation and ecological value	To preserve the wetlands (natural) attributes and functions
Resource Enhancement	Moderate natural and human use attributes that can be restored or enhanced	To restore wetlands through maintenance and enhancement of wetland functions and attributes
Multiple Use	Little remaining important wetland attributes, functions and ecological value	To use, develop and manage wetlands in the context of water, town and environmental planning

Wetland mapping has identified part of a Resource Enhancement Wetland (REW) (UFI: 13328) in the north-western portion of the site (DBCA 2018a) (Figure 4).

5.5 Contamination

5.5.1 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are naturally occurring soils that contain iron sulfides that are generally found in a layer of waterlogged soil or sediment that are benign in their natural state. However, when soils are disturbed and exposed to air, they oxidise to produce sulfuric acid, iron precipitates and concentrations of dissolved heavy metals (WAPC 2008).

Desktop mapping has identified that the entire site is mapped as having 'Moderate to Low' risk of ASS within the first 3 m of natural soil surface and 'High to Moderate' risk of ASS beyond 3 m (DWER 2018c) (Figure 5). It is noted however that the site has quarried of sand and this has lowered the level of the site and the level at which natural soils occur.

5.5.2 Contaminated Sites

A manufacturing facility that produced brick and paver products operated on Lot 705 between 1950 and 2013. A memorial was registered against the title of the then Lot 4 (now Lot 705) under Section 58(b) of the Contaminated Site Act 2003 (Cs Act) on 17 January 2011 with a site classification of Possibly contaminated - investigation required (PCIR) in accordance with Section 59 of the *Contaminated Sites Act 2003.*

Several phases of environmental investigations and subsequent remediation works have been undertaken for Lot 705 since 2005. The primary focus of this work has been on the former site of the manufacturing facility and its associated infrastructure. Remediation activities included removal of ACM, petroleum hydrocarbon, and metal impacted soils from selected 'hotspot' locations. Also, petroleum hydrocarbon impacted groundwater was removed by vacuum extraction.

At the completion of the remediation works a Voluntary Auditors Report (VAR) was prepared on Lot 705 (Senversa 2018). The VAR recommended Lot 705 be reclassified from Possibly Contaminated – Investigation Required" (PCIR) to Decontaminated, with the exclusion of the defined area containing fill,

Lot 705 was reclassified as Decontaminated with the exclusion of Fill Area A in June 2019. The reclassification of most of Lot 705 as Decontaminated could only occur after an Interest Only Deposited Plan (IODP) was lodged with Landgate that defines Fill Area A to allow for different classifications of Fill area A and the remainder of Lot 705. This process was completed shortly prior to June 2019 and the area defined by the IODP was classified as PCIR. The reason given in the Updated Site Classification is that "this portion of the site has not been fully investigated and remediated for asbestos-related issues".

Perron is responsible for the remediation of the uncontrolled fill including asbestos containing materials under the *Contaminated Sites Act 2003*. At the time of writing

Perron was in the process of planning the remediation of this part of the site. When this work is completed Perron will seek reclassification of the site to Decontaminated under the *Contaminated Sites Act 2003*.

5.6 Reserves and Conservation Areas

The north-western and northern portion of the site is within Bush Forever Site 390 (Department of Planning 2016). Two Perth Regional Ecological Linkages (ID: 46 and 47) intersect the eastern and north-western portion of the site (PBP 2008) (Figure 6a).

The site is not part of any Regional Parks or Department of Biodiversity Conservation and Attractions (DBCA) Managed Lands. The nearest conservation estate is a landholding which is part of Jandakot Regional Park and is located immediately to the east abutting the site boundary (DBCA 2018b; c) (Figure 6b). Jandakot Regional Park comprises a mosaic of landholdings from the southern end of Jandakot Airport to south of Casuarina Prison.

Environmentally Sensitive Areas (ESAs) are identified and protected under the *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*. Under the Notice it is an offence to kill or destroy native vegetation within an ESA without a clearing permit. A large portion of the site, except for the central southern portion, is mapped as an ESA (Figure 6a) (DWER 2018e).

5.7 Flora and Vegetation

5.7.1 Bioregion

The Site is located within the Swan Coastal Plain bioregion of the Interim Biogeographic Regionalisation of Australia (IBRA). The Swan Coastal Plain sub-region 2 (SWA02) is a low lying coastal plain composed of colluvial and Aeolian sands, alluvial river flats and coastal limestone rising to duricrusted Mesozoic sediments in the east. Outwash plains are extensive only in the south, while a complex series of seasonal wetlands and swamps extends from north to south. Vegetation comprises heath and/or Tuart woodlands on limestone, Banksia and Jarrah- Banksia woodlands on Quaternary marine dunes of various ages, Marri on colluvial and alluvial soils, *Casuarina obesa* on out-wash plains, and paperbark (*Melaleuca spp*.) in wetland areas (Mitchell *et al.* 2002).

5.7.2 Broad Vegetation Types

Vegetation mapping of the Swan Coastal Plain subregion of WA was completed on a broad scale (1:250,000) by Beard (1972-80). These vegetation units were re-assessed by Shepherd *et al.* (2001) to account for clearing in the intensive land use zone, dividing some larger vegetation units into smaller units.

The Site is within one vegetation unit described below (Shepherd *et al.* 2001)

- **Bassendean 1001:** Low forest, woodland or low woodland with scattered trees of Jarrah, Banksia or Casuarina, *Eucalyptus marginata*, *Banksia* spp., *Allocasuarina* spp.

Remnant vegetation statistics of the Bassendean 1001 vegetation association within the IBRA region, sub-region and local government area are detailed in Table 5 below.

Table 5: Remnant Vegetation Statistics (Government of Western Australia 2017)

	Pre–European (ha)	Current Extent (ha)	% Remaining	% Remaining in DBCA reserves
IBRA Region Swan Coastal Plain	1,501,221.93	578,997.37	38.57	38.47
State wide				
Beard Veg Assoc No. 1001	57,410.23	12,704.45	22.13	13.82
In IBRA Region Swan Coastal Plain				
Beard Veg Assoc No. 1001	57,410.23	12,704.45	22.13	13.82
In IBRA Sub-region SWA02				
Beard Veg Assoc No. 1001	57,410.23	12,704.45	22.13	13.82
Local Government Authority – City of Cockburn				
Beard Veg Assoc No. 1001	7,328.39	2,038.06	27.81	14.66

Within constrained areas on the Swan Coastal Plain, the EPA's Guidance Statement No. 33 – *Environmental Guidance for Planning and Development* document has set a threshold for the retention of 10 % of the pre-clearing extent of ecological communities (EPA 2008). The site is considered to be constrained as it is within the Perth Metropolitan region and is within close proximity to urban areas. All current vegetation extents within the State, IBRA region and Local Government area are above the aforementioned 10% threshold.

Vegetation complexes of the Southwest botanical district have been mapped by Heddle *et al.* (1980). One vegetation complex exists across the site which relates to the underlying soil profile:

- **Bassendean** Complex – **Central and South:** Vegetation ranging from woodland of Eucalyptus marginata – *Allocasuarina fraseriana* – *Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites. The area includes the transition of *Eucalyptus marginata* to *Eucalyptus todtiana* in the vicinity of Perth (Heddle *et al.* 1980).

5.7.3 Surveyed Vegetation

A Targeted Flora Survey was conducted on 12th and 15th October 2012 and a Level 2 Flora and Vegetation Survey was conducted on 24th October 2012 within Lot 705 (previously Lot 4). The survey area contained a total of four vegetation associations, the extent of these in the survey area and a description is presented in Table 6 below (ENV Australia 2013) (Figure 7).

The vegetation within Lot 707 has been historically cleared and not likely to contain remnant native vegetation.

Table 6: Vegetation Associations and their extents in the Survey Area (Lot 705) (ENV Australia 2013)

Landform	Vegetation Code	Vegetation Association	Extent in Survey Area (ha)	Extent in Survey Area (%)
Undulating plains	Ba	*Baumea articulata* population.	0.2	0.33
	BaBmEf	Low woodland of *Banksia menziesii* and *B. attenuata* over *Stirlingia latifolia, Eremaea fimbriata, Allocasuarina humilis, Patersonia occidentalis* and *Lyginia imberbis.*	1.1	1.82
	BaBm	Low open woodland of *Banksia menziesii* and *B. attenuata* over *Eremaea pauciflora* var. *pauciflora. Scholtzia involucrata*, *Stirlingia latifolia* and *Astroloma ciliatum.*	10.2	16.90
	Rehab	Planted mixed shrubs of *Kunzea glabrescens, Acacia pulchella, Adenanthos cygnorum, Bossiaea*	17.84	29.56

Landform	Vegetation Code	Vegetation Association	Extent in Survey Area (ha)	Extent in Survey Area (%)
		eriocarpa, Gompholobium tomentosum and *Stirlingia latifolia.*		
	Cleared	N/A	19.3	31.99
	OW	Open Water	1.5	2.49
	NN	Non-native planted species	7.6	12.60
Dampland	MpBi	Low open forest of *Melaleuca preissiana* and *Banksia ilicifolia* over *Dasypogon bromeliifolius, Astartea scoparia, Lepidosperma squamatum, Xanthorrhoea preissii* and *Phlebocarya ciliata.*	2.6	4.31

5.7.4 Vegetation Condition

The condition of the vegetation within the site ranged from 'Completely Degraded' to 'Excellent' with most of the survey area considered to be in 'Degraded' or 'Completely Degraded' (44.6%) (ENV Australia 2013) (Figure 8) (Table 7).

The 'Degraded' and 'Completely Degraded' areas within the site were cleared for sand extraction and brick making activities including the creation of artificial ponds, tracks, and brick-making plant. The extraction area has been subject to partial rehabilitation and has an abundance of weeds and a low diversity of rehabilitated species (ENV Australia 2013).

The fire age across the surveyed area was variable and ranged between Old (8-12 years) and Very Old (>12 years) (ENV Australia 2013).

Table 7: Vegetation Condition and Extents in the Survey Area (Lot 705) (ENV Australia 2013)

Condition	Extent in Survey Area (ha)	Extent in Survey Area (%)	Vegetation Association
Excellent	10	17	MpBi, BaBm, BaBmEf
Very Good	2	3	BaBm
Good	0.8	1	BaBm

Condition	Extent in Survey Area (ha)	Extent in Survey Area (%)	Vegetation Association
Degraded	23.4	40	Rehab, NN, Ba, BaBm
Completely Degraded	21.2	36	N/A
Open Water	1.5	3	N/A
Total	**58.9**	100	

5.7.5 Floristic Community Types

Statistical analysis identified the following inferred Floristic Community Types (FCTs) for the native vegetation within the site:

- FCT SCP23a – Central *Banksia attenuata – B. menziessi* woodlands; and
- FCT SCP4 – *Melaleuca preissiana* damplands (ENV Australia 2013).

5.7.6 Threatened and Priority Ecological Communities

Desktop searches of the (then) Department of Environment and Conservation (DEC)'s Threatened and Priority ecological community (TEC and PEC) database identified that no State TECs or PECs exist within the site. The nearest TEC record is:

- SCP10a – Shrublands on dry clay flats (Critically Endangered under the EPBC Act (DEC 2012).

Two PECs were recorded within 2 km of the site:

- SCP22 – *Banksia ilicifolia* woodlands (Priority 2) recorded 770 m north of the site; and
- SCP21c – Low lying *Banksia attenuata* woodlands or shrublands (Priority 3, recorded 770 m north of the site (DEC 2012).

Vegetation associations BaBmEf and BaBm are not listed as TECs under State legislation, however they are considered to form part of the PEC (Priority 3) 'Banksia dominated woodlands of the Swan Coastal Plain IBRA region'. Vegetation that has an overstorey dominated by Banksia is listed as Priority 3 ecological community. With this taken into consideration, it is likely the vegetation associations BaBmEf and BaBm are considered to be Priority 3 by the State.

5.7.7 Flora

Database searches were undertaken to identify the conservation significant flora occurring within a 5 km radius of the site, this included DBCA's NatureMap database, the DEE's Protected Matter Search Tool (PMST) (DEE 2018; DBCA 2018d) (Figure 9). The likelihood assessment of the results of these searches was conducted based on nearby records and suitable habitat on site (Table 8).

Table 8: Likelihood Assessment of Conservation Significant Flora Occurring within the Site (DEE 2018; DBCA 2018d)

Taxon	Conservation Status		Likelihood
	EPBC	STATE	
Grand Spider-orchid (*Caladenia huegelii*)	Endangered	Threatened	Recorded
Glossy-leaved Hammer Orchid (*Drakaea elastica*)	Endangered	Threatened	Likely
Drakaea micrantha	Vulnerable	Threatened	Likely
Slender Andersonia *(Andersonia gracilis)*	Endangered	Threatened	Unlikely
Dwarf Bee-orchid *(Diuris micrantha)*	Vulnerable	Threatened	Unlikely
Purdie's Donkey Orchid *(Diuris purdiei)*	Endangered	Threatened	Unlikely
Beaked Lepidosperma *(Lepidosperma rostratum)*	Endangered	Threatened	Unlikely
Narrow curved-leaf Grevillea *(Grevillea curviloba subsp. incurva)*	Endangered	Threatened	Unlikely
Selena's Synaphea *(Synaphea sp. Fairbridge Farm)*	Critically Endangered	Threatened	Unlikely
Cinnamon Sun Orchid *(Thelymitra dedmaniarum)*	Endangered	Threatened	Unlikely
Poranthera moorokatta	-	Priority 2	Unlikely
Rainbow Plant (*Byblis gigantea)*	-	Priority 3	Likely
Jasksonia gracillima	-	Priority 3	Likely
Cyathochaeta teretifolia	-	Priority 3	Unlikely
Phlebocarya pilosissima subsp. *pilosissima*	-	Priority 3	Likely
Schoenus pennisetis	-	Priority 3	Unlikely
Stylidium paludicola	-	Priority 3	Unlikely
Hackett's Hopbush (*Dodonaea hackettiana*)	-	Priority 4	Unlikely
Jacksonia sericea	-	Priority 4	Unlikely
Cape Arid Kennedia (*Kennedia beckxiana*)	-	Priority 4	Unlikely

Taxon	Conservation Status		Likelihood
	EPBC	STATE	
Jumping Jacks (*Stylidium longitubum*)	-	Priority 4	Possible
Tripterococcus sp. *Brachylobus*	-	Priority 4	Unlikely
Verticordia lindleyi subsp. *lindleyi*	-	Priority 4	Likely

Six flora species are considered Likely to occur and Possible to occur within the site, however, these conservation significant species are considered unlikely to occur within degraded portions of the site given historical land uses and vegetation being the product of rehabilitation. Conservation significant flora species are more likely to occur within the intact remnant native vegetation.

A total of 90 taxa (including species, subspecies, varieties and forms) from 70 genera and 32 families were recorded during the survey. One Threatened species pursuant to the EPBC Act and gazetted as Declared Rare Flora under the WC Act was recorded. 33 individuals of *Caladenia huegelii* from 16 locations within the site were identified within intact remnant native vegetation (ENV Australia 2013).

5.7.8 Weeds

A total of nine introduced species were recorded during the Flora and Vegetation survey (Table 9) (ENV Australia 2013). None of the species are Declared under the Biosecurity and Agriculture Management Act 2007 (BAM Act) or listed as Weeds of National Significance (WONS).

Table 9: Introduced Flora Recorded in the Survey Area (ENV Australia 2013)

Taxon	Common Name	Declared BAM Act	WONS
**Acacia longifolia*	Sydney Golden Wattle	No	No
**Aira caryophyllea*	Silver Hairgrass	No	No
**Briza maxima*	Blowfly Grass	No	No
**Carpobrotus edulis*	Pigface	No	No
**Ehrharta longiflora*	Veldt Grass	No	No
**Gladiolus caryophyllaceus*	Wild Gladiolus	No	No
**Hypochaeris glabra*	Smooth Cats-ear	No	No
**Ursinia anthemoides*	Solar Fire	No	No
**Wahlenbergia capensis*	Cape Bluebell	No	No

5.8 Fauna

5.8.1 Threatened and Priority Fauna

Conservation significant fauna potentially occurring within a 5 km radius of the site were determined through desktop searches using DEE's PMST and DBCA's NatureMap search tools and presented in Table 10 (DEE 2018; DBCA 2018d).

Table 10: Conservation Significant Fauna Potentially Occurring within 2 km of the Site (DEE 2018; DBCA 2018d)

TAXA	STATE STATUS	EPBC STATUS
Australasian Bittern (*Botaurus poiciloptilus*)	Threatened	Endangered
Red Knot (*Calidris canutus*)	Threatened	Endangered
Curlew Sandpiper (*Calidris ferruginea*)	Threatened	Critically Endangered
Malleefowl (*Leipoa ocellata*)	Threatened	Vulnerable
Eastern Curlew (*Numenius madagascariensis*)	Threatened	Critically Endangered
A native bee (*Neopasiphae simplicior*)	Threatened	Critically Endangered
Chuditch (*Dasyurus geoffroii*)	Threatened	Vulnerable
Western Ringtail Possum (*Pseudocheirus occidentalis*)	Threatened	Critically Endangered
Carnaby's Cockatoo (*Calyptorhynchus latirostris*)	Threatened	Endangered
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	Threatened	Vulnerable
Baudin's Cockatoo (*Calyptorhynchus baudinii*)	Threatened	Endangered
Pectoral Sandpiper (*Calidris melanotos*)	Threatened	Migratory/Marine
Australian Painted Snipe (*Rostratula australis*)	Threatened	Endangered
Numbat (*Myrmecobius fasciatus*)	Threatened	Endangered
Stylet Bush Cricket (*Throscodectes xiphos*)	Priority 1	-
Perth Slider (*Lerista lineata*)	Priority 3	-
Western Brush Wallaby (*Notamacropus irma*)	Priority 4	-
Graceful Sunmoth (*Synemon gratiosa*)	Priority 4	-
Blue-billed Duck (*Oxyura australis*)	Priority 4	-
Quenda (*Isoodon fusciventer*)	Priority 4	-
Hooded Plover (*Thinornis rubricollis*)	Priority 4	Marine

TAXA	STATE STATUS	EPBC STATUS
Common Sandpiper (*Actitis hypoleucos*)	International Agreement	Migratory/Marine
Sharp-tailed Sandpiper (*Calidris acuminata*)	International Agreement	Migratory/Marine
Red-necked Stint (*Calidris ruficollis*)	International Agreement	Migratory/Marine
Long-toed Stint (*Calidris subminuta*)	International Agreement	Migratory/Marine
Little Ringed Plover (*Charadrius dubius*)	International Agreement	Migratory/Marine
Wood Sandpiper (*Tringa glareola*)	International Agreement	Migratory/Marine
Common Greenshank (*Tringa nebularia*)	International Agreement	Migratory/Marine
Marsh Sandpiper (*Tringa stagnatilis*)	International Agreement	Migratory/Marine
Ruff (*Philomachus pugnax*)	International Agreement	Migratory/Marine
Glossy Ibis (*Plegadis falcinellus*)	International Agreement	Migratory/Marine
Black-tailed Godwit (*Limosa limosa*)	International Agreement	Migratory/Marine
Fork-tailed Swift (*Apus pacificus*)	International Agreement	Migratory/Marine
Grey Wagtail (*Motacilla cinerea*)	International Agreement	Migratory
Osprey (*Pandion haliaeetus*)	-	Migratory
Great Egret (*Ardea alba*)	-	Marine
Cattle Egret (*Ardea ibis*)	-	Marine
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	-	Marine
Rainbow Bee-eater (*Merops ornatus*)	-	Marine
Painted Snipe (*Rostratula benghalensis*)	-	Marine
Peregrine Falcon (*Falco peregrinus*)	Other specially protected species	-

It is not likely that the change in land use would have a significant impact on any conservation significant fauna species as the portion of the site proposed for development is in mostly Degraded and Completely Degraded. The surrounding environment is largely cleared of native vegetation, consists of rural landholdings and urban/commercial developments containing limited vegetation. The surrounding area also consists of large conservation areas and wetlands within Bush Forever Site 390 and Jandakot Regional Park that may support migratory waders and wetland species.

It is not likely that the developable footprint would contain a significant area of valuable fauna habitat that would be extensively utilised by conservation significant fauna species. The Carnaby's Cockatoo may utilise some habitat proposed to be cleared, however the clearing of this habitat is considered minimal (0.7 ha) considering the retention of vegetation to be retained into Bush Forever 390 as part of the development.

5.9 Heritage

5.9.1 Aboriginal Heritage

In Western Australia, the *Aboriginal Heritage Act 1972* protects places and objects customarily used by or traditional to the original habitants of Australia. A register of such places and objects are maintained under the Act, however, all sites are protected under the Act whether they are registered or not (DPLH 2018).

A desktop search has identified that no registered or lodged Aboriginal Heritage sites intersect with the site. One site 'Banjup: Calsil' intersects the eastern portion of the site, however, it is classified as 'Stored Data/Not a Site' by the Department of Planning, Lands and Heritage (DPLH) (DPLH 2018).

There are two registered Aboriginal Heritage sites located within 2 km of the site (Table 11; Figure 10) (DPLH 2018).

Table 11: Aboriginal Heritage Sites within the Vicinity of the Site (DPLH 2018)

Number	Site Name	Type	Status	Distance from Site (km)
3447	Mather Reserve	Mythological, Hunting Place	Registered	1.32
21811	Kraemer Reserve	Mythological, Camp, Hunting Place, Meeting Place, Water Source	Registered	1.36

5.9.2 European Heritage

No State, World or National heritage places are located in the vicinity of the site (SHO 2018; DEE 2018).

There is one Municipal inventory heritage site located to the south of Armadale Road:

- Armadale/Fremantle Rail Armadale to Cockburn – runs along the south side of Armadale Road between Liddelow Road and Armadale Road (SHO 2018) (Figure 10).

5.10 Site History

Review of historical aerial imagery was undertaken to identify and assess land use and development changes within the area over time. The earliest available aerial image of the area was taken in 1953 and more recent aerial images (from approximately 10 year intervals up to present) were viewed (Figures 11a-g).

The site was largely uncleared by 1953, with some evidence of clearing in the southeast portion of the site and the neighbouring lots. Between 1953 and 1965, further clearing and potential sand extraction has occurred within the southern portion of the site and the land to the south has been significantly cleared and Armadale Road was realigned during this time. The site was historically used for brickworks and sand extraction activities. Further clearing has occurred within the site for sand extraction and some access tracks by 1974 and to the north and east of the site for a powerline easement. Between 1974 and 1985, further clearing has occurred to the north of the site for rural purposes. Clearing within the site during this time has expanded with more tracks and the construction of ponds and the development of a brickworks. By 1995 rural residential development was developed to the south of the site and the clearing footprint increased. Some clearing had occurred within the neighbouring lot. Between 1995 and 2005, the clearing and works at the site have extensively increased and extended into the lot to the west. Land to the north was also cleared for sand extraction purposes and rural residential. By 2018, the majority of the cleared areas of the site and surrounding areas to the north, east and west were rehabilitated and building structures removed.

5.11 Surrounding Land Uses

The site abuts the Mixed Business Precinct adjoining the Kwinana Freeway and forming a component of the Cockburn Central Activity Centre. Surrounding land uses include rural residential to the north and south, urban residential development to the west and east. Uncleared and undeveloped land to the north and east.

Land directly to the east is reserved as Parks and Recreation but has been quarried for sand and remains covered by mining leases. The need for separation between this land use and the proposed residential development was considered during the MRS amendment process and no requirement was identified. Land to the north is zoned 'Rural - Water Protection' and abutting land to the west is zoned Urban and reserved as Parks and Recreation under the MRS.

5.11.1 Jandakot Airport and Armadale Road

The site is located approximately 1.8 km from the boundary of Jandakot Airport to the north-west and is within the frame area of State Planning Policy 5.3 – *Land Use Planning in the Vicinity of Jandakot Airport* (SPP 5.3). SPP 5.3 provides policy measures to protect Jandakot Airport from encroachment by incomputable land uses and development, and to minimise the impact of aircraft noise on existing and future communities (WAPC 2017).

The site abuts Armadale Road to the south which is identified as a Primary Regional Road under the MRS. As such, the site is subject to the provisions of State Planning Policy 5.4 – *Road and Rail Transport Noise and Freight Considerations* (SPP 5.4) to avoid or mitigate land use conflict between the transport route and future urban residential development of the site.

5.12 Groundwater Resources

A search of DWER's WIN Groundwater bore database identified 266 bores within 2 km of the site, of which 22 bores are known to be operational, 212 had an unknown status, 41 are in hibernation and one known to be decommissioned (DWER 2018f).

Prior to the purchase of the Site by Perron there was one groundwater licence applicable to the site from the Perth – Superficial Swan aquifer:

- Licence No. 163828: Boral Bricks Western Australia Pty Ltd, (DWER 2018f).

This licence was transferred to Perron upon purchase of the land and has the following authorised activities relating to an allocation with an allocation of 139,760k;

- Dust suppression for earthworks and construction purposes
- Irrigation of up to 7.9 ha of public open space
- School facilities
- Water requirements to maintain pool and lake levels.

6 Environmental Impacts and Management

The following key environmental considerations have been identified for urban development of the site and these are addressed in the following sections.

- Conservation Significant Flora
- Vegetation and Fauna Habitat
- Bush Forever 390
- Hydrology
- Wetlands
- Acid sulfate soils
- Contamination
- Bushfire Risk
- Noise.

6.1 Conservation Significant Flora

The site contains a total of 16 recorded *Caladenia huegelii* individuals. 13 of these are located within Bush Forever 390 and will be retained because of the retention of Bush Forever 390. The remaining three individuals are located within the clearing footprint and are proposed to be relocated.

The three individuals to be relocated currently occur within a small (0.8 ha) patch of remnant native vegetation. This patch of remnant vegetation is approximately 5 m in height above the surrounding landscape due to historical sand extraction activities surrounding the patch and is isolated from other remnant vegetation on a local scale. Given these factors, these *Caladenia huegelii* individuals are not considered to be a viable population and retention of this area of vegetation is considered impractical.

6.1.1 Management Measures

A referral of the proposed development was made under the EPBC Act to the (then) Federal Department of the Environment (DoE) in November 2013. The referral included the relocation of the affected *Caladenia huegelii* individuals and received a 'Not Controlled Action'.

The three *Caladenia huegelii* individuals will be relocated from the development footprint to mitigate the impacts of the development to the species. It is important to note that the relocation of the orchids is considered part of the proposal referred under the EPBC Act and as such the proposal must remain consistent.

A Permit to Take Declared Rare Flora will be sought under the Biodiversity Conservation Act 2016 and Biodiversity Conservation Regulations 2018 from the DBCA. Once the Permit to Take is approved and issued, advice will be sought from orchid cultivation

experts within the WA Botanic Gardens and Parks Authority to determine the best approach and location to relocate the affected *Caladenia huegelii* individuals. The proposal allows for both the avoidance and mitigation of potential impacts to *Caladenia huegelii* individuals within the site.

6.2 Vegetation and Fauna Habitat

The majority of the development footprint consists of vegetation from rehabilitation or is cleared land. The intact remnant native vegetation within the existing Bush Forever boundary will be retained, aside for a small area in the north-western corner of the lot to accommodate a connector road into the development.

The key potential impacts on terrestrial vegetation from future development of the site include:

- Clearing of a small area in the north-western corner of the lot to accommodate a connector road into the development
- Inadvertent damage to trees and vegetation marked for retention during the construction phase
- Silt and sediment run-off from uncontrolled run-off during site works
- Dust generation during construction
- Associated urban degradation and disturbances, including rubbish dumping, uncontrolled access, flower/seed harvesting
- Edge effects due to the proposed development caused by the interaction of native vegetation with urban land uses. This can lead to increased weed invasion, the inhibition or promotion of certain species from establishing along the edges and initiating a decline in vegetation condition
- Dieback disease
- Hydrological changes.

6.2.1 Management Measures

Potential impacts to retained vegetation can be appropriately managed through engineering design and the implementation of site management plans.

The retained vegetation within Bush Forever Site 390 will be fenced off. Discussion will be held in relation to the ceding of this land for conservation in perpetuity and potential inclusion in the Jandakot Regional Park conservation system.

The following management measures and plans will be prepared and implemented for the site to address potential impacts to retained vegetation:

- Development only within areas of previous disturbance;
- Retention of remnant native vegetation in Excellent and Very Good condition;
- Retention of ecological linkages;

6.3 Hydrology

Urban residential development of the site will increase the area of impervious services and has the potential to increase recharge of rainfall to groundwater through increased surface area of residential roofs, driveways, car parks and roads. Potential impacts to the surrounding retained environmental values include increased runoff from urban surfaces and groundwater level changes from land use and clearing. This can have an impact on the surrounding sensitive environments through changes in the hydrological regime and increased nutrients and sedimentation.

6.3.1 Management Requirements

A District Water Management Strategy (DWMS) has been prepared by JDA (2016) for the wider Treeby area and demonstrates the site is capable of supporting urban development and achieving best practice urban water management outcomes.

A LWMS has been prepared by JDA (2019) in accordance with the principles, objectives and key criteria of Better Urban Water Management (WAPC 2008) and the Treeby DWMS to support local structure planning. The LWMS provides a framework for the application of total water cycle management to the proposed urban development to demonstrate the development is capable of achieving appropriate water management outcomes. Stormwater is collected and disposed of within the development area and thus there are no hydrological impacts on the wetland and bushland within the site.

The LWMS includes management measures to ensure surface water flows match pre-development conditions, provide stormwater and flood management and Best Management Practices for drainage systems. The LWMS has been developed to consider the water management issues described in Table 12 which is taken from the JDA's LWMS.

Table 12: Summary of LWMS Design Principles and Objectives (JDA 2019)

KEY GUIDING PRINCIPLES		
• Facilitate implementation of sustainable best practice in urban water management • Provide integration with planning processes and clarity for agencies involved with implementation • Minimise public risk, including risk of injury or loss of life • Protection of infrastructure and assets from flooding and inundation • Encourage environmentally responsible development • Facilitate adaptive management responses to the monitored outcomes of development.		
CATEGORY	**DWMS OBJECTIVES**	**LWMS CRITERIA**
Stormwater Management	• Non-structural measures to reduce applied nutrient loads. • At source retention of small storm events (15 mm). • Onsite infiltration of all stormwater runoff up to 1% AEP. • Water quality treatment systems and water sensitive urban design structures designed in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007) Chapter 9 (Structural Controls) and Australian Runoff Quality (Ball et al (ed.), 2016).	• All small storm event runoff to be infiltrated at source. • All storm events up to the 1% AEP to be infiltrated onsite. • Manage surface water flows from major events to protect infrastructure and assets from flooding and inundation. • All stormwater management structures located outside of Bush Forever and REW 50 m buffer.
Groundwater Management	• No management of groundwater levels is proposed (subsoil drainage). • Finished levels to provide sufficient separation to groundwater to allow infiltration of stormwater onsite to enhance recharge to the Jandakot Mound. • Limit impacts to Bush Forever and wetland sites. • Limit groundwater abstraction. • Manage fertiliser and pesticide application in streetscapes and POS areas using soil amendments, appropriate plan selection, limiting turf areas and maintenance management plans.	• Manage and minimise changes in groundwater levels and groundwater quality following development, particularly from groundwater level increase from urbanisation within the Study Area and surrounds. • Use of subsoil drainage system to mitigate any groundwater level increase based on the availability of new information. This is a change from the DWMS objectives. • All lots to have soakwells sized to infiltrate up to the small storm event. • All stormwater management structures located outside of Bush Forever and REW 50 m buffer.
Water Conservation and Sustainability	• Ensure that non-potable water supply systems are considered as part of an integrated water supply. • Household target water use of 100 kL/person/year. • Scheme water target use of 40 to 60 kL/person/year. • Use of waterwise landscaping practices both at development and lot scale.	• Aim to achieve the State Water Plan target for water use of 100 kL/person/year. • Consider alternative fit for purpose water sources where appropriate and cost effective. • POS areas to be at least 50% native plants.

CATEGORY	DWMS OBJECTIVES	LWMS CRITERIA
Water Quality	• Adopt nutrient load reduction design objectives for stormwater runoff. • Use of amended soils and ephemeral bioretention systems to treat stormwater.	• Minimise the average annual pollution load by implementation of a treatment train design for stormwater runoff.

An Urban Water Management Plan (UWMP) will be prepared at subdivision stage and will be in accordance with the overarching DWMS and LWMS. The UWMP will be required to address compliance with the LWMS criteria and objectives to the satisfaction of the City of Cockburn and the DWER. It is expected that post construction groundwater monitoring will be required to demonstrate that the methodologies proposed to manage surface water and groundwater have been successful.

6.4 Wetlands

Under the Western Australian Planning Commission's *Guideline for the Determination of Wetland Buffer Requirements* (2005), the consideration of wetlands is required during a change in land use or a proposed development in the immediate vicinity of a wetland where the future land use is likely to conflict with the established wetland management objectives. Under the guidelines, an appropriate buffer distance should be identified to achieve an acceptable planning outcome. Buffer distances determined based on the wetland's category and no development is permitted within buffers (WAPC 2005).

The site contains part of an REW (UFI: 13328) within its far north-eastern corner that is within the existing Bush Forever 390 area. The REW, inclusive of its buffer is separated from urban development by about 100 m of vegetated land that is within Bush Forever 390. This vegetated land is to be retained for regional conservation consistent with the Treeby DSP. Consequently, the proposed development avoids any impact to the REW and its associated buffer.

6.4.1 Management Measures

No management measures are required.

7 Other Potential Impacts and Management

7.1 Acid Sulfate Soils

The entire site is mapped as having 'Moderate to Low' risk of ASS within the first 3 m of natural soil surface and 'High to Moderate' risk of ASS beyond 3 m. Previous sand quarrying has removed and altered the natural soil surface levels in most locations at the site and consequently there is a potential to disturb ASS during works associated with the development.

7.1.1 Future Investigations and Management Measures

Given that the site has been historically disturbed and future works of the site will be required, there is a possibility of existing or potential ASS disturbance. An ASS Investigation would likely be required to be conducted in accordance with the DER's *Identification and investigation of acid sulfate soils and acidic landscapes* guideline (DER 2013).

Dependent on the results of the ASS investigation, an ASS Management Plan may be required as a condition of subdivision. An ASS Management Plan would include:

- Avoidance or minimisation of ASS disturbance measures
- Site-specific measures to ensure water and the surrounding receiving environment are adequately protected
- Earthworks strategy
- Reporting, review and monitoring
- Roles and responsibilities.

7.2 Contamination

As described in Section 5.2.2 Lot 705 has been the subject of a process of investigation and remediation in relation to contaminated land issues associated with the site's past use as a sand quarry and brick making facility. Lot 705 was reclassified as Decontaminated with the exclusion of Fill Area A in June 2019. An area defined as Fill Area A remains classified as PCIR. The reason given in the Updated Site Classification is that "this portion of the site has not been fully investigated and remediated for asbestos-related issues".

Perron is responsible for the remediation of the uncontrolled fill including asbestos containing materials under the *Contaminated Sites Act 2003*. At the time of writing Perron was in the process of planning the remediation of this part of the site. When this work is completed Perron will seek reclassification of the site to Decontaminated under

the *Contaminated Sites Act 2003*. All other contaminated land issues have been resolved.

7.3 Bushfire Risk

The entire site is mapped as Bush Prone Area and is therefore subject to the provisions of State Planning Policy 3.7 – Planning in Bushfire Prone Areas (SPP 3.7) (DFES 2018; WAPC 2015). A Bushfire Management Plan (BMP) has been prepared in accordance with the Guidelines for Planning in Bushfire Prone Areas to support the LSP submission for the Project (Bushfire Management Consulting 2019).

7.4 Aboriginal Heritage

The site does not contain any 'Registered' or 'Lodged' Aboriginal Heritage sites as under Section 5 of the *Aboriginal Heritage Act 1972* (DPLH 2018).

7.4.1 Future Investigations and Management Measures

The client will liaise with the DPLH prior to development to determine any responsibilities under the *Aboriginal Heritage Act 1972.*

In the event that any artefacts are discovered during development, the DPLH will be notified and all work will cease immediately until advice is received from the Department.

7.5 Noise Management

Noise issues are addressed within a separate assessment report which should be directly consulted (Herring Storer Acoustics 2019). The site abuts Armadale Road which is identified as a Primary Regional Road under the MRS and is subject to the provisions of SPP 5.4 – Road and Rail Transport Noise and Freight Consideration. Herring Storer Acoustics, has prepared an Acoustic Assessment that considers the issue of noise and provides recommendations as to how these issues will be managed.

8 Summary

8.1 Outcome and Key Findings of Assessment

Potential environmental impacts that may result from the development of the site and their proposed management are summarised below. The proposed development has been designed to avoid direct impacts to the environmental values of the site. It is considered that the residual environmental issues identified can be adequately managed to mitigate any potential impacts.

The following environmental aspects have been identified as relevant to the site:

- **Conservation Significant Flora:** The site contains *Caladenia huegelii* individuals, of which all are proposed to be retained as part of the development. Three *Caladenia huegelii* occur within a small, isolated patch of vegetation within the development footprint and these will be relocated in accordance with the EPBC Referral for the Project.
- **Vegetation and Fauna:** The site contains remnant native vegetation that contains black cockatoo foraging habitat. The proposed development avoids the site's remnant native vegetation and will be retained as part of Bush Forever 390 that will be reserved for conservation purposes.
- **Wetlands**: Part of a Resource Enhancement Wetland is in the north eastern corner of the site, within Bush Forever 390. The wetland and a bushland buffer of over 100 m will be retained as part of Bush Forever 390 and retained for conservation purposes. Given the adequate vegetated separation distance from the REW and the development footprint, it is not considered that the wetland would be significantly impacted by the future urban development of the site. The preparation and implementation of a LWMS and UWMP will provide hydrological management measures to ensure potential indirect impacts to the wetland are mitigated or minimised.
- **Surface and Groundwater**: The site is within a Priority Drinking Water Source Area and requires good urban water management. A LWMS has been prepared to support local structure planning and a UWMP will be required at subdivision stage. These plans will ensure adequate surface water and groundwater management measures are in place to support urban development within the site whilst protecting the retained surrounding environmental values.
- **Acid Sulfate Soils:** Due to historic disturbance of the natural soils at the site, there is the potential for ASS to occur close to the surface. It is likely that an ASS Investigation would be required to identify the presence or risk of ASS within the site in relation to the proposed location of deep services. The results of the ASS Investigation would inform the requirement for an ASS Management

Plan to be prepared. ASS can be adequately managed to avoid and mitigate the potential impacts.

- **Contamination:** Most of the cleared area of the site has been successfully remediated and is now classified as Decontaminated under the *Contaminated Sites Act 2003*. Part of the site contains asbestos containing material and Perron will be responsible for the remediation of this area of uncontrolled fill including asbestos containing materials in accordance with the *Contaminated Sites Act 2003.*

8.2 Conclusion

The environmental characteristics of the site have strongly influenced the design of the proposed urban development. In doing so, large areas of intact, quality bushland containing *Caladenia huegelii* will be retained and conserved. The proposal is consistent with the Treeby DSP endorsed by the City of Cockburn.

The proposed development plan for the site has been assessed and it is concluded that the development will not have a significant impact on environmental values that cannot be managed. Environmental matters related to the construction phase, such as acid sulfate soil management, can be adequately managed through the implementation of management plans and these will be addressed at later stages in the planning approval process. Remaining potential environmental impacts from the development are considered minor and can be adequately managed through the implementation of management plans.

9 Limitations

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

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

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

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

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FIGURES



Legend

- Site Boundary
- Lot Boundaries
- State Road
- Local Road

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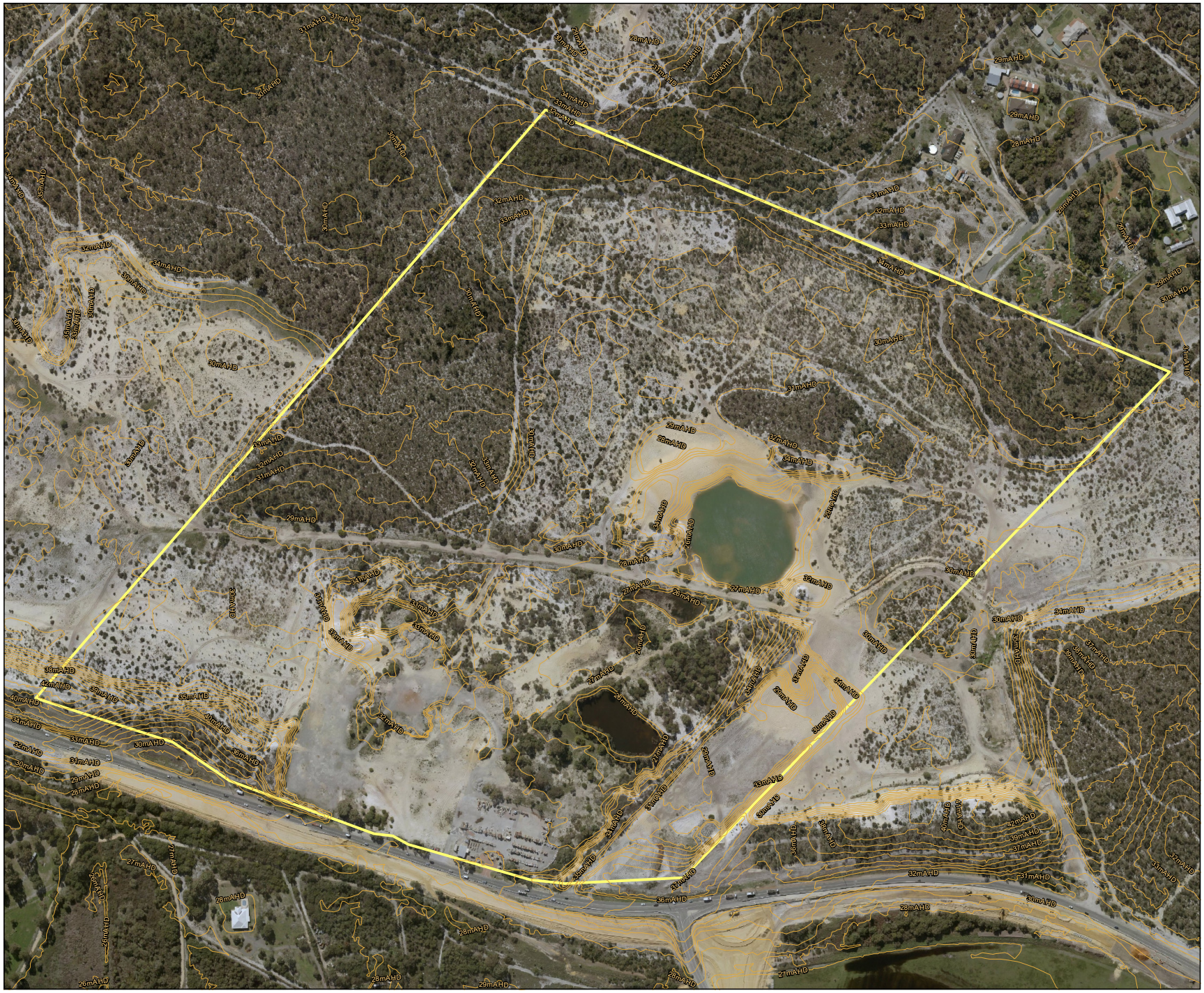
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Figure 1 Site Location

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- Site Boundary
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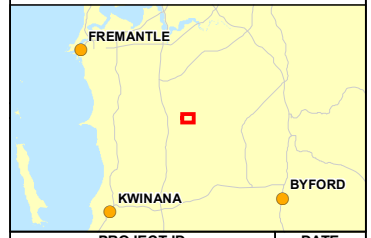
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Figure 2 Topography

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Legend

Site Boundary

Soils Subsystem

- 212BsW_SWAMP
- 212Bs__B1
- 212Bs__B2
- 212Bs__B3
- 212Bs__B4

Soils System

212Bs: Bassendean System

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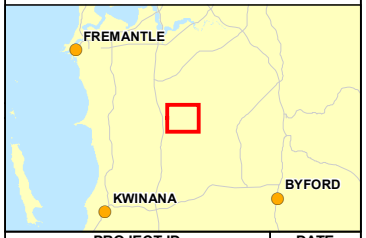
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Figure 3 Geology and Soils

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Legend

- Site Boundary
- Groundwater Contours - Max

Hydrography

- Drain - major
- Swamp
- Area Subject to Inundation

Geomorphic Wetlands

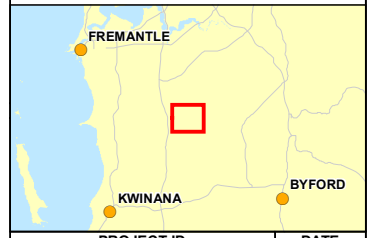
- Conservation Category
- Resource Enhancement Category
- Multiple Use Category

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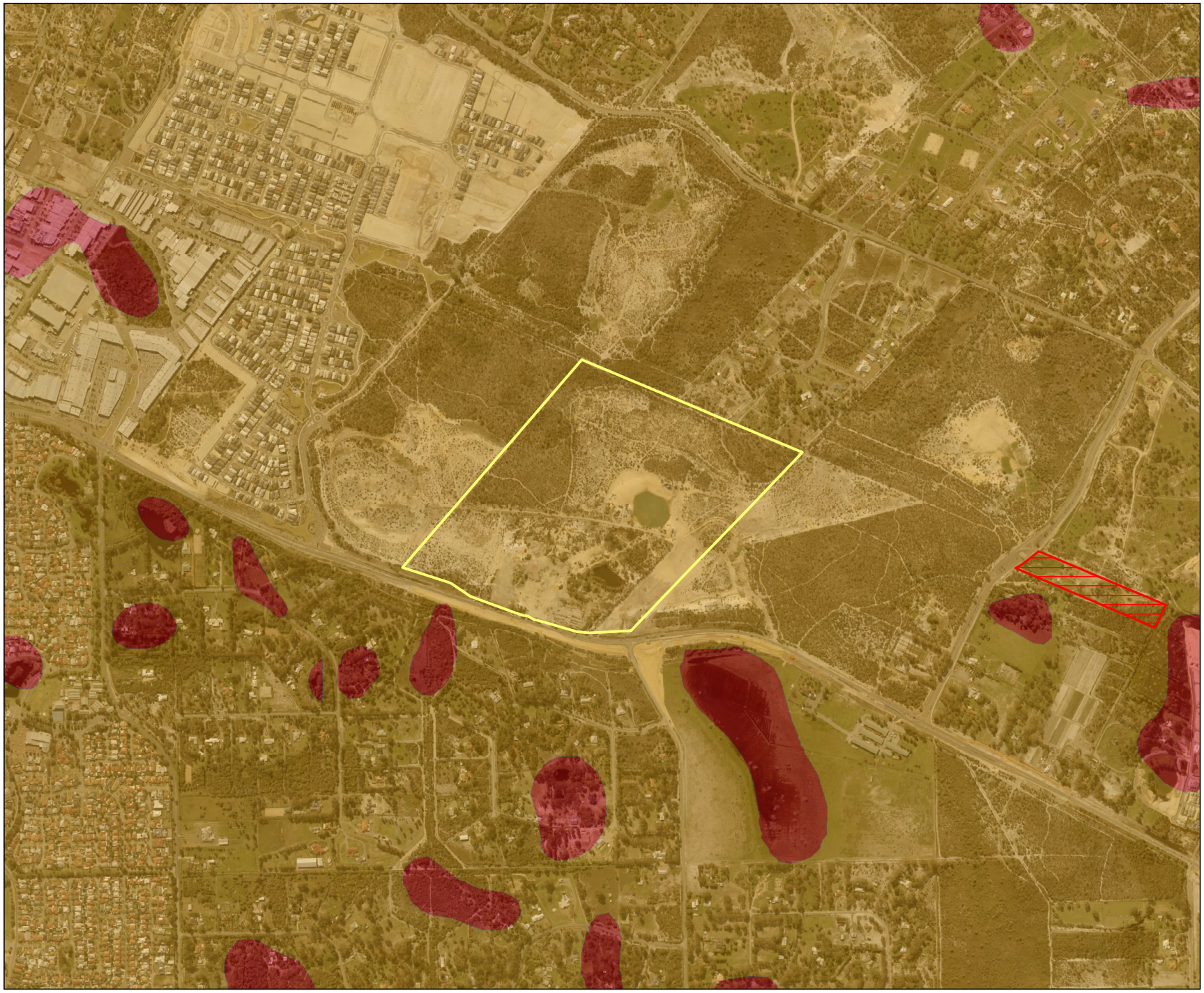
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Figure 4 Hydrology

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Site Boundary

Contaminated Sites

Contaminated: Remediation Required

Acid Sulfate Soils

High to moderate risk

Moderate to low risk

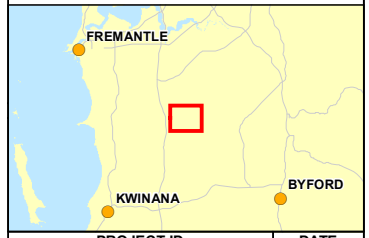
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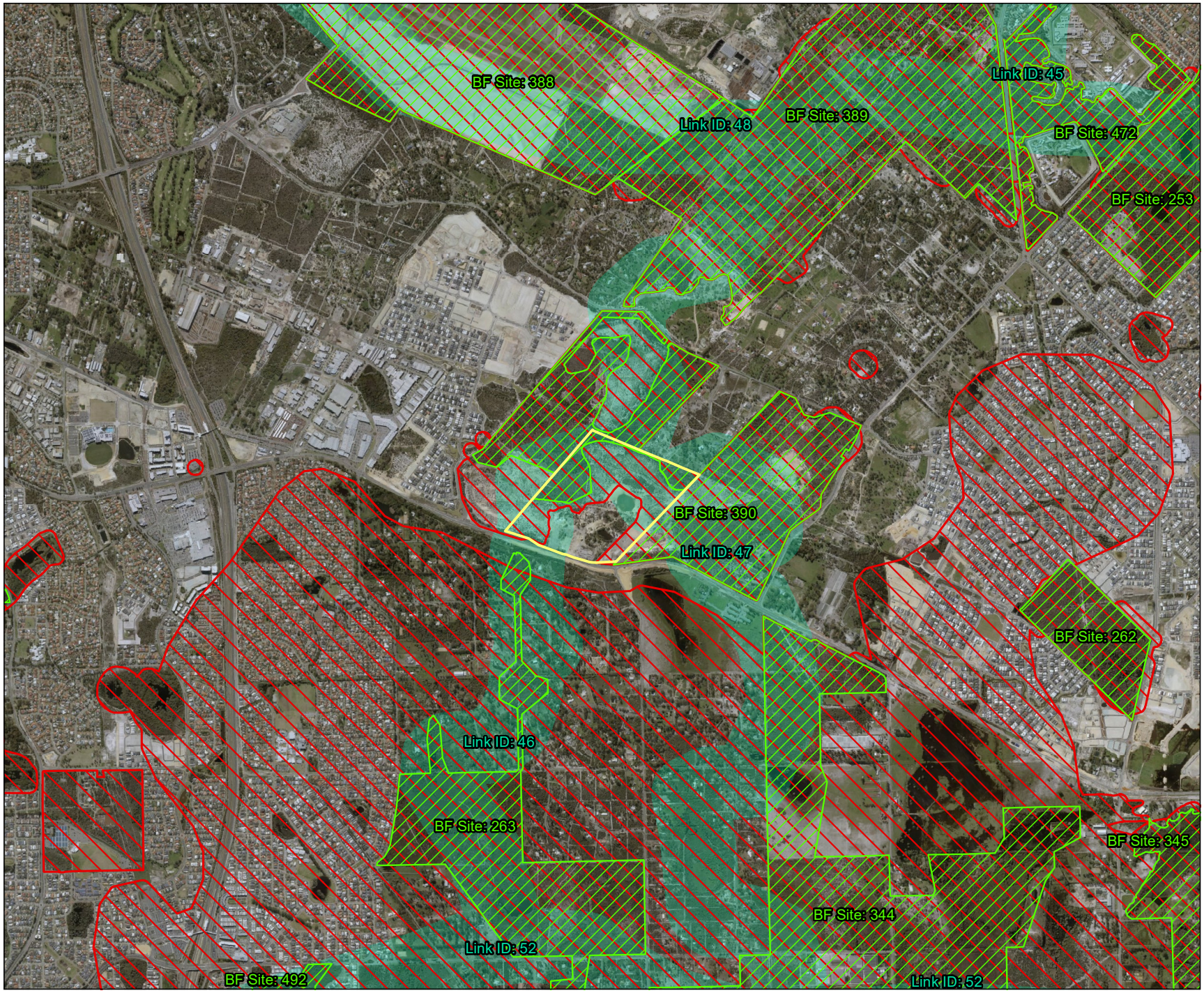
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Figure 5 **Acid Sulfate Soils**

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- Site Boundary
- Environmentally Sensitive Areas
- Bush Forever Sites
- Perth Regional Ecological Linkage

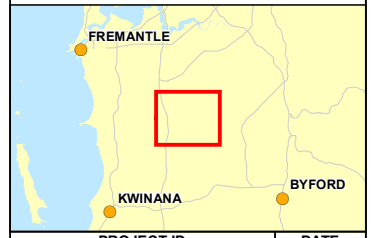
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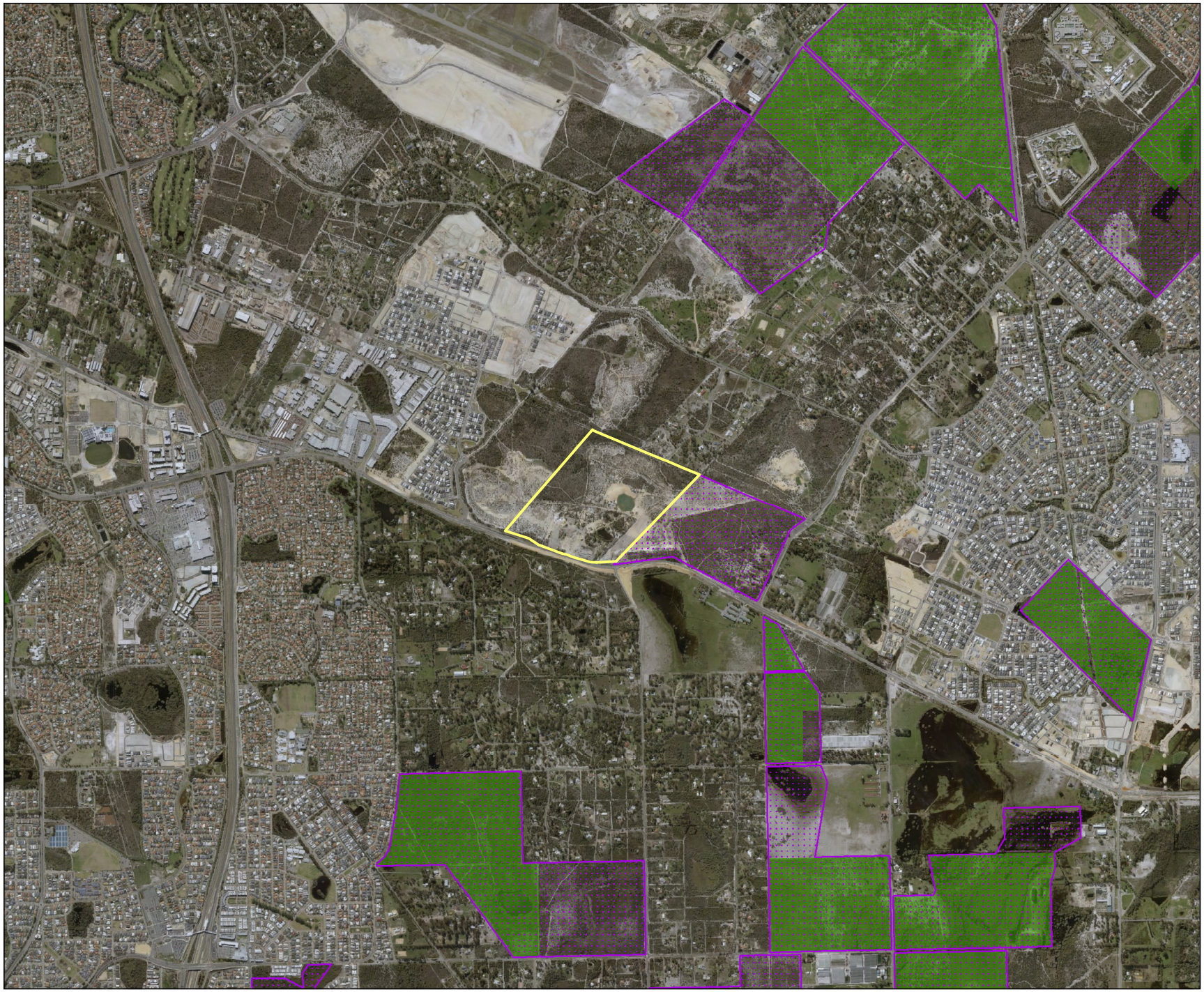
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Figure 6a Conservation Areas

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- Site Boundary
- Jandakot Regional Park
- DBCA Managed Land

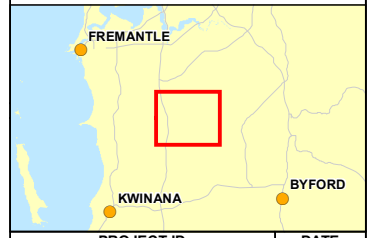
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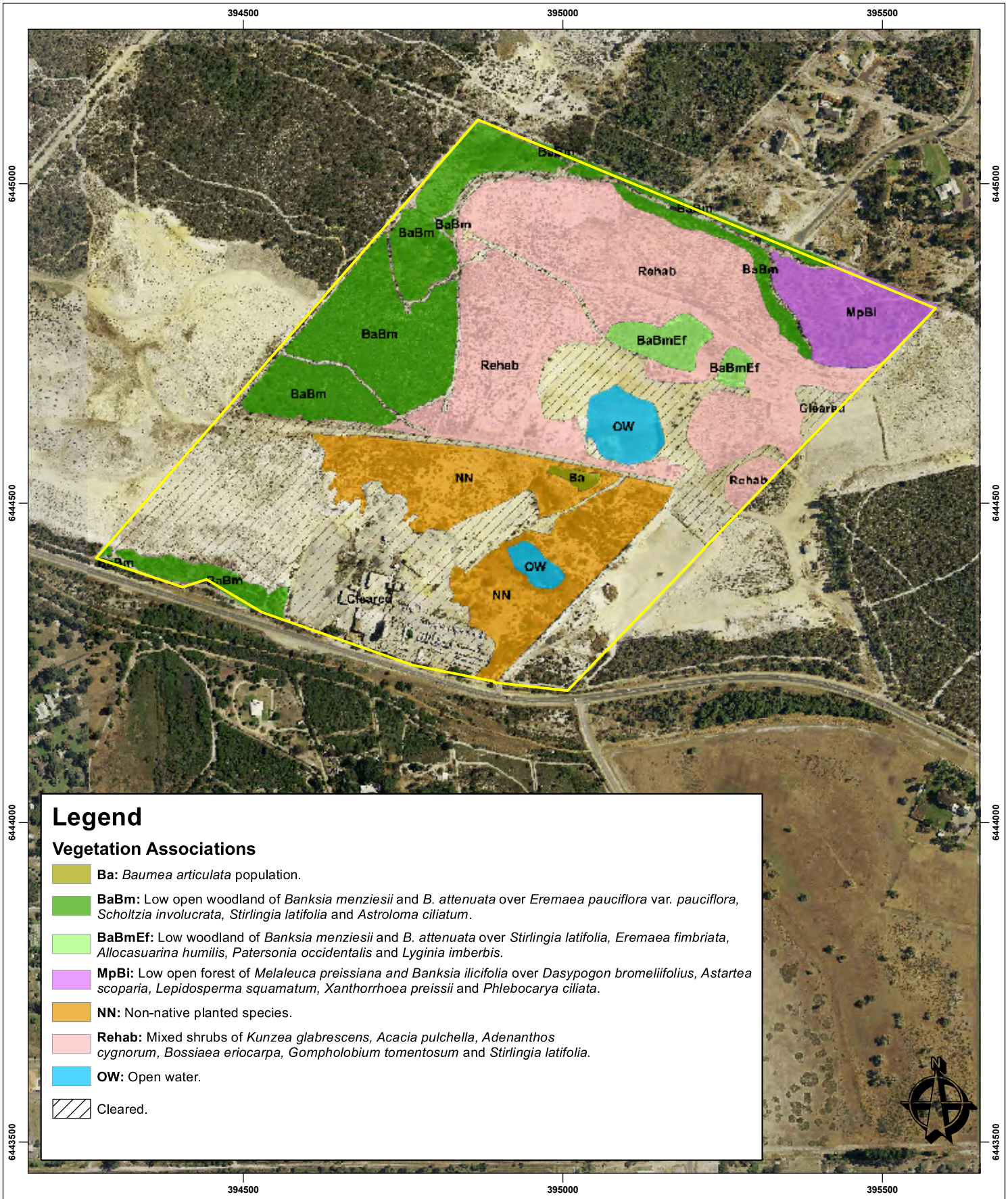
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Figure 6b Reserves

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Vegetation Associations

- **Ba:** *Baumea articulata* population.
- **BaBm:** Low open woodland of *Banksia menziesii* and *B. attenuata* over *Eremaea pauciflora* var. *pauciflora, Scholtzia involucrata, Stirlingia latifolia* and *Astroloma ciliatum*.
- **BaBmEf:** Low woodland of *Banksia menziesii* and *B. attenuata* over *Stirlingia latifolia, Eremaea fimbriata, Allocasuarina humilis, Patersonia occidentalis* and *Lyginia imberbis.*
- **MpBi:** Low open forest of *Melaleuca preissiana and Banksia ilicifolia* over *Dasypogon bromeliifolius, Astartea scoparia, Lepidosperma squamatum, Xanthorrhoea preissii* and *Phlebocarya ciliata.*
- **NN:** Non-native planted species.
- **Rehab:** Mixed shrubs of *Kunzea glabrescens, Acacia pulchella, Adenanthos cygnorum, Bossiaea eriocarpa, Gompholobium tomentosum* and *Stirlingia latifolia.*
- **OW:** Open water.
- Cleared.

Legend

Site Location (62.3 ha)

Note: Vegetation Mapping adapted from ENV 2013

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- GEOMORPHIC WETLANDS SOURCED DPAW 2013
- EPP LAKES SOURCED EPA 2010
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0 50 100 200 300

Metres

1:8,000 @ A4

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



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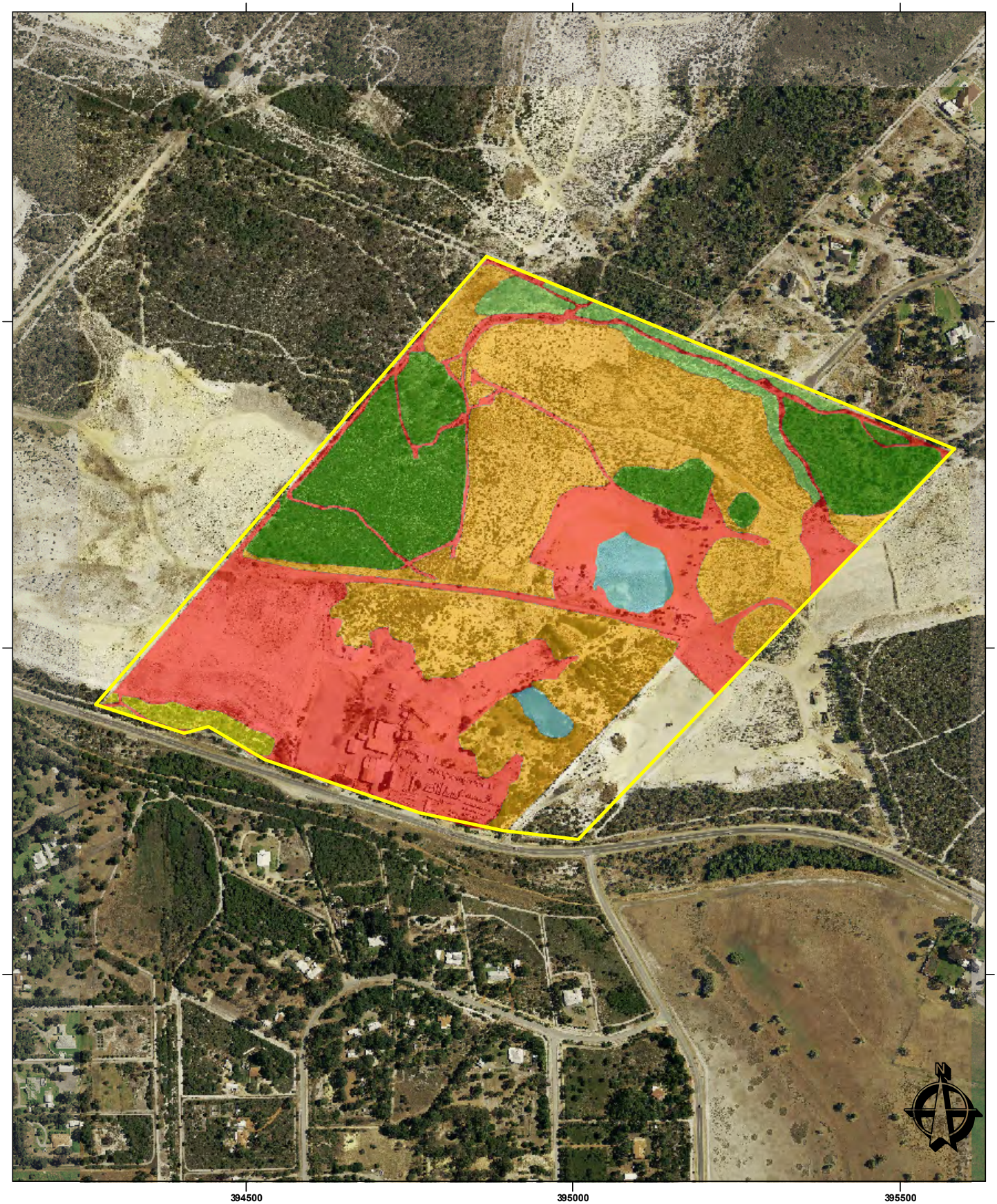
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GDA 1994 MGA Zone 50

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Figure 7 - Vegetation Types

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Note: Vegetation Mapping adapted from ENV 2013

Legend

Site Location (62.3 ha)

Vegetation Condition

- Excellent
- Very Good
- Good
- Degraded
- Completely Degraded
- Open Water

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Metres

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Figure 8 - Vegetation Condition

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Legend

- Site Location (62.3 ha)
- Artificial Lake
- Major Roads

TEC / PECs

- Priority 3

Threatened and Priority Flora

- Priority 4
- Priority 3
- Priority 2
- Priority 1
- Threatened

0 100 200 400 600 800
Metres
1:30,000 @ A4

NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



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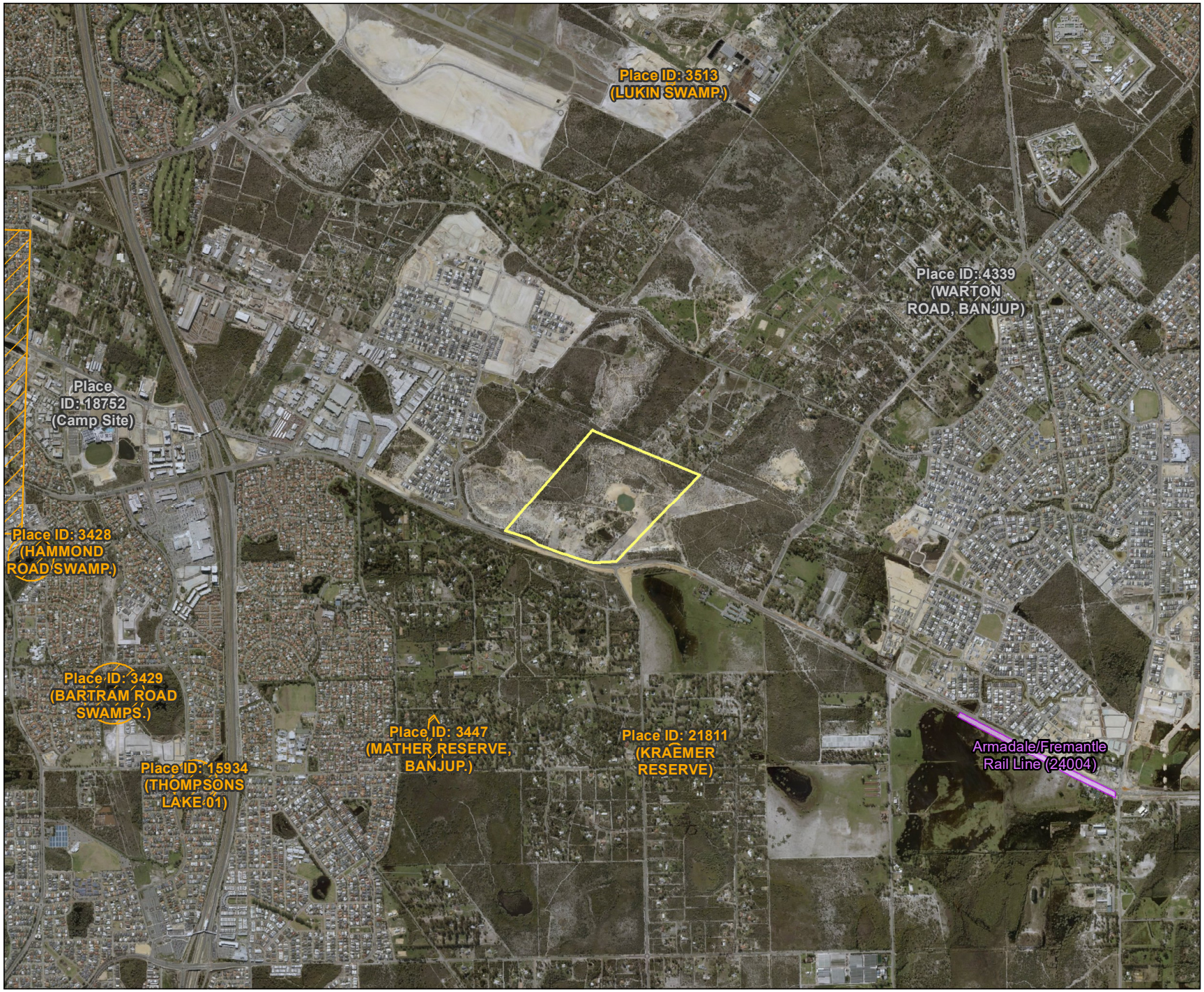
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Figure 9 - TECs, PECs, and Threatened and Priority Flora

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Legend

- Site Boundary
- State Heritage Office Registered Sites

Aboriginal Heritage Sites

- Registered Sites
- Lodged Sites

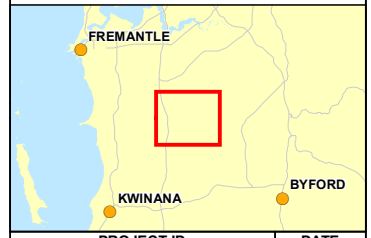
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Figure 10 Heritage

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Legend

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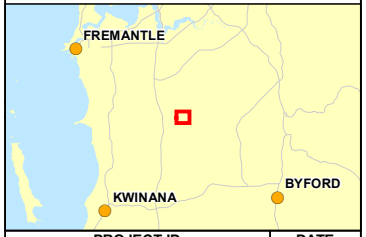
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Figure 11a Historical Aerial - 1953

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Site Boundary

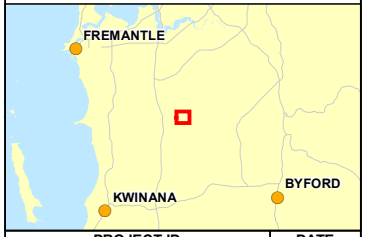
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Figure 11b Historical Aerial - 1965

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Legend

Site Boundary

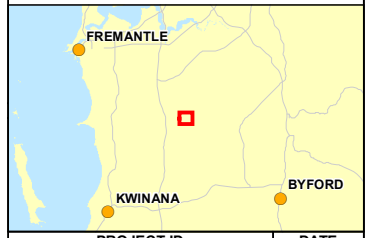
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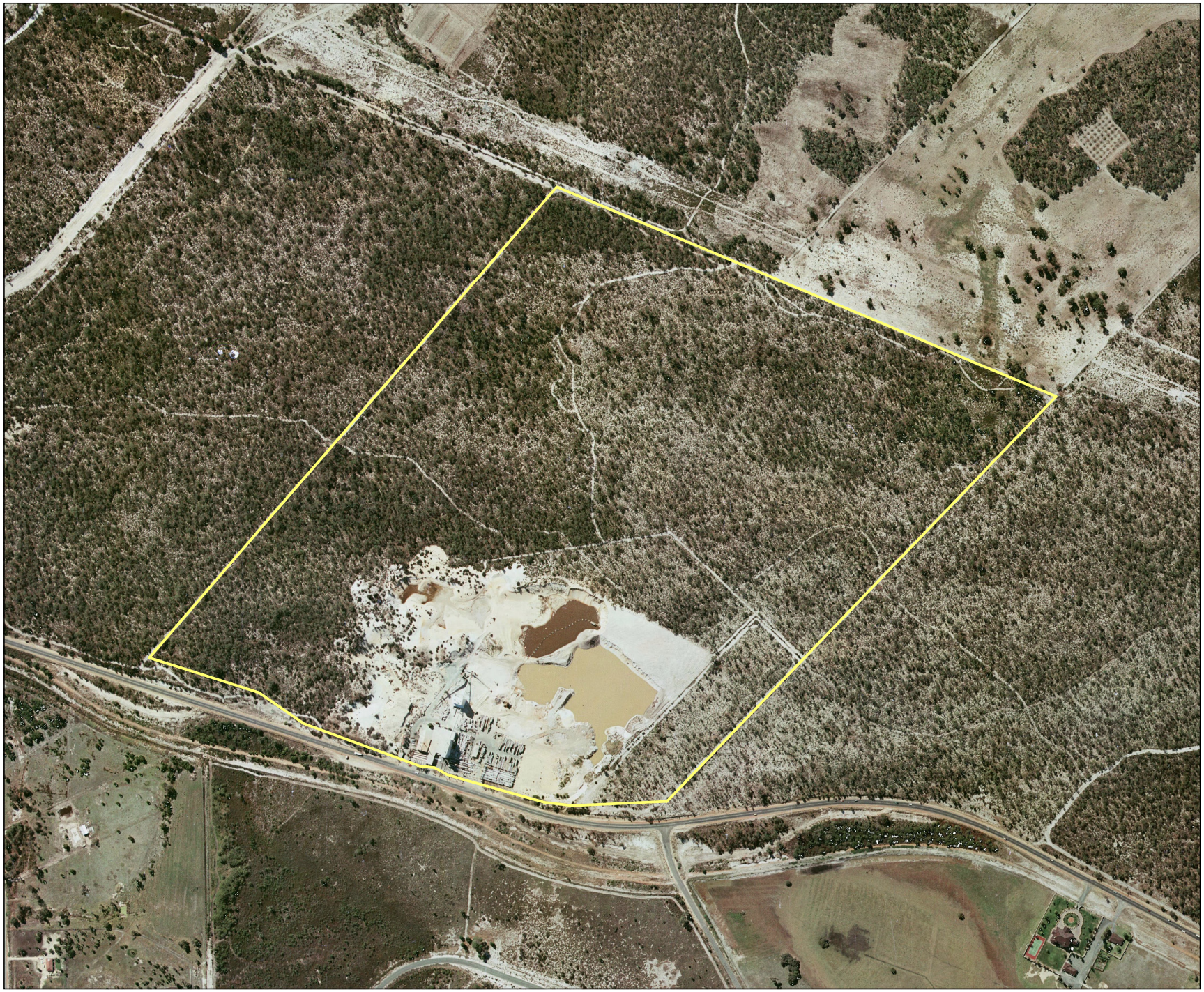
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Figure 11c Historical Aerial - 1974

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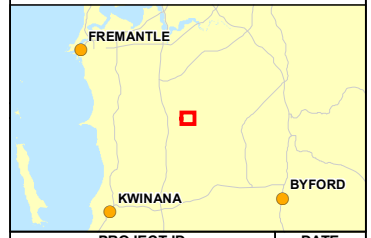
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Figure 11d Historical Aerial - 1985

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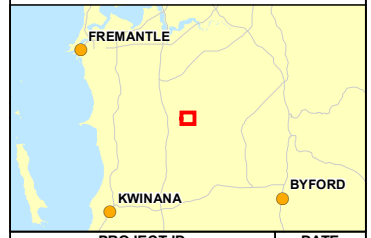
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Figure 11e Historical Aerial - 1995

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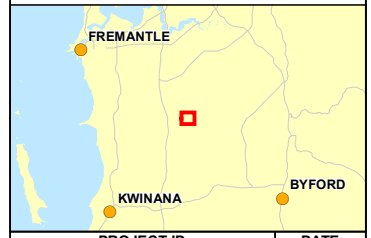
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Figure 11f Historical Aerial - 2005

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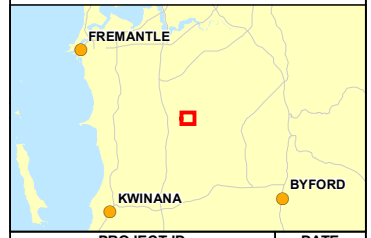
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Figure 11g Historical Aerial - 2018

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APPENDIX A

Indicative Concept Plan

LEGEND

- Subject Site
- Bush Forever Boundary
- Public Open Space
- Rural
- Transmission Powerline and Pylons
- 100m Offset from Powerline

This plan has no formal approval status and has been prepared by CLE to demonstrate one potential land use scenario for the land which could be investigated further by the Client. Implementation in any form would be subject to the receipt of all appropriate approvals. The plan may be changed without notice and should not be relied upon. This plan remains the property of CLE.

EXISTING POWERLINE PYLON

ROAD CONNECTION TO LOT 131 MODIFIED TO PROVIDE GREATER SEPARATION TO ORCHIDS AND POWERLINE PYLON

ROAD CONNECTION TO ADJACENT LAND

SKOTSCH ROAD

H.V. POWERLINE

ARMADALE ROAD

100m Setback to powerline

Bush Forever

Bush Forever

P.S.
4.02ha

P.O.S.
3.57ha

1.4686ha

5416m²

2461m²

3077m²

1135m²

6649m²

5286m²

2856m²

2181m²

503m²

3031m²

1123m²

1178m²

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0 50 100 150 200 250 300m

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CONCEPT PLAN
Armadale Road, Treeby

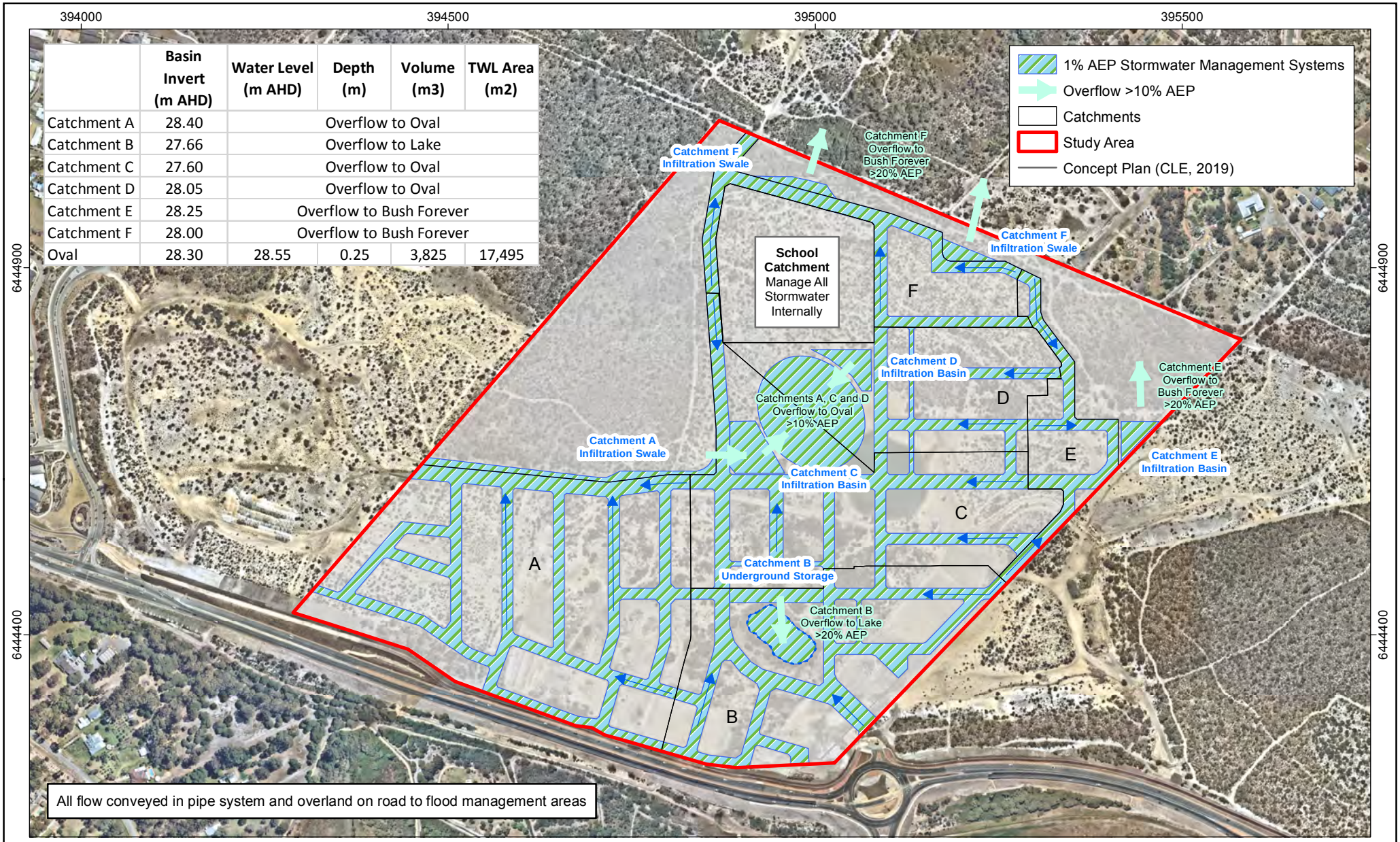
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plan no: **2310-233F-01**
date: 26 September 2019
scale: 1:4,000 @ A3, 1:2,000 @A1

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APPENDIX B

Location of Stormwater Management Systems



	Basin Invert (m AHD)	Water Level (m AHD)	Depth (m)	Volume (m3)	TWL Area (m2)
Catchment A	28.40	Overflow to Oval			
Catchment B	27.66	Overflow to Lake			
Catchment C	27.60	Overflow to Oval			
Catchment D	28.05	Overflow to Oval			
Catchment E	28.25	Overflow to Bush Forever			
Catchment F	28.00	Overflow to Bush Forever			
Oval	28.30	28.55	0.25	3,825	17,495

Data Source: ENV Australia (2013), Nearmap (October 2019)

Coordinate System: GDA 94, Zone 50

JDA

Job No. J6667
Scale: 1:7,000 @A4

0 100 200 300 400 Metres

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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 11: 1% AEP Stormwater Event Plan

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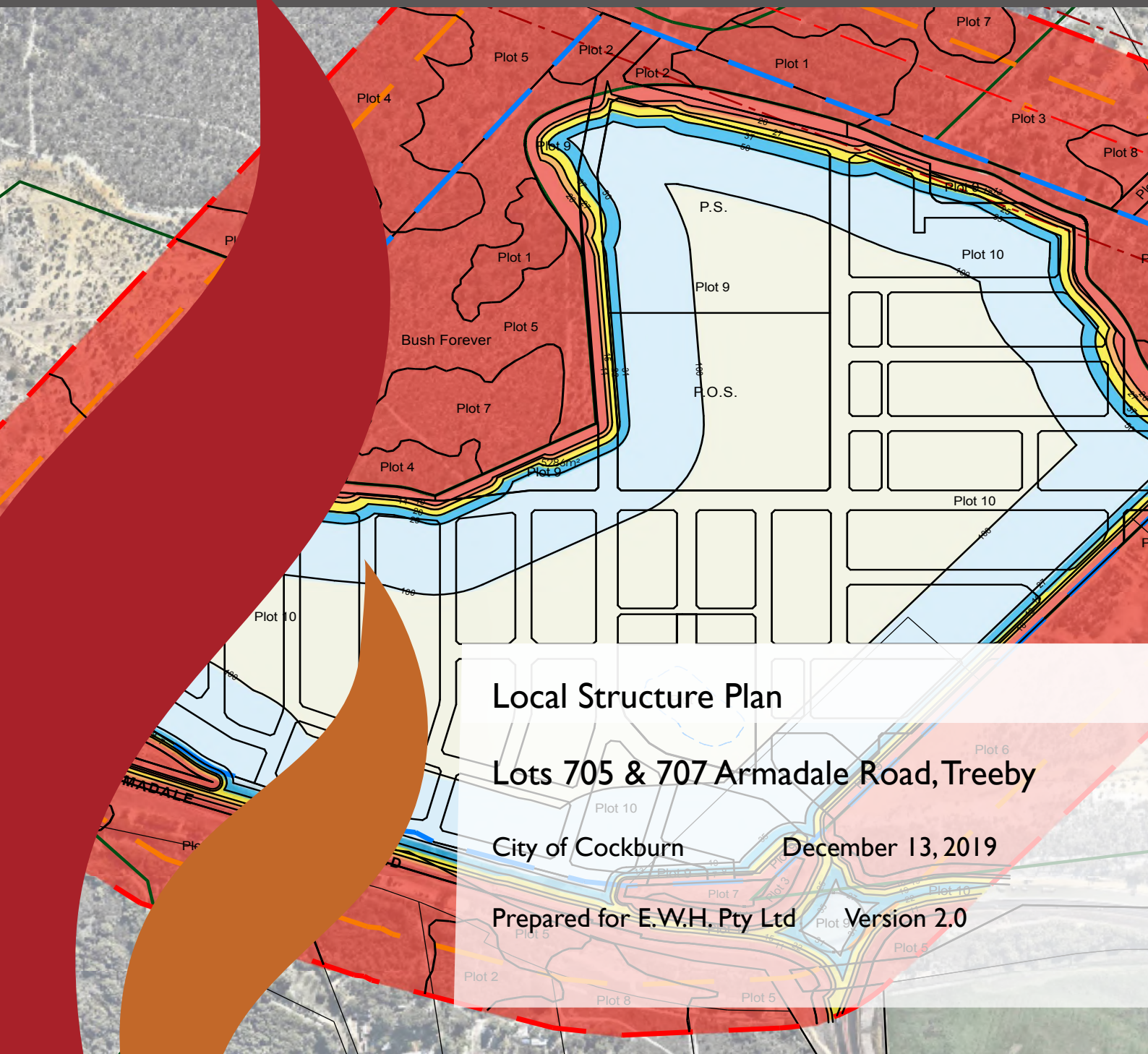
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APPENDIX TWO

Bushfire Management Plan (Bushfire Safety Consulting)

Bushfire Safety
CONSULTING

Bushfire Management Plan



Local Structure Plan

Lots 705 & 707 Armadale Road, Treeby

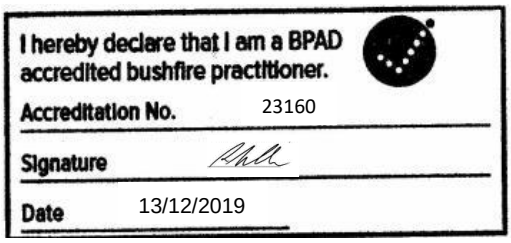
City of Cockburn December 13, 2019

Prepared for E.W.H. Pty Ltd Version 2.0

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Document Information

Prepared for:	E.W.H Pty Ltd
Project Name:	Local Structure Plan
Project Address:	Lots 705 & 707 Armadale Road, Treeby
Prepared by:	Rohan Carboon (Level 3 - BPAD 23160)
	& Dr Karen Brown (Level 1 - BPAD 48364)
	Bushfire Safety Consulting Pty Ltd





Document Control

Bushfire Management Plan – Lots 705 & 707 Armadale Road, Treeby			
REPORT VERSION	**PURPOSE**	**AUTHOR/REVIEWER AND ACCREDITATION DETAILS**	**DATE SUBMITTED**
V1	Draft for review	Rohan Carboon (Level 3 BPAD 23160) Dr Karen Brown (Level 1 BPAD 48364)	6/12/2019
V2	Final for Submission	Rohan Carboon (Level 3 BPAD 23160)	13/12/2019

Front cover photo: BAL Contour over the site

Bushfire Safety Consulting Pty Ltd
PO Box 84
STONEVILLE WA 6081

Tel: 0429 949 262
Email: enquiries@bushfiresafety.net
Web: www.bushfiresafety.net

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EXECUTIVE SUMMARY

This Bushfire Management Plan (BMP) has been prepared to support a proposed Local Structure Plan (LSP) for a portion of Lots 705 and 707 Armadale Road in Treeby. The LSP area is 47.9 hectares in size and herein referred to as 'the site'. The LSP proposes urban residential lots and associated infrastructure, with areas of Public Open Space (POS) varying in size and type to be provided throughout the site. A large 'Bush Forever' Conservation Reserve to the north-west and north-east of the development site is 13.6 ha in size and this connects to the Bush Forever Reserve on the east of the site.

Land immediately to the north and south of the site consists of existing rural residential development on lots 2 to 2.5 hectares in size.

The LSP provides a guide for residential development within the site and creates a framework for the future urban subdivision of the site into anticipated residential lots and areas of POS and a future school site. Following development, all classified vegetation within the site will be removed or modified into managed POS areas. The POS areas will be landscaped and be classified as low threat vegetation and contain irrigated and maintained turf and garden beds. Long term bushfire hazard exists in the Bush Forever Conservation Reserve within and adjacent to the site to the north and east.

All areas within 150 metres of the site boundary have been assessed for vegetation classification and BAL contours. It has been determined that all proposed future dwellings arising from the LSP will be exposed to BAL-29 or lower and will fall within the acceptable level of risk. There is good vehicular access both within and surrounding the site. A reticulated water supply will be provided and fire hydrants will be installed by the developer/s to meet the specifications of Water Corporation (Design Standard 63) and DFES.

The objective of this BMP is to address bushfire management issues within the LSP. If there is a bushfire within or near the site, implementing this BMP will reduce the threat to residents, property and emergency response personnel. This document sets out the roles and responsibilities of the developer, future residents and the City of Cockburn, and responds to the performance criteria in the *Guidelines for Planning in Bushfire Prone Areas* V1.3 (WAPC *et.al*. 2017). 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. At future stages of subdivision, the BMP will be updated a to confirm compliance with SPP 3.7 and BAL ratings will be confirmed to support building license applications.

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1 PROPOSAL DETAILS

This Bushfire Management Plan (BMP) has been prepared to support a Local Structure Plan (LSP) for a portion of Lots 705 and 707 Armadale Road, in Treeby (Figure 1). This area is herein referred to as "the site" and its location is shown in Figure 2. The site is 47.7 hectares (ha) in size and is located within the City of Cockburn, approximately 20 km south of the Perth Central Business District (CBD) and 2.5 kilometres west of the Cockburn City Centre. The site is within the Treeby District Structure Plan (Figure 3).

The site is currently zoned 'Development Contribution Area 13 Resource Zone' under the City of Cockburn Town Planning Scheme 3, and currently contains a combination of cleared earth, degraded bushland and more intact native vegetation. The LSP proposes a range of residential housing densities, as well as areas of Public Open Space (POS) ranging in size from 2218m^2 to 6.7 hectares. A large conservation 'Bushland Forever' reserve, approximately 13.6 hectares in size is found to the north-west and north-east of the site. Degraded vegetation also occurs in the Bush Forever Reserve east of the site.

Land to the west and north-west of the proposed LSP site is similarly zoned 'Development Contribution Area 13 Resource Zone' and contains both degraded and intact native vegetation.

Rural residential lots are present to the north of the site and vary in size from 2 to 2.5 hectares, with a conservation reserve containing a combination of vegetation classes.

To the south of the site and Armadale Road are additional 2 to 2.5 hectare rural residential lots, with a small conservation reserve along a stream running south.

All proposed lots will have direct driveway entrance onto one of the newly created internal public roads. Egress from the site is supplied by a main internal road that provides access to Armadale Road in the south. Two other internal roads will connect to an adjacent development in the west, and another to the north, providing additional egress in the future.

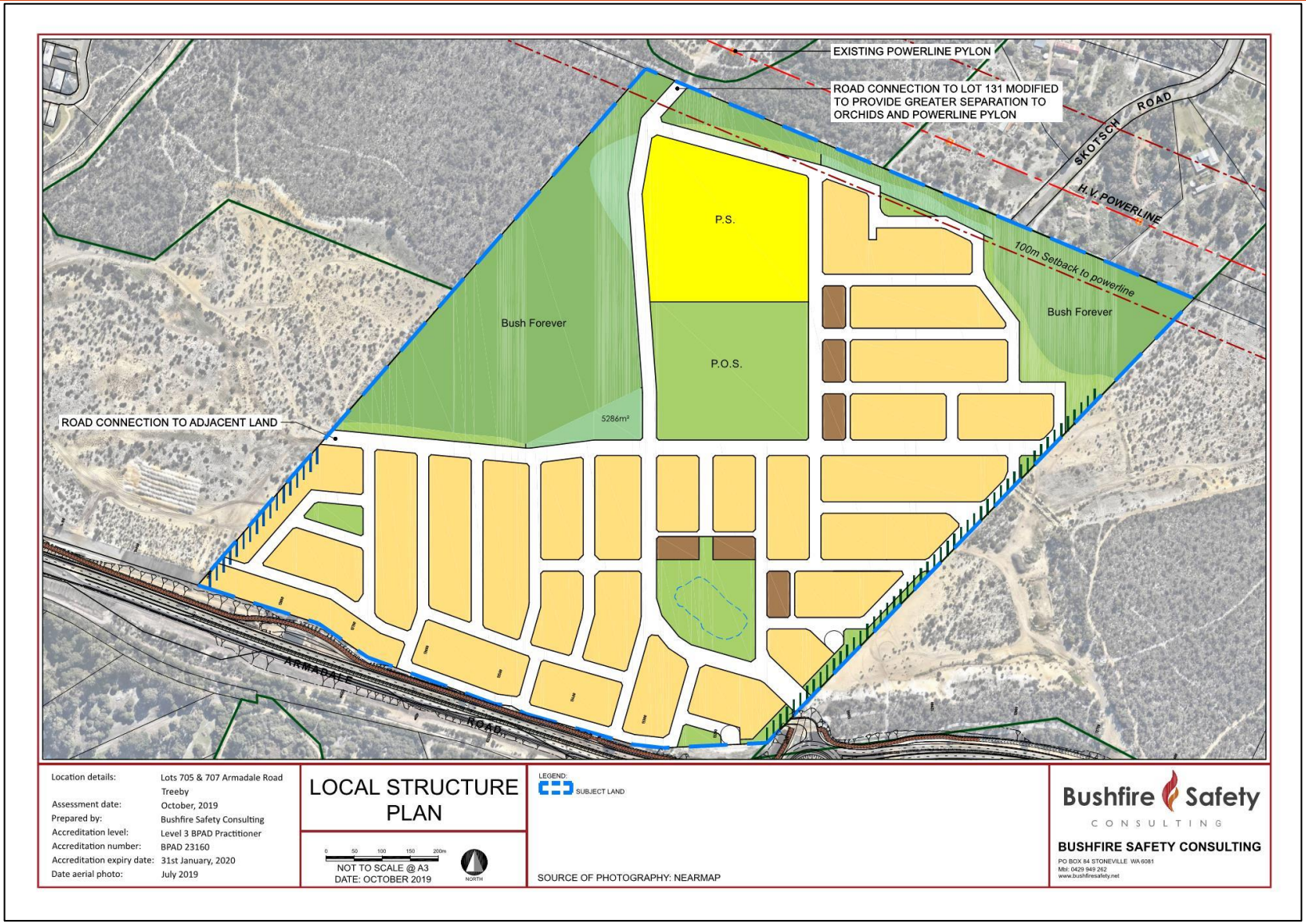


Figure 1: Local Structure Plan

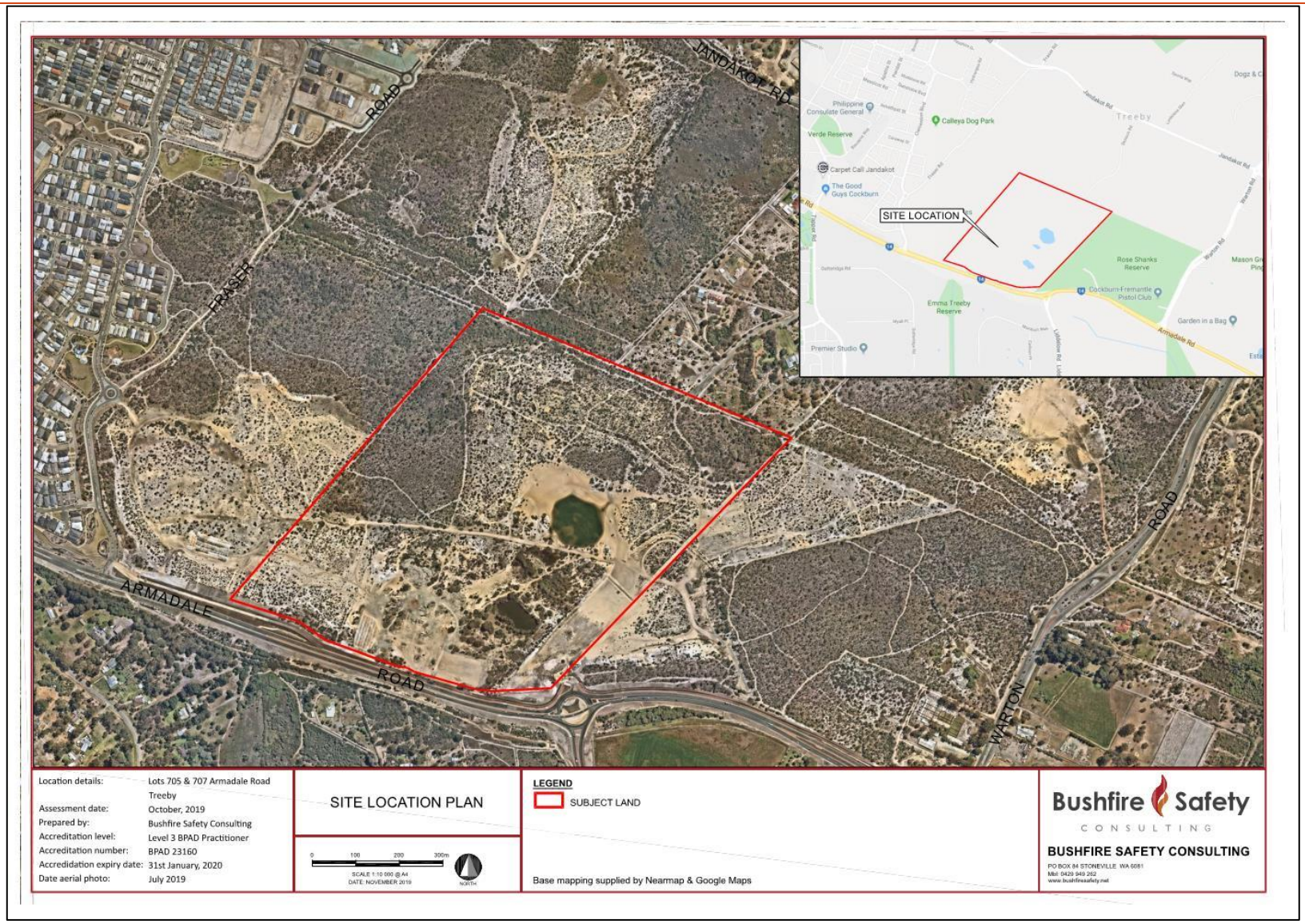


Figure 2: Site Overview and Location

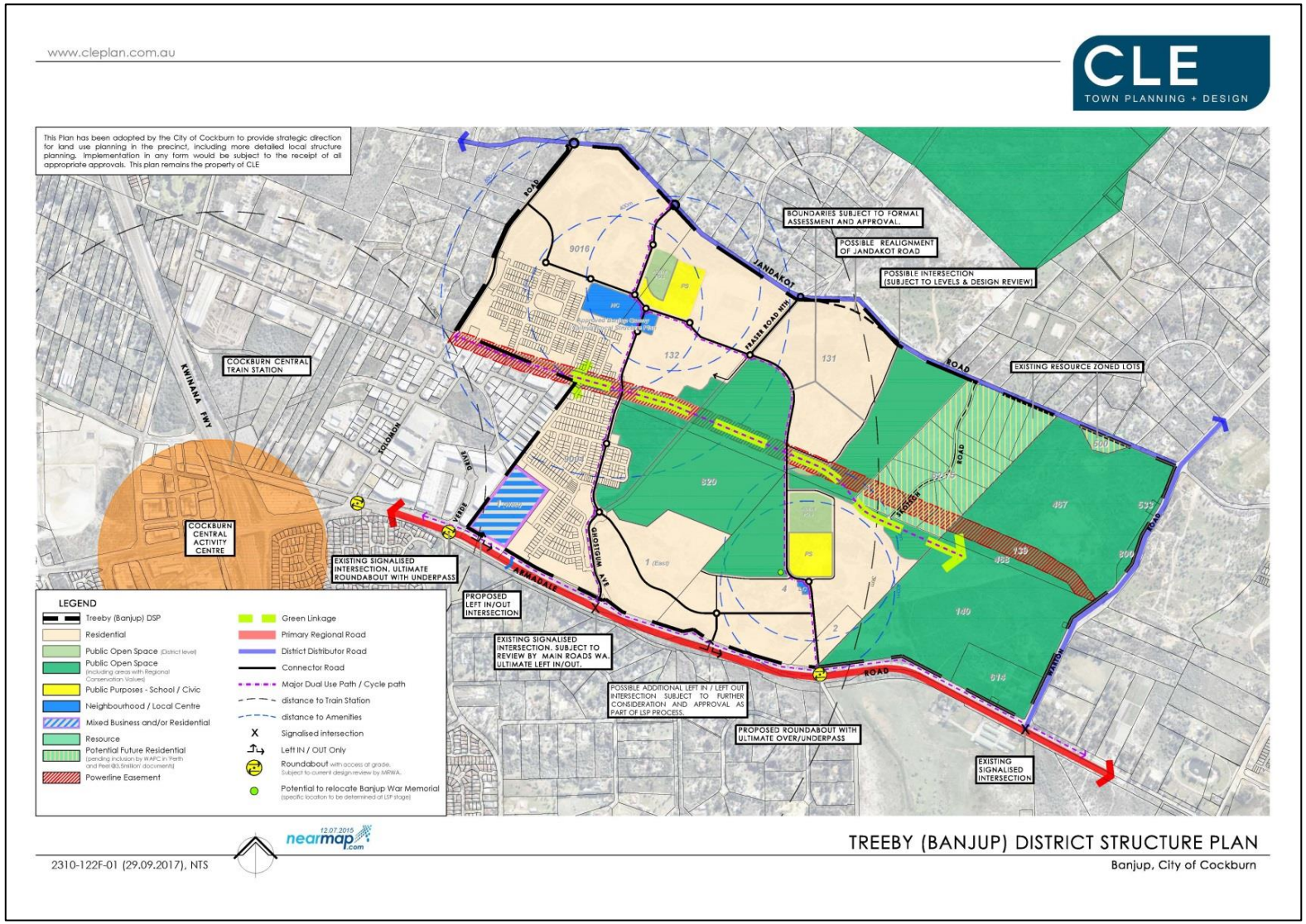


Figure 3: Treeby District Structure Plan

1.1 Policy and Guidelines

1.1.1 Application of SPP 3.7

The *State Planning Policy No. 3.7: Planning in Bushfire Prone Areas (SPP 3.7)* provides the foundation for land use planning to address bushfire risk management in Western Australia. It is used to inform and guide decision makers, referral agencies and land owners/ proponents to help achieve acceptable bushfire protection outcomes.

The policy contains objectives and policy measures as well as reference to the bushfire protection criteria as outlined in the Guidelines for Planning in Bushfire Prone Areas (WAPC 2017 V1.3; the 'Guidelines'). The policy applies to this Local Structure Plan (LSP) proposal because the site is located in a designated bushfire prone area on the WA Map of Bushfire Prone Areas (Figure 4).

The following policy measures will need to comply with SPP 3.7:

Table 1. Policy measures

Policy Measure 6.2	The site is located within a designated bushfire prone area (Figure 3) and will have a Bushfire Hazard Level above low and a Bushfire Attack Level rating above BAL-LOW.
Policy Measure 6.4	Policy 6.4 applies meaning the LSP application will be accompanied by: - BAL Contour Plan; - BAL ratings; - Identification of relevant issues; and - Demonstration of compliance with the guidelines.
Policy Measure 6.6	Policy Clause 6.6 applies to vulnerable land use applications. The LSP area designates a site for a future primary school. A primary school is considered a 'vulnerable land use' under the policy and a future development application for the school will therefore require a comprehensive emergency evacuation plan to be developed which specifically reflects the needs and circumstances of a school.

The site does not contain proposed minor or unavoidable development, or high-risk land use under *SPP 3.7.*

1.1.2 Guidelines for Planning in Bushfire Prone Areas V1.3 (2017)

The Department of Planning has released the *Guidelines for Planning in Bushfire Prone Areas V1.3 (2017).* The requirements of this document are accommodated within this BMP. The *Guidelines for Planning in Bushfire Prone Areas V 1.3 (2017)* is intended to inform and guide decision makers, referral authorities and proponents to achieve acceptable bushfire protection outcomes, including expectations at the different stages of planning.

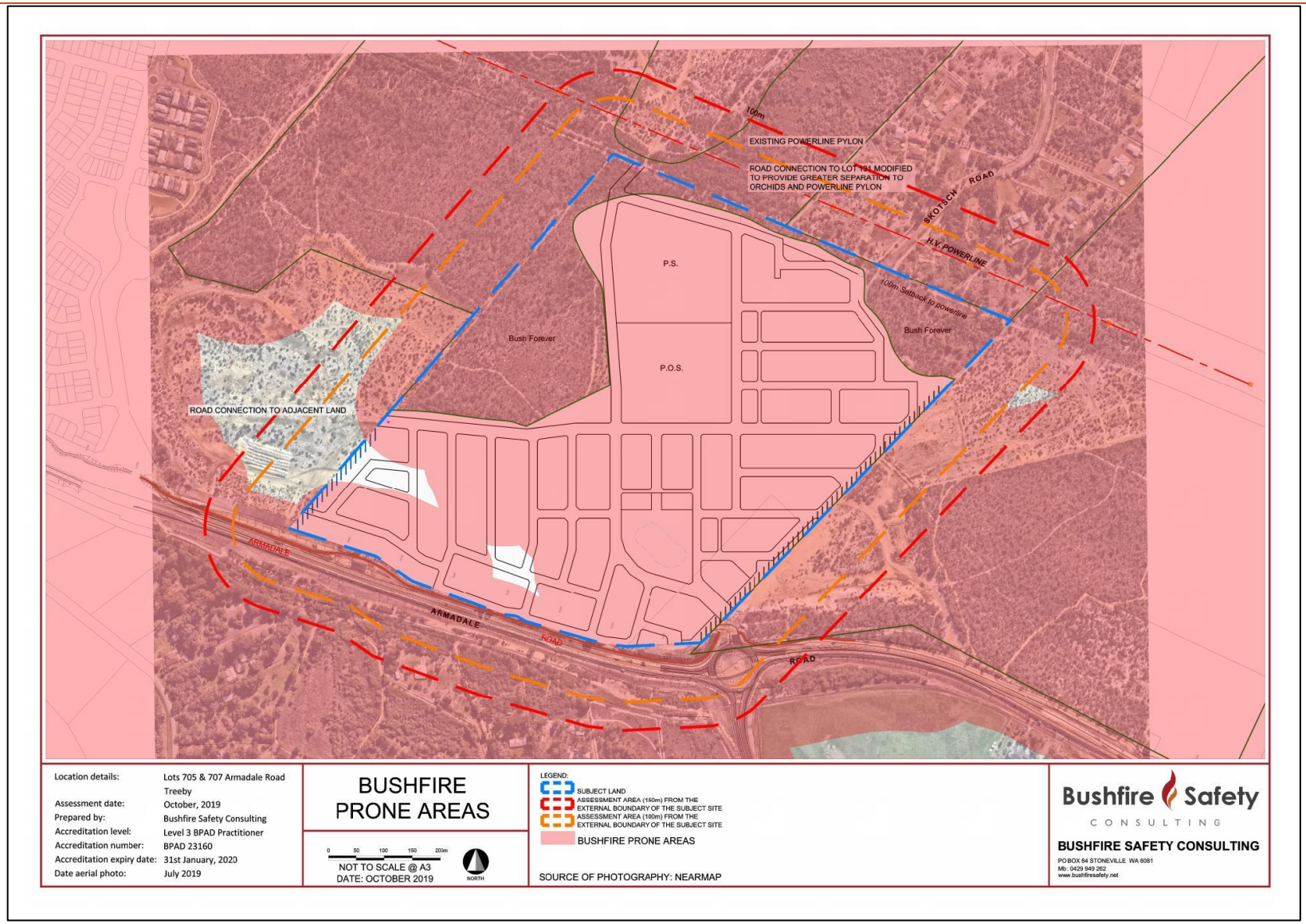


Figure 4: The site is contained within the declared Bushfire Prone Area of WA

2 ENVIRONMENTAL CONSIDERATIONS

2.1 Native Vegetation – Modification and Clearing

The development site proposed for residential use, POS areas and a future school is sited on degraded vegetation, which is a result of revegetation following the sand extraction activities which have previously occurred on the site. The development impact is concentrated in this degraded area and the more intact areas of undisturbed vegetation are contained in the Bush Forever Reserves where the vegetation is protected in perpetuity.

There are no environmental restrictions to limit a future development on the site.

2.2 Revegetation/Landscape Plans

There are a number of parks, gardens, sports ovals, educational and nature areas proposed within and around the perimeter of the site. The landscape design, plant selection and maintenance regime has thoroughly considered how to minimise and manage bushfire threat. The plans are found in Appendix 4. The key design features of the landscaped areas is the use of irrigation, low groundcovers, turf and clear stemmed trees. Hardscaped areas such as paths, walls and recreation sites are located throughout to ensure vegetation is not continuous and fine fuels are separated in the maintained garden beds.

The establishment and maintenance of all landscaped low threat POS areas will involve the following in perpetuity:

- Under pruning of shrubs, scrub and trees of all fine fuels (<6mm) 2 metres from ground level
- Annually removing leaf litter, accumulated fine fuels and dead plants and/or plant material.
- Keeping garden beds irrigated and turf areas mown and grass green.
- Pruning to keep clumps of trees and shrubs separated from one another.
- Removal of weeds and regenerating Eucalypts, Acacia and other native plants not intended to be included as part of the landscape plans.

The southern interface with Armadale Road has recently undergone significant civil works, the road has been expanded into two double lanes and a 4m wide dual access path has been sited adjacent to the boundary of the site. The dominant vegetation type being planted between the road and the southern site boundary is groundcovers and prostrate shrubs. This will create a low shrubland vegetation class which has been considered in the method 1 BAL assessment. The road interface at the moment is woodchip mulch only (see photo 31).

There are bare areas and some narrow strips of revegetation and street tree planting between the 4m wide bike path and the proposed 2.4m acoustic wall. These strips are between 2-5 metres wide and not considered a bushfire threat due to the insignificant fire impact they could create.

3 BUSHFIRE ASSESSMENT RESULTS

Bushfires are common in the City of Cockburn and local brigades respond to numerous bushfires in the district annually. This BMP plays a critical role in ensuring that the proposed LSP, and the inherent possibility of an increase in usage and intensity of the land, appropriately mitigates the risk from bushfire.

3.1 Assessment Inputs

The methodology used to assess the site is outlined in the *Guidelines for Planning in Bushfire Prone Areas V1.3 (2017).* The broad lot layout is known, and a strategic level bushfire hazard assessment is not required. A post development vegetation classification plan is provided, and a BAL Contour plan is provided in accordance with Appendix 3 of the guidelines.

Assessing bushfire threat at the site-specific level requires evaluating the predominant class of vegetation on the site and surrounding area for a minimum of 150 m, as shown in the Vegetation Classification Map (Figure 5).

3.1.1 Vegetation Classification

The vegetation surrounding the site consists of pockets of Class A Forest (photos 1-10) which is dominated by a mixture of eucalypts, Banksia trees and Casuarina trees with a defined middlestorey fuel structure and litter fuels. Foliage cover also exceeds 30%.

Where the canopy of the banksia trees are more separated (less than 30% foliage cover) and the trees exceed 6 metres in height, there is no middlestorey vegetation and it consists of predominantly low shrubs or grass fuels. This is classified as Class B Woodland (see photos 10-15). Where the vegetation does not exceed 6 metres and consists of low banksia trees and woolybush shrubs (photos 16-28), class D Scrub is identified. This includes degraded areas with minimal vegetation east and west of the site seen in photos 22-24.

Shrubland is found in a small elevated position in the Bush Forever reserve (phots 29-30) and the low ground covers will mature into a shrubland class of vegetation in Armadale Road Reserve (phot 31). An unvegetated area near the round-about has been classed as shrubland consistent with the ground cover vegetation that dominates in the road reserve. There are minimal areas of grassland (photos 33-34) and the degraded vegetation within the site is predominantly regrowth shrubs (class D Scrub) as seen in Photos 34-35.

The vegetation plots on and surrounding the site and within 150 metres of the site boundary are found in Figure 4 with plot descriptions below.

Photo ID: 1 **Plot Number:** 1 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	

Photo ID: 2 **Plot Number:** 1 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	
Photo ID: 3 **Plot Number:** 1 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	
Photo ID: 4 **Plot Number:** 1 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	
Photo ID: 5 **Plot Number:** 2 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	
Photo ID: 6 **Plot Number:** 2 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	
Photo ID: 7 **Plot Number:** 2 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	

Photo ID: 8 **Plot Number:** 2 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	
Photo ID: 9 **Plot Number:** 2 **Vegetation classification or exclusion clause:** Class A Forest **Description/justification of classification:** Eucalypts and Banksias with isolated Casuarina trees that exceed 6m in height and have a distinct middlestorey fuel layer of shrubs and regrowth trees.	
Photo ID: 10 **Plot Number:** 3 **Description/justification of classification:** Class B Woodland **Description/justification of classification:** Banksia dominated vegetation type with separated canopies less than 30% foliage cover and low shrubs and grassland understorey	
Photo ID: 11 **Plot Number:** 3 **Description/justification of classification:** Class B Woodland **Description/justification of classification:** Banksia dominated vegetation type with separated canopies less than 30% foliage cover and low shrubs and grassland understorey	
Photo ID: 12 **Plot Number:** 3 **Description/justification of classification:** Class B Woodland **Description/justification of classification:** Banksia dominated vegetation type with separated canopies less than 30% foliage cover and low shrubs and grassland understorey	
Photo ID: 13 **Plot Number:** 4 **Description/justification of classification:** Class B Woodland **Description/justification of classification:** Banksia dominated vegetation type with separated canopies less than 30% foliage cover and low shrubs and grassland understorey	

Photo ID: 14 **Plot Number:** 4 **Description/justification of classification:** Class B Woodland **Description/justification of classification:** Banksia dominated vegetation type with separated canopies less than 30% foliage cover and low shrubs and grassland understorey	
Photo ID: 15 **Plot Number:** 4 **Description/justification of classification:** Class B Woodland **Description/justification of classification:** Banksia dominated vegetation type with separated canopies less than 30% foliage cover and grassland understorey	
Photo ID: 16 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Woollybush and regrowth banksia dominated vegetation class in degraded area.	
Photo ID: 17 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Woollybush and banksia dominated vegetation class assessed as less than 6m in height and variety of vegetation heights. Staff is 5m high.	
Photo ID: 18 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Woolybush and banksia dominated vegetation class assessed as less than 6m in height and variety of vegetation heights. Staff is 5m high.	
Photo ID: 19 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Kunzea scrub which will mature to be less than 6m in height.	

Photo ID: 20 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Woollybush and banksia dominated vegetation class assessed as less than 6m in height and variety of vegetation heights.	
Photo ID: 21 **Plot Number:** 6 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Woollybush and regrowth banksia dominated vegetation class in degraded area.	
Photo ID: 22 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Woollybush and regrowth banksia dominated vegetation class in degraded area.	
Photo ID: 23 **Plot Number:** 6 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Woollybush shrubs in degraded area.	
Photo ID: 24 **Plot Number:** 6 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** degraded and unvegetated area but likely to revegetate over time into scrub vegetation.	
Photo ID: 25 **Plot Number:** 6 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Woolybush and banksia dominated vegetation class assessed as less than 6m in height.	

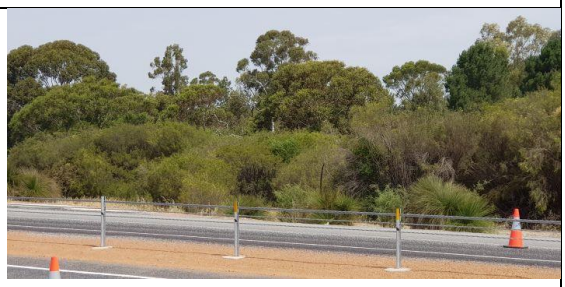
Photo ID: 26 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Kunzea dominated vegetation class assessed as less than 6m in height.	
Photo ID: 27 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Acacia and Kunzea dominated vegetation class assessed as less than 6m in height and variety of vegetation heights.	
Photo ID: 28 **Plot Number:** 5 **Description/justification of classification:** Class D Scrub **Description/justification of classification:** Acacia and Kunzea dominated vegetation class assessed as less than 6m in height and variety of vegetation heights.	
Photo ID: 29 **Plot Number:** 7 **Description/justification of classification:** Class C Shrubland **Description/justification of classification:** Low shrubland vegetation class assessed as less than 2m in height and 100% coverage.	
Photo ID: 30 **Plot Number:** 7 **Description/justification of classification:** Class C Shrubland **Description/justification of classification:** Low shrubs in open woodland area	
Photo ID: 31 **Plot Number:** 7 **Description/justification of classification:** Class C Shrubland **Description/justification of classification:** Woodchip mulch area proposed for low groundcovers in the Armadale Road landscape plan.	

Photo ID: 32 **Plot Number:** 7 **Description/justification of classification:** Class C Shrubland **Description/justification of classification:** Unvegetated area near round about entrance off Armadale road, classed as future low shrubland.	
Photo ID: 33 **Plot Number:** 8 **Description/justification of classification:** Class G Grassland **Description/justification of classification:** Low grasses on slope northwest of site.	
Photo ID: 34 **Plot Number:** 8 **Description/justification of classification:** Class G Grassland **Description/justification of classification:** Grass fuels on the side of Skotch Road and in the adjacent paddock.	
Photo ID: 35 **Plot Number:** 9 **Description/justification of classification:** Exclusion clause 2.2.3.2(f) **Description/justification of classification:** Woolybush and banksia dominated vegetation in degraded area previously used for sand extraction. This are will become a future primary school.	
Photo ID: 36 **Plot Number:** 10 **Description/justification of classification:** Exclusion Clause 2.2.3.2e **Description/justification of classification:** Woollybush and banksia dominated vegetation class inside the site proposed for clearing and residential development.	

3.1.2 Effective Slope

The effective slope of the landscape surrounding the site is the slope that will affect the behaviour of an approaching bushfire. The effective slope under the Class A Forest and Class B Woodland north of the site in the Bush Forever is downslope 0-5 degrees. There is also a gentle downslope of 0-5 degrees west of the future primary school. Slopes east and west of the site have been modified due to sand mining and slopes are generally flat adjacent to development lots. Once development occurs west of the site, the vegetation will be removed and effective slope is irrelevant.

Table 2. Summary of vegetation type and effective slope

Vegetation Area/ Plot	Applied Vegetation Classification	Effective Slope under the Classified Vegetation (degrees)
1	Class A Forest	Downslope 0-5
2	Class A Forest	Flat / upslope
3	Class B Woodland	Downslope 0-5
4	Class B Woodland	Flat / upslope
5	Class D Scrub	Downslope 0-5
6	Class D Scrub	Flat / upslope
7	Class C Shrubland	Flat / upslope
8	Class G Grassland	Flat / upslope
9	Exclusion Clause 2.2.3.2 (f)	N/A
10	Exclusion Clause 2.2.3.2 (e)	N/A

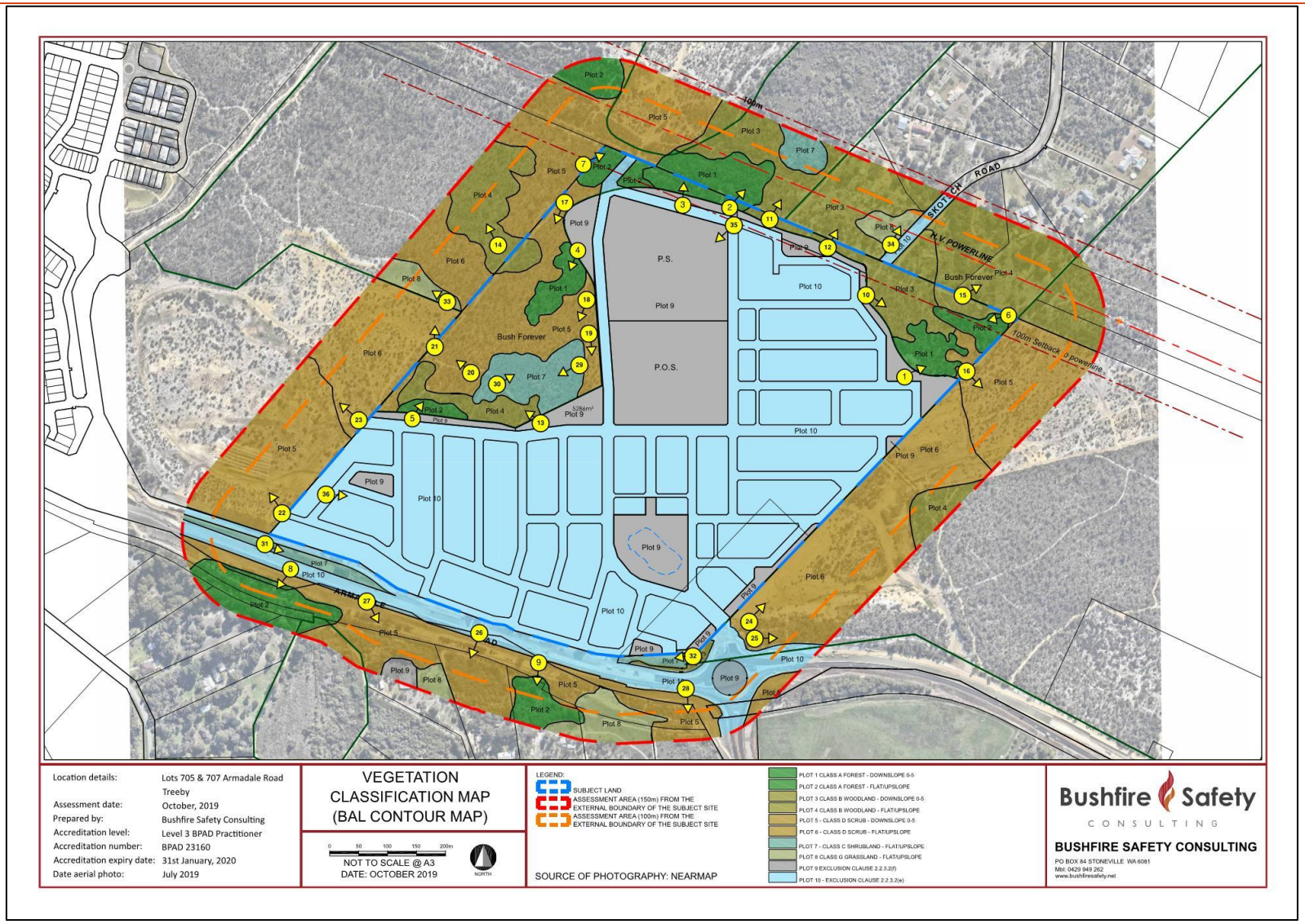


Figure 5: Vegetation classification map showing effective slope and photo points

3.2 Assessment Outputs

A post-development BAL contour assessment was undertaken according to Appendix 3 of the Guidelines and the results are found in Figure 6. A method 1 BAL Assessment was undertaken to determine the BAL contours impacting the site and the outputs are provided in Table 3.

Table 3. Summary of assessment outputs

LSP Interface	Plot No	Applied Vegetation Classification	Effective slope	Development lots	Minimum Separation Distance	Highest BAL Contour On Lots
North & West	1	Class A Forest	Downslope 0-5	Residential	27 m	BAL – 29
	2	Class A Forest	Flat/upslope	Future Primary School	18m road reserve 3m internal	BAL-29
	3	Class B Woodland	Downslope 0-5	Residential	21m	BAL – 29
	4	Class B Woodland	Flat/upslope	Residential	25m	BAL – 19
	5	Class D Scrub	Downslope 0-5	POS	18m	BAL – 29
	7	Class C Shrubland	Flat/upslope	Residential	42m	BAL-12.5
South & East	3	Class B Woodland	Downslope 0-5	Residential	18m	BAL-29
	5	Class D Scrub	Downslope 0-5	Residential	36m	BAL-12.5
	6	Class D Scrub	Flat/upslope	Residential	16m	BAL-29
	7	Class C Shrubland	Flat/upslope	Residential	13m	BAL-19

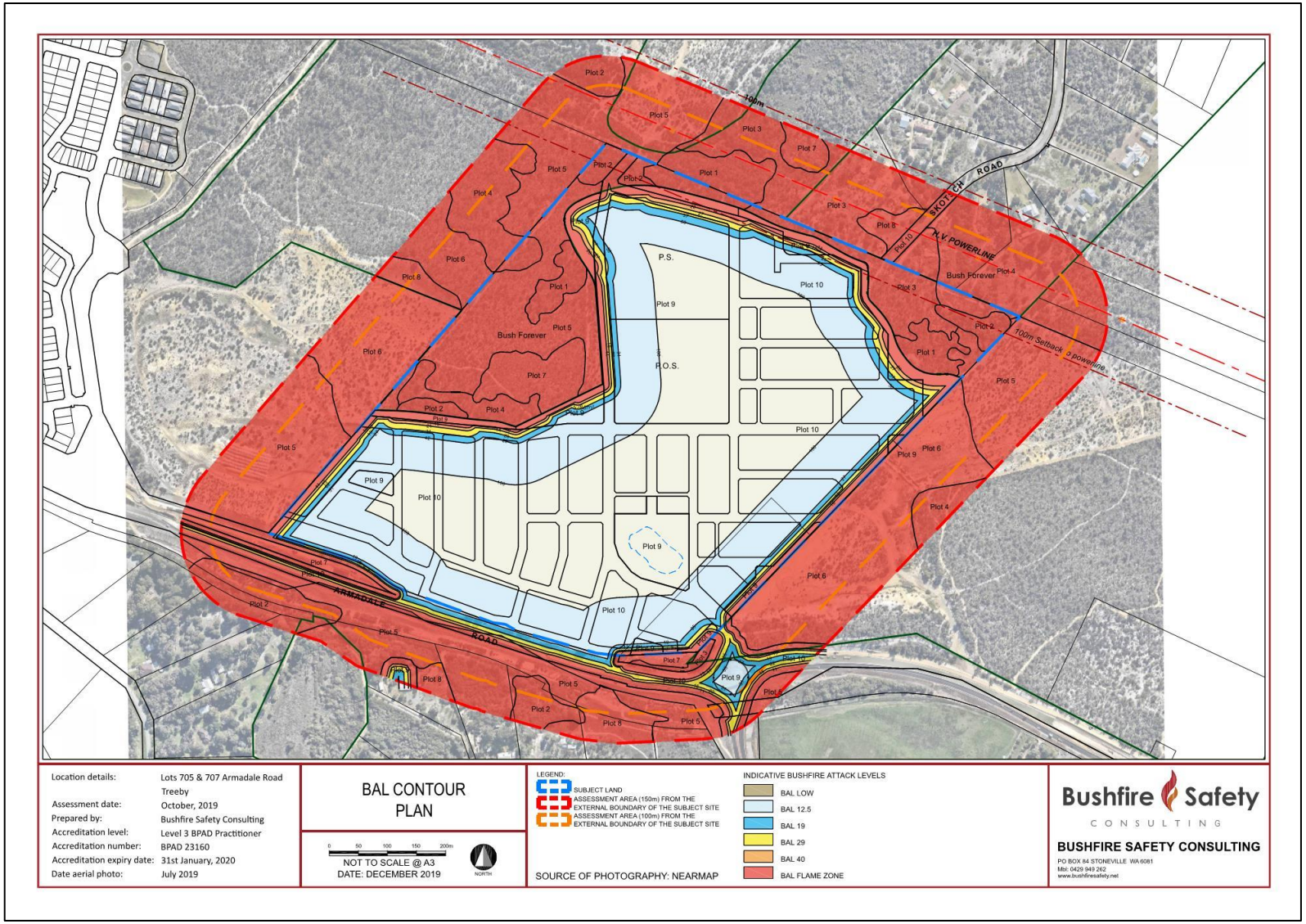


Figure 6: BAL Contour Plan

4 IDENTIFICATION OF BUSHFIRE HAZARD ISSUES

Classified vegetation in the Bush Forever reserve to the north of the developable site will pose a long term hazard to the adjacent residents and future school. Vegetation south of Armadale Road is similarly a long term hazard. The vegetation west of the site is degraded, contains lower quantities of fine fuels and is a temporary hazard until removed permanently.

The vegetation east of the site is similarly degraded, contains lower quantities of fine fuels and is contained with the Bush Forever Conservation Reserve. As this area revegetates, Class d Scrub will further mature and will continue to be a long term hazard to the site.

This bushfire threat to the proposed development will comply with SPP 3.7 and the *Guidelines for Planning in Bushfire Prone Areas V1.3 (2017)* based on the establishment of a perimeter Asset Protection Zone where required in the perimeter roads and landscaped parks and reserves.

5 ASSESSMENT AGAINST THE BUSHFIRE PROTECTION CRITERIA

The Local Structure Plan illustrated in Figure 1 provides details about the nature of any future proposed urban land use. This BMP outlines strategies for compliance with the bushfire protection criteria based on the LSP.

This report adopts an acceptable solution and performance-based system of control for each bushfire protection criteria. This methodology is consistent with Appendix 4 of the *Guidelines for Planning in Bushfire Prone Areas, Version 1.3 (2017).* The management issues are:

- Location of the development
- Siting and Design of Development
- Vehicular access.
- Water

5.1 Compliance Table

Acceptable solutions are proposed for all of the bushfire protection criteria and each illustrates a means of satisfactorily meeting the corresponding performance criteria. Land use planning bushfire risk mitigation strategies are comprehensively detailed in the following sections by providing responses to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in the *Guidelines for Planning in Bushfire Prone Areas V1.3 (2017).* The compliance checklist is provided in Table 4 and spatial representation of the bushfire management strategies are illustrated in Figure 7.

Table 4. Compliance Table

Bushfire Protection Criteria	Method of compliance Acceptable Solutions	Proposed bushfire management strategies
Element 1: Location	A1.1 Development Location	The Method 1 BAL Assessment in this report demonstrates the classified vegetation in the area surrounding the site does impact the proposed lots, but all lots will achieve a rating of BAL-29 or lower.
Element 2: siting and Design	A2.1 Asset Protection Zone (APZ)	A temporary and perimeter APZ is sited on the perimeter road reserves and adjacent landscape POS areas provide an additional low fuel managed setback to development. All internal POS areas within the site will be established in a low threat condition, with irrigated turf and mulched garden beds, and maintained in accordance with the details provided in Section 2.2 of this BMP. The APZ, consisting of the perimeter road reserve will achieve minimum APZ standards outlined in Appendix 1. The temporary APZ on the far western boundary is required as long as the vegetation remains adjacent to the site. Residential development is restricted in this zone until the vegetation is permanently cleared and the requirement for the temporary APZ is removed. Dwellings within 100 metres of classified vegetation will be managed in accordance with APZ standards (see Appendix 1).
Element 3: Vehicular Access	A3.1 Two access routes	All lots have direct driveway access onto one of many internal public roads which provide a number of ways to Armadale Road in the south. Armadale Road provides good egress to the east and west. Three proposed internal roads connect to future planned residential development to the west and north, providing additional egress from the site. All subdivision stages will require two access ways.
	A3.2 Public Road	Existing public roads and proposed roads comply with minimum public road standards outlined in Appendix 2.
	A3.3 Cul-de-sac	There are no cul-de-sacs proposed.
	A3.4 Battle-axe	There are no battle axes proposed.
	A3.5 Private driveway longer than 50 metres	There are no private driveways longer than 50m proposed.

Element 3: Vehicular Access (cont)	A3.6 Emergency access way	There are no emergency access ways proposed.
	A3.7 Fire Emergency access routes	There are no fire emergency access ways proposed.
	A3.8 Firebreak width	Compliance will be achieved with the current City of Cockburn Fire Control Order (Appendix 3).
Element 4: Water	A4.1 Reticulated areas	Reticulated water will be provided to the entire development. Fire hydrants will be spaced according to Water Corporation and DFES standards and provide emergency services with access to an adequate water supply.
	A4.2 Non-reticulated areas	Not applicable
	A4.3 Individual lots within non-reticulated areas	Not applicable

5.2 Additional Management Strategies

A perimeter APZ will be established and maintained in the road reserve along the northern and eastern boundary which ensures that all future lots will be exposed to BAL-29 or lower. In addition, vegetation in POS areas within the site will be established and maintained in low threat condition as per Section 2.2.

A summary of management strategies is outlined in Figure 7.

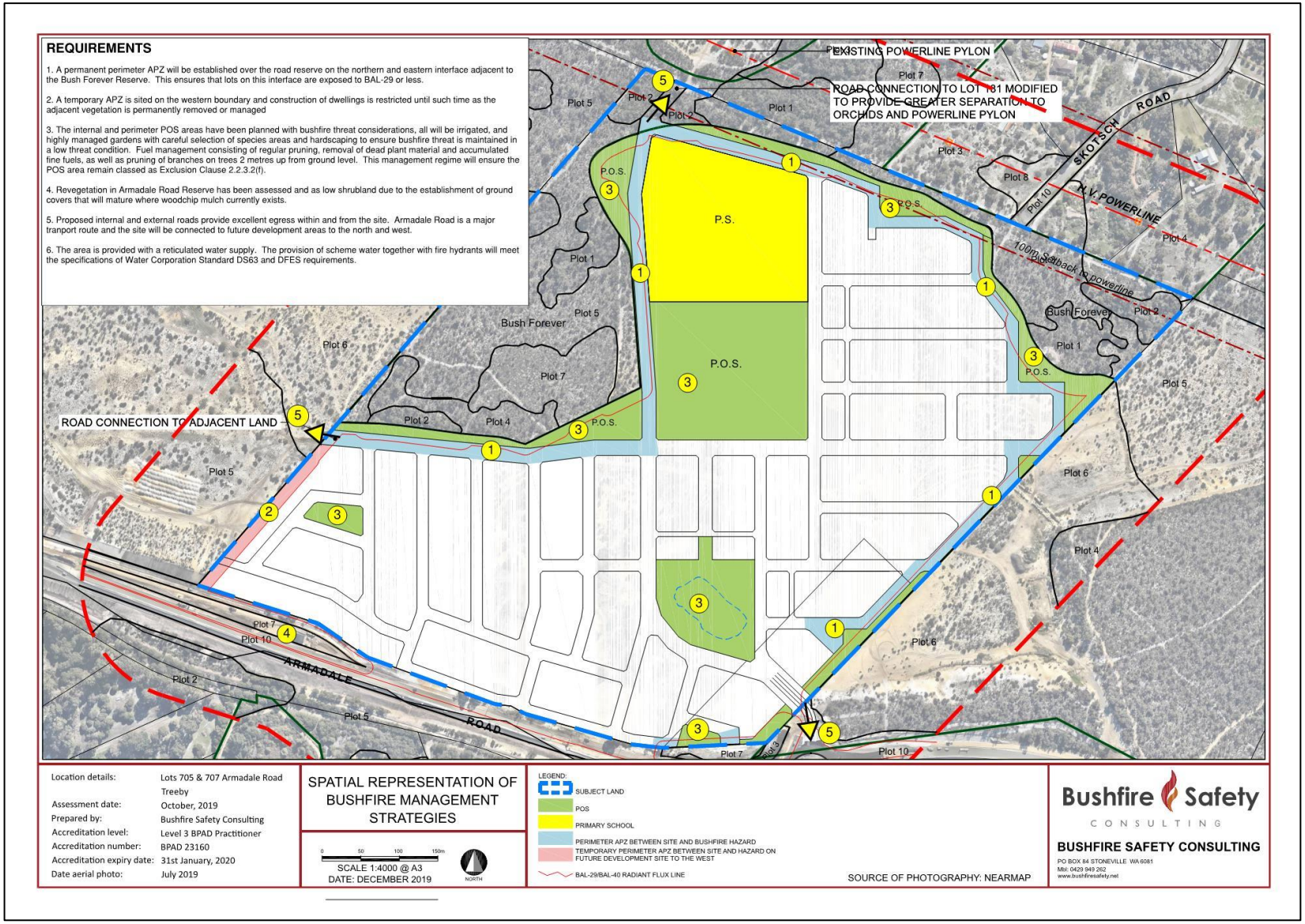


Figure 7: Spatial representation of bushfire management strategies

6 RESPONSIBILITIES FOR IMPLEMENTATION AND MANAGEMENT OF THE BUSHFIRE MEASURES

Table 5 outlines the broad ongoing responsibilities, actions and associated works that need to be undertaken by the future Developer / Proponent or Land Owner and the City of Cockburn. An accredited Bushfire Planning Practitioner will need to be engaged at Subdivision Application stage to update the BMP and assess the development against all of the bushfire protection criteria and SPP 3.7.

Table 5. Responsibility for bushfire measures

DEVELOPER / PROPONENT / LANDOWNER **LSP, SUBDIVISION STAGE AND ONGOING MANAGEMENT**	
1	**Ensure the POS areas are designed and established to a low threat condition with fuel loads and fuel structures managed as outlined in the landscape plans and section 2.2.**
2	**At subdivision stage update the BMP and ensure compliance with SPP 3.7 and the guidelines.**
3	**At subdivision stage, ensure vegetation within the site is removed and managed in a low threat condition within 100 metres of the subdivision boundaries where possible and confirm BAL ratings for individual lots prior to the creation of titles.**
4	**Install the public roads to standards outlined in Appendix 2.**
5	**Ensure the site complies with the City of Cockburn's Fire Control Order as published.**
6	**Ensure any future construction of buildings comply with AS 3959:2018 as and when required.**
7	**Update the Bushfire Management Plan as requested by the City of Cockburn if it has reason to believe site conditions have substantially changed, or new methodologies or practice are adopted as identified in future revisions of the "Guidelines".**
CITY OF COCKBURN – ONGOING MANAGEMENT	
8	**Maintain public roads to appropriate standards and ensure compliance with the City of Cockburn's Fire Control Order.**
9	**Provide fire prevention and preparedness advice to landowners upon request, including the *Homeowners Bush Fire Survival Manual, Prepare, Act, Survive* (or similar suitable documentation) and the City of Cockburn's Fire Control Order.**

7 CONCLUSION

This Plan provides acceptable solutions and responses to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in the Guidelines for Planning in Bushfire Prone Areas (WAPC 2017 V1.3). However, community bushfire safety is a shared responsibility between governments, fire agencies, communities and individuals.

The proposed LSP is located in the bushfire prone area (i.e. within 100 m of classified vegetation) and risk is reduced via compliance with *AS 3959:2018* standards.

Future lots will be exposed to < 29 kW/m². A minimum of two vehicular access options is achieved, and fire hydrant requirements for fire-fighting are met. The proposed development will fall within the acceptable level of risk.

REFERENCES

DFES. (2017). *PREPARE. ACT. SURVIVE.*

http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireManualsandGuides/DES_Bushfire-Prepare_Act_Survive_Booklet.pdf

Standards Australia. 2009. Construction of buildings in bushfire-prone areas (Amendments 1-3), AS 3959-2009, Standards Australia International Ltd, Sydney

Western Australian Planning Commission (WAPC). 2017. Guidelines for Planning in Bushfire Prone Areas. December 2017 V1.3. Western Australian Planning Commission and Department of Planning WA, Government of Western Australia.

Western Australian Planning Commission (WAPC). 2015b. State Planning Policy No. 3.7: planning in Bushfire Prone Areas (SPP3.7). December 2015. Western Australian Planning Commission and Department of Planning WA, Government of Western Australia.

APPENDICES

Appendix 1: Asset Protection Zone Standards
Appendix 2: Vehicular Access Technical Requirements
Appendix 3: City of Cockburn's Fire Control Order
Appendix 4: Landscape Plans for the site
Appendix 5: Armadale Road Landscape Plans

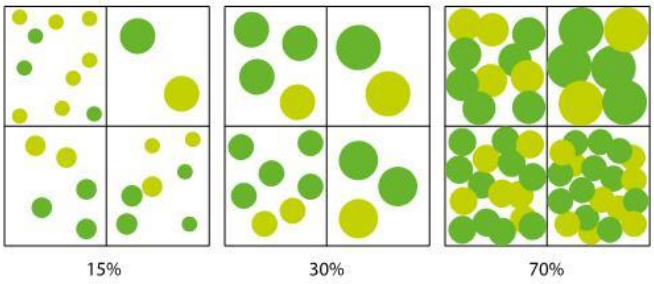
Appendix 1: Asset Protection Zone Standards

ELEMENT 2: SITING AND DESIGN OF DEVELOPMENT

SCHEDULE 1: STANDARDS FOR ASSET PROTECTION ZONES

- **Fences:** within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used.
- **Objects:** within 10 metres of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors.
- **Fine Fuel load:** combustible dead vegetation matter less than 6 millimetres in thickness reduced to and maintained at an average of two tonnes per hectare.
- **Trees (> 5 metres in height):** trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy.

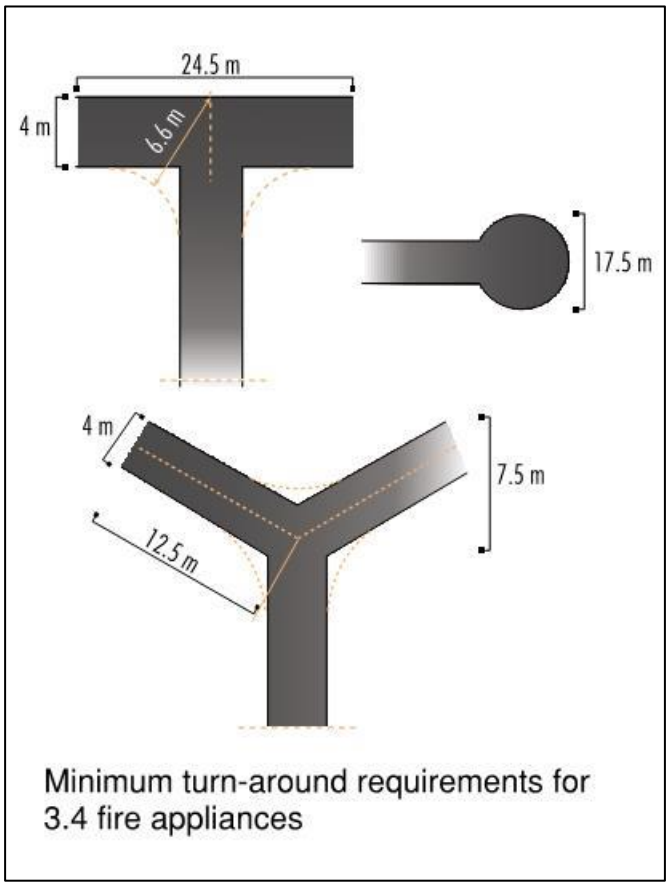
Figure 18: Tree canopy cover – ranging from 15 to 70 per cent at maturity



- **Shrubs (0.5 metres to 5 metres in height):** should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m^2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated as trees.
- **Ground covers (<0.5 metres in height):** can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 metres of a structure, but 3 metres from windows or doors if greater than 100 millimetres in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs.
- **Grass:** should be managed to maintain a height of 100 millimetres or less.

Appendix 2: Vehicle Access Technical Requirements

TECHNICAL REQUIREMENTS	1 Public road	2 Cul-de-sac	3 Private driveway	4 Emergency access way	5 Fire service access routes
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal clearance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	N/A	4.5	4.5	4.5
Maximum grade <50 metres	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum crossfall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius (m)	8.5	8.5	8.5	8.5	8.5
*Refer to E3.2 Public roads: Trafficable surface					



Minimum turn-around requirements for 3.4 fire appliances

Appendix 3: City of Cockburn Fire Control Order

City of Cockburn Fire Control Order

Effective from 10 May 2018

First and Final Notice



Pursuant to *Section 33 of the Bush Fires Act 1954* owners or occupiers of land situated within the City of Cockburn are required by law to comply with the prescribed Fire Control Order here within.

Definitions	
Authorised Officer	A person appointed by the City of Cockburn Chief Executive Officer as an authorised person/officer to exercise the powers and duties set out in the Local Government Act 1995, Bush Fires Act 1954 and Local Law(s).
Flammable Material	Any dead or dry grass, vegetation, substance, object, thing or material (except living flora including live and/ or habitat standing trees) that may or is likely to catch fire and burn or any other thing deemed by an Authorised Officer to be capable of combustion.
Maintained Grass	Soil covered land, planted with grasses or other durable plants, maintained green and less than 50mm in height.
Prohibited Burning Time	The time of each year where it is unlawful to set fire to the bush at any time. This time is normally from 1 December of each year until and including 31 March of the following year. This time may be amended, subject to prevailing seasonal conditions.
Restricted Burning Time	The time of each year where it is unlawful to set fire to the bush without a valid Permit to Set Fire To The Bush issued by an Authorised Officer. This period normally is from 1 April until and including 31 May and from 1 October until and including 30 November of any year. This time may be amended, subject to the prevailing seasonal conditions.
Unrestricted Burning Time	The time of each year where it is lawful to set fire to the bush at any time, in areas zoned rural under the Metropolitan Region Scheme. This time normally is from 1 June until and including 30 September. This time may be amended, subject to the prevailing seasonal conditions.
Firebreak Time	The time of each year where fire hazard reduction works must be maintained as specified in this Fire Control Order. This time is 1 November of each year until and including 15 April of the following year.
Structure	A building, as defined in the Building Codes of Australia (BCA) may be made up of a number of classes if it has a mixed use.

1. All property (vacant or developed) – less than 4,047m²

To reduce the fire hazard on your land and to comply with the requirements of this Fire Control Order you are required to;

1.1 Have all flammable materials such as dry grass and weeds slashed, mown or trimmed down by other means to a maximum height of 50mm across the entire property for the duration of this Firebreak Time; and

1.2 Remove all dead vegetation.

2. All property (vacant or developed) – 4,047m² or greater

To reduce the fire hazard on your land and to comply with the requirements of this Fire Control Order you are required to;

2.1 Construct a firebreak (as defined within section 3 of this order) immediately inside all external property boundaries, this includes those adjacent to roads, drains, rail reserves and any public open space reserves; and

2.2 Remove all dead vegetation surrounding and over all habitable structures to a radius of 3 metres except living trees, shrubs, maintained grass and gardens under cultivation.

3. Firebreak Specifications

A firebreak is an area of land cleared of flammable material, installed to minimise the spread or extension of a fire and to provide suitable access for fire fighting vehicles. The standards of a compliant firebreak are as follows;

3.1 A firebreak must be constructed of bare earth, stone, or sealed surfaces and be clear of all flammable materials to create a 3 metre wide trafficable surface;

3.2 Maintained grass may occupy a firebreak;

3.3 Overhanging branches must be pruned to provide a 4 metre vertical clearance above the full width of the 3 metre firebreak surface; and

3.4 A firebreak must be a continuous trafficable surface for a fire fighting vehicle, clear of any obstructions and must not terminate in a cul-de-sac (dead end).

4. Additional Works

Regardless of land size and location, the City of Cockburn or its Authorised Officer(s) may require you to undertake additional work(s) on your property to improve access and/or undertake further works where in the opinion of that Authorised Officer(s), these works would be conducive to preventing the outbreak and/or the spread or extension of a fire.

5. Fire Control Order Variations

A variation will be considered where the owner and/or occupiers believe it is impractical to meet the compliance requirements of this Fire Control Order.

Approved structure's occupying a firebreak will not require a variation approval. However, a firebreak will be required to be installed as close as practical around the approved structure.

If approved, variations will be valid in perpetuity, unless a new variation has been approved or the property changes ownership.

The City of Cockburn reserves the right to review, amend or revoke an existing variation in writing at any time. Should a request to vary the Fire Control Order requirements on your property not be approved in writing, this Fire Control Order must be complied with as applicable in its entirety.

6. Burning

During the declared Prohibited Burning Time owners and/or occupiers must not undertake any bush or garden refuse burning activities.

During the declared Restricted Burning Time only, owners and/or occupiers may:

6.1 Apply for a permit to burn the bush for bush fire risk mitigation purposes, by following the conditions imposed on a permit to burn as issued by an Authorised Officer.

6.2 In areas zoned rural by the Metropolitan Region Scheme you may undertake burning of leaves, tree branches, and other dry vegetation in piles no larger than 1m³ in size, without a permit to burn, subject to the following conditions:

6.2.1 No flammable material (other than that being burned) is to be within 5m of the fire at any time while the fire is burning;

6.2.2 The fire is lit between 6pm and 11pm and is completely extinguished before midnight on the same day;

6.2.3 At least one person is present at the site of the fire at all times until it is completely extinguished; and

6.2.4 When the fire is no longer required, the person ensures that the fire is completely extinguished by the application of water or earth.

During the Unrestricted Burning Time, owners and/or occupiers in areas zoned rural under the Metropolitan Region Scheme may burn garden refuse and set fire to bush on their land without a permit 'To Set Fire To The Bush'. Burning of the bush must be in accordance with all relevant State legislative requirements.

Burning of garden refuse in areas not zoned rural shall not be undertaken within the City of Cockburn, unless approved by an Authorised Officer.

Burning of household waste is prohibited in all areas of the City of Cockburn.

7. Penalties

Failing to comply with this Fire Control Order will result in a penalty of up to $5,000. A person in default is also liable whether prosecuted or not to pay the costs of performing the work directed by a City's Authorised Officer.

Any owner and/or occupier who engages a contractor to undertake works on their behalf is responsible to ensure that the works completed meet the requirements of this Fire Control Order.

Any Fire Control Order previously published by the City of Cockburn in the Government Gazette or in any Western Australian newsprint is hereby revoked.

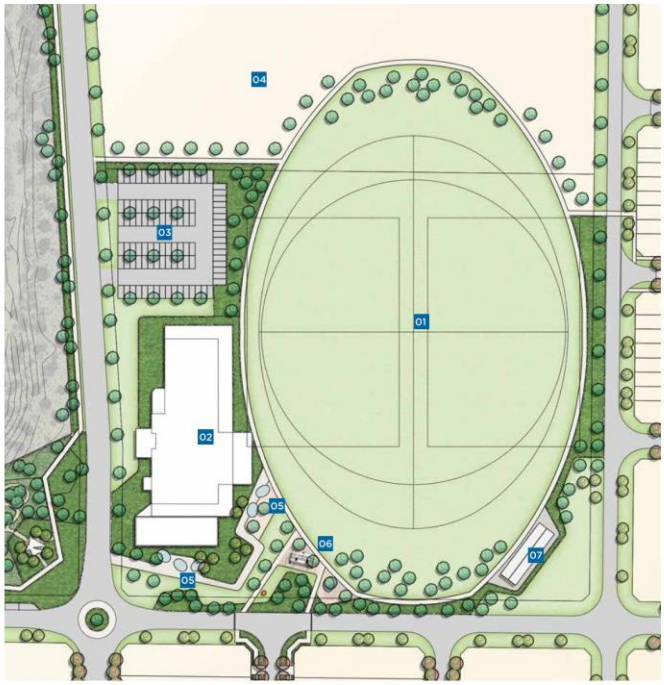
By Order of Council

Document Set ID: 7874932
Version: 1, Version Date: 12/10/2018

The City of Cockburn Fire Control Order is available in Chinese, Portuguese, Italian and Croatian by contacting the City on 08 9411 3444.

Appendix 4: Landscape Masterplan and POS Management





3.2 The Activity Park

This park area will share the playing field surface with the adjacent school site to the north. The area provides formal recreation to the future community with the provision of grassed playing fields for a range of sports, with associated cricket practise nets, shade and spectator seating.

The park will include facilities that encourage and accommodate group and family gatherings that complement and enhance the formal sporting activity. A utility shaded area provides a flexible space for a diverse range of activities to bring a variety of options to the park for all the family.

As part of the health and wellbeing, the park will also have an exercise node with fitness equipment set within the open space, to provide space for boot camps, group sessions and the like. The circular footpath around the oval provides regular park access, but can also be a walking/ running track with distance markers.

This park could also provide a site for a possible future community facility and some car parking facilities which would meld with and enhance the other activities. Should a community facility be located here, the car parking numbers are anticipated to be supplemented by the school car park under some share arrangement to help encourage the inclusion of the school facilities into the community, rather than fencing it off.

Due to the potential bushfire threat that exists to the west of the Activity Park, the community facilities and evacuation routes will be considered in the design and layout of this area.

As this park is close to the adjacent bushland this active park will extend the path system across to the managed access trails around the periphery of the bushland and in some cases through to the adjacent bush forever, extending the opportunities for circuit walks and jogging trails.

The design of this park will be a 'formal' approach with vegetation selected and maintained to be low to mid groundcover, clear stemmed trees and full irrigation, being maintained as low threat vegetation and compliant with AS3959-2018 as stipulated in the Bushfire Management Plan.

This park will also serve an important storage function in the overall drainage strategy of the site, providing stormwater attenuation devices integrated into the overall park design. The intention is to use underground storage systems to accommodate the drainage and to retain the amenity of the park unhindered. This park will require the most irrigation due to the proposed expanse of high level turf playing fields.

1. Formal sport ground
2. Site for possible future community facility
3. Car parking
4. School site
5. Fitness equipment
6. Community pavilion
7. Cricket practise nets

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EPCAD

Appendix 4: Landscape Masterplan and POS Management



The Lake Park

The location of this park was determined by the location of an existing lake and associated vegetation which we consider to have amenity value. The design intent is to retain and enhance both features and to exploit all the positive aspects of amenity that a lake brings from attracting wildlife, to the visual interest and the sound of water.

The intention is to formalise the edges of the existing water body, depending on the current situation. Where trees exist, there will be careful intergration of low walls, boulders or rock pitching to make the slopes safe, with low shrub planting and limited access to these areas through the use of fences. Other clear areas will have higher wall finishes with balustrades to allow a close relationship with the water in complete safety. This combination of treatments and the meandering footpath provides a circular walk around the lake, sometimes up close, sometimes further away, to give a variety of views and experiences.

Cascades into the lake would provide water circulation with the bonus of the visual and audio amenity value.

The spaces in and around this lake will have a variety of uses, from low key quiet spaces beneath existing trees with yoga decks and reclined seating through to more active spaces of educational play and activity for all ages, bringing old and young together. The park is intended to have something for everyone.

Although this park is separate to the periphery areas of classified vegetation, we have still considered the local bushfire threat that could be created in the retention of the existing trees around the lake. All new vegetation will be fully irrigated and species chosen as low to mid groundcovers, with clear stemmed trees and maintained formally as low threat vegetation and compliant with AS3959-2018 as stipulated in the Bushfire Management Plan.

From this park there are two important links: north through to the activity park and south across to the sales office.

The sales office is where the inclusion of a pop up facility such as a café is proposed and the hope is to strongly link this facility with the park and to secure a more permanent local business of this nature in the future. The inclusion of a small community edible garden would be a positive addition to this space.

The strong connection north to the activity park will be accentuated using arbors, shade trees and feature sculptural elements to provide legibility and easy access between the reserves. The idea is to encourage walking and connectivity in shaded comfort wherever possible.

1. Retained lake with cascade
2. Multi-use play and amenity for all ages
3. Quiet and relaxing area for all ages
4. Strong green link between parks
5. Pop up cafe and community hub

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The Arrival Experience

The southern entry to this community is designed to immediately influence road traffic to slow down and to bring an instant character narrative of a green, lush, calm place that is in contrast to the Armadale Road left behind.

The road layout is specifically designed to bifurcate around a group planting of large trees, and is slightly raised to slow traffic and to give the feeling that the trees were there first. This instantly provides a sense of shade and green aspect to the arrival experience.

Small parks lay to either side of this entry and are the start point to the circular walks around the community, with gateway entry walls bringing legibility. These walks (cycleways) connect into the main Armadale Road cycleway. The use of walls, art and paving, together with cascading plants and lush tree and shrub species combine to bring a sense of oasis.

Planting to the bund along Armadale Road is unfortunately outside the lot boundary and so negotiations will have to take place to make any changes to the bunds at this entry. As the bund treatment is outside our control, the arrival area and internal linear vegetation has been designed to be more formal, with full irrigation and maintained as low threat vegetation compliant with the Bushfire Management Plan. The hope is to achieve some ability to influence the shrub planting to the new bund, to try to bring some synergy between the two landscape environments.

1. Bifurcated road with mature tree planting
2. Road treatment to slow traffic
3. Gateway park to circuit walks
4. Cascading wall and plant treatment

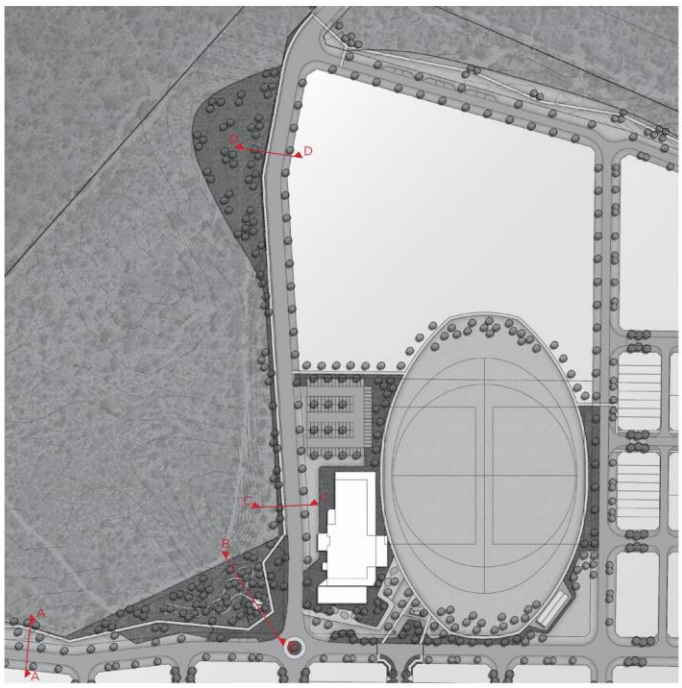






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Appendix 4: Landscape Masterplan and POS Management



The Interface with Bush Forever

The extensive areas of bush forever retained around this development area will be a precious passive resource for the community. The interface with the residential areas and school site will be defined creating a distinct separation but also providing useable space. The interface space will in effect become linear parkways that accommodate walks and punctuating nodes that form a component of the broader recreation path network.

These linear parkways are intended as being a more 'controlled' landscape experience, designed with external bush threat considerations, with irrigation throughout and maintained as low threat vegetation to comply with the AS3959-2018 and the Bushfire Management Plan. Footpaths will meander through low groundcovers, turf and clear stemmed trees.

Nodes within linear space will include elements such as outdoor class rooms that relate to the values that can be observed within the bushland. Such nodal points will be located in positions that optimise their use. Two selected areas of existing bush will be retained within the buffer zone and this will be intensively managed in line with the Bushfire Management Plan and used to educate people on the importance of the bush environment, with safe access using compacted gravel paths and boardwalks.

By designating routes and providing interpretive material it can be ensured that the reserves are valued by the community for passive recreation, but not degraded by uncontrolled access. Walking tracks through the reserve will utilise informal trails that are already present in order to avoid clearing of new tracks.

Management of public access through the area will be achieved utilising:

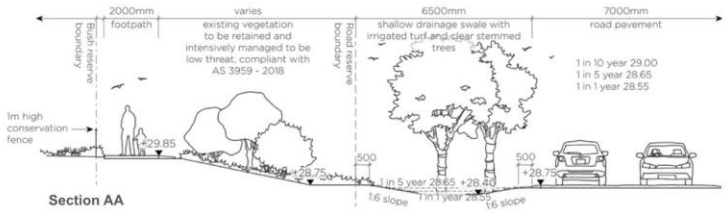
- Signage (both informative and interpretive)
- Passive surveillance where practicable from adjacent residences
- Conservation fencing preventing uncontrolled access to bushland (post and wire)
- Stabilised footpaths
- Interpretive and directional signage

The opportunity for isolation in the reserves presents potential security and safety issues and therefore careful management of public access will be required in accordance with CPTED principles. Consideration for passive surveillance will be included in designing possible path routes to ensure a safe yet uncompromised journey.

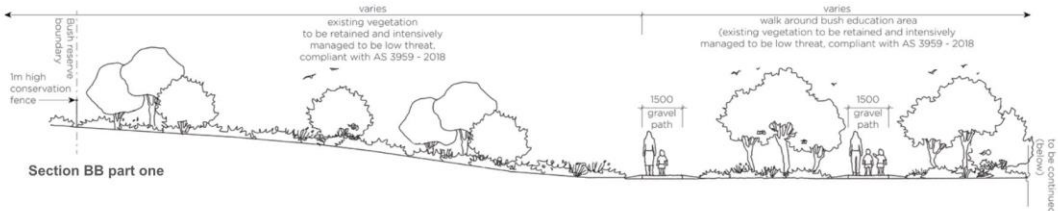
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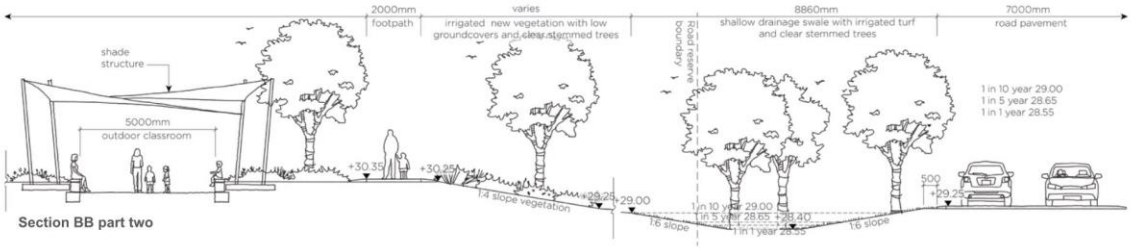
Key Plan nts



Section AA



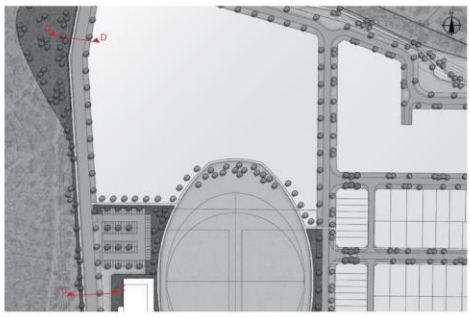
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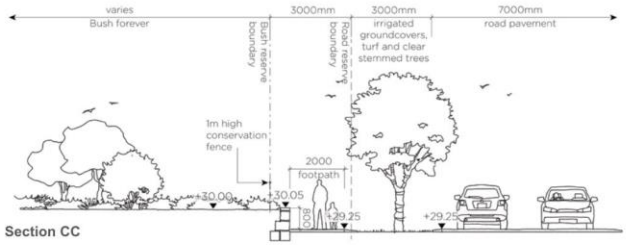
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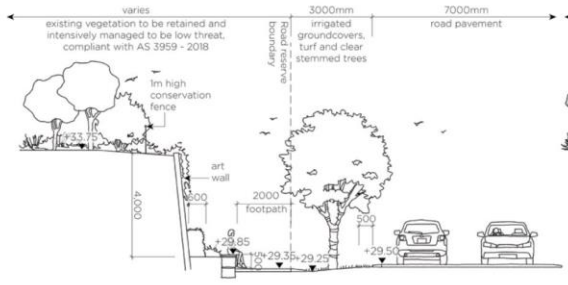
Appendix 4: Landscape Masterplan and POS Management



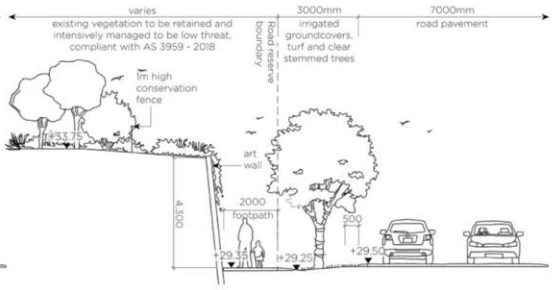
Key Plan nts



Section CC



Section DD Option one



Section DD Option two



Streetscapes

One of the main drivers for a successful community lies in the streets. This is where people live, where their neighbour is and where the community develops. One of the main focus areas in this landscape masterplan is in rethinking the street design.

There has been interesting research into the design of streets and the opportunities to make them slower, safer and more people friendly. Also the identity of a street and the need to feel like it is a welcome experience to the residents. It is the crux of the neighbourhood.

In our climate, the user comfort value of any walking experience is so important. Streets that offer little tree cover can be too hostile and harsh to encourage any major walking or perambulating activity and so shade is paramount. Getting people using the streets more regularly to get to their local park enables residents to meet their neighbours, stop and chat, or sit and relax. Also, a mature tree canopy developed within a 10 to 15 year period can reduce the ambient urban temperature by 2-4 degrees with knock on benefits to reduce power consumption for air conditioning etc.

The intent of this design is to widen the verge wherever there are side lots, to enable large street tree planting for instant shade and identity to the streetscape. This also slows traffic to make the street safer, and provides a wider area to bring in elements of interest to the street. Perhaps a bird bath on one corner, a hopscotch game, a simple seat, book exchange box or piece of art. Bollards could be decorated or designed to pick out the street name and bring a sense of ownership to the street. The design would be improved with an element of shrub planting, but if maintenance was considered an issue, trees could be within permeable paving or bonded gravels. If required, these areas could also be used as underground storage for drainage at source.

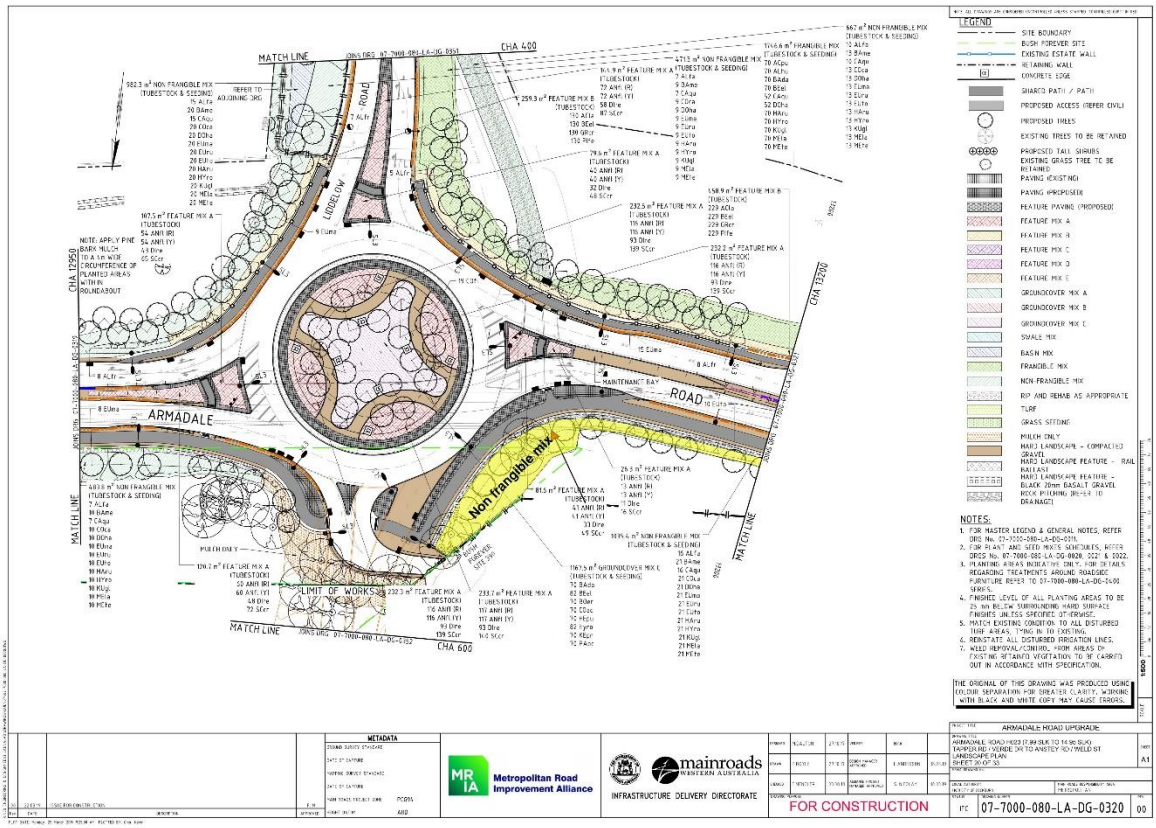
In addition, to meander the road pavement slightly in one location within the reserve to enlarge the verge for group planting in the middle of that same street, again takes away the usual stark, straight street profile with single lot trees.

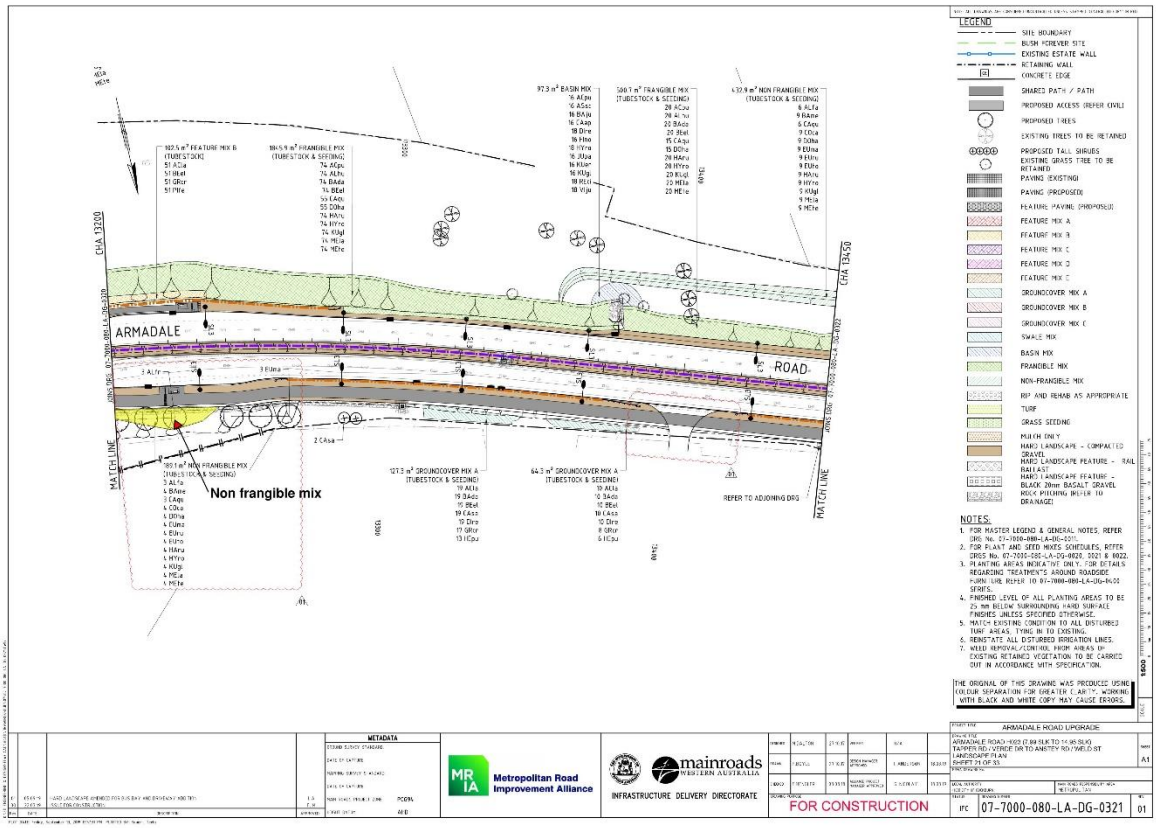
If there are existing trees in a development, we try to retain and work around them, which creates some of the best street outcomes. We are reversing this and accommodating new large trees as though they were there already to bring that same point of interest to the street.

Supplemented with the usual street trees, this approach should bring more shade to the street and bring a different aspect to the street on day one, making them more user friendly.

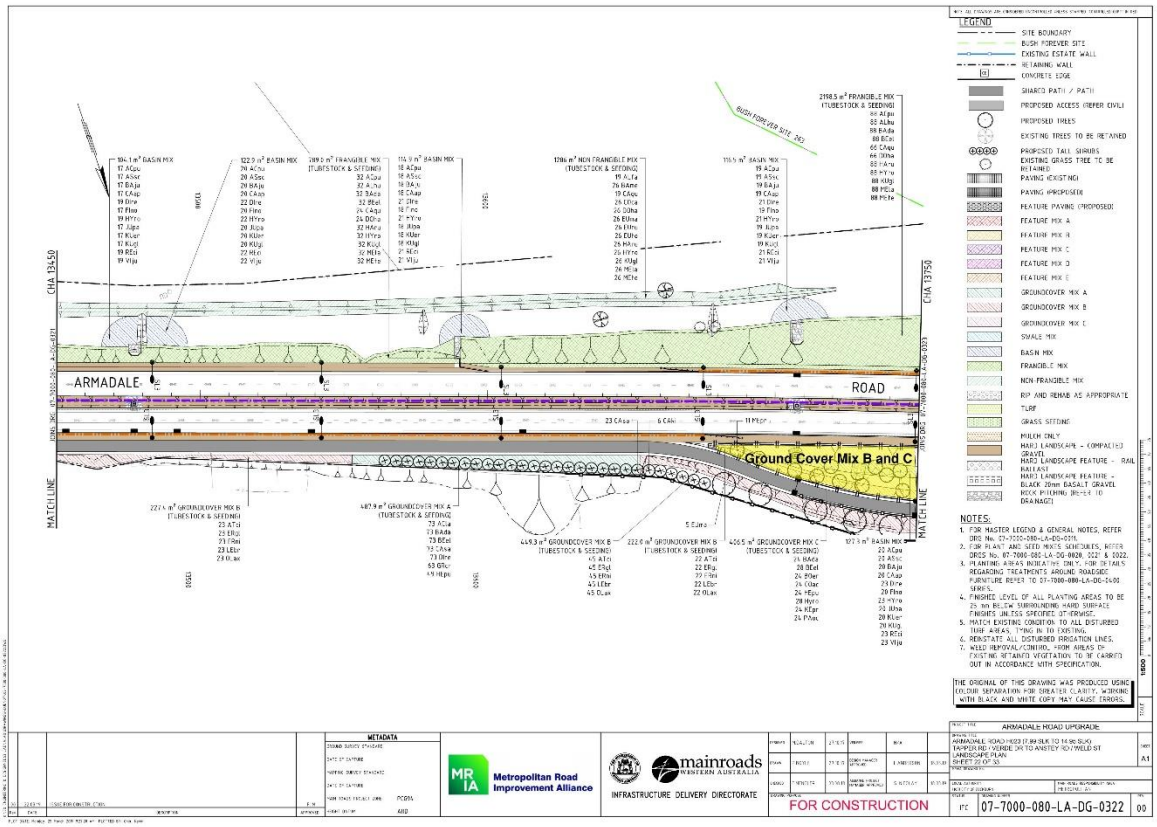
Each street should develop its own character and sense of place.

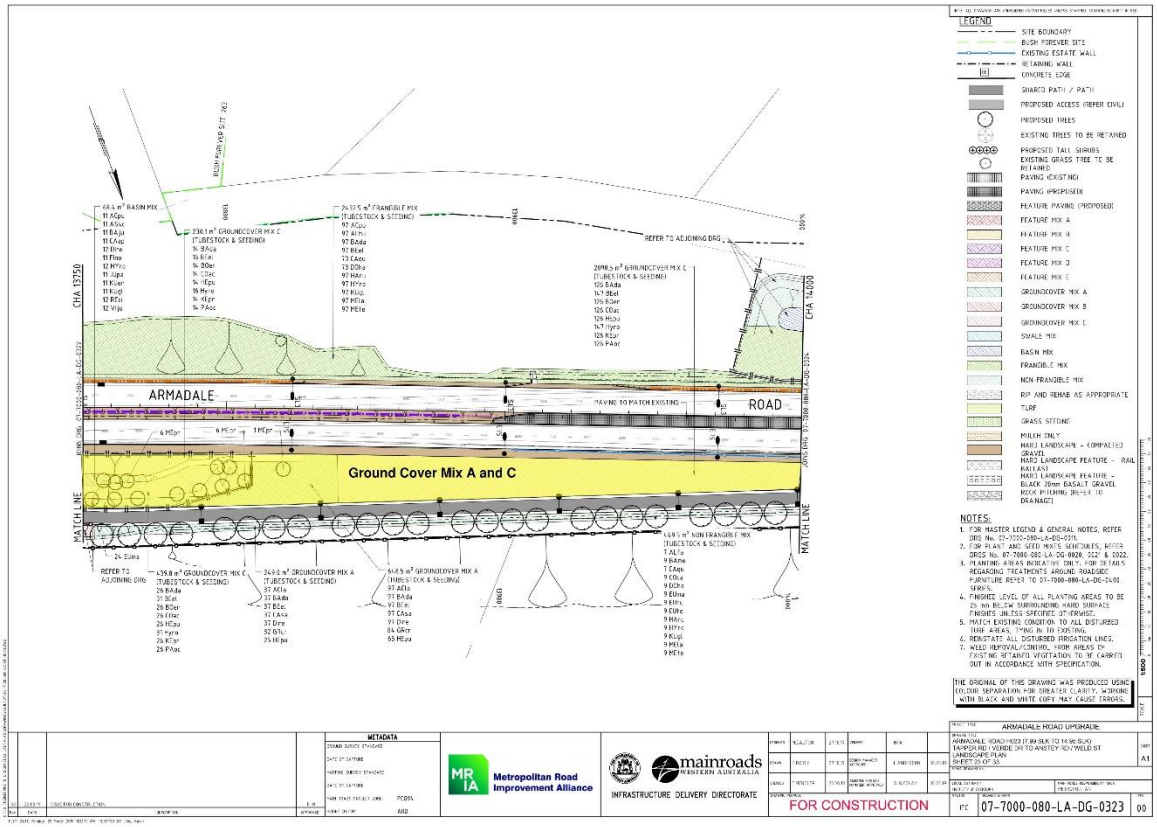
Appendix 5: Armadale Road Landscape Plans



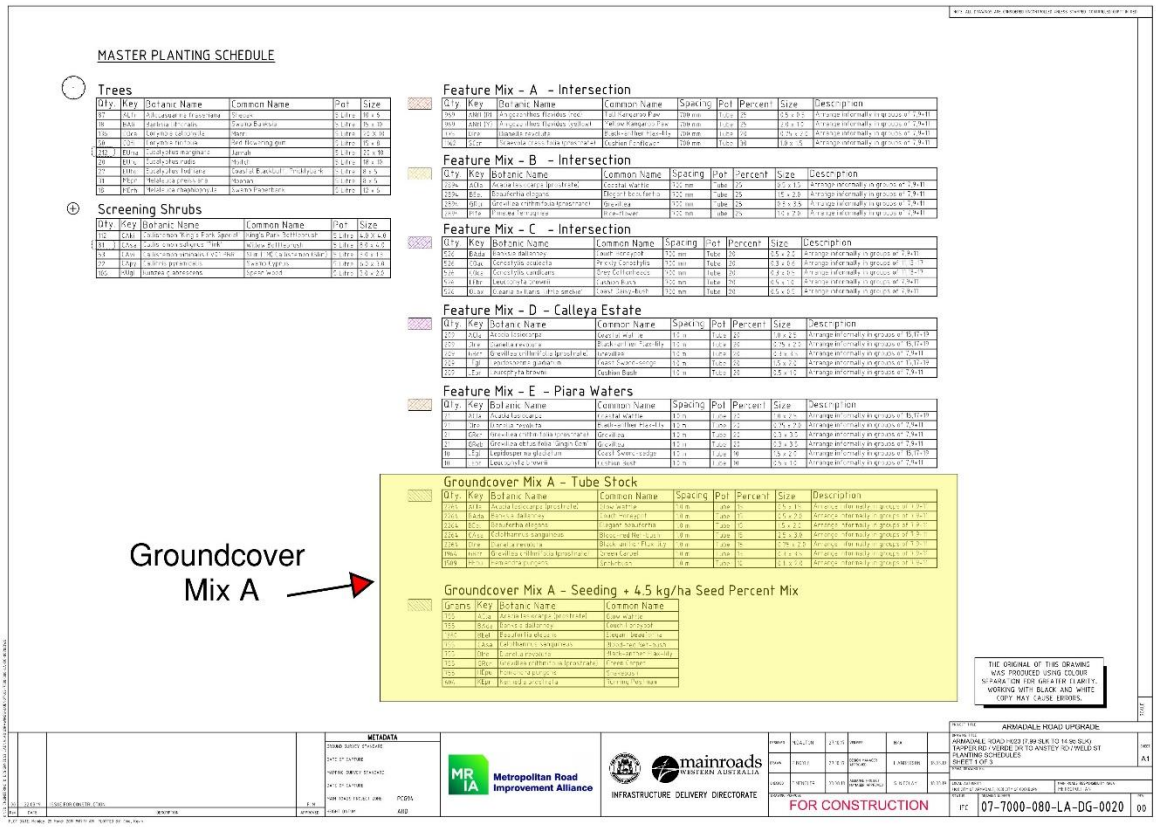


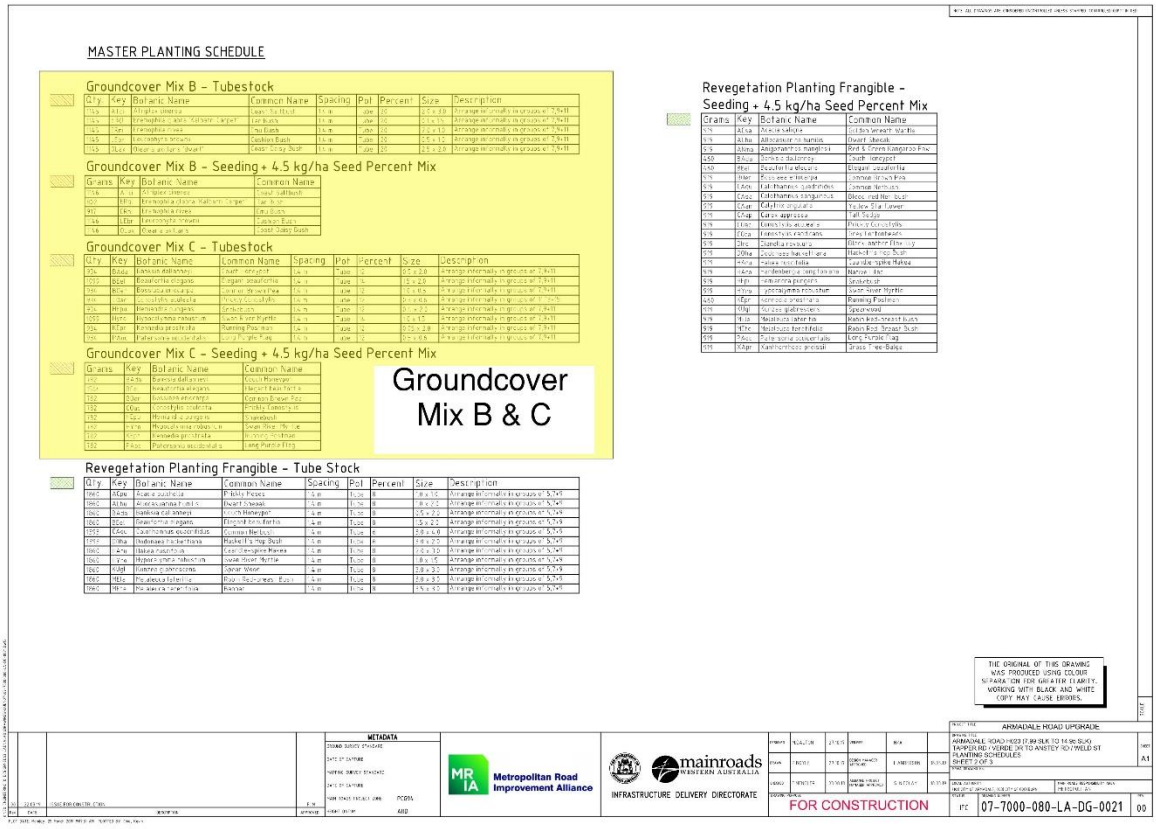
Appendix 5: Armadale Road Landscape Plans





Appendix 5: Armadale Road Landscape Plans





Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Lots 705 & 707 Armadale Road Treeby

Site visit: Yes ☑ No ☐

Date of site visit (if applicable): Day 18th Month November Year 2019

Report author or reviewer: Rohan Carboon

WA BPAD accreditation level (please circle):

Not accredited ☐ Level 1 BAL assessor ☐ Level 2 practitioner ☐ Level 3 practitioner ☑

If accredited please provide the following.

BPAD accreditation number: 23160 Accreditation expiry: Month January Year 2020

Bushfire management plan version number: V2.0

Bushfire management plan date: Day 13th Month December Year 2019

Client/business name: E.W.H. Pty Ltd

	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?		✓
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the bushfire protection criteria elements)?		✓

Is the proposal any of the following (see SPP 3.7 for definitions)?	Yes	No
Unavoidable development (in BAL-40 or BAL-FZ)		✓
Strategic planning proposal (including rezoning applications)		✓
High risk land-use		✓
Vulnerable land-use		✓

None of the above ☑

Note: Only if one (or more) of the above answers in the tables is yes should the decision maker (e.g. local government or the WAPC) refer the proposal to DFES for comment.

Why has it been given one of the above listed classifications (E.g. Considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

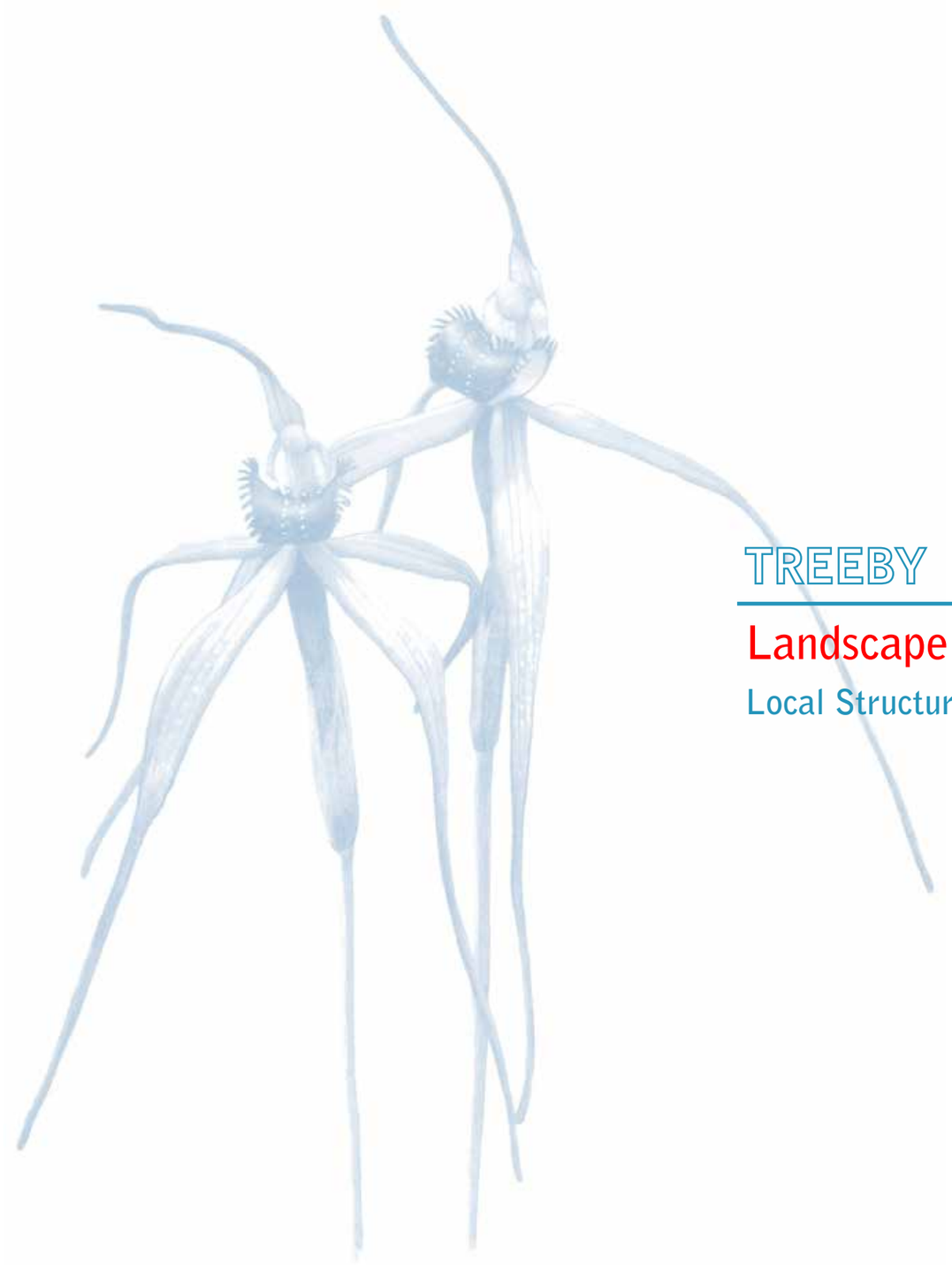
The information provided within this bushfire management plan to the best of my knowledge is true and correct:

Signature of report author or reviewer 

Date 13/12/2019

APPENDIX THREE

Landscape Strategy (EPCAD)



TREEBY

Landscape Management Plan 25/11/19

Local Structure Plan

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Document No: B1006-LSP-ISSUE 1 - Rev A 14/11/19

Issue	Issue to	Date	Reviewed	Approved
B1006-LSP-Draft	Perron	12/11/19	RM	KL
	CLE	12/11/19	RM	KL
B1006-LSP-Rev A	Perron	14/11/19	RM	KL
	CLE	14/11/19	RM	KL
B1006-LSP-Rev A	Team	15/11/19	RM	KL
B1006-LSP-Rev B	Team	25/11/19	RM	KL

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Introduction



This report describes the landscape infrastructure, open spaces and public realm uses of the proposed community at Lot 705 and 707 Armadale Road Treeby.

The Treeby development adopts a landscape approach that will provide the resident community with a diverse range of high quality open spaces, reserves, parks and public realm experiences. Places will include space for active recreation, passive repose and relaxation, play and walks all set within a distinctive character that defines this community.

The approach also integrates community development initiatives and placemaking within the planning and design of the landscape. The open space framework is planned to facilitate and accommodate change and evolution of use to reflect the emerging community needs and expectations.

The plans have been subjected to rigorous review and development through project visioning exercises, community feedback and innovation workshops. The landscape plan has been developed in consultation with all other disciplines such as engineering, planning, hydrological, and environmental. Consultation with the bushfire consultant was paramount to ensure the bushfire threat is considered and design features are included to minimise bushfire threat to the community.

This document therefore sets out guidance for the delivery of a quality open space and streetscape network establishing a valued urban environment for the new community in this location.

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one

1 Landscape Analysis

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1.1 Existing Landscape

The existing character of the location reflects its historical use in brickmaking and the excavation of the base resource. The topography of the site is dominated by various excavations which are in contrast with retained levels identified as Bush Forever sites. The large areas of remnant bushland standing proud of the disturbed landscape can be observed as skyline features from parts of the site.

The old use has left much of the site as a disturbed landscape. In many areas, brick rubble is evident at the surface being testimony to the historic use. There has been regrowth of vegetation including some larger trees especially around ponds. The water bodies that have been the result of excavations are superficially a feature however set challenges if they are to be incorporated within the new urban landscape.

The majority of good quality existing trees are around the southern waterbody with some additional ones punctuating the degraded and debris strewn landscape.

The larger northern waterbody is devoid of any vegetation, presenting a sandy shoreline and sand hills surrounding it. There are some Acacia bushes in small pockets where the ground has not been disturbed to the same extent as the older excavations.

Although the site presents as highly disturbed with remnant bushland, areas of brick rubble, sand hills vehicle tracks, some specific areas of old machinery and abandoned cars, it does have attributes that have been identified for retention and referencing within the landscape design.

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1.2 Contextual Landscape

The surrounding landscape character can be summarised as being in transition. What was previously rural is now being urbanised with new major road infrastructure, housing developments, commercial and industrial developments contrasting with retained remnant bushland and special rural lifestyle blocks.

The southern boundary is dominated by the dual carriageway and earthworks of the Armadale Road corridor. This busy road has yet to mature and has no mature vegetation associated with it. It is therefore a new element within the landscape and will be sometime before it positively contributes to the landscape character of the district.

Further south the contextual landscape presents a view of low woodland which is formed by the matrix of mature perimeter trees that envelop large special rural residential blocks. This vegetative framework effectively screens residences and forms a strong visual edge running alongside Armadale Road.

To the west, the land is zoned urban and yet to be developed being an area of disturbed land with sparse regrowth vegetation across it. The developing community of Calleya lies further west and presents a typical new suburb of low rise residences set within a streetscape that is still to attain any great tree framework.

The north is bounded by power transmission lines which are a dominant feature in the landscape, particularly close up, and will always be subject to management which complies with Western Power's requirements. The north east is an area of special rural living, with more mature trees and a broad open nature of a gently rolling landscape.

East of the planned community, there is a Bush Forever site which is partially degraded and devoid of vegetation but generally covered with low woodland. The Rose Shanks Reserve forms part of the Jandakot Regional Park and Bush Forever Site 390 . It is an important ecological area of bush that is being restored as part of the Jandakot Airport expansion offsets project.

In this location also is the Cockburn-Fremantle Pistol Club. This is a secure area defined by low bunding and perimeter mature trees excluding views into this site and so the perimeter trees are the defining element in the landscape.

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two

2 Landscape Approach

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2.1 Landscape Approach

The new landscape is planned to reference some of the historical use, adopt an innovative way of managing urban water but most importantly deliver places that are a catalyst and venue for community development, health and wellbeing.

Through analysis of the site and coordination with planners and engineers, a concept open space framework has been devised to optimise the sites attributes and create a new distinctive urban landscape. Places are created from remnant features of value such as waterbodies, associated existing trees and the important interface with the surrounding bush forever.

The public open space strategy therefore comprises a number of landscape typologies based upon key existing site features and the need for quality environments within the proposed urban setting. The arrangement of open space and landscape elements creates useable pedestrian and cyclist circulation routes while reinforcing an obvious legibility within the neighbourhood. New view corridors and landmarks are created within the public realm to inform users and aid in legibility of place.

The landscape typologies identified and proposed are as follows;

- The Activity Park
- The Lake Parkland
- The Entry Experience
- The Interface with Bush Forever
- The Streetscapes

Each landscape typology defines the place and is to be designed to facilitate uses and opportunities that aid community development as well as providing an early open space asset. The landscape will seek to provide the best possible outcome for the urban environment with a managed demand for irrigation that will be an integral part of the urban water management system. Irrigation will be directly related to vegetative structure with an aim to reduce micro climate temperatures of streets and parks.

A major consideration in the landscape masterplan is the unique treatment of streets to bring walkability, safety and friendliness. The entry to this community off Armadale Road provides an immediate character narrative, with a green, lush street leading the eye to the main park. This narrative will continue through the street design and present a series of green path networks, bringing character to the streets and delivering the community to their parks and reserves.

The overall principles for the open spaces are:

- Places, parks and streets, to instil wellbeing in the user
- Street tree planting to ameliorate urban heat island effect
- Provide logical connections throughout all areas of residential development
- Provide new landmark views and relationships that assist in orientation and legibility
- Create highly utilised and valued open spaces that are venues and catalysts for community development
- Provide a landscape environment that considers bushfire threat and is designed to minimise the bushfire threat to the community.
- Provide diverse spaces from highly naturalistic related to the retained bushland to managed parkland incorporating play, community and family facilities
- Provide a hierarchy of walks and circuits, from short walks through the more manicured parklands and extending into longer walks through bushland for those more adventurous
- Integrate planned urban water management into valued open spaces in accordance with the LWMS

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2.2 Health and Wellbeing of the Community

In developing the LSP, the project team has been through a series of workshops and asked the question: What makes a great community?

In looking at various survey results and researching publications on the subject, the conclusion is that a great community tends to go hand in hand with a community that has good health and wellbeing. There are 5 ways to Wellbeing and they are to:

Element	Activity	Tangible things to deliver
Connect	Develop relationships, join a club, talk to neighbours, gather and communicate	• Multi-Use Community Pavilion • Coffee shop or similar with multi purpose space • Artwork for newcomer contribution • Create streets that are safe (speed and clear vision), shaded and walkable. • Mix age group activities and ensure paths pass by activities • Provide gathering spaces within the POS • Community Garden and shed • Book/ recipe swap stations
Be active	Walk, run, play, move	• Create walking trails of different lengths - many through 'controlled' parklands, some through bushland. • Fitness and Boot Camp equipment • Play equipment for all ages • Space for family games, cricket, football etc. • Exercise stations within the streets and paths • Family fun trends such as frisbee golf, bocce etc • Basket ball, scooter or pump tracks
Take Notice	Take time for you, be aware of yourself and your environment, take time to smell the roses	• Provide areas of calm and repose within the POS • Slow the spaces down through points of interest, bird hides, etc • Yoga decks • Reclining seating areas • Points of calm throughout the landscape - kinetic art or movement to capture eye, stop and watch • Sound of water - cascade
Keep Learning	Explore new things, try something new, work to achieve	• Interpretation signs throughout the landscape and walkways • Exploration and learning through play • Outdoor Classroom
Give	Acts of kindness on any level, volunteer	• Book / recipe swap stations • Community gardens • Produce Box

This spreadsheet shows ideas of how to deliver tangible places and spaces for these elements to occur in the landscape as a whole. A ‘vision’ plan was then developed to show how these elements could be brought into the landscape masterplan. The vision plan can be seen overleaf.

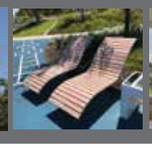
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FOCAL TOWER AND OPEN PAVILLION

A large, covered, multi-use community space with moveable tables and seating.

Large focal feature in park.






OUTDOOR CLASSROOMS AND INTERPRETIVE SIGNAGE

Shaded, circular seating areas with an outdoor blackboard as meeting points for educating children and the community about the natural environment, health and wellbeing and sustainability.

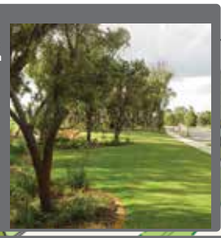
POSSIBLE FUTURE COMMUNITY FACILITY

BUSH FOREVER

Interface with bush forever will accommodate drainage within neat swales, with a meandering footpath and manicured landscape treatments to create a formal and clear transition to the natural bushland.

Potential for bush trail access points for longer, more adventurous walking.

Nature Bush Walk
Long Parkland Walk
Medium Parkland Walk
Short Park Land Walk



EXCERCISE NODE

Outdoor exercise equipment or boot camp equipment set in a circuit either around the oval or in one area. Caters for all ages and abilities and to be less about sheer strength and more about tuning in to balance, posture, agility and resistance.




MULTI-GENERATIONAL ACTIVITY AREA

Designed to provide a full spectrum of play, intrigue, exploration, and education whilst encouraging movement and activity. Play for all ages, designed to be interactive and bring families together.






COMMUNITY CAFE AND HUB

Potential for a café or kiosk with outdoor seating and shade to create a meeting point for the community. Potentially linked to the sales office with a small multi-use space that can be hired for mothers groups, yoga and the like.




SAFE STREETS

Create streets that are safe, shaded and walkable to encourage neighbour interaction.

ARMADALE ROAD

PRIMARY SCHOOL SITE

OVAL

The hub of activity: Large sports recreation area for more formal sports activities and games.

Encourage other community weekend activities such as growers markets, kite flying days, cinema evenings, music evenings, fairs and the like.




BUSH FOREVER

Interface with bush forever will accommodate drainage within neat swales, with a meandering footpath and manicured landscape treatments to create a formal and clear transition to the natural bushland.

Potential for bush trail access points for longer, more adventurous walking.

Nature Bush Walk
Long Parkland Walk
Medium Parkland Walk
Short Park Land Walk



OUTDOOR CINEMA SCREEN LOCATION

CRICKET PRACTICE NETS

PUMP STATION

PARKLAND LINK

A strong link between the two parks with mature tree planting and a feature arbor or similar. Absolute pedestrian priority and widened verge to enable this strong pedestrian link.

AREA OF WELLNESS

Area of intimate spaces and places of repose to encourage the community to stop, relax and take a moment. Strong link to the falling water of the cascade.





ARRIVAL PARKLAND

This part of the park to have open grassed areas with views across to the lake framed by mature trees. This provides the opening 'arrival' to the community, but is also a place to lay down in the shade of trees and relax.




WELCOME ENTRY

A green, warm, mature entry zone which has a strong sense of arrival and says 'Welcome Home you can relax now'. The entry needs to strongly present the vision and set the scene for the community within.




THE LAKE

A destination feature to walk around, sit by and view across. A place of repose, peace and calm.



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three

3 Landscape Typologies

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Legend

01 The Activity Park with formal sports ground

02 Site for possible future community facility

03 Car parking

04 School site

05 Fitness area with equipment and shade

06 Community multi-use pavilion

07 Cricket practise nets

08 Green link between parks with arbors and focal features

09 Outdoor classroom and educational walk

10 Linear park with irrigated grass, groundcovers, clear-stemmed trees and stormwater storage

11 Activity node along the linear park

12 Circular walks of varying lengths around the parklands

13 Linear park with irrigated grass, groundcovers, and clear-stemmed trees

14 Widened verge treatment to the street entry points for safe, green streets

15 Pocket park with low key activity

16 The Lake Park with retained trees, lake and cascade

17 Multi-use activity for all ages

18 Area of calm and relaxation for all ages

19 Potential pop-up café and community hub

20 Arrival experience and gateway to circular walks

21 Armadale Road bund

SKOTSCH ROAD

ARMADALE ROAD

ARMADALE ROAD

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Treeby

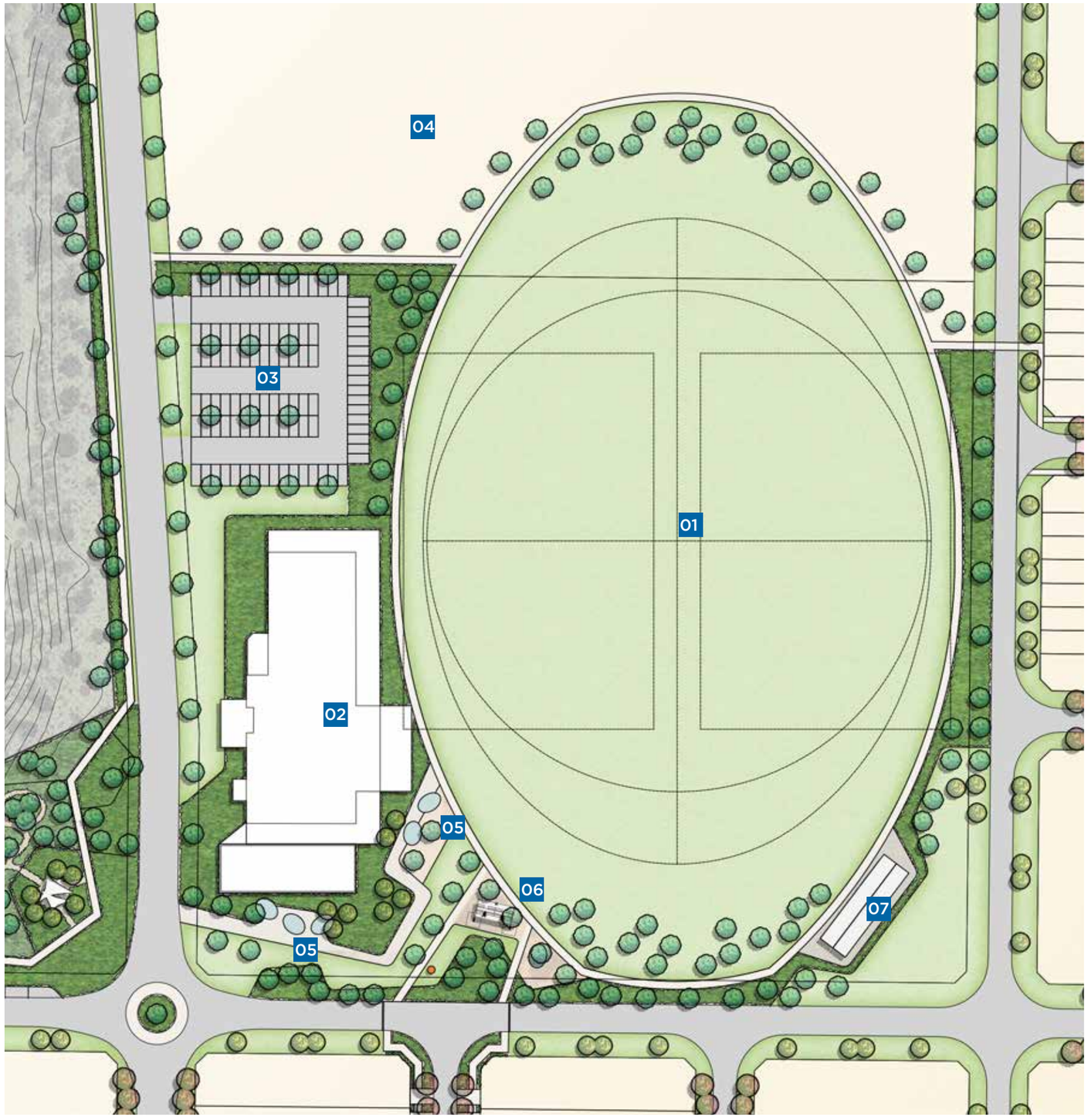
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scale : NTS date : 12 November 2019

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EPCAD



3.2 The Activity Park

This park area will share the playing field surface with the adjacent school site to the north. The area provides formal recreation to the future community with the provision of grassed playing fields for a range of sports, with associated cricket practise nets, shade and spectator seating.

The park will include facilities that encourage and accommodate group and family gatherings that complement and enhance the formal sporting activity. A utility shaded area provides a flexible space for a diverse range of activities to bring a variety of options to the park for all the family.

As part of the health and wellbeing, the park will also have an exercise node with fitness equipment set within the open space, to provide space for boot camps, group sessions and the like. The circular footpath around the oval provides regular park access, but can also be a walking/ running track with distance markers.

This park could also provide a site for a possible future community facility and some car parking facilities which would meld with and enhance the other activities. Should a community facility be located here, the car parking numbers are anticipated to be supplemented by the school car park under some share arrangement to help encourage the inclusion of the school facilities into the community, rather than fencing it off.

Due to the potential bushfire threat that exists to the west of the Activity Park, the community facilities and evacuation routes will be considered in the design and layout of this area.

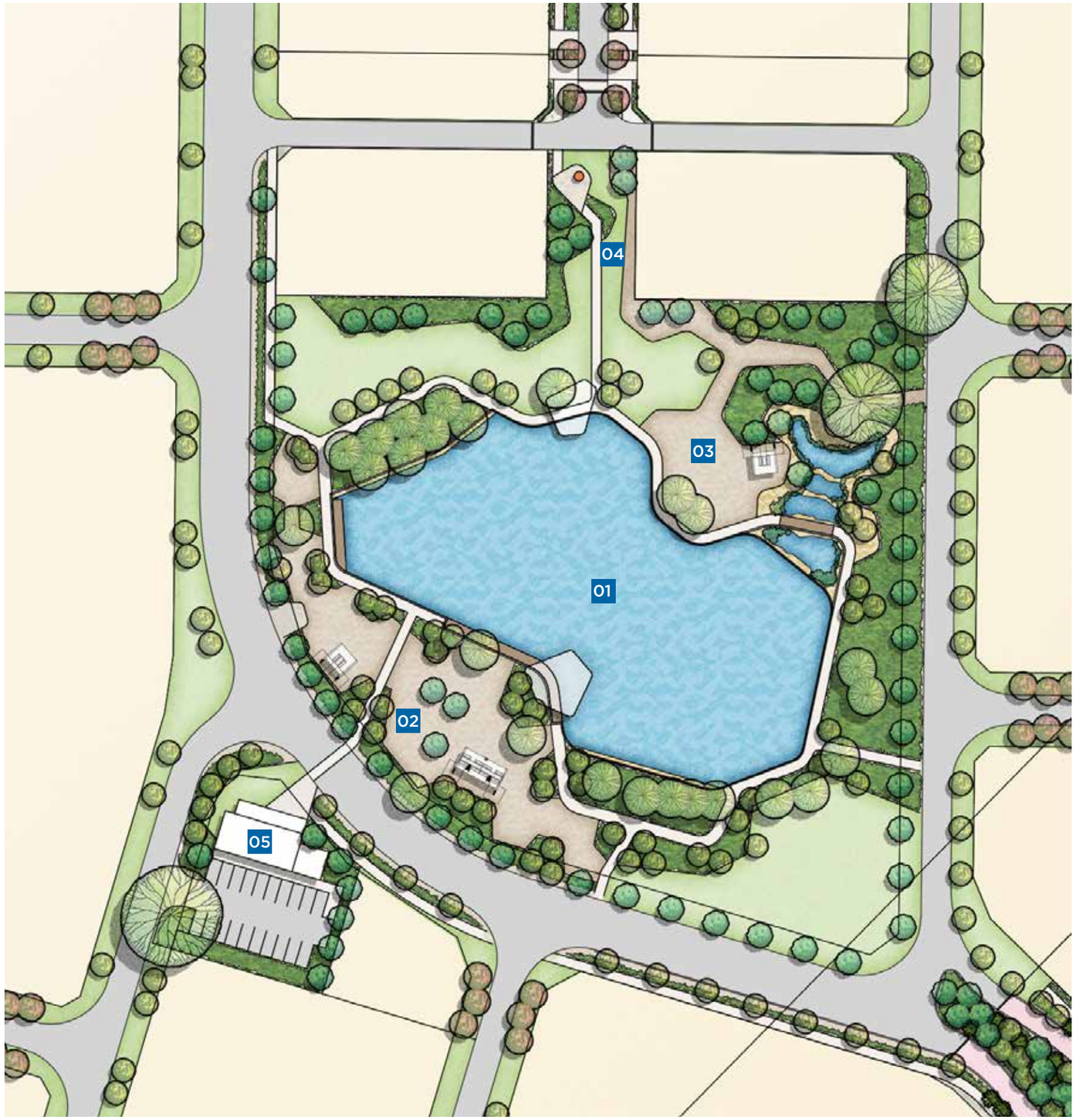
As this park is close to the adjacent bushland this active park will extend the path system across to the managed access trails around the periphery of the bushland and in some cases through to the adjacent bush forever, extending the opportunities for circuit walks and jogging trails.

The design of this park will be a ‘formal’ approach with vegetation selected and maintained to be low to mid groundcover, clear stemmed trees and full irrigation, being maintained as low threat vegetation and compliant with AS3959-2018 as stipulated in the Bushfire Management Plan.

This park will also serve an important storage function in the overall drainage strategy of the site, providing stormwater attenuation devices integrated into the overall park design. The intention is to use underground storage systems to accommodate the drainage and to retain the amenity of the park unhindered. This park will require the most irrigation due to the proposed expanse of high level turf playing fields.

1. Formal sport ground
2. Site for possible future community facility
3. Car parking
4. School site
5. Fitness equipment
6. Community pavilion
7. Cricket practise nets

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The Lake Park

The location of this park was determined by the location of an existing lake and associated vegetation which we consider to have amenity value. The design intent is to retain and enhance both features and to exploit all the positive aspects of amenity that a lake brings from attracting wildlife, to the visual interest and the sound of water.

The intention is to formalise the edges of the existing water body, depending on the current situation. Where trees exist, there will be careful intergration of low walls, boulders or rock pitching to make the slopes safe, with low shrub planting and limited access to these areas through the use of fences. Other clear areas will have higher wall finishes with balustrades to allow a close relationship with the water in complete safety. This combination of treatments and the meandering footpath provides a circular walk around the lake, sometimes up close, sometimes further away, to give a variety of views and experiences.

Cascades into the lake would provide water circulation with the bonus of the visual and audio amenity value.

The spaces in and around this lake will have a variety of uses, from low key quiet spaces beneath existing trees with yoga decks and reclined seating through to more active spaces of educational play and activity for all ages, bringing old and young together. The park is intended to have something for everyone.

Although this park is separate to the periphery areas of classified vegetation, we have still considered the local bushfire threat that could be created in the retention of the existing trees around the lake. All new vegetation will be fully irrigated and species chosen as low to mid groundcovers, with clear stemmed trees and maintained formally as low threat vegetation and compliant with AS3959-2018 as stipulated in the Bushfire Management Plan.

From this park there are two important links: north through to the activity park and south across to the sales office.

The sales office is where the inclusion of a pop up facility such as a café is proposed and the hope is to strongly link this facility with the park and to secure a more permanent local business of this nature in the future. The inclusion of a small community edible garden would be a positive addition to this space.

The strong connection north to the activity park will be accentuated using arbors, shade trees and feature sculptural elements to provide legibility and easy access between the reserves. The idea is to encourage walking and connectivity in shaded comfort wherever possible.

1. Retained lake with cascade
2. Multi-use play and amenity for all ages
3. Quiet and relaxing area for all ages
4. Strong green link between parks
5. Pop up cafe and community hub

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The Arrival Experience

The southern entry to this community is designed to immediately influence road traffic to slow down and to bring an instant character narrative of a green, lush, calm place that is in contrast to the Armadale Road left behind.

The road layout is specifically designed to bifurcate around a group planting of large trees, and is slightly raised to slow traffic and to give the feeling that the trees were there first. This instantly provides a sense of shade and green aspect to the arrival experience.

Small parks lay to either side of this entry and are the start point to the circular walks around the community, with gateway entry walls bringing legibility. These walks (cycleways) connect into the main Armadale Road cycleway. The use of walls, art and paving, together with cascading plants and lush tree and shrub species combine to bring a sense of oasis.

Planting to the bund along Armadale Road is unfortunately outside the lot boundary and so negotiations will have to take place to make any changes to the bunds at this entry. As the bund treatment is outside our control, the arrival area and internal linear vegetation has been designed to be more formal, with full irrigation and maintained as low threat vegetation compliant with the Bushfire Management Plan. The hope is to achieve some ability to influence the shrub planting to the new bund, to try to bring some synergy between the two landscape environments.

1. Bifurcated road with mature tree planting
2. Road treatment to slow traffic
3. Gateway park to circuit walks
4. Cascading wall and plant treatment



Artist impression of entry statement

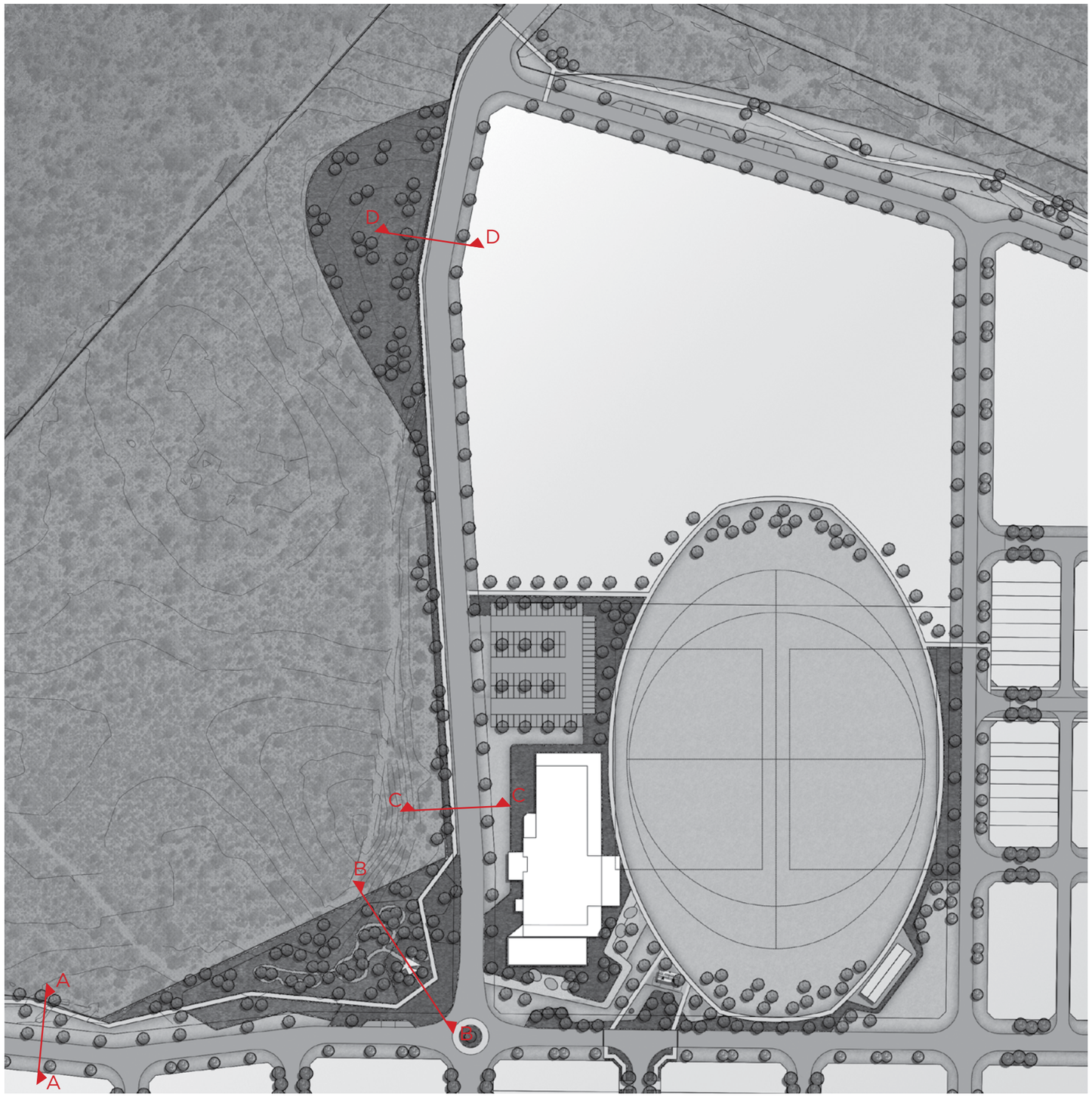


Feature wall with wall cut out and cascading plants.



Terracing walls with 'cousin-it' cascading plants. Feature artwork with 'Estate name' cut out of corten steel.

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The Interface with Bush Forever

The extensive areas of bush forever retained around this development area will be a precious passive resource for the community. The interface with the residential areas and school site will be defined creating a distinct separation but also providing useable space. The interface space will in effect become linear parkways that accommodate walks and punctuating nodes that form a component of the broader recreation path network.

These linear parkways are intended as being a more ‘controlled’ landscape experience, designed with external bush threat considerations, with irrigation throughout and maintained as low threat vegetation to comply with the AS3959-2018 and the Bushfire Management Plan. Footpaths will meander through low groundcovers, turf and clear stemmed trees.

Nodes within linear space will include elements such as outdoor class rooms that relate to the values that can be observed within the bushland. Such nodal points will be located in positions that optimise their use. Two selected areas of existing bush will be retained within the buffer zone and this will be intensively managed in line with the Bushfire Management Plan and used to educate people on the importance of the bush environment, with safe access using compacted gravel paths and boardwalks.

By designating routes and providing interpretive material it can be ensured that the reserves are valued by the community for passive recreation, but not degraded by uncontrolled access. Walking tracks through the reserve will utilise informal trails that are already present in order to avoid clearing of new tracks.

Management of public access through the area will be achieved utilising:

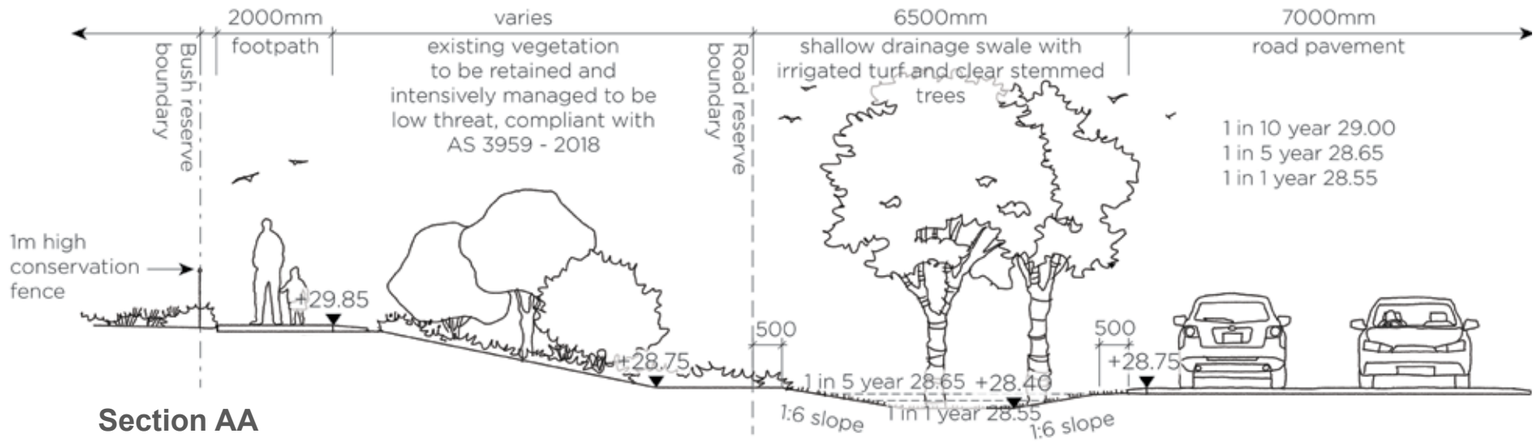
- Signage (both informative and interpretive)
- Passive surveillance where practicable from adjacent residences
- Conservation fencing preventing uncontrolled access to bushland (post and wire)
- Stabilised footpaths
- Interpretive and directional signage

The opportunity for isolation in the reserves presents potential security and safety issues and therefore careful management of public access will be required in accordance with CPTED principles. Consideration for passive surveillance will be included in designing possible path routes to ensure a safe yet uncompromised journey.

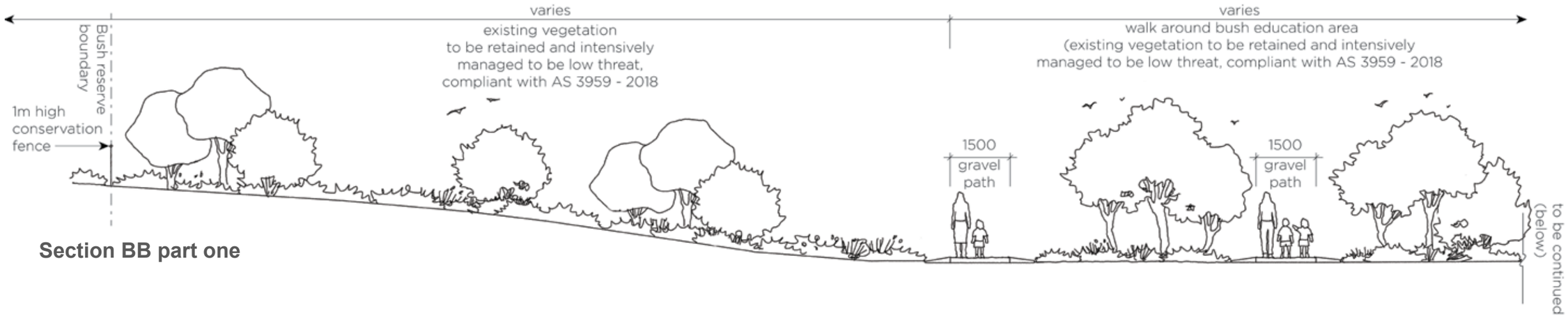
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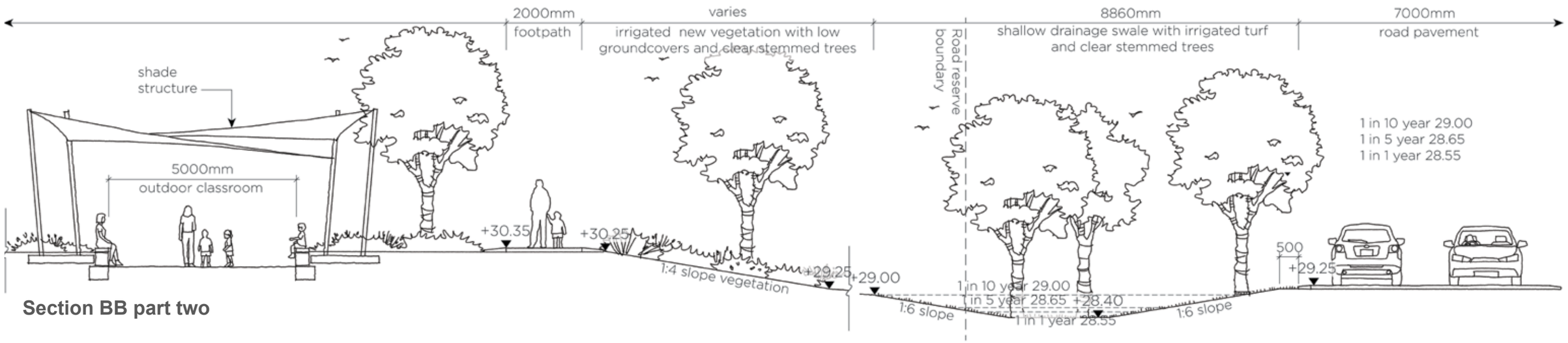
Key Plan nts



Section AA



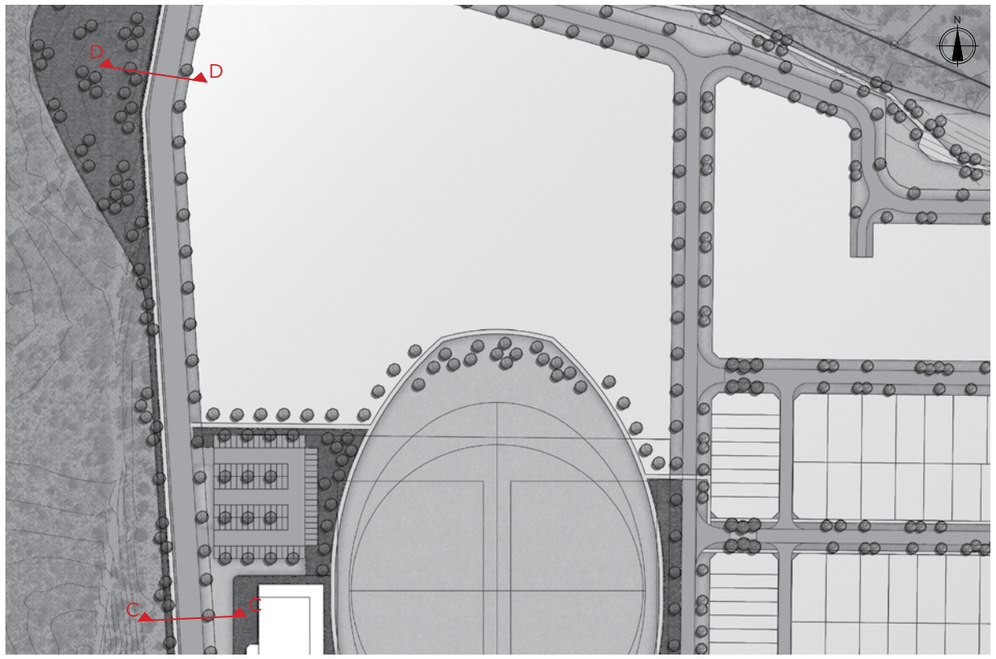
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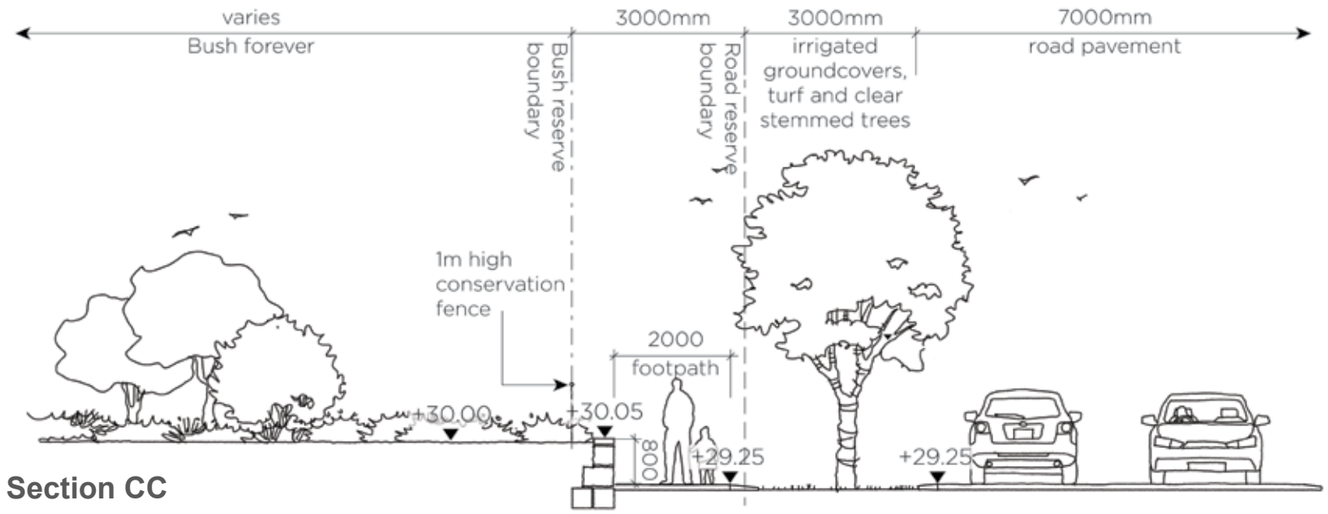
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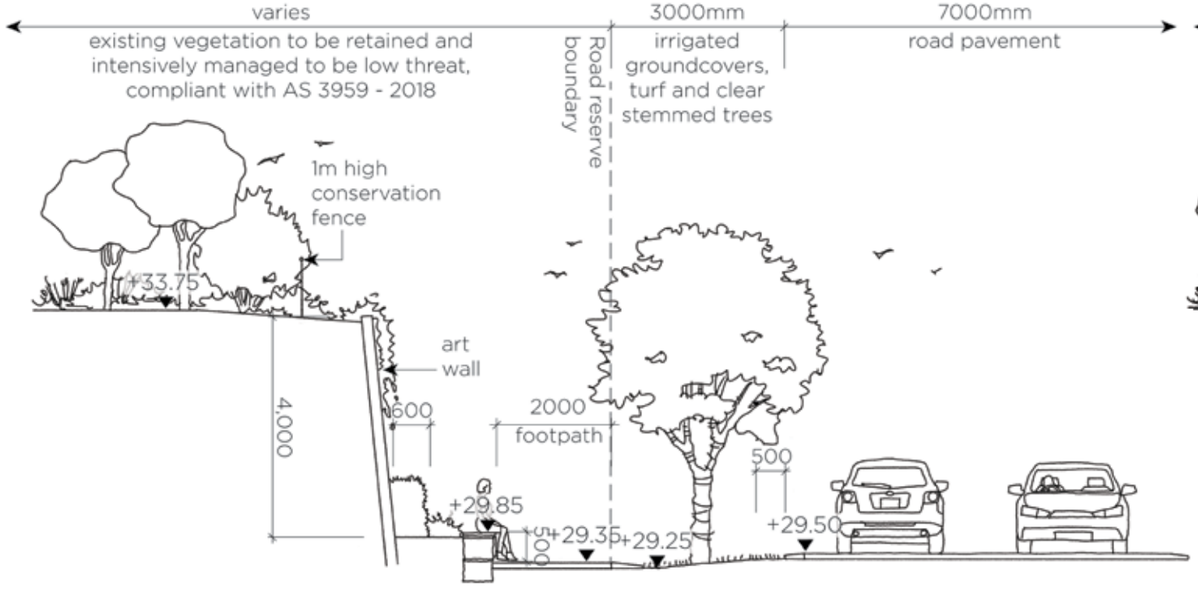
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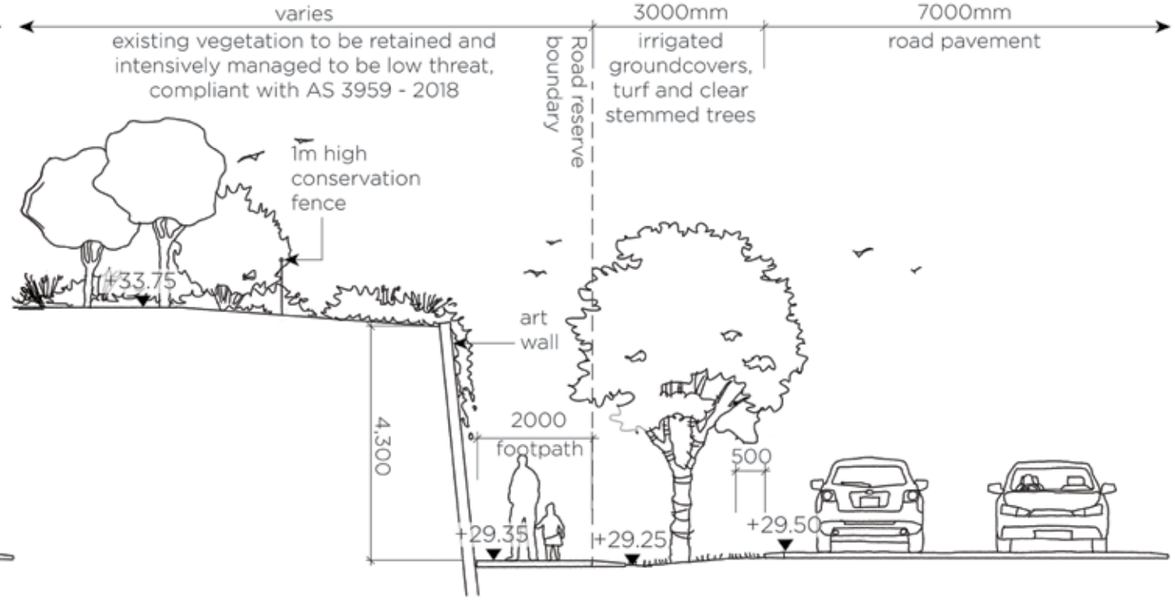
Key Plan nts



Section CC



Section DD Option one



Section DD Option two

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Streetscapes

One of the main drivers for a successful community lies in the streets. This is where people live, where their neighbour is and where the community develops. One of the main focus areas in this landscape masterplan is in rethinking the street design.

There has been interesting research into the design of streets and the opportunities to make them slower, safer and more people friendly. Also the identity of a street and the need to feel like it is a welcome experience to the residents. It is the crux of the neighbourhood.

In our climate, the user comfort value of any walking experience is so important. Streets that offer little tree cover can be too hostile and harsh to encourage any major walking or perambulating activity and so shade is paramount. Getting people using the streets more regularly to get to their local park enables residents to meet their neighbours, stop and chat, or sit and relax. Also, a mature tree canopy developed withn a 10 to 15 year period can reduce the ambient urban temperature by 2-4 degrees with knock on benefits to reduce power consumption for air conditioning etc.

The intent of this design is to widen the verge wherever there are side lots, to enable large street tree planting for instant shade and identity to the streetscape. This also slows traffic to make the street safer, and provides a wider area to bring in elements of interest to the street. Perhaps a bird bath on one corner, a hopscotch game, a simple seat, book exchange box or piece of art. Bollards could be decorated or designed to pick out the street name and bring a sense of ownership to the street. The design would be improved with an element of shrub planting, but if maintenance was considered an issue, trees could be within permeable paving or bonded gravels. If required, these areas could also be used as underground storage for drainage at source.

In addition, to meander the road pavement slightly in one location within the reserve to enlarge the verge for group planting in the middle of that same street, again takes away the usual stark, straight street profile with single lot trees.

If there are existing trees in a development, we try to retain and work around them, which creates some of the best street outcomes. We are reversing this and accommodating new large trees as though they were there already to bring that same point of interest to the street.

Supplemented with the usual street trees, this approach should bring more shade to the street and bring a different aspect to the street on day one, making them more user friendly.

Each street should develop its own character and sense of place.

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Increase verges at street entry to:
- Slow traffic
- Provide more space for group planting
- Enable small activation such as bird bath, seat or book exchange.
- Traffic calming as bio retention devices
- Provide space for annual ‘bloom’ festival.

Street design as PLACE - the neighbourhood deinition
Safe street design
Play in streets
Streets as shared space
Measured street temperature reduction modelling.



TYPICAL RESIDENTIAL ROAD PLAN



Rethinking Streetscapes












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four

4 Plant Palette and Irrigation

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Trees - 5m+

Australian Native Species


Agonis flexuosa

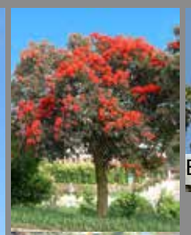

Callistemon Kings Park Special




Eucalyptus leucoxylon Rosea


Eucalyptus torquata


Grevillea robusta




Corymbia ficifolia


Banksia grandis

Exotic Feature Species


Liquidambar styraciflua


Pyrus ussuriensis




Magnolia grandiflora Exmouth

Low / Medium Colourful Shrubs - 1m - 2m


Anigozanthos flavidus Big Red


Cycas revoluta




Strelitizia reginae


Rhaphiolepsis Snow Maiden


Banksia ashbyii


Kunzea baxteri Solomons Pink


Grevillea ‘Bonnie Prince Charlie’


Xanthorrhoea preissii

Groundcovers and Climbers - to 1m


Hardenbergia Happy Wanderer

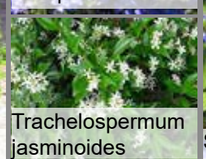

Acacia cognata Limelight


Casuarina Cousin It


Callistemon Little John


Cuphea Hyssopifolia


Dampieria linearis


Trachelospermum jasminoides


Scaevola crassifolia

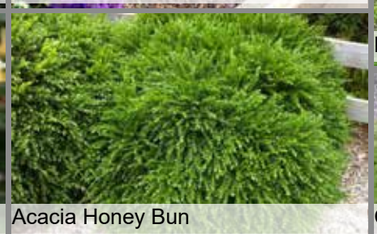

Hemiandra pungens

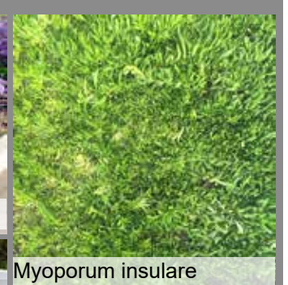

Hibbertia scandens


Leptospermum Pink Cascade


Lonicera japonica


Limonium perezii


Acacia Honey Bun


Myoporum insulare


Grevillea Gin Gin Gem

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Treeby B1006-LSP - REV B

0 20 40 60 80 100m

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Maintenance

Any landscape environment requires manitenance and new landscapes within a development are maintained specifically in accordance with the local authorities' requirements. With the existing bush forever to the periphery of the site, maintenance becomes a key component to be considered in the design of the landscape masterplan to reduce the bushfire threat to the community. This is covered in detail in the Bushfire Report, but we list the basic principles in the design and maintenance of the landscape below.

The Landscape Masterplan falls into four main areas of maintenance and these are represented on the adjacent plan:

1. Retained native bushland for amenity value

- Initial clearing and pruning of dead vegetation
- Annual pruning of trees and shrubs and removal of fine fuels
- Strategic mulching of ground around existing vegetation
- Strategic location of irrigation alongside footpaths
- Concrete and/or compacetd gravel footpaths for breaks and access
- Access for fire truck if required

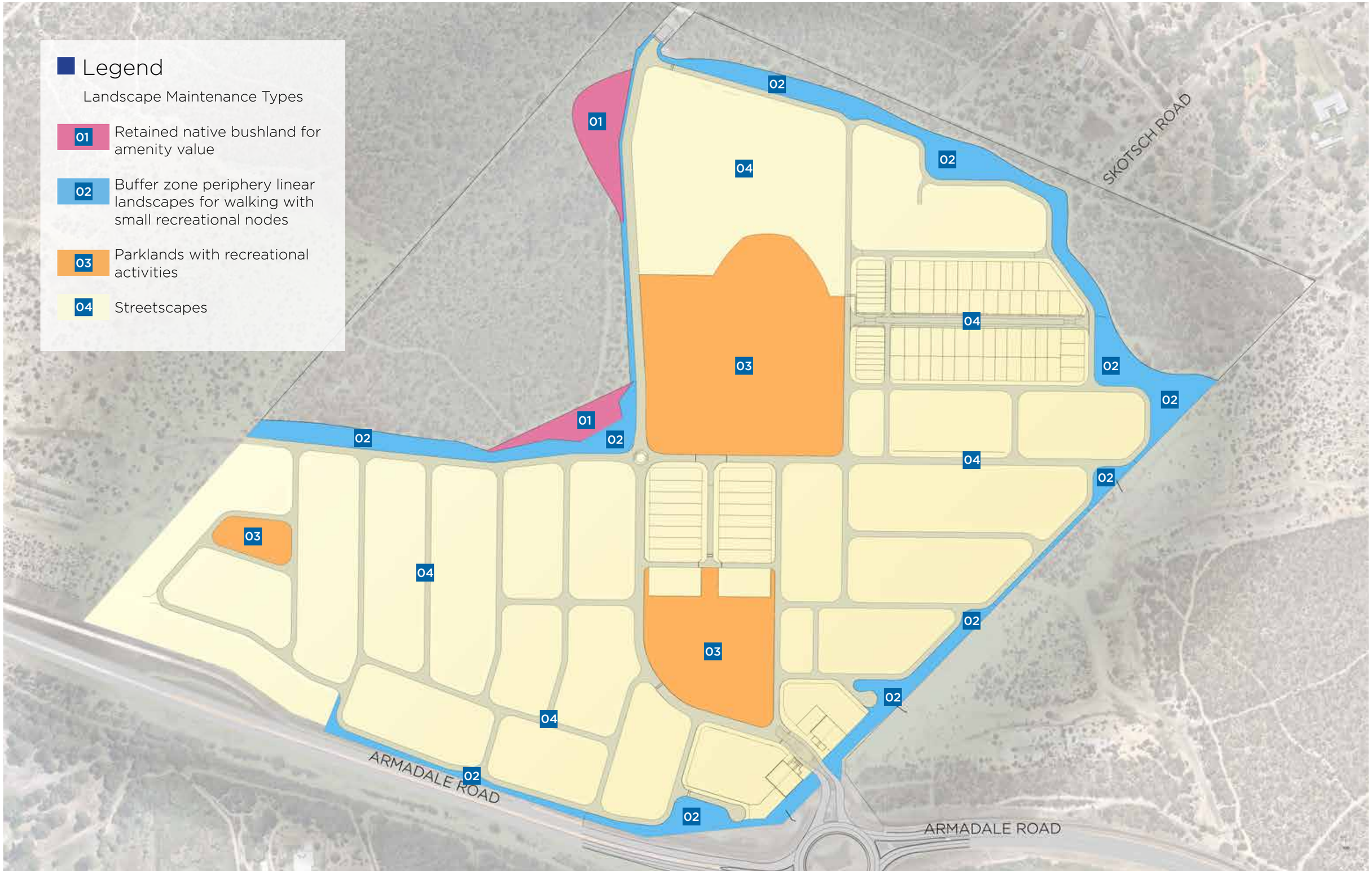
2. Buffer zone periphery linear landscapes for walking with small recreational nodes
- Irrigation to all planted areas
- Areas of mown turf
- Low groundcover planting no greater than 500mm
- Annual under-pruning of trees to maintain clear stems
- Annual pruning of shrubs and removal of fine fuels
- Annual top up of mulch
- Concrete paths for breaks and access for fire truck from adjacent road.
- Regular general park maintenance as required by City of Cockburn

3. Parklands with recreational activities
- Irrigation to all planted areas
- Areas of mown turf
- Low groundcover planting no greater than 500mm
- Annual under-pruning of trees to maintain clear stems
- Annual pruning of shrubs and removal of fine fuels
- Annual top up of mulch
- Concrete paths for breaks and access for fire truck from adjacent road.
- Regular general park maintenance as required by City of Cockburn

4. Streetscapes
- Irrigated low groundcover planting no greater than 500mm
- Annual under-pruning of trees to maintain clear stems
- Annual pruning of shrubs and removal of fine fuels
- Annual top up of mulch
- Regular general park maintenance as required by City of Cockburn

All areas will be designed and maintained with external bushfire threat considerations, and will be maintained as low threat and compliant with AS3959-2018 definition of exclusion clause 2.2.3.2 (F) as stipulated in the Bushfire Management Plan.

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APPENDIX FOUR

Local Water Management Strategy (JDA Consulting Hydrologists)

Prepared for:

PERRON TREEBY PTY LTD

Lots 705 & 707 Armadale Rd, Treeby

Local Water Management Strategy



DECEMBER 2019

Report ref. J6667f

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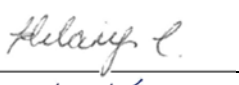
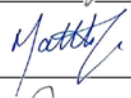
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Approved by	Jim Davies		19/12/2019

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1. EXECUTIVE SUMMARY

JDA has been engaged by Perron Treeby Pty Ltd to complete a Local Water Management Strategy (LWMS) for Lots 705 & 707 Armadale Rd, Treeby, herein referred to as the Study Area. The Study Area occupies a total of 47.9 ha (gross urban-zoned acreage) within the City of Cockburn (Figure 1).

This LWMS has been prepared in support of Lots 705 & 707 Armadale Rd, Treeby (formerly Lots 4 & 2) Local Structure Plan (LSP). The LWMS provides the framework for the application of total water cycle management to the proposed urban structure within the LSP, consistent with the District Water Management Strategy (DWMS) and Department of Water and Environmental Regulation (DWER) principles of Water Sensitive Urban Design (WSUD) described in the Stormwater Management Manual (DoW, 2007).

A summary of the LWMS design principles and objectives are presented in Table 1.

TABLE 1: SUMMARY OF LWMS DESIGN PRINCIPLES AND OBJECTIVES

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Provide integration with planning processes and clarity for agencies involved with implementation • Minimise public risk, including risk of injury or loss of life • Protection of infrastructure and assets from flooding and inundation • Encourage environmentally responsible development • Facilitate adaptive management responses to the monitored outcomes of development		
Category	**DWMS Objectives**	**LWMS Criteria**
Stormwater Management	• Non-structural measures to reduce applied nutrient loads. • At source retention of small storm events (15 mm). • Onsite infiltration of all stormwater runoff up to 1% AEP. • Water quality treatment systems and water sensitive urban design structures designed in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007) Chapter 9 (Structural Controls) and Australian Runoff Quality (Ball et al (ed.), 2016).	• All small storm event runoff to be infiltrated at source. • All storm events up to the 1% AEP to be infiltrated onsite. • Manage surface water flows from major events to protect infrastructure and assets from flooding and inundation. • All stormwater management structures located outside of Bush Forever and REW 50 m buffer.
Groundwater Management	• No management of groundwater levels is proposed (subsoil drainage). • Finished levels to provide sufficient separation to groundwater to allow infiltration of stormwater onsite to enhance recharge to the Jandakot Mound. • Limit impacts to Bush Forever and wetland sites. • Limit groundwater abstraction. • Manage fertiliser and pesticide application in streetscapes and POS areas using soil amendments, appropriate plan selection, limiting turf areas and maintenance management plans.	• Manage and minimise changes in groundwater levels and groundwater quality following development, particularly from groundwater level increase from urbanisation within the Study Area and surrounds. • Use of subsoil drainage system to mitigate any groundwater level increase based on the availability of new information. This is a change from the DWMS objectives. • All lots to have soakwells sized to infiltrate up to the small storm event. • All stormwater management structures located outside of Bush Forever and REW 50 m buffer.
Water Conservation and Sustainability	• Ensure that non-potable water supply systems are considered as part of an integrated water supply. • Household target water use of 100 kL/person/year. • Scheme water target use of 40 to 60 kL/person/year. • Use of waterwise landscaping practices both at development and lot scale.	• Aim to achieve the State Water Plan target for water use of 100 kL/person/year. • Consider alternative fit for purpose water sources where appropriate and cost effective. • POS areas to be at least 50% native plants.
Water Quality	• Adopt nutrient load reduction design objectives for stormwater runoff. • Use of amended soils and ephemeral bioretention systems to treat stormwater.	• Minimise the average annual pollution load by implementation of a treatment train design for stormwater runoff.

2. INTRODUCTION

2.1 Background

This Local Water Management Strategy (LWMS) has been prepared by JDA Consultant Hydrologists on behalf of Perron Treeby Pty Ltd in support of the Local Structure Plan (LSP) for Lots 705 & 707 Armadale Rd (formerly Lots 4 & 2), herein referred to as the Study Area (Figure 1).

The LWMS provides the framework for the application of total water cycle management to the proposed urban structure, consistent with the Department of Water and Environmental Regulation (DWER) principles of Water Sensitive Urban Design (WSUD) described in the Stormwater Management Manual (DoW, 2007).

2.2 Statutory Framework

2.2.1 Regional Planning

Lots 705 & 707 Armadale Rd, Treeby owned by Perron Treeby Pty Ltd, are currently zoned “Urban” under the Metropolitan Regional Scheme. The land was rezoned from “Rural/Water Protection” following gazettal of an MRS Amendment on 18 April 2019.

2.2.2 District Planning

A District Water Management Strategy (DWMS) was prepared by JDA in 2018 and provides guidance on water reuse options, stormwater retention basins, monitoring requirements and structural and non-structural controls for stormwater treatment. The DWMS was accepted by DWER on 15 May 2018.

2.2.3 Local Structure Plan

This LWMS addresses the LSP area for Lots 705 & 707 Armadale Rd, Treeby and provides a refinement of the flood modelling and surface water and groundwater management strategy to a local scale. This LWMS is consistent with the DWMS (JDA, 2018) and water sensitive urban design practices as described in the Stormwater Management Manual of WA (DoW, 2007).

2.3 Key Design Principles and Objectives

The LWMS employs the following key documents to define its content, key principles and objectives:

- Stormwater Quantity Management Manual for Western Australia (DoW, 2007).
- Better Urban Water Management (WAPC, 2008).
- Lots 2 & 4 Armadale Rd, Banjup District Water Management Strategy (JDA, 2018).

A summary of the key design principles and objectives from these documents is provided in Table 1 and summarised below.

2.3.1 Stormwater Management Manual for Western Australia (DoW, 2007)

The Waters and Rivers Commission (now Department of Water and Environmental Regulation, DWER) released a Manual for Managing Urban Stormwater Quality in Western Australia in 1998 to define and practically describe Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aims to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by Waters and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

The Department of Water (formerly Waters and Rivers Commission, now DWER) completed a major review of the Manual in consultation with a working team comprising industry and government representatives, published in August 2007.

Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.

Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

2.3.2 Better Urban Water Management (WAPC, 2008)

The guideline document Better Urban Water Management (WAPC, 2008) focuses on the process of integration between land use and water planning and specifying the level of investigations and documentations required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management.

This LWMS complies with the Better Urban Water Management process.

2.3.3 Interim: Developing a Local Water Management Strategy (DoW, 2008)

Interim: Developing a local water management strategy (DoW, 2008) provides guidance on:

- The urban water management issues that need to be addressed at the local planning stage of the land development process.
- Preparation of documentation to support decisions about urban structure and landscape for new residential, rural-residential, commercial or industrial development (including redevelopment) areas.

This LWMS addresses all elements of the total water cycle relevant to the development area as outlined in this guidance document as well as provides a 'proof of concept' for how water will be managed and addressed.

2.3.4 Lots 2 & 4 Armadale Rd, Banjup DWMS (JDA, 2018)

The DWMS was prepared to support rezoning of Lots 2 & 4 (now Lots 707 & 705) Treeby and demonstrate that the area was capable of supporting the proposed urban rezoning.

The aims of the DWMS are to:

1. Define land area requirements for conveyance of flood flows and protection of future development from peak flood events.
2. Propose a drainage design strategy appropriate for local conditions in the strategy area that incorporates best practice water sensitive urban design measures. The strategy identifies Water Sensitive Urban Design practices to be implemented within both private allotments and the public domain, and the legal mechanisms by which all identified practices will be implemented.
3. Prescribe the design criteria for water quantity and water quality for each catchment.
4. Outline the hydrologic and hydraulic framework parameters and subsequently develop the overall drainage network concept.
5. Define an implementation framework for the drainage design objectives.
6. Recommend monitoring programs for water quantity and quality pre- and post-development as well as for ensuring hydraulic performance over the lifetime of the drainage structure.

3. PROPOSED DEVELOPMENT

The Study Area considered in this LWMS is 47.9 ha gross urban-zoned acreage for Lots 705 & 707 situated within the City of Cockburn, approximately 19 km south of Perth. The Study Area is bounded by Lots 69 to 71 and Lot 131 to the north, Armadale Rd to the south, Rose Shanks Reserve to the east and Lots 703 and 820 to the west (Figure 1). The proposed land use is for residential development, consistent with regional planning. The Structure Plan for the Study Area is shown on Figure 2.

Key elements of the Structure Plan related to urban water management include:

- At-source infiltration of frequently occurring storm events for the small rainfall event (first 15mm rainfall), and up to 1% AEP storm event in lot and POS where practical.
- Use of road network as overland flow path for conveyance of stormwater runoff from major rainfall events to POS.
- Integration of POS for flood management of minor and major rainfall events.
- Use of ephemeral bioretention areas for management of local stormwater in POS.
- Use of high density urban residential zonings to reduce landscape nutrient input at a domestic scale (eg. Less lawn and garden area corresponds to lower fertiliser application).
- Use of local native species in open spaces, streetscapes and wetland buffers to reduce nutrient input and conserve water resources.
- Minimisation of fill consistent with sustainability principles.
- Use of non-potable groundwater for irrigation of POS.
- Retention of existing open water body.

4. PRE-DEVELOPMENT ENVIRONMENT

4.1 Existing Land Use

The Study Area has operated as a sand quarry and brickworks since 1966. With the recent removal of the brickworks and closure of the site's sales office, the Study Area will become available for infill development as a 'brownfields' site.

4.2 Topography

The existing topography of the Study Area is shown on Figure 3. Substantial amounts of sand have been removed from the Study Area as part of the previous sand quarry and brickworks land use resulting in a highly modified landscape. A number of ridges are present within the Study Area including along the southwestern boundary (up to 40 m AHD). A number of low points remain as a result of removal of sand of which the majority will be filled-in prior to development. Bush Forever sites are at approximately 32 m AHD with sand quarrying removing sand down to 30 m AHD across the majority of the site.

4.3 Climate

The Treeby area is characterised by a Mediterranean climate with warm dry summers and cool wet winters. Rainfall data from the Bureau of Meteorology's Jandakot Aero (Station No: 009172), located 2.5 km north of the Study Area shows a long-term average annual rainfall (1972 to 2018) of 796 mm. The short term (2008 to 2018) average annual rainfall is 757 mm, a decrease of approximately 5%, with most of the reduction occurring during the winter months.

4.4 Geology and Soils

Surface geology mapping by Jordan (1986) is shown on Figure 4. The Study Area is wholly situated within the Bassendean Dune system (S8). The thickness of the Bassendean Sands varies and overlies clays of the Guildford Formation. The Bassendean sands are characterised as "very light at surface, yellow at depth, fine to medium grained, sub-rounded quartz moderately well sorted of aeolian origin" (Jordan, 1986).

On 8 October 2019, JDA undertook soil sampling near proposed stormwater infiltration basin locations at depths between 1.5 m to 3.5 m below natural surface (Figure 4). A total of 5 locations and 8 tests for Particle Size Distribution (PSD) was completed. PSD results are provided in Appendix A. Permeability values were derived from the PSD results using Hazens' formula (Freeze and Cherry, 1979) based on d_{10} and ranged between 28 m/d within natural bush area to 46 m/d in quarried areas. Table 2 summarises the general soil profile and associated permeability results.

TABLE 2: PSD TESTING AND DERIVED PERMEABILITY RESULTS

Name	Location		Basin	Natural Surface (m AHD)	Tested Depth (m)	Approximate RL (m AHD)	d_{10} (mm)	Derived K (m/d)
	Easting	Northing						
K1	394944	6445013	Catchment F Infiltration Basin	30.4	3.2 to 3.3	27.1 to 27.2	0.18	28
K2	395438	6444683	Catchment E Infiltration Basin	29.75	3.0 to 3.5	26.25 to 26.75	0.18	31
K3	395062	6444757	Catchment D Infiltration Basin	30.85	2.6 to 3.0	27.85 to 28.25	0.20	35
K4	0394905	6444632	Catchment C Infiltration Basin	30.0	2.5 to 3.0	27.0 to 27.5	0.19	31
K7	394843	6444644	Catchment A Infiltration Swale	30.1	1.5 to 2.0	28.1 to 28.6	0.21	46
					2.0 to 2.5	27.6 to 28.1	0.19	31
					3.0 to 3.2	26.9 to 27.1	0.20	35

4.5 Acid Sulphate Soils

Regional Acid Sulphate Soil (ASS) mapping is shown on Figure 4. The Study Area is located within moderate to low risk of actual acid sulphate soils (AASS) or potential acid sulphate soils (PASS) occurring at depths <3 m from the soil surface.

Detailed ASS investigations will be undertaken at the time of subdivision. In the event that any ASS is encountered an ASS Management Plan will be prepared and implemented as part of the subdivision process in accordance with WAPC Bulletin No. 64 (WAPC, 2003).

4.6 Surface Water Hydrology

No natural surface water features are present within the Study Area. Groundwater expressions are found in two locations on Lot 705 and are the result of previous sand extraction. These expressions are referred to as lakes. It is Perron's intent to fill in the northern lake on Lot 705 so the groundwater is no longer exposed. The southern lake on Lot 705 will be incorporated into POS due to the high amenity and number of existing mature trees along the lake surrounds.

4.7 Wetlands and Vegetation

The location of geomorphic wetlands within the Study Area are shown on Figure 5. There is one Resource Enhancement management category wetland located on the northern boundary of the site. This wetland forms part of Bush Forever Site 390 and will be maintained as part of the Structure Plan.

Vegetation association mapping was undertaken by ENV Australia in 2013. Of the 6 vegetation associations identified one is to be retained within the development in either Bush Forever or POS:

MpBi *– Low open forest of Melaleuca preissiana and Banksia ilicifolia over Daypogon bromeliifolius, Astartea scoparia, Lepidosperma squamatum, Xanthorrhoea preissii and Phlebocarya ciliate.*

Caladenia huegelii, a Declared Rare Flora (DRF), was identified in a number of locations within the Study Area (Figure 5).

4.8 Groundwater Hydrology

4.8.1 Aquifers

Superficial Aquifer

The superficial aquifer in the vicinity of the Study Area is referred to as the Jandakot Mound and has an extent of approximately 522 km^2. The aquifer has a maximum thickness of 40 m and includes three formations which are, in order of increasing depth: Bassendean Sand, Gnangara Sand and Ascot Formation. Aquifer transmissivities range between 200 to 1,000 m^2/d (Davidson & Yu, 2008).

The Bassendean Sand consists of fine to coarse grained, moderately sorted, sub-rounded to rounded quartz sand. The sand is mapped as highly permeable with horizontal hydraulic conductivity ranging between 10 to 50 m/d, consistent with JDA testing described above. In the Jandakot area where 'coffee rock' is present, limonite cement may reduce the horizontal hydraulic conductivity to less than 10 m/d (Davidson & Yu, 2008).

Gnangara Sand is present beneath the Bassendean Sand and consists of pale-grey, fine to very coarse grained, very poorly sorted, sub-rounded to rounded quartz sand and feldspar (Davidson & Yu, 2008).

The Ascot Formation is present beneath the Gnangara Sand. The Ascot Formation consists of hard to friable, grey calcarenite with thinly interbedded sand commonly containing shell fragments near the base of the formation. Sands are fine to coarse and are poorly sorted and angular to rounded in shape (Davidson and Yu, 2008).

Ascot Formation overlies the Kardinya Shale (part of the Osborne Formation) which is a confining bed, consisting of moderately to tightly consolidated, interbedded siltstones and shales (Davidson & Yu, 2008).

Vertical fluctuations in the water table may be several metres and occur seasonally, consistent with Perth's winter-dominated rainfall pattern, as can be seen in nearby DWER bore JM19 (Appendix B).

Lot 705 Drilling Investigations

Eight paired groundwater monitoring bores (BQ1 to BQ8 shallow and deep) were installed on Lot 705 by Direct Push Probe Drilling (February 2013) and Proline Drilling (July 2013), supervised by JDA. A borelog was recorded for each bore. The logs show the geological sequence generally agrees with the description provided in Davidson and Yu (2008), with Bassendean Sand overlying Gnangara Sand and the Ascot Formation. A hydrogeological report prepared by JDA (2013) summarised the results of the site investigations which provides a more detailed analysis of the hydrogeology at Lot 705 (JDA, 2013). Cross-sections of the Study Area, as presented in the Hydrogeological Report, are provided in Appendix C.

The report identified the presence of ferruginous sands within the Bassendean Sand formation. Ferruginous sand is common in the Jandakot area. Ferruginous sand forms within the Bassendean Sand by the leaching of iron minerals over time, which accumulate and coat the sand grains at or near the water table to form a low permeability layer of limonite. The limonite is characterised by brown colour and massive texture of iron hydroxides. Cemented ferruginous sands are referred to informally as 'coffee rock'.

Cross-sections provided in Appendix C show the extent and thickness of this layer, which is relevant to the interpretation of water quality data. The iron rich sands can influence water quality as the water migrates vertically through the superficial aquifer to the deeper parts of the aquifer, where Water Corporation groundwater production bores are screened between 40 and 63 m depth.

Leederville Aquifer

The Osborne Formation overlies the Leederville Formation from approximately -15 m AHD to -110 m AHD and includes the Kardinya Shale (confining bed) and Henley Sandstone formations. The Henley Sandstone formation is included in the Leederville Aquifer (Davidson & Yu, 2008).

The Leederville aquifer is a major regional water resource of good quality water. Beneath the Jandakot Mound, groundwater salinity is typically <500 mg/L.

Yarragadee Aquifer

The South Perth Shale underlies the Leederville Aquifer and acts as the confining bed between the Leederville and Yarragadee aquifers (Davidson & Yu, 2008).

The Yarragadee aquifer is a major regional water resource of generally good quality water. South of Perth salinities vary between 1,000 and 2,000 mg/L.

4.8.2 Groundwater Levels

Groundwater levels shown in the Perth Groundwater Atlas (WRC, 1997) indicate that estimated maximum groundwater levels for the Study Area range from above 28 m AHD in the north of the Study Area to 27.3 m AHD along the southern boundary, with flow from north to south. (Figure 6).

To refine these regional groundwater contours, a pre-development groundwater monitoring program was completed by JDA between April 2013 and December 2015. Groundwater levels were measured at 8 paired groundwater monitoring bores BQ1 to BQ8 on Lot 705 (Figure 6). Details of the shallow bores are provided in Table 3. A time series plot of water levels recorded in the bores is included as Appendix D along with the lithological log for each bore. Maximum groundwater levels were recorded on 21 October 2014 with the highest reading observed in BQ2 (26.57 m AHD).

Monitoring data indicates a seasonal variation of 1.5 m as expected for sandy soils of the Swan Coastal Plain, and a south-easterly flow direction roughly consistent with regional estimates.

TABLE 3: DETAILS OF GROUNDWATER MONITORING BORES

Bore ID	GDA Coordinates		Top of Casing (m AHD)	Screened Interval (m BNS)	Water Level 21/10/2014 (m AHD)	Estimated AAMGL (m AHD)
	Easting	Northing				
BQ1	394389	6444478	30.79	4.5-7.5	26.38	26.57
BQ2	394577	6444738	33.50	7.5-10.5	26.57	26.76
BQ3	394856	6445003	31.84	4.5-7.5	26.49	26.68
BQ4	394847	6444640	30.72	3.5-6.5	26.34	26.53
BQ5	395076	6444963	30.41	3.0-7.0	26.37	26.56
BQ6	395239	6444801	30.42	3.5-6.5	26.32	26.51
BQ7	395235	6444479	30.84	3.7-6.7	26.26	26.45
BQ8	395378	6444700	30.25	3.0-6.0	26.27	26.46

To calculate Average Annual Maximum Groundwater Level (AAMGL) for the site, water levels recorded in the JDA bores on 21 October 2014 were correlated to long-term groundwater measurements recorded in Department of Water and Environmental Regulation (DWER) monitoring bore JM26, located approximately 500 m southeast of the Study Area, see Figure 6. The bore has long-term records spanning from 1975 to present. The water level recorded in JM26 in October 2014 is presented in Table 4.

DWER monitoring bore (JM19) with long term data is located to the northwest of the Study Area. JM19 has not been used in the AAMGL calculations as water levels recorded in this bore in recent years have been influenced by infiltration of stormwater runoff through a drainage basin located adjacent to it at Calleya Estate.

TABLE 4: DETAILS OF DWER MONITORING BORES

Bore ID	Record Period	Top of Casing (m AHD)	Water Level 01/10/2014 (m AHD)	Calculated Average of Annual Peaks (m AHD)	Difference (m)
JM26	1975 – present	30.524	26.75	26.94	+0.19

For DWER bore JM26 the AAMGL over the period 1975 to present is calculated to be 26.94 m AHD (Table 4). The water level of 26.75 m AHD measured on 1 October 2014 is 0.19 m below the estimated AAMGL (1975 – present). The AAMGL (1975 – present) for the BQ series bores was estimated by applying an adjustment of +0.19 m to the level recorded on 1 October 2014 (Table 3). Use of this length of period of data removes inaccuracy and inconsistencies from seasonal peaks and short term impacts. The estimated AAMGL contours are shown on Figure 6.

JDA recommenced monthly monitoring of groundwater levels at the BQ series bores between June and October 2019. BQ4(s)/(d) and BQ8(s)/(d) have been destroyed. Groundwater levels peaked in September 2019 and are lower than those measured in 2013 and 2014 (Appendix D). Water levels in BQ2(s), BQ3(s) and BQ5(s) continue to be monitored via logger with results to be reported in the UWMP.

4.8.3 Lakes

There are two existing lakes located within the Study Area, both on Lot 705. They are a result of the excavation of sand as part of the quarrying operations in the early 1900's.

Surface area of the northern lake is 1.15 ha and the southern lake has a surface area of 0.4 ha. Seasonal variation in water level in the lakes is approximately 1.2m. The lakes are recharged from direct rainfall and groundwater throughflow.

4.8.4 Groundwater and Lake Quality

A pre-development monitoring program was undertaken by JDA between April 2013 and December 2015. Monitoring was completed at 8 paired groundwater monitoring bores BQ1 to BQ8 and the two lakes BQS1 and BQS2 (see Section 4.6) (Figure 6). Table 5 summarises the monitoring program with full results provided in Appendix E.

TABLE 5: PRE-DEVELOPMENT GROUNDWATER AND LAKE QUALITY MONITORING PROGRAM

	Number of Sites	Frequency and Timing	Parameters
Shallow Bores			
Groundwater Quality (snapshot)	8 monitoring bores (BQ1(s) to BQ8(s))	One off snap shot (April 2013)	In-situ: pH, EC, temp Lab: nutrients, extensive metals, anions & cations, Organochlorine Pesticides, Organophosphate Pesticides and Hydrocarbons
Groundwater Quality (Biannually)	3 monitoring bores (BQ2, BQ3 and BQ7; shallow and deep)	Biannually intensive (Oct 2013 and Apr, Oct 2014)	In-situ: pH, EC, temp Lab: nutrients, extensive metals, anions & cations, Organochlorine Pesticides, Organophosphate Pesticides and Hydrocarbons
Groundwater Quality (Quarterly)	5 monitoring bores (BQ1, BQ4, BQ5, BQ6 and BQ8; shallow and deep)	Quarterly water sampling (Feb, Apr, Jul, Oct 2013 and Jan, Apr, Jul, Oct 2014)	In-situ: pH, EC, temp Lab: nutrients, selected metals and cations & anions
Deep Bores			
Groundwater Quality (Biannually)	3 monitoring bores (BQ2, BQ3 and BQ7; shallow and deep)	Biannually intensive (Oct 2013 and Apr, Oct 2014)	In-situ: pH, EC, temp Lab: nutrients, extensive metals, anions & cations, Organochlorine Pesticides, Organophosphate Pesticides and Hydrocarbons
Groundwater Quality (Quarterly)	5 monitoring bores (BQ1, BQ4, BQ5, BQ6 and BQ8; shallow and deep)	Quarterly water sampling (Feb, Apr, Jul, Oct 2013 and Jan, Apr, Jul, Oct 2014)	In-situ: pH, EC, temp Lab: nutrients, selected metals and cations & anions
Lakes			
Lake Water Quality	2 monitoring sites (BQS1 and BQS2)	Quarterly water sampling (Apr, Jul, Oct 2013 and Jan, Apr, Jul, Oct 2014)	In-situ: pH, EC, temp Lab: nutrients, selected metals and cations & anions

A summary of the monitoring results is as follows:

- Groundwater is generally acidic, except in the Ascot Limestone. The lakes are unusually alkaline.
- Except in the northwest bores of the site, calcium and bicarbonate ions are in higher proportion and commonly dominate in the shallow bores but not the deeper bores. All the deeper bores are of sodium-chloride type, except for the bore screen in the Ascot Limestone. This suggests that calcium and bicarbonate ions are being absorbed as they pass downwards through the ferruginous sands.
- Nitrogen concentrations are generally higher in the shallow bores. In contrast, total phosphorus is commonly higher in the deeper bores. As phosphorus would be expected to be absorbed by ferruginous sands, this indicates that it must have originated from deeper groundwater inflow, or perhaps by upward migration from phosphate nodules in the Ascot Limestone.
- Iron concentration is generally above Drinking Water Guidelines (DWG) in both shallow and deep bores. This is not surprising given the presence of the thick ferruginous sand layer across the Study Area (see Section 4.8.1).
- Aluminium values exceed DWG in several bores, both shallow and deep, where pH is particularly low, the aluminium is probably derived from clay minerals being more soluble in low pH water.
- Selenium concentrations exceed DWG in three of the deep bores. This probably originates from pyrite in the Bassendean Sand and Gnangara Sand.
- Total Recoverable Hydrocarbons (TRH) in the range of C_{16}-C_{34} have been continually present at 130 to 140 µg/L in bore BQ3(s). The source of this, at the margin of bushland in the northwest corner of the Study Area, is unclear. TRH C_{15}-C_{28} have been recorded in the two lakes, probably from fuel or oil contamination during quarrying operations. Polycyclic Aromatic Hydrocarbons (PAH) (fluorene and phenanthrene) have been detected in bore BQ7(s). These would have probably originated from asphalt which was dumped in close proximity to the bore for a short period of time before being removed.
- In general, the groundwater quality below the coffee rock is fresh and suitable for drinking, but would require pH adjustment to make it less acid, and probably treatment for removal of aluminium, iron and selenium.
- Lake water quality is very similar to groundwater quality, indicating that the lakes are representative of groundwater being expressed at the surface. Lake water contains sodium as sodium chloride with pH, salinity and TDS slightly higher than levels recorded in groundwater bores, most likely due to the effects of evaporation concentrating salts at the surface.

4.9 Water Resources

The Study Area is located within the Jandakot Groundwater Area and the Canning Vale sub-area.

The most feasible irrigation supply is from the Superficial Aquifer. As of 18 April 2019, DWER advised there was 241,675 kL/yr available for allocation in the superficial aquifer (Table 6).

TABLE 6: GROUNDWATER AVAILABILITY

Aquifer	Allocation Limit	Licenced Allocation	Total Allocated & Committed	% Committed & Additional Allocations
Perth-Superficial Swan	310,000 kL	68,325 kL	0 kL	22.04%

Licence to Take Water GWL163828 was transferred from the previous lot owners Boral Bricks Western Australia Pty Ltd and consisted of an allocation of 18,000 kL/yr. An application to amend the licence to increase the allocation to 139,760 kL/yr was approved by DWER on 22 October 2019. The amended licence covers dust suppression for earthworks and construction purposes, irrigation of up to 7.9 ha of public open space, maintenance of lake level, irrigation within the school facilities (Appendix F).

5. WATER MANAGEMENT STRATEGY

5.1 Water Sustainability Initiatives

5.1.1 Water Supply

Water Corporation commenced conceptual water supply planning for the site as part of the extension of the Thomson Lake Gravity Supply Scheme. Project engineers (WGE pers. comm.) have indicated the water supply scheme is likely to come from Armadale Rd with further detail and confirmation to be presented in the Engineering Servicing report.

Residential Lots

In order to minimise any potential impact on the groundwater resource the development will aim to:

- Utilise scheme water as the main water supply for residents.
- Appropriately manage bore use through structure planning and community education.

Public Open Spaces

A non-potable water supply from groundwater abstraction is proposed for irrigation of POS areas. The valid water licence for Lot 705 allowing for the abstraction of 18,000 kL/yr was transferred to Perron Treeby Pty Ltd and amended to increase the allocation to 139,760 kL/yr (Appendix F). This water licence provides allocation for construction and irrigation of the development and primary school (see Section 4.9).

5.1.2 Wastewater Management

Project engineers (WGE pers. comm.) have advised that whilst the Study Area is currently outside of the Water Corporation's sewer planning scheme, a review of the wastewater planning scheme will most likely result in wastewater servicing likely to come from Armadale Rd, via a connection at Liddlelow Rd, southeast of the site. Further detail and confirmation to be presented in the Engineering Servicing report.

5.1.3 Water Efficiency Measures

The objective for water conservation is to minimise use of water and maximise water use efficiency where possible. This objective can be achieved at both the development scale and lot scale and is identified in the State Water Plan (Government of Western Australia, 2007) as a priority item for potable water. The State Water Plan target for household water use is 100 kL/person/year (potable and non-potable water), with a consumption target for scheme water of 40 to 60 kL/person/year (potable water).

Consistent with the State Water Plan, the main objectives for the development are:

- Avoid use of potable water for irrigation in POS areas.
- Reduce household water use to not more than 100 kL/person/year.
- Minimise use of potable water where drinking water quality is not essential, particularly ex-house.
- Household consumption targets for in-house potable water use of 40 to 60 kL/person/year.

Development Scale

Development scale water conservation measures appropriate for the site include:

- Strategic planning (orientation, shape, elevation etc.) of irrigation areas such as pocket parks, active and passive public open space areas, and road reserves to minimise long-term irrigation demand.
- Where possible co-locate facilities with significant irrigation demand.
- Use of non-potable water supply source (groundwater abstraction bore). This bore will be screened below the coffee rock layers to provide a source with minimum iron concentration.
- Within irrigation areas, the use of waterwise landscaping practices including hydrozoning, mulching, soil amendments, water retention products and installation of appropriate water efficient irrigation fixtures.
- Retain and where appropriate rehabilitate native bush areas.

Lot Scale

Lot scale water conservation measures appropriate for the site include:

- Increased residential density, including smaller lots with reduced ex-house irrigation areas.
- Buildings constructed to current Building Codes of Australia (BCA) water efficiency standards and the State Government 5 Star Plus Scheme. These include using AAA rated appliances such as toilets, washing machines, dishwashers, water saving showerheads, taps and toilets and sub-surface irrigation where possible. The Water Corporation's Waterwise Rebate Program will also assist in encouraging the purchase of waterwise AAA rated appliances.
- Initiatives to encourage waterwise landscaping of residential lots including hydrozoning, mulching, soil amendments, water retention products and installation of appropriate irrigation fixtures.
- Encourage use of non-potable water supply options for ex-house irrigation uses (ie. Rainwater tanks, greywater recycling, garden bore etc.)

5.2 Stormwater Management

5.2.1 Stormwater System Design

The stormwater drainage system will be designed using a major/minor approach. The major drainage system is defined as the arrangement of roads, drainage reserves, infiltration basins and open space planned to provide safe passage of stormwater runoff from major events which exceed the capacity of the minor system, typically greater than 20% AEP storm event.

The minor drainage system is defined as the series of pipes, kerbs and gutters etc. designed to carry runoff generated by higher frequency AEP storms, typically less than 20% AEP storm event. The minor drainage system incorporates a treatment train of best management practice (BMP) water quality structural controls that provide water quality treatment from the proposed development. Rainfall runoff for 1EY will be managed by infiltration in accordance to water sensitive urban design.

The Study Area was delineated into 7 drainage catchments (Figure 7). A summary of catchment areas is provided in Table 7. Catchment areas do not include Bush Forever sites.

TABLE 7: CATCHMENT AREAS

Catchment	Area (ha)
A	14.18
B	8.54
C	9.17
D	5.32
E	2.54
F	3.57
School	4.16

5.2.2 Stormwater Modelling

The infiltration storages were modelled using PC-SUMP Shallow Water Table Module as the depth to groundwater is less than 5 m. The storage locations were determined based on existing topographic contours, survey levels, depth to groundwater mapping, local structure plan constraints, Resource Enhancement Wetland 50 m buffer and location of Declared Rare Flora and vegetation to be retained (see Section 4.7) with the following assumptions:

- Groundwater levels conservatively based on location of subsoils under basins to simulate a worst case scenario where groundwater levels rise and must be controlled by subsoils (see Section 5.3). Catchment A does not have subsoils proposed beneath the swale and the groundwater level is based on the AAMGL calculated in Section 4.8.2.
- Base of aquifer set as depth of coffee rock as estimated from bore logs provided in Appendix C.
- Hydrological Loss Model:
    - Traditional Lots – 15 mm Initial Loss, 5 mm/hr Continuing Loss (no lot runoff assumed for 1EY and 20% AEP)
    - Compact Lots – 20% Proportional Loss (no lot runoff assumed for 1EY and 20% AEP)
    - POS – 90% Proportional Loss
    - Roads – 20% Proportional Loss
- Swale and basin side slopes of 1:6.
- Hydraulic conductivity of 7.5 m/d (derived hydraulic conductivity in Section 4.4 is much higher however a conservative cap of 15 m/d with 0.5 clogging factor has been applied). Hydraulic conductivity to be refined at UWMP stage.

Modelling results are summarised in Table 8 and Table 9 and attached as Appendix G.

5.2.3 Modelling Results

Modelling results for all Catchments A to F and the Oval for 1EY, 20% AEP and 10% AEP are presented in Table 8. The minor and major drainage systems are shown on Figures 8 to 11.

Major Drainage System

The major drainage system is designed to manage rainfall events greater than the 20% AEP storm event, up to the 1% AEP storm event. Key points of the major drainage system strategy are as follows:

- All lot finished levels will have a minimum 0.3 m clearance above the estimated 1% AEP flood level of the infiltration swales and basin.
- Storage up to the 10% AEP storm event in a combination of underground and above ground (basin) structures in Catchments C and D.
- Catchment A infiltration swale (0.6 m deep) and Catchment C and Catchment D underground infiltration storages (1.0 m and 0.55 m deep respectively) all overflow to the oval located in the POS south of the school in >10% AEP storm events. Maximum depth of inundation in the oval is 0.25 m.
- Catchment B underground infiltration storage overflows to the POS lake in >20% AEP storm events. Increases in water level within the lake are 0.28 m and 0.80 m in the 10% AEP and 1% AEP storm events respectively.
- Catchment E and F infiltration basins (0.5 and 0.3 m deep respectively) overflow in >20% AEP storm events to the adjacent Bush Forever sites. Conservatively assuming no infiltration for the overflow, the overflow volume is equivalent to a water depth in the adjacent localised depressions of 0.06 and 0.20 m in the 1% AEP storm event for Catchments E and F respectively. However, due to high infiltration rates measured across the site, any overflow is considered to dissipate immediately within close proximity to the basins.
- Primary School is to infiltrate all stormwater onsite. Indicative storage requirements for the 1% AEP storm event in a 1.2 m deep infiltration basin has been modelled assuming 50% impervious area, but is required to be refined by the Department of Education during detailed design.
- All stormwater is infiltrated on site, with no direct discharge to the Atwell Drain.

Minor Drainage System

The minor drainage system is designed to manage rainfall events up to the 20% AEP via pit and pipe system. To meet the design criteria for the minor drainage system, the following strategies are proposed:

- All lots to have soakwells to infiltrate the small storm event (15 mm). Where the lot area is 350 m^2 or less, soakwells are to be interconnected within the lot, with overflow to the street drainage system.
- The roadside pipe network will be sized to convey the 20% AEP flow.
- Infiltration of stormwater within infiltration swales, infiltration basin and underground infiltration cells:
    - Catchment A Infiltration Swale – up to 10% AEP.
    - Catchment B Underground Infiltration Cells – up to 20% AEP.
    - Catchment C Underground Infiltration Cells – up to 20% AEP.
    - Catchment D Underground Infiltration Cells – up to 20% AEP.
    - Catchment E Infiltration Basin – up to 20% AEP.
    - Catchment F Infiltration Basin – up to 20% AEP.
- All stormwater is infiltrated on site, with no direct discharge to the Atwell Drain.

TABLE 8: DRAINAGE STORAGE RESULTS (CATCHMENTS A TO F)

Storm Event	Parameter	Catchment A	Catchment B[2]	Catchment C[2]	Catchment D[2]	Catchment E	Catchment F	Oval[4]
	AAMGL (m AHD)[1]	*26.7*	*26.5*	*26.5*	*26.5*	*26.5*	*26.6*	*26.6*
	Subsoil Invert (m AHD)[6]	*None*	*27.36*	*27.1*	*27.54*	*27.74*	*27.5*	*27.8*
	Basin/Storage Invert (m AHD)	*28.4*	*27.66*	*27.6*	*28.05*	*28.25*	*28*	*28.3[7]*
	Base of Aquifer (m AHD)	*23.0*	*22.0*	*25.0*	*22.0*	*25.0*	*24.0*	*25.0*
	Basin/Storage Base Area (m^2)	*2,160*	*1,435*	*2,400*	*1,610*	*945*	*2,450*	*17,495*
	Catchment Area (ha)	*14.18*	*8.54*	*9.17*	*5.32*	*2.54*	*3.57*	-
1 EY	Critical Storm Duration (hrs)	0.5	48	168	6	24	24	Receives no runoff in <10% AEP storm events
	Storm Rainfall (mm)	13.8	66.3	105	34.2	53.9	53.9	
	Runoff Volume (m^3)	455	1,420	3,185	345	625	790	
	Top Water Level (m AHD)	28.45	28.20	28.20	28.20	28.60	28.20	
	Water level rise (m)	0.05	0.55	0.60	0.15	0.20	0.20	
	Stored Volume (m^3)	85	765	1,665	215	360	480	
	Water Surface Area (m^2)	2,320	1,435	3,175	1,735	1,210	2,690	
	% Volume Stored	19%	54%	52%	62%	58%	61%	
20% AEP	Critical Storm Duration (hrs)	0.5	48	144	9	48	24	
	Storm Rainfall (mm)	19.7	93.7	134	55.6	93.7	76.8	
	Runoff Volume (m^3)	650	2,010	4,275	560	1,080	1,125	
	Top Water Level (m AHD)	28.55	28.45	28.45	28.30	28.75	28.30	
	Water level rise (m)	0.15	0.80	0.85	0.25	0.50	0.30	
	Stored Volume (m^3)	265	1,135	2,490	360	660	760	
	Water Surface Area (m^2)	2,645	1,435	3,520	1,820	1,350	2,825	
	% Volume Stored	41%	56%	58%	64%	61%	68%	

TABLE 8 (CONTINUED): DRAINAGE STORAGE RESULTS (CATCHMENTS A TO F)

Storm Event	Parameter	Catchment A	Catchment B[2]	Catchment C[2]	Catchment D[2]	Catchment E	Catchment F	Oval[3]
	AAMGL (m AHD)	*26.7*	*26.5*	*26.5*	*26.5*	*26.5*	*26.6*	*26.6*
	Subsoil Invert (m AHD)	*None*	*27.36*	*27.1*	*27.54*	*27.74*	*27.5*	*27.8*
	Basin/Storage Invert (m AHD)	*28.4*	*27.66*	*27.6*	*28.05*	*28.25*	*28*	*28.3*[7]
	Base of Aquifer (m AHD)	*23.0*	*22.0*	*25.0*	*22.0*	*25.0*	*24.0*	*25.0*
	Basin/Storage Base Area (m^2)	*2,160*	*1,435*	*2,400*	*1,610*	*945*	*2,450*	*17,495*
	Catchment Area (ha)	*14.18*	*8.54*	*9.17*	*5.32*	*2.54*	*3.57*	-
10% AEP	Critical Storm Duration (hrs)	3	Same as 20% AEP with overflow[3] of approx. 1,195 m^3 to Lake, equivalent to 0.28 m rise in Lake assuming surface area of 4,311 m^2	168	9	Same as 20% AEP with overflow[3] of approx. 335 m^3 to Bush Forever, equivalent to 0.02 m rise in Bush Forever assuming surface area of 21,720 m^2	Same as 20% AEP with overflow[3] of approx. 805 m^3 to Bush Forever, equivalent to 0.08 m rise in Bush Forever assuming surface area of 10,000 m^2	Receives no runoff in <10% AEP storm events
	Storm Rainfall (mm)	43.8		163	65.6			
	Runoff Volume (m^3)	3,565		5,340	1,335			
	Top Water Level (m AHD)	29.00		28.60	28.60			
	Water level rise (m)	0.60		1.00	0.55			
	Stored Volume (m^3)	2,060		3,050	1,035			
	Water Surface Area (m^2)	4,810		3,745	2,185			
	% Volume Stored	58%		57%	78%			
1% AEP	Critical Storm Duration (hrs)	Same as 10% AEP with overflow to Oval	Same as 20% AEP with overflow[3] of approx. 3,450 m^3 to Lake, equivalent to 0.80 m rise in Lake assuming surface area of 4,311 m^2	Same as 10% AEP with overflow to Oval	Same as 10% AEP with overflow to Oval	Same as 20% AEP with overflow[3] of approx. 1,210 m^3 to Bush Forever, equivalent to 0.06 m rise in Bush Forever assuming surface area of 21,720 m^2	Same as 20% AEP with overflow[3] of approx. 1,955 m^3 to Bush Forever, equivalent to 0.20 m rise in Bush Forever assuming surface area of 10,000 m^2	6
	Storm Rainfall (mm)							91.6
	Runoff Volume (m^3)							19,190[5]
	Top Water Level (m AHD)							28.55
	Water level rise (m)							0.25
	Stored Volume (m^3)							3,825
	Water Surface Area (m^2)							17,495
	% Volume Stored							20%

1 AAMGL used as design groundwater level for Basin A without subsoil; all other basins the subsoil invert is conservatively used, assuming groundwater rise

2 Underground Storage configuration to be refined during detail design and presented in UWMP.

3 Overflow volume calculated in PC-SUMP, surface areas derived from aerial photography in GIS. No infiltration in Lake/Bush Forever has been assumed.

4 Receives overflow in >10% AEP storm event from Catchments A, C and D.

5 Total runoff volume from Catchments A, C and D. Oval modelled as basins in PC-SUMP with Catchments A, C and D each a swale (oval has POS as catchment area only).

6 See Figure 12

7 Modelled in PC-SUMP as 27.6 m AHD due to model input restraints

TABLE 9: SCHOOL DRAINAGE STORAGE RESULTS (INDICATIVE)

Storm Event	Parameter	School (Indicative)
	AAMGL	*26.6*
	Subsoil Invert[1]	*27.5*
	Basin Invert	*28.8*
	Base of Aquifer (m AHD)	*24.0*
	Basin Base Area (m^2)	*1,040*
	Catchment Area (ha)	*4.16*
1% AEP	Critical Storm Duration (hrs)	24
	Storm Rainfall (mm)	144.0
	Runoff Volume (m^3)	3,000
	Top Water Level (m AHD)	30.00
	Water level rise (m)	1.20
	Stored Volume (m^3)	1,875
	TWL Surface Area (m^2)	2,185
	% Volume Stored	63%

1 The subsoil invert is conservatively used as the design groundwater level, assuming groundwater rise

5.3 Groundwater Management

5.3.1 Design Criteria

Groundwater management for the Study Area has been prepared in line with design criteria presented in the DWMS and the Stormwater Management Manual for Western Australia (DoW, 2007):

- Manage groundwater levels to protect infrastructure and assets.
- Maintain groundwater regime for the protection of groundwater-dependent ecosystems.
- Protect the value of groundwater resources.
- Reduce nutrients infiltrating to groundwater.

5.3.2 Managing Changes to Groundwater Levels

Observations in DWER Ministerial Bore JM19 shows a marked increase in groundwater levels in the past two years (Appendix B). This is likely the aquifer's response to increased recharge resulting from urbanisation of the surrounding land. There is currently no DWER modelling of possible groundwater changes on the Jandakot Mound in response to urbanisation.

Should the water table rise in response to urbanisation, increased groundwater gradient will result in increased throughflow until a new equilibrium is established. Groundwater rise will not continue year after year following an increase in recharge, but will occur for several years, and be more rapid if the depth to water table is shallow rather than deep.

Given the shallow water table present within the Study Area it is possible that the water table could rise up to 2 m from its current position.

To control any potential groundwater rise, subsoil drainage is proposed for the development. It will be located beneath drainage infrastructure (basins and swales) and set at or above the pre-development AAMGL. Subsoil will discharge into the Atwell Drain at 26.5 m AHD beneath Armadale Rd (Figure 12). Perron Treeby Pty Ltd are currently seeking confirmation of this subsoil connection to the Atwell Drain with the City of Cockburn, separate to this LWMS.

Use of subsoil in other areas will be assessed following collection and review of further groundwater monitoring data and documented during detail design in the UWMP.

Note that finished lot levels and fill requirements will be addressed during detailed design and submitted for council approval at that stage. Other factors such as integration with neighbouring urban developments and constructed road levels may be the determining factor for fill level, rather than groundwater clearance.

Groundwater mapping presented in Figure 6 should be considered indicative only for assisting in LWMS strategy development purposes and subject to further investigation/refinement during detailed design.

5.4 Water Quality Management

5.4.1 Nutrient Source Controls

The effective implementation of the structural and non-structural controls as part of the urban development will enhance water quality from this site as a result of the land use change.

Non-structural and structural source controls provide a complete treatment train for stormwater movement through the development. The following strategies are proposed:

- Local native plants make up a minimum 50% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements.
- Street sweeping and pit eductions. The UWMP will outline the schedule and cleaning requirements for street sweeping and pit eductions, which will be coordinated with the City of Cockburn.
- The use of bioretention systems to treat road runoff.

Minimum specifications for all bioretention systems are in Table 10.

TABLE 10: MINIMUM SPECIFICATIONS FOR BIORETENTION SYSTEMS

Item	Specification
Amended soil media	• Minimum 300 mm thick. • Phosphorus Retention Index (PRI) >10. • Hydraulic Conductivity in the range of 2.5 and 7.5 m/d, once compacted. • Total clay and silt fraction <3% in total (w/w). • Organic matter content <5% (w/w). • Phosphorus content <100 mg/kg. • Infiltration testing of material prior to installation and again once construction is complete. On-going testing as per the monitoring program.
Plant selection, planting density and distribution	• As per southwest vegetation guidelines (Monash University, 2014). • Plants selected should be suited to frequent inundations up to 0.5 m, which dries out in less than a day after rain ceases.

A minimum treatment capacity of approximately 2% of the connected impervious area must be provided over the whole Study Area.

Recent research conducted by the Facility of Advancing Water Bio-filtration (FAWB, 2008) indicates that the desired K_{sat} is in the range of 2.5 to 7 m/d, to fulfil the drainage requirements as well as retain sufficient moisture to support the vegetation. The FAWB (2008) research also specifies that for vegetated systems some clogging will occur in the first few years until the vegetation is established. Once the plants are established, the roots and associated biological activity maintain the conductivity of the soil media over time.

It should be recognised that data currently guiding the design of bioretention systems is only recent and largely based on laboratory testing. Details of plant selection, maintenance and likely nutrient uptake in the Treeby environment are not well known at this stage. The specifications provided in this document should

be considered as the best available information at the time. Some flexibility in the specifications will be required as the knowledge base increases.

5.4.2 Land Use Change Nutrient Impacts

The UNDO (Urban Nutrient Decision Outcomes) decision support tool (DoW, 2016) has been used to help quantify the nutrient inputs for the post-development scenario. The UNDO tool analyses inputs for Total Phosphorus and Total Nitrogen only. Results were calculated for the Study Area (Appendix H). Bush Forever sites were not included in the analysis as these areas will not be altered. The Primary School was not included in the analysis as the proposed structural and non-structural controls are not known.

The implementation of the proposed structural and non-structural controls results in a reduction of 30% for Nitrogen and 27% for Phosphorus, compared to urban development without WSUD. These estimates correspond to a reduced Nitrogen input of 1.44 kg/ha/yr (down from 2.07 kg/ha/yr) and a reduced Phosphorus input of 0.07 kg/ha/yr (down from 0.11 kg/ha/yr). It should be noted that the current land use is a combination of bushland and cleared land with low nutrient inputs and the estimated nitrogen and phosphorus inputs following urban development are also relatively low. Due to infiltration of stormwater onsite the estimated nitrogen and phosphorus exports following urban development are low.

6. IMPLEMENTATION

6.1 Urban Water Management Plan (Subdivision)

Processes defined in Better Urban Water Management (WAPC, 2008a) require an Urban Water Management Plan (UWMP) at subdivision stage. With an approved LWMS, a UWMP is required as a condition of subdivision and prior to any subdivision activities.

Further work that is identified for inclusion in the UWMP:

- Design of treatment structures, vegetated swales and infiltration storages as outlined in the Stormwater Management Manual (DoW, 2007).
- Refinement of configuration (storage side slopes, etc.) of flood storages once final earthworks, drainage and road design levels are determined for the development.
- Refinement of post-development groundwater levels, taking into consideration a potential rise from urbanisation.

6.2 Construction Management

6.2.1 Dewatering

Given the separation to groundwater dewatering is not expected to be required. If dewatering is required, prior to the commencement of dewatering the construction contractor will apply for and obtain from DWER a “Licence to Take Water”. All dewatering will be carried out in accordance with the conditions of this licence.

6.2.2 Acid Sulphate Soils

Management of Acid Sulphate Soils (ASS) will be addressed as a separate process to the urban water management document approvals process (LWMS/UWMP).

ASS will be investigated and managed in accordance with the applicable DWER Acid Sulphate Soil Guideline Series and requirements of dewatering licences as they arise.

6.2.3 Stormwater System Operation and Management

The stormwater system will require regular maintenance to ensure correct operation. It is considered that the following operating and maintenance practices will be required periodically:

- Removal of debris to prevent blockages.
- Street sweeping to reduce particulate build up on road surface and gutters.
- Maintenance of vegetation in storages as outlined in the UWMP.
- Cleaning of sediment build up and litter layer on the bottom of storages as specified in the UWMP.
- Undertake education campaigns regarding source control practise to minimise pollution runoff into stormwater drainage system.

6.2.4 Monitoring Program

The monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development.

The post-development monitoring program is designed to operate over a 3 year period. The program will be periodically reviewed to ensure suitability and practicality. The program may need to be modified as data is collected to increase or decrease the monitoring effect in a particular area or alter the scope of the program itself.

The proposed post-development monitoring is to monitor groundwater levels and quality at 4 pre-development groundwater sites (BQ2, BQ3, BQ4 and BQ8, see Figure 6) for comparison to pre-development data (Appendix E). Trigger values for selected analytes were calculated as 20% over the maximum reported values and are provided in Table 11. As BQ4 and BQ8 have been destroyed these bores will need to be reinstalled.

A summary of the proposed monitoring program and reporting schedule is shown in Table 12 with the frequency of water quality target review and the contingency action plan detailed in Table 13.

All sampling is to be conducted according to Australian Standards and all water quality sample testing will be conducted by a NATA approved laboratory.

TABLE 11: GUIDELINE TRIGGER VALUES FOR POST-DEVELOPMENT MONITORING

Parameter		Groundwater			
		BQ2	BQ3	BQ4	BQ8
Water Level (mAHD)	Trigger Value	27.07	26.99	26.84	26.77
pH[1]	Low Trigger Value[2]	3.76	2.98	3.38	5.00
	Upper Trigger Value[3]	6.44	6.46	8.35	8.20
EC (µS/cm)	Trigger Value [3]	0.31	1.33	0.29	0.98
TN (mg/L)	Trigger Value [3]	15.6	7.0	2.3	57.6
TP (mg/L)	Trigger Value [3]	0.06	0.06	0.06	0.06
TDS (mg/L)	Trigger Value [3]	132	600	168	456
Al (mg/L)	Trigger Value [3]	0.42	5.76	3.12	0.10
Fe (mg/L)	Trigger Value [3]	0.07	4.32	7.32	0.14
Se (mg/L)	Trigger Value [3]	0.0012	0.0012	0.0012	0.0012
NH_3N	Trigger Value [3]	0.096	0.672	0.084	0.084

1. pH values to be between range provided
2. 20% deducted from present minimum recorded value
3. 20% applied to present maximum recorded value

TABLE 12: MONITORING SCHEDULE AND REPORTING

Monitoring Type	Location	Method	Frequency, Timing & Responsibility	Parameter	Reporting
Groundwater Level	4 monitoring sites (BQ2, BQ3, BQ4, BQ8)	Electrical depth probe or similar	Quarterly for 3 years by Developer (typically Jan, April, July, October)	Water Level (m AHD)	Annual reports to be provided by the developer for a period of 3 years. Reports will be submitted to DWER/CoA within 3 months of completion of the reporting period.
Groundwater Quality	4 monitoring sites (BQ2, BQ3, BQ4, BQ8)	Pumped bore samples	Quarterly for 3 years by Developer (typically Jan, April, July, October)	In-situ: pH, EC, temp Lab: TN, TP, TDS, Al, Fe, Se, NH_3N	
			Annually for 3 years by Developer	Lab: extensive metals, anions and cations, organochlorine pesticides, organophosphate pesticides, hydrocarbons	

TABLE 13: CONTINGENCY PLANNING

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action
Groundwater Level	Groundwater levels not to exceed the estimated post-development phreatic line (i.e. mounding between subsoil drains) by more than 1 m	After monitoring occasion	1. Review design and operation of subsoil and stormwater drainage system. 2. Perform maintenance as required.
Groundwater Quality	Nutrient concentrations in shallow bores should not exceed 20% of the maximum recorded pre-development level.	Annual review of water quality targets	1. Identify and remove any point sources. 2. Consider reinforcement of Community Education/Awareness program. 3. Review operational and maintenance (e.g. fertilising, cleaning) practices.

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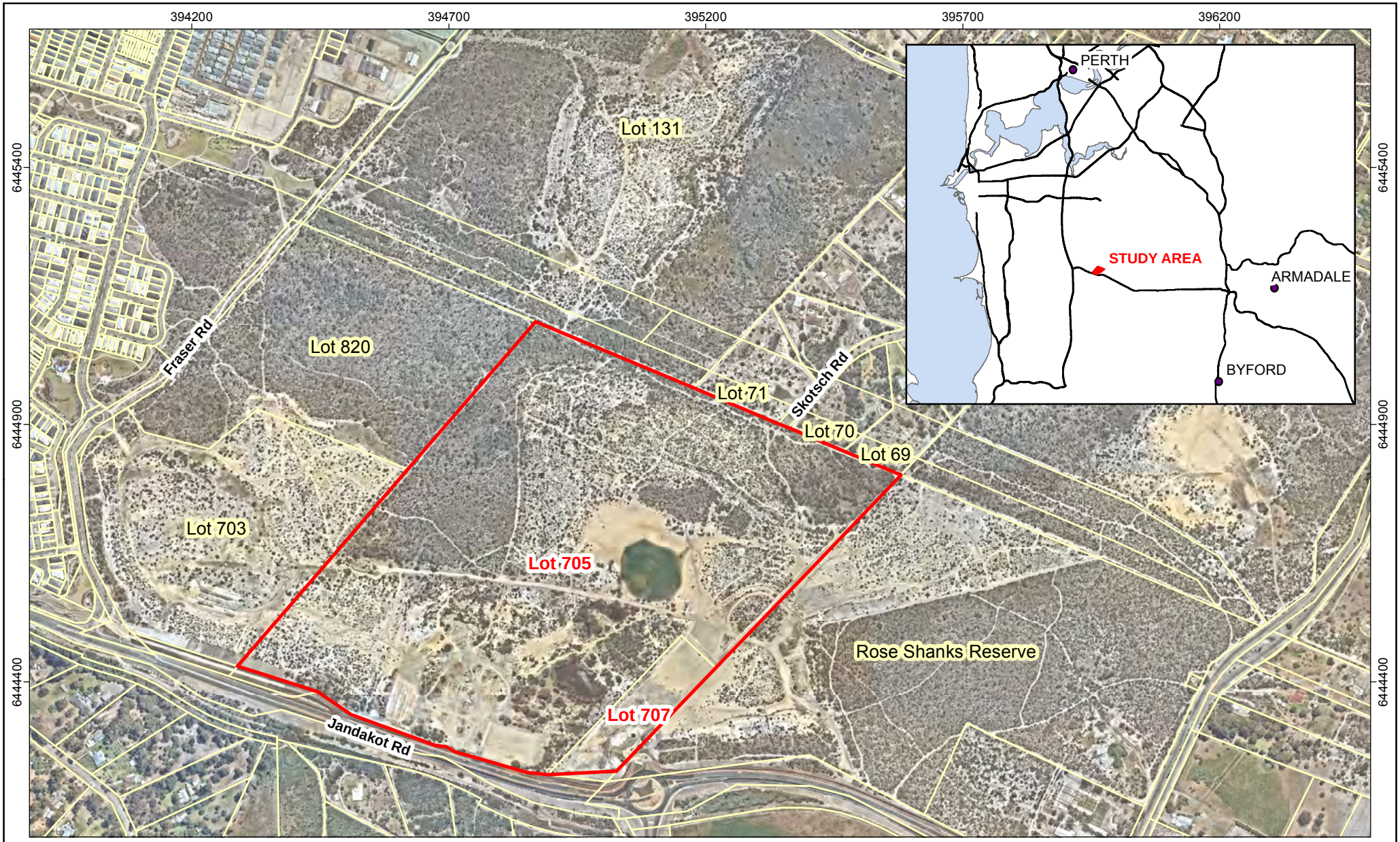
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FIGURES



Data Source: Nearmap (October 2019)

Coordinate System: GDA 94, Zone 50

JDA

Job No. J6667

Scale: 1:10,000 @A4

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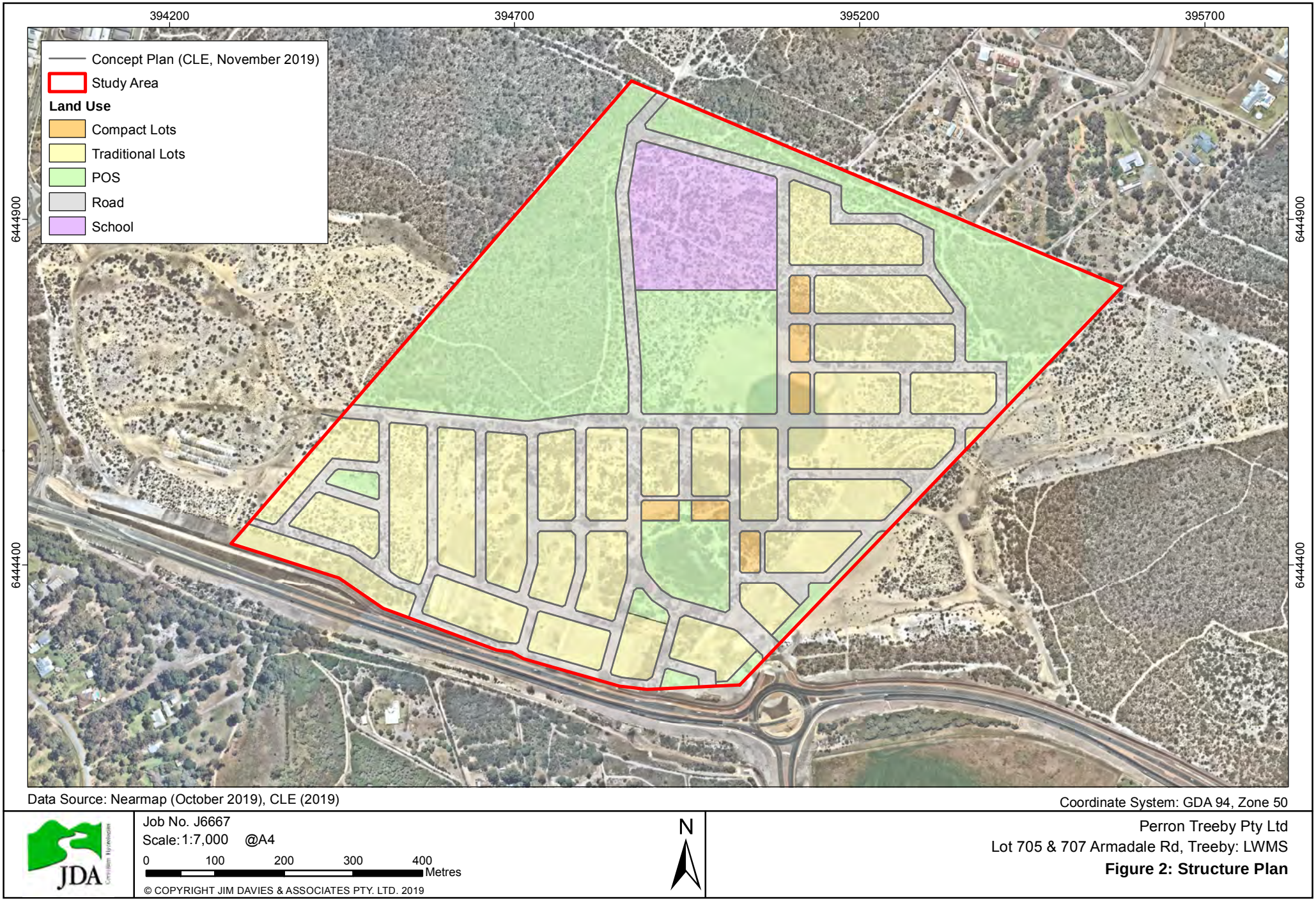
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Perron Treeby Pty Ltd

Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 1: Location Plan



Data Source: Nearmap (October 2019), CLE (2019)

Coordinate System: GDA 94, Zone 50

Job No. J6667
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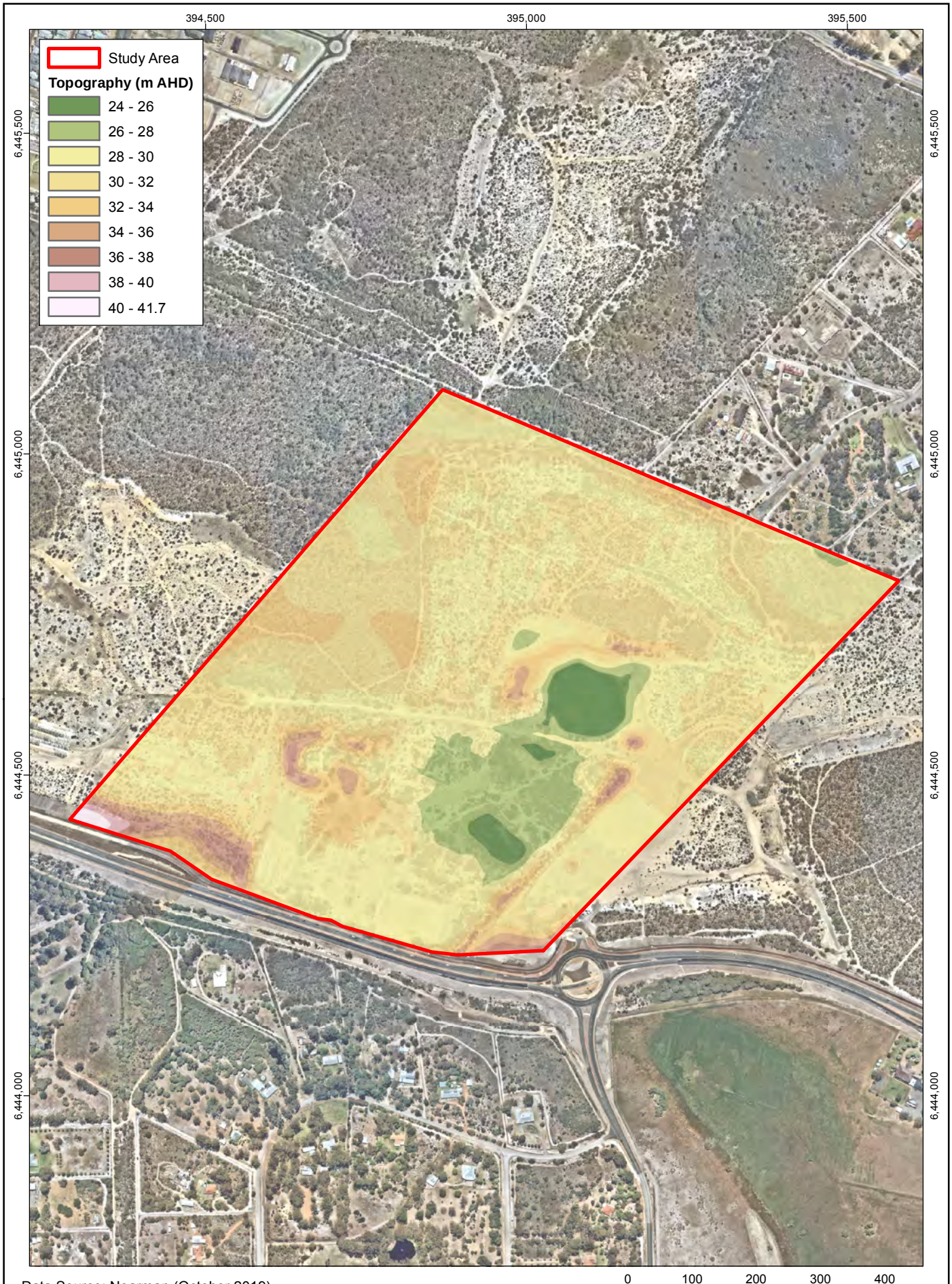
0 100 200 300 400 Metres

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N

Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 2: Structure Plan



Data Source: Nearmap (October 2019)

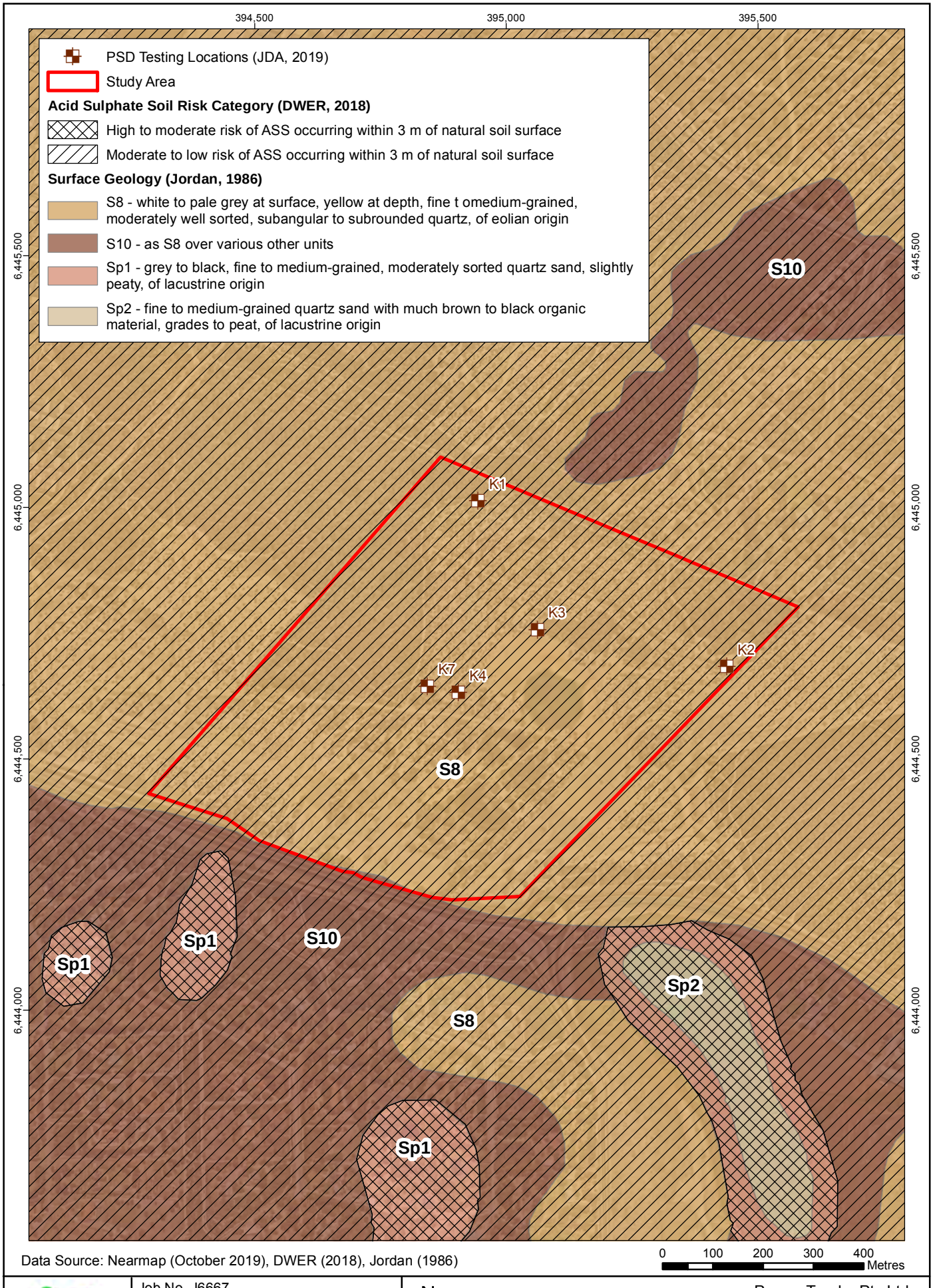
JDA

Job No. J6667
Scale 1:8,000 @A4
Coordinate System: GDA 94, Zone 50
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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 3: Topography



Data Source: Nearmap (October 2019), DWER (2018), Jordan (1986)

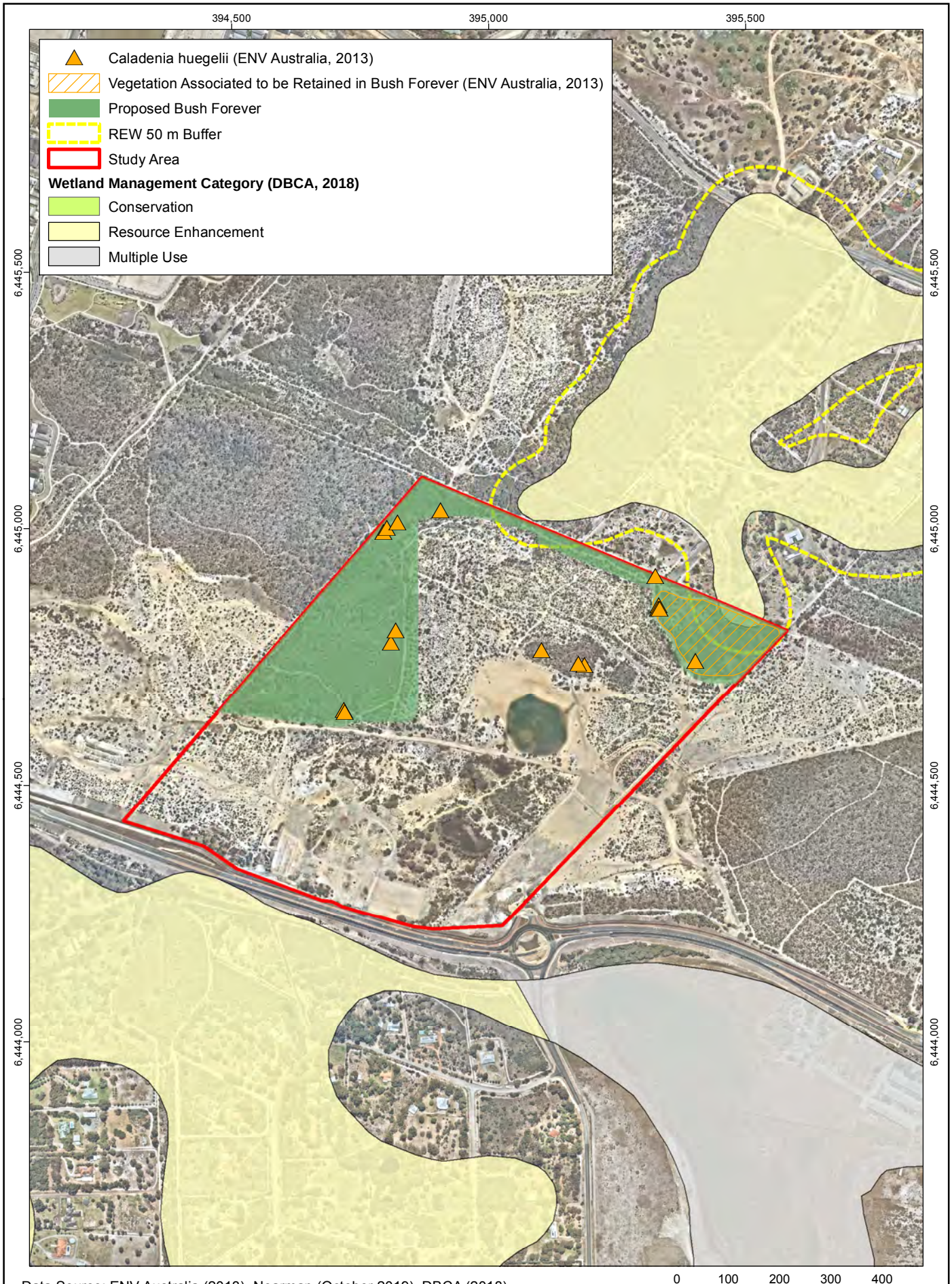
JDA

Job No. J6667
Scale 1:10,000 @A4
Coordinate System: GDA 94, Zone 50
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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 4: Geology and Acid Sulphate Soils



Data Source: ENV Australia (2013), Nearmap (October 2019), DBCA (2018)

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Scale 1:10,000 @A4
Coordinate System: GDA 94, Zone 50
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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 5: Wetlands and Vegetation

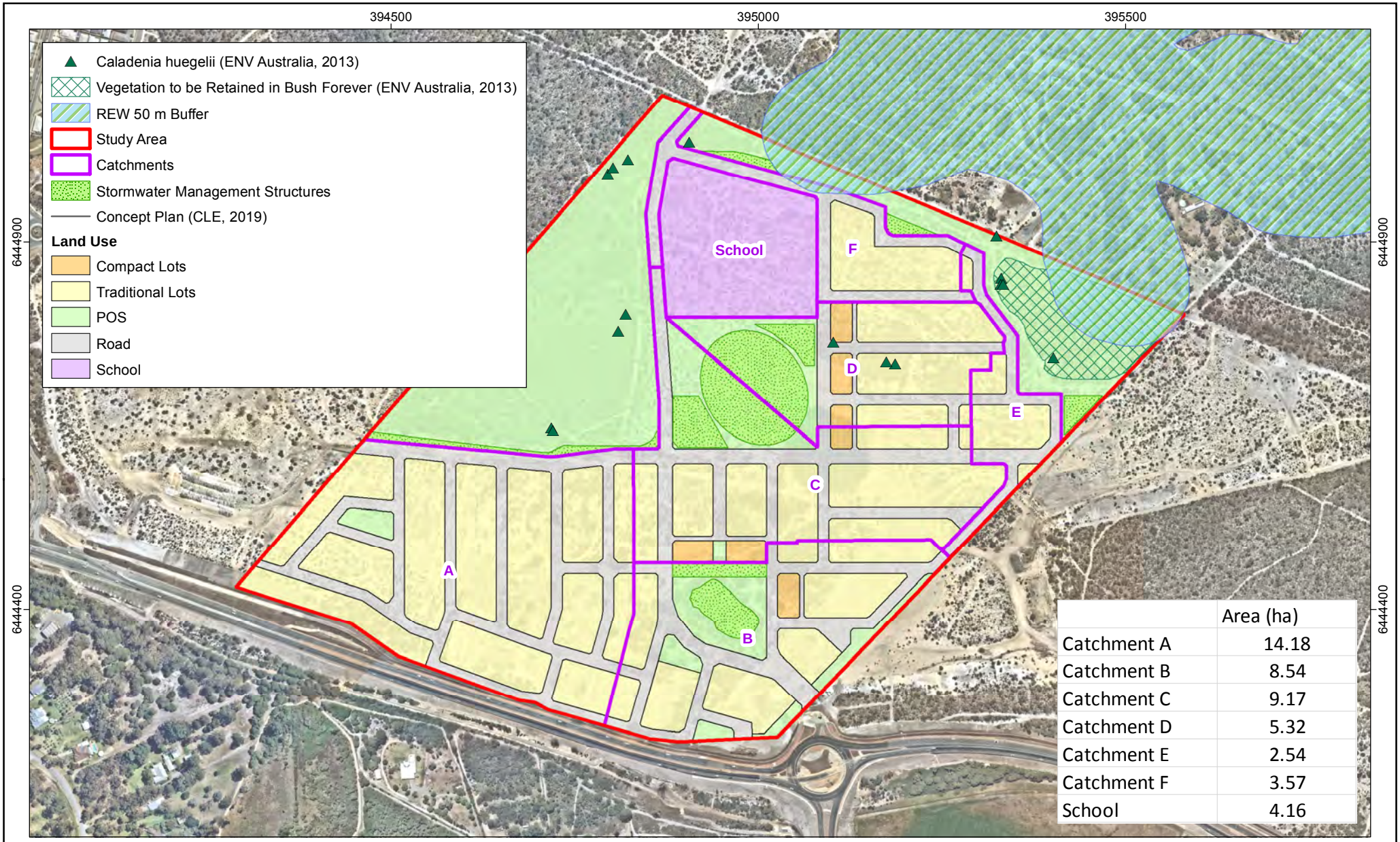


Data Source: Nearmap (October 2019), WRC (1997)

Job No. J6667
Scale 1:8,000 @A4
Coordinate System: GDA 94, Zone 50
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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby; LWMS
Figure 6: Groundwater Levels and Pre-Development Monitoring Locations



	Area (ha)
Catchment A	14.18
Catchment B	8.54
Catchment C	9.17
Catchment D	5.32
Catchment E	2.54
Catchment F	3.57
School	4.16

Data Source: Nearmap (October 2019)

Coordinate System: GDA 94, Zone 50

JDA

Job No. J6667
Scale: 1:7,000 @A4

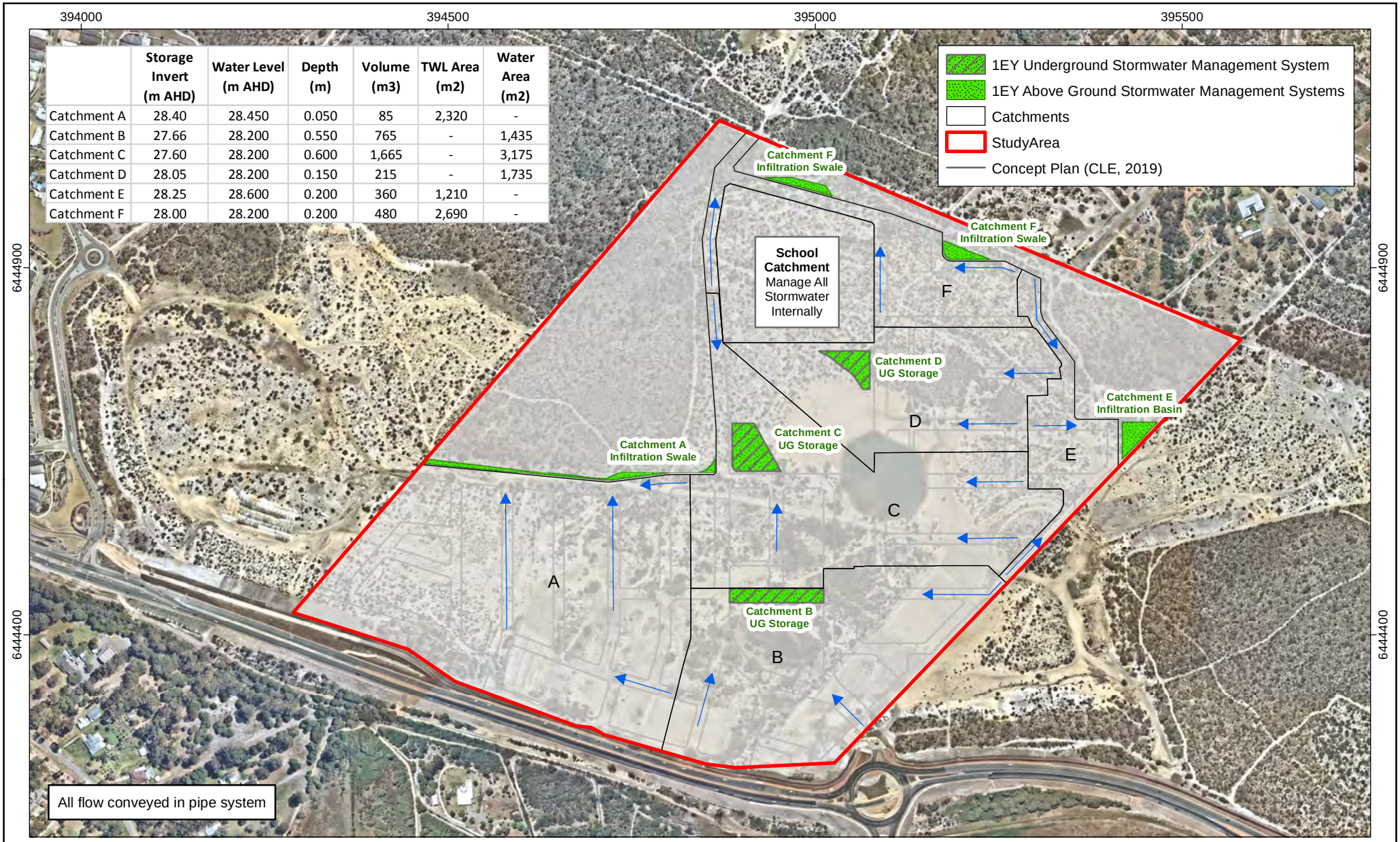
0 100 200 300 400 Metres

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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 7: Catchments



	Storage Invert (m AHD)	Water Level (m AHD)	Depth (m)	Volume (m3)	TWL Area (m2)	Water Area (m2)
Catchment A	28.40	28.450	0.050	85	2,320	-
Catchment B	27.66	28.200	0.550	765	-	1,435
Catchment C	27.60	28.200	0.600	1,665	-	3,175
Catchment D	28.05	28.200	0.150	215	-	1,735
Catchment E	28.25	28.600	0.200	360	1,210	-
Catchment F	28.00	28.200	0.200	480	2,690	-

Data Source: ENV Australia (2013), Nearmap (October 2019)

Coordinate System: GDA 94, Zone 50

JDA Consultant Hydrologists

Job No. J6667
Scale: 1:7,000 @A4

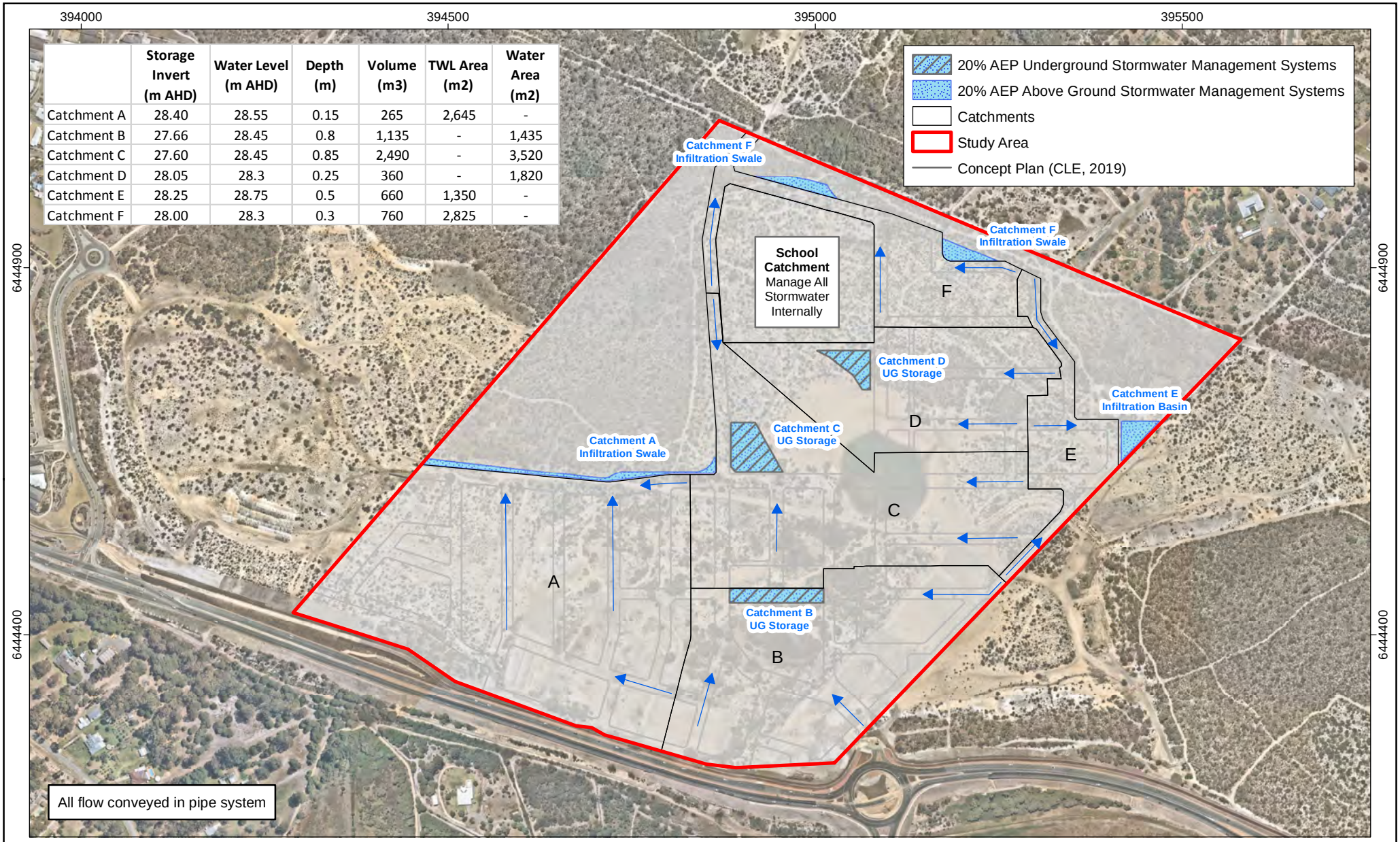
0 100 200 300 400 Metres

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N

Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 8: 1EY Stormwater Event Plan



	Storage Invert (m AHD)	Water Level (m AHD)	Depth (m)	Volume (m3)	TWL Area (m2)	Water Area (m2)
Catchment A	28.40	28.55	0.15	265	2,645	-
Catchment B	27.66	28.45	0.8	1,135	-	1,435
Catchment C	27.60	28.45	0.85	2,490	-	3,520
Catchment D	28.05	28.3	0.25	360	-	1,820
Catchment E	28.25	28.75	0.5	660	1,350	-
Catchment F	28.00	28.3	0.3	760	2,825	-

Data Source: ENV Australia (2013), Nearmap (October 2019)

Coordinate System: GDA 94, Zone 50

Job No. J6667
Scale: 1:7,000 @A4

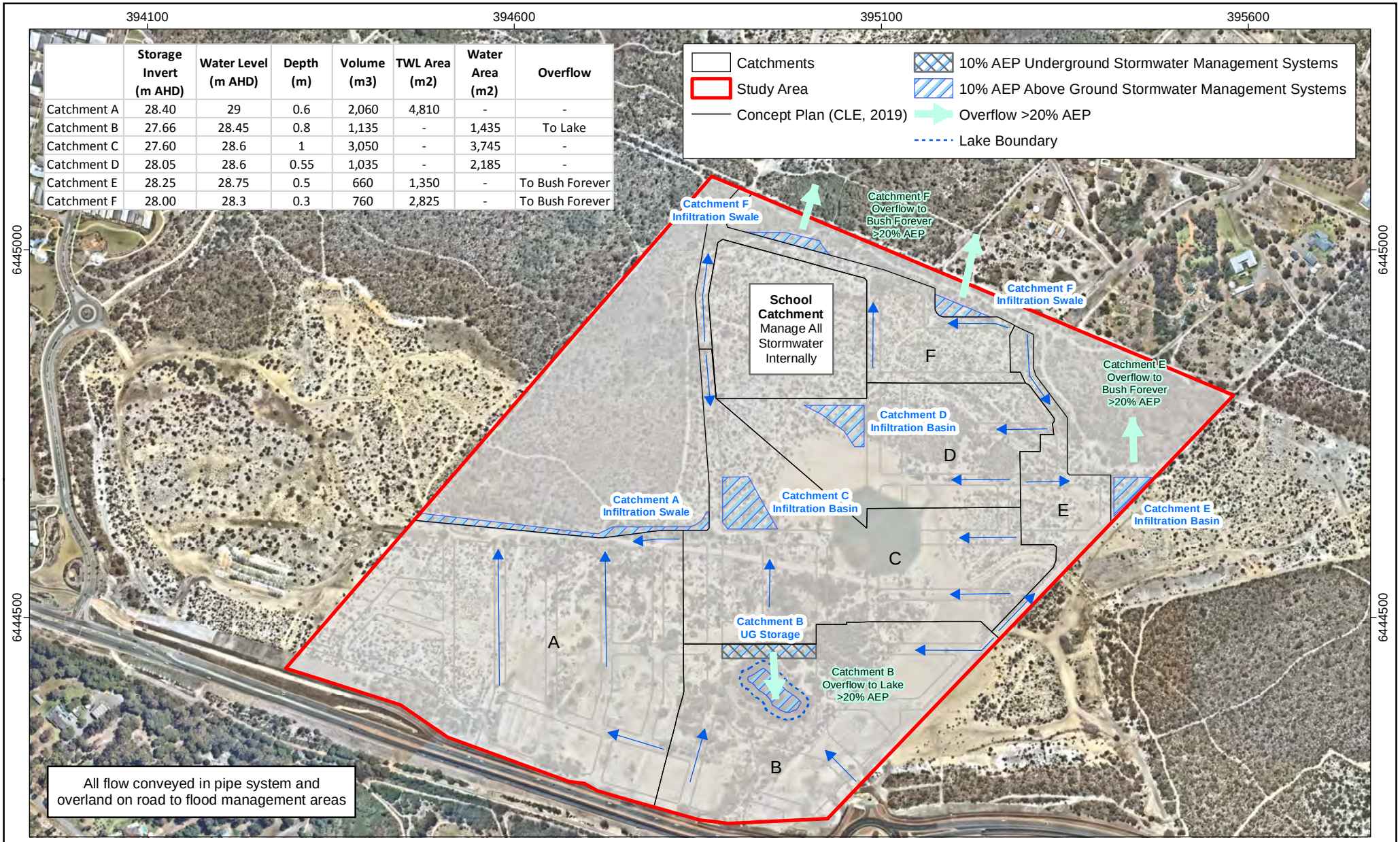
0 100 200 300 400 Metres

N

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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 9: 20% AEP Stormwater Event Plan



	Storage Invert (m AHD)	Water Level (m AHD)	Depth (m)	Volume (m3)	TWL Area (m2)	Water Area (m2)	Overflow
Catchment A	28.40	29	0.6	2,060	4,810	-	-
Catchment B	27.66	28.45	0.8	1,135	-	1,435	To Lake
Catchment C	27.60	28.6	1	3,050	-	3,745	-
Catchment D	28.05	28.6	0.55	1,035	-	2,185	-
Catchment E	28.25	28.75	0.5	660	1,350	-	To Bush Forever
Catchment F	28.00	28.3	0.3	760	2,825	-	To Bush Forever

Data Source: ENV Australia (2013), Nearmap (October 2019)

Coordinate System: GDA 94, Zone 50

JDA

Job No. J6667

Scale: 1:7,000 @A4

0 100 200 300 400 Metres

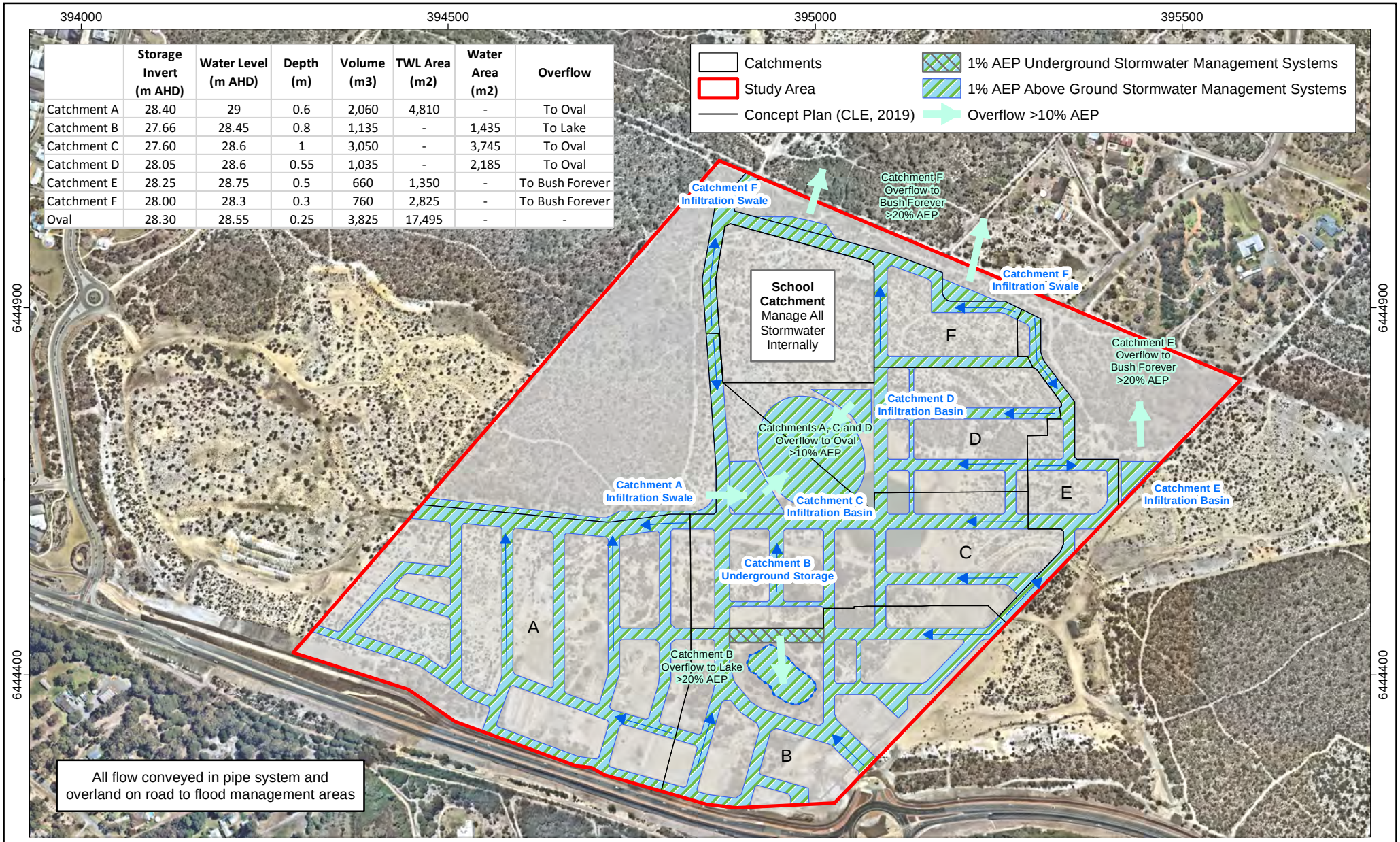
N

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Perron Treeby Pty Ltd

Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 10: 10% AEP Stormwater Event Plan



	Storage Invert (m AHD)	Water Level (m AHD)	Depth (m)	Volume (m3)	TWL Area (m2)	Water Area (m2)	Overflow
Catchment A	28.40	29	0.6	2,060	4,810	-	To Oval
Catchment B	27.66	28.45	0.8	1,135	-	1,435	To Lake
Catchment C	27.60	28.6	1	3,050	-	3,745	To Oval
Catchment D	28.05	28.6	0.55	1,035	-	2,185	To Oval
Catchment E	28.25	28.75	0.5	660	1,350	-	To Bush Forever
Catchment F	28.00	28.3	0.3	760	2,825	-	To Bush Forever
Oval	28.30	28.55	0.25	3,825	17,495	-	-

Data Source: ENV Australia (2013), Nearmap (October 2019)

Coordinate System: GDA 94, Zone 50

JDA

Job No. J6667
Scale: 1:7,000 @A4

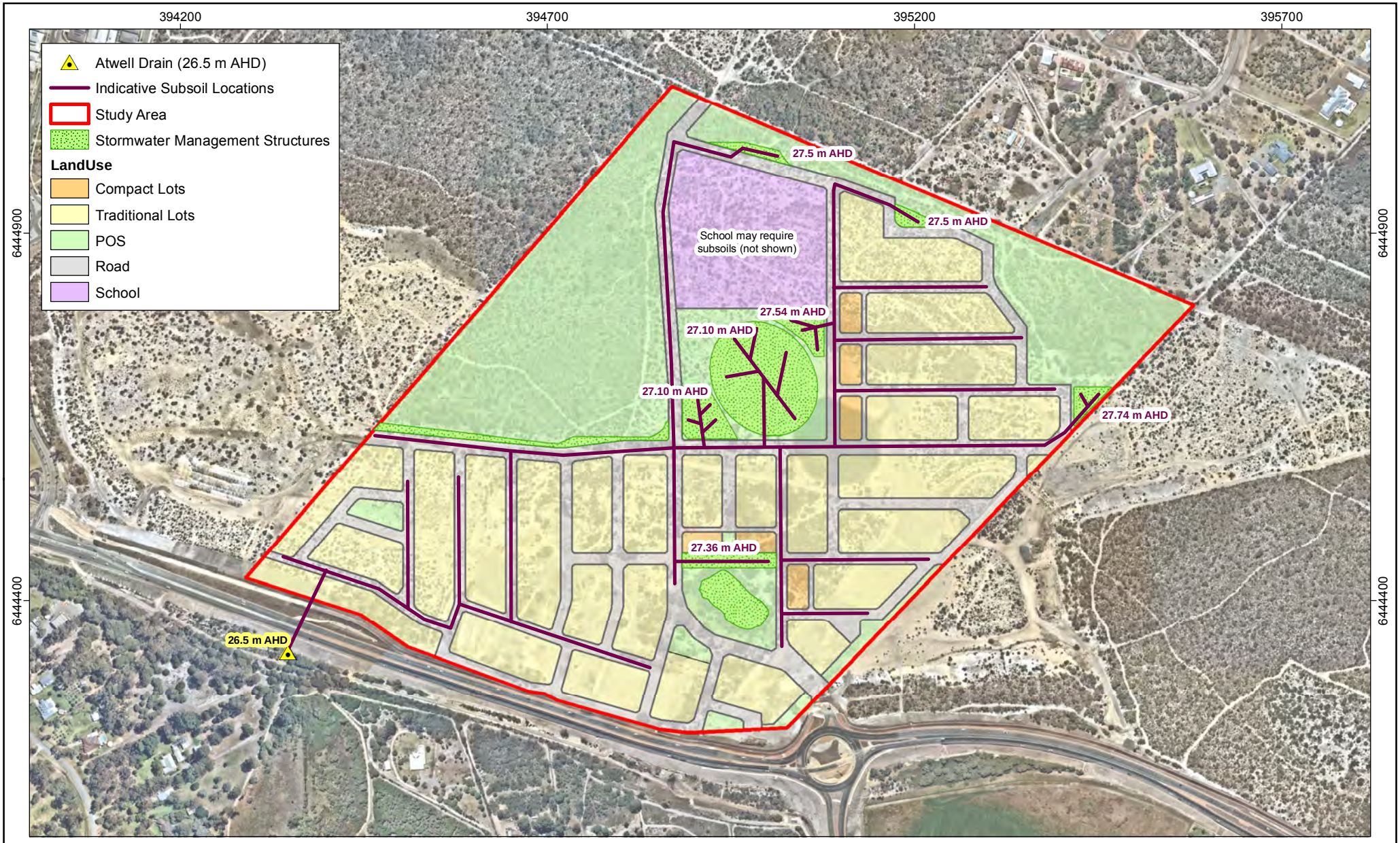
0 100 200 300 400 Metres

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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 11: 1% AEP Stormwater Event Plan



Data Source: Nearmap (October 2019)

Coordinate System: GDA 94, Zone 50

JDA

Job No. J6667
Scale: 1:7,000 @A4

0 100 200 300 400 Metres

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Perron Treeby Pty Ltd
Lot 705 & 707 Armadale Rd, Treeby: LWMS

Figure 12: Indicative Subsoil Locations

APPENDIX A

PSD Testing Results

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

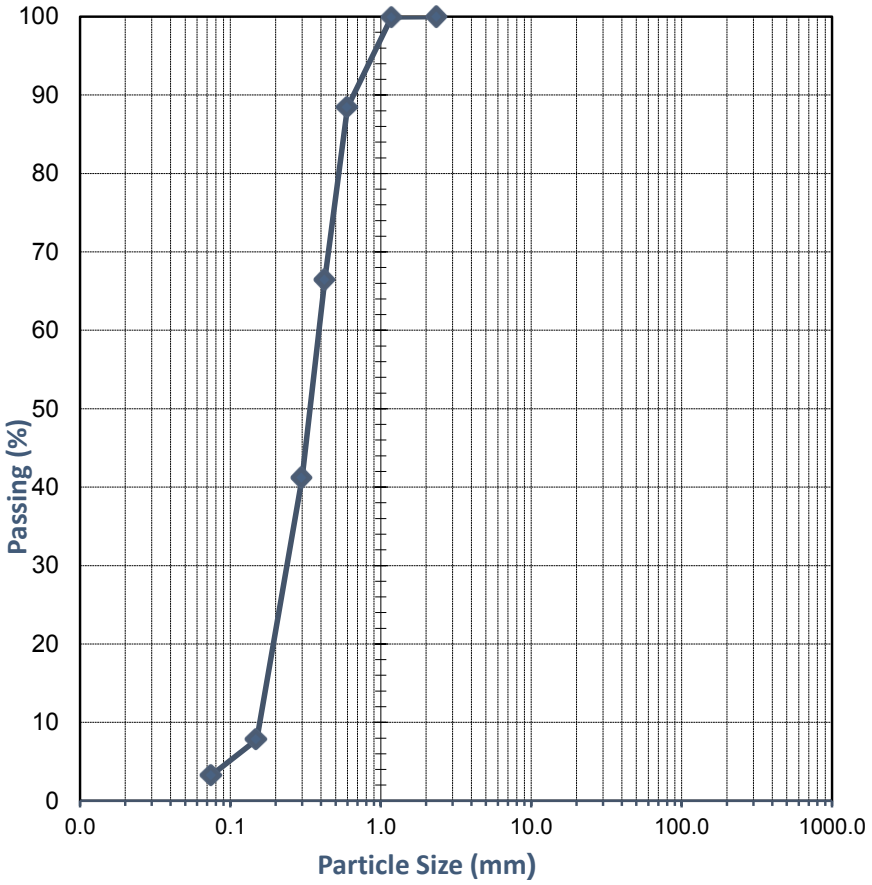
TEST REPORT - AS 1289.3.6.1

Client:	JDA Consultant Hydrologists	*Ticket No.*	S433
Client Address:	PO Box 117, Subiaco WA 6904	*Report No.*	WG19/3227_2_PSD
Project:	Lot 705 Armadale Road	*Sample No.*	WG19/3227
Location:	Treeby	*Date Sampled:*	7-10-2019
Sample Identification:	J6667c01 - K1 (3.2-3.3m)	*Date Tested:*	8-10-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	88
0.425	66
0.300	41
0.150	8
0.075	3



Comments:

Approved Signatory:

Name: Brooke Elliott
Function: Quality Manager
Date: 14-October-2019

Accreditation No. 20599
Accredited for compliance with ISO/IEC 17025 - Testing

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

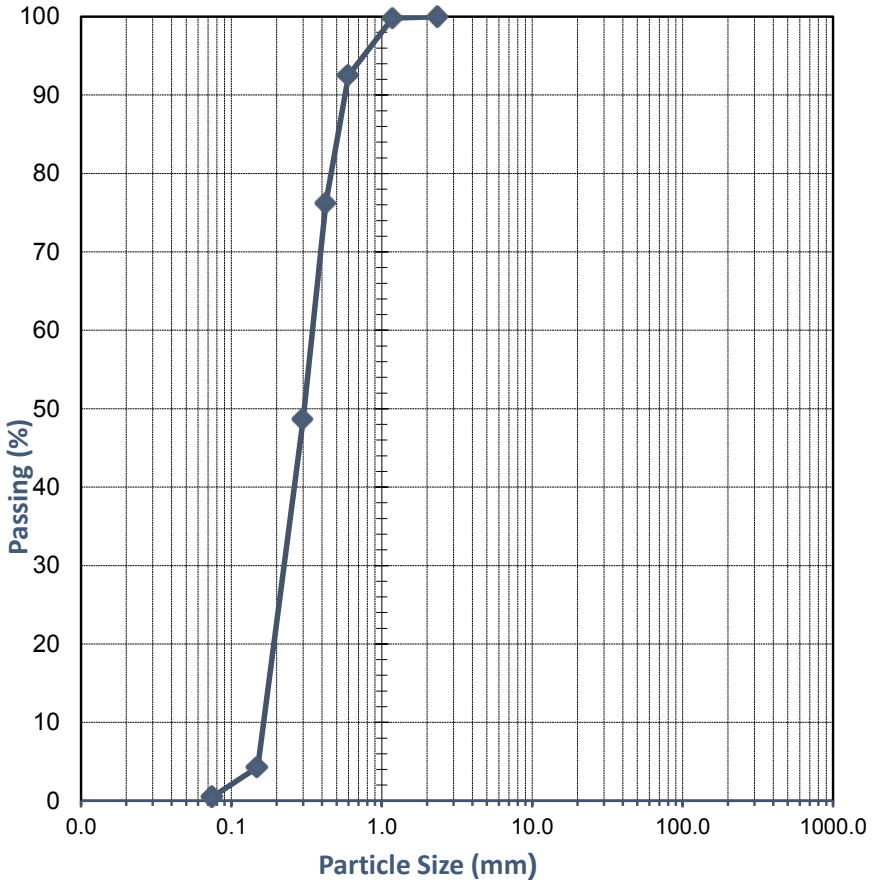
TEST REPORT - AS 1289.3.6.1

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Client Address:	PO Box 117, Subiaco WA 6904	*Report No.*	WG19/3228_2_PSD
Project:	Lot 705 Armadale Road	*Sample No.*	WG19/3228
Location:	Treeby	*Date Sampled:*	7-10-2019
Sample Identification:	J6667c01 - K2 (3.0-3.5m)	*Date Tested:*	8-10-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	92
0.425	76
0.300	49
0.150	4
0.075	1



Comments:

Approved Signatory:

Name: Brooke Elliott
Function: Quality Manager
Date: 14-October-2019

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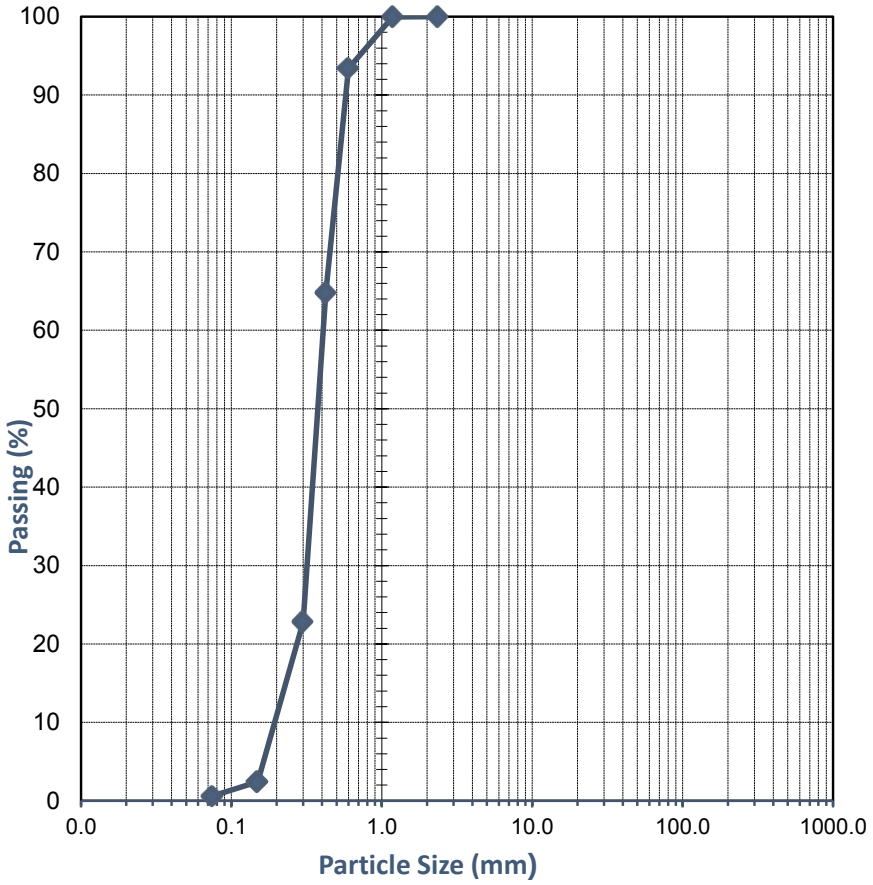
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Client:	JDA Consultant Hydrologists	*Ticket No.*	S433
Client Address:	PO Box 117, Subiaco WA 6904	*Report No.*	WG19/3229_2_PSD
Project:	Lot 705 Armadale Road	*Sample No.*	WG19/3229
Location:	Treeby	*Date Sampled:*	7-10-2019
Sample Identification:	J6667c01 - K3 (2.6-3.0m)	*Date Tested:*	8-10-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	93
0.425	65
0.300	23
0.150	2
0.075	1



Comments:

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Name: Brooke Elliott
Function: Quality Manager
Date: 14-October-2019

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SOIL | AGGREGATE | CONCRETE | CRUSHING

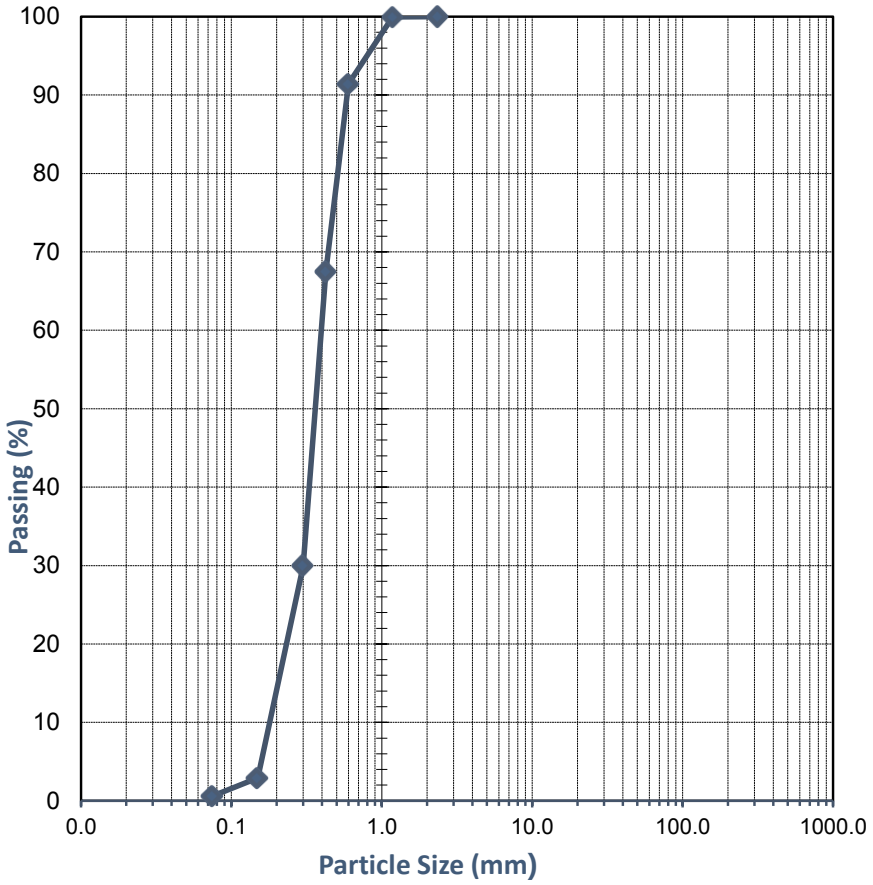
TEST REPORT - AS 1289.3.6.1

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Client Address:	PO Box 117, Subiaco WA 6904	*Report No.*	WG19/3230_2_PSD
Project:	Lot 705 Armadale Road	*Sample No.*	WG19/3230
Location:	Treeby	*Date Sampled:*	7-10-2019
Sample Identification:	J6667c01 - K4 (2.5-3.0m)	*Date Tested:*	8-10-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	91
0.425	67
0.300	30
0.150	3
0.075	1



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Name: Brooke Elliott
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SOIL | AGGREGATE | CONCRETE | CRUSHING

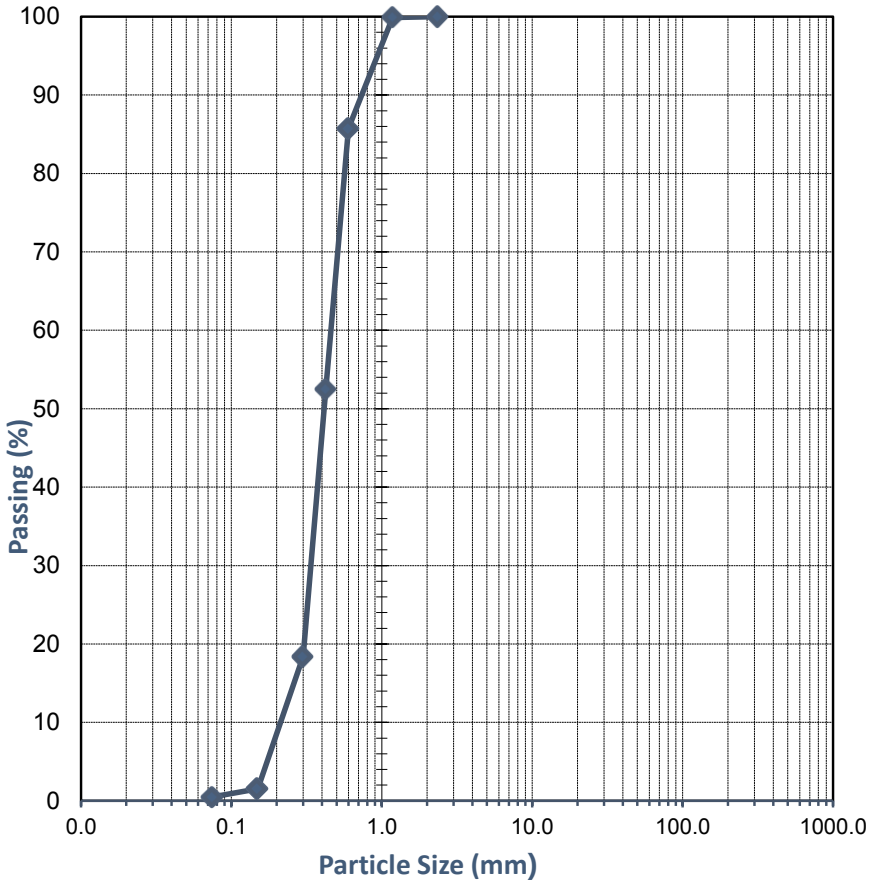
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Client Address:	PO Box 117, Subiaco WA 6904	*Report No.*	WG19/3231_2_PSD
Project:	Lot 705 Armadale Road	*Sample No.*	WG19/3231
Location:	Treeby	*Date Sampled:*	7-10-2019
Sample Identification:	J6667c01 - K7 (1.5-2.0m)	*Date Tested:*	8-10-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	86
0.425	53
0.300	18
0.150	2
0.075	1



Comments:

Approved Signatory:

Name: Brooke Elliott
Function: Quality Manager
Date: 14-October-2019

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SOIL | AGGREGATE | CONCRETE | CRUSHING

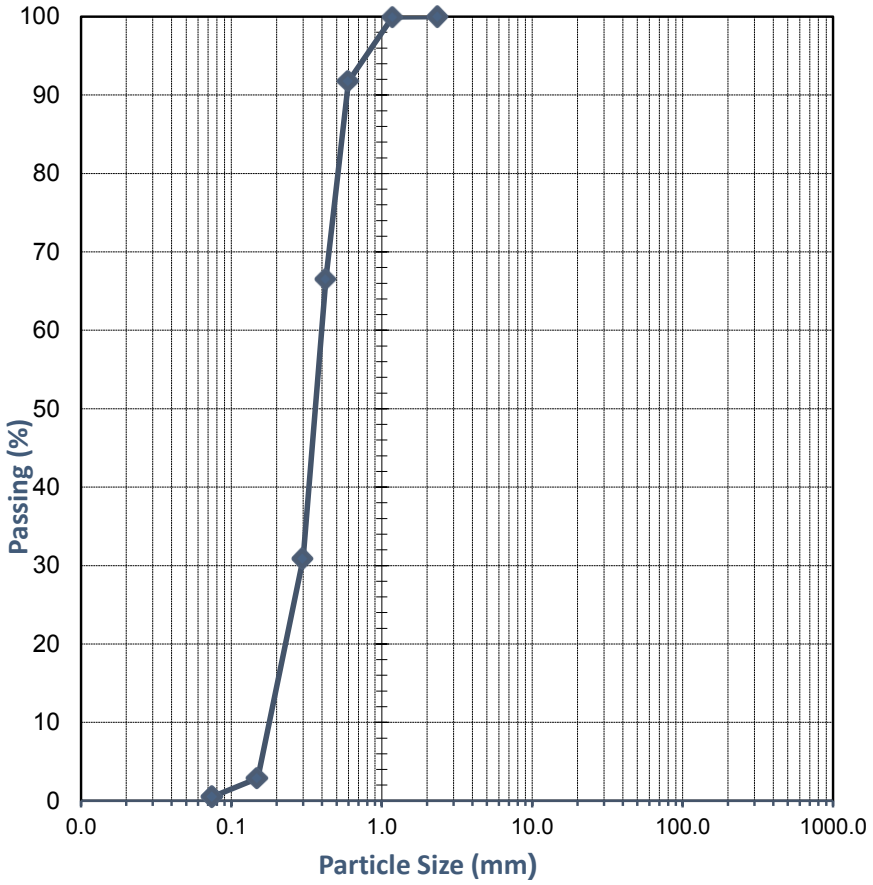
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Client:	JDA Consultant Hydrologists	*Ticket No.*	S433
Client Address:	PO Box 117, Subiaco WA 6904	*Report No.*	WG19/3232_2_PSD
Project:	Lot 705 Armadale Road	*Sample No.*	WG19/3232
Location:	Treeby	*Date Sampled:*	7-10-2019
Sample Identification:	J6667c01 - K7 (2.0-2.5m)	*Date Tested:*	8-10-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	92
0.425	66
0.300	31
0.150	3
0.075	1



Comments:

Approved Signatory:

Name: Brooke Elliott
Function: Quality Manager
Date: 14-October-2019

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SOIL | AGGREGATE | CONCRETE | CRUSHING

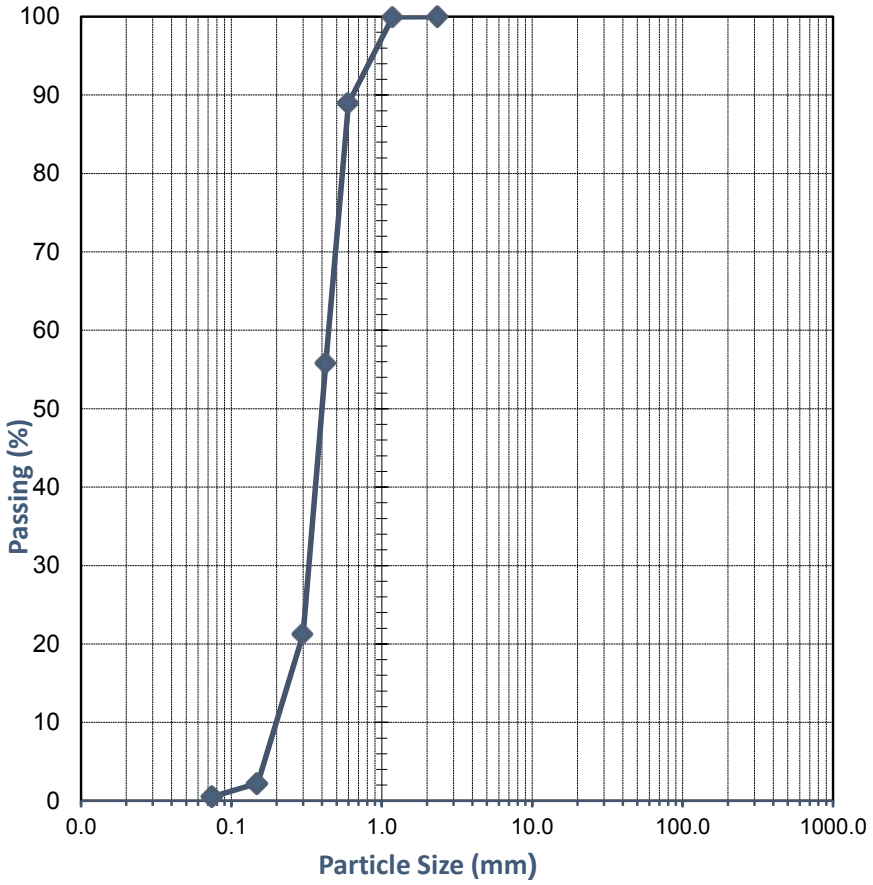
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Client:	JDA Consultant Hydrologists	*Ticket No.*	S433
Client Address:	PO Box 117, Subiaco WA 6904	*Report No.*	WG19/3233_2_PSD
Project:	Lot 705 Armadale Road	*Sample No.*	WG19/3233
Location:	Treeby	*Date Sampled:*	7-10-2019
Sample Identification:	J6667c01 - K7 (3.0-3.2m)	*Date Tested:*	8-10-2019

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve
75.0	
53.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	89
0.425	56
0.300	21
0.150	2
0.075	1



Comments:

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Name: Brooke Elliott
Function: Quality Manager
Date: 14-October-2019

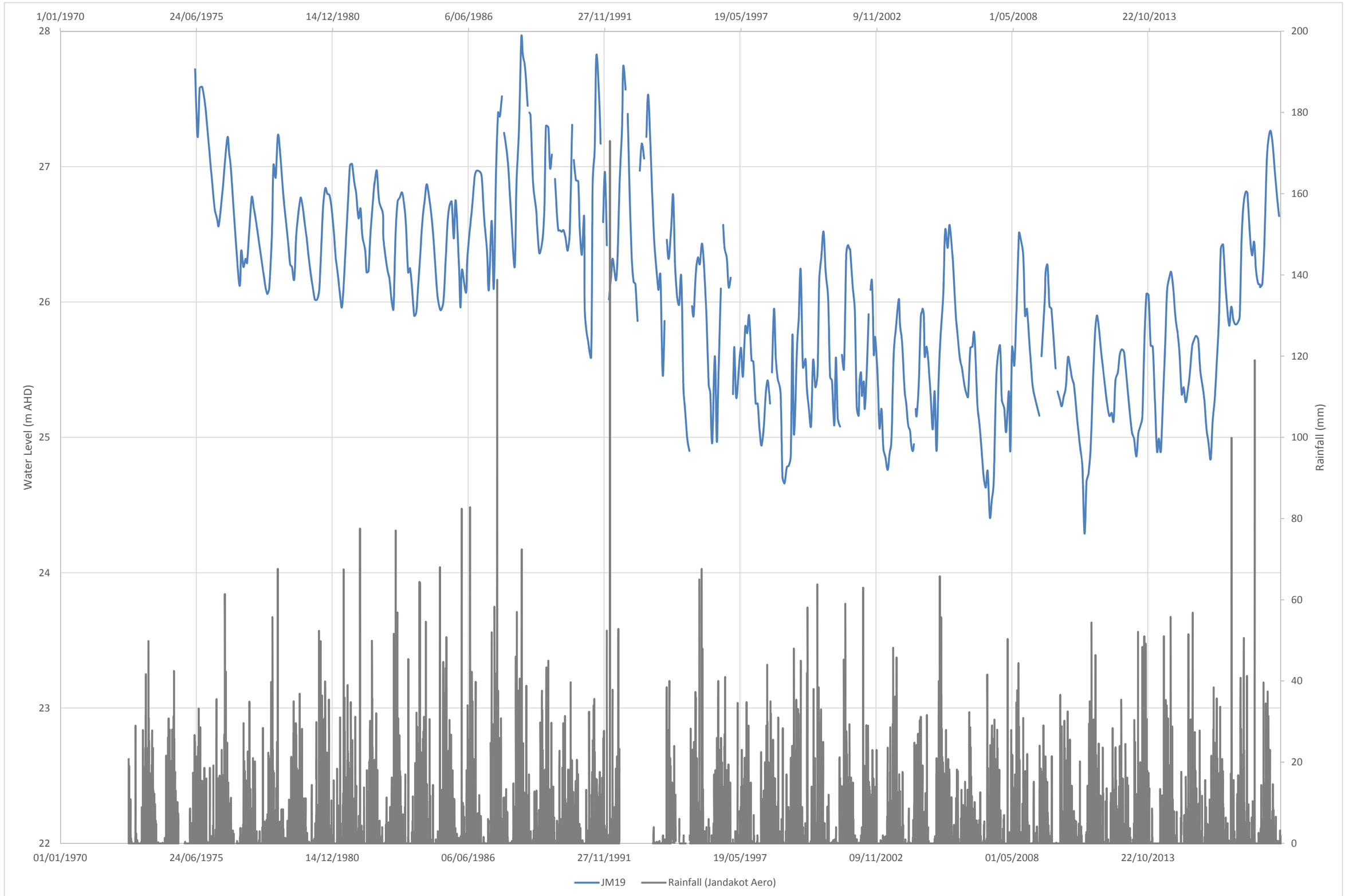
Accreditation No. 20599
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Name	Location		Depth	d10 (mm)	d60 (mm)	CU	k (cm/sec)	k (m/d)	PSD test	Notes
K1	394944E 6445013N	Basin F	0.5-1.0							Not quarried /natural bush
			1.5-1.0							
			3.2-3.3	0.18	0.4	2.22	0.032	28.0	Y	
K2	395438E 6444683N	Basin E	0.0-1.0							
			1.0-1.5							Cofffee rock
			1.5-2.0							White sand
			2.0-2.5							
			2.7-2.8							Coffee rock layer (Thin, white/yelllow crash sand)
			3-3.5	0.19	0.35	1.84	0.036	31.2	Y	
K3	395062E 6444757N	Basin D	0.0-1.0							Yellow sand
			1.0-2.0							Yellow sand-coarse
			2.0-3.0	0.20	0.30	1.50	0.040	34.6	Y	No coffee rocks
K4	0394905E 6444632N	Basin C	0.0-1.0							
			1.0-1.5							
			1.5-2.0							
			2.5-3	0.19	0.4	2.11	0.036	31.2	Y	White sand
K7	394843E 6444644N	Swale A	0.5-1.0							Yellow sand/ coffee rocks /quarried
			1.0-1.5							Minor cemented fragments /dark brown
			1.5-2.0	0.23	0.49	2.13	0.053	45.7	Y	
			2.0-2.5	0.19	0.4	2.11	0.036	31.2	Y	
			2.5-3.0							White sand
			3.0-3.2	0.2	0.45	2.25	0.040	34.56	Y	

APPENDIX B

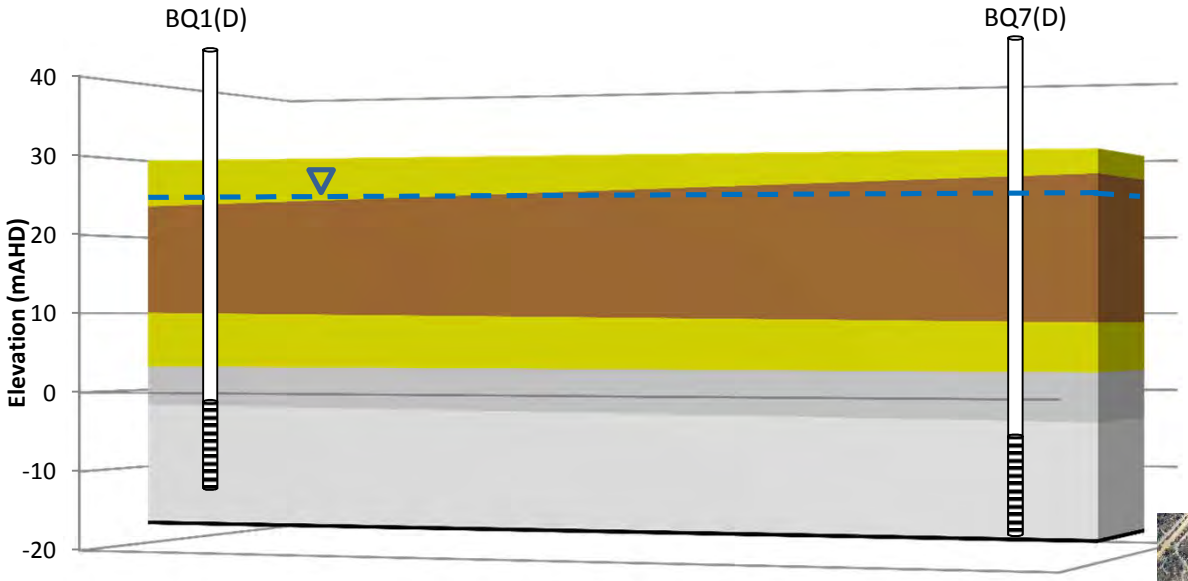
DWER Bore JM19 Groundwater Levels


1/01/1970
24/06/1975
14/12/1980
6/06/1986
27/11/1991
19/05/1997
9/11/2002
1/05/2008
22/10/2013
Water Level (m AHD)
28
27
26
25
24
23
22
Rainfall (mm)
200
180
160
140
120
100
80
60
40
20
0
JM19
Rainfall (Jandakot Aero)

APPENDIX C

Hydrogeological Cross-Sections (JDA, 2013)

Cross Section A



- Bassendean Sand
- Ferruginous Sand
- Gnangara Sand
- Ascot Formation
- Kardinya Shale
- Groundwater Level

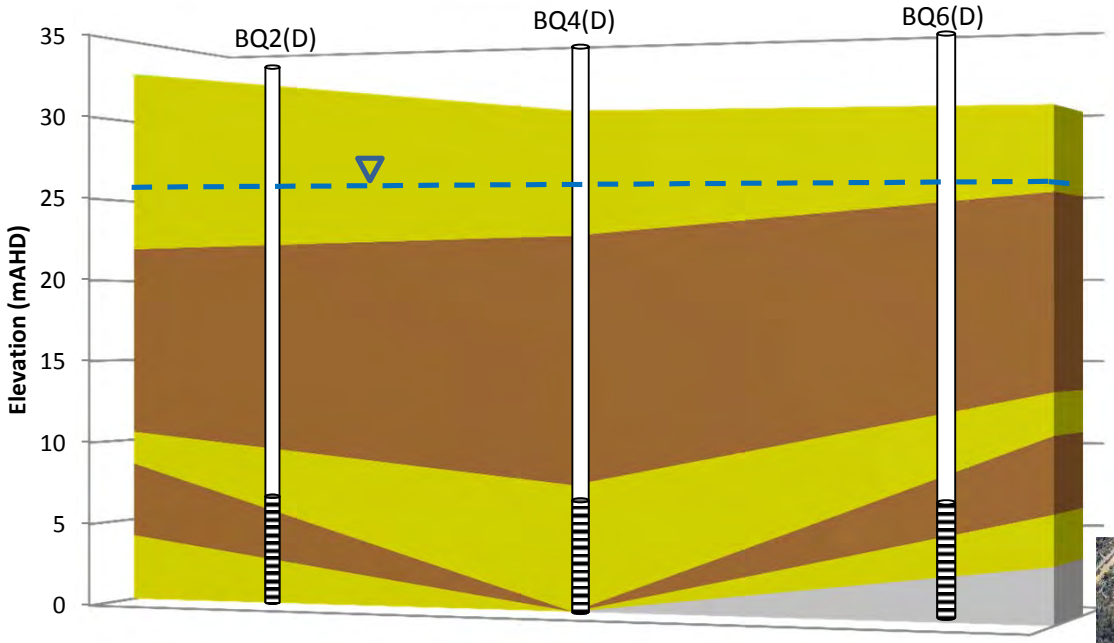


Job No. J5248

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Lot 2 &4 Armadale Rd, Banjup DWMS
Figure B1: Hydrogeological Cross-section A

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Cross Section B





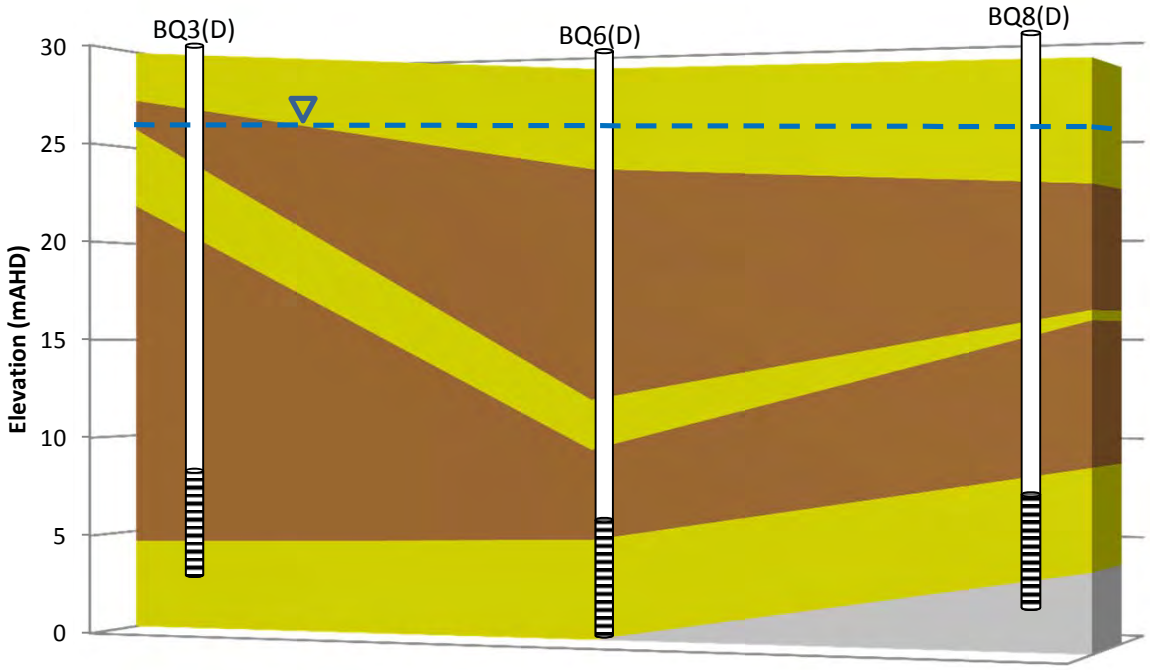
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Figure B2: Hydrogeological Cross-section B

Cross Section C





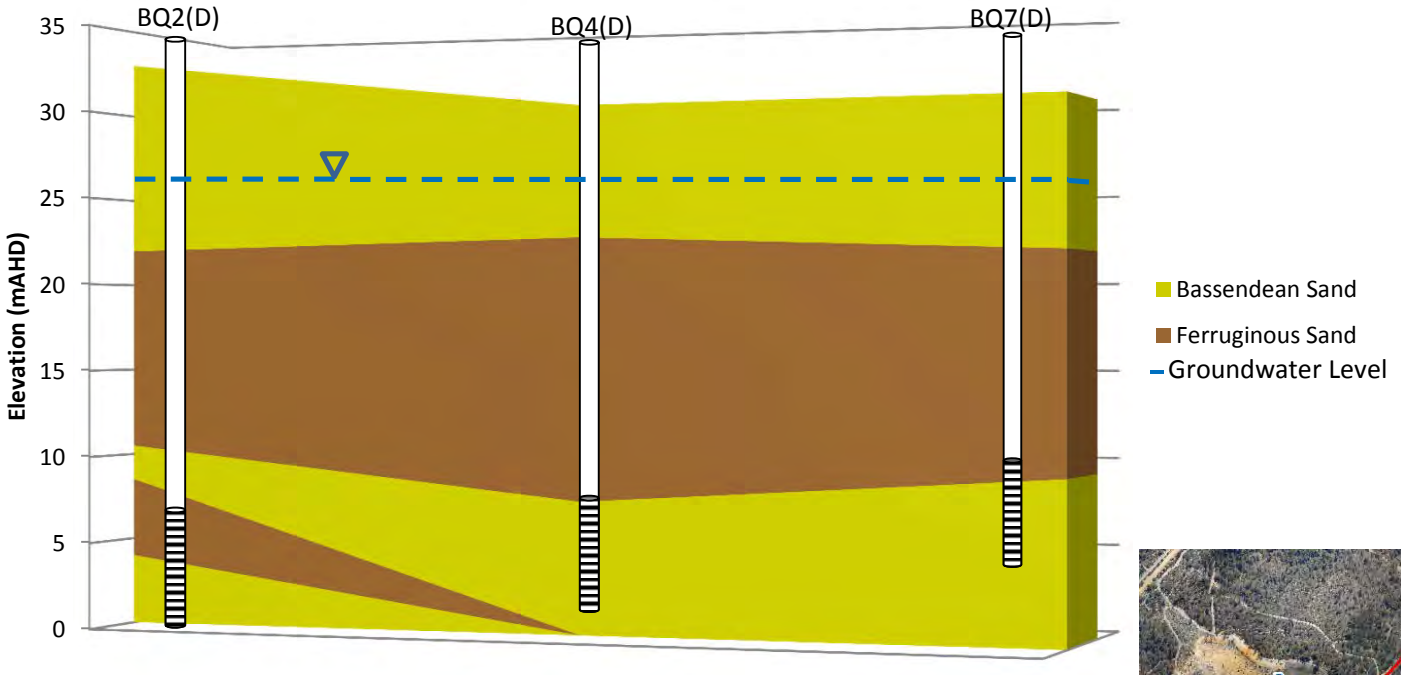
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Figure B3: Hydrogeological Cross-section C

Cross Section D





Job No. J5248

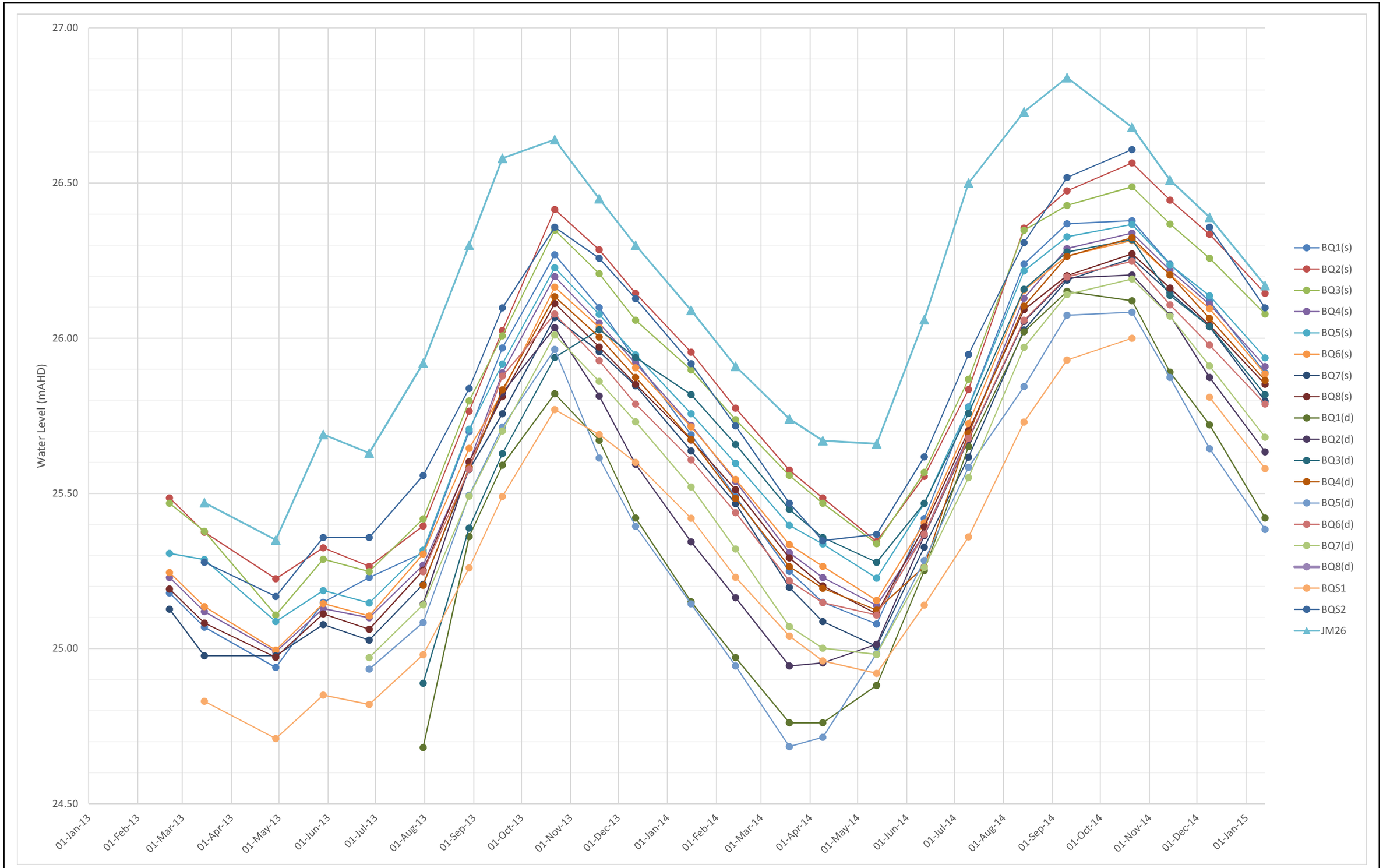
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Figure B4: Hydrogeological Cross-section D

APPENDIX D

Monitoring Bore Time Series and Lithological Logs



Data Source:

Job No. J5248

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Perron Developments Pty Ltd

Lot 4 Armadale Rd, Banjup - Pre-Development Monitoring 2013 - 2014

Groundwater Levels 2013 & 2014

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Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup Groundwater Investigation	Hole commenced:	6/02/2013
Bore location:	394389E 6444478N	Hole completed:	6/02/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ1(S)	Total Depth:	7.5 m
Drill type:	Hollow Auger	R.L. TOC:	30.79 mAHD
Hole diameter:	300 mm	Natural Surface:	30.10 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
0.5m			sand	light grey		fine to medium	moderately	sub-rounded		
1.0m				cream						
1.5m										
2.0m										Bassendean Sand
2.5m				light brown						
3.0m									silt	
3.5m				dark cream						
4.0m										
4.5m				white						
5.0m			ferruginous sand	very dark brown	10yr 2/2				non-cemented	ferruginous sand
5.5m				black	10yr 2/1					
6.0m				dark grey					silt	Bassendean Sand
6.5m										
7.0m				light grey						
7.5m			ferruginous sand	brown	10yr 5/3				non-cemented	ferruginous sand
										EOH

Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	9/07/2013
Bore location:	394389E 6444478N	Hole completed:	10/07/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ1 (D)	Total Depth:	40.5 m
Drill type:	Air rotary	R.L. TOC:	30.64 mAHD
Hole diameter:	90 mm	Natural Surface:	30.06 mAHD

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG							
			LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
2.5m			sand	yellow/ brown		fine to medium	well	sub-rounded		Bassendean Sand
				cream						
				light grey						
				cream						
				pale yellow						
5.0m				yellow			moderately			
				dark brown						
				grey						
				light grey		medium				
7.5m			ferruginous sand	brown	10yr 5/3					ferruginous sand
				light yellowish brown	10yr 6/4					
				brown	10yr 4/3					
10.0m				dark yellowish brown	10yr 3/4	fine to medium			semi-cemented	
									cemented	
12.5m				dark yellowish brown	10yr 4/4					
				very dark greyish brown	10yr 3/2					
15.0m				black	10yr 2/1					
				dark yellowish brown	10yr 3/4	medium				
17.5m				very dark greyish brown	10yr 3/2					
20.0m				dark yellowish brown	10yr 4/4	medium to coarse				
			sand	grey		fine	well		silt	Bassendean Sand
22.5m				white		fine to medium	moderately			
25.0m				grey		medium				
				light grey						
27.5m				dark grey		coarse	poor			Gnangara Sand
						coarse to gravel			pebbles up to 60mm, quartizite and grey quartzite	
30.0m				grey		coarse				
						fine to coarse			minor clay	
32.5m			sand	grey		fine to coarse	moderately	well rounded	minor clay/silt, minimal shell fragments	Ascot Formation
35.0m				dark grey		fine to medium				
37.5m										
40.0m										EOH
42.5m										

Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client: Perron Developments
Project: Banjup groundwater investigation
Bore location: 384577E 6444738N
Datum: GDA (1994) zone 50

Bore Name: BQ2(S)
Drill type: Hollow Auger
Hole diameter: 300 mm

Job No: J5248
Hole commenced: 6/02/2013
Hole completed: 6/02/2013
Logged by: RD

Total Depth: 10.5 m
R.L. TOC: 33.50 mAHD
Natural Surface: 32.86 mAHD

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG: LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
0.0m				grey					organic matter	
0.5m				white						
1.0m				pale yellow						
1.5m				yellow						
2.0m										
2.5m										
3.0m										
3.5m				light yellow						
4.0m										
4.5m				pale yellow						
5.0m			sand			fine to medium	moderatley	sub-rounded		
				cream						Bassendean Sand
5.5m										
6.0m				white					silt	
6.5m										
7.0m				cream						
7.5m										
8.0m				white						
8.5m				cream						
9.0m										
9.5m				white/cream						
10.0m				light grey						
10.5m										EOH

Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client: Perron Developments		Job No:	J5248
Project: Banjup groundwater investigation		Hole commenced:	12/07/2013
Bore location: 384577E 6444738N		Hole completed:	12/07/2013
Datum: GDA (1994) zone 50		Logged by:	RD
Bore Name: BQ2 (D)		Total Depth:	33.0 m
Drill type: Air rotary		R.L. TOC:	33.42 mAHD
Hole diameter: 90 mm		Natural Surface:	32.89 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
2.5m			sand	grey						
				cream		medium	well			
				yellow		fine to medium	moderately			
				light yellow						
5.0m				pale yellow		fine	moderately to well	sub-rounded		Bassendean Sand
				white						
7.5m										
10.0m				grey						
				white		medium				
			ferruginous sand	very dark brown	10yr 2/2	fine to medium	moderately		minor cementing	ferruginous sand
12.5m				dark brown	10yr 3/3				cemented layers	
				dark yellowish brown	10yr 4/4					
				yellowish brown	10yr 5/4	medium	well	rounded		
15.0m				light yellowish brown	10yr 6/4	fine to coarse	poor	sub-rounded	minor cementing	
				yellowish brown	10yr 5/4	fine to medium	moderately			
				dark yellowish brown	10yr 3/4				minor cementing	
				light yellowish brown	10yr 6/4	fine to coarse	poor			
17.5m				dark yellowish brown	10yr 3/4	fine to medium	moderately			
				yellowish brown	10yr 5/4	fine to coarse	poor			
				dark yellowish brown	10yr 4/4	fine to medium	moderately			
20.0m				yellowish brown	10yr 5/4	fine	moderately to well	sub-rounded to rounded		
				light brownish grey	10yr 6/2					
22.5m				pale grey						
				grey		fine to medium	moderately	sub-rounded	minor clay	Bassendean Sand
				white/grey		medium to coarse				
25.0m			ferruginous sand	dark yellowish brown	10yr 3/4	fine to coarse				
				light brownish grey	10yr 6/2	fine	poor			ferruginous sand
				yellowish brown	10yr 5/4		well	rounded		
27.5m				light yellowish brown	10yr 6/4	fine to medium	moderately	sub-rounded		
30.0m			sand	grey		fine	moderately to well	sub-rounded to rounded	minor clay	Bassendean Sand
				dark grey						
32.5m				grey		fine to medium	moderately	sub-rounded		EOH
35.0m										

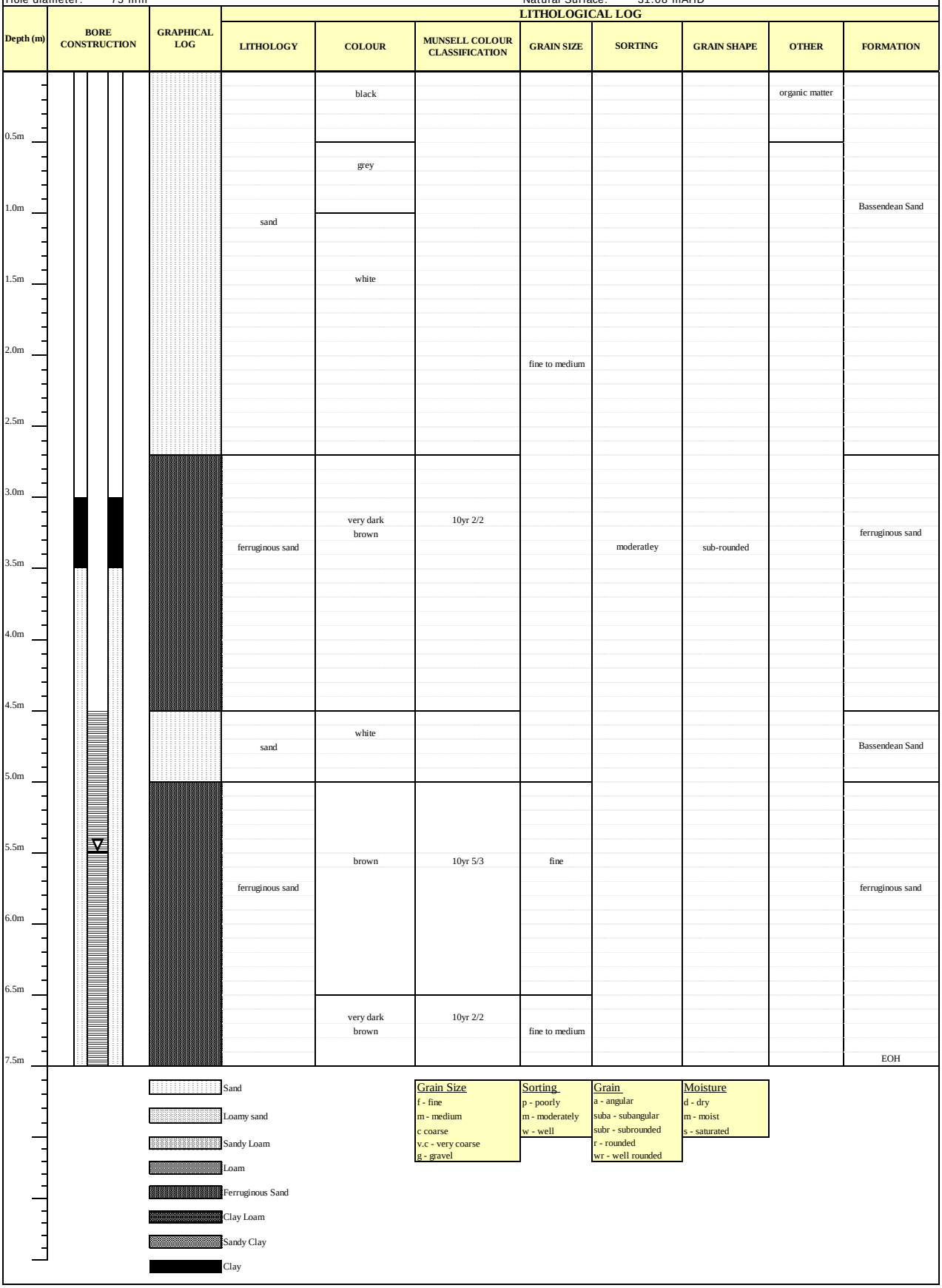
Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	5/02/2013
Bore location:	394856E 6445003N	Hole completed:	5/02/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ3(S)	Total Depth:	7.5 m
Drill type:	Push Probe	R.L. TOC:	31.84 mAHD
Hole diameter:	75 mm	Natural Surface:	31.08 mAHD



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LITHOLOGICAL LOG

Client: Perron Developments		Job No:	J5248
Project: Banjup groundwater investigation		Hole commenced:	11/07/2013
Bore location: 394856E 6445003N		Hole completed:	11/07/2013
Datum: GDA (1994) zone 50		Logged by:	RD
Bore Name: BQ3 (D)		Total Depth:	28.5 m
Drill type: Air rotary		R.L. TOC:	31.83 mAHD
Hole diameter: 90 mm		Natural Surface:	31.24 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
2.5m			sand	grey		fine to medium	well	sub-rounded	organic matter	Bassendean Sand
				light grey						
				white						
			ferruginous sand	dark yellowish brown	10yr 4/4		moderately		cemented	ferruginous sand
				light yellowish brown	10yr 6/4		well			
				dark greyish brown	10yr 4/2		moderately			
5.0m			sand	grey		fine				Bassendean Sand
				cream						
				light brownish grey	10yr 6/2					ferruginous sand
				pale brown	10yr 6/3	fine to medium				
7.5m				dark cream		medium	poor		minor clay	Bassendean Sand
				grey						
				very pale brown	10yr 7/3					
				very dark brown	10yr 2/2				minor cementing	
10.0m				dark yellowish brown	10yr 3/4	fine to coarse				
12.5m				dark brown	10yr 3/3					
				dark yellowish brown	10yr 4/4					
15.0m			ferruginous sand	dark brown	10yr 3/3	fine to medium	moderately			ferruginous sand
17.5m				very dark greyish brown	10yr 2/3					
				dark brown	10yr 3/3					
20.0m				dark yellowish brown	10yr 3/4					
22.5m				dark yellowish brown	10yr 4/4	fine				
				dark yellowish brown	10yr 3/4	fine to medium				
25.0m				white						
			sand	cream		fine	well	rounded	minor clay	Bassendean Sand
27.5m				white		fine to medium	moderately			
				cream		fine	well		minor clay	EOH
30.0m										

Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	6/02/2013
Bore location:	394847E 6444640N	Hole completed:	6/02/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ4(S)	Total Depth:	6.5 m
Drill type:	Hollow Auger	R.L. TOC:	30.72 mAHD
Hole diameter:	300 mm	Natural Surface:	30.00mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
0.0m				black					organic matter	
			sand							
0.5m				yellow						bassendean sands
			ferruginous sands	brown	10yr 5/3				non-cemented	ferruginous sands
1.0m										
1.5m				yellow						
2.0m										
			sand							
2.5m						fine to medium	moderatley	sub-rounded		Bassendean Sand
3.0m										
3.5m										
				white						
4.0m										
4.5m										
5.0m										
5.5m										
6.0m										
6.5m										
7.0m										
7.5m										
8.0m			ferruginous sand	very dark brown	10yr 2/2	fine to medium	well	sub-rounded	semi-cemented / cemented / backfilled	ferruginous sand
8.5m										
9.0m										
9.5m										
10.0m										EOH

Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size
f - fine
m - medium
c coarse
v.c - very coarse
g - gravel

Sorting
p - poorly
m - moderately
w - well

Grain Shape
a - angular
suba - subangular
subr - subrounded
r - rounded
wr - well rounded

Moisture
d - dry
m - moist
s - saturated

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LITHOLOGICAL LOG

Client: Perron Developments		Job No:	J5248
Project: Banjup groundwater investigation		Hole commenced:	10/07/2013
Bore location: 394847E 6444640N		Hole completed:	10/07/2013
Datum: GDA (1994) zone 50		Logged by:	RD
Bore Name: BQ4 (D)		Total Depth:	27.0 m
Drill type: Air rotary		R.L. TOC:	30.67 mAHD
Hole diameter: 90 mm		Natural Surface:	30.00 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
2.5m			sand	dark cream		fine to medium	moderately	sub-rounded	organic matter	Bassendean Sand
				brown/gold						
				light yellow						
				pale yellow						
5.0m	▽			white		fine	well			
7.5m				light brown		medium to coarse	poor			
				very dark grey	10yr 3/1	fine to medium	moderately			
10.0m				very dark brown	10yr 2/2					
				very dark greyish brown	10yr 3/2					
				black	10yr 2/1	medium	moderately to well	sub-rounded to rounded		
12.5m			ferruginous sand	very dark greyish brown	10yr 3/2	fine to medium	moderately	sub-rounded	minor cementing	ferruginous sand
15.0m				brown	10yr 4/3				cemented	
				very dark greyish brown	10yr 3/2					
17.5m				dark yellowish brown	10yr 3/4					
20.0m				light yellowish brown	10yr 6/4	fine	well			
22.5m			sand	light grey				sub-rounded to rounded		Bassendean Sand
						fine to medium	moderately	sub-rounded		
25.0m				grey		fine	well	sub-rounded to rounded	minor clay	EOH
27.5m										

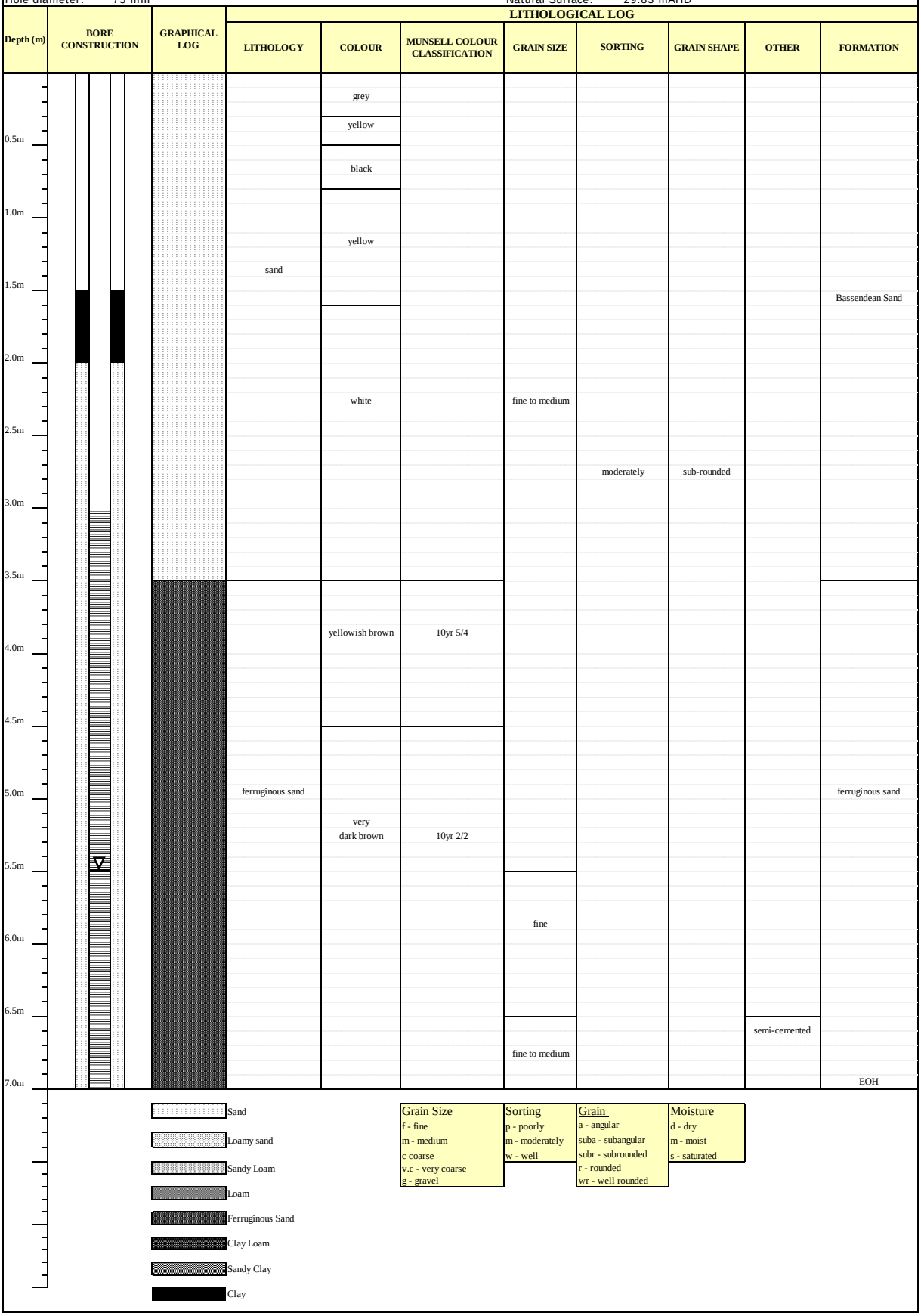
Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	5/02/2013
Bore location:	395076E 6444936N	Hole completed:	5/02/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ5(s)	Total Depth:	7.0 m
Drill type:	Push Probe	R.L. TOC:	30.41 mAHD
Hole diameter:	75 mm	Natural Surface:	29.83 mAHD



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LITHOLOGICAL LOG

Client: Perron Developments		Job No:	J5248
Project: Banjup groundwater investigation		Hole commenced:	11/06/2013
Bore location: 395076E 6444936N		Hole completed:	13/06/2013
Datum: GDA (1994) zone 50		Logged by:	RD
Bore Name: BQ5 (D)		Total Depth:	47.5 m
Drill type: Air rotary		R.L. TOC:	30.41 mAHD
Hole diameter: 90 mm		Natural Surface:	29.89 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
2.5m			sand	black		fine to medium	well			Bassendean Sand
				grey						
				pale yellow						
				yellow						
				white						
5.0m				yellowish brown	10yr 5/4	fine	moderate		cemented	ferruginous sand
						fine to coarse	poor to moderate		cemented	
7.5m				very dark brown	10yr 2/2				cemented	
10.0m			ferruginous sand			fine to medium	moderate			
				dark greyish brown	10yr 4/2					
12.5m				brown	10yr 5/3				thin layer cemented 13.5-14m	
15.0m								sub-rounded		
						fine to coarse	poor		'high yielding'	
17.5m				pale brown	10yr 6/3				thin cemented, 10yr 2/2, very dark brown	
				dark greyish brown	10yr 4/2					
				yellowish brown	10yr 5/6				highly cemented, 10yr 2/2, very dark brown	
20.0m				yellowish brown	10yr 5/4					
				pale brown	10yr 6/3	fine to medium	moderate			
22.5m				dark yellow					thin shale layer (black) present between 22.5-23.0m and 24.5-25.0m (photo)	Bassendean Sand
25.0m										
				dark grey			well		minor clay	
27.5m				light grey		fine to very coarse			feldspar	Gnangara Sand
30.0m			sand			fine to gravel			minimal feldspar	
				grey					feldspar	
32.5m				dark grey		fine to very coarse		sub-rounded to rounded	minor limestone	
35.0m				grey		medium to gravel	poor	sub-rounded	sandstone with calcrete lenses	Ascot Formation
37.5m				grey/ green tinge				angular to sub-rounded	very hard layer, shells present limestone large shells	
40.0m									small shell fragments	
42.5m						fine to coarse		sub-rounded		
45.0m			sand	dark grey		fine to very coarse		sub-angular	crushed shell some shale present	
						fine to gravel			shells	
47.5m			sandy clay			fine to coarse			minimal shell	
			clay	black		fine	well		shale	Kardinya Shale
										EOH

Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	6/02/2013
Bore location:	395239E 6444801N	Hole completed:	6/02/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ6(S)	Total Depth:	6.5 m
Drill type:	Hollow Auger	R.L. TOC:	30.42 mAHD
Hole diameter:	300 mm	Natural Surface:	29.70 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
0.5m				grey						
1.0m				cream						
1.5m				pale yellow					silt	
2.0m				yellow						Bassendean Sand
2.5m			sand							
3.0m				dark yellow						
3.5m				pale yellow		fine to medium	moderately	sub-rounded		
4.0m				cream						
4.5m			ferruginous sand	pale brown	10yr 6/3					ferruginous sand
5.0m	▽		sand	cream					silt	Bassendean Sand
5.5m				very dark grey	10yr 3/1					
6.0m			ferruginous sand	very dark brown	10yr 4/2					ferruginous sand
6.5m										EOH

Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	17/07/2013
Bore location:	395239E 6444801N	Hole completed:	17/07/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ6 (D)	Total Depth:	28.5 m
Drill type:	Air rotary	R.L. TOC:	30.40 mAHD
Hole diameter:	90 mm	Natural Surface:	29.77 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATIONS
2.5m			sand	cream		fine to medium	moderately			Bassendean Sand
				yellow		fine				
				pale yellow		fine to medium				
				cream		fine	well		silt	
5.0m			ferruginous sand	very dark grey	10yr 3/1					ferruginous sand
				dark greyish brown	10yr 4/2	medium	moderately	sub-rounded		
				very dark brown	10yr 2/2	fine	well			
7.5m				very dark greyish brown	10yr 3/2	fine to coarse	poor		minor cementing, 10yr 3/2, very dark greyish brown	
				dark yellowish brown	10yr 4/4					
				dark greyish brown	10yr 4/2	medium	moderately			
				yellowish brown	10yr 5/4	fine	well			
				pale brown	10yr 6/3	medium to coarse	moderately			
10.0m				brown	10yr 5/3	fine to coarse	poor			
				dark yellowish brown	10yr 3/4	fine to medium	moderately		minor cementing	
12.5m				white		coarse				
				brown	10yr 5/3	fine to medium				
				brown	10yr 4/3					
				pale brown	10yr 6/3	fine to coarse	poor		minor cementing, 10yr 2/2, very dark brown	
15.0m				brown	10yr 5/3	fine to medium	well	sub-rounded to rounded		
17.5m			sand	light grey	10yr 7/2	medium				Bassendean Sand
						coarse		rounded		
20.0m			ferruginous sand	brown	10yr 5/3	medium	moderately		minor cementing, 10yr 2/2, very dark brown	ferruginous sand
				dark yellowish brown	10yr 4/4	fine to medium				
						fine	well			
22.5m				yellowish brown	10yr 5/4	fine to medium	poor			
				pale brown	10yr 6/3	medium to coarse		sub-rounded		
			clay	grey/brown		fine	well			Bassendean Sand
25.0m			sand	grey		medium				
						fine			minor clay	
						fine to medium	moderately			
27.5m						medium to very coarse	poor			Gnangara Sand
30.0m										

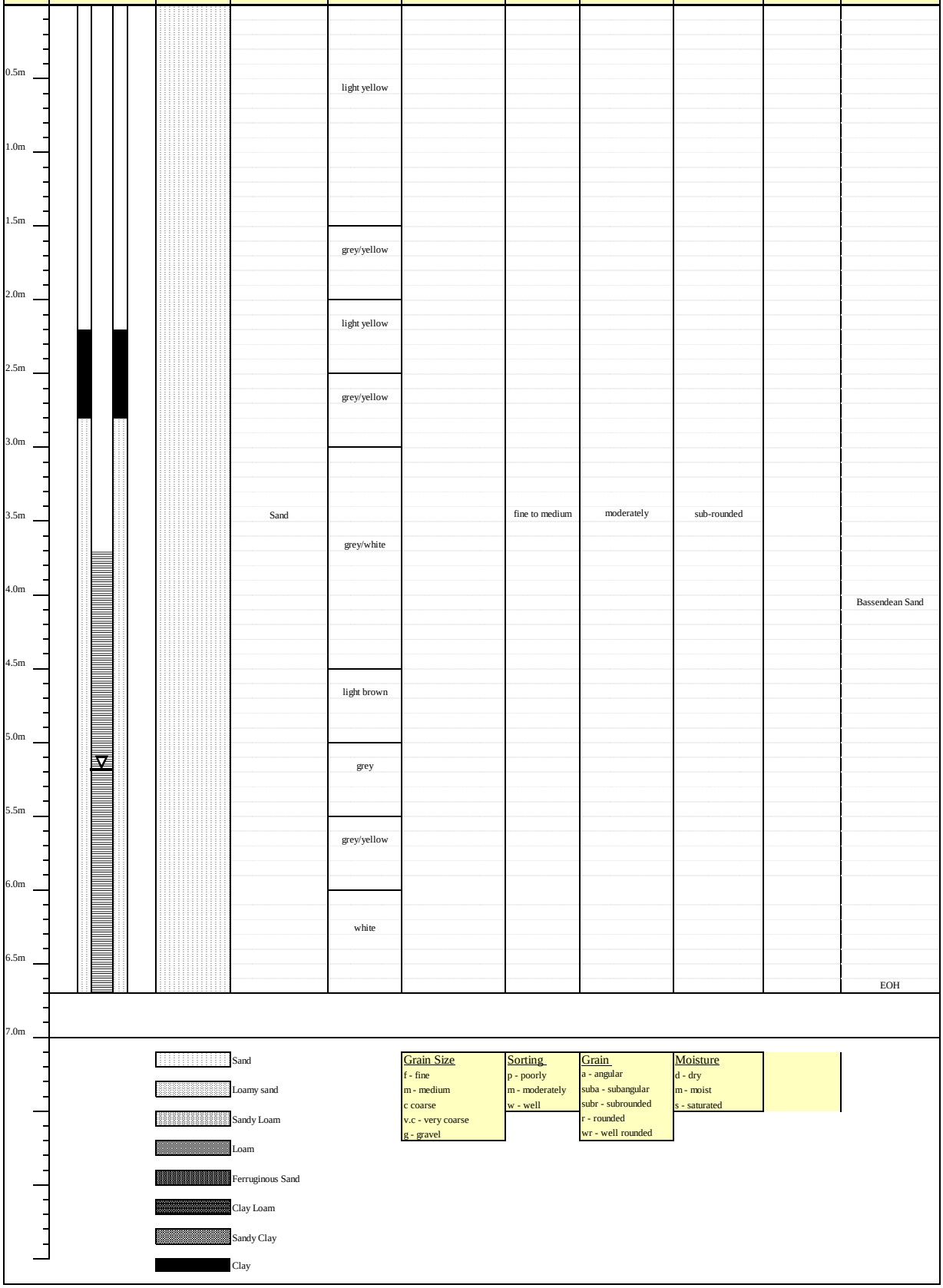
Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
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LITHOLOGICAL LOG

Client:	Perron	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	6/02/2013
Bore location:	395235E 6444479N	Hole completed:	6/02/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ7(S)	Total Depth:	6.7 m
Drill type:	Hollow Auger	R.L. TOC:	30.84 mAHD
Hole diameter:	300 mm	Natural Surface:	30.12 mAHD



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LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	14/06/2013
Bore location:	395235E 6444479N	Hole completed:	14/06/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ7 (D)	Total Depth:	24.5 m
Drill type:	Air rotary	R.L. TOC:	30.69 mAHD
Hole diameter:	90 mm	Natural Surface:	30.17 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
2.5m			sand	grey light yellow yellow grey light brown						Bassendean Sand
5.0m				pale yellow white		fine to medium	well			
7.5m				grey					silt	
				dark grey				sub-rounded		
10.0m				very dark greyish brown dark brown brown	10yr 3/2 10yr 3/3 10yr 4/3		moderately		minor cementing cemented	
12.5m				brown pale brown brown	10yr 5/3 10yr 6/3 10yr 5/3	fine to coarse fine to medium	poor moderately		minor cementing	
15.0m			ferruginous sand	brown	10yr 4/3	fine to coarse	poor			ferruginous sand
17.5m				brown	10yr 5/3	fine to medium	moderately			
20.0m				brown pale brown	10yr 4/3 10yr 6/3	fine to coarse	poor			
22.5m			sand	white				sub-angular to sub-rounded	feldspar	Bassendean Sand
25.0m										EOH

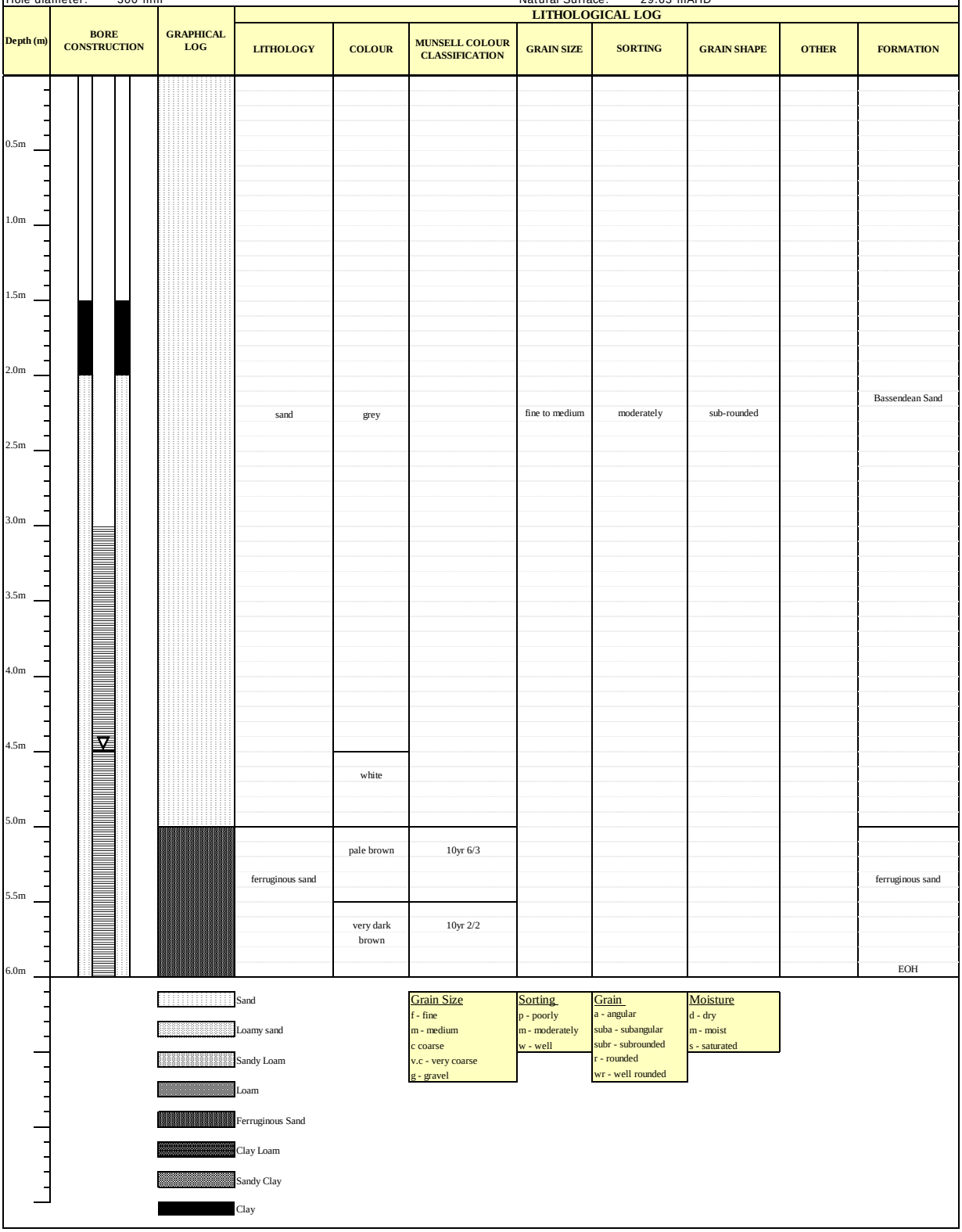
Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
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c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

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LITHOLOGICAL LOG

Client:	Perron Developments	Job No:	J5248
Project:	Banjup groundwater investigation	Hole commenced:	6/02/2013
Bore location:	395378E 6444700N	Hole completed:	6/02/2013
Datum:	GDA (1994) zone 50	Logged by:	RD
Bore Name:	BQ8(S)	Total Depth:	6.0 m
Drill type:	Hollow Auger	R.L. TOC:	30.25 mAHD
Hole diameter:	300 mm	Natural Surface:	29.63 mAHD



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LITHOLOGICAL LOG

Client: Perron Developments		Job No:	J5248
Project: Banjup groundwater investigation		Hole commenced:	19/07/2013
Bore location: 395378E 6444700N		Hole completed:	19/07/2013
Datum: GDA (1994) zone 50		Logged by:	RD
Bore Name: BQ8 (D)		Total Depth:	25.5 m
Drill type: Air rotary		R.L. TOC:	30.28 mAHD
Hole diameter: 90 mm		Natural Surface:	29.68 mAHD

LITHOLOGICAL LOG

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGY	COLOUR	MUNSELL COLOUR CLASSIFICATION	GRAIN SIZE	SORTING	GRAIN SHAPE	OTHER	FORMATION
2.5m			sand	grey		fine to medium	poor	sub-rounded		Bassendean Sand
				light grey		medium	moderately			
				dark cream		fine				
				cream			well			
5.0m	▽			white/grey		fine to coarse	poor	sub-angular		
			ferruginous sand	very dark brown	10yr 2/2	fine to medium	moderately		highly cemented	ferruginous sand
7.5m						fine				
						fine to medium			minor cementing, 10yr 2/2, very dark brown	
				brown	10yr 4/3					
10.0m				dark yellowish brown	10yr 3/4					
				brown	10yr 4/3					
12.5m			sand	light grey	10yr 7/1	fine	moderate to well	sub-rounded		Bassendean Sand
			ferruginous sand	light brownish grey	10yr 6/2		moderately			ferruginous sand
				pale brown	10yr 6/3					
				brown	10yr 5/3	fine to medium	well			
15.0m						fine				
						fine to medium	moderately		minor cementing, 10yr 2/2, very dark brown	
17.5m				dark brown	10yr 3/3					
20.0m			sand	white		fine to medium	moderate to well			Bassendean Sand
				cream		fine	well		minor clay	
				white/grey						
				cream					minor clay	
22.5m				grey/cream						
				grey/yellow					silt	
				grey		medium				
25.0m						medium to coarse	moderately			Gnangara Sand
						fine to very coarse	poor			EOH
27.5m										

Sand
Loamy sand
Sandy Loam
Loam
Ferruginous Sand
Clay Loam
Sandy Clay
Clay

Grain Size	Sorting	Grain Shape	Moisture
f - fine	p - poorly	a - angular	d - dry
m - medium	m - moderately	suba - subangular	m - moist
c coarse	w - well	subr - subrounded	s - saturated
v.c - very coarse		r - rounded	
g - gravel		wr - well rounded	

APPENDIX E

Pre-Development Groundwater
and Lake Water Quality

Water Quality List of Analytes		
	Parameter	**Results Summary** **(Results less than PQL not displayed in Tables)**
Physicochemical	pH	Table C1
	Total Alkalinity	"
	EC (us/cm)	Table C2
	TDS (mg/l)	"
Nutrients	Total Nitrogen (TN) (mg/L)	Table C3
	Total Kjeldahl Nitrogen (TKN) (mg/L)	"
	Nitrogen Oxides (No_x-N) (mg/L)	Table C4
	Ammonia (NH3_N) (mg/L)	"
	Total Phosphorus (TP) (mg/L)	Table C5
	PO4-P (mg/L)	"
Metals	Silver (Ag) (mg/L)	All values less than PQL
	Aluminium (Al) (mg/L)	Table C6
	Arsenic (As) (mg/L)	"
	Boron (B) (mg/L)	Table C7
	Barium (Ba) (mg/L)	"
	Cadmium (Cd) (mg/L)	Table C8
	Chromium (VI) (CR+6) (mg/L)	"
	Copper (Cu) (mg/L)	Table C9
	Mercury (Hg) (mg/L)	All values less than PQL
	Manganese (Mn) (mg/L)	Table C9
	Molybdenum (Mo) (mg/L)	Table C10
	Nickel (Ni) (mg/L)	"
	Lead (Pb) (mg/L)	Table C11
	Uranium (U) (mg/L)	"
	Zinc (Zn) (mg/L)	Table C12
	Iron (Fe) (mg/L)	"
	Selenium (Se (mg/L)	Table C13
Anions	Chloride (mg/L)	Table C14
	Sulphate (mg/L)	"
	Fluoride (mg/L)	All values less than PQL
	Bicarbonate (mg/L)	Table C15
	Total Cyanide (mg/L)	All values less than PQL
	Iodide (mg/L)	All values less than PQL
	Nitrate (mg/L)	Table C15
	Nitrite (mg/L)	All values less than PQL
	Hydroxide (mg/L)	Table C16
	Hardness (mg/L)	"
Cations	Sodium (mg/L)	Table C17
	Potassium (mg/L)	"
	Calcium (mg/L)	Table C18
	Magnesium (mg/L)	"

	Parameter	Results Summary (Results less than PQL not displayed in Tables)
Hydrocarbons	TRH C6 - C9 (µg/L)	All values less than PQL
	TRH C6 - C10 (µg/L)	All values less than PQL
	TRH C6-C10 less BTEX (F1) (µg/L)	All values less than PQL
	Benzene (µg/L)	All values less than PQL
	Toluene (µg/L)	All values less than PQL
	Ethylbenzene (µg/L)	All values less than PQL
	m+p-xylene (µg/L)	All values less than PQL
	o-xylene (µg/L)	All values less than PQL
	Naphthalene (µg/L)	All values less than PQL
	Surrogate Dibromofluoromethane (%)	Table C19
	Surrogate toluene-d8 (%)	"
	Surrogate 4-BFB (%)	Table C20
	TRH C10 - C14 (µg/L)	All values less than PQL
	TRH C15 - C28 (µg/L)	Table C20
	TRH C29 - C36 (µg/L)	All values less than PQL
	TRH >C10 - C16 (µg/L)	All values less than PQL
	TRH >C10-C16 less N (F2) (µg/L)	All values less than PQL
	TRH >C16 - C34 (µg/L)	Table C21
	TRH >C34 - C40 (µg/L)	All values less than PQL
Volatile/ Aromatic Organic Compound (VOC)	MTBE (µg/L)	All values less than PQL
	Dichlorodifluoromethane (µg/L)	All values less than PQL
	Chloromethane (µg/L)	All values less than PQL
	Vinyl Chloride (µg/L)	All values less than PQL
	Bromomethane (µg/L)	All values less than PQL
	Chloroethane (µg/L)	All values less than PQL
	Trichlorofluoromethane (µg/L)	All values less than PQL
	1,1-Dichloroethene (µg/L)	All values less than PQL
	Trans-1,2-Dichloroethene (µg/L)	All values less than PQL
	1,1-dichloroethane (µg/L)	All values less than PQL
	Cis-1,2-dichloroethene (µg/L)	All values less than PQL
	Bromochloromethane (µg/L)	All values less than PQL
	Chloroform (µg/L)	All values less than PQL
	2,2-dichloropropane (µg/L)	All values less than PQL
	1,2-dichloroethane (µg/L)	All values less than PQL
	1,1,1-trichloroethane (µg/L)	All values less than PQL
	1,1-dichloropropene (µg/L)	All values less than PQL
	Cyclohexane (µg/L)	All values less than PQL
	Carbon tetrachloride (µg/L)	All values less than PQL
	Benzene (µg/L)	All values less than PQL
	Dibromomethane (µg/L)	All values less than PQL
	1,2-dichloropropane (µg/L)	All values less than PQL
	Trichloroethene (µg/L)	All values less than PQL
	Bromodichloromethane (µg/L)	All values less than PQL
	trans-1,3-Dichloropropene (µg/L)	All values less than PQL
	cis-1,3-Dichloropropene (µg/L)	All values less than PQL
	1,1,2-Trichloroethane (µg/L)	All values less than PQL
	Toluene (µg/L)	All values less than PQL

	Parameter	Results Summary (Results less than PQL not displayed in Tables)
Volatile/ Aromatic Organic Compound (VOC)	1,3-dichloropropane (µg/L)	All values less than PQL
	Dibromochloromethane (µg/L)	All values less than PQL
	Tetrachloroethene (µg/L)	All values less than PQL
	1,1,1,2-tetrachloroethane (µg/L)	All values less than PQL
	Chlorobenzene (µg/L)	All values less than PQL
	Ethylbenzene (µg/L)	All values less than PQL
	Bromoform (µg/L)	All values less than PQL
	m+p-Xylene (µg/L)	All values less than PQL
	Styrene (µg/L)	All values less than PQL
	1,1,2,2-Tetrachloroethane (µg/L)	All values less than PQL
	o-Xylene (µg/L)	All values less than PQL
	1,2,3-Trichloropropane (µg/L)	All values less than PQL
	Isopropylbenzene (µg/L)	All values less than PQL
	Bromobenzene (µg/L)	All values less than PQL
	n-Propyl benzene (µg/L)	All values less than PQL
	2-Chlorotoluen (µg/L)	All values less than PQL
	1,3,5-Trimethyl benzene (µg/L)	All values less than PQL
	Tert-butyl benzene (µg/L)	All values less than PQL
	1,2,4-Trimethyl benzene (µg/L)	All values less than PQL
	1,2-Dichlorobenzene (µg/L)	All values less than PQL
	1,3-Dichlorobenzene, µg/L	All values less than PQL
	1,4-Dichlorobenzene, µg/L	All values less than PQL
	1,2,3-trichlorobenzene (µg/L)	All values less than PQL
	1,2,4-Trichlorobenzene (µg/L)	All values less than PQL
	Sec-butyl benzene (µg/L)	All values less than PQL
	4-Isopropyl toluene (µg/L)	All values less than PQL
	n-butyl benzene (µg/L)	All values less than PQL
	Hexachlorobutadiene (µg/L)	All values less than PQL
	Surrogate Dibromofluoromethane (%)	Table C22
	Surrogate toluene-d8 (%)	"
	Surrogate 4-BFB (%)	Table 23
Polycyclic Aromatic Hydrocarbons (PAH)	Naphthalene (µg/L)	All values less than PQL
	Acenaphthylene (µg/L)	All values less than PQL
	Acenaphthene (µg/L)	All values less than PQL
	Fluorene (µg/L)	Table C24
	Phenanthrene (µg/L)	"
	Anthracene (µg/L)	All values less than PQL
	Fluoranthene (µg/L)	All values less than PQL
	Pyrene (µg/L)	All values less than PQL
	Benzo(a)anthracene (µg/L)	All values less than PQL
	Chrysene (µg/L)	All values less than PQL
	Benzo(b+k)fluoranthene (µg/L)	All values less than PQL
	Benzo(a)pyrene (µg/L)	All values less than PQL
	Benzo(a)pyrene TEQ (µg/L)	All values less than PQL
	Indeno(1,2,3-c,d)pyrene (µg/L)	All values less than PQL
	Benzo(g,h,i)perylene (µg/L)	All values less than PQL
	Dibenzo(a,h)anthracene (µg/L)	All values less than PQL
	p-Terphenyl-D14 (%)	Table C25

	Parameter	Results Summary (Results less than PQL not displayed in Tables)
Organochlorine (OCP)	Aldrin (µg/L)	All values less than PQL
	alpha-BHC (µg/L)	All values less than PQL
	beta-BHC (µg/L)	All values less than PQL
	delta-BHC (µg/L)	All values less than PQL
	alpha-Chlordane (µg/L)	All values less than PQL
	gamma-Chlordane (µg/L)	All values less than PQL
	Dieldrin (µg/L)	All values less than PQL
	Endosulfan I (µg/L)	All values less than PQL
	Endosulfan II (µg/L)	All values less than PQL
	Endosulfan Sulphate (µg/L)	All values less than PQL
	Endrin (µg/L)	All values less than PQL
	Hexachlorobenzene (HCB) (µg/L)	All values less than PQL
	Heptachlor Epoxide (µg/L)	All values less than PQL
	Heptachlor (µg/L)	All values less than PQL
	Lindane (gamma-BHC) (µg/L)	All values less than PQL
	Methoxychlor (µg/L)	All values less than PQL
	pp-DDD (µg/L)	All values less than PQL
	pp-DDE (µg/L)	All values less than PQL
	pp-DDT (ug/L)	All values less than PQL
	op-DDT (µg/L)	All values less than PQL
	Endrin Aldehyde (µg/L)	All values less than PQL
Organophosphate Pesticides (OPP)	Azinphos-methyl (µg/L)	All values less than PQL
	Chlorpyrifos (µg/L)	All values less than PQL
	Diazinon (µg/L)	All values less than PQL
	Dimethoate (µg/L)	All values less than PQL
	Fenitrothion (µg/L)	All values less than PQL
	Malathion (µg/L)	All values less than PQL
	Parathion-methyl (µg/L)	All values less than PQL
	Parathion-ethyl (µg/L)	All values less than PQL
	Ethion (µg/L)	All values less than PQL
	Bromophos Ethyl (µg/L)	All values less than PQL
	Bromophos Ethylp-Terphenyl-D14 (%)	Table C26

Field pH										
PQL (mg/L): NA, ADWG Value (mg/L): 6.5 to 8.5 (Aesthetic)										
Sampling Date	21-Feb-13	29-Apr-13	31-Jul-13	22-Oct-13	16-Jan-14	09-Apr-14	10-Jul-14	21-Oct-14	Min	Max
BQ1(s)		6.12	6.51	5.90	6.550	6.66	6.70	5.38	5.38	6.70
BQ2(s)		5.37	4.94	4.85	5.090	5.30	5.00	4.70	4.70	5.37
BQ3(s)		4.60	4.08	3.89	4.040	5.38	4.57	3.72	3.72	5.38
BQ4(s)		5.83	6.01	5.59	5.700	6.30	6.96	4.23	4.23	6.96
BQ5(s)		5.43	4.30	4.10	4.050	4.99	4.33	4.05	4.05	5.43
BQ6(s)		5.44	5.05	6.59	5.730	5.52	5.63	5.96	5.05	6.59
BQ7(s)		6.88	6.27	6.74	6.720	6.45	7.23	6.33	6.27	7.23
BQ8(s)		6.68	6.25	6.83	6.540	6.73	6.73	6.37	6.25	6.83
BQ1(d)				5.91		5.49		5.01	5.01	5.91
BQ2(d)				5.10		5.11		4.21	4.21	5.11
BQ3(d)				5.27		5.24		4.95	4.95	5.27
BQ4(d)				5.17		5.60		5.24	5.17	5.60
BQ5(d)				7.32		6.79		7.02	6.79	7.32
BQ6(d)				5.37		6.70		5.28	5.28	6.70
BQ7(d)				5.85		5.43		4.55	4.55	5.85
BQ8(d)				5.99		5.89		5.26	5.26	5.99
BQS1		8.340	7.27	7.99		7.15	7.47	6.61	6.61	8.34
BQS2		8.260	7.65	8.26	8.260	6.26	7.84	7.61	6.26	8.26
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Total Alkalinity mg/L										
PQL (mg/L): 5, ADWG Value (mg/L): NA										
Sampling Date	21-Feb-13	29-Apr-13	31-Jul-13	22-Oct-13	16-Jan-14	09-Apr-14	10-Jul-14	21-Oct-14	Min	Max
BQ1(s)			15		11	11	22	14	11	22
BQ2(s)			<5		<5	<5	7	<5	-	7
BQ3(s)			<5		<5	<5	<5	<5	-	-
BQ4(s)			9		14	14	9	<5	-	14
BQ5(s)			<5		<5	<5	<5	<5	-	-
BQ6(s)			<5		11	18	<5	18	-	18
BQ7(s)			62		90	68	77	81	62	90
BQ8(s)			140		130	190	180	170	130	190
BQ1(d)						23		42	23	42
BQ2(d)						<5		<5	-	-
BQ3(d)						52		31	31	52
BQ4(d)						12		10	10	12
BQ5(d)						170		170	170	170
BQ6(d)						12		14	12	14
BQ7(d)						6		<5	-	6
BQ8(d)						14		14	14	14
BQS1			87		95	110	91	77	77	110
BQS2			110		180	180	130	150	110	180
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Field EC (uS/cm)										
PQL (mg/L): 1, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		0.69	0.14	0.12	0.08	0.13	0.10	0.11	0.08	0.69
BQ2(s)		0.26	0.20	0.17	0.12	0.17	0.18	0.04	0.04	0.26
BQ3(s)		1.11	0.88	0.67	0.92	0.53	0.50	0.75	0.50	1.11
BQ4(s)		0.24	0.12	0.21	0.11	0.23	0.04	0.01	0.01	0.24
BQ5(s)		0.22	0.13	0.22	0.25	0.20	0.07	0.11	0.07	0.25
BQ6(s)		0.26	0.25	0.22	0.21	0.21	0.08	0.03	0.03	0.26
BQ7(s)		0.25	0.25	0.23	0.28	0.25	0.14	0.44	0.14	0.44
BQ8(s)		0.58	0.58	0.60	0.56	0.58	0.42	0.82	0.42	0.82
BQ1(d)				0.23		0.26		0.64	0.23	0.64
BQ2(d)				0.18		0.20		0.57	0.18	0.57
BQ3(d)				0.30		0.32		0.18	0.18	0.32
BQ4(d)				0.25		0.30		0.01	0.01	0.30
BQ5(d)				0.95		0.47		0.23	0.23	0.95
BQ6(d)				0.28		0.35		0.14	0.14	0.35
BQ7(d)				0.36		0.37		0.87	0.36	0.87
BQ8(d)				0.19		0.26		0.65	0.19	0.65
BQS1		1.15	0.66	0.99		1.85	0.42	0.65	0.42	1.85
BQS2		1.02	0.63	0.57	0.78	1.03	0.47	2.03	0.47	2.03
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

TDS (mg/L)										
PQL (mg/L): 5, ADWG Value (mg/L): 600 (Aesthetic)										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	86	100		76		82		69	69	100
BQ2(s)	88	100		110		110		110	88	110
BQ3(s)	550	500		380		330		400	380	550
BQ4(s)	160	110		140		130		97	97	160
BQ5(s)	100	66		150		120		200	66	200
BQ6(s)	200	130		150		57		140	57	200
BQ7(s)	210	150		160		150		150	150	210
BQ8(s)	480	320		380		360		310	310	480
BQ1(d)				150		160		160	150	160
BQ2(d)				130		130		110	110	130
BQ3(d)				200		210		210	200	210
BQ4(d)				160		190		170	160	170
BQ5(d)				280		290		280	280	290
BQ6(d)				190		190		180	180	190
BQ7(d)				240		200		210	200	240
BQ8(d)				140		150		140	140	150
BQS1		520		260		510		270	260	520
BQS2		560		300		650		380	300	650
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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TN (mg/L)										
PQL (mg/L): 0.1, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	5.2	4.2	5.2	3.1	3.7	4.1	3.0	2.0	2.0	5.2
BQ2(s)	7.0	7.7	12.0	10.0	11.0	7.5	13.0	11.0	7.0	13.0
BQ3(s)	1.5	1.6	1.2	4.0	5.8	1.3	2.0	2.5	1.2	5.8
BQ4(s)	1.4	1.9	1.0	1.0	1.8	0.3	1.0	1.0	0.3	1.9
BQ5(s)	3.5	1.9	1.0	2.2	4.2	1.2	1.7	3.1	1.0	4.2
BQ6(s)	1.3	1.0	0.2	<0.1	4.6	0.5	0.4	0.1	0.1	4.6
BQ7(s)	4.7	8.0	7.5	7.1	3.9	8.1	4.3	4.7	3.9	8.1
BQ8(s)	23.0	18.0	48.0	41.0	30.0	21.0	18.0	17.0	17.0	48.0
BQ1(d)				0.1		1.5		15.0	0.1	15.0
BQ2(d)				0.5		0.5		0.4	0.4	0.5
BQ3(d)				0.6		33.0		14.0	0.6	33.0
BQ4(d)				0.5		1.0		0.5	0.5	1.0
BQ5(d)				0.2		0.5		0.2	0.2	0.5
BQ6(d)				0.3		0.7		0.3	0.3	0.7
BQ7(d)				0.2		0.4		0.2	0.2	0.4
BQ8(d)				0.2		0.6		0.3	0.2	0.6
BQS1		2.5	1.4	0.6	0.7	2.5	1.6	1.0	0.6	2.5
BQS2		2.6	1.3	0.3	0.6	3.2	1.4	1.2	0.3	3.2
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

TKN (mg/L)										
PQL (mg/L): 0.1, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	0.6	2.0	1.6	1.1	0.2	0.5	0.4	0.4	0.2	2.0
BQ2(s)	0.3	3.1	13.0	<0.1	0.6	1.2	4.6	2.1	-	13.0
BQ3(s)	1.4	1.6	1.2	1.8	2.9	1.2	1.8	2.0	1.2	2.9
BQ4(s)	0.8	1.2	<0.1	0.2	1.7	0.3	0.6	0.2	-	1.7
BQ5(s)	3.5	1.7	1.0	1.2	4.2	1.2	1.4	1.0	1.0	4.2
BQ6(s)	1.3	0.8	0.1	<0.1	4.6	0.4	0.4	<0.1	-	4.6
BQ7(s)	0.4	4.9	0.4	<0.1	0.1	3.0	1.5	0.5	-	4.9
BQ8(s)	2.4	15.0	22.0	17.0	4.3	3.5	12.0	2.4	2.4	22.0
BQ1(d)				<0.1		1.5		15.0	-	15.0
BQ2(d)				0.5		0.5		0.4	0.4	0.5
BQ3(d)				0.6		33.0		14.0	0.6	33.0
BQ4(d)				0.5		1.0		0.5	0.5	1.0
BQ5(d)				0.2		0.5		0.1	0.1	0.5
BQ6(d)				0.3		0.7		0.3	0.3	0.7
BQ7(d)				0.2		0.4		0.2	0.2	0.4
BQ8(d)				0.2		0.6		0.3	0.2	0.6
BQS1		2.5	1.3	0.6	0.7	2.4	1.6	0.9	0.7	2.5
BQS2		2.5	1.3	0.3	0.6	3.2	1.4	1.2	0.3	3.2
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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NOx_N (mg/L)										
PQL (mg/L): 0.005, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	4.700	2.200	3.600	2.100	3.500	3.600	2.700	1.600	1.600	4.700
BQ2(s)	6.700	4.600	13.000	10.000	11.000	6.300	8.400	8.800	4.600	13.000
BQ3(s)	0.160	0.078	0.080	2.200	2.900	0.010	0.200	0.570	0.010	2.900
BQ4(s)	0.620	0.640	1.100	0.780	0.057	0.019	0.490	0.770	0.019	1.100
BQ5(s)	<0.005	0.140	<0.005	0.960	0.069	<0.005	0.280	2.100	-	2.100
BQ6(s)	0.045	0.230	0.026	0.019	0.029	0.034	0.039	0.012	0.012	0.230
BQ7(s)	4.200	3.100	7.100	7.100	3.800	5.100	2.800	4.200	2.800	7.100
BQ8(s)	21.000	3.700	26.000	25.000	25.000	18.000	6.600	14.000	3.700	26.000
BQ1(d)				0.006		0.006		0.014	0.006	0.014
BQ2(d)				<0.005		0.006		<0.005	-	0.006
BQ3(d)				0.023		0.010		0.007	0.007	0.023
BQ4(d)				<0.005		0.010		<0.005	-	0.010
BQ5(d)				0.033		<0.005		<0.005	-	0.033
BQ6(d)				0.012		0.013		<0.005	-	0.013
BQ7(d)				0.012		0.010		<0.005	-	0.012
BQ8(d)				<0.005		0.015		<0.005	-	0.015
BQS1		<0.005	0.051	0.036	0.011	0.027	0.042	0.041	-	0.051
BQS2		0.030	<0.005	0.026	<0.005	<0.005	<0.005	<0.005	-	0.030
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

NH3_N (mg/L)										
PQL (mg/L): 0.005, ADWG Value (mg/L): 0.5 (Aesthetic)										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)			0.080	<0.005	<0.005		<0.005		-	0.080
BQ2(s)			0.070	<0.005	0.080	<0.005	<0.005	<0.005	-	0.080
BQ3(s)			0.260	0.210	0.560	0.150	0.110	0.220	0.110	0.560
BQ4(s)			0.070	<0.005	<0.005		0.010		-	0.070
BQ5(s)			0.320	0.190	0.230		0.130		0.130	0.320
BQ6(s)			0.070	<0.005	<0.005		0.010		-	0.070
BQ7(s)			0.070	<0.005	0.070	<0.005	<0.005	<0.005	-	0.070
BQ8(s)			0.070	<0.005	0.010		<0.005		-	0.070
BQ1(d)				0.100					0.100	0.100
BQ2(d)				0.090		0.080		0.080	0.080	0.090
BQ3(d)				0.390		0.340		0.300	0.300	0.390
BQ4(d)				0.240					0.240	0.240
BQ5(d)				0.170					0.170	0.170
BQ6(d)				0.180					0.180	0.180
BQ7(d)				0.120		0.080		0.110	0.080	0.120
BQ8(d)				0.110					0.110	0.110
BQS1			0.090	<0.005	0.010		0.260		-	0.260
BQS2			0.080	<0.005	<0.005		0.010		-	0.080
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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TP (mg/L)										
PQL (mg/L): 0.01, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	0.03	0.03	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
BQ2(s)	<0.01	0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
BQ3(s)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
BQ4(s)	0.02	0.04	0.01	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
BQ5(s)	<0.01	<0.01	0.01	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
BQ6(s)	0.10	0.03	0.03	<0.01	0.06	<0.05	<0.05	<0.05	-	0.10
BQ7(s)	<0.01	0.01	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
BQ8(s)	0.05	0.01	0.02	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
BQ1(d)				10.00		4.00		9.20	4.00	10.00
BQ2(d)				<0.01		<0.05		<0.05	-	-
BQ3(d)				6.00		6.90		2.80	2.80	6.90
BQ4(d)				0.58		0.21		0.08	0.08	0.58
BQ5(d)				0.06		<0.05		<0.05	-	0.06
BQ6(d)				<0.01		<0.05		<0.05	-	-
BQ7(d)				<0.01		<0.05		<0.05	-	-
BQ8(d)				<0.01		<0.05		<0.05	-	-
BQS1		0.04	0.05	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
BQS2		0.05	0.05	<0.01	<0.01	<0.05	<0.05	<0.05	-	-
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

PO4-P (mg/L)										
PQL (mg/L): 0.005, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ2(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ3(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ4(s)	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.006
BQ5(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ6(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ7(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ8(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ1(d)				0.006		<0.005		<0.005	-	0.006
BQ2(d)				<0.005		<0.005		<0.005	-	-
BQ3(d)				<0.005		<0.005		<0.005	-	-
BQ4(d)				<0.005		<0.005		<0.005	-	-
BQ5(d)				0.033		0.028		0.03	0.028	0.033
BQ6(d)				<0.005		<0.005		<0.005	-	-
BQ7(d)				<0.005		<0.005		<0.005	-	-
BQ8(d)				<0.005		<0.005		<0.005	-	-
BQS1		0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.007
BQS2		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Aluminium (Al) mg/L										
PQL (mg/L): 0.01, ADWG Value (mg/L): 0.2, if Acid-soluble Al (Aesthetic)										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	0.05	0.19	0.02	0.04	0.09	0.06	0.04	0.04	0.02	0.19
BQ2(s)	0.18	0.20	0.30	0.18	0.26	0.35	0.28	0.22	0.18	0.35
BQ3(s)	3.70	3.70	3.10	2.70	4.80	2.00	3.80	2.80	2.00	4.80
BQ4(s)	0.04	0.07	0.04	0.06	0.07	0.02	0.03	2.60	0.02	0.07
BQ5(s)	0.33	0.32	0.28	0.52	0.70	0.13	0.50	0.59	0.13	0.70
BQ6(s)	0.01	0.04	0.05	0.02	0.01	0.06	0.05	0.03	0.01	0.06
BQ7(s)	<0.01	0.03	<0.01	0.02	<0.01	<0.01	<0.01	0.01	-	0.03
BQ8(s)	0.04	0.03	0.03	0.08	0.08	0.04	0.04	0.05	0.03	0.08
BQ1(d)				16.00		0.02		0.03	0.02	16.00
BQ2(d)				0.19		0.20		0.19	0.19	0.20
BQ3(d)				0.32		0.35		0.43	0.32	0.35
BQ4(d)				0.47		0.15		0.14	0.15	0.47
BQ5(d)				<0.01		<0.01		0.01	-	-
BQ6(d)				0.11		0.12		0.12	0.11	0.12
BQ7(d)				0.08		0.05		0.08	0.05	0.08
BQ8(d)				0.15		0.13		0.12	0.13	0.15
BQS1		0.22	0.07	0.05	0.09	0.09	0.04	0.06	0.04	0.22
BQS2		0.08	0.15	0.06	0.12	0.16	0.09	0.04	0.06	0.16
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Arsenic (As) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 0.01										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ2(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ3(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ4(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ5(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ6(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ7(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ8(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ1(d)				0.022		0.001		0.001	0.001	0.022
BQ2(d)				0.010		0.002		0.002	0.002	0.01
BQ3(d)				<0.001		<0.001		<0.001	-	-
BQ4(d)				0.007		<0.001		<0.001	-	0.007
BQ5(d)				<0.001		<0.001		<0.001	-	-
BQ6(d)				<0.001		<0.001		<0.001	-	-
BQ7(d)				<0.001		<0.001		<0.001	-	-
BQ8(d)				<0.001		<0.001		<0.001	-	-
BQS1		0.003	<0.001	<0.001	<0.001	0.001	<0.001	0.001	-	0.003
BQS2		0.001	0.002	0.002	<0.001	0.003	0.001	0.001	-	0.003
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Boron (B) mg/L										
PQL (mg/L): 0.005, ADWG Value (mg/L): 0.4										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	0.016	0.013		0.047		0.015		0.011	0.013	0.047
BQ2(s)	0.015	0.016		0.035		0.018		0.015	0.015	0.035
BQ3(s)	0.029	0.026		0.038		0.038		0.052	0.026	0.038
BQ4(s)	0.011	0.011		0.026		0.032		0.011	0.011	0.032
BQ5(s)	0.015	0.013		0.025		0.015		0.013	0.013	0.025
BQ6(s)	0.014	0.008		0.012		0.011		0.005	0.008	0.014
BQ7(s)	0.007	0.009		0.017		0.017		0.008	0.007	0.017
BQ8(s)	0.023	0.028		0.04		0.038		0.028	0.023	0.04
BQ1(d)				0.015		0.01		0.007	0.01	0.015
BQ2(d)				0.017		0.015		0.013	0.015	0.017
BQ3(d)				0.017		0.015		0.012	0.015	0.017
BQ4(d)				0.011		0.01		0.008	0.01	0.011
BQ5(d)				0.012		0.015		0.008	0.012	0.015
BQ6(d)				0.009		0.016		0.009	0.009	0.016
BQ7(d)				0.013		0.015		0.010	0.013	0.015
BQ8(d)				0.012		0.015		0.008	0.012	0.015
BQS1		0.061		0.044		0.086		0.036	0.044	0.086
BQS2		0.081		0.038		0.075		0.034	0.038	0.081
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Barium (Ba) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 2										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	0.002	0.001		0.001		0.002		<0.001	0.001	0.002
BQ2(s)	0.003	0.002		0.004		0.002		0.003	0.002	0.004
BQ3(s)	0.009	0.01		0.004		0.006		0.003	0.004	0.010
BQ4(s)	<0.001	<0.001		0.007		<0.001		0.011	-	0.007
BQ5(s)	0.001	0.002		0.003		0.003		0.004	0.001	0.003
BQ6(s)	0.002	0.002		0.002		0.003		0.002	0.002	0.003
BQ7(s)	<0.001	<0.001		0.002		<0.001		0.001	0.001	0.002
BQ8(s)	0.004	0.001		0.01		0.003		0.008	0.001	0.010
BQ1(d)				2.1		0.049		0.055	0.049	2.100
BQ2(d)				0.035		0.022		0.019	0.022	0.035
BQ3(d)				0.09		0.082		0.095	0.082	0.090
BQ4(d)				0.074		0.04		0.039	0.040	0.074
BQ5(d)				0.063		0.065		0.070	0.063	0.065
BQ6(d)				0.085		0.087		0.086	0.085	0.087
BQ7(d)				0.023		0.021		0.022	0.021	0.023
BQ8(d)				0.025		0.033		0.025	0.025	0.033
BQS1		0.014		0.009		0.017		0.010	0.009	0.017
BQS2		0.017		0.017		0.009		0.016	0.009	0.017
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Cadium (Cd) mg/L										
PQL (mg/L): 0.0001, ADWG Value (mg/L): 0.002										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
BQ2(s)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
BQ3(s)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
BQ4(s)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	0.0005	0.0005
BQ5(s)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
BQ6(s)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
BQ7(s)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
BQ8(s)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
BQ1(d)				0.0017		<0.0001		<0.0001	0.0017	0.0017
BQ2(d)				0.0001		<0.0001		<0.0001	0.0001	0.0001
BQ3(d)				<0.0001		0.0001		<0.0001	-	-
BQ4(d)				0.0001		<0.0001		<0.0001	-	-
BQ5(d)				<0.0001		<0.0001		<0.0001	-	-
BQ6(d)				<0.0001		<0.0001		<0.0001	-	-
BQ7(d)				<0.0001		<0.0001		<0.0001	-	-
BQ8(d)				<0.0001		<0.0001		<0.0001	-	-
BQS1		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
BQS2		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	-	-
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Chromium (VI) (Cr^{+6}) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 0.05										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001		-	-
BQ2(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	-	-
BQ3(s)	<0.001	<0.001	0.002	<0.001	0.003	<0.005	0.003	<0.005	-	-
BQ4(s)	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001		-	-
BQ5(s)	<0.001	<0.001	0.001	<0.001	0.002		0.002		-	0.002
BQ6(s)	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001		-	-
BQ7(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	-	-
BQ8(s)	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001		-	-
BQ1(d)				<0.001					-	-
BQ2(d)				<0.001		<0.005		<0.005	-	-
BQ3(d)				<0.001		<0.005		<0.005	-	-
BQ4(d)				<0.001					-	-
BQ5(d)				<0.001					-	-
BQ6(d)				<0.001					-	-
BQ7(d)				<0.001		<0.005		<0.005	-	-
BQ8(d)				<0.001					-	-
BQS1		<0.001	<0.001	<0.001	<0.001		<0.001		-	-
BQS2		<0.001	<0.001	<0.001	<0.001		<0.001		-	-
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Copper (Cu) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 2										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	-	0.008
BQ2(s)	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	-	0.003
BQ3(s)	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	-	0.002
BQ4(s)	0.002	<0.001	<0.001	0.002	0.001	<0.001	<0.001	<0.001	-	0.002
BQ5(s)	<0.001	<0.001	<0.001	0.003	0.002	<0.001	0.001	<0.001	-	0.003
BQ6(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ7(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ8(s)	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	-	0.002
BQ1(d)				0.011		<0.001		<0.001	-	0.011
BQ2(d)				<0.001		<0.001		<0.001	-	0.001
BQ3(d)				<0.001		<0.001		<0.001	-	-
BQ4(d)				<0.001		<0.001		<0.001	-	-
BQ5(d)				<0.001		<0.001		<0.001	-	-
BQ6(d)				<0.001		<0.001		<0.001	-	-
BQ7(d)				<0.001		<0.001		<0.001	-	-
BQ8(d)				<0.001		<0.001		<0.001	-	-
BQS1		0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	0.002
BQS2		0.002	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	-	0.002
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Manganese (Mn) mg/L										
PQL (mg/L): 0.005, ADWG Value (mg/L): 0.5										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ2(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ3(s)	<0.005	0.006	<0.005	0.006	0.005	<0.005	0.008	0.006	-	0.008
BQ4(s)	<0.005	<0.005	<0.005	0.017	<0.005	<0.005	<0.005	0.011	-	0.017
BQ5(s)	0.059	0.015	0.009	0.025	0.017	<0.005	0.006	0.005	-	0.059
BQ6(s)	0.026	0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.026
BQ7(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-
BQ8(s)	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.007
BQ1(d)				0.030		0.008		0.007	0.007	0.030
BQ2(d)				0.008		<0.005		<0.005	-	0.008
BQ3(d)				0.012		0.009		0.009	0.009	0.012
BQ4(d)				0.010		0.007		<0.005	-	0.010
BQ5(d)				0.021		0.020		0.018	0.018	0.021
BQ6(d)				0.024		0.022		0.015	0.015	0.024
BQ7(d)				<0.005		<0.005		<0.005	-	-
BQ8(d)				0.006		0.008		<0.005	-	0.008
BQS1		0.013	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.013
BQS2		0.016	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.016
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Molybdenum (Mo) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 0.05										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.001	<0.001		<0.001		<0.001		<0.001	-	-
BQ2(s)	<0.001	<0.001		<0.001		<0.001		<0.001	-	-
BQ3(s)	<0.001	<0.001		<0.001		<0.001		<0.001	-	-
BQ4(s)	0.001	<0.001		<0.001		0.001		<0.001	-	0.001
BQ5(s)	0.001	<0.001		<0.001		<0.001		<0.001	-	0.001
BQ6(s)	<0.001	<0.001		0.001		<0.001		<0.001	-	0.001
BQ7(s)	0.002	0.002		0.001		0.002		<0.001	-	0.002
BQ8(s)	0.002	0.001		0.001		<0.001		0.002	-	0.002
BQ1(d)				<0.001		<0.001		0.001	-	0.001
BQ2(d)				<0.001		<0.001		0.001	-	0.001
BQ3(d)				<0.001		<0.001		0.001	-	0.001
BQ4(d)				<0.001		<0.001		0.001	-	0.001
BQ5(d)				0.002		<0.001		0.001	-	0.002
BQ6(d)				<0.001		<0.001		<0.001	-	-
BQ7(d)				<0.001		<0.001		<0.001	-	-
BQ8(d)				<0.001		<0.001		<0.001	-	-
BQS1		0.015		<0.001		0.001		0.001	-	0.015
BQS2		0.002		0.008		0.016		0.008	0.002	0.016
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Nickel (Ni) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 0.02										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.001	<0.001		<0.001		<0.001		<0.001	-	-
BQ2(s)	<0.001	<0.001		<0.001		<0.001		<0.001	-	-
BQ3(s)	0.005	0.004		0.005		0.002		0.003	0.002	0.005
BQ4(s)	0.002	<0.001		0.003		<0.001		0.008	-	0.008
BQ5(s)	0.003	0.004		0.006		<0.001		0.002	-	0.006
BQ6(s)	<0.001	<0.001		<0.001		<0.001		<0.001	-	-
BQ7(s)	<0.001	<0.001		<0.001		<0.001		<0.001	-	-
BQ8(s)	<0.001	<0.001		0.001		<0.001		<0.001	-	0.001
BQ1(d)				0.009		<0.001		<0.001	-	0.009
BQ2(d)				0.004		<0.001		<0.001	-	0.004
BQ3(d)				<0.001		<0.001		<0.001	-	-
BQ4(d)				0.004		0.001		<0.001	-	0.004
BQ5(d)				<0.001		<0.001		<0.001	-	-
BQ6(d)				<0.001		<0.001		<0.001	-	-
BQ7(d)				<0.001		<0.001		<0.001	-	-
BQ8(d)				<0.001		<0.001		<0.001	-	-
BQS1		0.001		<0.001		<0.001		0.001	-	0.001
BQS2		<0.001		<0.001		0.002		0.001	-	0.002
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Lead (Pb) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 0.01										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ2(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ3(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ4(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ5(s)	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	-	-
BQ6(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ7(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ8(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ1(d)				0.085		<0.001		<0.001	-	0.085
BQ2(d)				<0.001		<0.001		<0.001	-	-
BQ3(d)				<0.001		<0.001		<0.001	-	-
BQ4(d)				0.002		<0.001		<0.001	-	0.002
BQ5(d)				<0.001		<0.001		<0.001	-	-
BQ6(d)				<0.001		<0.001		<0.001	-	-
BQ7(d)				<0.001		<0.001		<0.001	-	-
BQ8(d)				<0.001		<0.001		<0.001	-	-
BQS1		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQS2		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Uranium (U) mg/L										
PQL (mg/L): 0.0005, ADWG Value (mg/L): 0.017										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.0005	<0.0005		<0.0005		<0.0005		<0.0005	-	-
BQ2(s)	<0.0005	<0.0005		<0.0005		<0.0005		<0.0005	-	-
BQ3(s)	<0.0005	<0.0005		<0.0005		<0.0005		<0.0005	-	-
BQ4(s)	<0.0005	<0.0005		<0.0005		<0.0005		<0.0005	-	-
BQ5(s)	<0.0005	<0.0005		<0.0005		<0.0005		<0.0005	-	-
BQ6(s)	<0.0005	<0.0005		<0.0005		<0.0005		<0.0005	-	-
BQ7(s)	<0.0005	<0.0005		<0.0005		<0.0005		<0.0005	-	-
BQ8(s)	<0.0005	0.0009		0.0006		0.0009		0.0005	0.0005	0.0009
BQ1(d)				0.0500		<0.0005		<0.0005	-	0.0500
BQ2(d)				<0.0005		<0.0005		<0.0005	-	-
BQ3(d)				<0.0005		<0.0005		<0.0005	-	-
BQ4(d)				0.0010		<0.0005		<0.0005	-	0.0010
BQ5(d)				<0.0005		<0.0005		<0.0005	-	-
BQ6(d)				<0.0005		<0.0005		<0.0005	-	-
BQ7(d)				<0.0005		<0.0005		<0.0005	-	-
BQ8(d)				<0.0005		<0.0005		<0.0005	-	-
BQS1		0.0006		<0.0005		0.0006		<0.0005	-	0.0006
BQS2		0.0007		<0.0005		0.0007		<0.0005	-	0.0007
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Zinc (Zn) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 3 (Aesthetic)										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	0.002	0.002	0.007	0.002	0.001	0.012	0.001	<0.001	-	0.012
BQ2(s)	0.003	0.002	0.008	0.001	<0.001	0.009	<0.001	<0.001	-	0.009
BQ3(s)	0.001	0.003	0.008	0.003	0.003	0.008	<0.001	<0.001	-	0.008
BQ4(s)	<0.001	0.001	0.008	0.003	0.002	0.007	<0.001	0.02	-	0.02
BQ5(s)	0.007	0.045	0.02	0.01	0.008	0.002	0.002	0.003	0.002	0.045
BQ6(s)	0.002	0.002	0.008	0.012	0.001	0.009	0.001	<0.001	-	0.012
BQ7(s)	<0.001	0.002	0.008	0.004	0.001	0.001	0.002	<0.001	-	0.008
BQ8(s)	0.001	0.002	0.008	0.007	0.003	0.001	0.002	0.002	0.001	0.008
BQ1(d)				0.032		0.007		<0.001	-	0.032
BQ2(d)				0.007		0.008		0.002	0.002	0.008
BQ3(d)				0.002		0.013		<0.001	-	0.013
BQ4(d)				0.006		0.008		<0.001	-	0.008
BQ5(d)				<0.001		0.002		<0.001	-	0.002
BQ6(d)				0.002		0.001		<0.001	-	0.002
BQ7(d)				0.007		0.009		0.003	0.003	0.009
BQ8(d)				<0.001		0.003		<0.001	-	0.003
BQS1		0.002	0.011	0.008	0.005	0.001	0.002	<0.001	-	0.011
BQS2		0.002	0.007	<0.001	<0.001	0.006	0.005	<0.001	-	0.007
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Iron (Fe) mg/L										
PQL (mg/L): 0.01, ADWG Value (mg/L): 0.3 (Aesthetic)										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	0.25	0.12	<0.01	0.08	0.06	0.230	0.03	0.03	-	0.25
BQ2(s)	0.07	0.06	0.01	0.02	0.01	0.060	<0.01	0.02	-	0.07
BQ3(s)	3.4	3.6	1.9	1.7	0.96	0.780	0.54	0.67	0.54	3.6
BQ4(s)	0.73	3	0.04	6.1	0.03	0.310	0.01	0.38	0.01	6.1
BQ5(s)	13	3.3	1.6	1.5	0.83	1.9	0.33	0.7	0.33	13
BQ6(s)	0.34	0.07	<0.01	0.23	<0.01	2.4	<0.01	0.02	-	2.4
BQ7(s)	0.14	0.2	<0.01	0.42	<0.01	0.01	<0.01	0.02	-	0.42
BQ8(s)	0.32	0.05	<0.01	0.12	0.02	0.02	<0.01	0.03	-	0.32
BQ1(d)				150		54		34	34	150
BQ2(d)				5.4		1.9		3.6	1.9	5.4
BQ3(d)				30		41		16	16	41
BQ4(d)				16		9		1.4	1.4	16
BQ5(d)				0.32		0.35		0.43	0.32	0.43
BQ6(d)				0.59		0.52		0.26	0.26	0.59
BQ7(d)				0.71		0.53		0.7	0.53	0.71
BQ8(d)				0.85		0.55		0.21	0.21	0.85
BQS1		0.11	0.16	0.19	<0.01		0.03	0.1	0.01	0.19
BQS2		0.27	0.12	0.34	0.02		0.05	0.31	0.02	0.34
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Selenium (Se) mg/L										
PQL (mg/L): 0.001, ADWG Value (mg/L): 0.01										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ2(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ3(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ4(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ5(s)	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	-	0.001
BQ6(s)	0.003	0.001	<0.001	0.003	0.002	<0.001	0.002	0.002	-	0.003
BQ7(s)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-
BQ8(s)	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	0.002
BQ1(d)				0.1		0.038		0.044	0.038	0.1
BQ2(d)				0.004		0.001		0.002	0.001	0.004
BQ3(d)				0.021		0.026		0.01	0.01	0.026
BQ4(d)				0.012		0.007		<0.001	-	0.012
BQ5(d)				<0.001		<0.001		<0.001	-	-
BQ6(d)				<0.001		<0.001		0.002	-	0.002
BQ7(d)				<0.001		<0.001		<0.001	-	0.001
BQ8(d)				0.004		0.001		<0.001	-	0.004
BQS1		<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	-	-
BQS2		<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	-	-
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Chloride (Cl^-) mg/L										
PQL (mg/L): 1, ADWG Value (mg/L): 250 (Aesthetic)										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		17	14	17	16	17	17	16	14	17
BQ2(s)		15	12	17	23	17	16	15	12	23
BQ3(s)		220	170	160	190	110	100	120	100	220
BQ4(s)		35	22	35	19	45	27	16	16	45
BQ5(s)		19	17	27	28	23	21	18	17	28
BQ6(s)		39	35	35	30	34	32	28	28	39
BQ7(s)		14	15	20	18	16	15	15	14	20
BQ8(s)		16	16	22	66	17	13	15	13	66
BQ1(d)				62		57		57	57	62
BQ2(d)				56		49		42	42	56
BQ3(d)				85		86		80	80	86
BQ4(d)				74		79		75	74	79
BQ5(d)				53		48		48	48	53
BQ6(d)				83		76		72	72	83
BQ7(d)				91		82		83	82	91
BQ8(d)				53		53		47	47	53
BQS1		180	130	93	120	170	99	81	81	180
BQS2		190	90	83	110	180	90	84	83	190
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Sulphate (SO_4^{-2}) mg/L										
PQL (mg/L): 1, ADWG Value (mg/L): 500										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		13	10	11	8	11	16	10	8	16
BQ2(s)		12	16	17	13	14	14	13	12	17
BQ3(s)		130	120	76	120	69	50	83	50	130
BQ4(s)		10	6	43	6	12	20	38	6	43
BQ5(s)		10	12	58	53	42	28	93	10	93
BQ6(s)		24	42	38	38	36	33	41	24	42
BQ7(s)		8	7	10	7	8	7	7	7	10
BQ8(s)		16	17	23	20	17	8	12	8	23
BQ1(d)				10		16		15	10	16
BQ2(d)				11		10		9	9	11
BQ3(d)				14		14		16	14	16
BQ4(d)				6		5		<1	-	6
BQ5(d)				1		1		<1	-	1
BQ6(d)				11		14		9	9	14
BQ7(d)				16		15		17	15	17
BQ8(d)				16		21		20	16	21
BQS1		63	22	15	21	25	12	12	12	63
BQS2		33	40	28	37	56	32	27	27	56
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Bicarbonate (HCO_3^-) mg/L										
PQL (mg/L): 5, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		17	15	28	11	11	22	14	11	28
BQ2(s)		<5	<5	9	<5	<5	7	<5	-	9
BQ3(s)		<5	<5	<5	<5	<5	<5	<5	-	-
BQ4(s)		11	9	9	14	14	9	<5	5	14
BQ5(s)		<5	<5	<5	<5	<5	<5	<5	-	-
BQ6(s)		6	<5	37	11	18	<5	18	-	37
BQ7(s)		91	62	72	90	68	77	81	62	91
BQ8(s)		190	140	130	130	190	180	170	130	190
BQ1(d)				54		23		42	23	54
BQ2(d)				11		<5		<5	-	11
BQ3(d)				31		52		31	31	52
BQ4(d)				14		12		10	10	14
BQ5(d)				170		170		170	170	170
BQ6(d)				21		12		14	12	21
BQ7(d)				47		6		<5	-	47
BQ8(d)				20		14		14	14	20
BQS1		190	87	72	95	110	91	77	72	190
BQS2		150	110	130	180	170	130	150	110	180
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Nitrate (NO_3_N) mg/L										
PQL (mg/L): 0.5, ADWG Value (mg/L): 50										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)					15.00		11.96		11.96	15.00
BQ2(s)					49.00		37.20		37.20	49.00
BQ3(s)					12.80		0.89		0.89	12.80
BQ4(s)					0.24		2.17		0.24	2.17
BQ5(s)					0.30		1.24		0.30	1.24
BQ6(s)					0.12		0.17		0.12	0.17
BQ7(s)					17.00		12.40		12.40	17.00
BQ8(s)					110.00		29.23		29.23	110.00
BQ1(d)									-	-
BQ2(d)									-	-
BQ3(d)									-	-
BQ4(d)									-	-
BQ5(d)									-	-
BQ6(d)									-	-
BQ7(d)									-	-
BQ8(d)									-	-
BQS1					0.04		0.19		0.04	0.19
BQS2					0.02		<0.022		-	0.02
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Hydroxide (OH^-) (mg/L)										
PQL (mg/L): 5, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	130	160		120				120	120	160
BQ2(s)	140	150		170				180	140	180
BQ3(s)	860	1100		590				670	590	1100
BQ4(s)	160	170		210				160	160	210
BQ5(s)	100	100		230				330	100	330
BQ6(s)	200	200		230				230	200	230
BQ7(s)	210	230		250				250	210	250
BQ8(s)	480	490		590				510	480	590
BQ1(d)				240				260	240	260
BQ2(d)				200				180	180	200
BQ3(d)				310				340	310	340
BQ4(d)				250				290	250	290
BQ5(d)				430				470	430	470
BQ6(d)				290				300	290	300
BQ7(d)				370				350	350	370
BQ8(d)				210				240	210	240
BQS1		1000		410				440	410	1000
BQS2		870		460				630	460	870
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Hardness as $CaCO_3$ (mg/L)										
PQL (mg/L): NA, ADWG Value (mg/L): 200 (Aesthetic)										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		39	38	34		35	45	28	28	45
BQ2(s)		39	59	66		44	64	50	39	66
BQ3(s)		120	90	97		55	78	63	55	120
BQ4(s)		24	20	41		29	36	23	20	41
BQ5(s)		12	13	42		47	26	80	12	80
BQ6(s)		47	54	77		43	50	65	43	77
BQ7(s)		95	90	110		94	110	92	90	110
BQ8(s)		250	240	290		260	260	210	210	290
BQ1(d)				110		23		22	22	110
BQ2(d)				22		20		16	16	22
BQ3(d)				30		25		28	25	30
BQ4(d)				28		25		25	25	28
BQ5(d)				170		150		140	140	170
BQ6(d)				26		24		22	22	26
BQ7(d)				27		23		27	23	27
BQ8(d)				14		16		13	13	16
BQS1		80	120	99		140	120	93	80	140
BQS2		170	61	100		74	94	98	61	170
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

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Sodium (Na^+) mg/L										
PQL (mg/L): 0.5, ADWG Value (mg/L): 180 (Aesthetic)										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		9.0	8.4	10.0	7.4	7.9	10.0	6.8	6.8	10.0
BQ2(s)		8.2	6.6	8.3	7.4	7.5	7.7	6.6	6.6	8.3
BQ3(s)		130.0	95.0	88.0	110.0	60.0	75.0	73.0	60.0	130.0
BQ4(s)		17.0	12.0	25.0	8.6	23.0	16.0	9.0	8.6	25.0
BQ5(s)		12.0	9.8	24.0	18.0	14.0	14.0	10.0	9.8	24.0
BQ6(s)		16.0	17.0	15.0	12.0	15.0	15.0	16.0	12.0	17.0
BQ7(s)		8.0	7.7	10.0	8.6	7.8	9.6	7.2	7.2	10.0
BQ8(s)		9.2	11.0	11.0	9.8	9.3	9.8	7.1	7.1	11.0
BQ1(d)				38.0		33.0		33.0	33.0	38.0
BQ2(d)				29.0		25.0		23.0	23.0	29.0
BQ3(d)				48.0		39.0		42.0	39.0	48.0
BQ4(d)				36.0		35.0		37.0	35.0	37.0
BQ5(d)				29.0		26.0		25.0	25.0	29.0
BQ6(d)				46.0		41.0		40.0	40.0	46.0
BQ7(d)				48.0		42.0		46.0	42.0	48.0
BQ8(d)				38.0		37.0		32.0	32.0	38.0
BQS1		160.0	63.0	48.0	58.0	82.0	58.0	43.0	43.0	160.0
BQS2		98.0	76.0	68.0	94.0	140.0	81.0	73.0	68.0	140.0
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Potassium (K^+) mg/L										
PQL (mg/L): 0.5, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		1.6	1.7	1.8	1	1.1	1.5	0.7	0.7	1.8
BQ2(s)		1.3	1.5	1.8	1.3	1.1	1.3	1.2	1.1	1.8
BQ3(s)		8.7	6.4	6.4	8.2	4.7	6.2	5.4	4.7	8.7
BQ4(s)		0.7	<0.5	0.5	<0.5	<0.5	<0.5	0.8	-	0.8
BQ5(s)		1.1	1.2	2.7	2.1	<0.5	1.6	1.5	0.5	2.7
BQ6(s)		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-
BQ7(s)		1.2	1.1	1.5	1.1	1.1	1.1	1	1.0	1.5
BQ8(s)		2.7	2.5	2.8	2.7	2.9	2.1	1.6	1.6	2.9
BQ1(d)				4.8		1.8		1.8	1.8	4.8
BQ2(d)				1.5		1.4		1.2	1.2	1.5
BQ3(d)				3.0		2.4		2.3	2.3	3.0
BQ4(d)				1.7		1.4		1.4	1.4	1.7
BQ5(d)				3.6		3.1		2.9	2.9	3.6
BQ6(d)				2.6		2.2		2	2.0	2.6
BQ7(d)				1.3		1.1		1.2	1.1	1.3
BQ8(d)				1.5		1.4		1.2	1.2	1.5
BQS1		47	4.6	3.4		6.5	4.2	3.1	3.1	47.0
BQS2		7.5	23	18		39	22	19	7.5	39.0
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Data Source:

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Calcium (Ca^{+2}) mg/L										
PQL (mg/L): 0.5, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		13.0	13.0	11.0	9.7	11.0	15.0	9.3	9.3	15.0
BQ2(s)		10.0	17.0	18.0	13.0	12.0	18.0	14.0	10.0	18.0
BQ3(s)		5.0	3.5	7.3	7.0	3.1	6.0	5.9	3.1	7.3
BQ4(s)		5.5	4.9	9.7	7.9	10.0	9.8	6.3	4.9	10.0
BQ5(s)		1.7	1.2	8.6	7.9	11.0	4.7	19.0	1.2	19.0
BQ6(s)		7.5	12.0	24.0	15.0	9.7	11.0	19.0	7.5	24.0
BQ7(s)		34.0	31.0	35.0	39.0	33.0	37.0	32.0	31.0	39.0
BQ8(s)		88.0	85.0	100.0	79.0	91.0	93.0	74.0	74.0	100.0
BQ1(d)				16.0		2.3		2.2	2.2	16.0
BQ2(d)				1.8		1.9		1.7	1.7	1.9
BQ3(d)				2.9		2.0		2.2	2.0	2.9
BQ4(d)				2.0		1.6		1.7	1.6	2.0
BQ5(d)				61.0		55.0		52.0	52.0	61.0
BQ6(d)				2.9		2.8		2.3	2.3	2.9
BQ7(d)				1.1		1.0		1.1	1.0	1.1
BQ8(d)				1.0		1.5		1.4	1.0	1.5
BQS1		24.0	31.0	26.0	32.0	33.0	32.0	25.0	24.0	33.0
BQS2		44.0	20.0	34.0	37.0	21.0	32.0	33.0	20.0	44.0
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Magnesium (Mg^{+2}) mg/L										
PQL (mg/L): 0.5, ADWG Value (mg/L): NA										
Sampling Date	**21-Feb-13**	**29-Apr-13**	**31-Jul-13**	**22-Oct-13**	**16-Jan-14**	**09-Apr-14**	**10-Jul-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)		1.5	1.5	1.9	1.6	1.9	1.9	1.3	1.3	1.9
BQ2(s)		3.3	4.3	5.4	4.0	3.7	4.8	4.0	3.3	5.4
BQ3(s)		25.0	20.0	19.0	19.0	11.0	15.0	12.0	11.0	25.0
BQ4(s)		2.5	1.8	4.2	1.2	0.9	2.7	1.8	0.9	4.2
BQ5(s)		1.9	2.4	5.1	6.0	4.7	3.6	8.2	1.9	8.2
BQ6(s)		6.9	5.7	4.0	5.1	4.4	5.5	4.4	4.0	6.9
BQ7(s)		2.6	3.2	4.5	2.6	2.8	3.0	2.9	2.6	4.5
BQ8(s)		6.3	7.2	9.8	8.3	8.3	6.8	5.8	5.8	9.8
BQ1(d)				17.0		4.3		4.1	4.1	17.0
BQ2(d)				4.2		3.6		2.9	2.9	4.2
BQ3(d)				5.5		4.9		5.5	4.9	5.5
BQ4(d)				5.6		5.1		5.0	5.0	5.6
BQ5(d)				4.2		3.5		3.3	3.3	4.2
BQ6(d)				4.5		4.1		3.9	3.9	4.5
BQ7(d)				5.8		4.9		6.0	4.9	6.0
BQ8(d)				2.7		3.1		2.3	2.3	3.1
BQS1		5.1	11.0	8.1	10.0	14.0	10.0	7.3	5.1	14.0
BQS2		16.0	2.9	3.7	4.9	5.4	3.7	4.0	2.9	16.0
Notes: Shaded values indicate where results exceed ADWG Values. Results are compared against ADWG 'Health' values unless other stated.										

Data Source:

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Surrogate Dibromofluoromethane, %						
PQL: -						
ADWG Value: NA						
Sampling Date	29-Apr-13	22-Oct-13	9-Apr-14	21-Oct-14	Min	Max
BQ1(s)	104				-	-
BQ2(s)	104	93	104	112	93	112
BQ3(s)	101		103	111	101	111
BQ4(s)	102	91			91	102
BQ5(s)	101				-	-
BQ6(s)	105				-	-
BQ7(s)	106	96	109	112	96	112
BQ8(s)	100				-	-
BQ1(d)		107			-	-
BQ2(d)		96	106	110	96	110
BQ3(d)		96	103	112	96	112
BQ4(d)		99			-	-
BQ5(d)		101			-	-
BQ6(d)		98			-	-
BQ7(d)		97	110	111	97	111
BQ8(d)		99			-	-
BQS1	103				-	-
BQS2	105				-	-

Surrogate toluene-d8, %						
PQL: -						
ADWG Value: NA						
Sampling Date	29-Apr-13	22-Oct-13	9-Apr-14	21-Oct-14	Min	Max
BQ1(s)	103				-	-
BQ2(s)	104	105	99	111	99	111
BQ3(s)	103		96	109	96	109
BQ4(s)	103	104			103	104
BQ5(s)	101				-	-
BQ6(s)	104				-	-
BQ7(s)	103	105	99	108	99	108
BQ8(s)	102				-	-
BQ1(d)		111			-	-
BQ2(d)		106	99	110	99	110
BQ3(d)		105	99	110	99	110
BQ4(d)		104			-	-
BQ5(d)		110			-	-
BQ6(d)		108			-	-
BQ7(d)		105	100	110	100	110
BQ8(d)		106			-	-
BQS1	103				-	-
BQS2	104				-	-

Data Source:

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Surrogate 4-BFB, %						
PQL: -						
ADWG Value: NA						
Sampling Date	29-Apr-13	22-Oct-13	9-Apr-14	21-Oct-14	Min	Max
BQ1(s)	100				-	-
BQ2(s)	99	100	93	99	93	100
BQ3(s)	100		94	97	94	100
BQ4(s)	99	99			99	99
BQ5(s)	98				-	-
BQ6(s)	100				-	-
BQ7(s)	100	107	90	97	90	107
BQ8(s)	99				-	-
BQ1(d)		94			-	-
BQ2(d)		99	94	98	94	99
BQ3(d)		100	94	98	94	100
BQ4(d)		99			-	-
BQ5(d)		100			-	-
BQ6(d)		91			-	-
BQ7(d)		86	91	99	86	99
BQ8(d)		87			-	-
BQS1	99				-	-
BQS2	100				-	-

TRH C15 - C28, µg/L						
PQL: 100 µg/L						
ADWG Value: NA						
Sampling Date	29-Apr-13	22-Oct-13	9-Apr-14	21-Oct-14	Min	Max
BQ1(s)	<100				-	-
BQ2(s)	<100	<100	<100	<100	0	0
BQ3(s)	<100		<100	<100	0	0
BQ4(s)	<100	<100			0	0
BQ5(s)	<100				-	-
BQ6(s)	<100				-	-
BQ7(s)	<100	<00	<100	<100	0	0
BQ8(s)	<100				-	-
BQ1(d)		<1000			-	-
BQ2(d)		<100	<100	<100	0	0
BQ3(d)		<1000	<1000	<1000	0	0
BQ4(d)		<100			-	-
BQ5(d)		<100			-	-
BQ6(d)		<100			-	-
BQ7(d)		<100	<100	<100	0	0
BQ8(d)		<100			-	-
BQS1	250				-	-
BQS2	120				-	-

Data Source:

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TRH >C16 - C34, µg/L						
PQL: 100 µg/L						
Sampling Date	29-Apr-13	22-Oct-13	9-Apr-14	21-Oct-14	Min	Max
BQ1(s)	<100				-	-
BQ2(s)	<100	<100	<100	<100	0	0
BQ3(s)	130		140	130	130	140
BQ4(s)	<100	<100			0	0
BQ5(s)	<100				-	-
BQ6(s)	<100				-	-
BQ7(s)	<100	<100	<100	<100	0	0
BQ8(s)	<100				-	-
BQ1(d)		<1000			-	-
BQ2(d)		<100	<100	<100	0	0
BQ3(d)		<1000	<1000	<1000	0	0
BQ4(d)		<100			-	-
BQ5(d)		<100			-	-
BQ6(d)		<100			-	-
BQ7(d)		<100	<100	<100	0	0
BQ8(d)		<100			-	-
BQS1	310				-	-
BQS2	130				-	-

Data Source:

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Surrogate Dibromofluoromethane, %						
Sampling Date	**29-Apr-13**	**22-Oct-13**	**9-Apr-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	102				-	-
BQ2(s)	101	97	107	108	97	108
BQ3(s)	99		105	108	99	108
BQ4(s)	99	95			95	99
BQ5(s)	99				-	-
BQ6(s)	103				-	-
BQ7(s)	103	100	111	108	100	111
BQ8(s)	97				-	-
BQ1(d)		110			-	-
BQ2(d)		100	108	106	100	108
BQ3(d)		100	105	108	100	108
BQ4(d)		103			-	-
BQ5(d)		105			-	-
BQ6(d)		102			-	-
BQ7(d)		101	112	107	101	112
BQ8(d)		103			-	-
BQS1	101				-	-
BQS2	102				-	-

Surrogate toluene-d8, %						
Sampling Date	**29-Apr-13**	**22-Oct-13**	**9-Apr-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	100				-	-
BQ2(s)	102	97	97	104	97	104
BQ3(s)	100		94	102	94	102
BQ4(s)	100	95			95	100
BQ5(s)	98				-	-
BQ6(s)	101				-	-
BQ7(s)	100	97	98	102	97	102
BQ8(s)	99				-	-
BQ1(d)		118			-	-
BQ2(d)		98	98	103	98	103
BQ3(d)		97	97	103	97	103
BQ4(d)		96			-	-
BQ5(d)		101			-	-
BQ6(d)		99			-	-
BQ7(d)		97	98	103	97	103
BQ8(d)		98			-	-
BQS1	100				-	-
BQS2	101				-	-

Data Source:

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Surrogate 4-BFB, %						
Sampling Date	**29-Apr-13**	**22-Oct-13**	**9-Apr-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	100				-	-
BQ2(s)	99	90	87	95	87	99
BQ3(s)	100		88	93	88	100
BQ4(s)	99	90			90	99
BQ5(s)	98				-	-
BQ6(s)	100				-	-
BQ7(s)	99	97	84	93	84	99
BQ8(s)	99				-	-
BQ1(d)		91			-	-
BQ2(d)		89	88	94	88	94
BQ3(d)		91	88	94	88	94
BQ4(d)		90			-	-
BQ5(d)		90			-	-
BQ6(d)		82			-	-
BQ7(d)		78	85	95	78	95
BQ8(d)		79			-	-
BQS1	99				-	-
BQS2	100				-	-

Data Source:

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Fluorene, µg/L						
PQL: 0.01 µg/L						
ADWG Value: NA						
Sampling Date	29-Apr-13	22-Oct-13	9-Apr-14	21-Oct-14	Min	Max
BQ1(s)	<0.01				-	-
BQ2(s)	<0.01	<0.01	<0.01	<0.01	-	-
BQ3(s)	<0.01		<0.01	<0.01	-	-
BQ4(s)	<0.01	<0.01			-	-
BQ5(s)	<0.01				-	-
BQ6(s)	<0.01				-	-
BQ7(s)	<0.01	<0.01	0.02	<0.01	0.02	0.02
BQ8(s)	<0.01				-	-
BQ1(d)		<0.1			-	-
BQ2(d)		<0.01	<0.01	<0.01	-	-
BQ3(d)		<0.1	<0.1	<0.1	-	-
BQ4(d)		<0.01			-	-
BQ5(d)		<0.01			-	-
BQ6(d)		<0.01			-	-
BQ7(d)		<0.01	<0.01	<0.01	-	-
BQ8(d)		<0.01			-	-
BQS1	<0.01				-	-
BQS2	<0.01				-	-

Note: Increased PQL in some results indicate where a portion of the sample is spiked to monitor performance of analytical method and to determine if matrix interference exists..

Phenanthrene, µg/L						
PQL: 0.01 µg/L						
ADWG Value: 0.01 µg/L (health)						
Sampling Date	29-Apr-13	22-Oct-13	9-Apr-14	21-Oct-14	Min	Max
BQ1(s)	<0.01				-	-
BQ2(s)	<0.01	<0.01	<0.01	<0.01	-	-
BQ3(s)	<0.01		<0.01	<0.01	-	-
BQ4(s)	<0.01	<0.01			-	-
BQ5(s)	<0.01				-	-
BQ6(s)	<0.01				-	-
BQ7(s)	<0.01	<0.01	0.02	<0.01	0.02	0.02
BQ8(s)	<0.01				-	-
BQ1(d)		<0.1			-	-
BQ2(d)		<0.01	<0.01	<0.01	-	-
BQ3(d)		<0.1	<0.1	<0.1	-	-
BQ4(d)		<0.01			-	-
BQ5(d)		<0.01			-	-
BQ6(d)		<0.01			-	-
BQ7(d)		<0.01	<0.01	<0.01	-	-
BQ8(d)		<0.01			-	-
BQS1	<0.01				-	-
BQS2	<0.01				-	-

Note: Increased PQL in some results indicate where a portion of the sample is spiked to monitor performance of analytical method and to determine if matrix interference exists..

Data Source:

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p-Terphenyl-D14, %						
PQL: -						
ADWG Value: NA						
Sampling Date	**29-Apr-13**	**22-Oct-13**	**9-Apr-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	63				-	-
BQ2(s)	60	59	79	68	59	79
BQ3(s)	64		76	31	31	76
BQ4(s)	61	71			61	71
BQ5(s)	43				-	-
BQ6(s)	71				-	-
BQ7(s)	64	49	70	90	49	90
BQ8(s)	64				-	-
BQ1(d)		29			-	-
BQ2(d)		51	71	81	51	81
BQ3(d)		39	25	49	25	49
BQ4(d)		16			-	-
BQ5(d)		55			-	-
BQ6(d)		79			-	-
BQ7(d)		45	88	90	45	90
BQ8(d)		48			-	-
BQS1	43				-	-
BQS2	48				-	-

Note: Increased PQL in some results indicate where a portion of the sample is spiked to monitor performance of analytical method and to determine if matrix interference exists..

Data Source:

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Bromophos Ethyl p-Terphenyl-D14, %						
PQL: NA						
ADWG Value: NA						
Sampling Date	**29-Apr-13**	**22-Oct-13**	**9-Apr-14**	**21-Oct-14**	**Min**	**Max**
BQ1(s)	63				-	-
BQ2(s)	60	59	79	68	59	79
BQ3(s)	64		76	31	31	76
BQ4(s)	61	71			61	71
BQ5(s)	43				-	-
BQ6(s)	71				-	-
BQ7(s)	64	49		90	49	90
BQ8(s)	64				-	-
BQ1(d)		29			-	-
BQ2(d)		51	71	81	51	81
BQ3(d)		39	25	49	25	49
BQ4(d)		16			-	-
BQ5(d)		55			-	-
BQ6(d)		79			-	-
BQ7(d)		45		90	45	90
BQ8(d)		48			-	-
BQS1	43				-	-
BQS2	48				-	-

Note: Increased PQL in some results indicate where a portion of the sample is spiked to monitor performance of analytical method and to determine if matrix interference exists..

Data Source:

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APPENDIX F

GWL163828

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	PERRON TREEBY PTY LTD		
Description of Water Resource	Jandakot Perth - Superficial Swan	**Annual Water Entitlement**	139,760kL
Location of Water Source	LOT 705 ON PLAN 413032 - Volume/Folio 2941/50 - Lot 705 ARMADALE RD TREEBY		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dust suppression for earthworks and construction purposes	LOT 705 ON PLAN 413032 - Volume/Folio 2941/50 - Lot 705 ARMADALE RD TREEBY
	Irrigation of up to 7.9 ha of public open space	LOT 705 ON PLAN 413032 - Volume/Folio 2941/50 - Lot 705 ARMADALE RD TREEBY
	School Facilities	LOT 705 ON PLAN 413032 - Volume/Folio 2941/50 - Lot 705 ARMADALE RD TREEBY
	Water requirements to maintain pool and lake levels	LOT 705 ON PLAN 413032 - Volume/Folio 2941/50 - Lot 705 ARMADALE RD TREEBY
Duration of Licence	From 22 October 2019 to 28 September 2027	

This Licence is subject to the following terms, conditions and restrictions:

1. The annual water year for water taken under this licence is defined as 1 June to 31 May.

2. The licensee shall not use water for non-commercial irrigation or lawn and garden irrigation between 9 am and 6 pm except for the establishment of newly planted areas. For newly planted areas water may be used within these hours for a period of up to 28 consecutive days, commencing from the date of planting.

3. Between 1 June and 31 August in any year, the licence-holder must not water a lawn, garden, or grass-covered area ("turf") by reticulation, provided always that this restriction shall not apply; watering with a hand held hose; or watering, by way of reticulation: golf course tees and greens, turf wickets, bowling greens and active sporting areas; newly planted areas for a period of up to 28 days from the date of planting; for renovating turf; or for maintenance of reticulation systems

End of terms, conditions and restrictions

APPENDIX G

PC-SUMP Modelling Results

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

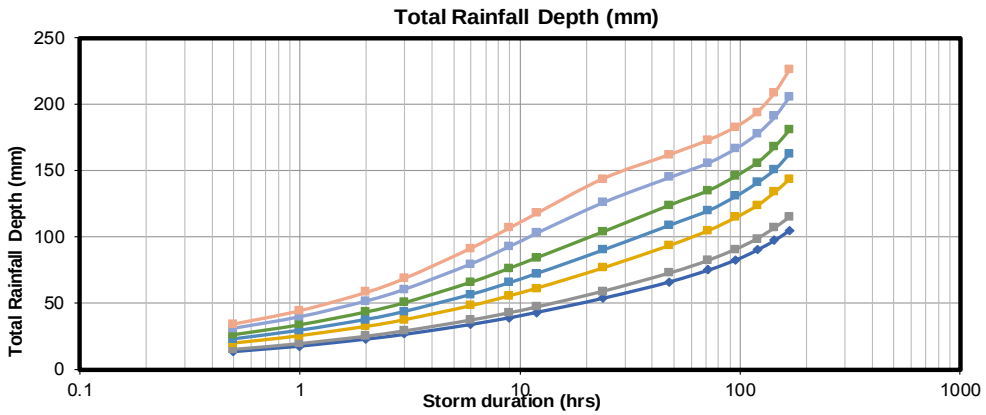
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment A

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
POS	0.16			90.0%
Road	4.08			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	23
Design Groundwater Level (mAHD)	26.7
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	360
Base Width (m)	6
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.4
Maximum Allowable TWL (mAHD)	29

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment A

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	13.8	1 EY	0.04	28.44	0.56	81	2,319	10
	2	1 hour	17.9	1 EY	0.02	28.42	0.58	33	2,225	1
	3	2 hour	23.1	1 EY	0.01	28.41	0.59	17	2,195	1
	4	3 hour	26.8	1 EY	0	28.40	0.60	-	2,160	10
	5	6 hour	34.2	1 EY	0	28.40	0.60	-	2,160	1
	6	9 hour	39.3	1 EY	0	28.40	0.60	-	2,160	1
	7	12 hour	43.3	1 EY	0	28.40	0.60	-	2,160	1
	8	24 hour	53.9	1 EY	0	28.40	0.60	-	2,160	1
	9	48 hour	66.3	1 EY	0	28.40	0.60	-	2,160	1
	10	72 hour	75.2	1 EY	0	28.40	0.60	-	2,160	1
	11	96 hour	82.9	1 EY	0	28.40	0.60	-	2,160	1
	12	120 hour	90.3	1 EY	0	28.40	0.60	-	2,160	1
	13	144 hour	97.6	1 EY	0	28.40	0.60	-	2,160	1
	14	168 hour	105.0	1 EY	0	28.40	0.60	-	2,160	1
Critical	***1***	***30 min***	***13.8***	***1 EY***	***0.04***	***28.44***	***0.56***	***81***	***2,319***	***10***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

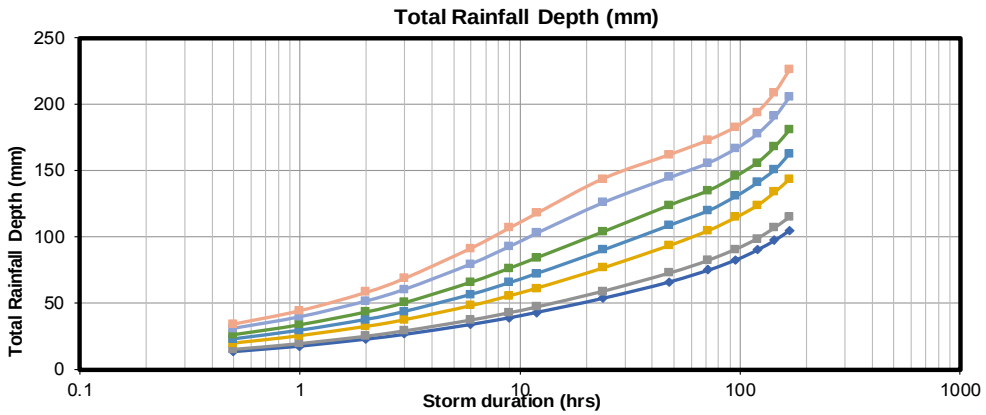
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment A

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	20% AEP (4.48 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
POS	0.16			90.0%
Road	4.08			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	23
Design Groundwater Level (mAHD)	26.7
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	360
Base Width (m)	6
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.4
Maximum Allowable TWL (mAHD)	29

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment A

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	19.7	20%	0.11	28.51	0.49	263	2,642	10
	2	1 hour	25.4	20%	0.09	28.49	0.51	211	2,554	6
	3	2 hour	32.4	20%	0.08	28.48	0.52	192	2,521	3
	4	3 hour	37.4	20%	0.06	28.46	0.54	134	2,416	9
	5	6 hour	48.1	20%	0	28.40	0.60	-	2,160	10
	6	9 hour	55.6	20%	0	28.40	0.60	-	2,160	10
	7	12 hour	61.4	20%	0	28.40	0.60	-	2,160	1
	8	24 hour	76.8	20%	0	28.40	0.60	-	2,160	1
	9	48 hour	93.7	20%	0	28.40	0.60	-	2,160	1
	10	72 hour	105.0	20%	0	28.40	0.60	-	2,160	1
	11	96 hour	115.0	20%	0	28.40	0.60	-	2,160	1
	12	120 hour	124.0	20%	0	28.40	0.60	-	2,160	1
	13	144 hour	134.0	20%	0	28.40	0.60	-	2,160	1
	14	168 hour	144.0	20%	0	28.40	0.60	-	2,160	1
Critical	***1***	***30 min***	***19.7***	***20%***	***0.11***	***28.51***	***0.49***	***263***	***2,642***	***10***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

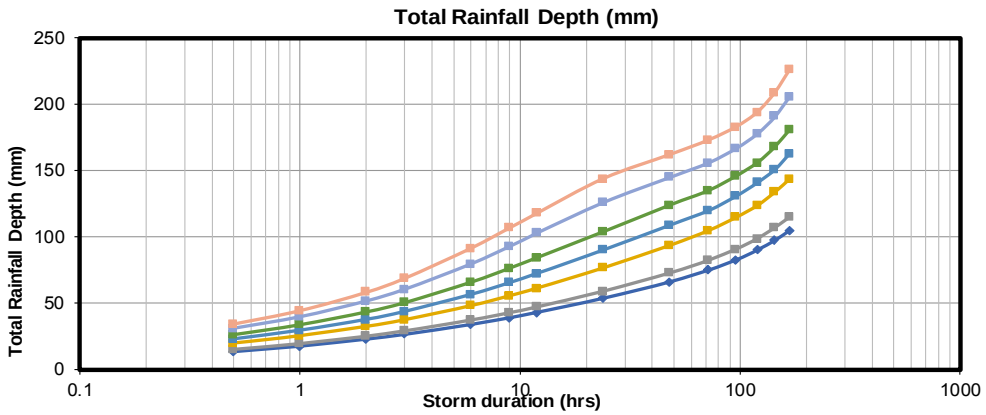
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment A

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	10% AEP (10 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Trad Lots	8.98	15	5	
Compact Lots	0.96			20.0%
POS	0.16			90.0%
Road	4.08			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	23
Design Groundwater Level (mAHD)	26.7
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	360
Base Width (m)	6
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.4
Maximum Allowable TWL (mAHD)	29

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment A

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	23.0	10%	0.37	28.77	0.23	1,114	3,813	4
	2	1 hour	29.5	10%	0.47	28.87	0.13	1,500	4,246	8
	3	2 hour	37.7	10%	0.55	28.95	0.05	1,861	4,615	10
	4	3 hour	43.8	10%	0.59	28.99	0.01	2,057	4,808	6
	5	6 hour	56.6	10%	0.58	28.98	0.02	1,980	4,731	7
	6	9 hour	65.6	10%	0.53	28.93	0.07	1,784	4,539	7
	7	12 hour	72.5	10%	0.43	28.83	0.17	1,345	4,076	2
	8	24 hour	90.2	10%	0.22	28.62	0.38	575	3,123	4
	9	48 hour	109.0	10%	0	28.40	0.60	-	2,160	10
	10	72 hour	120.0	10%	0.03	28.43	0.57	74	2,304	4
	11	96 hour	131.0	10%	0	28.40	0.60	-	2,160	10
	12	120 hour	141.0	10%	0	28.40	0.60	-	2,160	10
	13	144 hour	151.0	10%	0	28.40	0.60	-	2,160	10
	14	168 hour	163.0	10%	0	28.40	0.60	-	2,160	10
Critical	***4***	***3 hour***	***43.8***	***10%***	***0.59***	***28.99***	***0.01***	***2,057***	***4,808***	***6***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

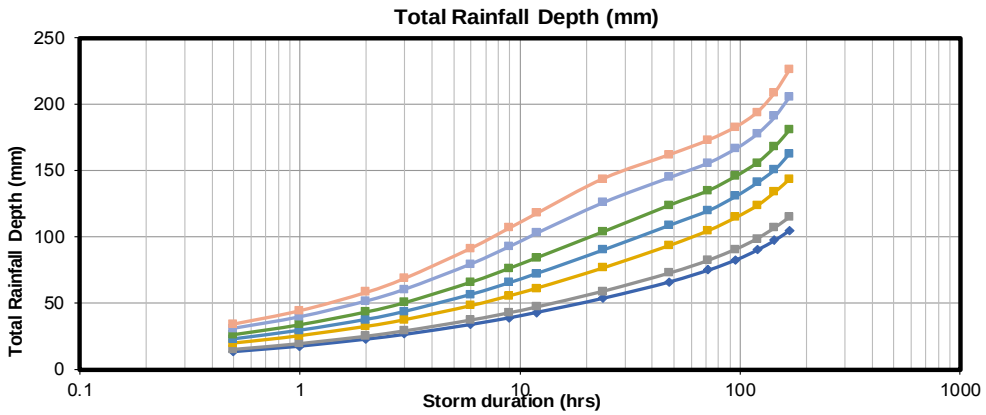
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment B

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
POS	1.96			90.0%
Road	2.43			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	22
Design Groundwater Level (mAHD)	27.36
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	41
Base Width (m)	35
Average Slope (1 in X)	0.0001
Basin Base Elevation (mAHD)	27.66
Maximum Allowable TWL (mAHD)	28.46

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment B

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	13.8	1 EY	0.19	27.85	0.61	278	1,435	1
	2	1 hour	17.9	1 EY	0.25	27.91	0.55	356	1,435	10
	3	2 hour	23.1	1 EY	0.32	27.98	0.48	454	1,435	1
	4	3 hour	26.8	1 EY	0.36	28.02	0.44	512	1,435	1
	5	6 hour	34.2	1 EY	0.42	28.08	0.38	596	1,435	1
	6	9 hour	39.3	1 EY	0.45	28.11	0.35	650	1,435	1
	7	12 hour	43.3	1 EY	0.47	28.13	0.33	680	1,435	1
	8	24 hour	53.9	1 EY	0.51	28.17	0.29	737	1,435	10
	9	48 hour	66.3	1 EY	0.53	28.19	0.27	762	1,435	9
	10	72 hour	75.2	1 EY	0.53	28.19	0.27	755	1,435	4
	11	96 hour	82.9	1 EY	0.52	28.18	0.28	744	1,435	2
	12	120 hour	90.3	1 EY	0.52	28.18	0.28	744	1,435	8
	13	144 hour	97.6	1 EY	0.51	28.17	0.29	733	1,435	6
	14	168 hour	105.0	1 EY	0.51	28.17	0.29	736	1,435	2
Critical	***9***	***48 hour***	***66.3***	***1 EY***	***0.53***	***28.19***	***0.27***	***762***	***1,435***	***9***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

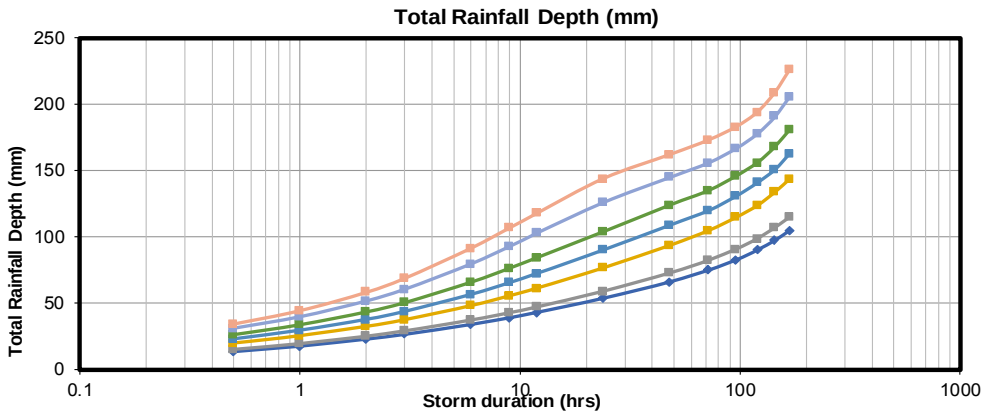
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment B

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	20% AEP (4.48 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
POS	1.96			90.0%
Road	2.43			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	22
Design Groundwater Level (mAHD)	27.36
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	41
Base Width (m)	35
Average Slope (1 in X)	0.0001
Basin Base Elevation (mAHD)	27.66
Maximum Allowable TWL (mAHD)	28.46

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
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Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment B

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	19.7	20%	0.28	27.94	0.52	401	1,435	1
	2	1 hour	25.4	20%	0.36	28.02	0.44	511	1,435	10
	3	2 hour	32.4	20%	0.45	28.11	0.35	644	1,435	1
	4	3 hour	37.4	20%	0.5	28.16	0.30	723	1,435	1
	5	6 hour	48.1	20%	0.6	28.26	0.20	857	1,435	1
	6	9 hour	55.6	20%	0.66	28.32	0.14	942	1,435	1
	7	12 hour	61.4	20%	0.69	28.35	0.11	994	1,435	1
	8	24 hour	76.8	20%	0.76	28.42	0.04	1,092	1,435	10
	9	48 hour	93.7	20%	0.79	28.45	0.01	1,133	1,435	9
	10	72 hour	105.0	20%	0.78	28.44	0.02	1,117	1,435	4
	11	96 hour	115.0	20%	0.76	28.42	0.04	1,097	1,435	2
	12	120 hour	124.0	20%	0.76	28.42	0.04	1,094	1,435	7
	13	144 hour	134.0	20%	0.76	28.42	0.04	1,086	1,435	5
	14	168 hour	144.0	20%	0.76	28.42	0.04	1,086	1,435	2
Critical	***9***	***48 hour***	***93.7***	***20%***	***0.79***	***28.45***	***0.01***	***1,133***	***1,435***	***9***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

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Environmental and Water Resource Software

Project Number/Name: J6667

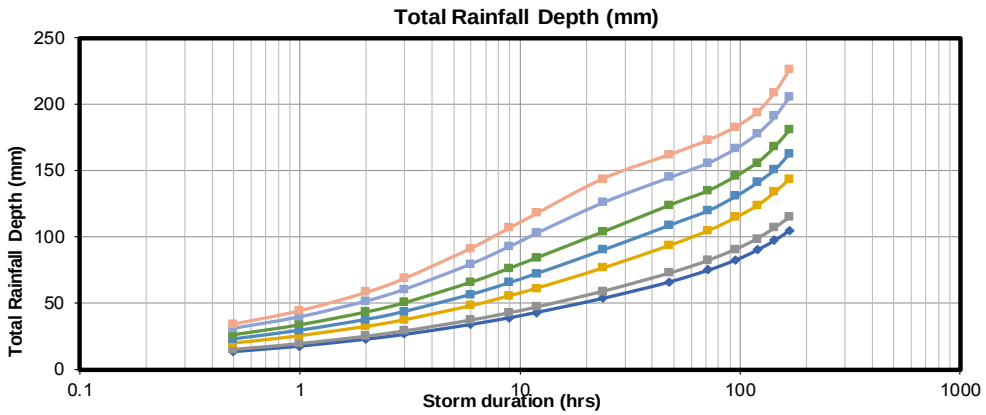
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment C

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Trad Lots	3.86	15	5	
Compact Lots	1.05			20.0%
POS	1.74			90.0%
Road	2.52			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	25
Design Groundwater Level (mAHD)	27.1
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	60
Base Width (m)	40
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	27.6
Maximum Allowable TWL (mAHD)	28.6

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

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Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment C

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	13.8	1 EY	0.16	27.76	0.84	408	2,599	1
	2	1 hour	17.9	1 EY	0.23	27.83	0.77	585	2,683	8
	3	2 hour	23.1	1 EY	0.33	27.93	0.67	847	2,806	8
	4	3 hour	26.8	1 EY	0.36	27.96	0.64	945	2,850	6
	5	6 hour	34.2	1 EY	0.44	28.04	0.56	1,162	2,949	7
	6	9 hour	39.3	1 EY	0.46	28.06	0.54	1,229	2,979	1
	7	12 hour	43.3	1 EY	0.48	28.08	0.52	1,303	3,012	5
	8	24 hour	53.9	1 EY	0.53	28.13	0.47	1,447	3,075	6
	9	48 hour	66.3	1 EY	0.54	28.14	0.46	1,468	3,085	4
	10	72 hour	75.2	1 EY	0.54	28.14	0.46	1,491	3,095	8
	11	96 hour	82.9	1 EY	0.56	28.16	0.44	1,553	3,122	4
	12	120 hour	90.3	1 EY	0.58	28.18	0.42	1,603	3,144	5
	13	144 hour	97.6	1 EY	0.59	28.19	0.41	1,649	3,164	4
	14	168 hour	105.0	1 EY	0.6	28.20	0.40	1,664	3,171	10
Critical	***14***	***168 hour***	***105.0***	***1 EY***	***0.6***	***28.20***	***0.40***	***1,664***	***3,171***	***10***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

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Environmental and Water Resource Software

Project Number/Name: J6667

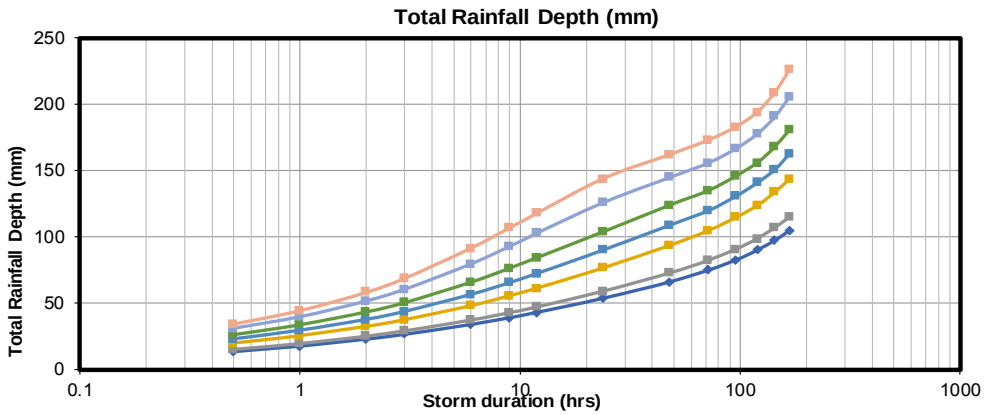
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment C

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	20% AEP (4.48 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Trad Lots	3.86	15	5	
Compact Lots	1.05			20.0%
POS	1.74			90.0%
Road	2.52			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	25
Design Groundwater Level (mAHD)	27.1
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	60
Base Width (m)	40
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	27.6
Maximum Allowable TWL (mAHD)	28.6

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

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Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment C

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	19.7	20%	0.29	27.89	0.71	735	2,754	8
	2	1 hour	25.4	20%	0.4	28.00	0.60	1,056	2,901	7
	3	2 hour	32.4	20%	0.51	28.11	0.49	1,385	3,049	5
	4	3 hour	37.4	20%	0.57	28.17	0.43	1,557	3,124	10
	5	6 hour	48.1	20%	0.68	28.28	0.32	1,934	3,286	3
	6	9 hour	55.6	20%	0.73	28.33	0.27	2,074	3,345	1
	7	12 hour	61.4	20%	0.74	28.34	0.26	2,121	3,365	6
	8	24 hour	76.8	20%	0.8	28.40	0.20	2,312	3,445	2
	9	48 hour	93.7	20%	0.77	28.37	0.23	2,223	3,408	7
	10	72 hour	105.0	20%	0.77	28.37	0.23	2,221	3,407	1
	11	96 hour	115.0	20%	0.8	28.40	0.20	2,340	3,457	1
	12	120 hour	124.0	20%	0.82	28.42	0.18	2,391	3,478	7
	13	144 hour	134.0	20%	0.85	28.45	0.15	2,486	3,516	3
	14	168 hour	144.0	20%	0.85	28.45	0.15	2,519	3,530	1
Critical	***13***	***144 hour***	***134.0***	***20%***	***0.85***	***28.45***	***0.15***	***2,486***	***3,516***	***3***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

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Environmental and Water Resource Software

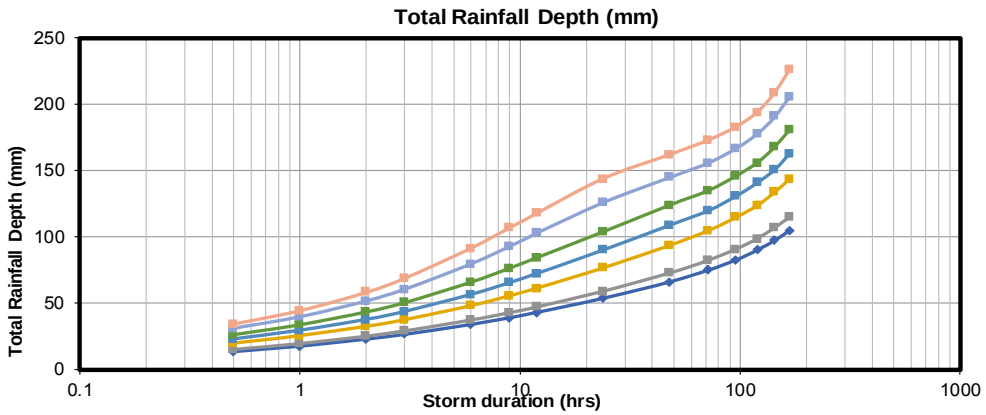
Project Number/Name:	J6667
Project Description:	Lot 705 Armadale Rd, Treeby LWMS - Catchment C

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	10% AEP (10 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Trad Lots	3.86	15	5	
Compact Lots	1.05			20.0%
POS	1.74			90.0%
Road	2.52			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	25
Design Groundwater Level (mAHD)	27.1
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	60
Base Width (m)	40
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	27.6
Maximum Allowable TWL (mAHD)	28.6

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

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Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment C

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	23.0	10%	0.36	27.96	0.64	948	2,852	1
	2	1 hour	29.5	10%	0.49	28.09	0.51	1,324	3,021	1
	3	2 hour	37.7	10%	0.61	28.21	0.39	1,707	3,189	10
	4	3 hour	43.8	10%	0.7	28.30	0.30	2,003	3,316	6
	5	6 hour	56.6	10%	0.82	28.42	0.18	2,380	3,473	8
	6	9 hour	65.6	10%	0.88	28.48	0.12	2,609	3,567	7
	7	12 hour	72.5	10%	0.85	28.45	0.15	2,516	3,529	2
	8	24 hour	90.2	10%	0.93	28.53	0.07	2,795	3,642	2
	9	48 hour	109.0	10%	0.89	28.49	0.11	2,660	3,588	4
	10	72 hour	120.0	10%	0.9	28.50	0.10	2,688	3,599	6
	11	96 hour	131.0	10%	0.91	28.51	0.09	2,704	3,606	8
	12	120 hour	141.0	10%	0.91	28.51	0.09	2,708	3,607	4
	13	144 hour	151.0	10%	0.97	28.57	0.03	2,930	3,696	6
	14	168 hour	163.0	10%	1	28.60	0.00	3,050	3,745	1
Critical	***14***	***168 hour***	***163.0***	***10%***	***1***	***28.60***	***0.00***	***3,050***	***3,745***	***1***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

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Environmental and Water Resource Software

Project Number/Name: J6667

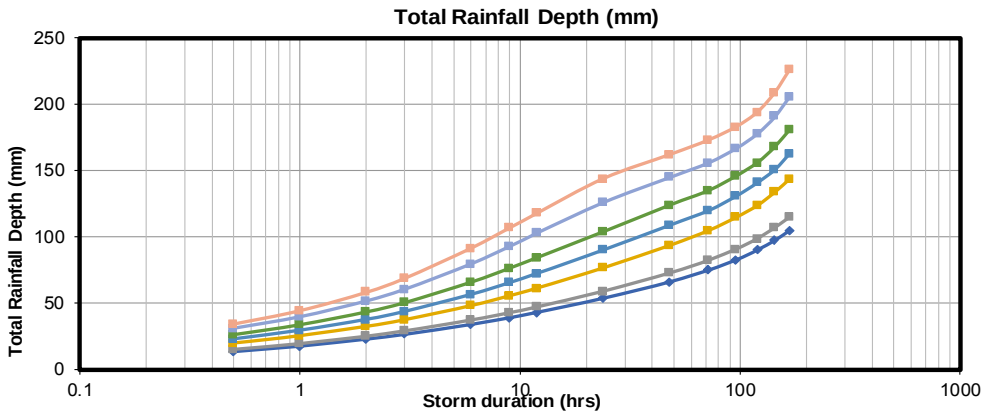
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment D

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
POS	1.78			90.0%
Road	1.03			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	22
Design Groundwater Level (mAHD)	27.54
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	46
Base Width (m)	35
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.05
Maximum Allowable TWL (mAHD)	28.6

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment D

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	13.8	1 EY	0.07	28.12	0.48	116	1,679	1
	2	1 hour	17.9	1 EY	0.09	28.14	0.46	146	1,697	10
	3	2 hour	23.1	1 EY	0.11	28.16	0.44	189	1,722	1
	4	3 hour	26.8	1 EY	0.12	28.17	0.43	206	1,732	1
	5	6 hour	34.2	1 EY	0.13	28.18	0.42	212	1,735	1
	6	9 hour	39.3	1 EY	0.13	28.18	0.42	218	1,738	1
	7	12 hour	43.3	1 EY	0.13	28.18	0.42	212	1,735	10
	8	24 hour	53.9	1 EY	0.12	28.17	0.43	193	1,724	3
	9	48 hour	66.3	1 EY	0.08	28.13	0.47	136	1,691	2
	10	72 hour	75.2	1 EY	0.06	28.11	0.49	96	1,667	10
	11	96 hour	82.9	1 EY	0.04	28.09	0.51	63	1,648	10
	12	120 hour	90.3	1 EY	0.06	28.11	0.49	101	1,670	5
	13	144 hour	97.6	1 EY	0.04	28.09	0.51	66	1,650	7
	14	168 hour	105.0	1 EY	0.05	28.10	0.50	86	1,661	2
Critical	***5***	***6 hour***	***34.2***	***1 EY***	***0.13***	***28.18***	***0.42***	***212***	***1,735***	***1***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

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Environmental and Water Resource Software

Project Number/Name: J6667

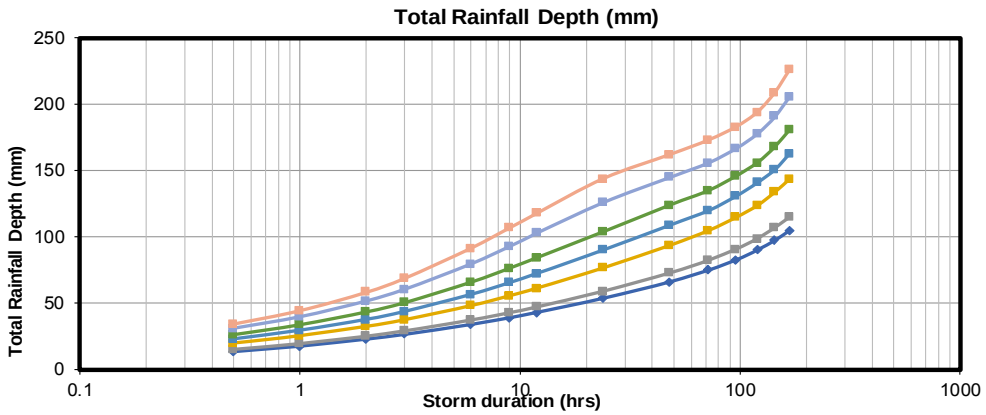
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment D

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	20% AEP (4.48 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
POS	1.78			90.0%
Road	1.03			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	22
Design Groundwater Level (mAHD)	27.54
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	46
Base Width (m)	35
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.05
Maximum Allowable TWL (mAHD)	28.6

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment D

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	19.7	20%	0.11	28.16	0.44	174	1,713	1
	2	1 hour	25.4	20%	0.13	28.18	0.42	219	1,739	10
	3	2 hour	32.4	20%	0.16	28.21	0.39	279	1,774	1
	4	3 hour	37.4	20%	0.18	28.23	0.37	307	1,790	1
	5	6 hour	48.1	20%	0.2	28.25	0.35	337	1,807	1
	6	9 hour	55.6	20%	0.21	28.26	0.34	359	1,820	1
	7	12 hour	61.4	20%	0.21	28.26	0.34	363	1,822	10
	8	24 hour	76.8	20%	0.21	28.26	0.34	364	1,823	10
	9	48 hour	93.7	20%	0.19	28.24	0.36	319	1,797	2
	10	72 hour	105.0	20%	0.16	28.21	0.39	279	1,773	1
	11	96 hour	115.0	20%	0.15	28.20	0.40	245	1,754	1
	12	120 hour	124.0	20%	0.13	28.18	0.42	218	1,738	7
	13	144 hour	134.0	20%	0.12	28.17	0.43	195	1,725	5
	14	168 hour	144.0	20%	0.11	28.16	0.44	174	1,713	6
Critical	***6***	***9 hour***	***55.6***	***20%***	***0.21***	***28.26***	***0.34***	***359***	***1,820***	***1***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

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Environmental and Water Resource Software

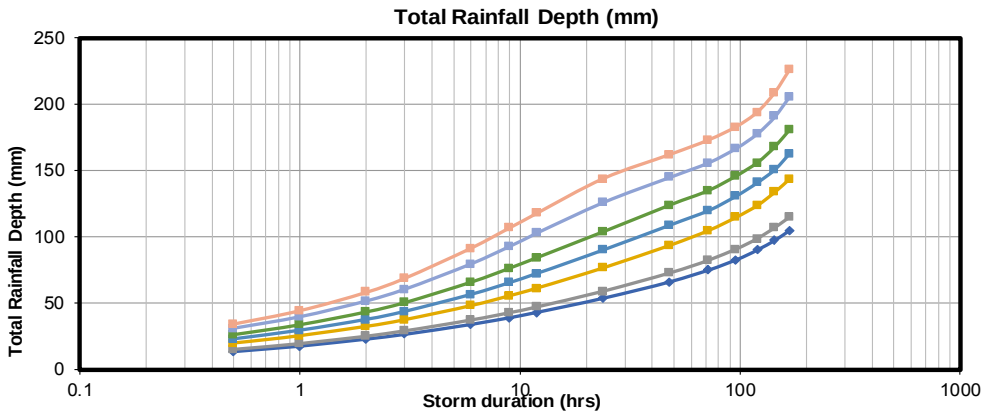
Project Number/Name:	J6667
Project Description:	Lot 705 Armadale Rd, Treeby LWMS - Catchment D

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	10% AEP (10 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Trad Lots	2.07	15	5	
Compact Lots	0.45			20.0%
POS	1.78			90.0%
Road	1.03			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	22
Design Groundwater Level (mAHD)	27.54
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	46
Base Width (m)	35
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.05
Maximum Allowable TWL (mAHD)	28.6

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment D

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	23.0	10%	0.25	28.30	0.30	428	1,858	4
	2	1 hour	29.5	10%	0.34	28.39	0.21	601	1,954	1
	3	2 hour	37.7	10%	0.43	28.48	0.12	789	2,055	10
	4	3 hour	43.8	10%	0.48	28.53	0.07	897	2,113	4
	5	6 hour	56.6	10%	0.52	28.57	0.03	977	2,155	7
	6	9 hour	65.6	10%	0.55	28.60	0.00	1,031	2,183	7
	7	12 hour	72.5	10%	0.5	28.55	0.05	934	2,133	2
	8	24 hour	90.2	10%	0.51	28.56	0.04	961	2,147	2
	9	48 hour	109.0	10%	0.42	28.47	0.13	768	2,045	4
	10	72 hour	120.0	10%	0.4	28.45	0.15	716	2,017	4
	11	96 hour	131.0	10%	0.35	28.40	0.20	627	1,968	7
	12	120 hour	141.0	10%	0.33	28.38	0.22	577	1,941	6
	13	144 hour	151.0	10%	0.31	28.36	0.24	556	1,930	5
	14	168 hour	163.0	10%	0.34	28.39	0.21	607	1,957	7
Critical	***6***	***9 hour***	***65.6***	***10%***	***0.55***	***28.60***	***0.00***	***1,031***	***2,183***	***7***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

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Environmental and Water Resource Software

Project Number/Name: J6667

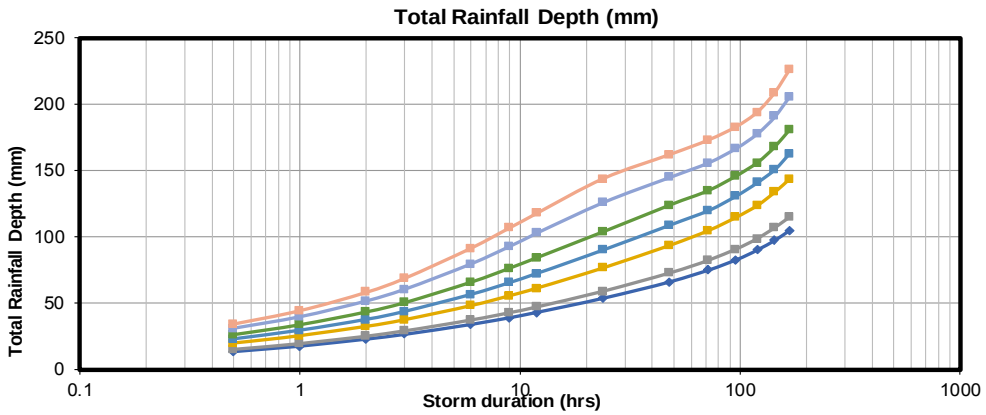
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment E

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Road	1.44			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	25
Design Groundwater Level (mAHD)	27.74
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	35
Base Width (m)	27
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.25
Maximum Allowable TWL (mAHD)	28.75

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment E

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	13.8	1 EY	0.15	28.40	0.35	146	1,056	1
	2	1 hour	17.9	1 EY	0.18	28.43	0.32	184	1,084	10
	3	2 hour	23.1	1 EY	0.23	28.48	0.27	236	1,122	1
	4	3 hour	26.8	1 EY	0.26	28.51	0.24	268	1,145	1
	5	6 hour	34.2	1 EY	0.29	28.54	0.21	307	1,173	1
	6	9 hour	39.3	1 EY	0.31	28.56	0.19	327	1,187	1
	7	12 hour	43.3	1 EY	0.32	28.57	0.18	343	1,198	10
	8	24 hour	53.9	1 EY	0.33	28.58	0.17	358	1,208	10
	9	48 hour	66.3	1 EY	0.33	28.58	0.17	352	1,204	9
	10	72 hour	75.2	1 EY	0.32	28.57	0.18	342	1,197	4
	11	96 hour	82.9	1 EY	0.31	28.56	0.19	327	1,187	1
	12	120 hour	90.3	1 EY	0.3	28.55	0.20	321	1,183	7
	13	144 hour	97.6	1 EY	0.28	28.53	0.22	293	1,163	5
	14	168 hour	105.0	1 EY	0.3	28.55	0.20	313	1,177	4
Critical	***8***	***24 hour***	***53.9***	***1 EY***	***0.33***	***28.58***	***0.17***	***358***	***1,208***	***10***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

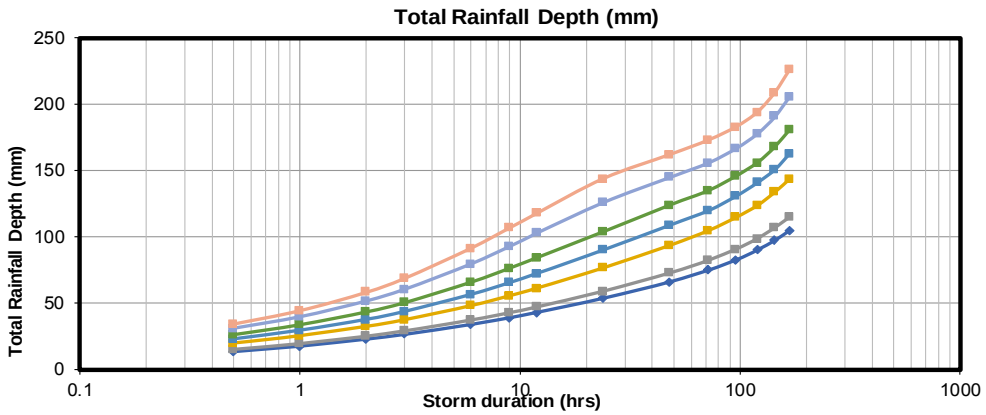
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment E

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	20% AEP (4.48 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Road	1.44			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	25
Design Groundwater Level (mAHD)	27.74
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	35
Base Width (m)	27
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.25
Maximum Allowable TWL (mAHD)	28.75

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment E

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	19.7	20%	0.21	28.46	0.29	212	1,105	1
	2	1 hour	25.4	20%	0.26	28.51	0.24	268	1,145	10
	3	2 hour	32.4	20%	0.32	28.57	0.18	340	1,196	1
	4	3 hour	37.4	20%	0.35	28.60	0.15	384	1,226	1
	5	6 hour	48.1	20%	0.41	28.66	0.09	450	1,272	1
	6	9 hour	55.6	20%	0.44	28.69	0.06	490	1,299	1
	7	12 hour	61.4	20%	0.46	28.71	0.04	517	1,316	10
	8	24 hour	76.8	20%	0.49	28.74	0.01	560	1,345	10
	9	48 hour	93.7	20%	0.5	28.75	0.00	565	1,348	9
	10	72 hour	105.0	20%	0.49	28.74	0.01	554	1,341	4
	11	96 hour	115.0	20%	0.48	28.73	0.02	539	1,331	2
	12	120 hour	124.0	20%	0.47	28.72	0.03	528	1,324	7
	13	144 hour	134.0	20%	0.44	28.69	0.06	493	1,300	5
	14	168 hour	144.0	20%	0.47	28.72	0.03	529	1,324	2
Critical	***9***	***48 hour***	***93.7***	***20%***	***0.5***	***28.75***	***0.00***	***565***	***1,348***	***9***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

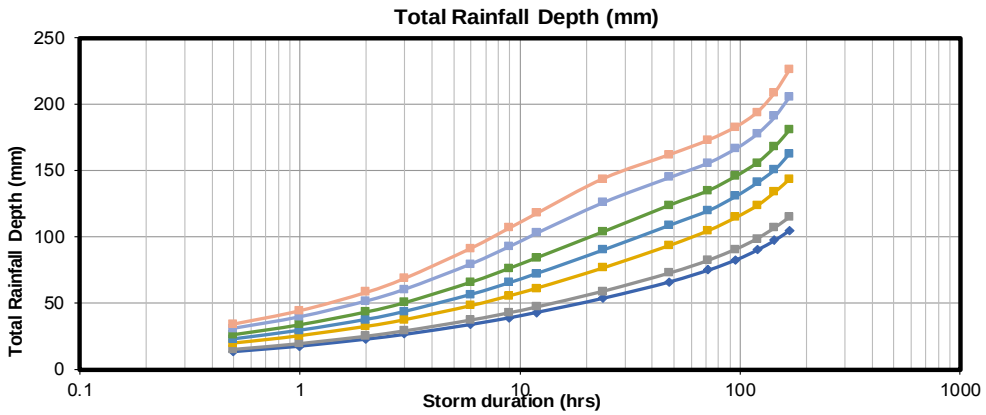
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment F

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Road	1.83			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	24
Design Groundwater Level (mAHD)	27.5
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	70
Base Width (m)	35
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28
Maximum Allowable TWL (mAHD)	28.3

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment F

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	13.8	1 EY	0.08	28.08	0.22	188	2,546	1
	2	1 hour	17.9	1 EY	0.1	28.10	0.20	239	2,571	10
	3	2 hour	23.1	1 EY	0.12	28.12	0.18	309	2,605	1
	4	3 hour	26.8	1 EY	0.14	28.14	0.16	355	2,628	1
	5	6 hour	34.2	1 EY	0.16	28.16	0.14	416	2,658	1
	6	9 hour	39.3	1 EY	0.17	28.17	0.13	432	2,666	1
	7	12 hour	43.3	1 EY	0.18	28.18	0.12	449	2,674	1
	8	24 hour	53.9	1 EY	0.19	28.19	0.11	477	2,688	10
	9	48 hour	66.3	1 EY	0.18	28.18	0.12	465	2,683	9
	10	72 hour	75.2	1 EY	0.17	28.17	0.13	438	2,669	1
	11	96 hour	82.9	1 EY	0.17	28.17	0.13	427	2,664	1
	12	120 hour	90.3	1 EY	0.16	28.16	0.14	420	2,660	1
	13	144 hour	97.6	1 EY	0.15	28.15	0.15	386	2,643	5
	14	168 hour	105.0	1 EY	0.16	28.16	0.14	410	2,656	4
Critical	***8***	***24 hour***	***53.9***	***1 EY***	***0.19***	***28.19***	***0.11***	***477***	***2,688***	***10***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

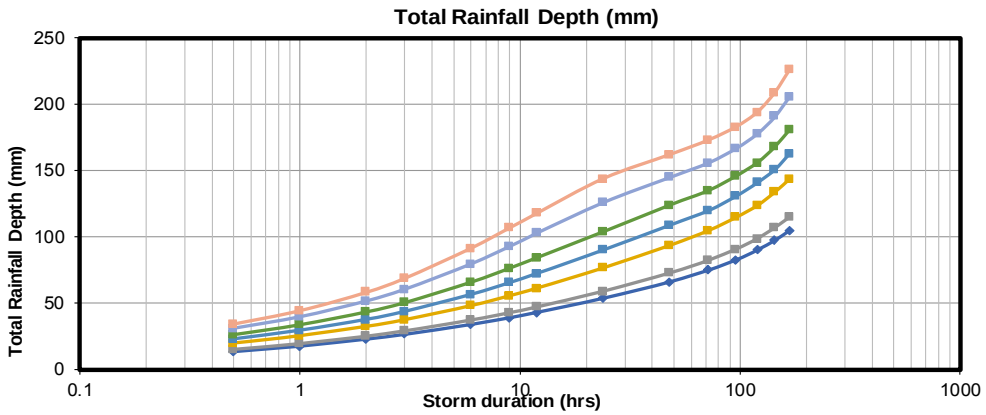
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Catchment F

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	20% AEP (4.48 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Road	1.83			20.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	24
Design Groundwater Level (mAHD)	27.5
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	70
Base Width (m)	35
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28
Maximum Allowable TWL (mAHD)	28.3

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Catchment F

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	19.7	20%	0.11	28.11	0.19	273	2,588	1
	2	1 hour	25.4	20%	0.14	28.14	0.16	348	2,625	10
	3	2 hour	32.4	20%	0.17	28.17	0.13	442	2,671	1
	4	3 hour	37.4	20%	0.2	28.20	0.10	507	2,703	1
	5	6 hour	48.1	20%	0.23	28.23	0.07	609	2,752	1
	6	9 hour	55.6	20%	0.25	28.25	0.05	651	2,772	1
	7	12 hour	61.4	20%	0.26	28.26	0.04	687	2,790	1
	8	24 hour	76.8	20%	0.29	28.29	0.01	758	2,824	10
	9	48 hour	93.7	20%	0.29	28.29	0.01	772	2,831	9
	10	72 hour	105.0	20%	0.29	28.29	0.01	754	2,822	4
	11	96 hour	115.0	20%	0.28	28.28	0.02	744	2,817	10
	12	120 hour	124.0	20%	0.28	28.28	0.02	744	2,817	7
	13	144 hour	134.0	20%	0.26	28.26	0.04	693	2,793	5
	14	168 hour	144.0	20%	0.28	28.28	0.02	749	2,820	2
Critical	***8***	***24 hour***	***76.8***	***20%***	***0.29***	***28.29***	***0.01***	***758***	***2,824***	***10***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

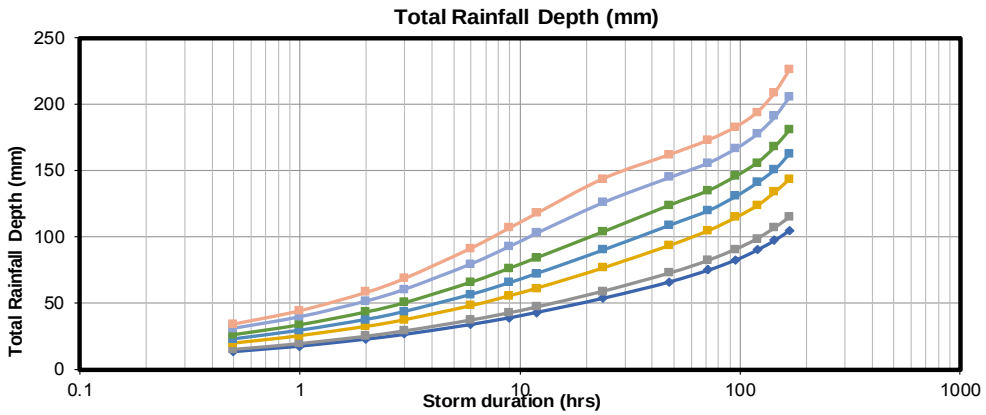
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - Oval 1% AEP

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	Y

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Swale 1:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Trad Lots	8.98	15	5	
Compact Lots	0.96			20.0%
Road	4.08			20.0%

Swale 2:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Trad Lots	3.86	15	5	
Compact Lots	1.05			20.0%
Road	2.52			20.0%

Swale 3:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Trad Lots	2.07	15	5	
Compact Lots	0.45			20.0%
Road	1.03			20.0%

Swale Geometry:

Swale Length (m)	360.0
Swale Base Width (m)	6.0
Left Batter (1 in X)	6.0
Right Batter (1 in X)	6.0
Ave. Swale Base Elevation (mAHD)	28.40
Maximum Swale Depth (m)	0.60
Swale Slope (m/m)	0.000
Manning's Roughness	0.03

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Design Groundwater Level	26.7
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	60
Swale Base Width (m)	40
Left Batter (1 in X)	6
Right Batter (1 in X)	6
Ave. Swale Base Elevation (mAHD)	27.6
Maximum Swale Depth (m)	1
Swale Slope (m/m)	1E-10
Manning's Roughness	0.03

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Design Groundwater Level	27.1
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	46
Swale Base Width (m)	35
Left Batter (1 in X)	6
Right Batter (1 in X)	6
Ave. Swale Base Elevation (mAHD)	28.05
Maximum Swale Depth (m)	0.55
Swale Slope (m/m)	1E-10
Manning's Roughness	0.03

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Design Groundwater Level	27.54
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
POS	3.0284			90.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	7.5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	25
Design Groundwater Level (mAHD)	27.1
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	Y
Base Length (m)	120
Base Width (m)	145
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	27.6
Maximum Allowable TWL (mAHD)	27.9

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - Oval 1% AEP

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	34.5	1%	0.13	27.73	0.17	2,239	17,495	1
	2	1 hour	44.6	1%	0.12	27.72	0.18	2,101	17,495	5
	3	2 hour	58.4	1%	0.19	27.79	0.11	3,354	17,495	3
	4	3 hour	68.9	1%	0.17	27.77	0.13	2,911	17,495	6
	5	6 hour	91.6	1%	0.22	27.82	0.08	3,823	17,495	1
	6	9 hour	107.0	1%	0.2	27.80	0.10	3,413	17,495	3
	7	12 hour	118.0	1%	0.1	27.70	0.20	1,814	17,495	7
	8	24 hour	144.0	1%	0.14	27.74	0.16	2,378	17,495	4
	9	48 hour	162.0	1%	0.07	27.67	0.23	1,293	17,495	3
	10	72 hour	173.0	1%	0.12	27.72	0.18	2,079	17,495	2
	11	96 hour	183.0	1%	0.14	27.74	0.16	2,390	17,495	9
	12	120 hour	194.0	1%	0.1	27.70	0.20	1,702	17,495	9
	13	144 hour	209.0	1%	0.12	27.72	0.18	2,034	17,495	5
	14	168 hour	226.0	1%	0.11	27.71	0.19	1,921	17,495	1
Critical	***5***	***6 hour***	***91.6***	***1%***	***0.22***	***27.82***	***0.08***	***3,823***	***17,495***	***1***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: J6667

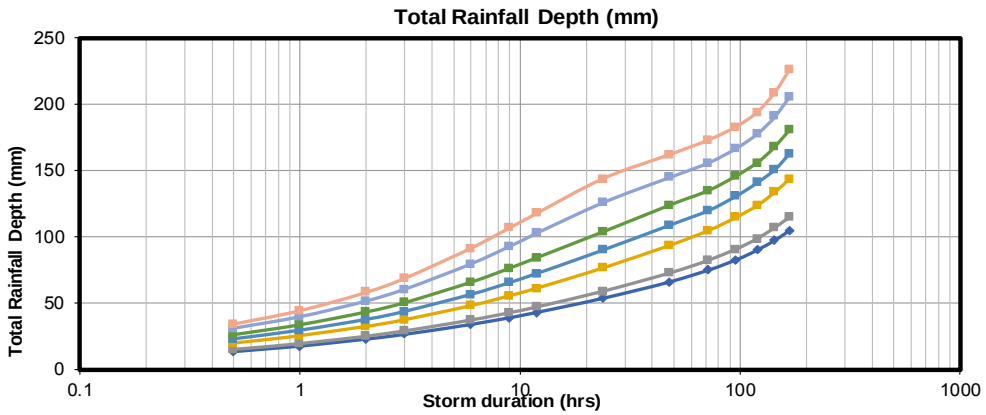
Project Description: Lot 705 Armadale Rd, Treeby
LWMS - School

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1375 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.8	15.2	19.7	23	26.3	30.9	34.5
1 hour	17.9	19.6	25.4	29.5	33.8	39.7	44.6
2 hour	23.1	25.2	32.4	37.7	43.4	51.6	58.4
3 hour	26.8	29.2	37.4	43.8	50.5	60.5	68.9
6 hour	34.2	37.3	48.1	56.6	65.8	79.7	91.6
9 hour	39.3	42.9	55.6	65.6	76.4	92.9	107
12 hour	43.3	47.3	61.4	72.5	84.5	103	118
24 hour	53.9	59.1	76.8	90.2	104	126	144
48 hour	66.3	72.7	93.7	109	124	145	162
72 hour	75.2	82.4	105	120	135	156	173
96 hour	82.9	90.8	115	131	146	167	183
120 hour	90.3	98.7	124	141	156	178	194
144 hour	97.6	107	134	151	168	191	209
168 hour	105	115	144	163	181	206	226



Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
School	4.16			50.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	24
Design Groundwater Level (mAHD)	26.6
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	40
Base Width (m)	26
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.8
Maximum Allowable TWL (mAHD)	30

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

J6667

Project Description:

Lot 705 Armadale Rd, Treeby
LWMS - School

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	34.5	1%	0.53	29.33	0.67	676	1,503	1
	2	1 hour	44.6	1%	0.64	29.44	0.56	835	1,602	10
	3	2 hour	58.4	1%	0.78	29.58	0.42	1,080	1,748	1
	4	3 hour	68.9	1%	0.89	29.69	0.31	1,275	1,860	1
	5	6 hour	91.6	1%	1.05	29.85	0.15	1,587	2,031	1
	6	9 hour	107.0	1%	1.11	29.91	0.09	1,714	2,099	10
	7	12 hour	118.0	1%	1.15	29.95	0.05	1,789	2,139	10
	8	24 hour	144.0	1%	1.19	29.99	0.01	1,873	2,183	7
	9	48 hour	162.0	1%	1.09	29.89	0.11	1,666	2,074	4
	10	72 hour	173.0	1%	0.98	29.78	0.22	1,442	1,952	6
	11	96 hour	183.0	1%	0.9	29.70	0.30	1,291	1,869	2
	12	120 hour	194.0	1%	0.86	29.66	0.34	1,226	1,832	3
	13	144 hour	209.0	1%	0.65	29.45	0.55	860	1,617	9
	14	168 hour	226.0	1%	0.57	29.37	0.63	729	1,537	7
Critical	***8***	***24 hour***	***144.0***	***1%***	***1.19***	***29.99***	***0.01***	***1,873***	***2,183***	***7***

Notes:

Temporal pattern matching closest to mean water level
If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

APPENDIX H

UNDO Modelling Results

Government of Western Australia
Department of Water and Environmental Regulation

Project: J6667

Date: 17/04/2019

Version: Version 1.1.2.17327

Subregion name: Lots

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	100	23.92	964.89	259.15
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	0	0.00	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total area	Total percent (%)
23.92	52

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
45.57	10.98

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
1.85	0.16

Residential

Size (m²)	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
<400	60	14.35	337.18	98.78
400-500 m²	40	9.57	627.72	160.37
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	0	0.00	0.00	0.00

Total area	Total percent (%)
23.92	100

Nitrogen input (kg)	Phosphorus input (kg)
964.89	259.15

Soil and drainage information

Type of drainage	**Infiltration**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**No**
Depth to groundwater (m)	**1.5**		
Groundwater slope (%)	**0.05**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: POS

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	100	7.82	409.14	12.54
Road reserve	0	0.00	0.00	0.00

Total area	Total percent (%)
7.82	17

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
57.55	1.75

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
5.62	0.11

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	36	2.82
Non-native gardens	0	0.00
Not fertilised	0	0.00
Nature	0	0.00
Sport	0	0.00
Recreation	64	5.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	0	0.00
Water body	0	0.00

Total area	Total percent (%)
7.82	100

Nitrogen input (kg)	Phosphorus input (kg)
409.14	12.54

Soil and drainage information

Type of drainage	**Infiltration**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**No**
Depth to groundwater (m)	**1.5**		
Groundwater slope (%)	**0.5**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: Road

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	0	0.00	0.00	0.00
Road reserve	100	14.26	0.00	0.00

Total area	Total percent (%)
14.26	31

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
5.23	0.15

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
0.50	0.01

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	80	11.41
Road reserve - impervious	0	0.00
Road reserve - native garden	0	0.00
Road reserve - non-native garden	0	0.00
Road reserve - turf	0	0.00
Road reserve - not fertilised	20	2.85

Total area	Total percent (%)
14.26	100

Nitrogen input (kg)	Phosphorus input (kg)
0.00	0.00

Soil and drainage information

Type of drainage	**Infiltration**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**No**
Depth to groundwater (m)	**1.5**		
Groundwater slope (%)	**0.5**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Summary: Nutrient stripping devices

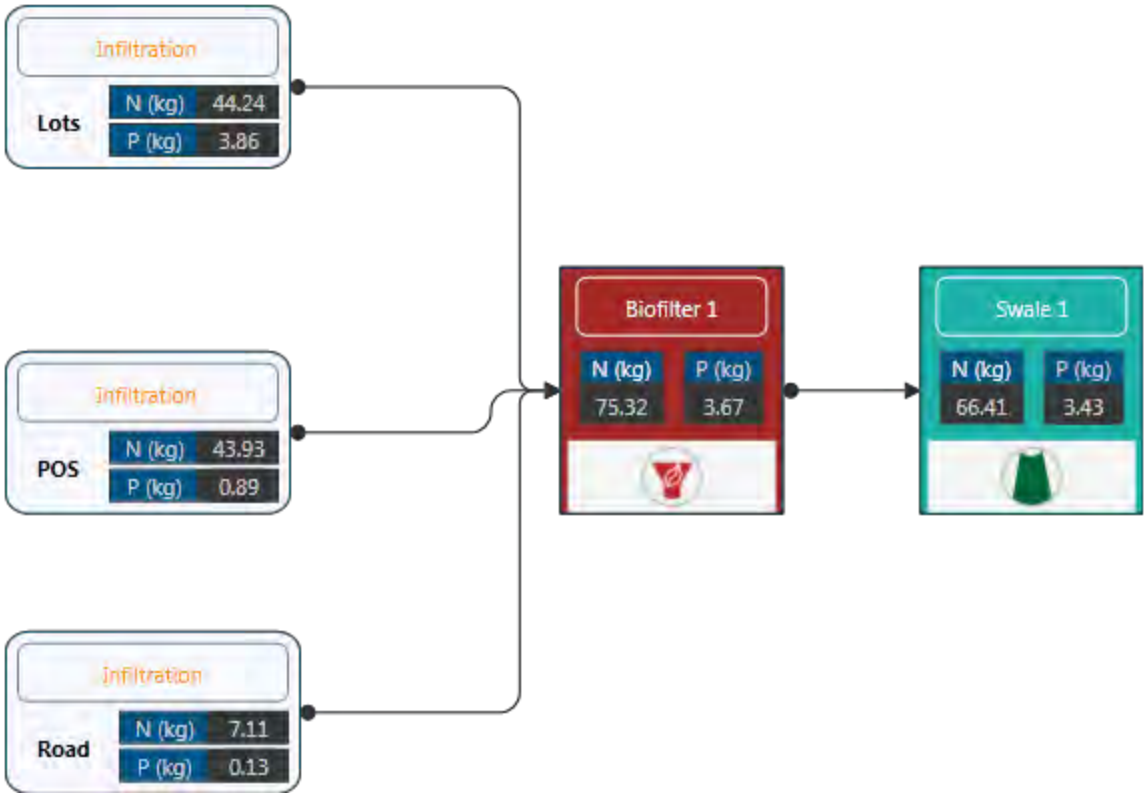
Treatment	Name	Size (m²)	Treated area (ha)	Treating	N removed (kg/ha/yr)	P removed (kg/ha/yr)
Biofilter	Biofilter 1	12145.00	46.00	Sandy soils – Runoff only (infiltration on lots)	1.67	0.07
Swale	Swale 1	175000.00	46.00	Sandy soils – Runoff only (infiltration on lots)	0.74	0.01
Load removed					**0.63**	**0.03**
Net export					**1.44**	**0.07**

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/ha/yr)	N export (kg/ha/yr)
Lots	23.92	0.16	1.85
POS	7.82	0.11	5.62
Road	14.26	0.01	0.50

PRE-TREATMENT LOAD (kg/ha/yr)		LOAD REMOVED (kg/ha/yr)		NET LOAD EXPORT (kg/ha/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
2.07	**0.11**	**0.63**	**0.03**	**1.44**	**0.07**

Treatment diagram



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APPENDIX FIVE

Transport Impact Assessment (Transcore)

Lot 705 and 707 Armadale Road, Treeby

Transport Impact Assessment

PREPARED FOR:
Perron Treeby Pty Ltd

November 2019

Document history and status

Author	Revision	Approved by	Date approved	Revision type
M Rasouli	r01	B Bordbar	11/02/2019	Draft
M Rasouli	r01a	M Rasouli	15/10/2019	Final
M Rasouli	r01b	M Rasouli	15/11/2019	Minor Revision

File name: t18.240.mr.r01b

Author: Mohammad Rasouli

Project manager: Mohammad Rasouli

Client: Perron Treeby Pty Ltd

Project: Lot 705 and 707 Armadale Road, Treeby

Document revision: r01b

Project number: t18.240

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1.0 Introduction

This Transport Impact Assessment (TIA) report has been prepared by Transcore on behalf of Perron Treeby Pty Ltd. The subject of this transport assessment is the proposed Local Structure Plan (LSP) for Lot 705 and 707 Armadale Road, in Treeby.

In 2010 Transcore prepared a Transport Impact Assessment report with respect to the rezoning application for the above Lots. The TIA report for rezoning was updated in 2018 to reflect the up to date strategic planning for the Treeby District Structure Plan (DSP) and to be in accordance with the latest WAPC Transport Impact Assessment Guidelines (August 2016). The Treeby DSP has been endorsed by the City of Cockburn in September 2017. A copy of the DSP is provided in **Appendix A**.

For the purpose of this TIA report and in order to be consistent with the outcome of the strategic planning for the DSP area, the transport model developed for the Treeby DSP area was utilised and the Concept Plan for the proposed LSP prepared by CLE has been coded into this model.

The site is currently vacant. **Figure 1** shows the subject site in relation to different zonings and reservations of the Metropolitan Region Scheme.

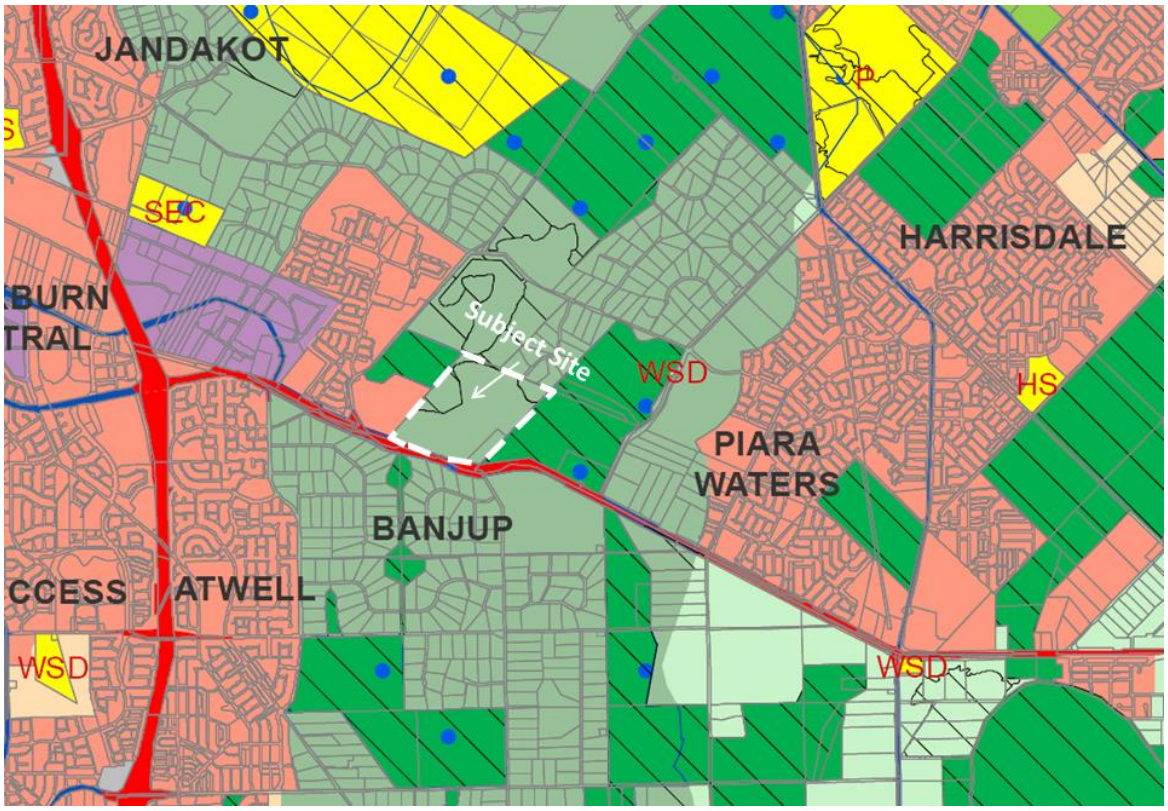


Figure 1: Location of the subject site

2.0 Proposed Local Structure Plan

The proposed Local Structure Plan prepared for the subject site is shown in **Figure 2**. A total number of about 660 lots, a Primary School and a local centre are planned for the LSP area.



Figure 2: Proposed Local Structure Plan

The proposed road network and access arrangements for the LSP area are in line with the adopted Treeby DSP.

The primary access intersection for the proposed LSP area is through the proposed 4-way intersection of Armadale Road/ Liddelow Road. A roundabout intersection is proposed at this location as shown in the Appendix A of DSP. This roundabout intersection being constructed currently and is expected to ultimately be upgraded to an interchange.

The main north-south road through the LSP area connects Liddelow Road to Fraser Road which would provide a connection to Jandakot Road to the north and Solomon Road to the west.

The proposed LSP also shows the possible road network connection into the future developments to the west of the subject site (Lot 821).

3.0 Existing Situation

3.1 Existing Land Use

The site currently is vacant. Areas to the west and north of the site are subject to future residential developments. The Armadale Road forms the southern boundary of the subject site (refer **Figure 3**).



Figure 3: Existing land use

3.2 Existing Road Network

The existing road network and its classification in the Main Roads WA functional road hierarchy is illustrated in **Figure 4.**

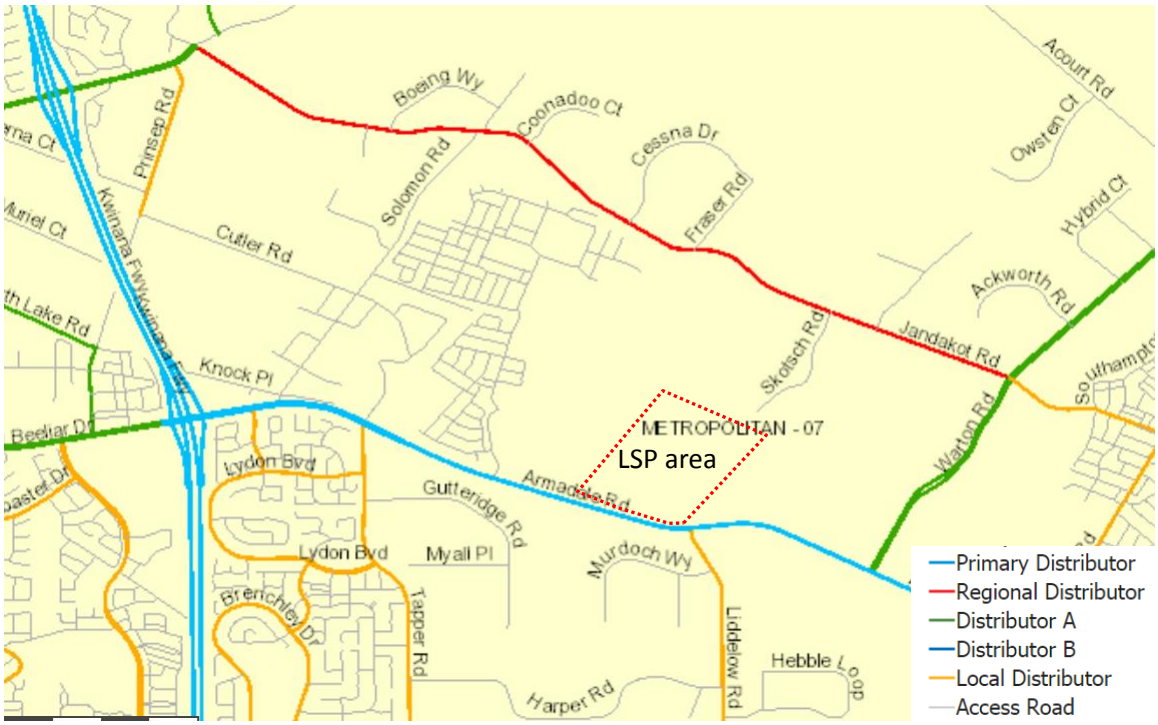


Figure 4: Existing road hierarchy

Armadale Road is a Primary Distributor road according to Main Roads WA Functional Road Hierarchy and a Primary Regional Road in the Metropolitan Region Scheme. Armadale Road has been recently upgraded to dual carriageway standard at the intersection with Ghostgum Avenue. Armadale Road is of single carriageway standard with a speed limit of 80 km/h to the east of the Calleya LSP area and in the vicinity of the subject site and becomes dual carriageway again immediately to the west of Calleya LSP.

According to traffic counts published by Main Roads WA Armadale Road in this vicinity (west of Liddelow Road) carried about 31,000vpd with 11% heavy vehicles in 2018. **Figure 5** shows the existing traffic profile along Armadale Road.

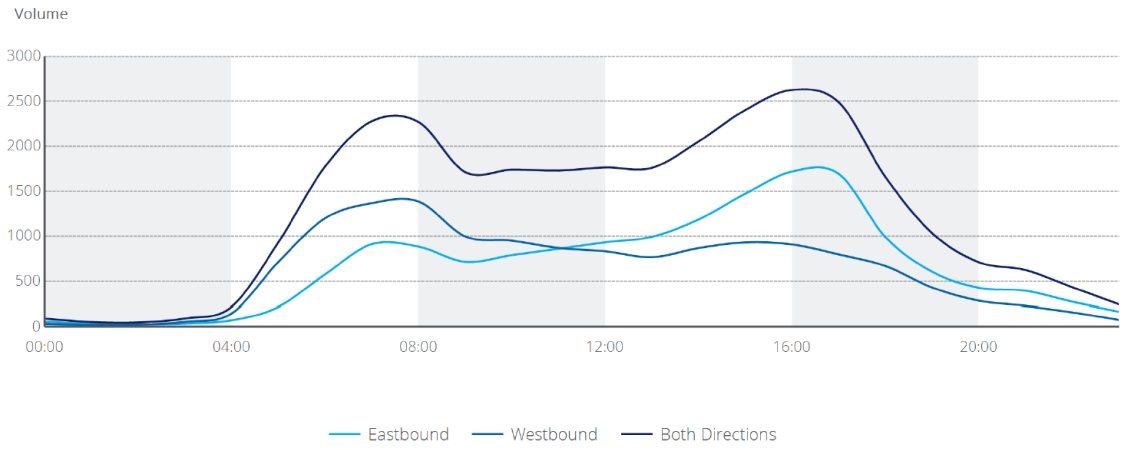


Figure 5: Existing traffic flow on Armadale Road (west of Liddelow Road)

Jandakot Road is of single carriageway standard with a speed limit of 80km/h in the vicinity of the subject site. According to Main Roads WA Functional Roads Hierarchy, Jandakot Road is a Regional Distributor and a District Distributor (B) in accordance with City of Cockburn classification. According to traffic counts provided by City of Cockburn, Jandakot Road, East of Berrigan Dr, carried about 16,800vpd in 2017. **Figure 6** shows the existing traffic profile along Jandakot Road.

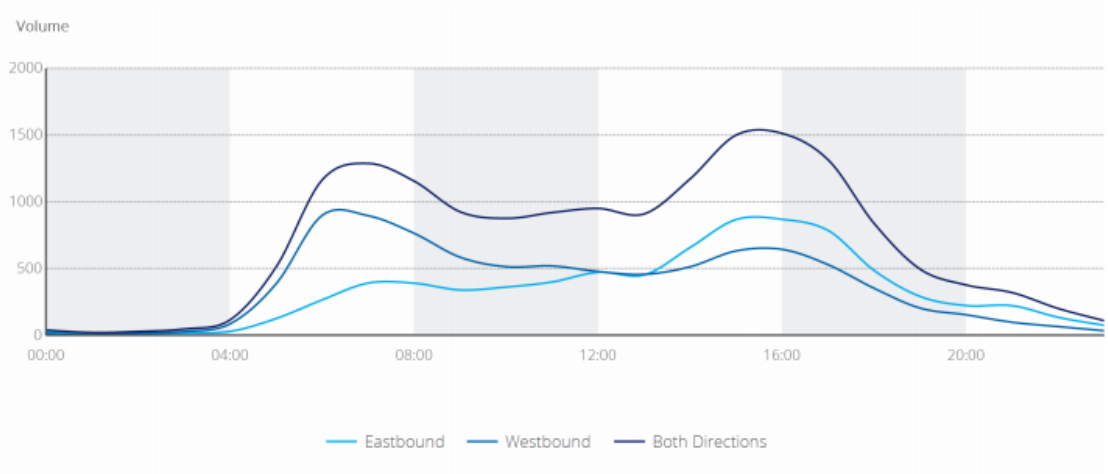


Figure 6: Existing traffic flow on Jandakot Road (east of Berrigan Dr)

Liddelow Road is a local Distributor road according to Main Roads WA Functional Road Hierarchy. According to the traffic counts provided by the City of Cockburn, Liddelow Road 300m south of Armadale Road carried average weekday traffic of about 3,760vpd with 5.3% heavy vehicles. The AM (6:00-7:00) and PM (16:00-17:00) peak hours are reported to be 300vph and 440vph respectively.

3.3 Existing Traffic Volumes

Existing average weekday traffic (AWT) volumes on the key roads surrounding the LSP area have been obtained from Main Roads WA and are illustrated in **Figure 7**and **Figure 8.**

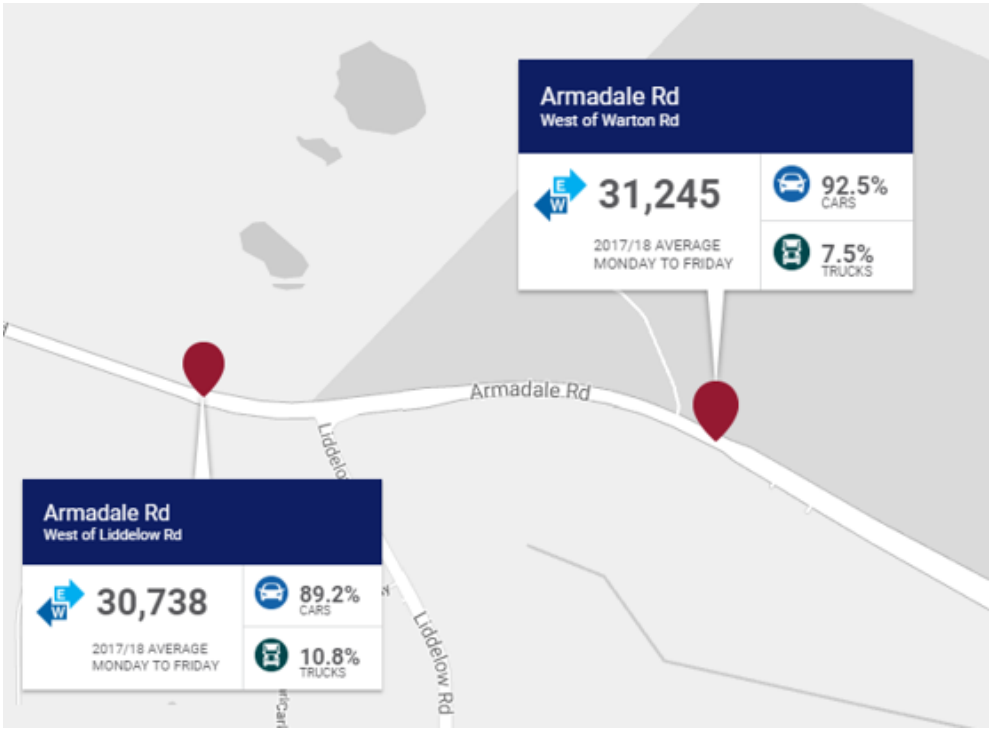


Figure 7: Existing traffic counts on Armadale Road

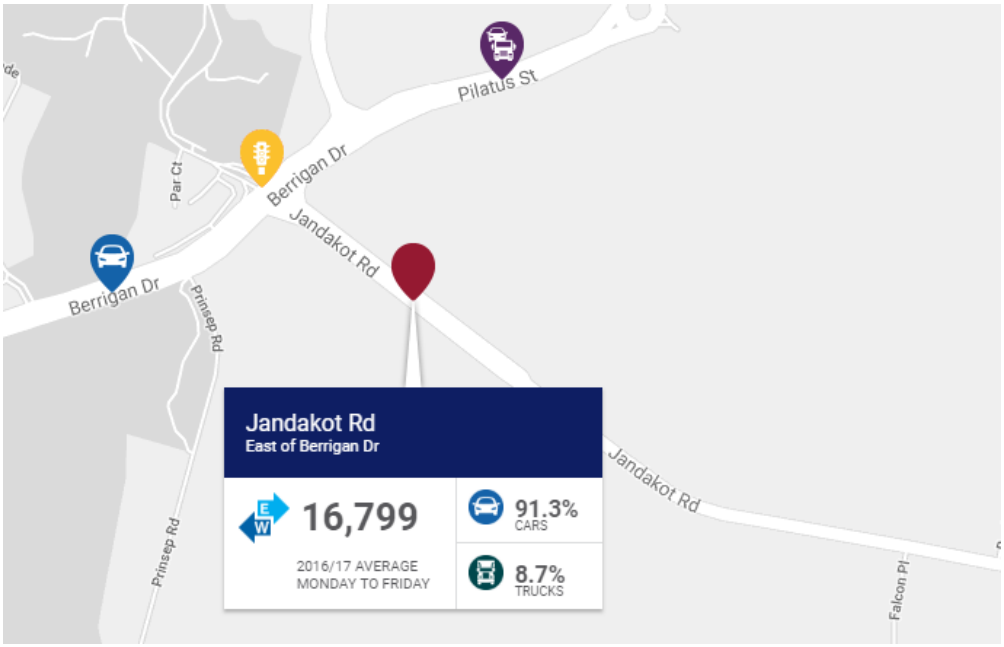


Figure 8: Existing traffic counts on Jandakot Road

3.4 Heavy Vehicle Routes

Restricted Access Vehicle (RAV) Network routes are designated for access by large heavy vehicle combinations. Main Roads WA manages the RAV Network. Armadale Road adjacent to the LSP area forms part of RAV Tandem Drive Network 4 (refer

Figure 9). The RAV 4 Network classification permits a variety of prime mover and trailer combinations, up to a maximum length of 27.5m.



Figure 9: Restricted Access Vehicles Network

To estimate the classified traffic profile of the Armadale Road, existing classified count data for this road was reviewed, which indicates around 10% to 11% heavy vehicles. The composition of heavy vehicle types is noted in Table 1.

Table 1: Composition of light and heavy vehicles on Armadale Road

	Armadale Rd(west of Liddelow Rd)		Armadale Rd(west of Warton Rd)	
	EB	WB	EB	WB
Vehicle Type	**% Composition**	**% Composition**	**% Composition**	**% Composition**
Light Vehicles Class 1	85.90%	89.70%	90.00%	91.40%
Rigid Truck / Bus Class 2-5	12.10%	8.50%	8.20%	6.90%
Semi-trailer Class 6-9	1.60%	1.40%	1.30%	1.30%
B-doubles Class 10	0.10%	0.10%	0.20%	0.20%
Double road train Class 11	0.20%	0.20%	0.20%	0.20%
Total	**100%**	**100%**	**100%**	**100%**

3.5 Public Transport

The closest bus service in the vicinity of the subject site is the existing 518 bus route running along Armadale Road to the south of the subject site.

The closest train station in the vicinity of the subject site is the Cockburn Central train station (refer **Figure 10**).

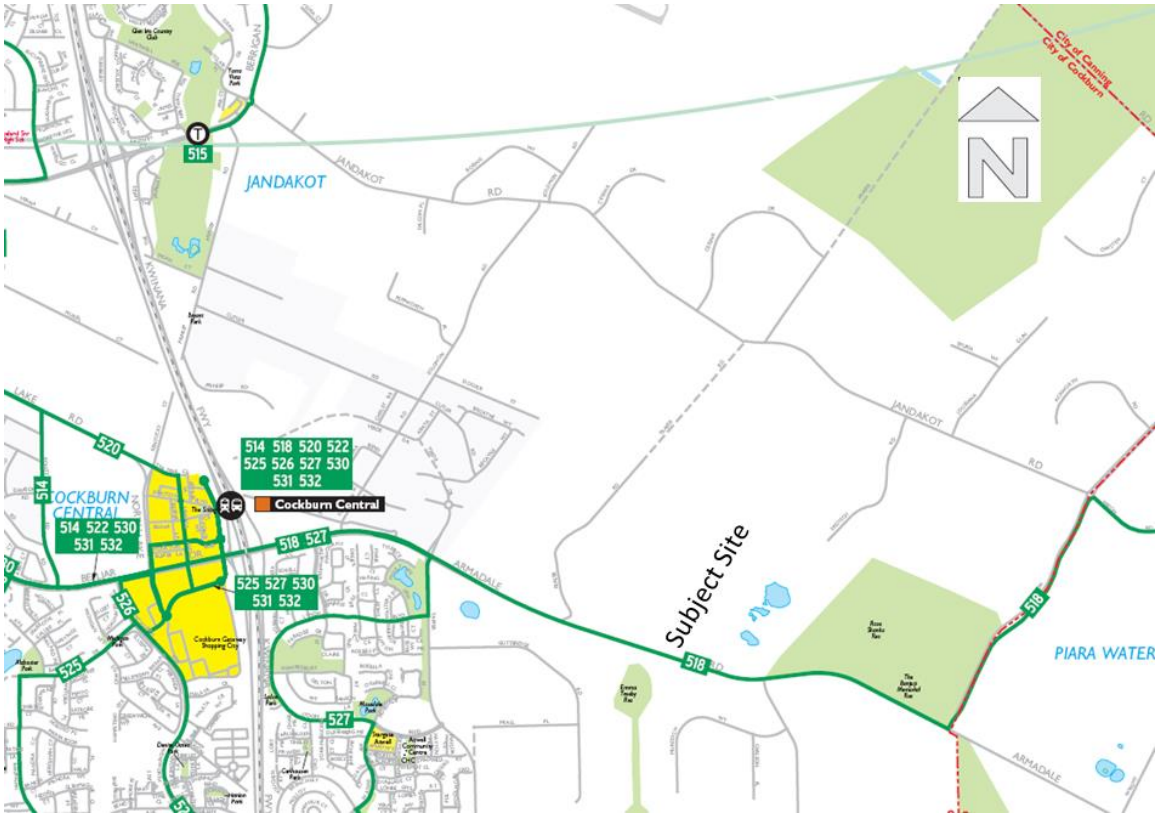


Figure 10: Existing bus routes

3.6 Pedestrian and Cyclist Facilities

There is no existing pedestrian or cycling facilities on Armadale Road or Jandakot Road in the vicinity of the subject site. The recent upgrading of Armadale Road through the Ghostgum Avenue intersection has provided on-road cycle lanes on Armadale Road along the frontage of the Calleya LSP although other sections of Armadale Road to the east and west have not yet been upgraded to this standard.

The Department of Transport's Perth Bike Map series (see **Figure 11**) shows that bicycle lanes or sealed shoulders are provided either side of Armadale Road and Jandakot Road.

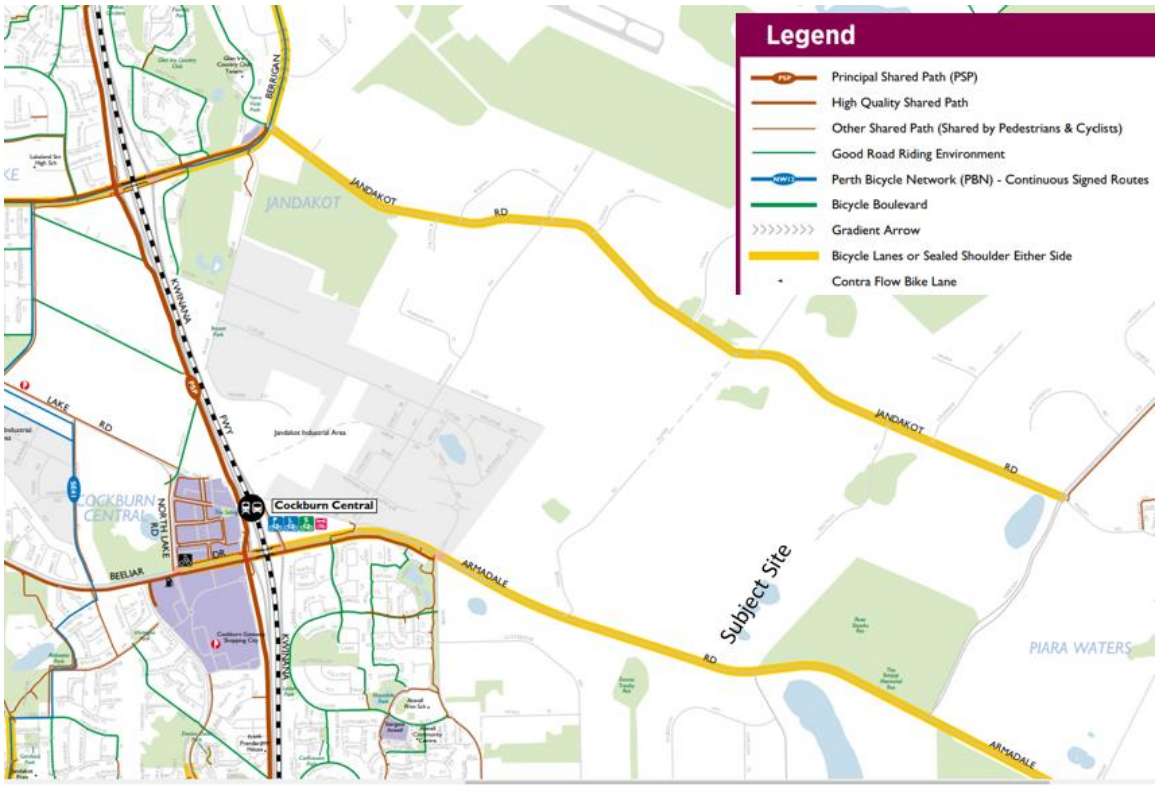


Figure 11: Bike map

3.7 Changes to the Surrounding Road Network

There are proposed regional and local changes to the surrounding road network in this area. Armadale Road is expected to be upgraded to 4 lanes in the medium term and 6 lanes in the longer term. Jandakot Road is also expected to be upgraded to 4 lanes in future.

The other proposed local changes to Armadale Road include conversion of the existing T-intersection of Armadale Road/ Liddelow Road into a roundabout intersection.

3.8 Public Transport Network Planning

According to the information obtained from PTA in the event that residential development extends east of Calleya LSP area and sufficient demand arises for secondary bus services, then there is likely to be a need for a supplementary bus route (indicated by the red line in **Figure 12**). The route would likely operate from Cockburn Central, along Armadale Road, then north-south through the eastern development across to the proposed Neighbourhood Activity Centre within Calleya LSP.

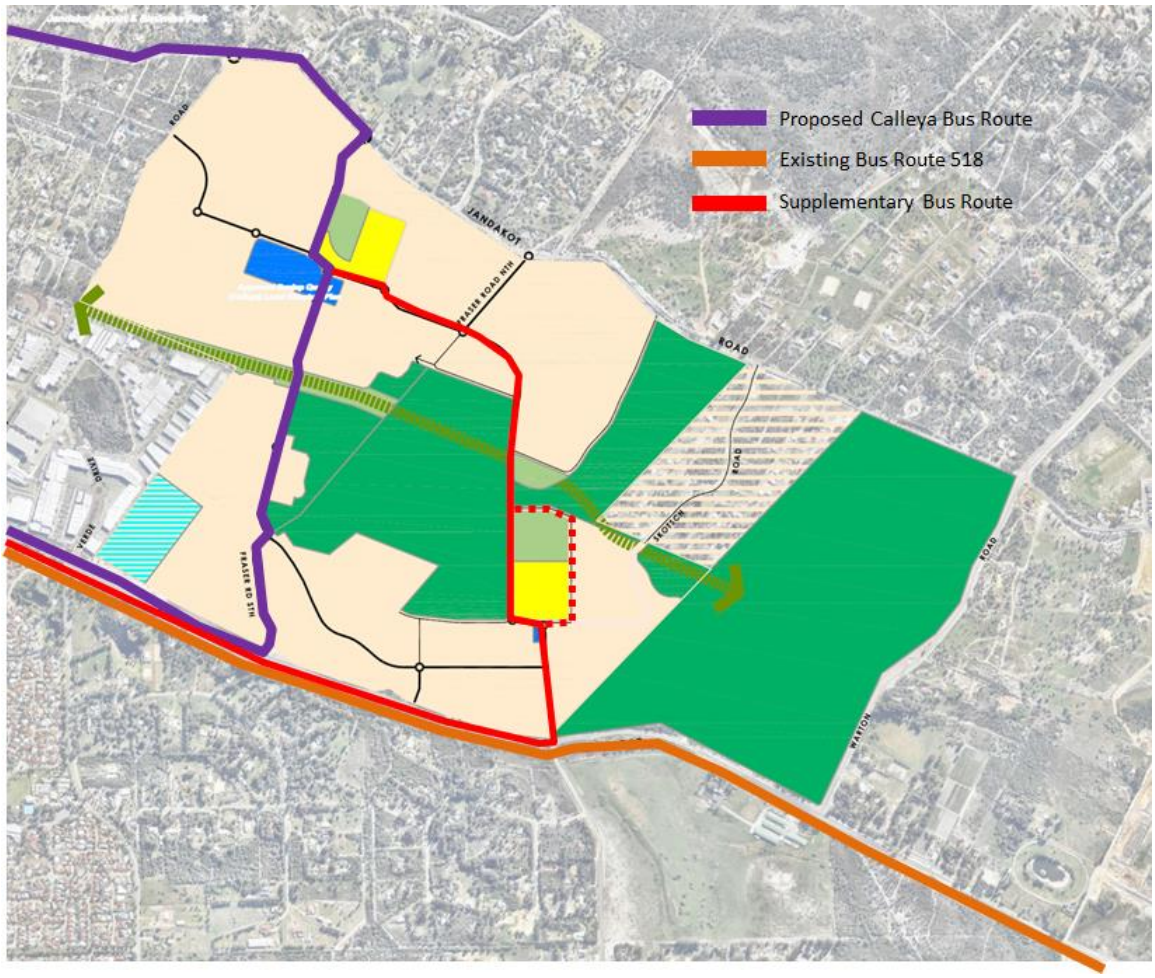


Figure 12: Potential future bus routes (PTA)

The Department of Transport plan, Public Transport for Perth in 2031, envisages a future bus rapid transit route from Armadale to Cockburn Central providing a cross-suburban link between the Mandurah and Armadale railway lines. However, this is part of the ultimate network and is indicated as a beyond 2031 initiative (refer **Figure 13**). According to the same plan extension of Thornlie rail line is also expected to connect Cannington to Cockburn Central and continuing further south-west towards Rockingham.



Figure 13: Department of Transport future service development plan

4.0 Proposed Transport Network

4.1 Road Hierarchy

The proposed hierarchy of roads within the LSP area is illustrated in **Figure 14** using the road hierarchy classification from Liveable Neighbourhoods (2007).

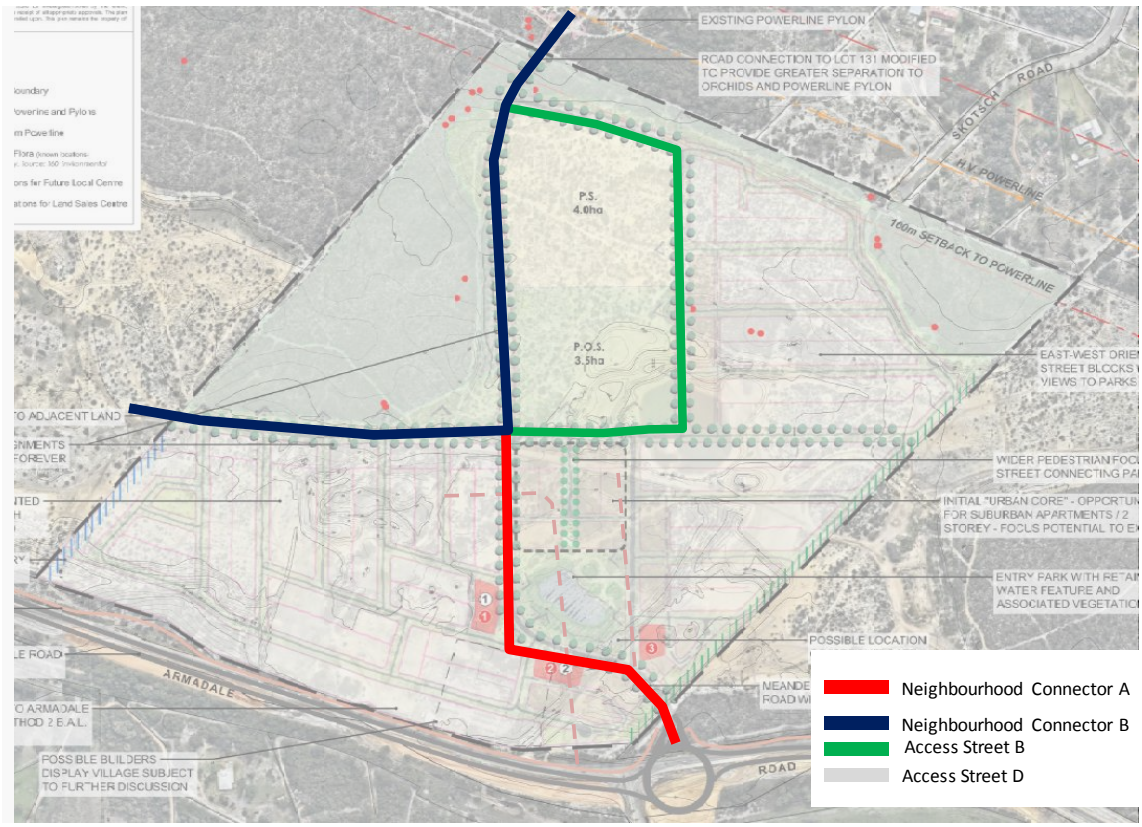


Figure 14: Proposed Road Hierarchy

Some key characteristics of the relevant road classifications have been summarised in **Table 2** below. These are generally based on Liveable Neighbourhoods guidelines although the proposed widths would vary slightly from the standard Liveable Neighbourhoods typical cross-section diagrams.

It should be noted that these reserve widths are indicative only and are subject to further adjustments in consultation with the Department of Planning Land and Heritage (DPLH) and City of Cockburn during detailed subdivision design process.

Table 2: Key Characteristics for the Proposed LSP Road Classifications

Road Classification	Indicative upper volume (vpd)	Indicative road reserve width (m)	Indicative road pavement width (m)
Neighbourhood Connector A	7,000	23m	2 x 5m (incl. cycle lanes), 2m median and embayed parking
Neighbourhood Connector B	3,000	20m (18m min)	7.4m (plus embayed parking)
Access Street B	3,000	18m	9.7m (with on-street parking) or 6m (plus embayed parking)
Access Street D	1,000	15m	6m

Neighbourhood Connectors

The LSP concept plan indicates a north-south and an east-west Neighbourhood Connector road within the LSP area which is in line with the proposed road hierarchy outlined in the DSP. The north-south neighbourhood connector road connects to Fraser Road and provides access to Jandakot Road and Solomon Road. The proposed east-west neighbourhood connector road will continue further west and connects to the proposed LSP for Lot 821.

Traffic flows on these Neighbourhood Connector roads within the LSP area are estimated to be below 3000vpd (except the southern part of the north-south road), so it is appropriate for these roads to be classified as Neighbourhood Connector B roads. The north-south road is providing a strong connection between the proposed LSP area and the Calleya LSP. Whilst the DSP showed this road as a Neighbourhood Connector A, detailed modelling based on the structure plan confirms that projected traffic volumes will be significantly less than the Neighbourhood Connector A threshold for the northern part of this road. Although the road provides an important connection to Calleya LSP, the northern section of this road (from the south end of the POS) can function adequately with a Neighbourhood Connector B cross section in an 18m-20m reserve.

Access Streets

The basic standard of Access Street D roads within the LSP area is a 6m wide carriageway in a 15m road reserve. The Access Street D generally entails 4.5m verges on both sides, with embayed parking accommodated in the verges where required, such as to provide visitor parking for lots serviced by rear laneways. This road standard is proposed where the future total traffic volumes are generally less than 1000vpd. It is anticipated that most of the access streets shown in the LSP would be of this category.

The access street abutting the primary school is recommended to be constructed to the Access Street B cross-section standard, which allows for parking on both sides of the street, either on street or as embayed parking. Parking will be required on both

sides of this street due to laneway lots located opposite the primary school along this street.

4.2 Public Transport

Existing bus services in this area are described in section 3.3 of this report and current planning by the Public Transport Authority is discussed in section 3.6.

4.3 Pedestrian and Cyclist Facilities

A highly permeable road network within the LSP area creates excellent opportunities for the provision of good pedestrian and cyclist facilities that maximise the use of non-motorised transport modes.

Figure 15 outlines the proposed shared paths for the LSP area and the currently constructed PSP along Armadale Road. Footpaths will be provided on at least one side of all roads. Laneway lots are to have footpath access to visitor parking bays provided in a nearby road reserve.

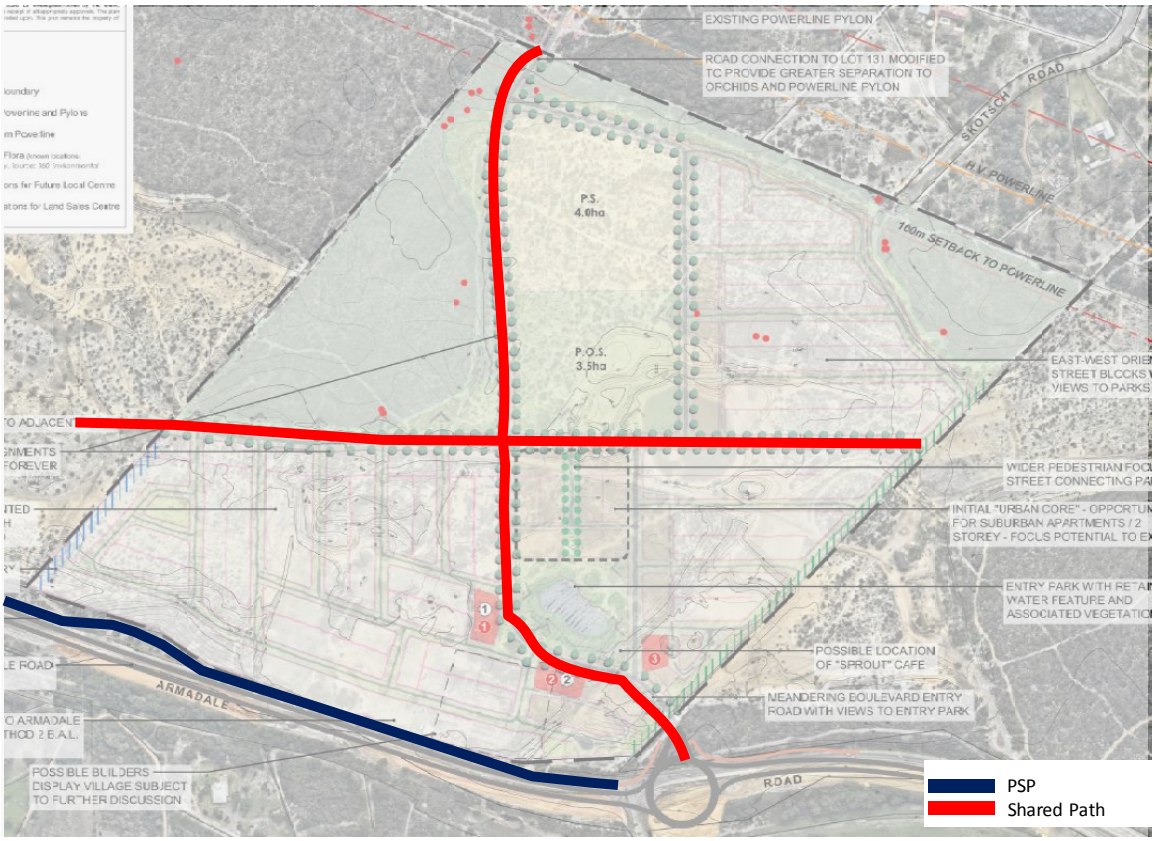


Figure 15: Proposed Pedestrian and Cyclist Network

5.0 Integration with Surrounding Area

The proposed land uses for the LSP are predominantly residential dwellings which are in line with the existing and future surrounding land uses in this area.

The road network of the LSP will connect to the surrounding road network at a number of locations. This will include connection to Armadale Road through the proposed roundabout intersection at Armadale Road/ Liddelow Road, a connection to the north towards Calleya LSP and Jandakot Road and a connection to the west to the proposed LSP for Lot 821 Armadale Road.

6.0 Analysis of the Transport Network

6.1 Assessment Period

The assessment year that has been adopted for this analysis is 2031, with full development of LSP and the entire DSP area assumed.

6.2 Traffic generation and distribution

Transcore has developed a subregional strategic transport model for weekday traffic flows for the Armadale area using the EMME transport modelling software package. This model also covers parts of City of Cockburn. This model was used for the adopted DSP and to estimate the traffic generation of the proposed LSP.

The daily traffic generation rate used for the LSP for this transport assessment is 8 vehicle trips per day (vpd) per dwelling, which corresponds to peak hour trip generation rates recommended in the Western Australian Planning Commission (WAPC) Transport Assessment Guidelines for Development (2016).

The anticipated 660 dwellings of the LSP will, therefore, generate approximately 5,280vpd.

For the primary school, the trip rate used is 1.0 vph per student during school peak periods (typically 8-9am and 3-4pm) and 2vpd per student daily. For this assessment, the Education Department's standard 430 student primary school design has been assumed, so this primary school is assumed to attract traffic flows of 860vpd.

The proposed local centre within the LSP area is also expected to generate approximately 400vpd.

The distribution of these trips is determined by the traffic model in proportion to the location of trip productions and attractors for work trips, education trips and other trips (shopping, social, recreational, etc.) among all the land uses in the traffic model.

6.3 Traffic Flow Forecasts

Figure 16 illustrates future total daily traffic flows estimated for the LSP road network.

The future total daily traffic flows on the road network in and around the LSP has been modelled for the future scenario of full development of this area as discussed above. The modelled surrounding district road network reflects future road network upgrades for this area. Accordingly, 6 and 4 lanes were assumed for Armadale and Jandakot Roads respectively to reflect the future upgrades proposed for these roads in the long term.

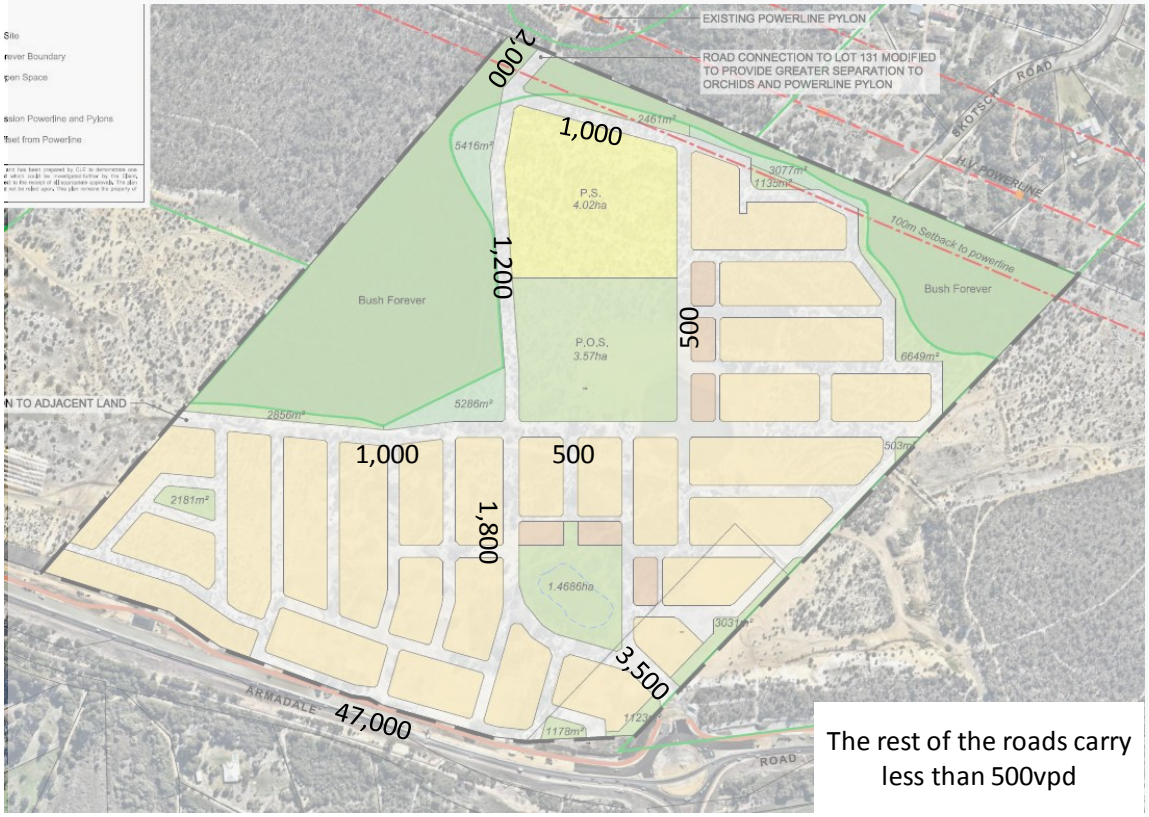


Figure 16: Projected Daily Traffic Volumes

6.4 Roads and Intersections

The proposed road network to accommodate these traffic volumes has been detailed in section 4 of this transport assessment, including the details of the proposed road hierarchy in section 4.1.

Figure 17 details the proposed intersection controls for key intersections within the LSP area. An internal roundabout is proposed at the south west corner of the proposed school. This roundabout will help traffic circulation within the LSP area and will assist with speed control on the neighbourhood connector roads.

There are a number of priority T-intersections along the proposed neighbourhood connector roads. These intersections are recommended to be constructed as a priority-controlled intersection with Give Way signs on the minor road approach as suggested in Liveable Neighbourhoods (LN Element 2 pages 31-33).

The primary access to the LSP area is proposed by a roundabout intersection on Armadale Road as shown in **Figure 17**.

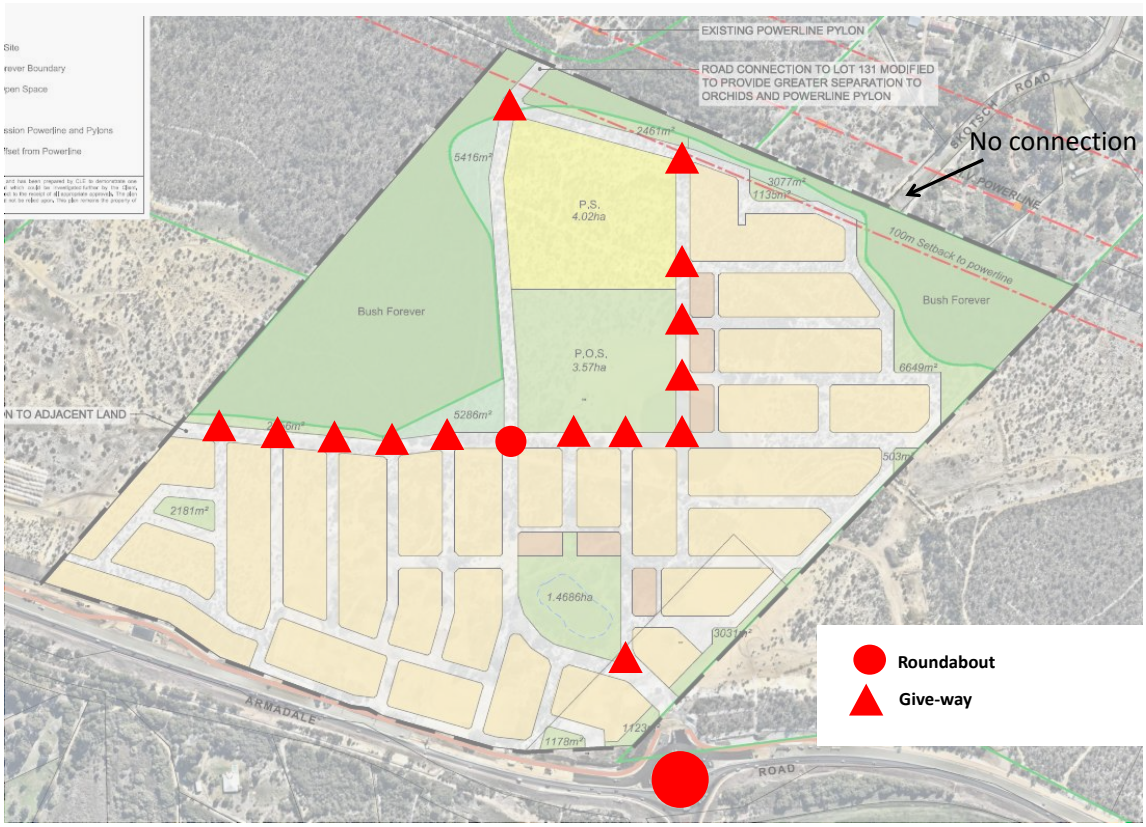


Figure 17: Intersection Treatments

6.5 Intersection Analysis

Capacity analysis of the proposed roundabout intersection on Armadale Road has been undertaken using the SIDRA computer software package for the AM and PM peak hours. SIDRA is an intersection modelling tool commonly used by traffic engineers for all types of intersections. SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95% Queue. These characteristics are defined as follows:

- Degree of Saturation is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The Degree of Saturation ranges from close to zero for infrequent traffic flow up to one for saturated flow or capacity.
- Level of Service is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. In general, there are 6 levels of service, designated from A to F, with Level of Service A representing the best operating condition (i.e. free flow) and Level of Service F the worst (i.e. forced or breakdown flow).
- Average Delay is the average of all travel time delays for vehicles through the intersection.
- 95% Queue is the queue length below which 95% of all observed queue lengths fall.

The results of the SIDRA analysis are summarised in **Appendix B**. The SIDRA intersection model was coded with reference to the *Main Roads Operation Modelling Guidelines Version No. 1.1*. All relevant parameters such as heavy vehicle groups, PCU factors etc. were coded as per the Main Roads Guidelines.

In order to establish the 2031 AM and PM peak hour traffic volumes at the intersection the projected daily traffic volumes at the intersection were extracted from the EMME model and converted to AM and PM peak hours assuming the In/ out traffic distribution of 20%/ 80% during the AM peak and reverse for the PM peak. **Figure 18** illustrates the AM and PM peak hour traffic movements at the intersection. It should be noted that currently, the AM and PM peak hour traffic on Armadale Road is about 7.5% and 8.5% of daily traffic respectively. The same factors were assumed for the 2031 traffic volumes along Armadale Road. The 10% factor was used for the side roads for the AM and PM peak hours.

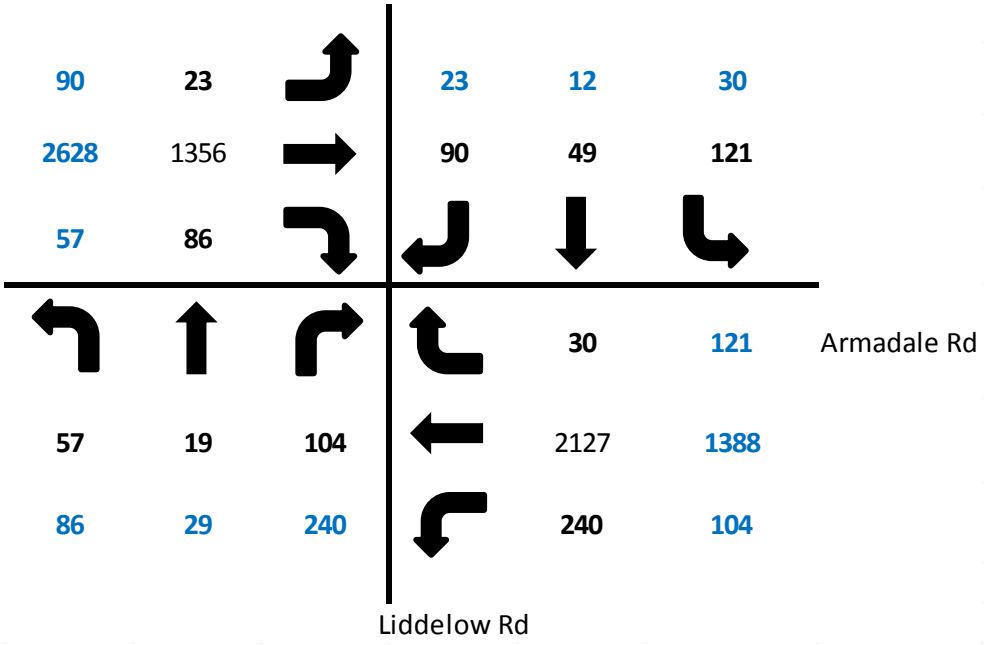


Figure 18: AM and PM peak hours (2031 projections)

The SIDRA analysis indicates that the proposed roundabout intersection at Liddelow Road/ Armadale Road/ LSP access road will operate satisfactorily with overall level of service A and C during the typical weekday AM and PM peak hours respectively. Some queues would be expected during the PM peak hour along Armadale Road eastbound approach which is due to the high level of through traffic on this road in year 2031. The reported queues on the side roads (Liddelow Road and LSP access road) are less than 12m during the AM and PM peak hours.

6.6 Access to Frontage Properties

The WAPC *Liveable Neighbourhoods* policy requires that "Development along integrator B and neighbourhood connector streets with ultimate vehicle volumes

over 5,000 vehicles per day should be designed either so vehicles entering the street can do so travelling forward, or are provided with alternative forms of vehicle access. Wider lots with paired driveways and protected reversing areas in the parking lane may be used on streets with up to 7,000 vehicles per day."

All of the neighbourhood connector roads in the LSP area are expected to carry less than 5,000vpd, so no restriction on vehicular access is required.

6.7 Pedestrian / Cycle Networks

The proposed network of shared paths for pedestrians and cyclists is described in section 4.3 of this transport assessment. This network of paths will provide an excellent level of accessibility and permeability for pedestrians and cyclists within the LSP area, and connections to neighbouring precincts at strategic locations.

6.8 Access to Schools

The proposed LSP plan includes a primary school site located in the middle of the LSP area, as shown on the LSP concept plan. The catchment area for the primary school will include this LSP area and the adjacent future residential area.

Information from the 2002-2006 *Perth & Regions Travel Survey* (PARTS) indicates that 25.4% of primary school students walk or cycle to school and 26.7% walk or cycle home from school. Therefore it is estimated that up to 100 primary school students may potentially walk or cycle across the Neighbourhood Connector roads in the vicinity of the school when this area is fully developed. Figure 16 Indicates daily traffic flows of about 1,200vpd and 500vpd on the surrounding neighbourhood connector A and B roads respectively which imply peak hour traffic flows of around 120vph or 50vph on these roads which is not expected to be problematic for students crossing these roads.

6.9 Access to Public Transport

WAPC Transport Assessment Guidelines for Developments (2006) suggest that it is desirable for at least 90 percent of dwellings to be within 400m straight line distance of a bus route. Provision of the supplementary bus route (indicated as the red line in Figure 6) would cover the majority of the LSP area.

7.0 Conclusions

The LSP area is anticipated to yield approximately 660 residential lots and includes a local centre site and a primary school site.

These residential lots would generate traffic flows of approximately 5,280 vehicles per day (vpd).

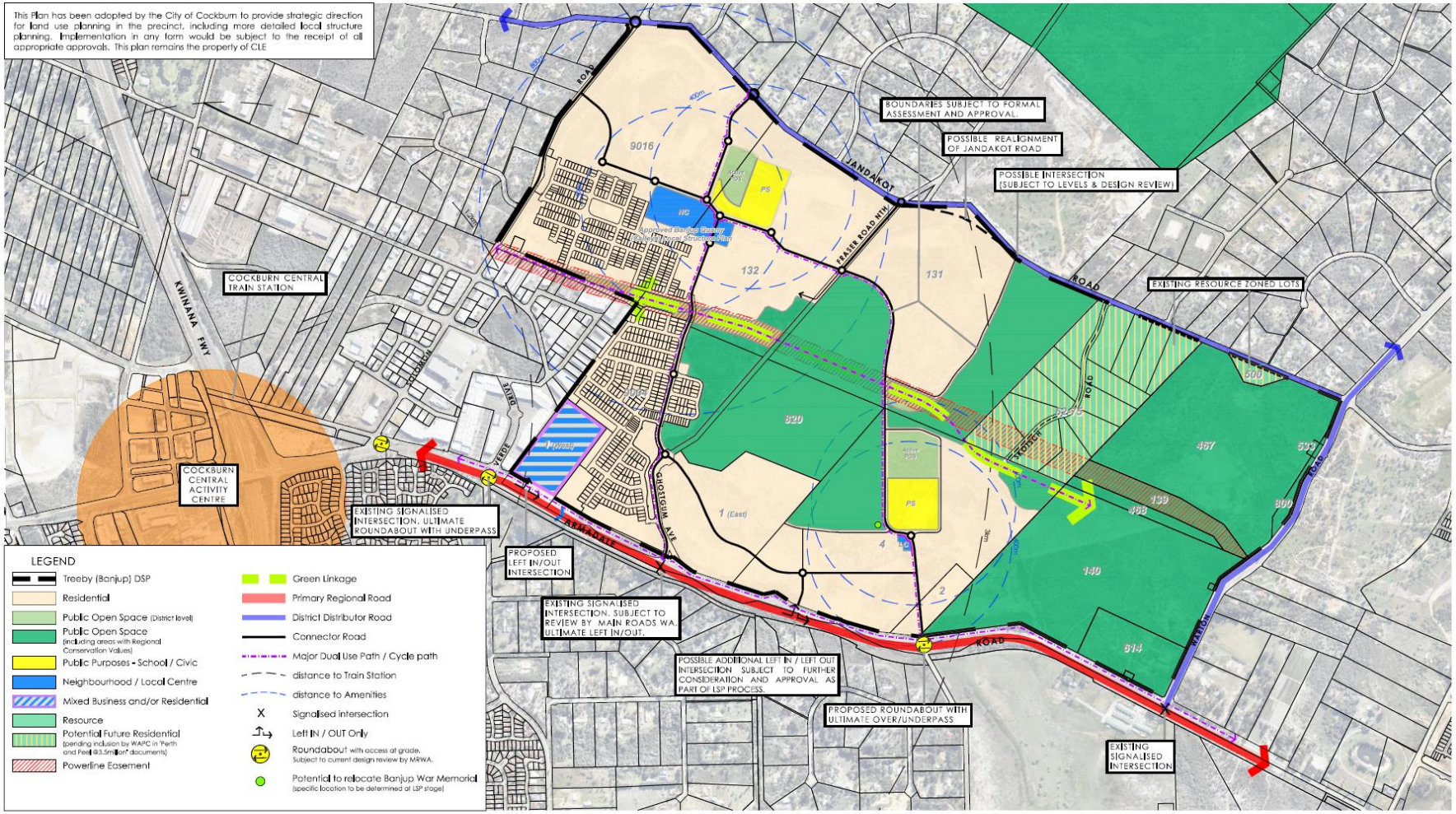
The road network of the LSP area has been designed in accordance with WAPC *Liveable Neighbourhoods* guidelines to accommodate the future traffic flows that will be generated in this area.

SIDRA analysis undertaken for future traffic flows (when the LSP and DSP areas are fully developed) indicates that the proposed roundabout intersection on Armadale Road will operate satisfactorily during weekday typical AM and PM peak periods.

The proposed LSP area provides for a comprehensive network of shared paths and footpaths to encourage and facilitate non-motorised travel.

Appendix A

TREEBY DISTRICT STRUCTURE PLAN



2310-122F-01 (29.09.2017), NTS

TREEBY (BANJUP) DISTRICT STRUCTURE PLAN

Banjup, City of Cockburn

Appendix B

INTERSECTION ANALYSIS

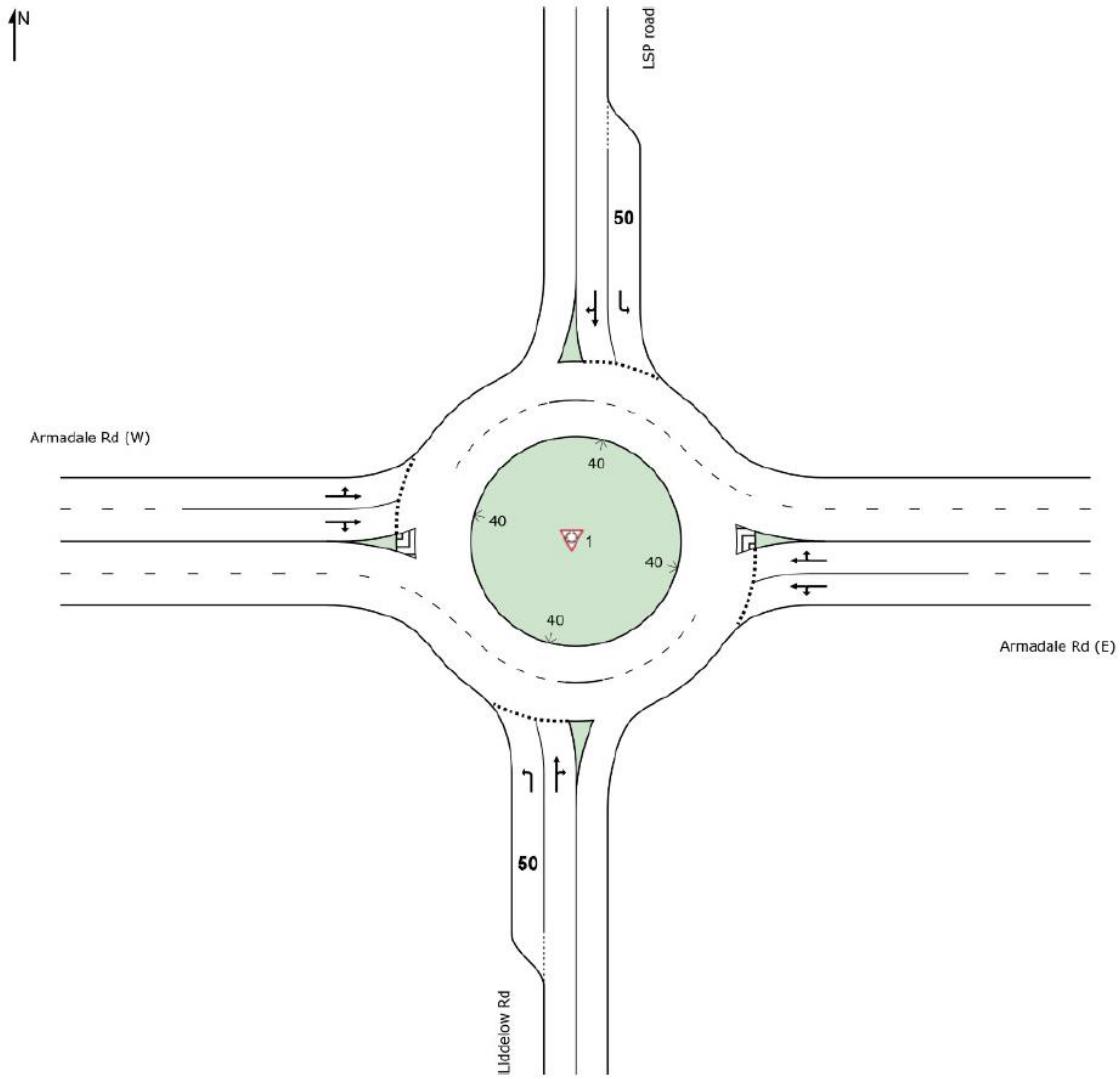


Figure B1: Proposed roundabout Intersection on Armadale Road, Intersection layout modelled in SIDRA

Table B1. SIDRA results – 2031 weekday AM peak hour with full development

Movement Performance - Vehicles												
Mov ID	Turn	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	Aver. No. Cycles	Average Speed km/h
South: Liddelow Rd												
4	L2	57	4.9	0.132	12.5	LOS B	0.7	5.1	0.83	0.92	0.83	60.1
5	T1	19	4.7	0.231	12.8	LOS B	1.5	11.4	0.93	0.98	0.93	57.7
6	R2	104	4.9	0.231	19.7	LOS B	1.5	11.4	0.93	0.98	0.93	57.5
Approach		180	4.9	0.231	16.7	LOS B	1.5	11.4	0.90	0.96	0.90	58.3
East: Armadale Rd (E)												
7	L2	240	5.0	0.796	6.8	LOS A	8.6	69.9	0.56	0.57	0.58	63.7
8	T1	2127	8.6	0.796	7.4	LOS A	8.6	69.9	0.60	0.61	0.64	65.0
9	R2	30	4.5	0.796	14.6	LOS B	8.5	69.6	0.64	0.65	0.70	65.4
Approach		2397	8.2	0.796	7.4	LOS A	8.6	69.9	0.60	0.60	0.64	64.9
North: LSP road												
10	L2	121	4.0	0.179	9.2	LOS A	0.7	5.6	0.67	0.84	0.67	63.8
11	T1	49	3.3	0.149	8.4	LOS A	0.7	5.5	0.70	0.82	0.70	62.5
12	R2	90	4.0	0.149	15.4	LOS B	0.7	5.5	0.70	0.82	0.70	62.3
Approach		260	3.9	0.179	11.2	LOS B	0.7	5.6	0.68	0.83	0.68	63.0
West: Armadale Rd (W)												
1	L2	23	5.0	0.492	5.8	LOS A	3.1	26.6	0.34	0.46	0.34	65.2
2	T1	1356	14.1	0.492	6.0	LOS A	3.1	26.6	0.35	0.48	0.35	65.1
3	R2	86	9.1	0.492	13.0	LOS B	2.9	24.9	0.36	0.51	0.36	65.5
Approach		1465	13.6	0.492	6.4	LOS A	3.1	26.6	0.35	0.48	0.35	65.1
All Vehicles		4302	9.6	0.796	7.7	LOS A	8.6	69.9	0.53	0.59	0.55	64.5

Table B2. SIDRA results – 2031 weekday PM peak hour with full development

Movement Performance - Vehicles												
Mov ID	Turn	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	Aver. No. Cycles	Average Speed km/h
South: Liddelow Rd												
4	L2	86	4.9	0.113	8.7	LOS A	0.4	3.4	0.63	0.82	0.63	64.1
5	T1	29	4.7	0.275	8.6	LOS A	1.3	10.2	0.69	0.87	0.69	60.9
6	R2	240	4.9	0.275	15.5	LOS B	1.3	10.2	0.69	0.87	0.69	60.7
Approach		355	4.9	0.275	13.3	LOS B	1.3	10.2	0.68	0.86	0.68	61.5
East: Armadale Rd (E)												
7	L2	104	5.0	0.500	5.7	LOS A	3.1	24.9	0.25	0.45	0.25	66.0
8	T1	1388	8.6	0.500	5.8	LOS A	3.1	24.9	0.25	0.47	0.25	67.3
9	R2	121	4.5	0.500	12.7	LOS B	2.9	23.7	0.27	0.50	0.27	67.6
Approach		1613	8.0	0.500	6.4	LOS A	3.1	24.9	0.25	0.47	0.25	67.3
North: LSP road												
10	L2	30	4.0	0.296	30.3	LOS C	1.1	8.7	0.96	1.00	1.05	46.7
11	T1	12	3.3	0.242	26.8	LOS C	1.3	9.9	0.97	0.99	0.97	48.7
12	R2	23	4.0	0.242	33.7	LOS C	1.3	9.9	0.97	0.99	0.97	48.6
Approach		65	3.9	0.296	30.9	LOS C	1.3	9.9	0.97	0.99	1.01	47.8
West: Armadale Rd (W)												
1	L2	90	5.0	1.014	34.1	LOS C	51.9	444.4	1.00	1.61	2.81	44.9
2	T1	2628	14.1	1.014	36.7	LOS D	51.9	444.4	1.00	1.66	2.92	43.8
3	R2	57	9.1	1.014	46.2	LOS D	45.1	387.5	1.00	1.72	3.06	42.8
Approach		2775	13.7	1.014	36.8	LOS D	51.9	444.4	1.00	1.66	2.92	43.8
All Vehicles		4808	11.0	1.014	24.8	LOS C	51.9	444.4	0.73	1.19	1.83	50.9

APPENDIX SIX

Traffic Acoustic Assessment (Herring Storer Acoustics)

LOT 705 ARMADALE ROAD, TREEBY
LOCAL STRUCTURE PLAN

ARMADALE ROAD TRAFFIC (SPP 5.4)
ACOUSTIC ASSESSMENT

OCTOBER 2019

OUR REFERENCE: 24932-1-18220

Rochdale Holdings Pty Ltd A.B.N. 85 009 049 067 trading as:
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ACOUSTIC ASSESSMENT

LOT 705 ARMADALE ROAD, TREEBY

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FOR

EWH Pty Ltd

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7.	DISCUSSION / RECOMMENDATION	6

APPENDICIES

A Local Structure Plan

B Figures B1 and B2 – $L_{Aeq\ (16hr)}$ Noise Contours for Armadale Road

C Figure – Lots Requiring “Quiet House” Design and Notifications

D “Quiet House” Design – General Information

E Future Road Design

1. INTRODUCTION

Herring Storer Acoustics was commissioned by EWH Pty Ltd, on behalf of Perron Developments Pty Ltd to undertake an acoustical assessment of noise received within the proposed Local Structure Plan (LSP) which front Armadale Road, Treeby.

As part of the study, the following was carried out:

- Determine by noise modelling the noise levels that would be received at residences within the development from vehicles travelling on the future Armadale Road.
- Assess the predicted noise levels received at residence for compliance with the requirements of the WAPC State Planning Policy 5.4 *"Road and Rail Transportation Noise and Freight Consideration in Land Use Planning"* (SPP 5.4).
- If exceedances are predicted, comment on possible noise amelioration options for compliance with the appropriate criteria.

It is noted that Armadale Road is currently undergoing a major upgrade as a part of the Armadale Road to North Lake Road Bridge Project.

For information, the local structure plan is attached in Appendix A.

2. SUMMARY

Under the WAPC State Planning Policy 5.4, for this development, the appropriate "Noise Targets" to be achieved under SPP 5.4, external to a residence are:

External

Day	Maximum of 55 dB(A) L_{Aeq}
Night	Maximum of 50 dB(A) L_{Aeq}

The policy states that the "outdoor targets are to be met at all outdoor areas as far as reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines". The Policy also states, under Section 6 – Policy Measures that "a reasonable degree of acoustic amenity for living areas on each residential lot". The policy recognises that "it may not be practicable to meet the outdoor noise targets".

The Policy states the following acceptable internal noise levels:

Internal

Living and Work Areas	$L_{Aeq(Day)}$ of 40 dB(A)
Bedrooms	$L_{Aeq(Night)}$ of 35 dB(A)

For this development, compliance with the requirements of SP 5.4, noise modelling and assessment are based on the day period for residence located adjacent to Armadale Road.

The results of the acoustic assessment indicate that noise received at residences located adjacent to Armadale Road would exceed the "Noise Targets" as outlined in SPP 5.4. To comply with the requirements of SPP 5.4, the following noise mitigation methods are recommended:

- Construct a 2.4 metre wall along the southern boundary of the development, facing Armadale Road.
- For residences with access roads between the residence and Armadale Road (i.e. front of residence facing Armadale Road) incorporate "Quiet House" design into the design of each residence. In these cases, the residence itself provides a barrier to the back yard, thus noise received at the outdoor area would comply with the required acoustic criteria.
- For residence backing on to Armadale Road (i.e., back yards bounding the 2.4m noise wall), Quiet House design as outlined in Appendix C will be required.
- Additionally, these residences also require Notifications on Titles.

It is noted that under the policy, that for those residences where noise would exceed the "Noise Target", notification of vehicle noise will need to be stated on the titles. These residences are indicated on Figure C1, attached in Appendix C. Information on Packages A and B "Quiet House" design measures are also attached in Appendix D.

3. CRITERIA

The Western Australian Planning Commission (WAPC) released on 6th September 2019 State Planning Policy 5.4 *"Road and Rail Noise".* The requirements of State Planning Policy 5.4 are outlined below.

POLICY APPLICATION (Section 4)

When and where it applies (Section 4.1)

SPP 5.4 applies to the preparation and assessment of planning instruments, including region and local planning schemes; planning strategies, structure plans; subdivision and development proposals in Western Australia, where there is proposed:

*a) noise-sensitive land-use within the policy's trigger distance of a transport corridor as specified in **Table 1**;*

*b) New or major upgrades of roads as specified in **Table 1** and maps **(Schedule 1,2 and 3);** or*

*c) New railways or major upgrades of railways as specified in maps (**Schedule 1, 2 and 3);** or any other works that increase capacity for rail vehicle storage or movement and will result in an increased level of noise.*

Policy trigger distances (Section 4.1.2)

***Table 1** identifies the State's transport corridors and the trigger distances to which the policy applies.*

*The designation of land within the trigger distances outlined in **Table 1** should not be interpreted to imply that land is affected by noise and/or that areas outside the trigger distances are un-affected by noise.*

*Where any part of the lot is within the specified trigger distance, an assessment against the policy is required to determine the likely level of transport noise and management/ mitigation required. An initial screening assessment (**guidelines: Table 2: noise exposure forecast**) will determine if the lot is affected and to what extent."*

TABLE 1: TRANSPORT CORRIDOR CLASSIFICATION AND TRIGGER DISTANCES

Transport corridor classification	***Trigger distance***	***Distance measured from***
Roads		
Strategic freight and major traffic routes *Roads as defined by Perth and Peel Planning Frameworks and/or roads with either 500 or more Class 7 to 12 Austroads vehicles per day, and/or 50,000 per day traffic volume*	*300 metres*	*Road carriageway edge*
Other significant freight/traffic routes *These are generally any State administered road and/or local government road identified as being a future State administered road (red road) and other roads that meet the criteria of either >=23,000 daily traffic count (averaged equivalent to 25,000 vehicles passenger car units under region schemes)*	*200 metres*	*Road carriageway edge*
Passenger railways		
	100 metres	*Centreline of the closest track*
Freight railways		
	200 metres	*Centreline of the closest track*

Proponents are advised to consult with the decision making authority as site specific conditions (significant differences in ground levels, extreme noise levels) may influence the noise mitigation measures required, that may extend beyond the trigger distance.

POLICY MEASURES (Section 6)

The policy applies a performance-based approach to the management and mitigation of transport noise. The policy measures and resultant noise mitigation will be influenced by the function of the transport corridor and the type and intensity of the land-use proposed. Where there is risk of future land-use conflict in close proximity to strategic freight routes, a precautionary approach should be applied. Planning should also consider other broader planning policies. This is to ensure a balanced approach takes into consideration reasonable and practical considerations.

Noise Targets (Section 6.1)

***Table 2** sets out noise targets that are to be achieved by proposals under which the policy applies. Where exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.*

In the application of the noise targets the objective is to achieve:

- *indoor noise levels as specified in **Table 2** in noise sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms); and*
- *a reasonable degree of acoustic amenity for outdoor living areas on each residential lot. For non-residential noise-sensitive developments, for example schools and child care centres the design of outdoor areas should take into consideration the noise target.*

It is recognised that in some instances, it may not be reasonable and/or practicable to meet the outdoor noise targets. Where transport noise is above the noise targets, measures are expected to be implemented that balance reasonable and practicable considerations with the need to achieve acceptable noise protection outcomes.

TABLE 2: NOISE TARGETS

Proposals	***New/Upgrade***	***Noise Targets***		
		Outdoor		***Indoor***
		Day (L_{Aeq}(Day) dB) (6 am-10 pm)	***Night (L_{Aeq}(Night)dB) (10 pm-6 am)***	***(L_{Aeq} dB)***
Noise-sensitive land-use and/or development	*New noise sensitive land use and/or development within the trigger distance of an existing/proposed transport corridor*	*55*	*50*	*L_{Aeq} (Day) 40(Living and work areas)* *L_{Aeq} (Night) 35 (bedrooms)*
Roads	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*
Railways	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*

Notes:

- *The noise target is to be measured at one metre from the most exposed, habitable façade of the proposed building, which has the greatest exposure to the noise-source. A habitable room has the same meaning as defined in State Planning Policy 3.1 Residential Design Codes.*
- *For all noise-sensitive land-use and/or development, indoor noise targets for other room usages may be reasonably drawn from Table 1 of Australian Standard/New Zealand Standard AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors (as amended) for each relevant time period.*
- *The 5dB difference in the criteria between new and upgrade infrastructure proposals acknowledges the challenges in achieving noise level reduction where existing infrastructure is surrounded by existing noise-sensitive development.*
- *Outdoor targets are to be met at all outdoor areas as far as is reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines. For example, it is likely unreasonable for a transport infrastructure provider to achieve the outdoor targets at more than 1 or 2 floors of an adjacent development with direct line of sight to the traffic.*

Noise Exposure Forecast (Section 6.2)

When it is determined that SPP 5.4 applies to a planning proposal as outlined in Section 4, proponents and/or decision makers are required to undertake a preliminary assessment using ***Table 2****: noise exposure forecast in the guidelines. This will provide an estimate of the potential noise impacts on noise-sensitive land-use and/ or development within the trigger distance of a specified transport corridor. The outcomes of the initial assessment will determine whether:*

- *no further measures is required;*
- *noise-sensitive land-use and/or development is acceptable subject to deemed-to- comply mitigation measures; or*
- *noise-sensitive land-use and/or development is not recommended. Any noise-sensitive land-use and/ or development is subject to mitigation measures outlined in a noise management plan."*

4. NOISE MONITORING

Due to the ongoing construction of Armadale Road through this area, current noise monitoring is not able to be undertaken, as the road traffic is not representative of normal conditions.

5. CALIBRATION OF TRAFFIC NOISE LEVELS

Whilst the Armadale Road major upgrade will utilise existing roads, existing noise monitoring data is unlikely to relate to the future major upgrades which would happen as a part of the Armadale Road to North Lake Road Bridge Project. Therefore, for this project, reference to the DEFRA publication has been sought and the difference between the $L_{A10,18hr}$ and the $L_{Aeq,8hr}$ and the $L_{Aeq,16hr}$ has been taken to be 10.3 and 2.8 dB(A) respectively. It was assumed that these differences would apply in the year 2041. Additionally, as outlined in the Implementation Guidelines, the standard correction of -1.7 dB has been applied to the noise model.

We note that with the difference between the $L_{Aeq,8hr}$ and the $L_{Aeq,16hr}$ being greater than 5 dB(A), achieving compliance with the day period criteria will also achieve compliance with the night period criteria.

6. MODELLING

The future road traffic volumes were based on information provided on the MRWA traffic web site for current traffic flows. For the future proposed traffic volumes, reference was made to the *MRIA Armadale Road to North Lake Road Bridge Noise Assessment Report*. This report details future (2041) traffic flows for this section of Armadale Road. This and other information relevant to the calculations are shown below in Table 6.1.

TABLE 6.1 - NOISE MODELLING INPUT DATA

Parameter	Current (2019)	Future (2041)
Traffic flows VPD Armadale Road	30,738	16,948 Eastbound 26,180 Westbound
Heavy Vehicles (%)	10.8%	7.1%
Traffic Speed km/hr	70	70
Road Surface	Dense Grade Asphalt	Dense Grade Asphalt
Façade Correction	+2.5	+2.5

Other input data for the model included:

- Traffic data from MRWA (https://mrapps.mainroads.wa.gov.au/TrafficMap/) and *MRIA Armadale Road to North Lake Road Bridge Noise Assessment Report 4000-090-NS-RP-0001-B.*
- Future road design as provided by MIRA and contained in Appendix E.
- Noise source heights for the three road source strings (Passenger Vehicles, Heavy Vehicles Engine and Heavy Vehicle Exhausts) are +0.5, +1.5 and +3.6m, with a noise correction of -0.8 and -8.0 applied to the heavy vehicles engine and exhaust noise sources.
- Topographical data, with the ground level within the development based on natural ground levels as per Google Earth.
- A +2.5 dB adjustment to allow for façade reflection.
- As outlined in the Implementation Guidelines, the standard correction of -1.7 dB has been applied to the noise model
- Development receiver heights at 1.4m above ground level.
- Future buildings located on the boundary of Armadale Road (assumed to be present for future road traffic volumes).

To determine the noise that would be received within the development from the surrounding road network, acoustic modelling was carried out using the computer program 'SoundPlan'.

The following scenarios were modelled:

1. Future traffic volumes, without any noise amelioration.

2. Future traffic volumes, with a 2.4m Wall on Armadale Road and Development boundary.

Based on the above, the noise contours plots for day and night periods for the above modelling scenarios are attached in Appendix B.

7. DISCUSSION / RECOMMENDATION

Under the WAPC State Planning Policy 5.4, for this development, the appropriate "Noise Targets" to be achieved under SPP 5.4, external to a residence are:

External	
Day	Maximum of 55 dB(A) L_{Aeq}
Night	Maximum of 50 dB(A) L_{Aeq}

The policy states that the "outdoor targets are to be met at all outdoor areas as far as reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines". The Policy also states, under Section 6 – Policy Measures that "a reasonable degree of acoustic amenity for living areas on each residential lot". The policy recognises that "it may not be practicable to meet the outdoor noise targets".

The Policy states the following acceptable internal noise levels:

Internal	
Living and Work Areas	$L_{Aeq(Day)}$ of 40 dB(A)
Bedrooms	$L_{Aeq(Night)}$ of 35 dB(A)

For this development, compliance with the requirements of SP 5.4, noise modelling and assessment are based on the day period for residence located adjacent to Armadale Road.

The results of the acoustic assessment indicate that noise received at residences located adjacent to Armadale Road would exceed the "Noise Targets" as outlined in SPP 5.4. To comply with the requirements of SPP 5.4, the following noise mitigation methods are recommended:

- Construct a 2.4 metre wall along the southern boundary of the development, facing Armadale Road.
- For residence with access roads between the residence and Armadale Road (i.e. front of residence facing Armadale Road) incorporate "Quiet House" design into the design of each residence. In these cases, the residence itself provides a barrier to the back yard, thus noise received at the outdoor area would comply with the required acoustic criteria.
- For residence backing on to Armadale Road (i.e., back yards bounding the 2.4m noise wall), Quiet House design as outlined in Appendix C will be required.
- Additionally, these residences also require Notifications on Titles.

It is noted that under the policy, that for those residences where noise would exceed the "Noise Target", notification of vehicle noise will need to be stated on the titles. These residences are indicated on Figure C1, attached in Appendix C. Information on Packages A and B "Quiet House" design measures are also attached in Appendix D.

Notes:

1 Given the location of the development and the projected market, we understand that 2 storey residences are unlikely, hence the Quiet House Design is for single storey residence only. If double storey residences are proposed, then it is recommended that specialist acoustic advice be sought by the proponent.

2 We understand that the development is a structure plan stage, hence the information contained in Appendix D regarding areas requiring "Quiet House" design will need to be refined once the lots have been defined. Additionally, any modifications to the Structure Plan, would vary the noise mitigation requirements relating to barriers and "Quiet House" design outlined in Appendix C.

3 The summary of the Quiet House Design Packages are attached in Appendix D, are "Deemed to Satisfy" constructions. Alternative constructions would be acceptable, provided they are supported by an acoustic report prepared by a suitably qualified acoustic consultant.

4 The noise wall at the boundary of the development is required to be a minimum of 15kg/m^2 which is generally masonry / concrete or the like.

APPENDIX A

LOCAL STRUCTURE PLAN



CLE Town Planning + Design
www.cleplan.com.au

CONCEPT PLAN

Armadale Road, Treeby

0 50 100 150 200 250 300m

DRAFT

plan no: 2310-233F-01
date: 26 September 2019
scale: 1:4,000 @ A3, 1:2,000 @A1

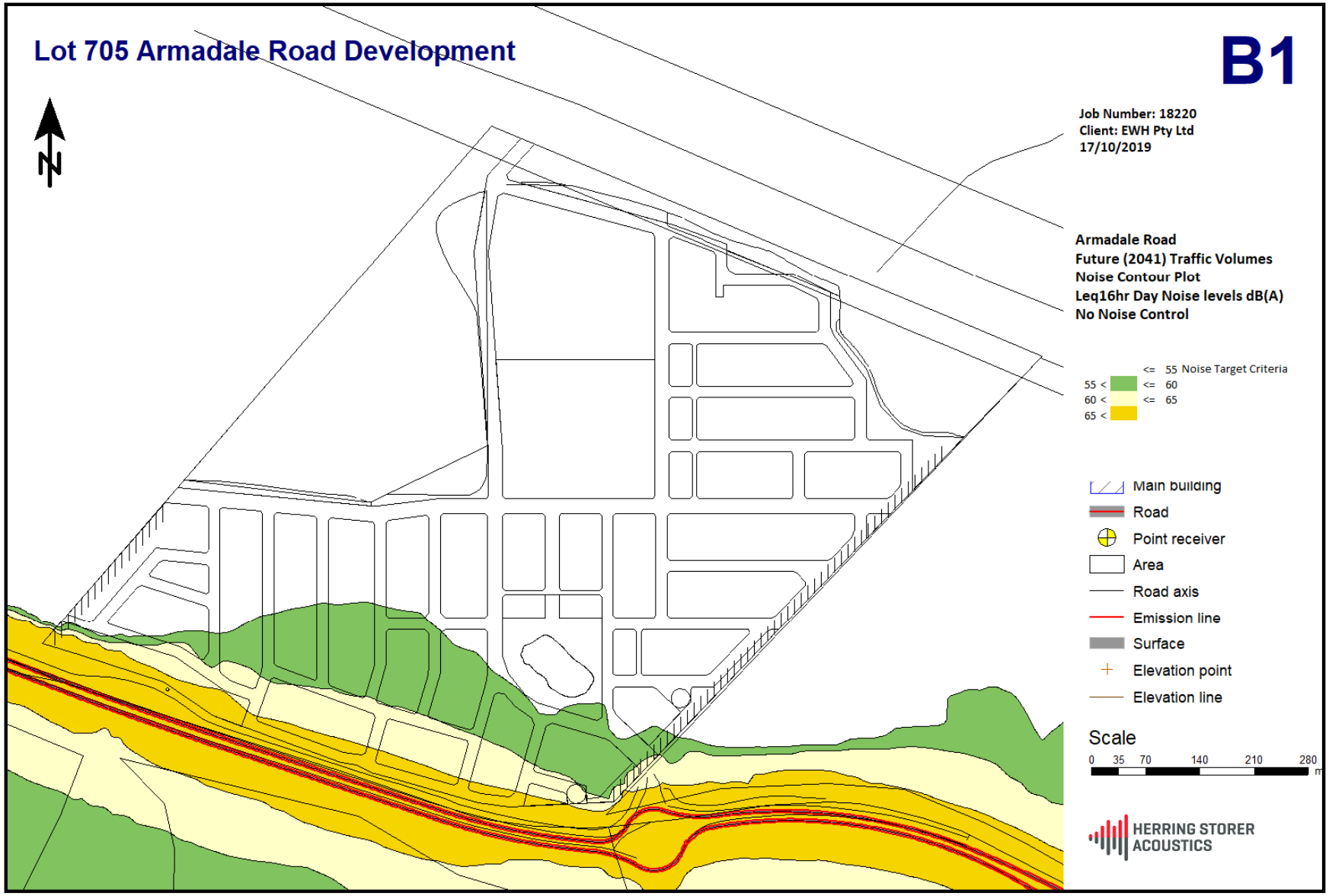
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APPENDIX B

FIGURES B1 and B2
$L_{Aeq(16hr)}$ DAY
NOISE CONTOURS FOR ARMADALE ROAD

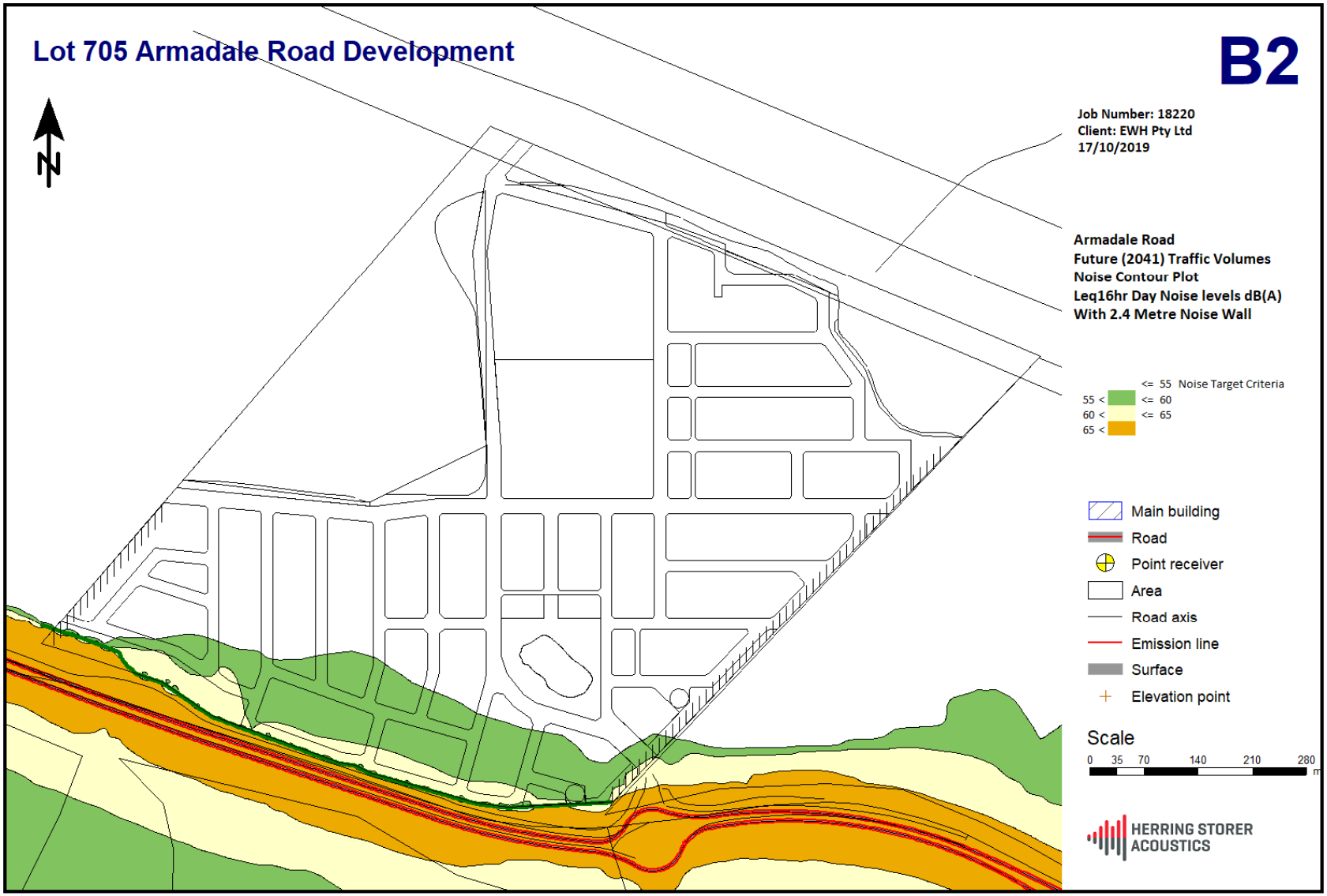
Lot 705 Armadale Road Development

B1



Lot 705 Armadale Road Development

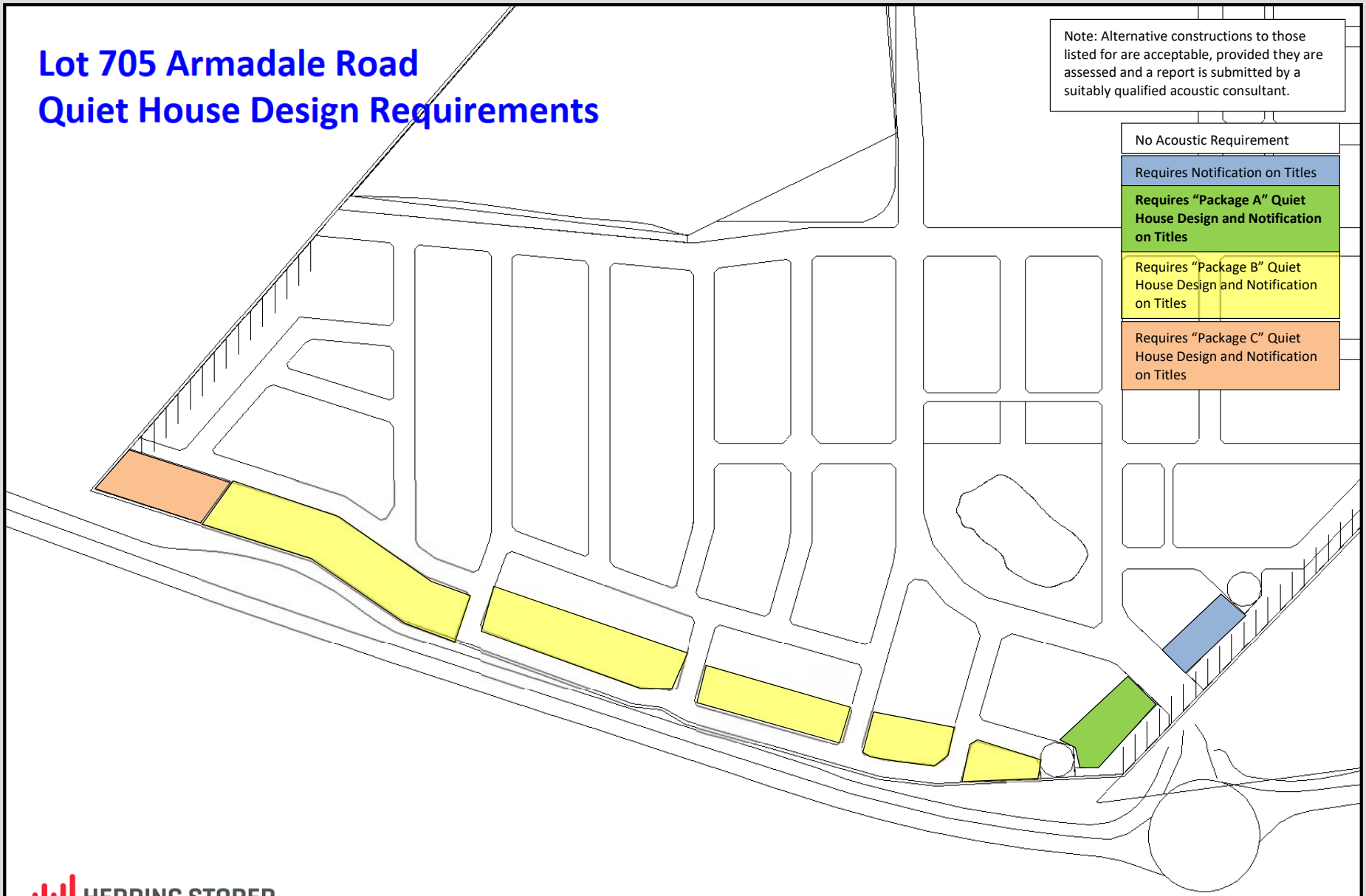
B2



APPENDIX C

LOTS REQUIRING “QUIET HOUSE” DESIGN AND NOTIFICATIONS

Lot 705 Armadale Road
Quiet House Design Requirements



HERRING STORER ACOUSTICS

APPENDIX D

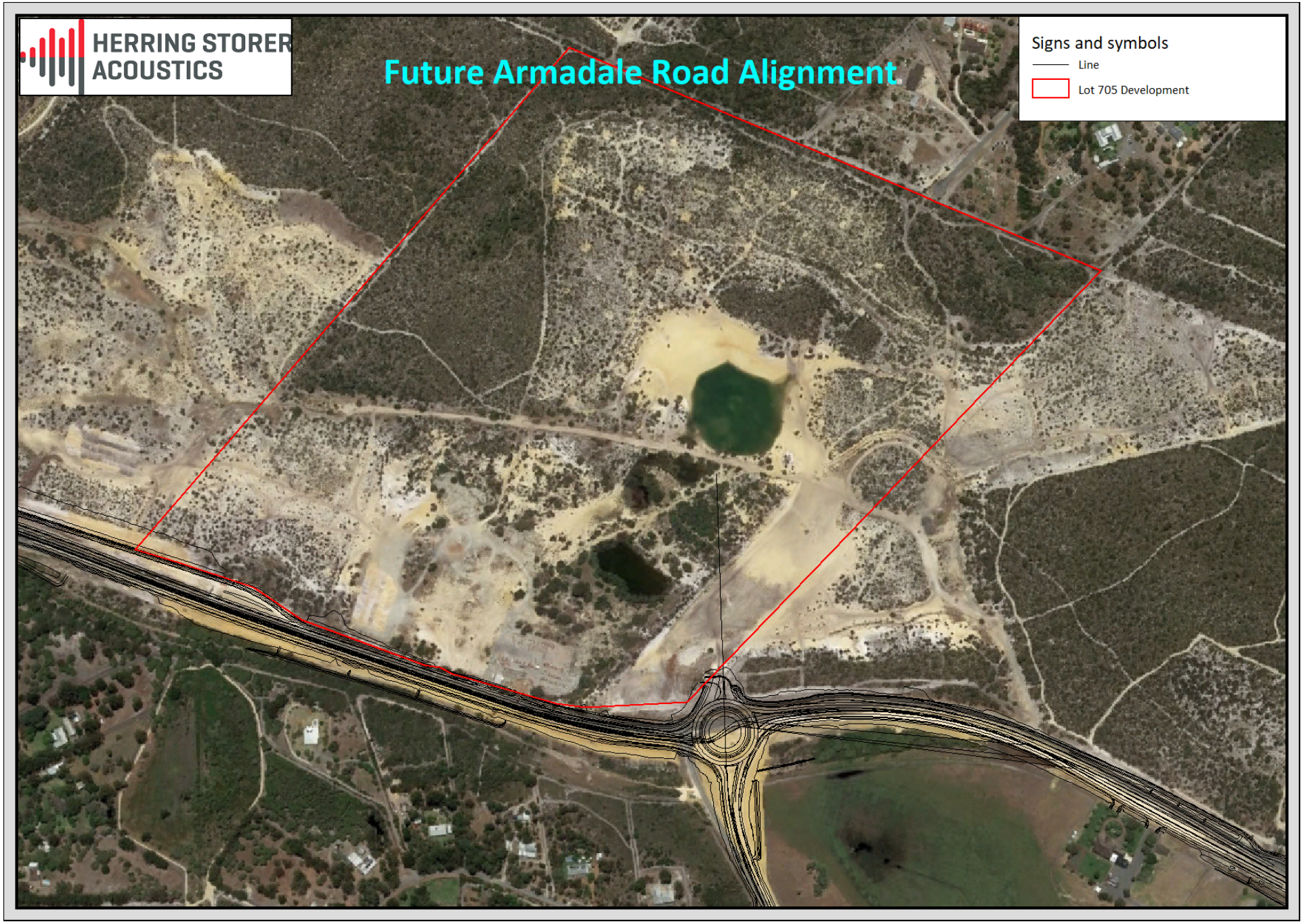
"QUIET HOUSE" DESIGN – GENERAL INFORMATION

SPP 5.4 TABLE 6.3 – ACCEPTABLE TREATMENT PACKAGES

Note: The above treatments are a deemed to satisfy construction. Alternative designs are acceptable, provided they are certified by a suitable qualified acoustic consultant

APPENDIX E

FUTURE ARMADALE ROAD ALIGNMENT


HERRING STORER ACOUSTICS
Future Armadale Road Alignment
Signs and symbols
Line
Lot 705 Development

APPENDIX SEVEN

Engineering Infrastructure Report (Wood & Grieve Engineers)

Lot 705 & 707 Armadale Road Treeby

Local Structure Plan

Engineering Infrastructure Report

Prepared for: Perron Treeby Pty Ltd

Attention: Ben Martin

Date: 12 November 2019

Prepared by: Jermayne Fabling

Ref: 25421

Wood & Grieve Engineers now part of Stantec
Ground Floor, 226 Adelaide Terrace, Perth WA 6000
Tel: +61 8 6222 7000 Email: perth@wge.com.au www.wge.com.au

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WOOD & GRIEVE ENGINEERS

NOW PART OF

Stantec

Revision

Revision	Date	Comment	Prepared By	Approved By
0	23/10/19	Original Issue	Jermayne Fabling	Jermayne Fabling
1	12/11/19	Minor Amendments	Jermayne Fabling	Jermayne Fabling

Contents

1. Introduction 2

2. Earthworks 2

2.1 Existing Geotechnical Conditions 2

2.2 Bulk Earthworks 3

2.3 Retaining Walls 3

3. Drainage 3

4. Site Servicing 4

4.1 Sewer Reticulation 4

4.2 Water Reticulation 4

4.3 Gas Reticulation 4

4.4 Power 4

4.5 Telecommunications 5

5. Roadworks 5

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7. Development Staging 5

Appendix A – Preliminary Wastewater Planning

Appendix B – Prelim Wastewater Concept Plan

Appendix C – Preliminary Water Planning

Appendix D – Preliminary Water Concept Plan

Appendix E – Preliminary Staging Plan

1. Introduction

Wood & Grieve Engineers now part of Stantec (WGE) have been engaged by Perron Treeby Pty Ltd, on the instruction of Mr Ben Martin, to undertake an assessment of civil infrastructure requirements for the development of Lots 705 & 707 Armadale Road, Treeby.

The purpose of this report is to outline the civil engineering servicing strategy in relation to the proposed Local Structure Plan for the site and is intended to be appended to the CLE Town Planning + Design's Local Structure Plan Report.

2. Earthworks

2.1 Existing Geotechnical Conditions

To assess the geotechnical characteristics, Structerre Consulting Engineers were engaged by Perron Treeby Pty Ltd to undertake a Geotechnical Investigation of each of Lot 705 and Lot 707. The results of these Geotechnical Investigations are summarised below:

2.1.1 Lot 705 Armadale Road

The investigation consisted of a geotechnical review of a number of previously excavated and logged test pits which were summarised as follows:

Depth to Base of Strata (m)	Material Description
0 – 3.2 (Ave 2.6) 0 – 5.0 (Ave 1.7) 0 – 8.0 (Ave 2.9) 0 – 3.6 (Ave 2.7)	Fill: Broken bricks/masonry/rubble Wood/metal straps/plastic/rags Reworked Sand comprising limestone and brick fragments/masonry Fine to medium grained sand
Not penetrated >5.0 >4.5 >9.2	Natural: Predominately Sand (fine to medium grained)

Provided the uncontrolled fill material encountered is screened with unsuitable material including vegetation, deleterious material and organic material removed from site and the material reworked as engineered fill, Structerre anticipate that the site would achieve an AS2870-2011 Class A classification.

2.1.2 Lot 707 Armadale Road

The investigation included 32 mechanically excavated test pits over the site and the results were summarised by Structerre and are reproduced below:

Depth to Base of Strata (m)	Material Description
0 – 0.6 (Ave 0.4) 0.2 – 0.4 (Ave 0.3)	Topsoil Bitumen (TP12 and TP19 only)
0.4 – 0.6 (Ave 0.5)	Sandy Gravel, yellow/brown (TP12 and TP19 only)
0.4 – 2.0 (Ave 1.2)	Fill: sand(fine to medium grained), non-plastic, trace silt (trace gravel in TP1,TP7)
Not Penetrated (>2.0m)	Natural: Sand (fine to medium grained), trace silt.

Provided that the topsoil is removed, and the uncontrolled fill material encountered is reworked as engineered fill, Structerre anticipate that the site would achieve an AS2870-2011 Class A classification.

2.2 Bulk Earthworks

The final earthworks levels for the site are a complex combination of geotechnical, hydrological, planning, environmental, engineering design and marketing factors.

The existing topography of the site varies in elevation from RL25 at the centre of the site to RL41.5 near Armadale Road, with undulation varying between these levels over the site. The gradient available provides the subject land with the flexibility to orientate the home sites to suit passive solar orientation and to obtain some cut material, together with imported fill material to achieve required lot levels to suit clearance to groundwater and major storm event flood routing.

The structure plan design has paid particular attention to matching into existing levels along the western and northern boundaries of the site to suit the preservation of Bush Forever vegetation. We note that existing excavations which expose ground water to the surface would be refilled as required.

Market forces presently dictate the provision of flat building sites with retaining walls to accommodate level differences. Lots will be designed with a maximum of 500mm front elevation from the verge level, with retaining walls installed for greater elevations.

Final earthwork levels will be designed to accommodate market requirements together to ensure adequate clearance to the 1% AEP flood level for the local and district drainage network, as well as providing adequate clearance to groundwater and ensuring roadway geometrical design incorporates flood routing constraints. Sufficient site levels will be required to be provided for the operation of gravity sewer connections.

Uncontrolled fill material identified on the site as noted within Section 2.1 (Existing Geotechnical Conditions) would be treated, deleterious material removed from site and be reworked as engineered fill material.

We note from observation of recent construction activity that Armadale Road Upgrade Works currently being undertaken by the Metropolitan Road Improvement Alliance (MRIA) on behalf Main Roads Western Australia has included the relocation of Optic Fibre to an alignment within the Armadale Road reserve in close proximity to the property boundary at the existing surface level. This would preclude the adjustment of road reserve levels along the boundary and will require boundary levels to be coordinated.

2.3 Retaining Walls

To accommodate the undulation in natural ground level and the proposed bulk earthworks to the site, flat building lots would be achieved by the installation of mass limestone/laterite/reconstituted stone retaining walls.

3. Drainage

JDA Consultant Hydrologists have prepared a Groundwater Level and Subsoil Drainage Strategy and a Stormwater Concept for Lot 705 and Lot 707 Armadale Road Treeby, which forms part of this proposal and should be referred to for detailed commentary.

In general, the stormwater drainage concept consists of a piped drainage network, draining road pavements with open base pits to promote at source soakage for the road reserve in accordance with City of Cockburn requirements. The pipe drainage network then conveys stormwater to various detention and soakage facilities.

A separate subsoil drainage network has been allowed to control the risk of groundwater rise. The subsoil drainage network is proposed to outfall to the Atwell Drain located south of Armadale Road.

4. Site Servicing

4.1 Sewer Reticulation

The Water Corporation have commenced conceptual wastewater supply planning about the subject site which is included as Appendix A.

A Preliminary Sewer Concept Plan included as Appendix B outlines the wastewater disposal strategy. Disposal of wastewater within the subject land will be achieved via a network of DN225 and DN150 reticulation sewers gravitating to a proposed Type 40 wastewater pumping station, located within the south east corner of the central Public open Space.

The Type 40 Wastewater Pumping Station would outfall via a DN100 pressure main, discharging to a DN225 gravity sewer which will be extended through Lot 821 from the existing DN300 gravity sewer located in Clementine Boulevard, Treeby.

The Local Structure Plan provides for a suitable centrally located site to house the required Water Corporation Wastewater Pumping Station infrastructure. It is anticipated an easement in the order of 1000m^2 in favour of the Water Corporation would be required at the south east corner of the central Public Open Space. An odour buffer in accordance with standard Water Corporation requirements would extend for 30m from the centre of the wet well to residential development.

4.2 Water Reticulation

The Water Corporation have commenced conceptual water supply planning about the subject site as an extension of the Thomson Lake Gravity Supply Scheme, which is included as Appendix C. This indicates that provision of a DN375 water main extension from the existing DN760 water distribution main crossing Liddelow Road south of Armadale Road would provide the supply route to the project.

The Preliminary Water Concept Plan which is included as Appendix D outlines the water supply strategy. Provision of a potable water supply to each of the proposed lots would be achieved the construction of a network of DN100 to DN250 throughout the internal road network of the landholding.

4.3 Gas Reticulation

The site is was previously serviced by a connection to Atco Gas's DN300 high pressure steel gas main located in Armadale Road.

It is anticipated that a pressure reducing valve will be required to reduce operating pressures at the site for the connection from the DN300 high pressure main to that suitable for residential reticulation.

It is proposed that ATCO Gas will service this development by reticulation an internal PE natural gas pipe network, utilising a common trench with water reticulation being provided by the developer, connecting to the existing gas mains adjacent to the site.

4.4 Power

4.4.1 Underground Power

Based on the Local Structure Plan and Western Power's standard load requirements it is envisaged that an overall project power load in the order of 3 MVA will be drawn.

Western Power's Network Capacity Mapping Tool indicates that the Southern River Zone Substation has 15 to 20 MVA of spare capacity, which is sufficient to service the project.

The provision of a power supply to each proposed lot would be achieved by the construction of a Western Power underground high voltage network interconnecting switchgear and transformers, in turn feeding an underground low voltage power network. This would also include the installation of standard Western Power LED streetlights.

Overhead powerlines located in Armadale Road have recently been relocated underground as part of the Armadale Road upgrade project completed by Main Roads Western Australia.

4.4.2 Power Transmission Line

Western Power's 330kV Northern Terminal to Southern Terminal Overhead Power Transmission Line is located with the adjacent landholdings to the north of the site.

The Local Structure Plan accommodates Western Power's 330 kV power transmission line buffer requirements by providing a 100m setback from the powerline to residential lots.

4.5 Telecommunications

The provision of a telecommunications connection to each proposed lot would be achieved by the construction of an extension to the National Broadband Network (NBN) from neighbouring developments.

This would entail the Developer funding and installing a pit and pipe infrastructure in accordance with NBN's requirements and then the transfer of ownership of the infrastructure to NBN via the execution of a Master Development Agreement in exchange for the provision of data infrastructure within the pit and pipe network.

The pit and pipe system will be extended inside the communications corridor, installed in a common trench with the underground power network.

5. Roadworks

A road connection to Lot 707 from Armadale Road is proposed to occur by connection to the northern stub of the roundabout currently being constructed on behalf of Main Road WA by the MRIA at the intersection of Liddlelow Road and Armadale Road.

Another access to the site would be via connection to proposed development of Lot 703 Armadale Road immediately to the west of the site.

Roadways within the proposed development would be constructed in accordance with the configurations established as part of the Traffic Engineering requirements of this proposal and the City of Cockburn's standard requirements. Road pavement configuration would be designed in accordance with specific geotechnical advice.

Standard concrete footpaths on one side of all roads and on both side of the entry road from Armadale Road would be provided.

6. Acoustic Wall

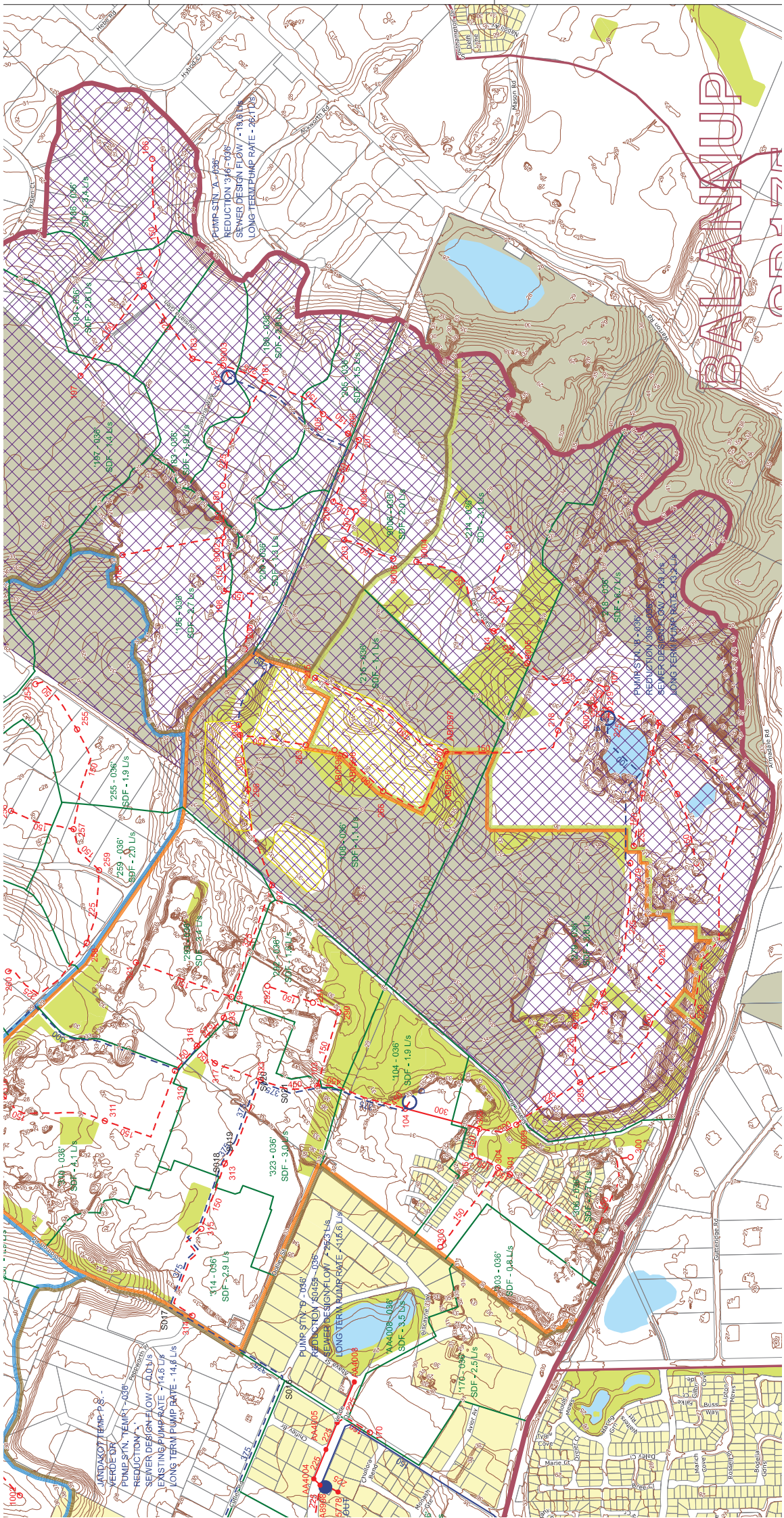
It is anticipated that an acoustic wall will be required along the Armadale Road frontage of the site.

This wall would be constructed in a configuration in accordance with Herring Storer Acoustic's Acoustic Assessment, which forms part of this proposal.

7. Development Staging

It is envisaged that the project will be developed in stages to suit the commercial demand in the locality and that the initial Stage 1 will include connection to Armadale Road at Liddlelow Road. Subsequent stages of the of the project will radiate out from the previous stage. An anticipated Staging Plan is attached as Appendix E

Appendix A – Preliminary Wastewater Planning


Preliminary
Wastewater
Planning
Only
BALLAJURA

Appendix B – Prelim Wastewater Concept Plan

ROAD CONNECTION TO ADJACENT LOT 131

FUTURE LOT 131 JANDAKOT ROAD(PART) INFLOW

FUTURE LONG TERM SKOTSCH ROAD INFLOW

SKOTSCH ROAD

BUSH FOREVER 8007

BUSH FOREVER 8009

820

821

131

71

70

505

504

567

568

569

506 30.0

POS 8008 28.6

PROPOSED TYPE 40 WASTEWATER PUMP STATION

PROPOSED ACCESS DISCHARGE CHAMBER

PROPOSED DN100 PRESSURE MAIN

ROAD CONNECTION TO ADJACENT LAND

DN225 CONNECTION TO EXISTING DN300 SEWER ON CLEMENTINE BOULEVARD (APPROX. 500m WEST)

ARMADALE ROAD

ARMADALE ROAD

LIDDELOW ROAD

5001 5002 5003 5004 5005 5006 5007 5008 5009 5010 5011 5012 5013 5014 5015 5016 5017 5018 5019 5020 5021 5022 5023 5024 5025 5026 5027 5028 5029 5030 5031 5032

POS 8001 POS 8002 POS 8003 POS 8004 POS 8005 POS 8006

LOCATION OF WORKS

JANDAKOT ROAD FRASER ROAD SKOTSCH ROAD ARMADALE ROAD LIDDELOW ROAD

LOCALITY PLAN
SCALE 1:20000 @ A3

PLAN
SCALE 1:2000 @ A3

LEGEND

- PROPOSED GRAVITY SEWER (DN150 UNO)
- PM — PROPOSED DN150 SEWER PRESSURE MAIN
- FUTURE GRAVITY SEWER
- 30m SEWER PS BUFFER ZONE
- 30.5 PROPOSED PAD LEVEL
- SEWER FLOW DIRECTION
- SITE BOUNDARY
- RESIDENTIAL FRONT LOAD LOT
- RESIDENTIAL REAR LOAD LOT
- POS
- SCHOOL

THIS PLAN IS TO BE READ IN COLOUR

REV	DESCRIPTION	DRW	DGN	VER	APPROVED	DATE
A	ORIGINAL ISSUE	LDB	JF	JF		

0 10 20 40 100
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WAPC No.	COORDINATES	DATUM
	PCG94	AHD

CLIENT
PERRON TREEBY PTY LTD

PROJECT
LOT 705 & 707 ARMADALE ROAD TREEBY

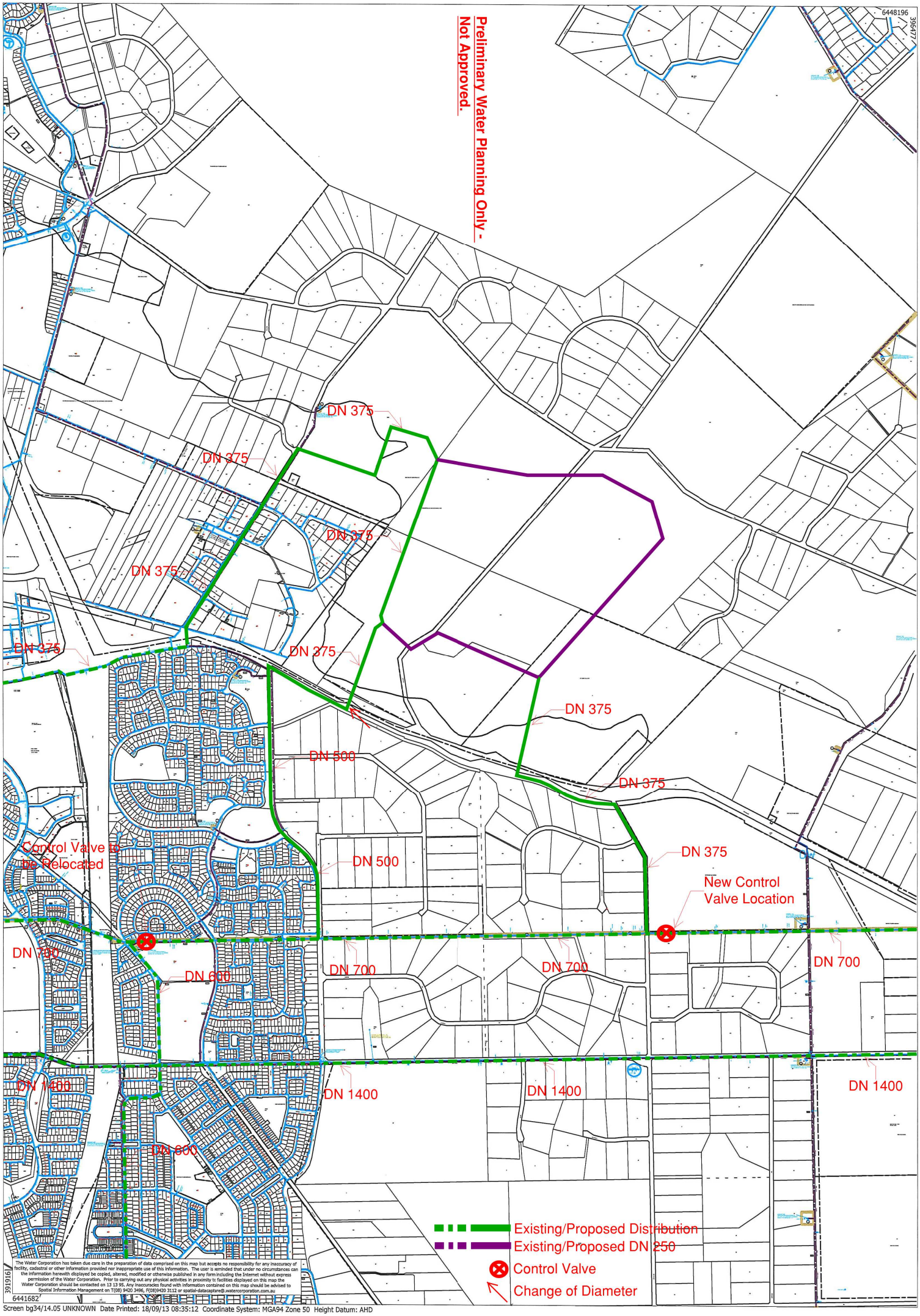
TITLE
PRELIMINARY SEWER CONCEPT PLAN

WOOD & GRIEVE ENGINEERS
NOW PART OF Stantec

PRELIMINARY ISSUE

PROJECT No.	DRAWING No.	REVISION
25421	CI-300-WW-SK1	A

Appendix C – Preliminary Water Planning


Preliminary Water Planning Only - Not Approved.
6448196
360477
DN 375
DN 375
DN 375
DN 375
DN 375
DN 375
DN 375
DN 375
DN 500
DN 500
Control Valve to be Relocated
New Control Valve Location
DN 700
DN 700
DN 700
DN 700
DN 600
DN 600
DN 1400
DN 1400
DN 1400
DN 1400
Existing/Proposed Distribution
Existing/Proposed DN 250
Control Valve
Change of Diameter
391916
6441682
The Water Corporation has taken due care in the preparation of data comprised on this map but accepts no responsibility for any inaccuracy of facility, cadastral or other information provided nor inappropriate use of this information. The user is reminded that under no circumstances can the information herewith displayed be copied, altered, modified or otherwise published in any form including the Internet without express permission of the Water Corporation. Prior to carrying out any physical activities in proximity to facilities displayed on this map the Water Corporation should be contacted on 13 13 95. Any inaccuracies found with information contained on this map should be advised to Spatial Information Management on T(08) 9420 3496, F(08)9420 3112 or spatial-datacapture@watercorporation.com.au
Screen bg34/14.05 UNKNOWN Date Printed: 18/09/13 08:35:12 Coordinate System: MGA94 Zone 50 Height Datum: AHD

Appendix D – Preliminary Water Concept Plan

ROAD CONNECTION TO ADJACENT LOT 131

DN250 RETICULATION MAIN FUTURE CONNECTION THROUGH LOT 131 TO EXISTING DN150 WATER MAIN IN FRANGIPANI ROAD (APPROX. 800m NORTH)

ROAD CONNECTION TO ADJACENT LAND

DN250 RETICULATION MAIN CONNECTION TO DN150 WATER MAIN ON CEDARLEAF ENTRANCE (APPROX. 500m WEST)

SCOTSCH ROAD

ARMADALE ROAD

FUTURE DN375

LIDDELOW ROAD

DN375 WATER DISTRIBUTION MAIN CONNECTION TO EXISTING DN760S-6 ARMADALE THOMSONS LAKE PIPE LINE (APPROX. 700m SOUTH OF ARMADALE ROAD)

ROAD RESERVE BOUNDARY TO BE CONFIRMED

BUSH FOREVER 8007

BUSH FOREVER 8009

SCHOOL SITE 506

POS 8001

POS 8002

POS 8003

POS 8004

POS 8005

POS 8006

POS 8008

5001 5002 5003 5004 5005 5006 5007 5008 5009 5010 5011 5012 5013 5014 5015 5016 5017 5018 5019 5020 5021 5022 5023 5024 5025 5026 5027 5028 5029 5030 5031 5032

820 821 131 71 70 505 504 567 568 569

LOCALITY PLAN
SCALE 1:20000 @ A3

LOCATION OF WORKS

JANDAKOT ROAD, FRASER ROAD, SCOTSCH ROAD, ARMADALE ROAD, LIDDELOW ROAD

PLAN
SCALE 1:2000 @ A3

LEGEND:

- SIZE & TYPE / CLASS (100P-12)
- EXISTING MAINS
- EXISTING VALVES

COLOUR LEGEND:

- FUTURE 375P-12 — FUTURE DN375 MAIN
- 250P-12 — DN250 MAIN
- 150P-12 — DN150 MAIN
- 100P-12 — DN100 OR SMALLER
- SITE BOUNDARY
- RESIDENTIAL FRONT LOAD LOT
- RESIDENTIAL REAR LOAD LOT
- POS
- SCHOOL

THIS PLAN IS TO BE READ IN COLOUR

REV	DESCRIPTION	DRW	DGN	VER	APPROVED	DATE
A	ORIGINAL ISSUE	LDB	JF	JF		

0 10 20 40 100
A1 @ 1:2000 (A3 @ 1:4000)

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WAPC No.	COORDINATES	DATUM
	PCG94	AHD

CLIENT
PERRON TREEBY PTY LTD

PROJECT
LOT 705 & 707 ARMADALE ROAD TREEBY

TITLE
PRELIMINARY WATER CONCEPT PLAN

WOOD & GRIEVE ENGINEERS
NOW PART OF Stantec

PRELIMINARY ISSUE

PROJECT No.	DRAWING No.	REVISION
25421	CI-600-WA-SK1	A

Appendix E – Preliminary Staging Plan



LOCALITY PLAN
SCALE 1:20000 @ A3

PLAN
SCALE 1:2000 @ A3

THIS PLAN IS TO BE READ IN COLOUR

REV	DESCRIPTION	DRW	DGN	VER	APPROVED	DATE
A	ORIGINAL ISSUE	LDB	JF	JF		

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A1 @ 1:2000 (A3 @ 1:4000)

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WAPC No.	COORDINATES	DATUM
	PCG94	AHD

CLIENT
PERRON TREEBY PTY LTD

PROJECT
LOT 705 & 707 ARMADALE ROAD TREEBY

TITLE
PRELIMINARY STAGING PLAN

WOOD & GRIEVE ENGINEERS
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PRELIMINARY ISSUE

PROJECT No.	DRAWING No.	REVISION
25421	CI-040-LL-SK1	A

Design with
community in mind

Ground Floor
226 Adelaide Terrace
Perth WA 6000
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E perth@wge.com.au

For more information please visit
www.wge.com.au

WOOD & GRIEVE ENGINEERS

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