VOLUME 2

element.

Technical Appendix A- EAMS



Element

Forrestfield North Residential Precinct

Numerous Lots
Roe Highway, Berkshire Road and Dundas Road

24 September 2021

57806 / 139,342 (Rev B)

JBS&G Australia Pty Ltd T/A Strategen-JBS&G

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Appendices

Appendix A	Forrestfield North Local Structure Plan
Appendix B	AECOM (2017a) Forrestfield North Level 2 Flora and Fauna Survey
Appendix C	AECOM (2017b) Floristic Community Type Analysis
Appendix D	Ethnosciences (2018) Report of an Ethnographic Assessment of the Forrestfield North DSP

1. Introduction

1.1 Background

In response to the State Government's Forrestfield Airport Rail Link-MetroNet project, The City of Kalamunda (CoK) is facilitating the design and subsequent implementation of the Forrestfield North District Structure Plan (DSP) process. The DSP area is approximately 190 ha and is bound by Roe Highway to the east, Sultana Road to the south, Dundas Road and railway to the west and Poison Gully Creek to the north.

The DSP is a guiding framework to maximise the opportunities, including the capacity for greater diversity in housing options, employment and economic development options while identifying and provide for the retention of key environmental assets.

To coordinate the development of the DSP area, the site has been divided into two Local Structure Plan (LPS) precincts:

- TOD Precinct (67.49 ha).
- Residential Precinct (123.05 ha).

This Environmental Assessment and Management Strategy (EAMS) has been developed to support the LSP for the Residential Precinct, the location of which is shown on Figure 1.1. The LSP Residential Precinct consists of the following elements (Appendix A):

- residential uses,
- aged care facility,
- primary school,
- public community purpose facility,
- public open space (POS) areas,
- existing Bush Forever sites, and
- environmental conservation areas.

1.1.1 Previous environmental planning amendments and considerations

In 2015, the precinct was amended from Rural to Urban under the MRS (1282/57). As part of this process the amendment was referred to the Environmental Protection Authority (EPA) who provided an assessment and advice, with no appeals. The EPA identified the following environmental factors as being relevant to the scheme:

- Flora and vegetation: Wavy-leaved Smokebush (*Conospermum undulatum*), and
- Terrestrial fauna: remnant vegetation providing roosting, foraging and potential breeding habitat for Carnaby's Cockatoo and Forest Red-tailed Black Cockatoos, and suitable habitat for the Quenda/Southern Brown Bandicoot.

The EPA (2015,2) noted the expectation that the local scheme text would be revised to include provisions for the management of specific environmental values:

"…specific mechanisms and adequately secure, protect and manage the significant environmental values within the amendment area".

In 2016, the CoK prepared amendment 75 to Local Planning Scheme No. 3 (the Scheme) to rezone the DSP from 'Light Industry', 'Industrial Development', and 'Special Rural' to 'Urban Development'. Through the amendment process, the scheme was referred to the EPA. Following examination of the

referral including the conduction of preliminary investigations and inquiries, the scheme amendment was not formally assessed. The EPA provided the following advice:

- *"the EPA expects that further detailed management plans and scheme provisions to address flora and vegetation will be addressed prior to the finalisation of the structure plan,*
- *the protection of declared rare flora, associated habitat, threatened fauna habitat, and low representation vegetation complexes in appropriately sized retention areas for conservation purposes. These retention areas shall be informed by Level 2 Flora and Vegetation and Fauna Surveys in accordance with EPA Guidance Statements 51 and 56 (or as revised), and targeted for Declared Rare Flora and threatened fauna, and associated habitat. The retention area size, location, protection and management mechanism shall be subject to OEPA advice prior to the WAPC endorsement of the structure plan, and*
- *all future subdivision and development proposals must be consistent with the retention areas agreed."*

1.1.2 Stakeholder consultation

The Kalamunda Environmental Advisory Committee (KEAC) was developed to make recommendations to the Council on matters relating to the environment and social/community. In the initiation of the LSP process the committee was consulted on the major considerations of the precinct (including noise/vibration, environment, water management, sustainability, ethnographic and public realm guidelines).

A Technical Advisory Group (TAG) made up of key agency and decision makers including the Department of Biodiversity, Conservation and Attractions (DBCA) and the Office of Environmental Protection Authority (OEPA) (now Department of Water and Environmental Regulation [DWER]) was established and chaired by the Department of Planning, Lands and Heritage (DPLH). During the LSP process TAG meetings were undertaken to discuss the key elements of the project including the rationale of LSP design and the inclusion of the key environmental attributes within the precinct.

Further to the DSP, a Community and Stakeholder Engagement and Communications Strategy was development by Element (formally TPG + Place Match) (2017) to guide community stakeholder consultation for the development of the LSP. This strategy includes two main phases of engagement, being the Preliminary Community and Stakeholder Engagement (May – June 2017), and the Public Advertising period (to be advised). The Preliminary engagement included the following:

- City of Kalamunda council briefing,
- landowners survey,
- landowner forum,
- community and stakeholder survey, and
- community and stakeholder workshop.

In late 2017, the EPA services branch and DBCA were consulted on the LSP design and the priority of key environmental factors and their retention within the Precinct. Preliminary State biodiversity advice from these agencies were received which subsequently was incorporated into the revised LSP design (refer to Appendix A) including the following:

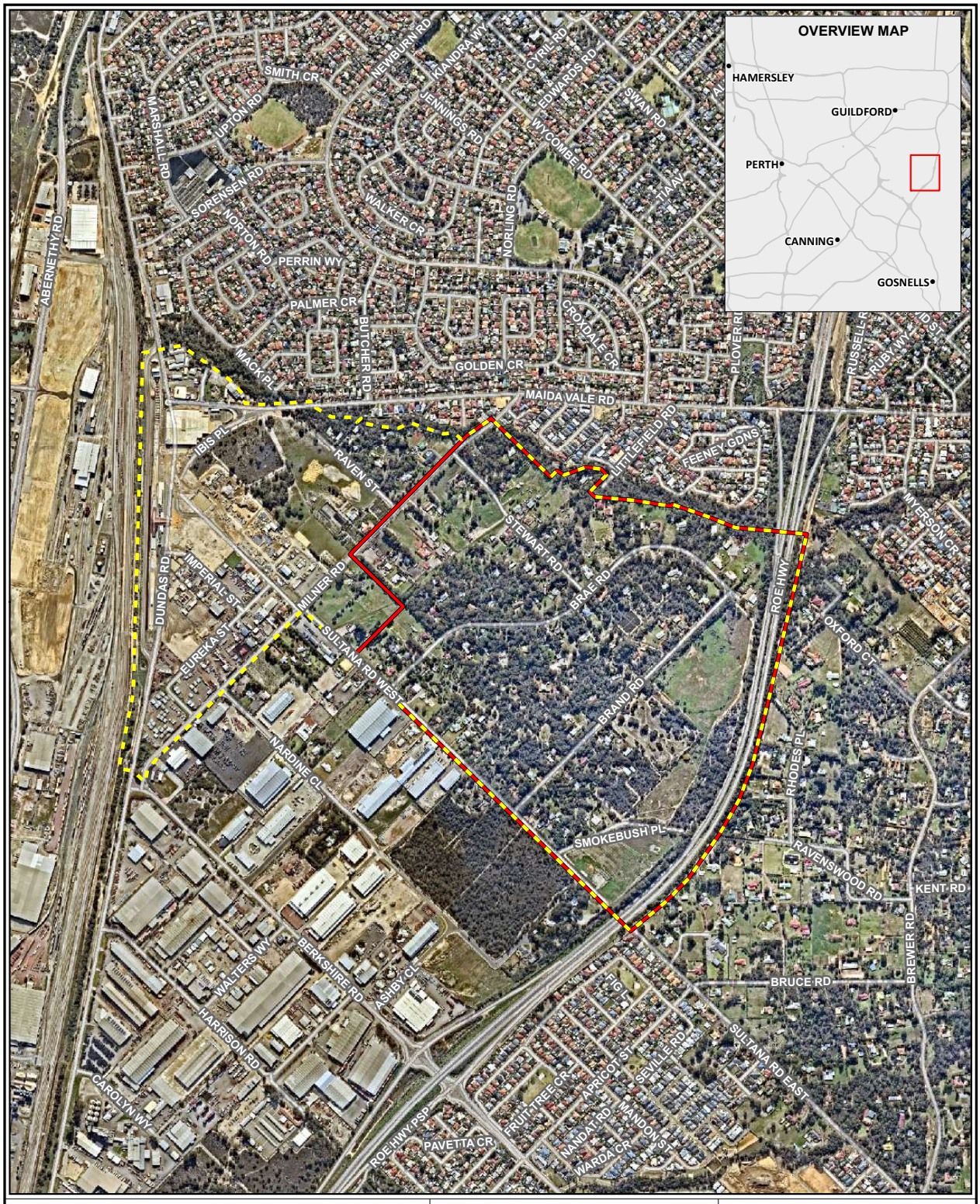
- retention of large clusters of Wavy-leaved Smokebush plants within high quality vegetation that are considered viable in the long-term, and
- retention of a functional ecological linkage between the Sultana Road West Bush Forever site (Bush Forever site 123) and Poison Gully Creek to assist in maintaining the ecological viability of both sites and the intervening retained areas within the corridor.

1.2 Objectives

This EAMS intends to meet the following objectives:

- describe the environmental and heritage values within the precinct and surroundings based on existing information, and
- identify potential opportunities to secure, protect and manage the significant environmental values on site and present management requirements.

To ensure that an integrated approach is developed for the precinct area the EAMS has been prepared in parallel with the Local Water Management Strategy (LWMS) and Bush Fire Management Plan (BMP), both prepared by Strategen-JBS&G (formally Strategen Environmental). These documents should be read in conjunction with this EAMS.



Legend:
- Residential precinct
- DSP area
- Roads (MRWA)

Scale 1:15,000 at A4 — 0 100 200 metres

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57806

Client: Element

Version: A | Date: 21-Jul-2021

Drawn By: hsullivan | Checked By: CT

Forrestfield North Residential Precinct, WA

SITE LOCATION

FIGURE 1.1

strategen JBS&G

File Name: W:\Projects\1)Open\Element (TPG)\57806 - FF North TOD & Res LWMS\GIS\Maps\R01_Rev_B\57806_01_SiteLocation.mxd
Image Reference: www.nearmap.com© - Imagery Date: 3 July2021.

1.3 Legislation, policies, and guidelines

The following legislation, policies and guidelines and their implementation may be applicable for the redevelopment of the Residential Precinct.

1.3.1 Federal

1.3.1.1 Environmental Protection and Biodiversity Conservation Act 1999

The *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Department of Agriculture, Water and the Environment (DAWE). The EPBC Act aims to protect and manage nine Matters of National Environmental Significance (MNES) throughout Australia including:

- World Heritage Properties,
- National Heritage Places,
- wetlands of international importance (listed under the Ramsar Convention),
- listed threatened species and ecological communities,
- migratory species protected under international agreements,
- Commonwealth Marine Areas,
- the Great Barrier Reef Marine Park, and
- nuclear actions (including uranium mines).

The MNES applicable to the site is listed threatened species and ecological communities:

- Banksia Woodlands of the Swan Coastal Plain Threatened Ecological Community (TEC)
- *Conospermum undulatum* (Wavy-leaved Smokebush)
- Black Cockatoo foraging habitat and breeding trees.

1.3.1.2 Assessment under the EPBC Act

Under the EPBC Act an action that could be a significant impact on any MNES in accordance with the Significant Impact Guidelines 1.1-Matters of National Significance (Department of the Environment, Water, Heritage and the Arts, 2013) should be referred to the DEE for assessment by the minister.

The existing environmental challenges for the site include the following:

- the distribution of MNES is across the precinct, and
- lots within the precinct (proposed Environmental Conservation Reserves -ECRs) are vested in different landowners (multiple stakeholders) and vary in size.

To provide a consolidated approach for the future direction and approvals for the site, there are two options to ensure long-term legislative protection of the key environmental areas within the precinct:

- **Strategic Assessment of the LSP area** - identification of the potential impacts associated with the implementation of the LSP (Appendix A) and the identification of areas to be retained within the precinct (refer to Section 1.3.2).
- **Case-by-case referral** - The potential impact on MNES that occurs within the precinct can be referred on a case-by-case basis by the landowner/proponent. While ECRs have been incorporated within the LSP design to retain a significant portion of MNES (i.e. Banksia Woodland TEC, black cockatoo foraging habitat and breeding trees and Wavy-leaved Smokebush individuals). An assessment to whether development of a particular area within the Residential Precinct would be considered a significant impact on any MNES in

accordance with the Significant Impact Guidelines 1.1-Matters of National Significance (Department of the Environment, Water, Heritage and the Arts, 2013) and warrant referral under the EPBC Act would be at the landowner/proponent discretion.

1.3.1.3 Policy, recovery plans, and conservation advice

The recovery plans and conservation advice relevant to the precinct are summarised in Table 1.1.

Table 1.1: Federal recovery plans and conservation advice and policies

Policy, recovery plan, or advice.	Description/objective	Regulatory authority	Relevance
Conservation advice for the Banksia Woodlands of the Swan Coastal Plain Ecological Community.	To mitigate the risk of extinction of the Banksia Woodlands of the Swan Coastal Plain ecological community, and to assist in the recovery of its biodiversity and function.	DAWE, DBCA DWER, and CoK.	The removal and protection/restoration of the Banksia Woodlands of the Swan Coastal Plain ecological community within the precinct.
Wavy-leaved Smokebush (*Conospermum undulatum*) Recovery Plan (2009).	To maintain or improve the conservation status of *Conospermum undulatum* during the term of this plan through the abatement of identified threats.	DAWE, DBCA, DWER, and CoK.	The removal and protection/restoration of *Conospermum undulatum* within the precinct.
Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan (2013).	To prevent further decline in the distribution and abundance of Carnaby's Cockatoo through protecting the birds throughout their life cycle and enhancing habitat critical for their survival within the breeding and non-breeding range, and ensuring the reproductive capacity of the species is maintained or improved.	DAWE, DBCA, DWER, and CoK.	The removal and protection/restoration of significant habitat for the species within the precinct.
Forest Black Cockatoo (Baudin's Cockatoo *Calyptorhynchus baudinii* and Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*) Recovery Plan (2008).	To prevent further decline in the breeding populations of Baudin's cockatoo and Forest Red-tailed Black Cockatoo and to ensure their persistence throughout their range in the south-west of Western Australia.	DAWE, DBCA, DWER, and CoK.	The removal and protection/restoration of significant habitat for the species within the precinct.
Environmental Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (2012).	To compensate for the significant, residual impacts of an action on the environment.	DAWE, CoK.	Any significant residual impacts caused by the development of the precinct.

The application of management measures and recommendations as specified within the above are discussed in Section 3.

1.3.2 State

Applicable legislation includes *Environmental Protection Act 1986* (EP Act), the *Planning and Development Act 2005* (PD Act) and the *Planning and Development (Local Planning Schemes) Regulations 2015* (PD Regulations). Under the PD Regulations the CoK must seek comments in regard to proposed structure plan (LSP) from any public authority or service provider that the CoK considers appropriate.

Other legislation relevant to the management of the precinct are outlined in Table 1.2.

Table 1.2: Other relevant legislation

Legislation	Description	Regulatory Authority	Relevance
Aboriginal Heritage Act 1972 (AH Act)	Protection of amendment sites of Aboriginal heritage significance, both known and as yet unknown.	DPLH.	Disturbance to Aboriginal heritage sites.
Bush Fires Act 1954	Minimising dangers resulting from bush fires, and the prevention, control and extinguishment of bush fires.	Department of Fire and Emergency Services (DFES), and CoK.	Bushfire management and compliance.
Conservation and Land Management Act 1984	Preservation and conservation of flora and fauna.	DBCA.	Removal of Threatened or Priority flora and ecological communities.
Contaminated Sites Act 2003 (CS Act)	Regulation of matters relating to the identification, assessment, recording, management and clean-up of contaminated land.	DWER.	Presence and management of contamination and/or acid sulfate soils.
Dangerous Goods and Safety Act 2004	Safe storage, handling and transport of dangerous goods.	Department of Mines, Industry Regulation and Safety (DMIRS).	Proposed land uses within the precinct.
Electricity Act 1945	Licensing of persons carrying out works relating to electricity.	DMIRS.	Proposed land uses within the site.
Health Act 1911	Regulations concerning emissions disposal of sewage.	Department of Health (DoH).	Management of sewage.
Native Title (State Provisions) Act 1999	Recognition and protection of native title.	DPLH.	Registered heritage sites.
Rights in Water and Irrigation Act 1914 (RIWI Act)	Protection and licensing of water resources.	DWER.	Development within the Perth Groundwater Area.
Waterways Conservation Act 1976	Conservation and management of waterways and their associated environment.	DWER.	Management of waterways.
Biodiversity Conservation Act 2016 (BC Act)	Conservation and protection of wildlife (flora and fauna). Special provisions and schedules apply to the protection and management of gazetted rare flora and fauna.	DBCA.	Removal of Threatened or Priority flora, ecological communities, and fauna.

In addition to the above legislation, there are several policy and guidance documents which relate to specific environmental factors that are relevant to the development of the precinct. The assessment has been designed to address the recommendations of the State regulatory guidance as described in Table 1.3.

Table 1.3: Relevant policies, guidance statements, and technical guidelines

Document type and number	Title	Application	Relevance
Guidance statements			
3	Separation Distances between Industrial and Sensitive Land Uses.	Outlines generic separation distances between industrial and sensitive land uses to avoid conflict between land uses.	Management of impacts to surrounding land uses.

Document type and number	Title	Application	Relevance
6	Rehabilitation of Terrestrial Ecosystems.	Outlines the principles to be applied during clearing in the areas that will be rehabilitated after construction. These areas may include batters, service infrastructure corridors and road verges.	Clearing of vegetation.
33	Environmental Guidance for Planning and Development.	Provides guidance on the environmental protection process in respect of the land use planning and development process.	Land use planning.
41	Assessment of Aboriginal Heritage.	If Aboriginal heritage values are identified on or associated with the Project area, this guidance statement will be used to assess the impact of the project on those values.	Protection and management of heritage site values.
EP Act provisions			
Factor statement	Social Surroundings.	Provides guidance on the management of noise and dust in relation to proposals and surrounding land uses.	Management of impacts to surrounding land uses.
Factor statement	Flora and Vegetation.	Outlines how the factor Flora and Vegetation is considered by the EPA in the environmental impact assessment (EIA) process.	Management of impacts to flora and vegetation.
Factor statement	Terrestrial Fauna.	Outlines how the factor Terrestrial Fauna is considered by the EPA in the EIA process.	Management of impacts to flora and vegetation.
Technical guidance or guidelines			
Technical Guidance	Flora and vegetation surveys for Environmental Impact Assessment.	Provides guidance on the assessment on the biodiversity implications of vegetation clearing.	Clearing of vegetation, or impact to threatened vegetation or flora species.
Technical Guidance	Sampling methods for terrestrial vertebrate fauna.	Provides guidance on the assessment on the biodiversity implications of vegetation clearing on fauna habitat.	Clearing of vegetation, or impact to threatened fauna species.
Technical Guidance	Terrestrial fauna surveys.	Provides direction and information on general standards and protocols for terrestrial fauna surveys for environmental impact assessment.	Clearing of vegetation, or impact to threatened fauna species.
Guidelines	WA Environmental Offset Guidelines.	• Clarifies the determination and application of environmental offsets in Western Australia,	Environmental management.

Document type and number	Title	Application	Relevance
Guidelines	Statement of Environmental Principles, Factors and Objectives, and some factor guidelines.	• Communicates how, for the purposes of environmental impact assessment, the EPA, • Considers the object and principles of the EP Act, • Uses environmental factors and objectives to organise and systemise environmental impact assessment and reporting, • Takes a holistic view of the environment and a proposal or scheme's potential impact on the environment, and • Considers significance when determining whether to assess a proposal or scheme and recommend whether an assessed proposal or scheme may be implemented.	Environmental management.
Guidelines	Assessment and Management of Contaminated Sites guidelines (DER 2014).	Provides guidance on the assessment and management of contaminated sites in Western Australia (WA) within the legislative framework provided by: the CS Act and the Contaminated Sites Regulations 2006 (CS Regulations); and the revised national site assessment framework provided in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM).	Environmental management.
Policies			
Government of Western Australia	WA Environmental Offsets Policy (EPA 2011).	Provides a framework for consistent application of environmental offsets to protect and conserve environmental and biodiversity.	Environmental management.
State Planning Policy 2	Environment and Natural Resources Policy (WAPC 2003).	Provides guidance on planning developments to conserve the natural environment.	Environmental management.
State Planning Policy 2.8	Bushland Policy for the Perth Metropolitan Region (WAPC 2010).	Provides guidance to ensure bushland protection in the Perth Metropolitan Region in the respect of land use planning.	Clearing of vegetation, or impact to threatened vegetation or flora species.

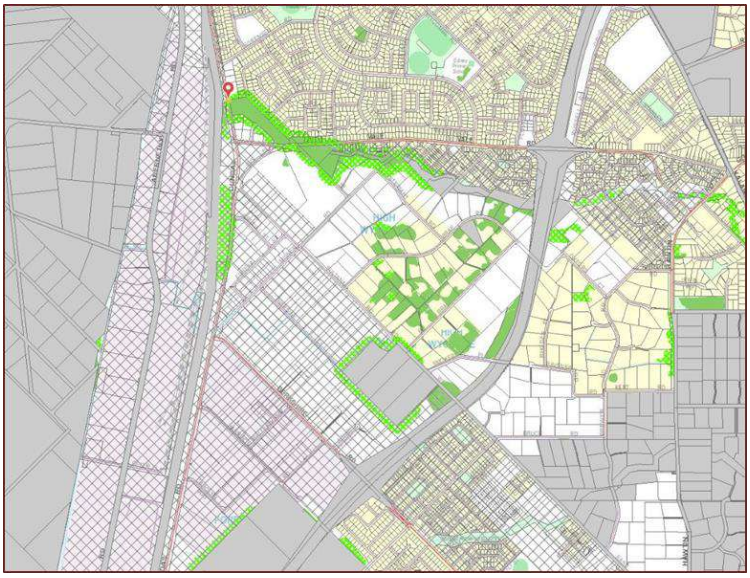
Document type and number	Title	Application	Relevance
State Planning Policy 2.9	Water Resources (WAPC 2006).	Provides guidance on how to protect, conserve, enhance and manage sustainable use of water resources of environmental value.	Impact on hydrological regime Urban water management.
State Planning Policy 5.4	Road and Rail Transport Noise and Freight Considerations in Land Use Planning, Section 5.3 – Noise Criteria.	Seeks to minimise the adverse impact of transport noise, without placing unreasonable restrictions on noise-sensitive residential development or adding unduly to the cost of transport infrastructure.	Management of impacts to surrounding land uses.
State Planning Policy 4.2	Activity Centres for Perth and Peel.	Specify broad planning requirements for the planning and development of new activity centres and the redevelopment and renewal of existing centres in Perth and Peel.	The development of an activity Centre is proposed as part of the Project.
Operational Policy 4.3	Identifying and establishing waterways foreshore areas (Department of Water 2012).	Describes the process for identifying and managing foreshore areas whose values are under pressure from land-use changes in the area around them.	Project area is located immediately adjacent to Poison Gully Creek.

1.3.2.1 Perth and Peel green growth plan for 3.5 million

Perth and Peel @ 3.5 Million (WAPC 2018) indicates that there are specific commitments identified within the precinct area. The Green Growth Plan does not specify which specific commitments are depicted by the Specific Commitments layer, which may include:

- threatened flora and threatened ecological communities (refer to Section 3)
- conservation category wetlands and wetlands of international importance (refer to Section 3)
- vegetation complexes with less than 10 per cent remaining (refer to Section 3)
- Bush Forever areas (excluding those within the 'rural complementary' and 'negotiated planning solution' categories) (refer to Section 3)
- Short Tongued Bee (*Leioproctus douglasiellus*) distribution (not applicable) (Department of the Premier and Cabinet, 2015).

As of the 6 April 2018, the State Government suspended work and will be re-evaluating the Strategic Assessment of the Perth and Peel Regions (SAPPR) through an independent review. The Government has advised that "SAPPR sought to secure up front environmental approval for future development and raw materials extraction for an identified development footprint for a 30-year period. It represents the largest and most complex land use reconciliation work, attempting to balance certainty for development and long-term environmental protection" (Department of the Premier and Cabinet, 2018). While the SAPPR has been suspended, the Specific Commitments mapping was reviewed and given due regard in formulating the design of the LSP. Refer to Plate 1.



Source: Government of Western Australia (2017)

Plate 1: Green Growth Plan for the Residential Precinct and surrounding DSP area

1.3.3 Local

The Strategies, Local Planning Policies and By-laws relevant to the CoK and precinct are presented in Table 1.4.

Table 1.4: Strategies, Local Planning Policies, and By-Laws

Reference No	Title	Application	Relevance to project
-	Local Biodiversity Strategy (2008)	Strategically plan natural area protection so that biodiversity conservation is incorporated into the CoK's planning and decision-making processes.	Retention of Local Natural Areas (LNA).
ENV4	Flood and Stream Management	Management programs and retention of open lands and structures which do not obstruct water movement nor destroy natural public water areas within the CoK.	All lands within 15m of the banks of the Poison Creek and Crumpet Creek and areas defined as the 'Flood and Stream Management Area'.
-	Pest Plants (1979)	Council may request the owner or occupier of private land within the district to destroy, eradicate or otherwise control any pest plant on that land.	Land use management.

2. Existing environment

2.1 Topography, geology and soils

2.1.1 Topography

The topography of the precinct ranges from approximately 46 m Australian Height Datum (AHD) in the north-eastern section to approximately 35 m AHD in the south-western corner. Topographic contours for the site are shown in Figure 2.1.

2.1.2 Geology and soils

Geological soil unit mapping indicates that the site is characterised by Sand (Figure 2.1), consisting of:

- S_{10}: Thin layer of SAND – very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz, moderately well sorted, of eolian origin over alluvial silts and sands of the Guildford formation
- S_{12}: SAND – yellow, fine to medium grained, sub-angular to rounded quartz, with some feldspar, well sorted, variable silt content, of colluvial origin (Gozzard 1986).

In 2011, several bores were drilled across the precinct (Figure 2.3), the lithology of the bores were:

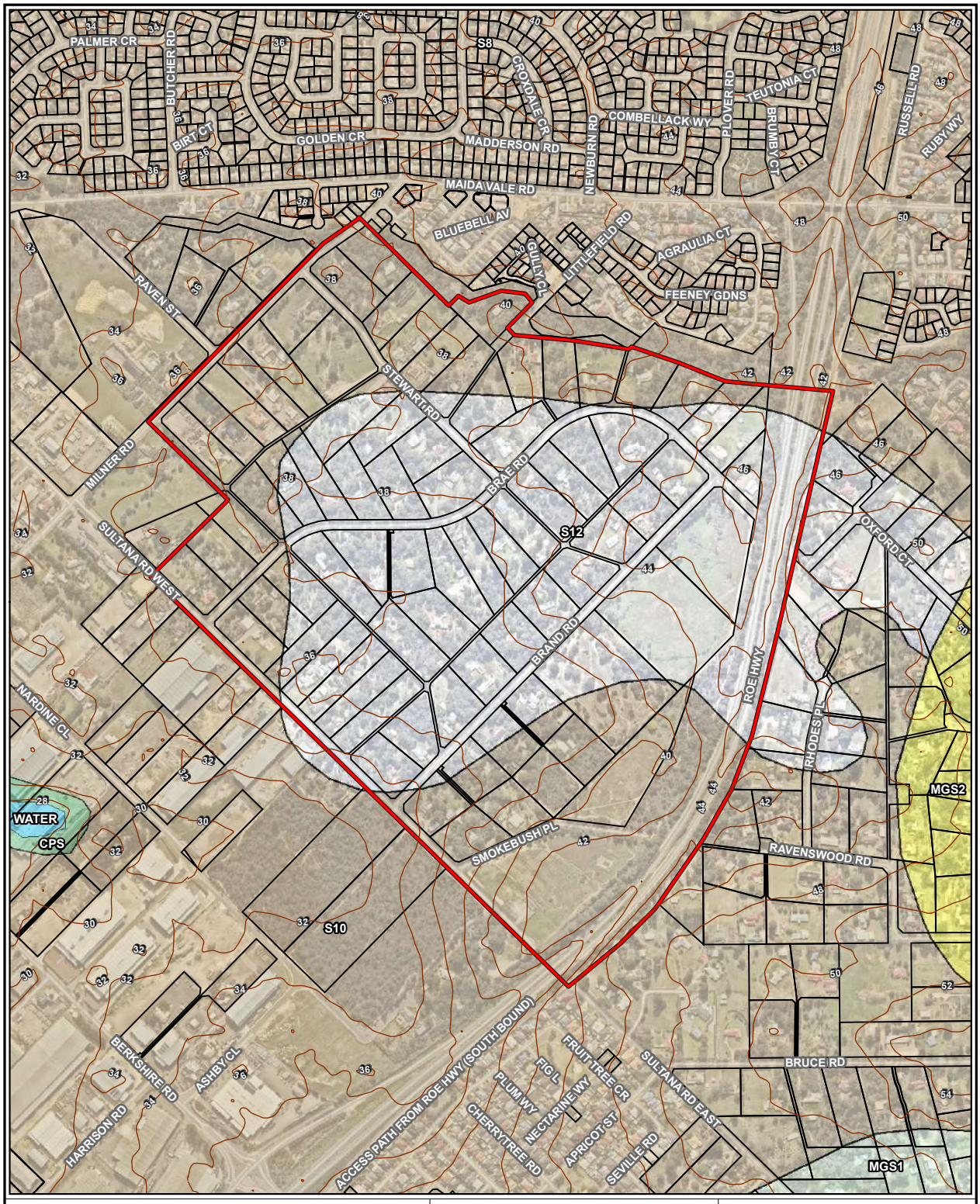
- MB02: predominantly sand with clayey sand at depth,
- MB04: gravelly sand at surface with sand at depth,
- MB05: predominantly sand (coarse to medium grained), and
- MB06: sand with clayey sand at depth (Strategen 2012a).

Relative permeability rates and Phosphorus Retention Index (PRI) for Bassendean Sands are 30+ m/day and 0-0.5 respectively (DoW nd). Currently, a geotechnical investigation for the precinct has not been undertaken to confirm soil properties/characteristics.

2.1.3 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are naturally occurring, iron-sulphide rich soils, sediments, or organic substrates, formed under waterlogged conditions. If exposed to air, these sulphides can oxidise and release sulphuric acid and heavy metals. This process can occur due to drainage, dewatering or excavation.

Review of regional mapping indicates that the precinct has a low to moderate risk of ASS occurring within 3 m of natural soil surface (Class 2) (DER 2015). Nearest high to moderate risk of ASS occurring within 3 m of natural soil surface is approximately 400 m south east of the precinct (Figure 2.2)



Legend:

- Residential precinct
- Cadastral boundary
- Topographic contours (mAHD)
- Roads (MRWA)

Geology 1:50,000

- Cps
- Mgs1
- Mgs2
- S10
- S12
- S8
- Water

Scale 1:10,000 at A4 (0 100 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**TOPOGRAPHY, GEOLOGY AND SOILS**
Job No: 57806		
Client: Element		**FIGURE 2.1**
Version: A	Date: 30-Jul-2021	strategen JBS&G
Drawn By: hsullivan	Checked By: CT	

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Legend:
- Residential precinct
- Cadastral boundary

Acid sulfate soil risk mapping (DWER)
- Moderate to low risk
- Roads (MRWA)

Scale 1:8,000 at A4 (0 100 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**ACID SULFATE SOILS**
Job No: 57806		
Client: Element		**FIGURE 2.2**
Version: A	Date: 30-Jul-2021	strategen JBS&G
Drawn By: hsullivan	Checked By: CT	

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2.2 Hydrology

A District Water Management Strategy (DWMS) was prepared by Strategen (2015) for the DSP area and approved by the Department of Water (DoW) (now Department of Water and Environmental Regulation [DWER]) and the CoK. The DWMS provides guidance on groundwater management, water sources for POS and sizing of stormwater systems.

A LWMS has also being prepared by Strategen-JBS&G (2020b) in accordance with *Better Urban Water Management* guidelines (WAPC 2008) on advice from DWER. The LWMS is consistent with regional and district scale urban water management planning, including the *State Water Plan* (DPC 2007) as well as *State Planning Policy 2.9 Water Resources* (WAPC 2006). The LWMS aims to meet the principles and objectives of stormwater management in Western Australia, as detailed in the *Stormwater Management Manual for Western Australia* (DoW 2007).

2.2.1 Groundwater

Groundwater attributes within the precinct are presented in Figure 2.3.

There are three aquifers underlying the DSP area; each assigned the name of the major geological unit in which the aquifer occurs (DWER 2017). In descending order of depth from natural surface they are:

- Superficial Aquifer (unconfined)
- Leederville Aquifer (confined)
- Yarragadee North (confined).

The Leederville and Yarragadee aquifers are both fully allocated in the Residential Precinct and adjacent areas. However, there are two options in satisfying future precinct groundwater requirements through the following options:

- a total of 137.4 ML is allocated for private use within the TOD and Residential Precinct areas. The two largest of these allocations are for 89.3 ML associated with a landscaping nursery and 32.1 ML associated with an orchard/market garden. Refer to LWMS (Strategen-JBS&G 2020b).
- the CoK currently have an allocation for irrigation of public open space (POS) in the superficial aquifer within the Perth Groundwater Area. This allocation is not being fully utilised and CoK has identified that 100 ML/year can be made available for irrigation within the DSP area if required (Varelis P [City of Kalamunda] 2017, pers. comm. 12 October).

Groundwater flow is in an approximately south-easterly direction. This is consistent with the findings of ENV (ENV 2012) reported in the LWMS for the adjacent industrial precinct and groundwater modelling (Strategen, 2018). There are currently no DWER groundwater bores within the precinct. The closest DWER bore with a long monitoring record is at the corner of Abernethy and Kewdale Roads in Kewdale, approximately 4 km south-east of the DSP area (DoE 2004). Groundwater levels within the Residential Precinct range from 28.5mAHD to 26mAHD (Figure 2.3).

Hydrogeological features of the DSP area are dominated by surface water/groundwater interactions resulting in variable groundwater gradients and flow directions across the site (EMRC, 2013). The local groundwater flow appears to be influenced by a combination of geology and drainage systems to the west and northwest of the site such as localised recharge features associated with industrial areas, Perth Airport and new developments (EMRC 2013:8).

As part of the LWMS, preliminary groundwater modelling (clearance from groundwater) has been completed. Depth to groundwater is indicated to be approximately 5 mbgl and is not considered likely to pose a constraint to development within the precinct.

Across the DSP area, groundwater is generally acidic to neutral with pH ranging between 4.62 to 7.21 (median of 5.84) (Strategen 2012). Groundwater is fresh with a median electrical conductivity (EC) level of 0.438 mS/cm. This mean EC level was identified to be within the expected range of 0.3–1.5 mS/cm for slightly disturbed ecosystems in south-west Australia (Strategen 2012).

Nutrient levels are slightly elevated. Groundwater monitoring conducted by Strategen in 2011 for the DWMS identified that total nitrogen (TN) levels varied from 0.31 mg/L to 25 mg/L throughout the monitoring period with a median of 2.1 mg/L. This median exceeds the Swan Canning Water Quality Improvement Plan's (SCWQIP) long-term and short-term target for TN (1 mg/L and 2 mg/L respectively) (Strategen 2012).

Total phosphorus (TP) results varied from <0.01 to 5.7 mg/L, with a median value of 0.72 mg/L. These levels are above the SCWQIP long-term and short-term target for TP (0.1 mg/L and 0.2 mg/L respectively) (Strategen 2012).

2.2.2 Surface water

Poison Gully Creek, is located immediately north and follows the precinct's cadastral boundary. Poison Gully Creek is an ephemeral creek that flows in a westerly direction via Limestone Creek (a tributary of Perth Airport Northern Main Drain) into the Swan River during the winter months. Previous monitoring has reported water present within September and October (Strategen 2011 and ERMC 2013).

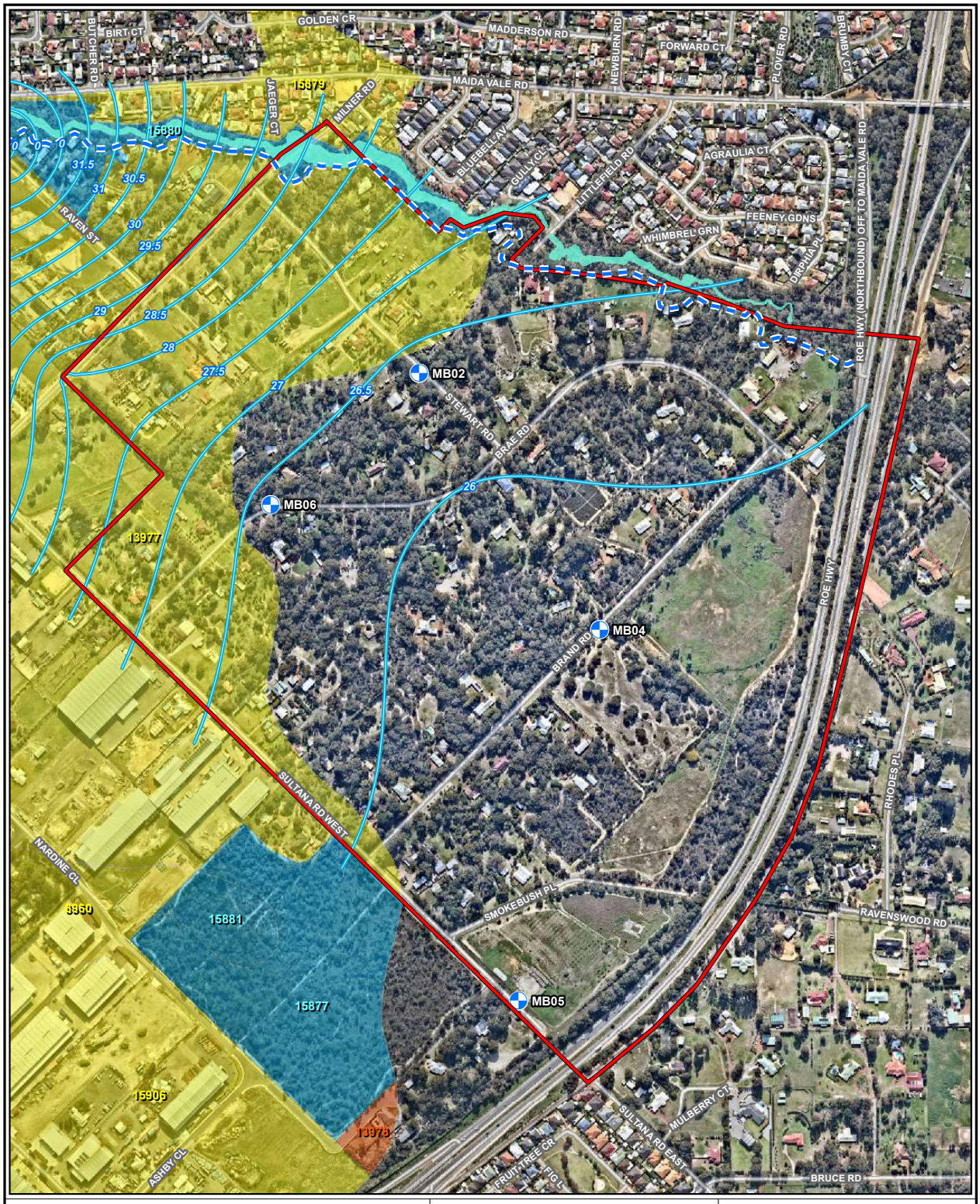
Poison Gully is part of the CoK's and the Water Corporation drainage network and has an extensive catchment to the east of the LSP area (Water Corporation 2010). It is estimated that Poison Gully has a catchment area of approximately 770 ha at the intersection of Maida Vale Rd and Dundas Rd.

No stream gauging data is publicly available for either drainage lines. It is understood that Water Corporation have previously maintained a stream gauging station for Poison Gully at Littlefield Rd (station 616015).

In 2012, a Foreshore assessment of Poison Gully was completed by Strategen and included in the DWMS which was approved by the Department of Water (now DWER) in 2015. The assessment considered the following biophysical criteria; vegetation, hydrology, soil type, geology, topography, habitat, land use and heritage, based on the guidelines in Determining Foreshore Reserves (WRC 2001). The Creek is deeply incised, with vertical exposed banks of 3 m to 5 m in height at some points, with the steepest gradient occurring on the eastern extent of the creek. Evidence of erosion was observed along the length of the creek line to varying degrees and is likely due to the steep gradient and degraded nature of fringing vegetation, which if intact would serve to stabilise the banks. Heavy infestation with a number of introduced plant species including Watsonia (*Watsonia bulbillifera*) and Spanish bamboo (*Arundo donax*) was recorded (Strategen 2012b). Poison Gully Creek's estimated foreshore boundary (in accordance with WRC, 2001 guideline) is depicted in Figure 2.3.

2.2.3 Flood potential

1 in 100-year Average Return Interval (ARI) flood level modelling for Poison Gully Creek was undertaken by the Water Corporation (2010). This flood modelling indicates a 1 in 100 year ARI flood level ranging between 39.81 mAHD at Roe Highway and 32.36 mAHD at Maida Vale Road (Strategen 2015), which is mostly contained within the valley area of the creekline. The flood height at Roe Highway was expected to be underestimated, as the invert level of the creek at this point is greater than 40 mAHD, above the Water Corporation Flood level. Based on the Water Corporation modelling, Poison Gully will overtop the road at Milner Road in the 1 in 100-year ARI event. However, as indicated, the 1 in 100-year ARI event is contained within the foreshore boundary.



Legend:

- Residential precinct
- Estimated 100 year flood area
- Geomorphic Wetlands (DBCA)
  - Resource Enhancement
  - Multiple Use
  - Not Applicable
- Groundwater monitoring bore
- Foreshore boundary
- Groundwater contour maximum (mAHD)
- Roads (MRWA)

Scale 1:8,000 at A4 (0 100 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**HYDROLOGY**
Job No: 57806		
Client: Element		**FIGURE 2.3**
Version: A	Date: 30-Jul-2021	strategen JBS&G
Drawn By: hsullivan	Checked By: CT	

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2.2.4 Wetlands

A search of the Geomorphic Wetlands of the Swan Coastal Plain Database shows that the western section of the precinct is mapped as a Multiple Use Wetland (MUW), and a portion of Poison Gully Creek is classified as a Palusplain Resource Enhancement Wetland (REW) (UFI 13997) (DBCA 2017).

REW's are considered as priority wetlands where they have been partially modified but still support substantial ecological attributes and function. The ultimate objective is to manage, restore and protect towards improving their conservation value. No unauthorised development is permitted within a REW. A generic wetland buffer to protect the wetlands ecosystem is usually associated with REW, site buffer assessment can be undertaken to determine the buffer widths (EPA 2008). The existing buffer (generic 30m) associated with REW (UFI 15880) (Poison Gully) is semi developed (i.e. residential properties, cleared footprints and sheds). Refer to Figure 2.3.

MUW's are the lowest management category assigned to wetlands by the DWER, and are generally considered appropriate for development, provided the hydrological regime is not disturbed (EPA 2008).

2.3 Potentially contamination activities

2.3.1 Contaminated Sites Register

The DWER (2017) Contaminated Site Database was searched and there are currently no registered contaminated sites within the precinct existing on the register.

2.3.2 Previous land uses

2.3.2.1 Brand Road Landfill

Brand Road landfill operations (Lot 13, 14 and 18 in plan 24292) commenced in approximately 1978. It was operated by Western Excavating from the beginning of the sand mining activities until 1989. The sanitary landfill operations started in 1989. The location of Brand Road Landfill is shown on Figure 2.4.

The DWER has classified the Site as "*Possibly Contaminated – Investigation Required*" under the CS Act (DEC Reference: DEC10015) and has requested further assessment of "current groundwater quality beneath this site, and delineation of the extent of any contamination identified, both beneath the site and off-Site".

A series of site investigations and reporting has been completed for the former landfill. A summary of is provided in Table 2.1

Table 2.1: Summary of contamination investigation and reports for Brand Road Landfill

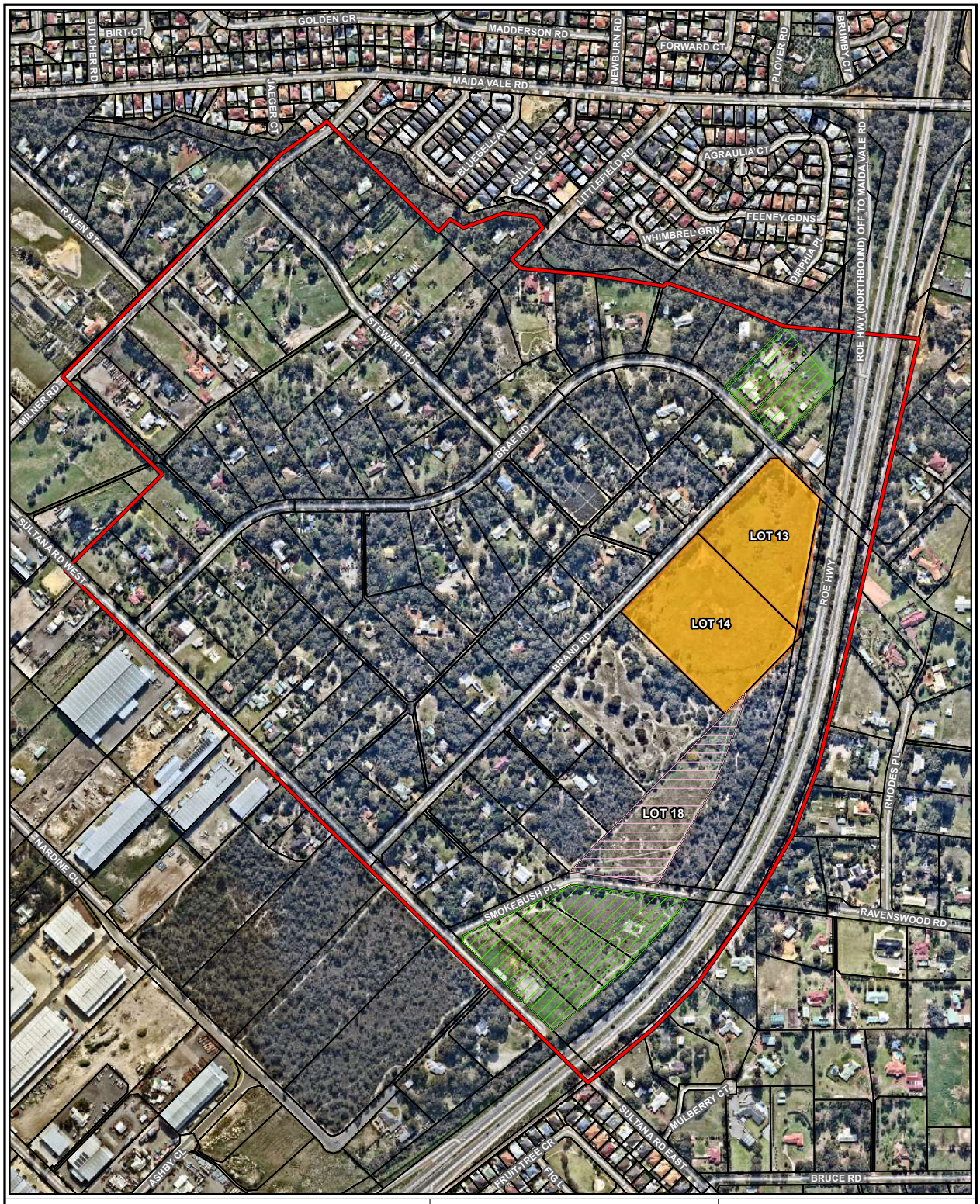
Report	Summary	Conclusion/Recommendation(s)
Preliminary Site Investigation (PSI) (GHD 2010)	• A PSI was conducted in 2010, the site had been referred to the DER Contaminated Sites Branch (CSB) previously and the site was classified as "Possibly Contaminated – Investigation Required" under the Contaminated Site Act 2003 as such the site was not added to the publicly available contaminated sites database. This is still the case with the site maintaining its current classification Brand Road landfill operations began just before 1978. It was operated by Western Excavating from the beginning of the sand mining activities until 1989. The sanitary landfill operations started in 1989. • Waste management activities formerly included the acceptance of municipal, commercial, demolition and industrial wastes; however, the operations ceased in 1996. Part of the site was capped with clay and rehabilitated (levelled and grassed) for potential recreational use.	Further groundwater monitoring investigations.

Report	Summary	Conclusion/Recommendation(s)
	• In 1996 Landfill Gas and Power commenced extraction of landfill gas as a means of reducing emissions and to provide an energy supply. • A review of previous groundwater investigations at the Site and in the immediate vicinity indicated the presence of contaminants in groundwater.	
Hydrogeological Assessment: Brand Road Landfill (EMRC 2013)	• Nine groundwater monitoring bores were sampled for inorganic and organic analysis. • Significant difference in groundwater quality exists between the Brand Rd bores and High Wycombe bores. • Groundwater quality monitored within the Brand Rd bores is being impacted by landfill leachate. However, based on the lack of gradient in groundwater flow it is estimated that it is unlikely that the plume would extensively migrate down-gradient. • Poison Gully shows no sign of contamination with surface water quality below the Department of the Environment (Now DWER) assessment levels for freshwater ecosystems.	Establishment of nested monitoring bores to the east of the Brand Road former landfill site to confirm whether groundwater contamination has migrated across the site and beyond the eastern boundary.
Bore Drilling: Brand Road Former Landfill (EMRC 2014)	• New groundwater monitoring bores were installed. • Groundwater quality from the newly installed bores was compared with the Brand Rd landfill bores and the surrounding High Wycombe bores showed that there is significant variability in groundwater quality within the site. • Overall, results are generally consistent with contamination by leachate within the boundary of the Brand Road old landfill. • The newly installed monitoring bores to the east and southeast of the landfill show no evidence of leachate contamination which indicates no lateral distribution of leachate contamination further away from the landfill.	Recommended that the Brand Rd network of monitoring bores be monitored on a biannual basis to allow for the assessment of analytical data, seasonal variations, and the identification of longer-term trends.
Biannual Water Monitoring Report (EMRC 2014a)	• Sampling (August 2014 and February 2015) of 12 GW monitoring wells and surface sample within Poison Gully. • Exceedances EC, Fem Cu NH) were recorded at one for more sample location against adopted assessment criteria.	• Continue monitoring Oxford Close and Smokebush Place bores to identify seasonal trends, especially for EC and ammonia concentrations. • Halogenated aliphatic compounds should continue to be analysed and closely monitored, particularly at site MW02I. • All sites should be monitored according to the current list of parameters to accommodate identification of trends.
Landfill Gas Contamination Assessment (EMRC 2015)	A subsurface landfill gas assessment and risk assessment was undertaken which classified most risks as low for existing commercial residential properties.	• Determine the extent of the landfill area at the eastern end where significant concentrations of methane were detected to confirm whether measurements were taken outside of the known landfill boundary. • Undertake an additional subsurface landfill gas investigation at the site to confirm results and if a series of permanent landfill gas bores should be installed across the site. • If permanent landfill gas bores are installed, data recorded can

Report	Summary	Conclusion/Recommendation(s)
		be used to undertake a Level 2 risk assessment in accordance with the NSW EPA Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases to gain a better understanding of the landfill gas risks associated with the site.
Brand Road Former Landfill Stage 1 (PSI) and Stage 2 Detailed Site Investigation (DSI) (360 Environmental 2018)	Data Gap Analysis and a Sampling Analysis and Quality Plan (SAQP) has been completed and endorsed by the Contaminated Site Auditor (CSA) DSI currently being undertaken to investigate the site as per the SAQP to develop a conceptual site model to ascertain the potential human and ecological risk factors.	To be confirmed and subject to the outcomes of the DSI.

2.3.2.2 Orchards

Based on historical aerial photography, there have been several hobby farms and/or orchards within Lots 94 and 98 Brae Road and Lots 100, 101, 102 and 103 Smokebush Place High Wycombe (Figure 2.4). These land uses and their associated activities are potentially contaminating due the uses of metals, Organochlorine pesticides, Organophosphate pesticides, Carbamate and fuels (Total petroleum hydrocarbons) (DoE 2004).



Legend:
- Residential precinct
- Cadastral boundary
- Historical orchard activity
- To be confirmed through further investigation
- Indicative landfill (source: GHD 2010)
- Roads (MRWA)

Scale 1:8,000 at A4 (0, 100, 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**POTENTIALLY CONTAMINATED SITES**
Job No: 57806		
Client: Element		**FIGURE 2.4**
Version: A	Date: 30-Jul-2021	strategen JBS&G
Drawn By: hsullivan	Checked By: CT	

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2.4 Biodiversity and natural assets

2.4.1 Flora and vegetation

2.4.1.1 Pre-European vegetation

Vegetation occurring within the region was initially mapped at a broad scale (1:1 000 000) by Beard during the 1970s. This dataset has formed the basis of several regional mapping systems, including physiographic regions defined by Beard (1981) which led to the delineation of botanical districts as described in Beard (1990); the biogeographical region dataset (Interim Biogeographic Regionalisation for Australia, IBRA) for Western Australia (DEE 2017a) and System 6 Vegetation Complex mapping undertaken by Heddle et al. (1980). The site is located within the Swan Coastal Plan 2 (SWA2) bioregion.

Beard (1980) vegetation association mapping indicates that the precinct resides within the 1001-Medium very sparse woodland; jarrah, with low woodland; banksia and casuarina. Remnant areas of the association are identified in Figure 2.5. WALGA (2017) estimates that there is approximately 10-30% of this vegetation complex within the IBRA subregion.

Heddle et al (1980) broadly mapped vegetation complexes across the Swan Coastal Plain. The precinct comprises the Southern River Complex and the Forrestfield Complex.

The Southern River Complex occurs in the western portion of the precinct area and is described as 'open woodland of *Eucalyptus calophylla* (now *Corymbia calophylla*) – *E. marginata* – *Banksia spp*. with fringing woodland of *E. rudis* – *M. rhaphiophylla* along creek beds' (Heddle et al 1980).

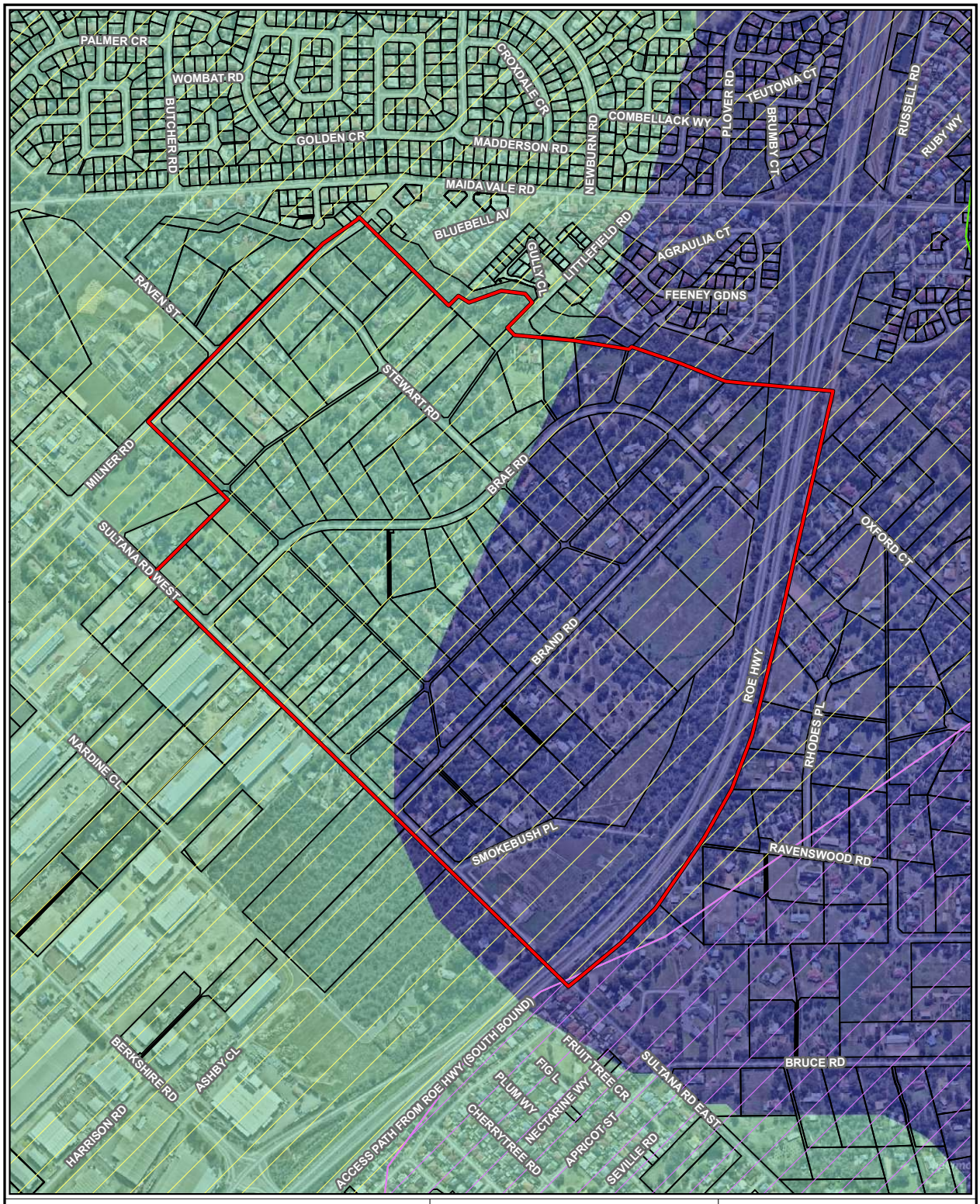
The Forrestfield Complex occurs in the eastern portion of the precinct area and is described as 'vegetation ranges from open forest of *Eucalyptus calophylla* (now *Corymbia calophylla*) – *E. wandoo* – *E. marginata* to open forest of *E. marginata* – *C. calophylla* – *C. Fraseriana* – *Banksia spp*. Fringing woodland of *E. rudis* in the gullies that dissect this landform' (Heddle et al 1980).

It is estimated that approximately 2,324 ha (11%) of the Forrestfield Complex and approximately 6,822 ha (17%) of the Southern River Complex remains in the Perth Peel Regional compared to the pre-European extent (GovWA 2019). Within the SCP area vegetation complexes that are less than 10% of the original extent are considered to be significant with focus on the retention of the remaining vegetation complex within the SCP, the remaining areas for both complexes are above the 10% threshold.

Table 2.2: Remnant vegetation complexes of the Perth and Peel regions for the Swan Coastal Plain and Jarrah Forest IBRA regions (GovWA 2019).

Vegetation complexes	Perth and Peel Region current 2019 (extent ha)	Perth and Peel Region remaining 2019 (%)	PRR reserved in region schemes P&R or ROS (%)
Forrestfield Complex	2324	11	2
Southern River Complex	6822	17	5

Remnant vegetation on site has been fragmented through semi-rural land development and clearing for building footprints, the remaining areas supporting mapped vegetation complexes within the precinct are represented in Figure 2.5 (WALGA 2017).



Legend:

- Residential precinct
- Cadastral boundary

Vegetation system associations (Beard)

- Bassendean 3
- Bassendean 1001
- Bassendean 1009

Vegetation complexes (Heddle)

- Forrestfield Complex
- Southern River Complex
- Roads (MRWA)

Scale 1:10,000 at A4 (0, 100, 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**REGIONAL VEGETATION ASSOCIATION AND COMPLEX**
Job No: 57806		
Client: Element		**FIGURE 2.5**
Version: A	Date: 30-Jul-2021	strategen JBS&G
Drawn By: hsullivan	Checked By: CT	

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2.4.1.2 Vegetation communities and condition

In 2011, The CoK completed a flora and vegetation survey which broadly identified the vegetation type and condition for the DSP area, which was included within the Environmental Review for the MRS amendment (1282/57). It was noted at that time that there were several properties that were not included within the survey area (Strategen 2012). A subsequent spring flora and vegetation survey was completed by Strategen for several lots and Poison Gully Creek which were not included within the 2011 survey.

To address the EPA recommendations associated with the MRS amendment (1282/57) and the 2016 listed Banksia Woodland of the Swan Coastal Plan Threatened Ecological Community (Banksia Woodland TEC) conservation advice (DEE 2016) a level 2 Flora and Vegetation assessment was completed for the DSP area including the precinct by AECOM (2017; Appendix A) and included the following:

- ecological community mapping and vegetation condition mapping
- targeted threatened flora surveys for *Conospermum undulatum*
- develop a comprehensive species list
- threatened Ecological Community assessments for patches of native vegetation (Appendix A).

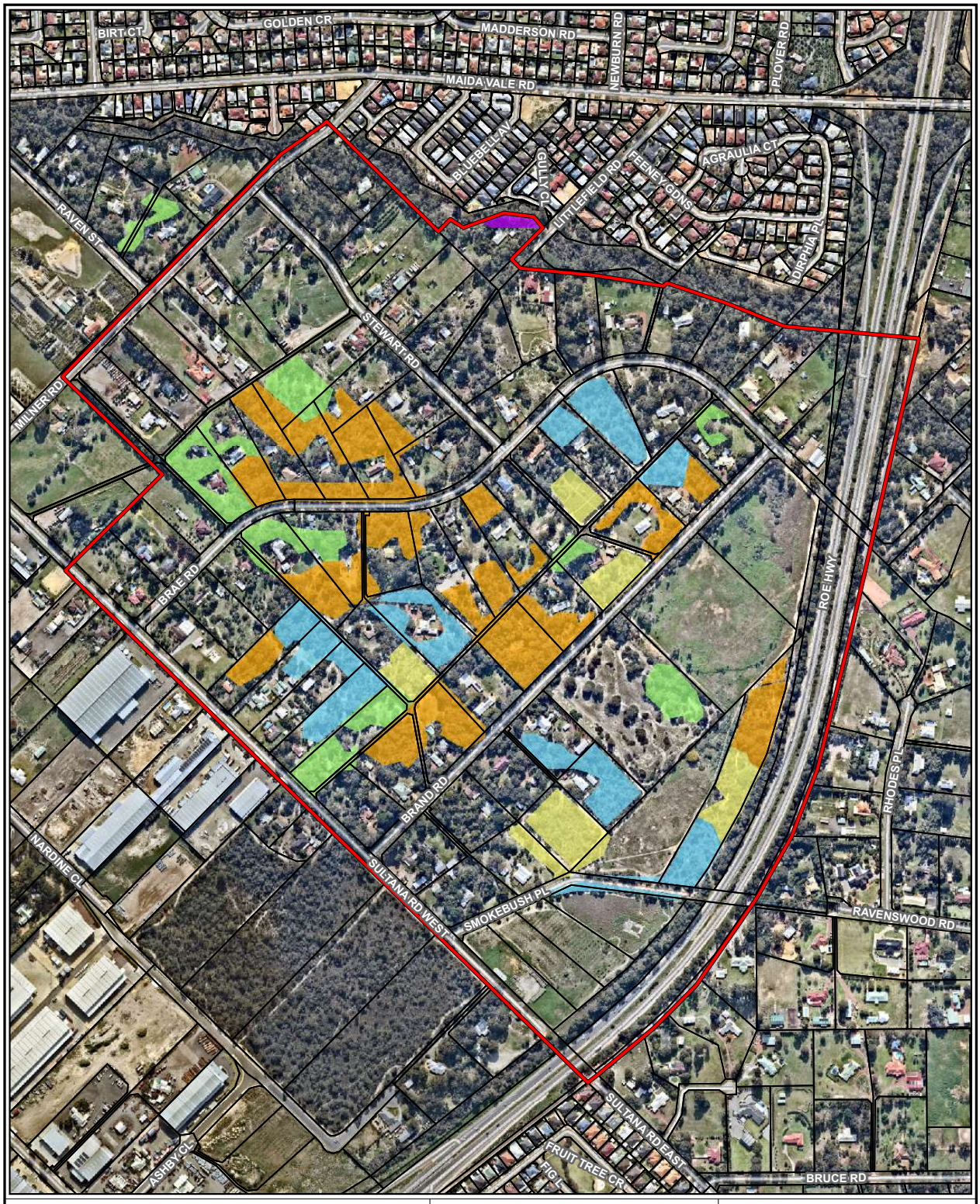
A total of 142 species from 96 genera and 33 families were recorded within the DSP area during the assessment. The total includes 131 (93%) locally native species. Families with the highest representation are Proteaceae (24 native taxa), Fabaceae (14 native taxa) and Myrtaceae (11 native taxa) (AECOM 2017:38).

Five vegetation communities (EmAcMt, EmToDo, AfHhMp, ErApEh and trees) totalling approximately 23.8ha were mapped within the precinct which ranged from 'Degraded' to 'Excellent' condition (Keighery. 1994) (AECOM 2017) Refer to Table 2.3 and Figure 2.6 and Figure 2.7 respectively.

Table 2.3: Vegetation communities and condition (adapted from AECOM 2017a and 2017b)

Vegetation community	Description	Area (ha) within precinct	FCT Analysis	Condition
AfHhMp	*Allocasuarina fraseriana, Banksia attenuata, Banksia menziesii* and *occasional Nuytsia floribunda* low woodland over *Xanthorrhoea preissii, Lambertia multiflora, Adenanthos cygnorum* subsp. *cygnorum* and *Xanthorrhoea acanthostachya* mid sparse shrubland over *Hibbertia hypericoides, Banksia dallanneyi* var. *dallanneyi, Bossiaea eriocarpa, Calothamnus torulosus* and *Petrophile macrostachya* low sparse shrubland with *Mesomelaena pseudostygia, Schoenus brevisetis, Lepidosperma leptostachyum, Caustis dioica* and *Tricostularia exsul* tall open sedgeland with *Dasypogon obliquifolius, Scaevola repens* var. *repens, Haemodorum laxum, Gladiolus caryophyllaceus*, Burchardia congesta* and *Anigozanthos manglesii* low sparse forbland.	5.71	46-52% similarity to FCT20a	'Good' to 'Excellent'

Vegetation community	Description	Area (ha) within precinct	FCT Analysis	Condition
EmAcMt	*Eucalyptus marginata* and *Banksia menzies*ii low open woodland over *Adenanthos cygnorum* subsp. *cygnorum, Lambertia multiflora* and *Xanthorrhoea acanthostachya* mid open shrubland over *Melaleuca trichophylla, Hibbertia hypericoides, Eremaea pauciflora* var. *pauciflora, Allocasuarina humilis* and *Stirlingia latifolia* low shrubland with *Mesomelaena pseudostygia, Cyathochaeta avenacea, Tricostularia exsul* and *Lepidosperma leptostachyum* mid to low sedgeland over *Tricoryne elatior, Dasypogon obliquifolius, Lyginia barbata, Scaevola repens* var. *repens, Haemodorum laxum* and *Lomandra sericea* low sparse forbland.	3.23	46-52% similarity to FCT20a	'Good' to 'Excellent'
EmToDo	*Eucalyptus marginata* and *Allocasuarina fraseriana* mid woodland over *Banksia attenuata, Banksia menziesii* and *Persoonia elliptica* low woodland over *Lambertia multiflora* and *Xanthorrhoea preissii* mid open shrubland over *Banksia dallanneyi* var. *dallanneyi, Hibbertia hypericoides, Bossiaea eriocarpa, Stirlingia latifolia,* and *Gastrolobium capitatum* low shrubland with *Tetraria octandra, Mesomelaena pseudostygia, Mesomelaena tetragona* and *Lepidosperma leptostachyum* low sedgeland over *Dasypogon obliquifolius, Patersonia occidentalis, Dampiera linearis, Haemodorum laxum, Scaevola repens* var. *repens* and *Lomandra preissii* low sparse forbland.	10.34	Representing FCT20a	'Degraded' to 'Excellent'
ErApEh	*Corymbia calophylla* and *Eucalyptus rudis* tall woodland over *Trymalium odoratissimum* thicket over *Acacia pulchella, Hibbertia hypericoides* and *Xanthorrhoea preissii* mid sparse shrubland over **Ehrharta calycina, *Cynodon dactylon*, **Gladiolus caryophyllaceus* and *Tetraria octandra* grassland/herbland on clay soils within Poison Gully.	0.15	N/A	'Very Good'
Jarrah and Trees	Areas mapped as trees comprise of scattered to clumps of native trees (mostly *Eucalyptus marginata*) located in either cleared paddocks, roadsides, or over planted vegetation. This vegetation unit was mapped using field survey observations. No quadrats were completed to represent this vegetation community as it lacks all native species except trees.	4.35	N/A	'Completely Degraded'



Legend:

- Residential precinct
- Cadastral boundary

Vegetation communities

- AfHhMp
- EmAcMt
- EmToDo
- ErApEh
- Trees
- Roads (MRWA)

Scale 1:8,000 at A4 — 0 100 200 metres

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57806

Client: Element

Version: A | Date: 30-Jul-2021

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Forrestfield North Residential Precinct, WA

VEGETATION COMMUNITIES

FIGURE 2.6

strategen JBS&G

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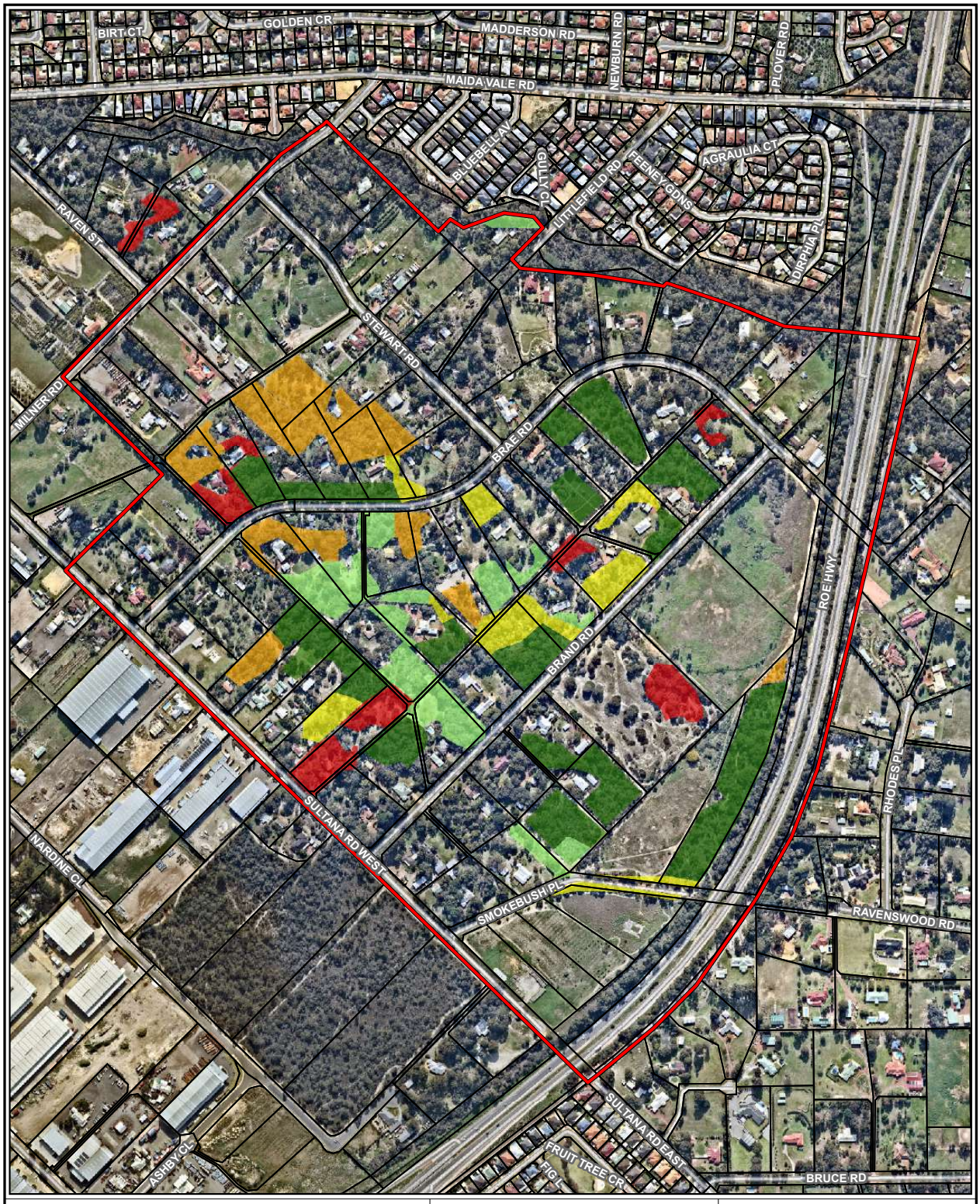

Legend:

- Residential precinct
- Cadastral boundary

Vegetation condition

- Excellent
- Very good
- Good
- Degraded
- Completely degraded
- Roads (MRWA)

Scale 1:8,000 at A4 (0 100 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**VEGETATION CONDITION**
Job No: 57806		
Client: Element		**FIGURE 2.7**
Version: A	Date: 30-Jul-2021	strategen JBS&G
Drawn By: hsullivan	Checked By: CT	

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2.4.1.3 Threatened and Priority Flora

The Threatened Wavy-leaved Smokebush (*Conospermum undulatum*) is listed as Vulnerable under the EPBC Act and Threatened under the BC Act. A total of 520 individuals of *C. undulatum* were recorded within the Residential Precinct (Figure 2.8), out of 525 that were recorded within the entire DSP area. 11,453 individuals are known to occur within the SCP region according to recent population estimates by DBCA.

Isopogon drummondii, listed as Priority 3 by DBCA, was also recorded within the precinct area. Under the BC Act, there is no statutory mechanism for the protection of Priority species, however the individuals will be retained where possible.

2.4.1.4 Threatened and Priority Ecological Communities

The FCT analysis undertaken by AECOM (2017a) indicated that VTs AfHhMp, EmAcMt and EmToDo were representative of the EPBC Act-listed Banksia Woodlands of the Swan Coastal Plain (Appendix C). Five patches of banksia woodland vegetation were recorded within the precinct, all of which met all of the key diagnostic criteria provided by DEE (2016) including:

- location and physical environment
- soils and landform
- structure
- composition
- contra-indicators.

A summary of the TEC and PECs recorded within the precinct is provided in Table 2.4.

Table 2.4: Summary of TEC and PECs within the Residential Precinct

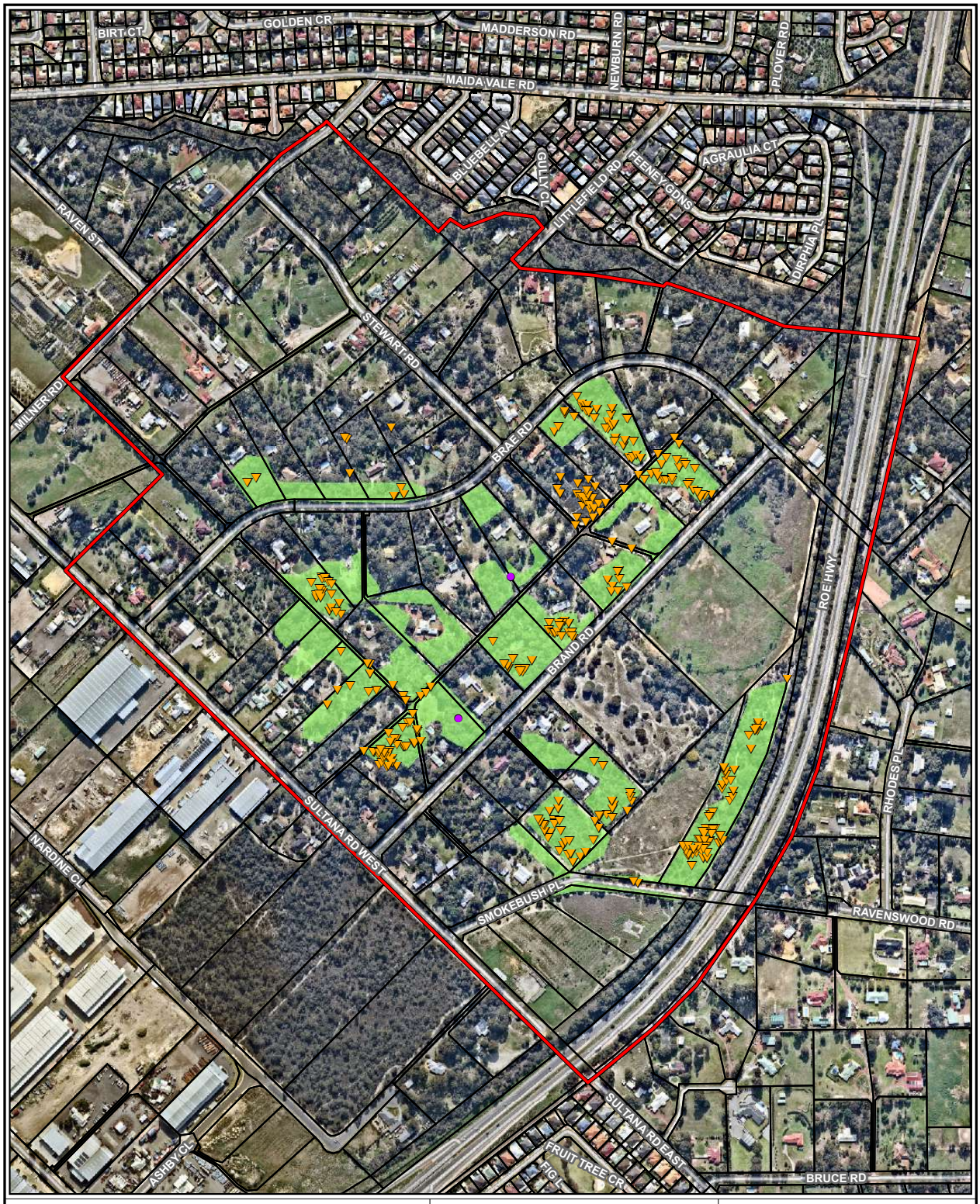
Ecological Community	Conservation status		Representative vegetation communities	Extent within the Residential Precinct
	State	Commonwealth		
Banksia woodlands of the Swan Coastal Plain.	Priority 3	Endangered	AfHhMp EmAcMt EmToDo	15.30 ha across five patches in 'Good' to 'Excellent' condition.
Banksia woodlands over species-rich, dense shrublands.	Threatened			

Banksia Woodland TEC/PEC within the precinct was co-dominated by a mix of *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* and *Eucalyptus marginata subsp. marginata*. The vegetation varied from 'Good' to 'Excellent' condition. Many of these patches were found to support populations of *Conospermum undulatum*.

The FCT analysis (of quadrats undertaken) identified FCT20a Banksia Woodlands over Species-rich Dense Shrubland as the most representative FCT to survey area quadrats (AECOM 2017a; Table 2.3). As shown in Table 2.4, FCT 20a is also listed as Endangered and is a Threatened Ecological Community under the BC Act.

2.4.1.5 Weeds

During the Strategen (2016) survey a total of 29 introduced (exotic) taxa were recorded within specific lots within the DSP, while AECOM (2017) recorded 11 species within the DSP area. Two species (*Zantedeschia aethiopica* [Arum Lily] and *Asparagus asparagoides* [Bridal Creeper]) recorded within the precinct are Declared Plant species in Western Australia pursuant to section 22 of the Biosecurity and Agriculture Management Act 2007 (BAM Act) according to the Western Australian Department of Agriculture and Food (DAFWA 2015) (Strategen 2016).



Legend:

- Residential precinct
- Cadastral boundary
- Banksia woodlands of the Swan Coastal Plain TEC
- *Isopogon drummondii* (P3)
- *Conospermum undulatum* (T)
- Roads (MRWA)

Scale 1:8,000 at A4 — 0 100 200 metres

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57806

Client: Element

Version: A | Date: 30-Jul-2021

Drawn By: hsullivan | Checked By: CT

Forrestfield North Residential Precinct, WA

THREATENED AND PRIORITY FLORA AND BANKSIA WOODLAND TEC

FIGURE 2.8

strategen JBS&G

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2.4.1.6 Dieback

A Dieback (Phytophthora cinnamomic) survey has not been completed for the precinct area. It was noted during the AECOM (2017) survey that no visual evidence of dieback existed within the DSP area (based on the health of Xanthorrhoea, Banksia, and Eucalyptus species).

2.4.2 Terrestrial fauna and habitat

A Level 1 Fauna Assessment was conducted in accordance with EPA Guidance Statement No. 56 (EPA 2004b) was completed by AECOM (2017) for the DSP area. Twelve fauna species were recorded during the AECOM (2017) field survey. This included nine birds, one mammal and two reptiles.

It was reported that four species of conservation significance including three birds and one mammal and three types of habitats were recorded within the precinct area (Table 2.5). These include:

- Carnaby's Cockatoo listed as Endangered under the EPBC Act and the WC Act
- Forest Red-tailed Black Cockatoo listed as Vulnerable under the EPBC Act and the WC Act
- Rainbow Bee-eater listed as Marine under the EPBC Act
- Quenda listed as Priority 4 by DBCA.

The Rainbow Bee-eater was seen and heard at one location in the DSP area. This species is listed as Marine and as such, is not considered protected unless it is in Commonwealth land (AECOM 2017).

Black Cockatoos

Carnaby's Cockatoos (CC), feed on the seeds, nuts and flowers, of a variety of native and introduced plant species and insect larvae (DEE 2017b). Food plants generally occur within proteaceous genera such as Banksia, Dryandra, Hakea and Grevillea, though are known to forage on eucalypt species in woodland areas. CC have also adapted to feeding on exotic species such as pines and cape lilac and weeds such as wild radish and wild geranium (DEE 2017b). CC usually breed between July and December in the hollows of live or dead eucalypts; primarily in Salmon Gum and Wandoo, but also within Jarrah, Marri and other eucalypt species (Johnstone 2010). Hollows are usually at least 2 m above ground, sometimes over 10 m and the depth of the hollow varies from 0.25 m to 6 m (DEE 2017b). The Western Australian Department of Parks and Wildlife (now DBCA), renewed the Carnaby's Cockatoo Recovery Plan in 2013, clearly mapping the distribution of likely breeding and non-breeding areas in southwest WA for CC (Parks and Wildlife 2013). Based on this map, the Residential Precinct is situated within the CC breeding range.

Forest Red-tailed Black-Cockatoos, listed as Vulnerable under the EPBC Act, depend primarily on Marri and Jarrah trees for both foraging and nesting. The seeds of both eucalypts are the favoured food source of the birds and hollows within live or dead individual trees are utilised for nesting purposes (Johnstone & Kirkby 1999). Breeding varies between years and occurs at times of Jarrah and Marri fruiting. These black cockatoos breed in woodland, forest or artificial nest boxes, but may also breed in former woodland or forest that has been reduced to isolated trees (DEE 2017b).

Quenda

The Quenda (*Isoodon obesulus*) is considered to likely occur in the DSP area. During the survey, evidence that Quenda are present within the precinct was observed. Preferred habitat usually consists of a combination of sandy soils and dense heathy vegetation (AECOM 2017).

2.4.2.1 Fauna habitat assessment

Four fauna habitats have been defined and mapped for the DSP area, three of these occur within the precinct.

Table 2.5: Fauna habitats within the Residential Precinct (AECOM 2017)

Type	Vegetation community present	Precinct area	Species habitat availability
Woodland	AfHhMp EmToDo EmAcMt	29.9ha	• Quenda habitat • Foraging and potential nesting for Forest Red-tail and Carnaby's Cockatoo.
Riparian	ErApEh	0.15ha	• Quenda habitat • Foraging habitat for Forest Red-tail and Carnaby's Cockatoo.
Jarrah and planted trees over garden	trees	4.35	• Foraging and potential nesting for Forest Red-tail and Carnaby's Cockatoo.

Foraging habitat

The Residential Precinct was divided into three different vegetation types (Table 2.5) all of which constitute foraging habitat for CC and FRTBC (AECOM, 2017).

Foraging habitat quality is displayed in Figure 2.9, as per the following (AECOM 2017):

- high quality: based on suitable foraging species, Jarrah woodlands, presence of water availability within 2 km, and support of trees with potential to be used for breeding, and
- valued quality: low quality vegetation comprised of native trees over planted vegetation or cleared paddocks, lack of suitable foraging plants present (mostly due to lack of complexity in vegetation structure).

AECOM (2017) identified 'Quality' habitat for FRTBC. This classification related to low quality vegetation for FRTBC but had a higher value due to the vegetation being near a known roosting site, water and other areas of quality foraging habitat. The boundaries for 'Quality' habitat for FRTBC are the same as 'Valued' quality for CC.

No foraging evidence was recorded for CC; however, all native vegetation, including trees with planted vegetation, was considered by AECOM (2017) to be suitable foraging habitat for CC. Vegetation communities AfHhMp, EmAcMt and EmToDo had 10-57% foliage cover of suitable foraging species (Table 2.5). The variety of cover is directly related to the condition of the vegetation. Degraded vegetation lacks the Proteaceous species in the understorey and has reduced Banksia cover. Suitable CC foraging species included 24 Proteaceous species and Jarrah trees (AECOM 2017).

All native vegetation within the DSP area is considered by AECOM (2017) to be suitable FRTBC foraging habitat. AECOM (2017) also identified ten observations of foraging evidence by FRTBC. Communities AfHhMp, EmAcMt, EmToDo and VdCd all support suitable foraging species. These are limited to three overstorey species including Jarrah, Sheoak and Snottygobble. The foliage cover of these species varies from 1.5–57%. The DSP area supports Eucalypt woodlands dominated by Jarrah, contains trees with potential to become breeding trees, supports a known large roost site (more than 10 birds), and is less than 2 km from a watering location (AECOM 2017). The trees with planted vegetation or in paddocks were classified as 'Quality' habitat and were located near known roosting site, water and other areas of quality foraging habitat (AECOM 2017).

Based on the results of the foraging assessment, the Residential Precinct contains a total of 23.64ha of foraging habitat for CC and FRTBC black cockatoos of which:

- 19.28 ha comprises of high quality foraging habitat, and

- 4.35 ha comprises of valued[1] quality foraging habitat.

Roosting habitat

Black Cockatoo roosting habitat is generally found in or near riparian vegetation, close to fresh water and typically is comprised of the tallest trees in these areas (AECOM 2017). There is a known roosting site located within Precinct on Lot 47 Brae Road, as provided in DBCA Black Cockatoo observational data (AECOM 2017).

Breeding habitat

Breeding habitat for black cockatoos is defined in DSEWPaC (2012) as trees of species known to support breeding within the range of the species which either have a suitable nest hollow or are of a suitable DBH to develop a nest hollow (> 300 mm for salmon gum and wandoo, and >500 mm for other species). These trees are known as significant trees. Trees of this size may also be large enough to provide roosting habitat (i.e. trees which provide a roost or rest area for the birds).

A total of 458 potentially significant trees (with DBH >500 mm) were recorded in the DSP area, of which 411 are located within the Residential Precinct (Figure 2.9) (Table 2.6). 26 of these trees, contained a total of 42 suitable hollow(s)[2], within the DSP area. A total of 26 trees with suitable hollow(s) where within the Residential Precinct (Table 2.7). (AECOM 2017). No evidence of black cockatoo occupancy was identified within these hollows, there were signs of use by bees and/or galahs on some hollows (AECOM 2017).

Table 2.6: Summary of potentially significant trees recorded within the Residential Precinct (AECOM 2017)

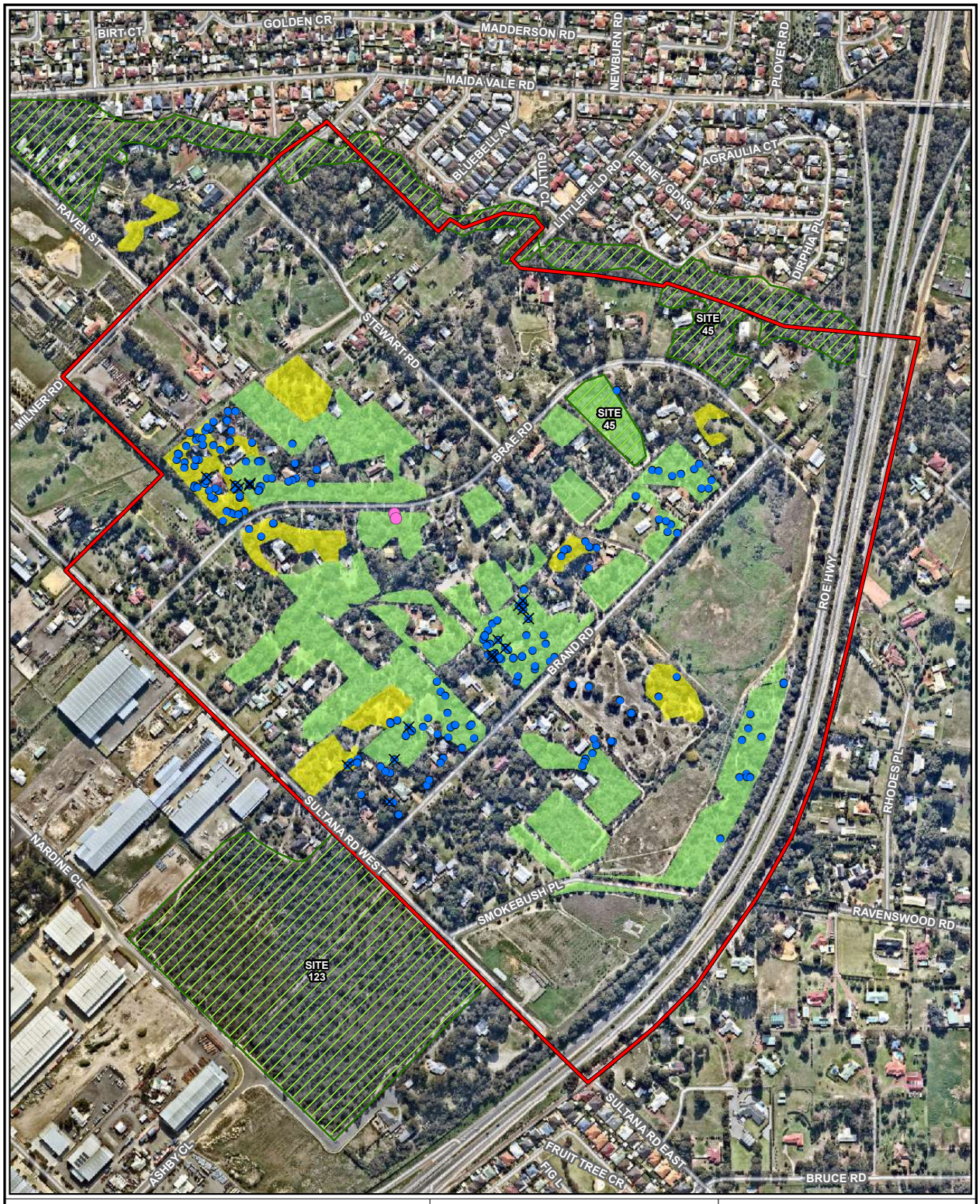
Species	Number of trees recorded within DSP Area	Number of trees recorded within Residential Precinct	Usage by Black Cockatoos	
			CC	FRTBC
Corymbia calophylla (Marri)	54	11	Roosting and breeding	Roosting and breeding
Eucalyptus gomphocephala (Tuart)	11	10	Roosting and breeding	Breeding
Eucalyptus marginata (Jarrah)	384	382	Roosting and breeding	Roosting and breeding
Eucalyptus megacarpa (Bullich)	1	1	Nil	Breeding
Unknown	8	7	Unknown	Unknown
Total	**458**	**411**		

Table 2.7: Summary of potential breeding trees with suitable hollows (AECOM 2017)

Species	Number of trees within DSP with suitable hollows	Number of trees within Residential Precinct with suitable hollows
Eucalyptus marginata	23	23
Unknown	3	3
Total	**26**	**26**

[1] AECOM (2017, 44) valued area (score 6) were considered to be 'low quality' due to the lack of suitable foraging plants present, however additional scores were given for potential breeding presence and within 2km of water near a roosting site.

[2] Not including currently occupied by bees. Some trees contained more than one hollow.



Legend:

- Residential precinct
- Bush forever site

Black cockatoo habitat

- High quality
- Valued quality
- Roosting tree location
- Black cockatoo habitat trees
- Black cockatoo habitat trees (with hollows)
- Roads (MRWA)

Scale 1:8,000 at A4	0 100 200 metres	**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**BLACK COCKATOO HABITAT**
Job No: 57806		
Client: Element		**FIGURE 2.9**
Version: A	Date: 30-Jul-2021	strategen JBS&G
Drawn By: hsullivan	Checked By: CT	

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2.4.3 Bush Forever and local natural areas

Bush forever site No. 45 Poison Gully Bushland runs along the northern cadastral boundary of the precinct and extending into Lots 80 and 81. Lot 78 has recently been included within Bush forever site No. 45. Bush forever Site No. 123 Sultana Road West Bushland is located outside of the precinct, and is located on the southern cadastral boundary of the precinct.

Local Natural Areas (LNA) have been identified for priority of retention, protection and management. These areas are usually the responsibility of the Local Government Area (Del Marco et al. 2004). The LNA mapped by WALGA (2017) within the precinct are shown Figure 2.10.

2.4.4 Ecological linkages

According to Del Marco et al. (2004) the importance of ecological linkage is to connect natural areas, preferably with continuous corridors of native vegetation, which assists in fauna movement between the areas and to access resources and habitats. The protection, management and buffering of existing natural areas within an ecological linkage is a higher priority than revegetation of cleared portions of the link. The precinct has been identified within the Perth Regional Ecological Linkage network (Figure 2.10).

2.4.5 Environmentally sensitive areas

Environmentally Sensitive Areas (ESAs) are areas that have been identified for protection due to their environmental significance as outlined in the Western Australian Environmental Protection (Environmentally Sensitive Areas) Notice 2005, which was gazetted on 8 April 2005.

Exceptions offered for clearing under Regulation 5 of the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 do not apply within ESAs. ESAs are protected under the EP Act, and include the following:

- World Heritage areas
- areas included on the National Estate Register
- defined wetlands and associated buffers
- vegetation within 50 m of a listed Threatened species
- TECs.

ESA mapping includes the entire precinct (WALGA, 2017). These are likely to be associated with the known presence of the Declared Rare Flora Wavy-leaved Smokebush (*Conospermum undulatum*), Bush Forever Sites and State listed TEC within and adjacent to the precinct.

2.4.6 Bushfire risk

Based on regional Bush Fire Prone Mapping (Department of Fire and Emergency Services, 2017) all of the precinct is mapped within the designated bushfire prone area (Plate 2).

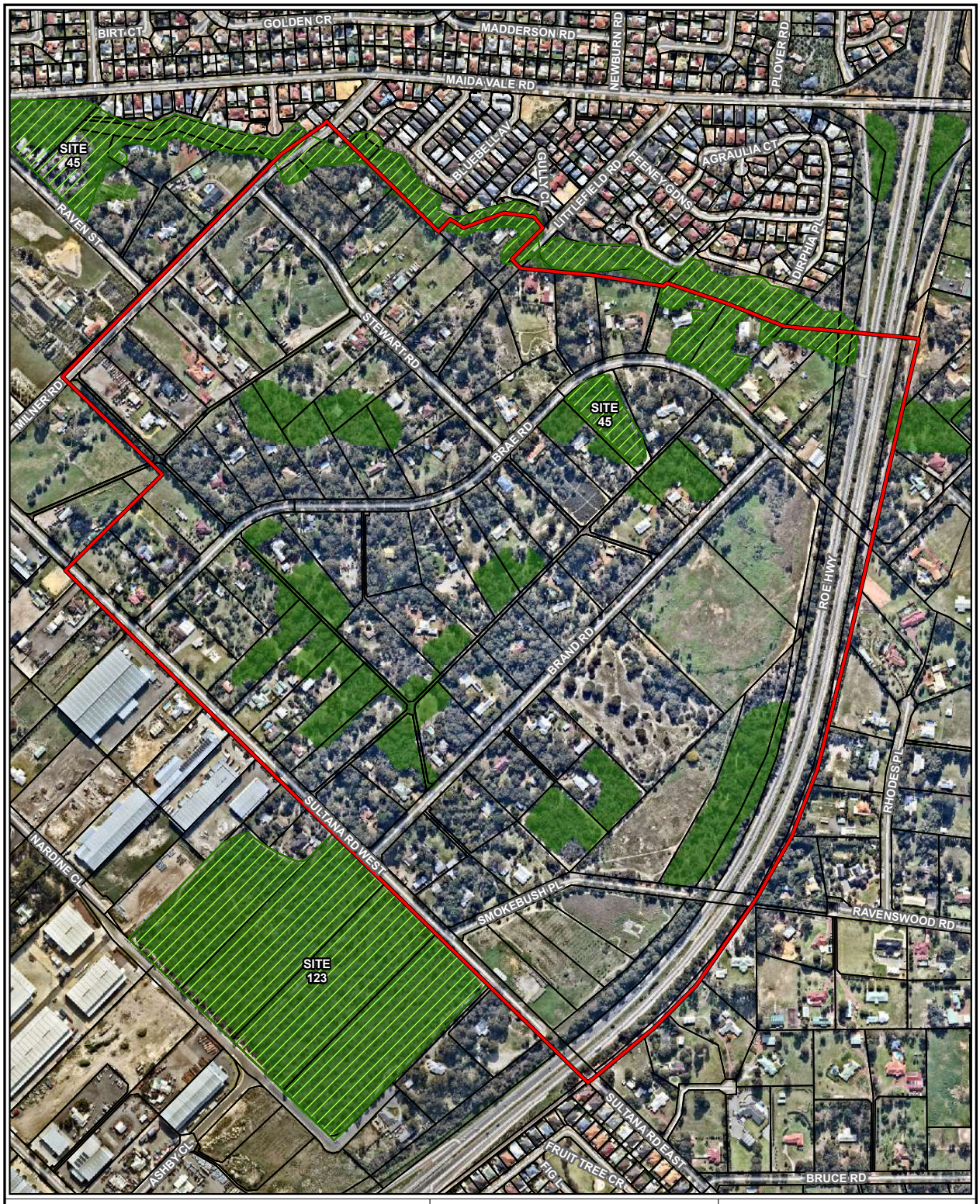
As a result of the bushfire prone status of the site, a Bushfire Management Plan (BMP) is required to accompany the Structure Plan to address the following requirements of *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7; namely Policy Measure 6.3):

- Bushfire hazard level assessment or where lot layout is known a Bushfire Attack Level (BAL) assessment.
- Identification of any bushfire hazard issues arising from the above assessments.
- Assessment against the bushfire protection criteria requirements contained within the Guidelines demonstrating compliance can be achieved in subsequent planning stages.

The BMP is required to be prepared in accordance with *Guidelines for Planning in Bushfire Prone Areas* (the Guidelines). The BMP is a separate document and should be read concurrently with this EAMS.



Plate 2: Bush fire prone area (DFES, 2017)



Legend:
- Residential precinct
- Cadastral boundary
- Bush forever site
- Local natural areas
- Roads (MRWA)

Scale 1:8,000 at A4 — 0 100 200 metres

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57806

Client: Element

Version: A | Date: 30-Jul-2021

Drawn By: hsullivan | Checked By: CT

Forrestfield North Residential Precinct, WA

BUSH FOREVER SITES AND LOCAL NATURAL AREAS

FIGURE 2.10

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Image Reference: www.nearmap.com© - Imagery Date: 3 July 2021.

2.5 Heritage and culture

2.5.1 Aboriginal Heritage

The Forrestfield area including the Residential Precinct and surrounds hold significant value to Nyungar people, and known to contain many places of major significance to Perth Nyungars i.e. Allawah Grove Reserve, Monday Swamp located at the Perth Airport and Poison Gully Creek, which is located along the northern boundary of the Residential Precinct. Ongoing heritage investigations in and around the airport indicate that Munday Swamp is still being used for hunting and foraging (Turner *et al*. (Ethnosciences) 2018).

Nyungar families have continued to use areas in and around Forrestfield for camping, hunting and rural-based employment. Of particular interest is the old Welshpool Reserve or Maamba (DPLH ID 3773) located in Forrestfield to the south of the DSP area. The old reserve(s), which is a Registered Aboriginal Site, is depicted on the AHIS as continuous with the boundaries of the present-day Hartfield Park, Forrestfield/Wattle Grove, Kalamunda, though the exact boundaries of the place are problematic as there seems to have been at least two Aboriginal reserves in the area with different reserve numbers and which may have overlapped (Turner *et al*. (Ethnosciences) 2018).

The Department of Planning and Lands and Heritage (2017) Aboriginal Heritage Inquiry System (AHIS) was searched are there is one registered site Poison Gully Creek (Site ID 25023) as it is a water source and a historical birth place. This place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972 (AHA)*. There is one Other Heritage site, High Wycombe Brooklands (ID3637) for Artefacts/Scatter. In regard to this site, information has been received by the Department of Planning Lands and Heritage in relation to the place, but an assessment has not been completed at this stage to determine if it meets Section 5 of *the* AHA.

2.5.1.1 Ethnographic heritage assessment

An ethnographic heritage assessment was completed by Turner *et al*. (Ethnosciences) (2018) for the Forrestfield North DSP area (which included the Residential Precinct). The assessment involved both desktop research and community consultation (South West Aboriginal Land and Sea Council [SWALSC] and selection of a panel of relevant Aboriginal people having association and knowledge of Poison Gully) and separate ethnographic consultations with women's and men's on-site meetings. A summary of the assessment outcomes is provided below. A copy of the full assessment is provided in Appendix D.

The search of the online AHIS and other archival sources confirmed that Poison Gully Creek (DPLH ID 25023) is the only Registered Aboriginal Site in the DSP study area. Two 'Other Heritage Places' (DPLH ID 3667 Crumpet Creek and DPLH ID 3637 High Wycombe: Brooklands Estate, both artefact scatters) are also listed.

Poison Gully Creek (DPLH ID 25023) was the only place within the Residential Precinct reported by the Aboriginal consultants that might reasonably be considered to be an Aboriginal Site within the meaning of s5 of the AHA. Turner *et al*. (Ethnosciences) (2018:27) reports that as the site file is 'Closed', the boundaries on the AHIS are 'restricted' and therefore 'dithered'; i.e., the spatial representation published on the AHIS website is broader than the actual boundary, because of the site's reported significance and hence confidentiality regarding the place's precise boundaries.

Turner *et al*. (Ethnosciences) (2018) discusses that areas around the Residential Precinct, such as the Perth Airport land and the Newburn Marshalling Yards, have been intensively surveyed and as a result many archaeological sites, typically artefact scatters, have been recorded. The Residential Precinct has not been surveyed in detail, forming only a part of a previous regional survey. Based on regional information it is reasonable to assume, that should an archaeological survey of the Forrestfield North DSP (including the Residential Precinct) be completed it is likely that additional

archaeological sites to DPLH ID 3667 and DPLH ID 3637 would be found. As noted above, the Forrestfield North DSP/LSP area has not been specifically surveyed archaeologically.

Both the women's and the men's consultations confirmed the cultural significance of Poison Gully Creek and highlighted its importance to Nyungar women in particular as a 'birthing place' with associated rituals and still seen as a place for teaching and learning about traditional cultural knowledge, both specific to the site and country more generally. The key issues raised during the consultation included:

- protection of remnant vegetation and creek and foreshore between Dundas Road and Milner Road and in particular the open space adjacent to the Dundas Road crossing,
- improvement and restoration of water flow and water quality within Poison Gully Creek to reflect the waterways original state,
- Poison Gully Creek as a place of significant values and is related to other significant areas such as Munday Swamp and Allawah Grove, traditionally linked by the flow of water and the bidi or tracks and part of a meshwork in which place is to be understood as an outcome of movement, practice and event, which result in the experience of 'biographical entanglements',
- continuing access to and control of the land as its traditional owners and custodians, and
- linkages between the Forrestfield North DSP/LSP area and the surrounding landscape.

2.5.2 European heritage

The State Heritage Register (2017) was searched for registered sites, there are currently no sites within the precinct area.

3. Management Strategy

As part of the formulation of the LSP, the documentation and assessment of the opportunities and constraints of the existing environment (refer to Section 3) was undertaken which influenced the design of the precinct including the placement of POS areas, drainage basins/swales and environmental conservation reserves (ECRs) and ecological linkages.

3.1 Landforms

3.1.1 Policy and management objectives

Where possible, maintain the gentle sloping topography across the precinct and to retain the rural lifestyle amenity of the precinct. To also ensure that the subdivision and development of land containing ASS is planned and managed to avoid potential adverse effects on the natural and built environment.

3.1.2 Local Structure Plan considerations

The opportunity and constraints analysis of regional landform mapping (i.e. topography, soils and potential ASS) environmental elements has indicated that there are no significant elements that are required to be considered or potentially impede development opportunities.

3.1.3 Management requirements

Management measures have been identified to assist in achieving the Landforms management objectives (Table 3.1).

Table 3.1: Management measures for Landforms

Parameter	Management actions	Timing/Responsibility
Geotechnical	Complete a geotechnical assessment (infiltration rates) of key drainage areas.	Once drainage design has been confirmed (refer to the LWMS). City of Kalamunda/developer.
ASS	Confirm if dewatering below the water table or the excavation of more than 100 m^3 is required as part of earthworks for the Residential Precinct.	Prior to earthworks commencing within the precinct. City of Kalamunda/developer.
	Complete an ASS desktop investigation and completion of a self-assessment form to confirm whether ASS investigations are required.	Completion and finalisation precinct earth works plans (cut and fill, infrastructure, drainage services). City of Kalamunda/developer.
	Prepare an ASS Management Plan (if ASS is present, and site works will intersect ASS areas) that includes: • potential environmental impacts—groundwater drawdown, disruption to existing bore users, vegetation stress, reduction in water quality, noise and air impacts, • earthwork strategy—soil extraction methods, stockpile management, soil treatment/neutralisation, calculated liming rate and disposal techniques, • dewatering strategy—procedure and control measures, treatment and disposal options, contingency measures if acidification of groundwater occurs, and • monitoring program—soil, groundwater, vegetation, noise and air.	Before earthworks commence onsite (Subdivision). City of Kalamunda/developer.

3.1.4 Expected outcomes

Through the implementation of the management recommendations outlined in Table 3.1, the quality of land and soils can be maintained so that landform values within the Residential Precinct are incorporated through LPS design.

3.2 Potential contamination and future land use

3.2.1 Potential impacts

As described in Section 2.3.2, the Brand Road former landfill (Lot 13, 14 and 18 in plan 24292) is within the precinct, without further investigation (and potential remediation) there are currently limited opportunities to re-develop and/or effectively utilise the site.

3.2.2 Policy and management objectives

To incorporate the former Brand Road Landfill within the Residential Precinct.

3.2.3 Local Structure Plan considerations

Within the CoK there is a lack of active recreation open space. The Residential Precinct LSP has identified the former Brand Road landfill area as a potential recreation field area which will meet the existing and future recreation needs for the regional catchment.

3.2.4 Management requirements

A series of site investigations and reporting have already been completed for the former landfill. A preliminary review of the key site investigation reports provided highlighted the following:

- preliminary indications are that contamination by leachate is within the boundary of the former Brand Road Landfill and is consistent with previous land use. Further testing is necessary to determine the nature and extent of leachate
- further landfill gas assessments should be undertaken to determine the potential risk to surrounding land use and to determine if permanent landfill gas bores should be installed
- it appears there have been no soil investigations on-site, and this should be undertaken to determine the suitability of the soil for any proposed change in land use
- it was noted that an Accredited Contaminated Sites Auditor has not been engaged for this site.

Management measures have been identified to assist in achieving the management objectives (Table 3.2) and to ascertain with certainly the incorporation and transformation of this area into a key regional recreational facility.

Table 3.2: Management measures for contamination assessment and confirmation

Parameter	Management actions	Timing/Responsibility
Asbestos Containing material (ACM)	Undertake an ACM audit of existing structures (buildings sheds) particularly those erected prior the mid-1980s.	Prior to subdivision Developer
Appointment of a Contaminated Sites Auditor and Undertake Gap Analysis	Data Gap Analysis has been completed and endorsed by the Contaminated Site Auditor (CSA). DSI currently being undertaken to investigate the site as per the SAQP to develop a conceptual site model to ascertain the potential human and ecological risk factors.	Completed
Sampling and Analysis Quality Plan (SAQP) for the former landfill	A Sampling Analysis and Quality Plan (SAQP) has been completed and endorsed by the Contaminated Site Auditor (CSA).	Completed
Potential Intrusive Site Investigations (Landfill)	**Soil sampling and Leachate Potential** The following identifies potential soil, groundwater and vapour assessments that may be required to be undertaken to further delineate the site's contamination risk and potential for the proposed future land use. Where possible, soil sampling may be undertaken in conjunction with geotechnical investigations. Based on the existing environmental studies, it appears that no soil investigations have been	During the implementation of the precinct LSP (prior to development occurring adjacent to or within the landfill area).

Parameter	Management actions	Timing/Responsibility

	undertaken on site. Therefore, it is recommended undertaking an intrusive soil sampling program, including analysis of data.
	• soil sampling should be conducted in accordance with National Environment Protection (Assessment of Site Contamination) Measure', National Environment Protection Council, December 1999, as amended 2013 (NEPM) and the approved SAQP and DER (2014) *Assessment and management of contaminated sites - Contaminated sites guidelines,*
	• soil bores should be installed to a minimum depth of 1 m below the maximum depth of the landfill,
	• soil bores should be advanced using a sonic push core and/or hand auger. Alternatively (if suitable) soil sampling can be undertaken concurrently with other programs such geotechnical site investigations provided direct push drilling is utilised,
	• all soil samples should be submitted to a NATA accredited laboratory. Target analytes will be in accordance with the Department of Water and Environmental Regulation Landfill Waste Classification (as amended 2009) guidelines and include:
	  ○ Metals
	  ○ Cyanide
	  ○ volatile hydrocarbons
	  ○ speciated phenols, total phenols, total petroleum hydrocarbons, polycyclic aromatic hydrocarbons
	  ○ chlorinated acidic pesticides
	  ○ OC/OPs and PCBs
	• quality control (QC) samples should be collected in accordance with those recommended by the DWER and will include the collection of duplicate and triplicate samples (1 per 20 primary samples collected) as well as rinsate and field blank samples as required.	

	Classification of waste into waste types and landfills The investigation of landfill sites is completed using the steps identified in the Department of Environment and Conservation Landfill Waste Classification and Waste Definitions 1996 (DEC as amended 2009).	During the implementation of the precinct LSP (prior to development occurring adjacent to or within the landfill area).
	Site Characterisation-Soil leachate testing Subject to the classification of waste investigation, if the classification of the soil results is not acceptable, or any contaminant concentration exceeds the relevant contaminant threshold value, the ASLP leachate concentrations for all relevant contaminants must be determined.	During the implementation of the precinct LSP (prior to development occurring adjacent to or within the landfill area).
	Groundwater Monitoring Ongoing groundwater monitoring from July 2010 confirms groundwater beneath the site and the immediate vicinity of the site has been impacted. The results of the latest biannual groundwater monitoring event identified exceedances in	During the implementation of the precinct LSP (prior to development occurring adjacent to or within the landfill area).

Parameter	Management actions	Timing/Responsibility
	contaminants of concern, above the adopted assessment criteria (EMRC, 2014). Continue the ongoing biannual groundwater monitoring program to delineate the nature and extent of groundwater contamination and to determine the groundwater impact on-site and off-site. Appoint an Auditor to review the groundwater program undertaken to date to confirm the suitability of future biannual groundwater monitoring events.	
	Landfill Gas Assessment Appoint an Auditor to review the landfill gas assessment program undertaken to date to confirm the suitability of the program going forward. Based on the outcomes of the above continue landfill gas assessment program to confirm the risk of landfill gas potentially migrating towards sensitive receptors (i.e. proposed school site).	During the implementation of the precinct LSP (prior to development occurring adjacent to or within the landfill area).

3.2.5 Predicted environmental outcomes

Further investigations (as recommended above) have commenced within the landfill area and will confirm the appropriateness and suitability of changing the current land use to support recreation facilities and identify appropriate controls for the operation / management of the site into the future.

3.2.6 Secondary approval requirements

Sites where potential contamination exists will be managed through the land use planning process in accordance with the *Contaminated Sites Act 2003* (CS Act). The CS Act specifies that to clear any conditions relating to the assessment and management of contaminated sites requires the approval of resulting investigations by a Western Australian accredited contaminated sites auditor. Approval to commence recreational activities/facilities within the former Brand Road landfill area will be required under the CS Act and prior to subdivision.

3.3 Hydrology

Previous site investigations (DWMS, 2012a) demonstrate that the hydrology features within the Residential Precinct are influenced by a combination of relatively complex geology, surface water/groundwater interactions resulting in variable groundwater gradients and flow directions across the DSP area.

3.3.1 Potential impacts

While the precinct pre-development and post-development surface water flows are to coincide in accordance with the WAPC (2008) Better Urban Water Management Guidelines, the estimated surface water volumes are expected to increase through urbanisation within the precinct. Therefore, the allocation of detention or infiltration basins and underground storage are proposed as per the LWMS.

As discussed in Section 2.2, a generic buffer to REWs are usually required as per EPA policy (EPA, 2008). There is currently no buffer associated with the REW (UFI 13997). The area surrounding the REW within the Residential Precinct is highly modified and currently provides minimal protection to the wetland function area i.e. management of land degradation processes - edge effects, weed encroachment, rubbish dumping and uncontrolled access.

3.3.2 Policy and management objectives

The key principles and objectives for sustainable water management for the Residential Precinct is provided in the following:

- *Liveable Neighbourhoods Edition 4* (WAPC 2009)
- *Water Resources Statement of Planning Policy 2.9* (WAPC 2004)
- *Stormwater Management Manual for WA* (Department of Water 2007)
- *Decision Making Process for Stormwater in Western Australia* (Decision Process, DWER 2017)
- *Better Urban Water Management* (WAPC 2008)
- *Interim: Developing a Local Water Management Strategy* (DoW 2008)
- *Forrestfield North District Water Management Strategy* (Strategen 2015).

The key points of these policies are discussed in Table 3.3. For further information refer to the LWMS.

Table 3.3: Water management principles and objectives

Category	Principles	Objectives
Water use	• consider all potential water sources in water supply planning, • integration of water and land use planning, and • sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	• minimise the use of potable water where drinking water quality is not essential, and • achieve a significant reduction in water use below the 100 kL/person/year State Water Plan (Government of Western Australia 2007) target.
Groundwater and surface water quantity	• to retain natural drainage systems and protect ecosystem health, • to protect from flooding and water-logging, • to implement economically viable stormwater systems , and • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles, and • for flood management, manage up to the 1 in 100-year ARI event within the development area to pre-development flows and the requirements of Water Corporation (Water Corporation 2010).
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality, • where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater, and • where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	• maintain surface water and groundwater quality, and • ensure that the 1 in 1 year, 1 hour event (16 mm) receives treatment prior to discharge to a receiving environment.

3.3.3 Local Structure Plan considerations

The LSP northern boundary is allied along Poison Gully Creek, there is one section of a REW (Poison Gully) intersects the Residential Precinct, the design of the LSP has incorporated the following:

- REW (UFI 13997) and most of the associated buffer (<30m) is within POS No. 9. Other areas along Poison Gully Creek area is bounded by a hard edge (i.e. road). Fencing (i.e. conservation style) can be incorporated to control access along this interface
- Poison Gully Creek foreshore area which intersects the LSP boundary has been incorporated within ECR areas (i.e. No.10, 11, 12 and13)

- Establishment of a formal pedestrian connection between Littlefield Road and the LSP area (where there is an existing road/culvert over Poison Gully)
- Detention/infiltration basins area (refer to LWMS).

3.3.4 Management requirements

Management measures have been identified to assist in achieving the hydrology management objectives (Table 3.4). Refer to the LWMS for management objectives for specific surface water/drainage basin requirements for the project.

Table 3.4: Management measures for hydrology

Parameters	Management actions	Timing/Responsibility
Retention of Resource Enhancement Wetland and ECR areas along Poison Gully Creek (excluding existing Bush Forever Sites)	Development of a Strategic Conservation Management Plan (SCMP) for all ECRs, that considers the conservation objectives in DEC (2009) Waxy-leaved Smokebush Recovery Plan and to include (but not limited to): • areas to be rehabilitated (including revegetation low fuel plant species [FESA, 2011), KPIs planting densities, weed control) • controlled access and fencing requirements particularly along the interface of passive recreation and conservation areas • contingency measures • monitoring program implementation and responsibilities.	A draft SCMP has been developed by the state government and will be finalised subsequent to the approval of the LSP. Management of ECR's will be by CoK. Timing is to be prior to development commencing within each subdivision Stage.
Works proposed within the Poison Gully foreshore area (also refer to Section 4.6 Heritage)	Development of a Construction Management Plan (pre-and during construction): • consultations with the Nyungar community • environmental outcomes and performance indicators • risk assessment and management measures • monitoring • contingency response and corrective action • report and review.	Timing is to be prior to development/earth works within the creek foreshore area.

3.3.5 Secondary approval requirements

Refer to Section 2.5 - Heritage for further information regarding the AH Act and the LWMS.

3.4 Biodiversity and natural assets

3.4.1 Potential impact

The following potential impacts have been identified associated with the redevelopment of the residential; precinct in accordance with the DSP:

- removal of *Conospermum undulatum* plants,
- removal of TEC *Banksia Woodland of the Swan Coastal Plain,*
- removal of significant black cockatoo trees and foraging habitat for black cockatoos, and
- potential removal of a roosting site.

3.4.2 Policy and management objectives

The overall management objective for biodiversity and natural assets is to consolidate existing, fragmented environmental areas and to retain and conserve viable significant flora, TEC and fauna habitat. The intention of the management strategy is to create a planning outcome that will facilitate the long-term protection and enhancement of the proposed ECRs. The retention of these matters (i.e. black cockatoo habitat trees) within proposed POS areas is subject to drainage, landscaping, bushfire and engineering requirements and will be finalised during subsequent planning processes.

3.4.3 Local Structure Plan considerations

Vegetation, Flora and Fauna

As part of the opportunity and constraints analysis of environmental matters within the precinct, the outcomes of AECOM (2017) Level 2 Flora and Fauna Survey and previous documentation (Strategen, 2012) was analysed, which included the following key matters:

- Banksia Woodlands of the Swan Coastal Plain TEC
- *Conospermum undulatum* (Wavy-leaved Smokebush)
- black cockatoo habitat trees
- black cockatoo foraging habitat.

Figure 3.1 provides a spatial representation of the clustering of environmental values within the Residential precinct. In this way, the figure indicates which areas have the highest density of DRF, black cockatoo habitat trees, and TEC. This allowed for visual interpretation of where conservation areas and areas of POS would be best placed to provide the maximum retention of environmental values, and therefore conservation priorities. Consultation with Stakeholders (KEAC, TAG, DWER (OEPA) DBCA) confirmed that the key natural areas containing Banksia Woodland TEC, DRF and black cockatoo foraging, and potential breeding trees are of state significance. Of particular note is the importance of retaining and conserving the *Conospermum undulatum* population within the Residential Precinct given its conservation status and substantial presence within the Precinct.

Consideration was given to mapped regional ecological linkages (WALGA 2004) as well as local ecological linkages identified by Strategen (2012) during the design of the Residential Precinct. The POS width within the linkage between Bush Forever Site 123 and Poison Gully Creek ranges from 50m to 100m. This was designed based on the recommended ecological linkage width of 50 m (Del Marco et al. 2004).

In response to the above, proposed ECRs were developed and are depicted in the Forrestfield North LSP (Appendix A; Figure 3.1).

Table 3.5 and Figure 3.1 describe and illustrate the environmental values proposed for retention within conservation areas and areas of POS. Matters to be retained include:

- Banksia Woodlands of the Swan Coastal Plain TEC,
- Conospermum undulatum individuals,
- Black cockatoo habitat trees including those with hollows, and
- Black cockatoo foraging habitat.

The environmental and recreational values (i.e. vegetation type, condition and usage) of POS within the Precinct will significantly contribute to the ecological function between Sultana Road West Bush Forever site (No. 123) and Poison Gully Creek, which will in turn assist in maintaining the ecological viability of the ECRs and fauna corridor (linkage).

Table 3.5: Proposed environmental conservation reserves for retention and conservation of key environmental matters within the Residential Precinct

Environmental matter	Extent within LSP area	Extent proposed to be retained within conservation areas	Extent proposed to be retained within POS areas
Conospermum undulatum (Wavy smoke bush)	525 plants	Conservation: 416 Parks and Recreation: 38 Total: 454 (86.5%)	23 plants (4.4%)
TEC (FCT20a) / Banksia Woodlands of the SCP	15.5 ha	Conservation: 5.67 ha Parks and Recreation: 0.80 ha Total: 6.47 (41.7%)	2.81 ha (18.1%)
Potential habitat trees for black cockatoos	411 trees (26 with hollows)	Conservation: 63 (8 with hollows, 3 with suitable hollows) Parks and Recreation: 1 (no hollow) Total: 64 (9 hollows, 3 suitable) (15.6%; 34.6%)	118 trees (17 hollows, 13 suitable) 28.7% (65.4%)
High quality foraging habitat for black cockatoos	19.25 ha	Conservation: 6.15 ha Parks and Recreation: 0.80 ha Total: 6.95 ha (36.1%)	2.82 ha (14.6%)

3.4.4 Management requirements

Management measures have been identified to assist in achieving the Biodiversity and Natural Assets management objectives (Table 3.6).

Table 3.6: Management measures for Biodiversity and Natural Assets

Parameter	Management actions	Timing/Responsibility
Bushfire Risk	Implementation of the Bushfire Management Plan.	Once BMP approved by relevant government agencies- Ongoing. City of Kalamunda /developer.
Various ownership of lots within the ECR and POS areas	To consolidate the ownership of lots and investigation to options of acquiring the lots through state and/or local planning provisions.	Once LSP has been approved. City of Kalamunda/ WAPC/ Department of Planning.
Assessment of existing infrastructure (buildings) and remediation responsibilities	Complete an audit on buildings to be retained/decommission and removed within POS or adjacent to ECRs.	Once LSP has been approved. City of Kalamunda/Developer.
Protection of ECRs	Development of a Strategic Conservation Management Plan (SCMP) for all ECRs, that considers the conservation objectives in DEC (2009) Waxy-leaved Smokebush Recovery Plan and to include (but not limited to): • areas to be revegetated (including revegetation low fuel plant species [FESA, 2011), KPIs planting densities, weed control) • controlled access and fencing requirements particularly along the interface of passive recreation and conservation areas • contingency measures • monitoring program • implementation and responsibilities.	The state government (DPLH) is currently drafting the SCMP. Once LSP has been approved. City of Kalamunda in consultation with OEPA (DBCA).
	Development of a construction environmental management plan to incorporate environmental elements during pre-construction and during construction: • identification of potential threats/impacts and risks associated with construction	Once LSP has been approved and prior to the commencement of redevelopment within 100m of the ECRs. City of Kalamunda / developer.

Parameter	Management actions	Timing/Responsibility
	activities within and adjacent to the ECR (i.e. dieback, fauna and habitat management) • environmental outcomes and performance indicators • management measures and monitoring • contingency response and corrective actions • reporting and review.	
	Assess the viability of the retention of the black cockatoo roosting site development area. If possible, incorporate into future development design.	Subdivision design.
Ecological linkage of POS area between Bush Forever site No. 123) and Poison Gully Creek	• Complete a Landscape Feature and Tree Retention Plan, which location, species, size and structural health of significant trees (>50cm DBH) on site • Assess the feasibility of bushland retention in response to bushfire and recreational requirements.	Once LSP approved and prior to subdivision design. Developer in consultation with the CoK
	• Where possible retention of Black cockatoo habitat trees- with priority to trees containing hollows.	Prior to subdivision design. Developer in consultation with the CoK.
	• Complete feasibility assessment whether existing bridle trails (Crown reserve 37320) can be retained within the POS areas.	Prior to subdivision design. Developer in consultation with the CoK.
	• POS design will be undertaken to ensure that sustainable outcomes which reduce water and fertiliser use, are the implemented through the principles identified in the LWMS.	UWMP- when required. Developer.

3.4.5 Predicted environmental outcome

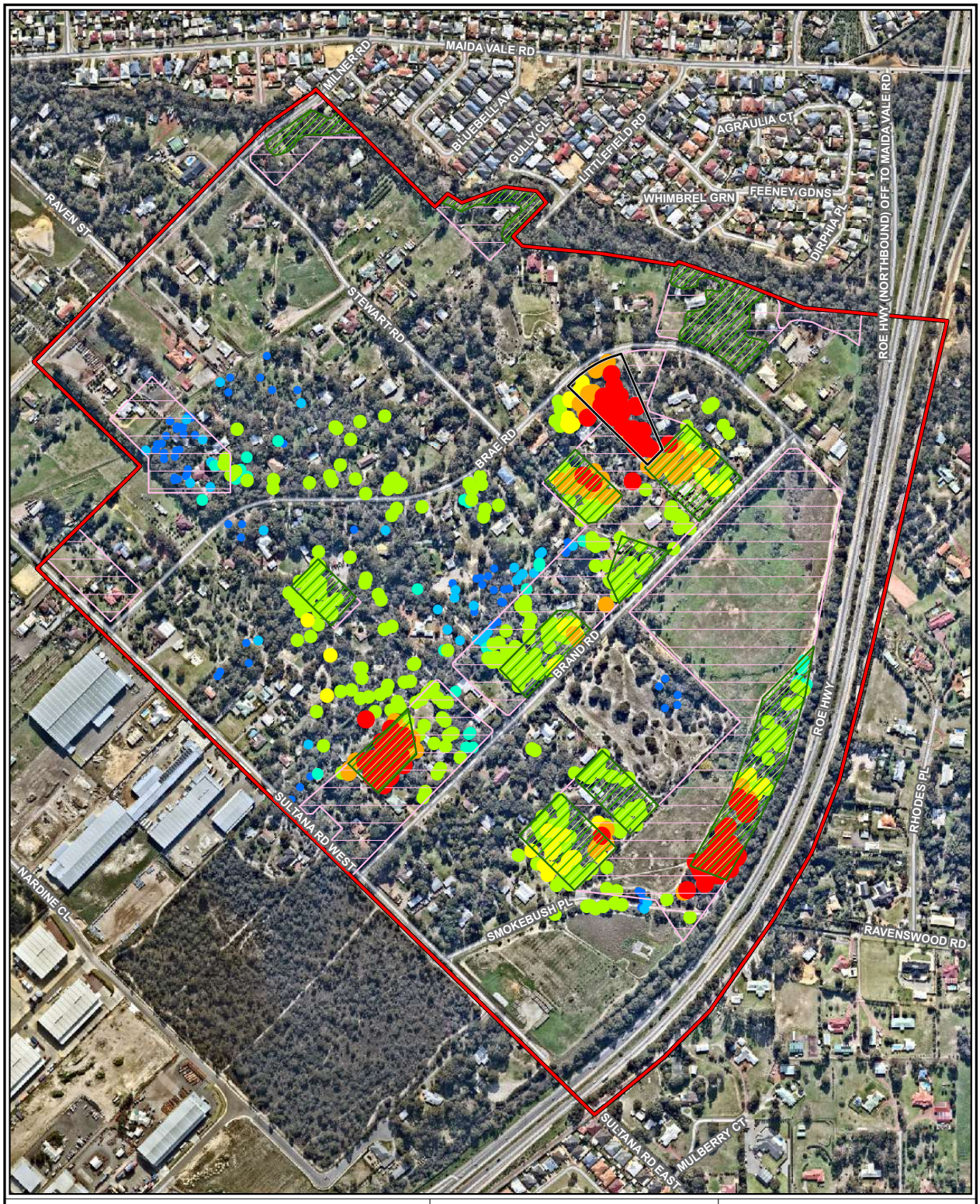
ECRs have been committed to by the CoK, which have been reflected in the LSP (Appendix A). Within the Residential Precinct these retention areas conserve:

- 42% Banksia Woodland TEC,
- 87% C*. undulatum* (wavy-leaved smoke bush),
- 16% Black cockatoo habitat trees (35% of those containing hollows), and
- 36% Black cockatoo foraging habitat.

3.4.6 Secondary approval process

As discussed in Section 2.1, due to the presence of MNES within the precinct, the LSP or its implementation (developable areas and areas to be retained) may be subject to an EPBC Act referral subject to the proposed action and the significance of potential impact.

Under the DP Act, application for subdivision to implement the development areas will be required. It is likely that there will be subdivision conditions associated with key environmental matters identified in 3.4.1.



Legend:

- Residential precinct
- Environmental conservation
- Local Open Space
- Parks and recreation
- Roads (MRWA)

Environmental values

- Lowest concentration
- Highest concentration

Scale 1:7,500 at A4 (0 100 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**SPATIAL REPRESENTATION OF THE CONCENTRATED RETENTION OF ENVIRONMENTAL VALUES**
Job No: 57806		
Client: Element		**FIGURE 3.1**
Version: A	Date: 30-Jul-2021	strategen JBS&G
Drawn By: hsullivan	Checked By: CT	

File Name: W:\Projects\1)Open\Element (TPG)\57806 - FF North TOD & Res LWMS\GIS\Maps\R01_Rev_B\57806_03_1_EnvtlValues.mxd
Image Reference: www.nearmap.com© - Imagery Date: 3 July 2021.

3.5 Bushfire risk

3.5.1 Policy and management objective

Ensure that the bushfire risks to future life, property and environmental assets are minimised through appropriate development design and implementation of bushfire management measures.

3.5.2 Local Structure Plan considerations

- a Strategic Bushfire Overlay was provided initially to inform early design stages of the LSP (Residential Precinct). The indicative bushfire advice assumed post-development conditions (i.e. all land within proposed development cells would be cleared, with any temporary internal hazards to be managed through specialised staging works). The following was provided/recommended at that time
- key areas of intact vegetation that may pose a post-development bushfire risk were identified
- application of BAL ratings via AS 3959 will need to be considered for any proposed development located within 100 m of classified vegetation
- critical bushland interfaces were depicted, which may result in development being situated in areas of BAL-40 or BAL-FZ, which would be non-compliant in regard to the siting and location of development under current bushfire planning guidelines
- these interfaces should be considered for potential redesign to introduce road reserves at the bushland interface and/or actively managed, low fuel POS areas. Should these options not be achievable, then the development cells will need to cater for internal building setbacks to ensure the future buildings within the cells are not situated in areas of BAL-FZ/40 and can achieve a rating of BAL-29 or lower. It is noted that some of the development cells identified at the critical bushland interfaces (particularly residential cells to the north) may be too small to fully cater for the necessary internal building setbacks. Some setbacks may be required to be as large as 20-27 m, particularly those adjacent to down-slope forest vegetation, which is likely to be the case along the northern interface with Poison Gully Creek
- eight potential cul-de-sacs/dead-ends in the early concept plan may be considered non-compliant with guideline requirements
- potential Vulnerable Land Uses (as defined under the Guidelines) i.e. Primary School appear capable of achieving the necessary bushfire compliance requirements and will require preparation of an Emergency Evacuation Plan at the Development Application stage
- all other areas of the proposed development site appear to be capable of achieving the necessary bushfire compliance requirements. Staging measures (e.g. clearing in advance, POS implementation in advance and provision of access in advance), will be an important consideration throughout any proposed staged subdivision to ensure active stages of development are not subject to unnecessary/temporary BAL impact or non-compliances imposed by adjacent undeveloped stages
- the subsequent LSP incorporated or considered the above recommendations, as shown in Appendix A. The BMP for the precinct has been prepared and should be read in conjunction with this EAMS, which includes the following:
    - proposal details
    - environmental considerations

- bushfire assessment results, including results of site assessment (classified vegetation, effective slope and exclusions) and bushfire hazard level assessment for pre-and post-development conditions
- identification of bushfire hazard issues
- assessment against the bushfire protection criteria of the Guidelines
- responsibilities for implementation and management.

3.5.3 Management requirements

Management measures have been identified to assist in achieving the Bushfire management objectives (Table 3.7).

Table 3.7: Management measures for bushfire risk

Parameter	Management actions	Timing/Responsibility
Bushfire Risk	Implementation of the Bushfire Management Plan.	Once BMP approved by relevant government agencies- Ongoing. City of Kalamunda /developer.

3.5.4 Predicted environmental outcome

The revegetation within the POS areas including ECRs particularly along the urban interface (development area) will need to incorporate bush fire requirements and management measures (i.e. low threat status). Refer to the BMP for further information.

3.6 Heritage and culture

3.6.1 Policy and management objectives

Ensure that the heritage values associated with Poison Gully Creek are preserved and where possible incorporated into the POS landscape design.

3.6.2 Local Structure Plan considerations

The LSP is reflective to the heritage values associated with Poison Gully Creek including:

- incorporating existing crossing (Maida Vale Road, Milner Road and Littlefield Road). Littlefield road will be a pedestrian/cycle access linking Maida Vale area with the DSP area
- control access along the interface of the precinct and Poison Gully foreshore area through designated paths, bollards, and fencing
- ECR has been allocated where the creek foreshore area impedes the precinct boundary, while potential drainage storage and outflow (via upgrades to existing culverts may be required), the focus of these areas will be passive recreation and revegetation to compliment the natural assets of the creek
- ecological linkage connection from Bush forever site 321 through the precinct and along Poison Gully Creek (Bush forever site 45) which will assist with fauna movement within the area.

3.6.3 Management requirements

Management measures have been identified to assist in achieving the Heritage management objectives (Table 3.8).

Table 3.8: Management measures for Heritage and Culture

Parameter	Management actions (Turner et al 2018)	Timing/Responsibility
Preservation of heritage values	CoK and key stakeholders to continue their consultations with the Nyungar community in respect of the Forrestfield North DSP, particularly as	Ongoing.

Parameter	Management actions (Turner et al 2018)	Timing/Responsibility
	this might impact on Poison Gully Creek (DPLH ID 25023).	The SCMP will be implemented by the COK Subdivision phase- Developer
	Nyungars are invited to engage in any works associated with Poison Gully Creek, including the rehabilitation of the creek and revegetation with native vegetation. This is relevant to implementation to the SCMP (refer to Section 4.4.4) for ECRs which have an interface with Poison Gully Creek i.e. ESR 10, 11, 12 and 13.	
Any required construction works within Poison Gully Creek and/or foreshore	Determine whether a s.18 permit is likely to be required under the *Aboriginal Heritage Act 1972* or approval under Regulation 10 from the Register of Aboriginal Site: consultation with DPLH and relevant Aboriginal groups to confirm the significance of existing Aboriginal Heritage sites, and to confirm whether an Aboriginal Heritage survey and/or s 18 permit is likely to be required an Aboriginal Heritage survey of the Project to provide further detail on the significance and location of Aboriginal Heritage sites, and prepare an s18 notice form under the AH Act, if required.	Prior to disturbing works- process approximately 6 months. CoK/ Developer.
Heritage education and opportunities	In conjunction with Nyungar women, examine ways in which the natural bush and creek between Dundas Road and Milner Road can be enhanced as a Nyungar women's place The potential incorporation of public art and interpretative/education signs within POS to reflect the heritage importance of the area.	Subdivision phase- CoK and Developer.
Further archaeological survey	Archaeological survey be undertaken for the Residential Precinct area.	Prior to the commencement of development-CoK and/or developer.

3.7 Acquisition of environmental conservation reserve and POS areas

3.7.1 Bush forever sites

The management structure of the existing Bush Forever sites within the Residential Precinct, includes the following:

Table 3.9: Management structure of Bush Forever sites

Site	Name	Management structure
45	Poison Gully Bushland, High Wycombe. Poison Gully Bushland runs along the northern cadastral boundary of the precinct and extending into Lots 80 and 81. Lot 78 has recently been included within Bush forever site No. 45	Crown Land Vested in Local Government, part Private
123	Sultana Road West Bushland, High Wycombe	Western Australian Planning Commission

It is proposed that the current management regime of existing Bush Forever sites is upheld and any future Bush Forever sites (including ECR becoming bush forever sites) are purchased under the

Metropolitan Region Improvement Fund (MRIF). The MRIF has previously been used to purchase Swan River foreshores, to protect the face of the Darling scarp, to implement the Bush Forever program and has also enabled the WAPC to create the outstanding system of regional open space which is emblematic of Perth (WAPC, 2007).

3.7.2 Environmental conservation reserve areas

The LSP identifies approximately 10 ha of land within 13 areas for environmental conservation purposes. These thirteen environmental conservation areas contain vegetation of state and national significance (Appendix A), warranting both the reservation of the sites and the use of public funds to secure their acquisition.

The sites will therefore be progressively acquired by the WAPC, using the Metropolitan Region Improvement Fund (MRIF) which becomes available through an amendment to the MRS, reserving the sites as 'Parks and Recreation.' This process can take up to 18 months to finalise, so to provide greater certainty to affected landowners and to ensure the protection to biodiversity values from development in the meantime, the WAPC intends to declare a Planning Control Area (PCA) over the environmental conservation areas under Part 7 of the Planning and Development Act 2005. It is noted that this level of statutory intervention by the WAPC is not typical and is only provided in this instance to support timely development of the Forrestfield North Residential Precinct as a METRONET related project, given the significance of the values and importance to achieving conservation outcomes. (Emerge 2019).

3.7.3 POS and drainage area

A Development Contribution Plan (DCP) has been prepared for the Residential Precinct in accordance with WAPC (2016) SPP 3.6-Development Contributions for Infrastructure. The DCP report contains:

- infrastructure funding principles
- strategic context of and basis for the DCP
- LSP areas and development scenario information
- infrastructure project list and details
- development contribution charging rates (cost apportionment method and schedule)
- administrative and procedural matters.

POS and drainage storage areas will be purchased through the DCP. The operation and maintenance of POS areas and the drainage system will initially be the responsibility of the developer until handover to the CoK (refer to the LWMS).

4. Limitations

Scope of services

This report ("the report") has been prepared by Strategen-JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen-JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen-JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen-JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen-JBS&G has also not attempted to determine whether any material matter has been omitted from the data. Strategen-JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen-JBS&G. The making of any assumption does not imply that Strategen-JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen-JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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Appendix A Forrestfield North Local Structure Plan

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LEGEND

Structure Plan Boundary

Region Scheme Reserves

Parks and Recreation

Primary Regional Road

Notice of Delegation

Bush Forever

Land Use and Residential Density

Environmental Conservation

Local Open Space

PS Public Purposes - Primary School

Residential Medium Density (R30 - R60)*

Residential High Density (R60 - R100)*

Other Categories

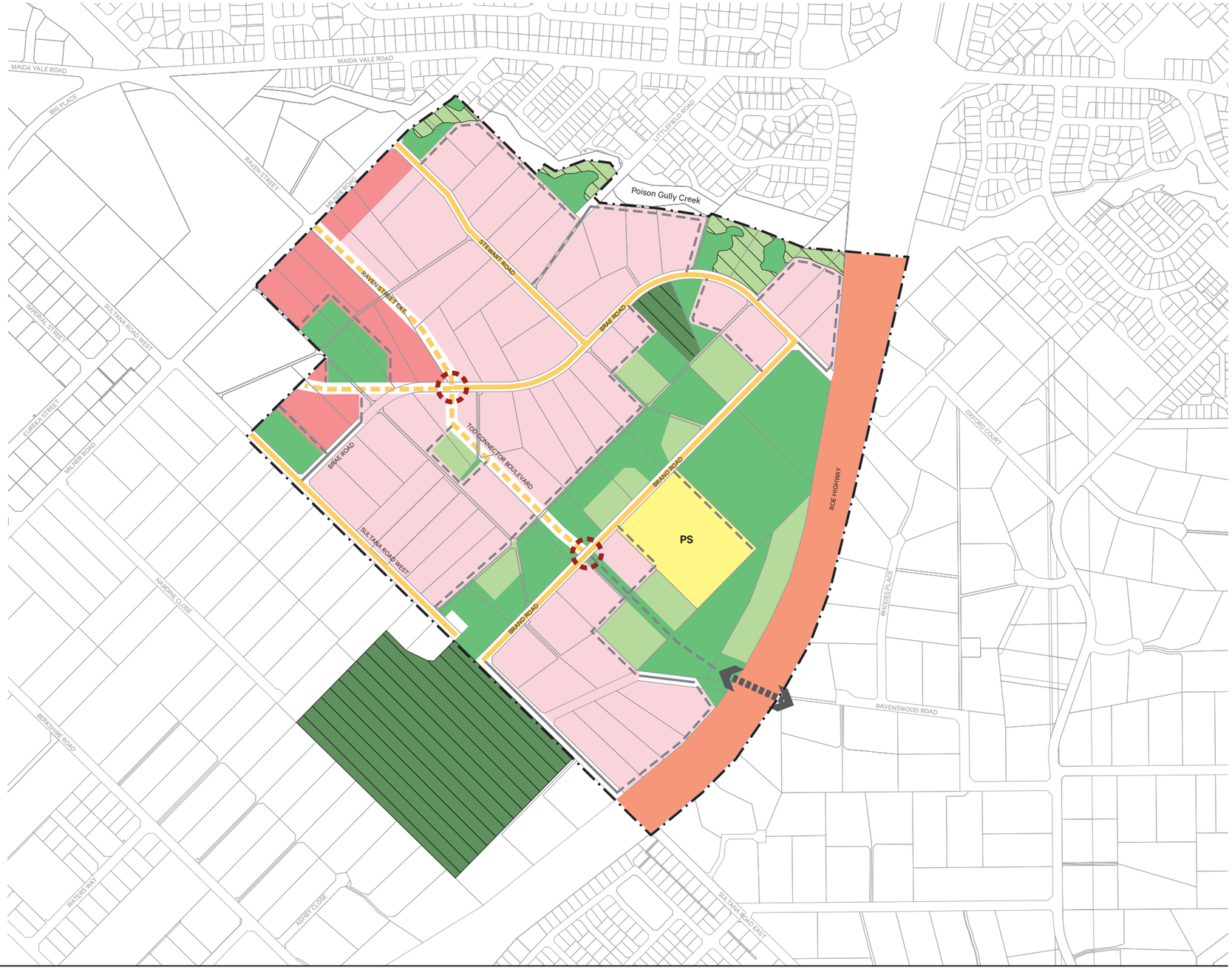
Neighbourhood Connector (Existing / Proposed)

Local Street (Existing / Proposed)

Proposed Roundabout

Future Roe Highway Overpass

* *Applications for subdivision or development at the higher end of the density band shall be assessed against a range of criteria. Refer Part One, Section 4.2 of the Local Structure Plan.*



Plan 1: Structure Plan

High Wycombe South Residential Precinct

0 80 160m

Date: 21 Sep 2021 Scale: 1:8000@ A3 1:4000 @ A1 File: **17-527 ST-1** **A** Staff: MC GW Checked: MC

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 I **E.** hello@elementwa.com.au **elementwa.com.au**

Appendix B AECOM (2017a) Forrestfield North Level 2 Flora and Fauna Survey

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AECOM

Shire of Kalamunda
15-Mar-2017

Forrestfield North Level 2 Flora and Fauna Survey



Forrestfield North Level 2 Flora and Fauna Survey

Client: Shire of Kalamunda

ABN: 60 741 095 678

Prepared by

AECOM Australia Pty Ltd
3 Forrest Place, Perth WA 6000, GPO Box B59, Perth WA 6849, Australia
T +61 8 6208 0000 F +61 8 6208 0999 www.aecom.com
ABN 20 093 846 925

15-Mar-2017

Job No.: 60527304

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Document Forrestfield North Level 2 Flora and Fauna Survey

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Prepared by F de Wit

Reviewed by L Kirchner

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Executive Summary

Shire of Kalamunda required biological assessments for a proposed development area associated with the Forrestfield Airport Link railway station being constructed in High Wycombe. The outcome of the assessment will inform management plans and the development of a retention plan required prior to rezoning and redeveloping the area. The survey area includes 112 private properties and includes areas with native and non-native vegetation. The primary objective of the biological assessments was to define the existing environment within the survey area and identify and map conservation significant flora, fauna and vegetation.

A level 2 flora and vegetation assessment was undertaken including targeted Threatened flora searches, an assessment for Banksia Woodlands of the Swan Coastal Plain (SCP) threatened ecological community (TEC), and mapping vegetation communities and condition. Eighteen quadrats were installed and floristic data collected by Floora de Wit (collection licence SL011912) and Lyn van Gorp (collection licence SL011913).

A level 1 fauna assessment and targeted Black Cockatoo survey was undertaken by Jared Leigh and Floora de Wit simultaneously with the flora and vegetation assessment. The fauna survey included five micro-habitat searches, mapping and characterising fauna habitats supported by fauna habitat sites and the flora and vegetation data, and targeting Quenda habitat. The Black Cockatoo assessment included mapping all potential Black Cockatoo breeding trees and completing a foraging quality assessment.

All field investigations were undertaken between 22 and 23 November and 28 and 29 November. In summary:

- One TEC listed as Endangered under the *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act) occurs in the survey area. All native vegetation in 'Good' or better condition within the survey area has met the key diagnostic criteria for the Banksia Woodlands of the Swan Coastal Plain TEC. This TEC extends for 14.22 ha.
- The Banksia Woodlands of the SCP TEC relates to one State-listed TEC *Banksia attenuata* woodlands over species rich dense shrublands, and one DPaW-listed priority ecological community (PEC) Banksia Woodlands of the SCP. Lack of detailed descriptions for this TEC means it was difficult to accurately delineate these TECs, and therefore all native vegetation in 'Good' or better condition could be considered the State-listed TEC which represents the highest conservation category.
- Five vegetation communities were recorded and mapped. Four of these are considered regionally significant as they represent a federally listed TEC. Many also support populations of the Threatened *Conospermum undulatum.*
- One Threatened flora species, *Conospermum undulatum* (Wavy-leaved Smokebush) was recorded extensively throughout the survey area. This species is listed as Vulnerable under both the EPBC Act and WC Act. One population comprising 525 individuals were recorded within the survey area. Current information shows a total of 25 populations occur on the SCP, comprising approximately 11,453 individuals.
- Two Declared Pest species listed under the BAM Act were recorded, including *Zantedeschia aethiopica* (Arum Lily) and *Asparagus asparagoides* (Bridal Creeper).
- Four conservation significant fauna species were recorded during the survey including the Carnaby's Black Cockatoo listed as Endangered under the EPBC Act and the WC Act, Forest Red-tailed Black Cockatoo listed as Vulnerable under the EPBC Act and the WC Act, Rainbow Bee-eater listed as Marine under the EPBC Act and the Quenda listed as Priority 4 by DPaW.

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- Four fauna habitats were mapped within the survey area, including
  - 22.97 ha of suitable Quenda habitat
  - 25.15 ha of Black Cockatoo potential breeding habitat
  - 19.32 ha of High quality foraging habitat for Carnaby's and Forest Red-tailed Black Cockatoos and 8.29 ha mapped as Valued foraging habitat for Carnaby's and Quality foraging habitat for Forest Red-tailed Black Cockatoos.

There were no significant limitations identified that may have affected the field survey results. The timing of the field survey in late November may not be considered optimal due to dry preceding months and lack of orchids and ephemerals able to be identified. However, this was not considered to have a large impact on the project. The Threatened targeted flora species was easily identified, and species richness was still considered high in all areas of native vegetation in 'Very Good' to 'Excellent' condition. Therefore no further work is recommended.

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1.0 Introduction

1.1 Background

In June 2014, the State Government announced the Forrestfield Airport Link, a $2 billion train line connecting with the Midland line near Bayswater Station, servicing the airport and finishing in the Forrestfield/High Wycombe area. The State Government requested the Shire of Kalamunda (the Shire) explore the opportunities that a new train station could bring to the surrounding area. This meant moving away from the industrial land uses, previously proposed, and focusing on residential and retail/commercial uses more suitable for a train station precinct. The new focus resulted in the Forrestfield North District Structure Plan (the DSP) being prepared which planned for the delivery of high density residential uses, a new activity centre and a commercially focused Transit Oriented Development precinct based around the new train station. The DSP was approved by the Western Australian Planning Commission (WAPC) in late September 2016.

As part of exploring these opportunities, the Shire proposes to rezone approximately 138 hectares (ha) in Forrestfield / High Wycombe to Urban Development as part of Local Planning Scheme No.3 (LPS3) Scheme Amendment 75 (Amendment 75). The rezoning is proposed to facilitate the detailed structure planning of the precincts within the approved DSP.

The EPA has considered Amendment 75 in accordance with the requirements of the *Environmental Protection Act 1986* (EP Act). The EPA advised that the potential impacts of Amendment 75 can be adequately managed to meet the EPA's objectives through the development and implementation of future structure plans and implementation of the responsible authority's scheme provisions that specifically address the environmental factors of flora and vegetation and terrestrial fauna. The EPA expects that further detailed management plans and scheme provisions to address flora and vegetation will be addressed prior to the finalisation of the structure plans.

Further information is required for the environmental values of the proposed development area before management plans and structure plans can be finalised. This will ensure that environmental assets and conservation significant factors are adequately protected and managed during the redevelopment process.

1.2 Location

The survey area is located in High Wycombe in the suburbs of Perth, Western Australia. The survey area is located between Maida Vale Road (north), Dundas Road (west), Sultana Road West (south) and Roe Highway (east). The survey area includes 144 ha of land, of which 116.2 ha is cleared and 27.80 ha is considered native vegetation.

The location and extent of the survey area is shown in Figure 1.

1.3 Objectives

The primary objective of the biological assessments was to define the existing environment within the survey area and identify and map conservation significant flora, fauna and vegetation. The assessment accordingly included the collection of information relating to flora, vegetation, fauna, and habitats.

The specific objectives included:

- Complete a desktop assessment to identify significant flora, vegetation and fauna that potentially occur in the area and collate existing information from available sources to develop a comprehensive overview of the survey area
- Undertake a Level 2 flora and vegetation assessment in accordance with relevant standards and technical guides
    - complete ecological community mapping and vegetation condition mapping
    - complete targeted Threatened flora surveys for *Conospermum undulatum*

  - develop a comprehensive species list
  - complete Threatened Ecological Community assessments for patches of native vegetation
- Undertake a Level 1 fauna assessment in accordance with relevant standards and technical guides
  - identifying suitable habitat for conservation significant species
  - defining fauna habitat values and potential presence of significant fauna species
- Survey and map Black Cockatoo potential breeding and foraging habitat.

The methods and results of the biological assessments are presented in this technical report.

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2.0 Existing Environment

2.1 Climate

The climate of the Perth Metropolitan Region is described as Warm Mediterranean (Mitchell et al 2002). A Mediterranean climate is characterised by warm to hot dry summers and mild to cool wet winters. The Mediterranean climate in Australia is a result of the Indian Ocean High, a high pressure cell that shifts towards the poles in summer and the equator in winter, playing a major role in the formation of the deserts of Western Australia, and the Mediterranean climate of southwest and south-central Australia. Precipitation occurs during winter months, with the possibility of some summer storms.

The closest meteorological station to the Study area with comprehensive data is Perth Airport (Station 009021), which is located 2.6 km south east of the Study area. Perth Airport meteorological station is maintained by the Bureau of Meteorology (BoM) and commenced recording in 1944.

Perth airport has experienced an average annual rainfall of 765.2 mm, with the majority of rainfall occurring between May and September. In the twelve months preceding the survey rainfall was near average for most months, with the exception of June and July (Figure 2). These months show a decline in rainfall by more than 20 mm for that month. In June 2016 only 86.4 mm of rainfall was recorded compared to the average 157 mm for that month. This, and the timing of the field surveys in late November, may have affected the ability to record ephemeral and orchid species.

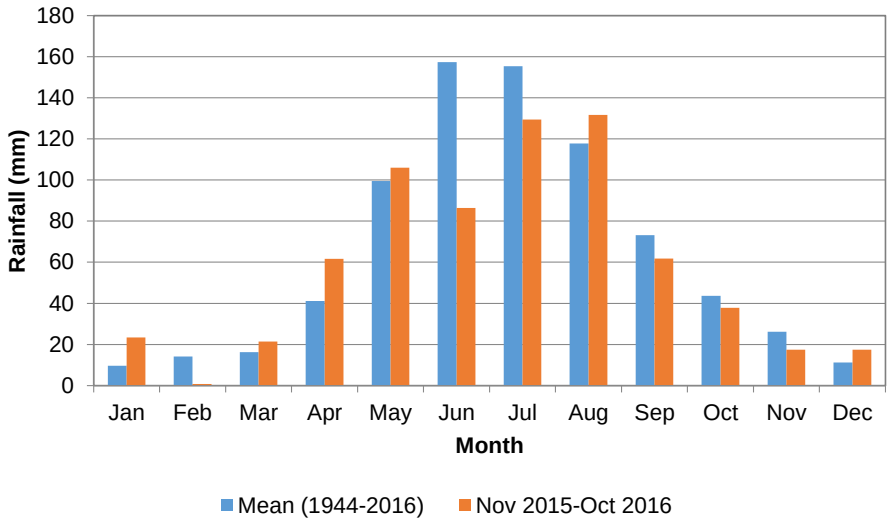

Figure 2 Rainfall data from weather station Perth Airport (009021) showing mean monthly rainfall and rainfall received in the 12 months preceding the field survey (source: BOM, 2016)

2.1 IBRA Regions

The Survey Area is located on the Swan Coastal Plain bioregion described in CALM (2002), including Perth and the outer suburbs (excluding the Hills suburbs). The Swan Coastal Plain consists of the Dandaragan Plateau and the Perth Coastal Plain and is comprised of a narrow belt less than 30 km wide of Aeolian, alluvial and colluvial deposits of Holocene or Pleistocene age incorporating a complex series of seasonal fresh water wetlands, alluvial river flats, coastal limestone and several offshore islands. Younger sandy areas and limestone are dominated by heath and/or Tuart woodlands, while *Banksia* and *Jarrah-Banksia* woodlands are found on the older dune systems.

The Swan Coastal Plain subregion, described by Mitchell *et al.* (2002), is a low-lying coastal plain covered with woodlands dominated by *Banksia* or Tuart on sandy soils, *Casuarina obesa* on outwash plains, and paperbark in swampy areas. The area includes a complex series of seasonal wetlands and includes Rottnest, Carnac and Garden Islands. Land use is predominantly cultivation, conservation, urban and rural residential. The area contains a number of rare features including Holocene dunes and wetlands and a large number of threatened species and ecological communities.

2.2 Vegetation

The Environmental Protection Authority's (EPA) objective is to retain at least 30% of all pre-European Heddle *et al.* (1980) vegetation complexes, which is consistent with recognised retention levels (EPA, 2002; EPA, 2015). In the metropolitan area a 10% threshold applies.

There is one Beard (1981) vegetation association mapped within the survey area. Vegetation association 1001: Medium very sparse woodland; Jarrah, with low woodland; Banksia and Casuarina has an estimated 22.43% of pre-European extent remaining on the Swan Coastal Plain (Government of Western Australia, 2015).

Heddle *et al.* (1980) completed vegetation complex mapping which used to assess the extent of pre-European vegetation. Two vegetation complexes are mapped within the survey area (Table 1).

Table 1 Vegetation complex mapping (Heddle *et al.* 1980) that intersect with the Survey Area showing percent remaining in the Perth-Peel region as published in EPA Perth @ 3.5 million (EPA, 2015)

Vegetation Complex	Percent Remaining
Forrestfield: vegetation ranges from open forest of *Corymbia calophylla – Eucalyptus wandoo – E. marginata* to open forest of *E. marginata – C. calophylla – A. fraseriana – Banksia* spp. with fringing woodland of *E. rudis* in the gullies that dissect this landform	10.3%
Southern River: open woodland of Marri-Jarrah-banksia on the elevated areas and a fringing woodland of Eucalyptus rudis-Melaleuca rhaphiophylla along the streams.	16.8%

3.0 Legislative Framework

3.1 Overview

Table 2 summarises the key legislation governing the protection and management of Western Australia's conservation significant species and communities, which are further discussed below and in Appendix A.

Table 2 Relevant legislation, regulations and guidance

Legislation	Purpose
Commonwealth of Australia	
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Provides for the protection of the environment and the conservation of biodiversity.
EPBC Act Referral Guidelines for Three Threatened Black Cockatoo Species.	To assist in determining whether an action needs to be referred to the Australian Government. Also provides guidance on Black Cockatoo survey methodology.
Western Australia	
Wildlife Conservation Act 1950 (WC Act)	Provides for the conservation and protection of Western Australia's wildlife.
Biodiversity Conservation Act 2016	Provides coverage for flora and fauna, communities, habitats, threatening processes, environmental pests and weeds. Objective is to conserve and protect biodiversity and biodiversity components in the State and promote the ecologically sustainable use of biodiversity components in the State.
Environmental Protection Act 1986 (EP Act)	Preventing, controlling and abating environmental harm and conserving, preserving, protecting, enhancing and managing the environment.
Biosecurity and Agriculture Management Act 2007 (BAM Act)	Provides for the management, control and prevention of certain plants and animals, and for the protection of agriculture and related resources generally.
Land Administration Act 1997 (LAA)	An Act to consolidate and reform the law about Crown land and the compulsory acquisition of land generally, to repeal the *Land Act 1933* and to provide for related matters. The Act allows for the
Rights in Water and Irrigation Act 1914 (RIWI Act)	An Act relating to rights in water resources, to make provision for the regulation, management, use and protection of water resources, to provide for irrigation schemes, and for related purposes.

3.2 EPBC Act

3.2.1 Matters of National Environmental Significance

Matters of national environmental significance include:

- listed threatened species and ecological communities
- migratory species protected under international agreements
- Ramsar wetlands of international importance
- the Commonwealth marine environment
- world Heritage properties

- national Heritage places
- Great Barrier Reef Marine Park
- a water resource, in relation to coal seam gas development and large coal mining development
- nuclear actions.

If an action is likely to have a significant impact on a MNES this action must be referred to the Minister for the Environment for a decision on whether assessment and approval is required under the EPBC Act.

3.2.2 Flora and fauna

The EPBC Act is the main piece of Federal legislation protecting biodiversity in Australia. Species at risk of extinction are recognised at a Commonwealth level and are categorised in one of six categories as outlined in Table 3.

Table 3 Categories of Species Listed under Schedule 179 of the EPBC Act (Commonwealth)

Conservation	Code Category
Ex	Extinct Taxa
ExW	Extinct in the Wild
CE	Critically Endangered
E	Endangered
V	Vulnerable
CD	Conservation Dependent
OS	Other specially protected fauna

3.2.3 Vegetation Communities

Communities can be classified as Threatened Ecological Communities (TECs) under the EPBC Act. The EPBC Act protects Australia's ecological communities by providing for:

- identification and listing of ecological communities as threatened
- development of conservation advice and recovery plans for listed ecological communities
- recognition of key threatening processes
- reduction of the impact of these processes through threat abatement plans.

Categories of federally listed TECs are described in Table 4.

Table 4 Categories of TECs that are listed under the EPBC Act

Conservation Code	Category
CE	Critically Endangered If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future.
E	Endangered If, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future.
V	Vulnerable If, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

3.3 Western Australian legislation

3.3.1 Flora and fauna

Plants and animals that are considered Threatened and need to be specially protected because they are under identifiable threat of extinction are listed under the WC Act. These categories are defined in Table 5.

Table 5 Conservation codes for WA flora and fauna listed under the *Wildlife Conservation Act 1950* updated November 2015

Code	Category
CR	Critically endangered species / Schedule 1
EN	Endangered species / Schedule 2
VU	Vulnerable species / Schedule 3
EX	Presumed extinct species / Schedule 4
IA	Migratory birds protected under an international agreement (fauna only) / Schedule 5
CD	Special conservation (fauna only) / Schedule 6
OS	Special protection for reasons other than those already mentioned (fauna only)

Species that have not yet been adequately surveyed to warrant being listed under the WA Act are added to a Priority flora List by the State Minister of Environment. Categories and definitions of Priority Flora and Fauna species are provided in Table 6 and expanded in Appendix A.

Table 6 Conservation codes for WA flora and fauna as listed by DPaW and endorsed by the Minister for Environment

Conservation Code	Category
Priority One	Poorly Known Species
Priority Two	Poorly Known Species
Priority Three	Poorly Known Species
Priority Four	Rare, Near Threatened and other species in need of monitoring

3.3.2 Vegetation Communities

State listed TECs are not protected under any legislation, rather they are endorsed by the Minister for Environment. Categories of TECs are defined in Table 7. PECs are endorsed by the Minister for Environment as having insufficient information available to be considered a TEC, or which are rare but not currently threatened. These categories are described in Table 8.

Table 7 Conservation codes for State listed Ecological Communities

Conservation Code	Category
PD	Presumed Totally Destroyed
CR	Critically Endangered
EN	Endangered
VU	Vulnerable

Table 8 Categories for Priority Ecological Communities

Conservation	Code Category
P1	Priority One: poorly-known ecological communities
P2	Priority Two: poorly-known ecological communities
P3	Priority Three: poorly known ecological communities
P4	Priority Four: ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list.

3.3.3 Biosecurity and Agriculture Management Act 2007

Biosecurity is the management of the risk of animal and plant pests and diseases entering, emerging, establishing or spreading in WA to protect the economy, environment and community. Biosecurity is managed under the BAM Act which came into effect 1 May 2013. Exotic animals and plants can become an invasive species if they can establish in new areas where local conditions are favourable for their growth.

Under the BAM Act declared pests are placed in one of three categories, as explained in Table 9. Many of the declared pest plant species are also on the list of Weeds of National Significance. This list was compiled to prioritise future management and allocation of resources for weed control. Species were selected based on their invasiveness and impact characteristics, potential and current area of spread and their environmental, industrial or socioeconomic impacts.

Table 9 Declared Pest categories under the BAM Act

Category	Definition
C1	**Exclusion -** Pests will be assigned to this category if they are not established in WA and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2	**Eradication -** Pests will be assigned to this category if they are present in WA in low enough numbers or in sufficiently limited areas that their eradication is still feasible.
C3	**Management** - Pests will be assigned to this category if they are established in WA but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

3.3.4 Land Administration Act 1997

The *Land Administration Act 1997* (LAA) is Western Australia's legislation dealing with the disposition of State land. The LAA is administered by the Minister for Lands, assisted by the Department of Regional Development and Lands (RDL).

Class A Reserves are established under the LAA. They are afforded the greatest degree of protection for Crown land and this classification is used solely to protect areas of high conservation or high community value. Should a proposal require development within a Class A Reserve, the subject land would require excision from the Class A Reserve. The process of excision requires that the proposal be tabled before, and gain approval from, both Houses of Parliament.

3.3.5 *Environmental Protection Act 1986* (and Clearing Regulations)

Section 38 (Part IV) of the EP Act provides that any person may refer a significant proposal (one that is likely to have a significant effect on the environment) to the EPA. The EP Act also states that where the environmental impact of a proposal can be adequately assessed and managed through other legislative mechanisms the proposal is unlikely to require formal environmental impact assessment.

If a proposal is not formally assessed by the EPA under Part IV of the EP Act, a Part V native Vegetation Clearing Permit may be required. Under Section 51C of the EP Act, clearing of native vegetation without a Native Vegetation Clearing Permit is an offence unless an exemption applies. Exemptions offered for clearing under Regulation 5 of the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* do not apply within Environmentally Sensitive Areas (ESA).

3.3.6 Rights in Water and Irrigation Act 1914

A licence under the RIWI Act is required if water is proposed to be taken from a watercourse or groundwater aquifer. In addition, a permit is required under the RIWI Act for any activity that will disturb the bed and banks of a watercourse or wetland.

4.0 Methodology

The flora and vegetation assessment of the Survey area was conducted in accordance with Environmental Protection Authority (EPA) Guidance Statement No. 51, Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004a) and EPA Position Statement No.3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA, 2002).

4.1 Desktop Assessment

The desktop assessment involved gathering background information for the local area. Desktop database searches were requested from the following government databases (including a 10 km buffer from Survey area boundary):

- Department of Parks and Wildlife (DPaW) Threatened and Priority Flora List
- WA Herbarium (WAH) records
- DPaW Threatened and Priority Ecological Communities database (received 9 Dec 2016)
- *Environment Protection and Biodiversity Conservation Act* (EPBC Act) Protected Matters database.

All flora of conservation significance identified in the desktop assessment were assessed for their likelihood of occurrence within the survey area (Table 10). Available literature was consulted to identify broad vegetation types and describe the existing environment. References included Beard (1981) vegetation mapping, the Biodiversity Audit of Western Australia (CALM 2002), and Heddle et al. (1980) vegetation mapping.

Table 10 Categories of likelihood of occurrence for species and communities

Likelihood Category	Flora	Fauna	Communities
Likely to occur	Habitat is present in the Survey area and the species has been recorded in close proximity to the Survey area	Survey area is within the known distribution of the species, habitat is present in the Survey area and the species has been recorded in close proximity to the Survey area	Known occurrences of the community in close proximity to the Survey area. Vegetation looks the same within the known occurrence and Survey area based on aerial imagery. Geographic location is similar to the Survey area
May occur	Habitat may be present and/or the species has been recorded in close proximity to the Survey area	Survey area is within the known distribution of the species, marginal habitat may be present and/or the species has been recorded in close proximity to the Survey area	Known occurrence of the community in the local area, and/or vegetation looks the same within known occurrence and Survey area based on aerial imagery. Geographic location is similar to the Survey area
Unlikely to occur	No suitable habitat is present and the species has not been recorded in close proximity to the Survey area	Survey area is outside the known distribution for the species, or no suitable habitat is present and the species has not been recorded in close proximity to the Survey area	Known occurrence of the community in close proximity to the survey area however geographic location does not occur in Survey area

4.2 Flora and Vegetation Survey

A Flora and Vegetation Assessment was conducted in accordance with EPA Guidance Statement No. 51 and the Flora Survey Technical Guide (EPA & DPaW, 2015). The Flora and Vegetation Assessment was conducted by two botanists Floora de Wit (Collection Permit SL011555) and Lyn van Gorp (Collection Permit SL011558) between 22-23 November and 29-30 November. Any species unable to be identified in the field were collected for identification in AECOM's in-house herbarium and the specimens and taxonomic references and keys at the Western Australian Herbarium (WAH). Naming of species followed the convention of the WAH.

Floristic data was collected at sample point locations using a combination of 10 x10 m non-permanent quadrats and relevés to document the floristics, vegetation composition and structure, condition, and other identifying features of the vegetation community. Floristic data was collected at 18 sample point locations within the Survey area. Sample point locations were selected to ensure accurate representation of native vegetation within the Survey area with a minimum of two quadrats in each vegetation community, supported by relevés where necessary.

The following parameters were recorded for each quadrat:

- location – Australian Map Grid (AMG) coordinates recorded in Geocentric Datum of Australia (GDA) 94 datum using a handheld Global Positioning System (GPS) unit, to an accuracy of 5 m
- photograph – taken from the north-west corner
- habitat, including a description of landform and soils
- a complete inventory of the observed flora species present within each quadrat at the time of the survey, including their height and proportionate cover within the quadrat
- vegetation condition rating of the vegetation within the quadrat using Keighery (1994) scale (Table 12).

4.2.1 Vegetation mapping

Quantitative flora species data were used to define the vegetation communities. Vegetation communities were described and mapped based on changes in dominant species composition and landform. Vegetation community descriptions were based on the National Vegetation Information System (NVIS) framework (Commonwealth of Australia, 2003).

Delineation of vegetation communities was supported by analysing floristic data collected within quadrats. The program PC Ord was used to assess the similarity between sites and review dendrograms using Ward's distance measure. This identified those sites that are most similar to one another and suitable for representing the same vegetation community. The analysis was done using presence absence data and scaled percentage cover applying the Braun-Blanquet scale as outlined in Table 11.

Areas that consisted of native trees only were mapped as such. It is possible that some native trees (as identified in the Black Cockatoo potential breeding tree assessment) are not captured in a 'Trees' polygon. In these instances, native trees are isolated and occur over planted or cleared land. Trees in paddocks were not captured in the 'Trees' category.

Areas previously mapped by Strategen were further refined in the survey area. These areas include Lot 105 Sultana Road West and 32 Bray Road. Communities mapped by Strategen (2015) that have not been altered have been included in this report to ensure that a comprehensive overview of the survey area is documented.

Table 11 Braun-Blanquet scale (Braun-Blanquet et al. 1932)

Scale	Range of cover
5	75-100
4	50-75
3	25-50
2	5-25
1	<5 numerous individuals
+	<5 few individuals
R	Solitary, with small cover

Vegetation condition was determined using the scale developed by M.E. Trudgen and published by the Wildflower Society WA (Keighery, 1994) condition scale (Table 12). The scale is based on disturbance (e.g. grazing, erosion), degree of alteration to community and habitat structure and site ecology.

Table 12 Bushland condition ratings (Keighery, 1994)

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

4.3 Fauna survey

A Level 1 Fauna Assessment was conducted in accordance with EPA Guidance Statement No. 56 (EPA, 2004b). Fauna species and habitat data was collected at sample point locations within the Survey area considered representative of the vegetation types and fauna habitat types present. Various habitat features were assessed and used to inform the fauna habitat map and be used to determine suitability of habitat for conservation significant fauna species, including consideration of structural diversity and refuge opportunities for fauna.

In addition to recording all observed fauna and birds identified from distinctive calls, details of indirect evidence such as scats, tracks and diggings was documented. In particular, attention was given to conservation significant species identified in the desktop assessment as having the potential to occur in the area.

Fauna occupancy searches were undertaken in microhabitats likely to support fauna species. Techniques include overturning logs and rocks, searching beneath the bark of trees, investigating dead trees and logs, investigating overhangs and crevices, and investigating burrows.

The taxonomy and nomenclature of vertebrate species for mammals, reptiles and amphibians used is in accordance with the Western Australian Museum's Checklist of Vertebrates of Western Australia (WAM, 2016), and for bird species the Bird's Australia Checklist of Australian Birds based on Christidis and Boles (2008) is used.

4.4 Black Cockatoos

A Black Cockatoo survey was conducted to identify potential breeding and foraging habitat for the three Threatened Black Cockatoo species that occur in WA. This survey focussed on the two species most likely to be present; the EPBC Act and WC Act listed Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*: Carnaby's), and Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii subsp. naso*: FRTBC). Foraging habitat quality was also quantified Black Cockatoo species. The surveys were undertaken in accordance with:

- Referral guidelines for three species of Western Australian black cockatoos species: Carnaby's Cockatoo (endangered), Baudin's Cockatoo (vulnerable), Forest Red-tailed Black Cockatoo (vulnerable) (Department of Sustainability, Environment, Water, Populations and Communities [DSEWPaC], 2012)
- Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA & DEC [Department of Environment and Conservation], 2010).

4.4.1 Breeding habitat

The Black Cockatoo breeding habitat assessment focussed on quantifying potential breeding trees and associated habitat. Table 13 defines breeding habitat and identifies those trees that Black Cockatoos will utilise as breeding trees, according to DSEWPaC (2012). The following information was collected for all potential breeding trees with a Diameter at Breast Height (DBH) >500 mm:

- location
- tree species
- number of hollows
- number of potentially suitable hollows.

Suitable hollows are hollows with an entrance bigger than 10cm diameter.

The results from the Bamford (2012) Black Cockatoo survey, in particular location of potential breeding trees, has been merged with the AECOM results to provide a comprehensive overview of environmental values for Black Cockatoo species.

Table 13 Potential Breeding Habitat (source: DSEWPaC, 2012)

	Carnaby's	FRTBC
Specific breeding habitat	Nest in hollows in live or dead trees of *E. salmonophloia, E. wandoo, E. gomphocephala*, *E. marginata*, *E. rudis*, *E. loxophleba* subsp. *loxophleba, E. accedens, E. diversicolor* and *Corymbia calophylla*.	Nest in hollows in live or dead trees of *E. diversicolor* and *Corymbia calophylla, E. wandoo, E. megacarpa*, *E. patens*, *E. gomphocephala* and *E. marginata*.
Definition of breeding habitat	'Breeding habitat' is defined in these referral guidelines as trees of species known to support breeding within the range of the species which either have a suitable nest hollow OR are of a suitable DBH to develop a nest hollow. For most tree species, suitable DBH is 500 mm. Note that *E. wandoo* is DBH >300 mm.	

4.4.2 Foraging habitat

The Black Cockatoo foraging habitat assessments focussed on mapping the area of potential foraging habitat within the Survey Area. Table 14 defines the foraging species for the FRTBC and Carnaby's. Vegetation communities and floristic data collected from quadrats were assessed for their potential to provide foraging habitat.

The quality of foraging habitat not only reflects the availability of food sources, but also the proximity to reliable water sources, connectivity to other suitable habitat, presence of potential breeding trees, and proximity to confirmed roost and breeding sites (amongst others). These parameters were utilised by the DotEE to produce a draft quality of foraging habitat scoring system (Table 15). This scoring system was utilised to assess potential foraging habitat for each Black Cockatoo species.

The scoring tool is used by initially defining the quality of the overall habitat present (i.e. High, Quality, Valued, Low) and then adding or subtracting points from this depending on the ecological values of the habitat (i.e. proximity to water, proximity to a known roost site, evidence of foraging material etc.). This determines an overall quantitative rating. These scores were then used as representative scores for that vegetation unit. Table 16 defines the levels of foraging habitat quality used during the assessment.

Table 14 Black Cockatoo suitable foraging species (sources: DSEWPaC, 2012; Johnstone *et al*., 2013)

Carnaby's	FRTBC
Native shrubland, kwongan heathland and woodland dominated by proteaceous plant species (e.g. *Banksia* sp., *Hakea* sp. and *Grevillea* sp.) as well as eucalypt woodland and forest that is dominated by foraging species. Also will feed on Callistemon, seeds of introduced species such as *Pinus* species and *Erodium* species, wild radish, canola, almonds and pecan nuts and occasionally apples and persimmons.	The principal foods of the FRTBC are the seeds of Marri and Jarrah. Other less important foods include Blackbutt *E. patens, E. wandoo,* Sheoak *A. fraseriana,* Snottygobble *P. longifolia*, *Hakea* spp., also introduced species (including Cape Lilac *Melia azedarach,* Spotted Gum *C. maculata,* Lemon-scented Gum *C. citriodora,* Silver Princess *E. caesia,* Illyarrie *E. erythrocorys* and Kaffir Plum *Harpephyllum caffrum*) and in southern forests Albany Blackbutt *E. staeri* and Karri *E. diversicolor*. Rarely observed grubbing for insect larvae on *Allocasuarina* spp.
Any area within the range of Black Cockatoo species that contains known food or nesting plant species is considered to be potential habitat for the Black Cockatoo species.	

Table 15 Quality of foraging habitat scoring tool for the three Threatened Black Cockatoos

Score	Carnaby's	Forest Red-tailed
≥10 High	Quality foraging habitat that is being managed for Black Cockatoos, including successful rehabilitation, and/or has some level of protection from clearing, and / or is Quality habitat described below with attributes contributing to meet a score of 10 or greater	Quality foraging habitat that is being managed for Black Cockatoos, including successful rehabilitation, and/or has some level of protection from clearing, and / or is Quality habitat described below with attributes contributing to meet a score of 10 or greater
7 Quality	Native shrubland, kwongan heathland and woodland dominated by proteaceous plant species (e.g. *Banksia* sp., *Hakea* sp. and *Grevillea* sp.) as well as eucalypt (not mallee) woodland and forest that is dominated by foraging species. Does not include orchards, canola, or areas under a RFA	Jarrah and Marri woodlands and forest, and edges of Karri forests, including Wandoo and Blackbutt, within the range of the subspecies. Does not include areas under a RFA
5 Valued	Pine plantation or introduced eucalypts	Introduced eucalypts as well as the introduced Cape lilac (*Melia acedarach*)

Score	Carnaby's	Forest Red-tailed
2 Moderate	Native shrubland, heathland and woodland that contains foraging species (that are not dominant)	Habitats not dominated by foraging species
1 Low	Individual foraging plants or small stand of foraging plants (≤2 ha)	Individual foraging plants or small stand of foraging plants (≤2 ha)
Additions: Context adjustor – attributes improving habitat quality		
+3	Is within the Swan Coastal Plain	Jarrah and/or Marri shows good recruitment (i.e. evidence of young trees)
+3	Contains trees known to be used for breeding	Contains trees known to be used for breeding
+2	Primarily comprises Marri	Primarily contains Marri and/or Jarrah
+2	Contains trees with potential to be used for breeding (DBH ≥500 mm or ≥300 mm for Salmon Gum and Wandoo	
+2	Is <6 km from a known large or key roosting site	
+1	Contains evidence of foraging by species	
+1	Is <12 km from known breeding location	
+1	Is <2 km from a watering point	
+1	Is used for roosting	
Subtractions: Context adjustor – attributes reducing habitat quality		
-3	Contain less than 25% Marri and proteaceous species	
-2	No other foraging habitat within 6 km	
-1	Is >6km from known roosting site	
-1	Does not contain evidence of foraging by species	
-1	Is >12 km from known breeding location	
-1	Is >2 km from watering point	
-1	Disease present (e.g. *Phytophthora cinnamomi* or Marri canker)	

Table 16 Black Cockatoo foraging assessment scoring

Score	Foraging Quality
1 - 3	Low
4 - 6	Valued
7 - 9	Quality
10	High

4.5 Survey Limitations

Factors that may have affected the completeness (and therefore the results) of the survey are addressed in Table 17. The EPA published these proposed limitations as a minimum requirement for level 2 flora and vegetation assessments (EPA, 2004a).

Table 17 Consideration of limitations that may affect the biological survey completeness

Limitation	Flora and Vegetation assessment	Fauna assessment
Competency/experience of consultant conducting survey	**Not a constraint.** The flora and vegetation assessment was led by Floora de Wit who has 8 years' experience addressing similar scopes on the Swan Coastal Plain.	**Not a constraint.** Jared Leigh is an Ecologist with over 14 years' experience in the environmental industry and has conducted fauna surveys and Black Cockatoo assessments in a range of bioregions within Western Australia.
Scope (i.e. what life forms were sampled)	**Not a constraint.** The level 2 flora and vegetation assessment included quadrat-based sampling in Spring, 2016 in accordance with Guidance Statement 51 (EPA, 2004a) and Flora Survey Technical Guide (EPA & DPaW, 2015).	**Not a constraint.** The Level 1 fauna survey assessed all fauna habitats within the Survey Area, documented secondary evidence (scats, diggings, burrows etc.) and fauna sightings, and included microhabitat searches at appropriate sites. Black Cockatoo foraging sites were undertaken simultaneously with the flor and vegetation quadrats.
Proportion of flora/fauna identified, recorded and/or collected (based on sampling, timing and intensity)	**Not a constraint.** To meet the objective of the project, the field sampling focussed on areas of 'Good' or better condition vegetation. Weeds and planted species were not opportunistically recorded. The weed species list is therefore not considered comprehensive. This is not considered to affect the outcome of the survey.	**Not a constraint.** Information gained for a Level 1 fauna survey was sufficient. Fauna were observed (through direct or indirect evidence) during daylight hours (0700 and 1800hrs).
Sources of information	**Not a constraint.** Sources of information included publicly available contextual information such as pre-European vegetation mapping and climate data. DPaW and WA Herbarium database results and historical surveys including the Environmental Review (Stragenen, 2012) and previous flora and vegetation assessment (Strategen, 2016) were utilised to inform the field survey and data analysis.	**Not a constraint.** The DPaW threatened fauna database, naturemap and Bamford (2012) fauna survey report were utilised to inform the field survey.
Completion (is further work needed)	The scope of the field surveys was adequate to meet the objective of the project. This included quadrat-based sampling, targeted flora surveys, and TEC assessments.	**Not a constraint.** The objectives of the Level 1 fauna survey and Black Cockatoo assessment were met and no further work is required.

Limitation	Flora and Vegetation assessment	Fauna assessment
Timing, weather, season, cycle	**Not a constraint.** Field surveys were undertaken in late November, 2016. Dry June and July months, and low rainfall in October and November may have affected the ability to record ephemeral and orchid species. Majority of orchids recorded were dying or already dead.	**Not a constraint.** The field survey was undertaken during Spring between 22-23 and 28-29 November, 2016. The weather was warm. No rainfall was received during the survey. Sufficient rainfall had been received in the preceding months of the survey.
Disturbances (e.g. fire flood, accidental human intervention) which affected results of the survey	**Minor constraint.** The survey area is within the metropolitan area of Perth and incorporates 112 private properties. Disturbances including infrastructure, clearing, firebreaks, regular removal of fuel load both manually and by burning were observed. Some patches of native vegetation of varying condition were cryptic to determine the original vegetation community they may have represented.	**Not a constraint.** Clearing for infrastructure, weed invasion and regular burning were observed however were not considered to impact the survey results.
Intensity (was the intensity adequate)	**Not a constraint.** Twelve quadrats and six relevés were completed. Vegetation communities were represented by three or more quadrats, with the exception of one isolated community which was represented by two quadrats. Species area curves compared to the Chao asymptote show that more than 70% of anticipated species richness has been captured within each vegetation community (Appendix B).	**Not a constraint.** The survey area was traversed on foot over four days. This time allowed for adequate targeted surveying for Quenda and Black Cockatoo habitat which formed the primary objective of the scope.
Completeness (was relevant area fully surveyed)	**Not a constraint.** The entire survey area was traversed on foot.	
Resources (degree of expertise available in plant/animal identification)	**Not a constraint.** The field surveys were undertaken by experienced Botanists. Plant taxonomy was undertaken by Floora de Wit at the WA Herbarium.	**Not a constraint.** The resources (time, equipment and expertise) were sufficient for a Level 1 fauna survey and the Black Cockatoo assessment.
Remoteness and/or access problems	**Minor constraint.** Access was not granted to 41 Brae Road. Native vegetation was confirmed as present. Extrapolation of mapping data was undertaken to determine vegetation communities and condition. *C. undulatum* could be present on the property.	**Not a constraint.** Black Cockatoo potential breeding trees were not mapped for 41 Brae Road as access was not granted.
Availability of contextual information on the region	All historical survey effort was provided priori to commencing the field surveys. This, along with publicly available information and desktop database results were adequate to provide contextual information.	

5.0 Desktop Assessment Results

5.1 Environmentally Sensitive Areas and Conservation Estates

5.1.1 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are areas that have been identified for protection due to their environmental significance as outlined in the Western Australian Environmental Protection (Environmentally Sensitive Areas) Notice 2005, which was gazetted on 8 April 2005.

Exceptions offered for clearing under Regulation 5 of the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 do not apply within ESAs. ESAs are gazetted due to supporting environmental values of State or Commonwealth importance and, in this situation, include:

- Declared World Heritage properties (EPBC Act)
- areas included on the Register of the National Estate
- defined wetlands and associated buffers
- vegetation within 50 m of rare flora
- TECs.

A total of two ESAs occur within the survey area. These are likely to be associated with the Bush Forever Sites in the local area, and Threatened Ecological Communities.

5.1.2 Bush Forever

No Bush Forever sites are located within the survey area. Two Bush Forever sites are located directly adjacent to the survey area, detailed in Table 18.

Table 18 Bush Forever sites of the survey area

Site number	Bush Forever Site
45	Poison Gully Woodland, High Wycombe
123	Sultana Road West Bushland, High Wycombe

5.1.3 Conservation Estates

There are no conservation estates within or directly adjacent to the survey area.

5.2 Wetlands

The locations of wetlands have been determined using the Geomorphic Wetlands of the Swan Coastal Plain dataset adapted from *Hill et al* (1996). The dataset displays the location, boundary, geomorphic classification (wetland type) and management category of wetlands of the Swan Coastal Plain.

One Resource Enhancement and one Multiple Use wetland occur within the survey area as outlined in Table 19.

Table 19 Wetlands of the survey area

Wetland	Management category	Geomorphic classification
11441	Resource Enhancement	Palusplain
4810	Multiple Use	Palusplain

5.3 Threatened and Priority Ecological Communities

The database searches identified two Threatened Ecological Communities (TECs) (Table 20). These communities directly overlap one another and both are encompassed in the recently listed Banksia Communities of the Swan Coastal Plain TEC, listed as Endangered under the EPBC Act. The description for the EPBC Act listed Banksia Communities of the SCP has been provided to encompass the TECs identified in the desktop assessment.

The Banksia Woodlands TEC, described by the Threatened Species Scientific Committee (TSSC, 2016) incorporates Woodland of *Banksia* species with scattered eucalypts and other tree species over a species rich mix of sclerophyllous shrubs, graminoids, and forbs. The community shows high endemism and considerable local variation in species composition across its range. It is restricted to the southwest of WA on the Swan Coastal Plain. It occurs mainly on deep Bassendean and Spearwood sands or occasionally on Quindalup sands.

Table 20 Threatened Ecological Communities identified in the desktop assessment

	State Listing	Commonwealth Listing
Banksia attenuata woodlands over species rich dense shrublands (FCT20a)	Endangered	Endangered
Banksia dominated woodlands of the Swan Coastal Plain	Priority 3	Endangered

5.4 Conservation Significant Flora

A total of 57 Threatened and Priority flora species were identified from the database search as potentially occurring within the survey area. Of these species, 22 are listed as Threatened under the WC Act and also under the EPBC Act. The remaining 35 species are listed as Priority Flora. The spatial location of desktop assessment results are shown in Figure 3

Based on desktop assessment of specimen records and preferred habitat, it has been determined that six flora species of conservation significance are likely to occur in the survey area and four flora species of conservation significance may occur in the survey area (Table 21). One species, *Conospermum undulatum* is known to occur, identified by DPaW as population 4. The remaining 46 flora species are considered unlikely to occur in the survey area. Many of these are associated with the Darling Scarp just east of the survey area, and are therefore considered unlikely to occur. The complete desktop assessment results are provided in Appendix A.

Table 21 Desktop results for Threatened and Priority Flora identified from DPaW database searches, the EPBC Protected Matters Report and previous reports

Species	Conservation Code	Habitat[1]	Likelihood of Occurrence in Survey area
Caladenia huegelii	EPBC Act: E WC Act: CR	Found between Perth and Capel growing in deep sandy soil in *Banksia-Eucalyptus marginata* woodland.	**May occur**. Habitat present, no known records in the vicinity.
Conospermum undulatum	EPBC Act: V WC Act: VU	Grey or yellow-orange clayey sand.	**Known to occur**. Database records within survey area.
Drakaea elastica	EPBC Act: E WC Act: CR	Found on coastal plain between Ruabon and Cataby growing in sandy soil in *Banksia* woodlands and tall shrubs (Brown *et al.,* 2013).	**May occur**. Suitable habitat present but no known records in vicinity.
Haemodorum loratum	DPaW: P3	Grey or yellow sand and gravel. Record from 1995.	**Likely to occur**. Suitable habitat and record in close proximity to survey area.
Isopogon drummondii	DPaW: P3	No information available on WAH (1998-). Database results describe flats on grey brown sand with or without gravel in Banksia woodlands.	**Likely to occur**. Numerous records in vicinity of survey area.
Jacksonia sericea	DPaW: P4	Calcareous and sandy soils. Record from 1962.	**May occur**. Suitable habitat may present, old record in vicinity.
Macarthuria keigheryi	EPBC Act: E WC Act: EN	White or grey sand. Records from north of Perth to Dandaragan.	**Likely to occur**. Suitable habitat present, numerous records in close proximity.
Melaleuca viminalis	DPaW: P2	No information available on WAH (1998-). Recorded in 2005 on brown sandy clay over clay.	**May occur**. Suitable habitat may be present, one record in the vicinity of the survey area.
Platysace ramosissima	DPaW: P3	Sandy soils.	**Likely to occur**. Suitable habitat present and three records in vicinity.
Schoenus griffinianus	DPaW: P4	White sand. One record from 2006.	**Likely to occur**. Suitable habitat present, one record in vicinity.
Verticordia lindleyi subsp. *lindleyi*	DPaW: P4	Grows in white to grey and yellow sand, often with or over clay and gravel, usually low-lying and winter-wet (George, 2002). Frequently in association with a few other verticordias in heath, shrubland and open woodland (George, 2002).	**Likely to occur**. Suitable habitat present, several records in close proximity.

1. Sourced from Florabase (WAH, 1998-) and DotEE (2016) unless otherwise referenced

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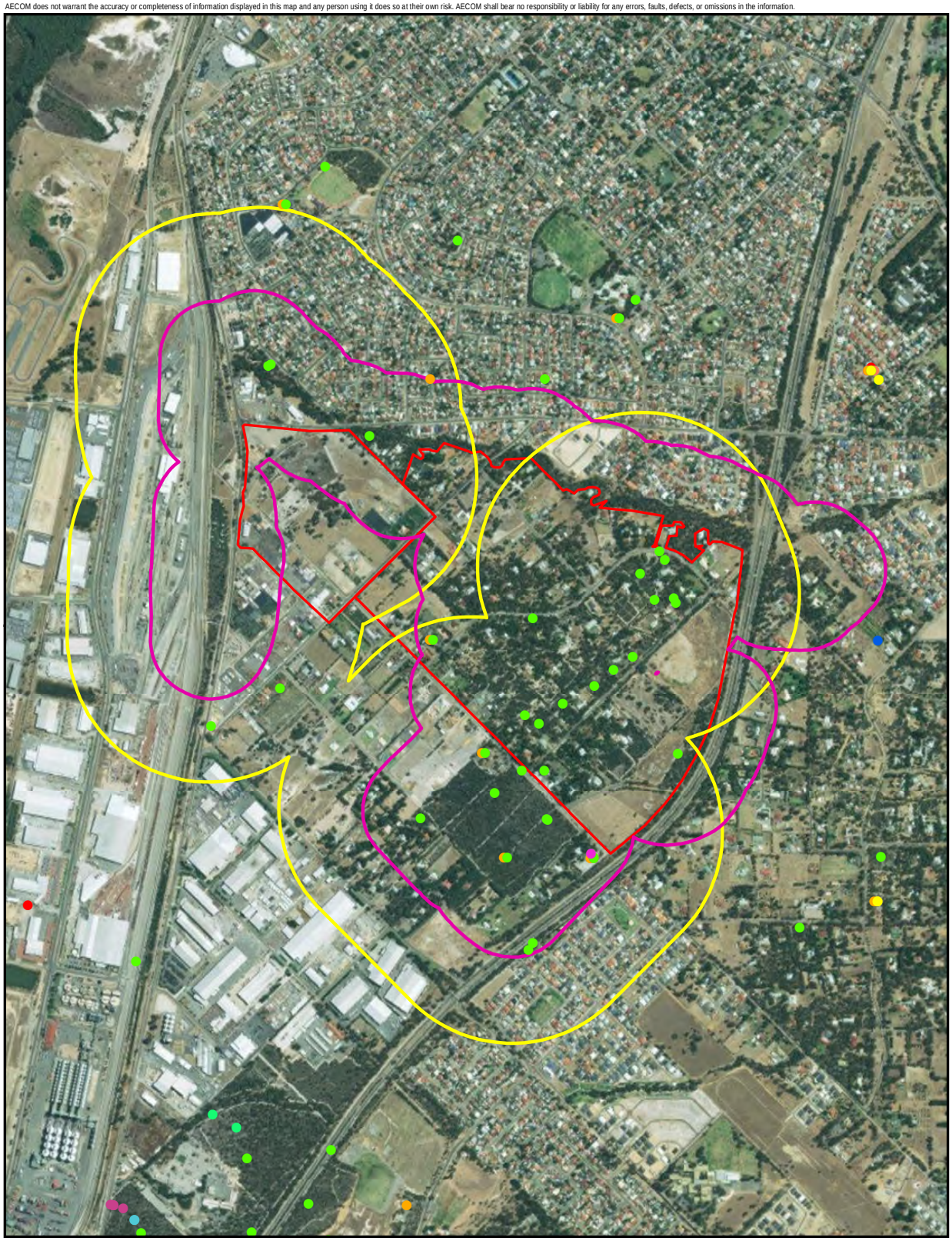

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LEGEND

Survey Area

TEC-PEC

Banksia Dominated Woodlands of the SCP (P3)

Banksia attenuata woodlands over species rich dense shrublands (EN)

Both listed under EPBC Act as endangered

Banksia pteridifolia subsp. vernalis
Conospermum undulatum
Haemodorum loratum
Isopogon drummondii
Macarthuria keigheryi
Orduffia submersa
Platysace ramosissima
Schoenus pennisetis
Thelymitra magnifica
Thelymitra stellata
Verticordia lindleyi subsp. lindleyi

Desktop results for Communities and Flora species

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure
3

Map Document: P:\605X\60527304\4. Tech Work Area\4.99 GIS\02_MXDs\Forrestfield_North_Jan2016\G60527304_Fig3_DesktopResultsFlora_v1_A4.mxd (fotheringhamd)

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5.5 Conservation Significant Fauna and Fauna Habitat

5.5.1 Fauna species

Eight Threatened, Priority and Migratory fauna species were identified from the database searches. This includes six birds and two mammals. Of these, three species are known to occur, two species may occur and three species are considered unlikely to occur. Database search results and the analysis of these are provided in Table 22.

Table 22 Records of Threatened and Priority Fauna from the vicinity of the survey area from DPaW database results, information obtained from DotEE (2017)

Species	Conservation Status	Habitat	Latest Observation Date	Likelihood of Occurrence
Ardea modesta Great Egret	EPBC Act: Mig & M WC Act: VU	The Great Egret occupies a wide variety of wet habitats including freshwater wetlands, dams, flooded pastures, estuarine mudflats, mangroves and reefs (Morcombe, 2003). The species is also known to visit shallows of rivers, sewage ponds and irrigation areas (Pizzey & Knight, 2007).	27/11/2001	**Unlikely to occur.** No suitable habitat present in the survey area.
Calyptorhynchus banksii subsp*. naso* Forest red-tailed black cockatoo	EPBC Act: V WC Act: VU	The Forest red-tailed black cockatoo requires tree hollows of Karri (*E. diversicolor*), Jarrah (*E*. *marginata*) and Marri (*Corymbia calophylla*) forests to nest and breed. Flocks move out onto the Swan Coastal Plain in search of food from exotic trees such as the White Cedar (Johnstone et al, 2010). The foraging habitat for the species consists of Jarrah and Marri woodlands and forest within its range. Black Cockatoo observational data shows five records of 120 individuals recorded within and in vicinity of survey area.	03/04/2016	**Known to occur**. Suitable habitat present. Known roosting site on Lot 47 Brae Road.
Calyptorhynchus baudinii Baudin's Black-Cockatoo	EPBC Act: V WC Act: EN	The Baudin's Black Cockatoo's habitat is critical to its survival; including forests of Karri (*E. diversicolor*), Jarrah (E. *marginata*) and Marri (*C. calophylla*), in areas of 600 mm average rainfall per year. Individuals typically move north through the Perth region from March to May and south through the Perth region from August to October. The species ranges from Gidgegannup and Hoddy Well in the north and west to the Eastern Strip of the Swan Coastal Plain. It includes West Midland in the north, heading south through Armadale, Byford and south and towards the coast until Lake Clifton where it continues to hug the coastline to east of Albany (Johnstone *et al,* 2010). Black Cockatoo observational data shows no records of this species from the vicinity of the survey area.	04/04/2014	**Unlikely to occur**. Less favoured habitat present, no known records in vicinity of survey area.

Species	Conservation Status	Habitat	Latest Observation Date	Likelihood of Occurrence
Calyptorhynchus latirostris Carnaby's Black-Cockatoo	EPBC Act: E WC Act: EN	Carnaby's Cockatoo is a postnuptial nomad and typically moves west soon after breeding. The species nests in hollows of smooth-barked eucalypts, particularly Salmon Gum (*Eucalyptus salmonophloia)* and Wandoo (*E. Wandoo)* but is not limited to these eucalypts. Diet consists of an array of Proteaceous and Eucalypt species prevalent on the Swan Coastal Plain. Foraging habitat, including *banksia* woodlands, is considered to be habitat critical to the survival of the species (Johnstone *et al.,* 2010). Cockatoo observational data shows 159 records of 509 individuals recorded in vicinity of survey area.	04/04/2014	**Known to occur**. Suitable habitat present and known records from within survey area.
Dasyurus geoffroii Western Quoll, Chuditch	EPBC Act: V WC Act: CR	Following European settlement the range of this species contracted dramatically, from much of the continent to a small area in the south west. It currently only occurs in areas dominated by sclerophyll forest or drier woodland, heath and mallee shrubland (Van Dyck & Strahan, 2008). The majority of records are found in the contiguous Jarrah forests of the south west of Western Australia (DotEE, 2017). Recent records exist within the Gnangara pine forest and Walyunga National Park.	20/11/2013	**May occur**. Less favoured habitat present (i.e. not continuous Jarrah Forest, but disjointed native vegetation). Records from northeast of
Isoodon obesulus subsp. *fusciventer* Quenda	DPaW: P4	The Quenda or Southern Brown Bandicoot exists only in a fragmented distribution to its former range in southern south western and eastern Australia. It is found in forest, woodland, heath and shrub communities in these regions. Preferred habitat usually consists of a combination of sandy soils and dense heathy vegetation (Van Dyck & Strahan, 2008).	29/11/2015	**Known to occur**. Suitable habitat present and four records from within survey area.
Merops ornatus Rainbow Bee-eater	EPBC Act: M	The Rainbow Bee-eater is a common species which occupies numerous habitats including open woodlands with sandy loamy soil, sand ridges, sandpits, riverbanks, road cuttings, beaches, dunes, cliffs, mangroves and rainforests. It is possible that this species will occupy open woodland areas within the survey area. The Rainbow Bee-eater avoids heavy forest that would hinder the pursuit of its insect prey (Morcombe, 2003).	14/11/2014	**May occur**. No suitable habitat present however recent record suggest species may occur.

Species	Conservation Status	Habitat	Latest Observation Date	Likelihood of Occurrence
Pandion haliaetus Osprey	EPBC Act: Mig & M	The breeding range of the Eastern Osprey includes the northern coast of Australia from Albany in WA to Lake Macquirie in NSW. This bird is moderately common in Australia, mostly in northern Australia. Eastern Osprey occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. Found mostly in coastal areas but can travel inland along major rivers. Areas of open fresh, brackish or saline water for foraging is essential for their habitat, visiting various wetland habitats including inshore waters, reefs, bays, coastal cliffs, beaches, estuaries, mangrove swamps and broad rivers, reservoirs and large lakes. They can also occur over atypical habitats such as heath, woodland or forest when travelling between foraging sites.	24/11/1995	**Unlikely to occur**. No suitable habitat present in survey area. May fly over.

Conservation categories are outlined in Section 3.0 Legislative Framework.

6.0 Field Survey Results and Discussion

6.1 Vegetation

6.1.1 Threatened and Priority Ecological Communities

Banksia Woodlands of the Swan Coastal Plain – EPBC Act-listed as Endangered

The presence of the EPBC Act-listed Banksia Woodlands of the Swan Coastal Plain has been confirmed as occurring within the survey area. The native vegetation within the survey area was grouped into patches. A patch was considered an area of continuous vegetation.

The survey area was divided into five patches. Of these, patches 1 – 4 met all key diagnostic features as published in the conservation advice for the TEC (TSSC, 2016). The vegetation within these patches was often co-dominated by a mix of *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* and *Eucalyptus marginata* subsp. *marginata*. The vegetation varied from 'Good' to 'Excellent' condition. Many of these patches also support populations of the Threatened flora species, *Conospermum undulatum*.

The total area of native vegetation representing this TEC is 14.22 ha.

A detailed assessment of each of these patches is provided in Appendix C.

***Banksia attenuata* woodlands over species rich dense shrublands – State-listed as Endangered**

It is likely that all patches in 'Good' or better condition represent the State-listed TEC "*Banksia attenuata* woodlands over species rich dense shrublands (FCT20a)". Gibson *et al.* (1994) describes FCT20a as being recorded on sandy soils at the base of the Scarp at Forrestfield covering the Southern River land system. The survey area lies on the Southern River land system, near Forrestfield at the base of the scarp. Furthermore, species richness was high for all vegetation quadrats completed in areas of 'Very Good' to 'Excellent' condition, exceeding 40 species within a 10x10 m quadrat.

Detailed FCT analysis was undertaken by Plantecology for Strategen (2016). These results showed one area (15 Milner Road) showed similarity to Gibson *et al.* (1994) FCT20. A number of limitations were recognised in undertaking data analysis for inferring FCTs. Results are often cryptic and require a variety of analysis methods in order to accurately infer the FCT. Lacking this detailed analysis, and given the description of the State-listed TEC, it is assumed that all vegetation mapped as the EPBC Act-listed community also represents the State-listed TEC.

Banksia woodlands of the Swan Coastal Plain – Priority 3

This community has no additional description other than it is not encompassed in FCT20a. It could be assumed that all vegetation considered the Banksia Woodlands EPBC Act-listed TEC also represents this Priority 3 PEC.

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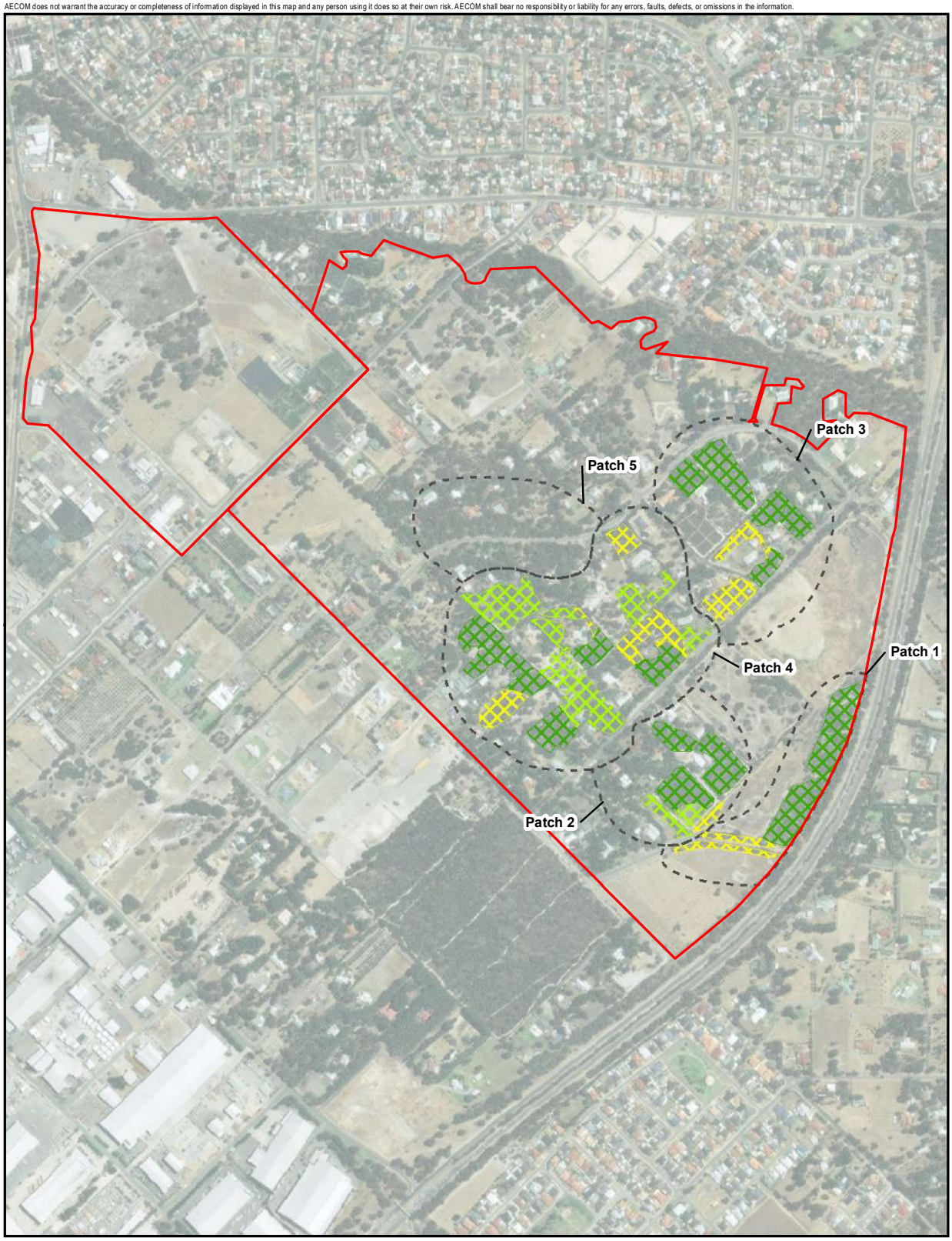

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LEGEND
Survey Area
Banksia Woodlands of the Swan Coastal Plain
Excellent Condition
Very Good Condition
Good Condition

Threatened Ecological Communities

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure 4

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6.1.2 Vegetation Communities

Five vegetation communities were described and mapped over 22.80 ha of native vegetation within the survey area. This encompassed:

- three woodlands
- one heath
- one riparian vegetation community.

Details of vegetation communities, survey effort, extent, and photograph are presented in Table 23. Vegetation mapping is provided in Figure 5.

Table 23 Vegetation communities recorded in the Survey area including code and description using the NVIS system, size of community, representative photograph and survey effort

Community Description	Additional Details	Photograph
AfHhMp *Allocasuarina fraseriana*, *Banksia attenuata, Banksia menziesii* and occasional *Nuytsia floribunda* low woodland over *Xanthorrhoea preissii, Lambertia multiflora, Adenanthos cygnorum* subsp. *cygnorum* and *Xanthorrhoea acanthostachya* mid sparse shrubland over *Hibbertia hypericoides, Banksia dallanneyi* var. *dallanneyi, Bossiaea eriocarpa, Calothamnus torulosus* and *Petrophile macrostachya* low sparse shrubland with *Mesomelaena pseudostygia, Schoenus brevisetis, Lepidosperma leptostachyum*, *Caustis dioica* and *Tricostularia exsul* tall open sedgeland with *Dasypogon obliquifolius*, *Scaevola repens* var. *repens*, *Haemodorum laxum*, *Gladiolus caryophyllaceus**, *Burchardia congesta* and *Anigozanthos manglesii* low sparse forbland. Regionally significant: supports *C. undulatum* populations and listed under EPBC Act as Banksia Woodlands of Swan Coastal Plain TEC. The community condition ranged from 'Good' to 'Excellent'.	Survey effort: four quadrats (1, 4, 6, 9) Species richness: 92 native and seven weed species. Area: 5.5 ha	
EmAcMt *Eucalyptus marginata* and *Banksia menziesii* low open woodland over *Adenanthos cygnorum* subsp. *cygnorum*, *Lambertia multiflora* and *Xanthorrhoea acanthostachya* mid open shrubland over *Melaleuca trichophylla*, *Hibbertia hypericoides, Eremaea pauciflora* var. *pauciflora, Allocasuarina humilis* and *Stirlingia latifolia* low shrubland with *Mesomelaena pseudostygia*, *Cyathochaeta avenacea, Tricostularia exsul* and *Lepidosperma leptostachyum* mid to low sedgeland over *Tricoryne elatior, Dasypogon obliquifolius, Lyginia barbata, Scaevola repens* var. *repens, Haemodorum laxum* and *Lomandra sericea* low sparse forbland. One isolated area (Lot 59 Brae Road) lacked any overstorey species. The understorey layers were however composed of similar species. No quadrats were completed on this block due to the small size and isolated occurrence of the community. Regionally significant: supports *C. undulatum* populations and listed under EPBC Act as Banksia Woodlands of Swan Coastal Plain TEC. The community condition ranged from 'Good' to 'Excellent'.	Survey effort: three quadrats (2, 5, 10) one relevè (14). Species richness: 79 native and four weed species, Area: 3.51 ha	

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Prepared for – Shire of Kalamunda – ABN: 60 741 095 678

Community Description	Additional Details	Photograph
EmToDo *Eucalyptus marginata* and *Allocasuarina fraseriana* mid woodland over Banksia *attenuata, Banksia menziesii* and *Persoonia elliptica* low woodland over *Lambertia multiflora* and *Xanthorrhoea preissii* mid open shrubland over *Banksia dallanneyi* var. *dallanneyi, Hibbertia hypericoides, Bossiaea eriocarpa*, *Stirlingia latifolia*, and *Gastrolobium capitatum* low shrubland with *Tetraria octandra, Mesomelaena pseudostygia, Mesomelaena tetragona* and *Lepidosperma leptostachyum* low sedgeland over *Dasypogon obliquifolius*, *Patersonia occidentalis, Dampiera linearis, Haemodorum laxum, Scaevola repens* var. *repens* and *Lomandra preissii* low sparse forbland. Regionally significant: supports *C. undulatum* populations and listed under EPBC Act as Banksia Woodlands of Swan Coastal Plain TEC. The community condition ranged from 'Degraded to 'Excellent'.	Survey effort: five quadrats (3, 11, 13, 16, 17) three relevès (12, 15 and 18). Species richness: 87 native and eight weed species. Area: 10.32 ha	
ErApEh *Corymbia calophylla* and *Eucalyptus rudis* tall woodland over *Trymalium odoratissimum* thicket over *Acacia pulchella*, *Hibbertia hypericoides* and *Xanthorrhoea preissii* mid sparse shrubland over **Ehrharta calycina, *Cynodon dactylon, *Gladiolus caryophyllaceus* and *Tetraria octandra* grassland/herbland on clay soils within Poison Gully. This community was mapped by Strategen (2015), no additional effort was spent on this community. The community condition was mapped as 'Very Good'.	Area: 0.18 ha	No photograph taken.

Community Description	Additional Details	Photograph
VdCd *Eucalyptus marginata* subsp. *marginata* mid isolated trees over *Verticordia densiflora* var. *densiflora, Daviesia angulata, Hypocalymma angustifolium, Stirlingia latifolium* and *Banksia bipinnatifida* subsp. *bipinnatifida* low open shrubland with *Caustis dioica, Mesomelaena tetragona, Tetraria octandra* and *Schoenus brevisetis* tall open sedgeland over *Patersonia occidentalis, Lyginia barbata, Haemodorum spicatum*, *Tricoryne elatior* and *Anigozanthos manglesii* low open forbland. The community condition was mapped as 'Excellent'.	Survey effort: two quadrats (7, 8) Species richness: 45 native and five weed species. Area: 2.65 ha	
Trees Areas mapped as trees comprise of scattered to clumps of native trees (mostly *Eucalyptus marginata*) located in either cleared paddocks, roadsides, or over planted vegetation. This vegetation unit was mapped using field survey observations. No quadrats were completed to represent this vegetation community as it lacks all native species except trees. The condition is mapped as 'Completely Degraded'.	Area: 5.64 ha	

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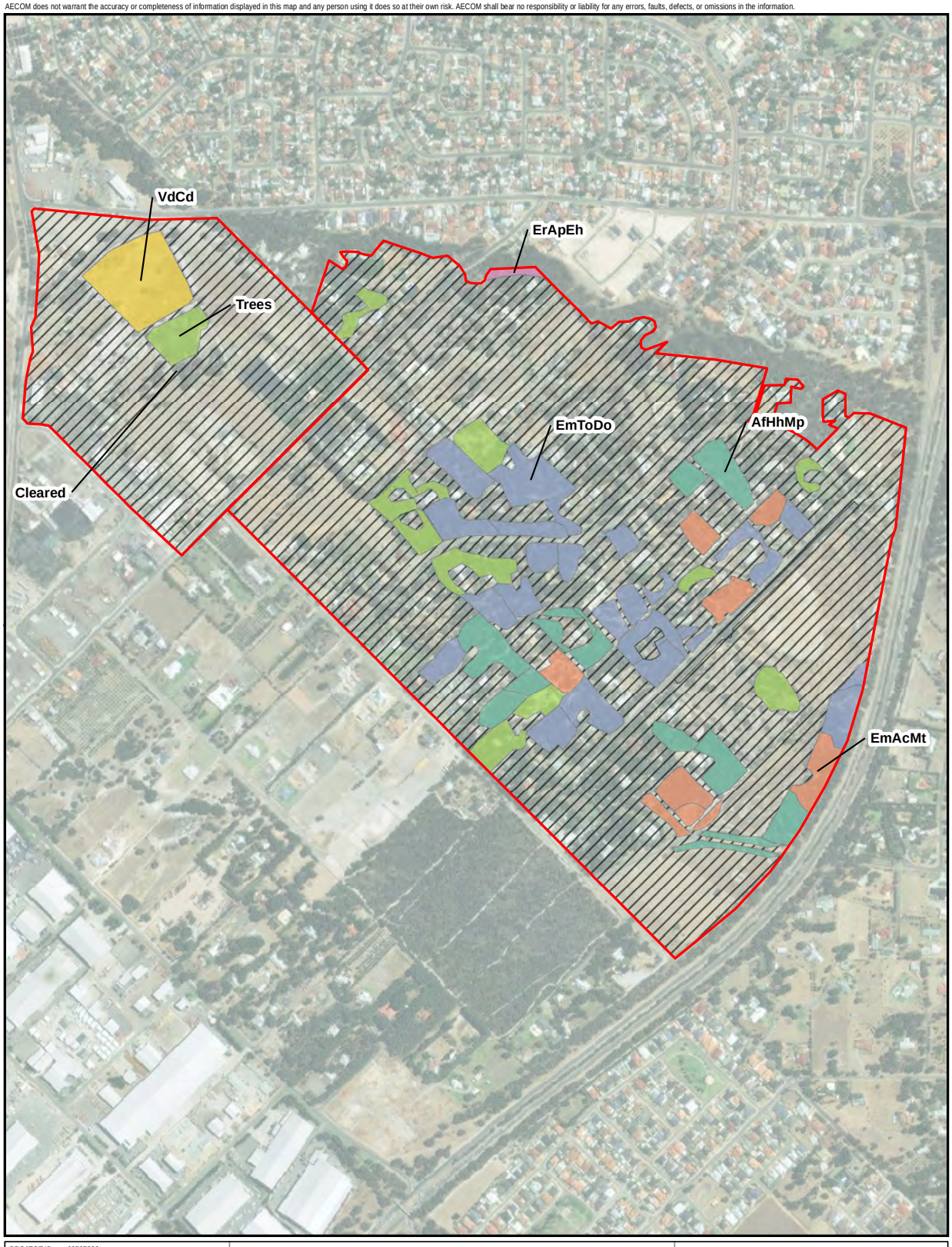

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LEGEND

Survey Area

Community

- Cleared
- AfHhMp
- EmAcMt
- EmToDo
- ErApEh
- Trees
- VdCd

Vegetation Mapping

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure

5

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A4 size

6.1.3 Vegetation Condition

Vegetation condition within the Survey area varied from 'Excellent' to 'Completely Degraded'. The majority was mapped as 'Excellent', extending over 12.17 ha (comprising 43.76 % of the total vegetated area). Vegetation condition has been mapped in Figure 6.

A major cause of degradation includes weeds and clearing of native vegetation. Weed invasion is a result of edge effects, plant escapes and invasion from cleared paddocks. Weeds can modify ecosystem processes and function by changing community structure. This is evident in some areas where understorey native vegetation has been displaced by more competitive and hardy perennial grasses.

Illegal rubbish dumping was observed in the native vegetation patch alongside Roe Highway (Plate 1).Clearing by land owners is occurring as the land is further developed. Areas that historically show native vegetation are now occupied by infrastructure and tracks (including firebreaks).

No evidence of dieback was observed during the field survey. This is a preliminary observation based on the presence and health of *Xanthorrhoea, Banksia* and *Eucalyptus* species.

Cleared area was mapped for 116.20 ha of the survey area. This was not included in the percentage calculations in Table 24.

Table 24 Vegetation Condition mapped within the Survey area

Condition Rating	Area (ha)	Percentage of Survey area (%)
Excellent	12.17	43.76
Very Good	4.00	14.40
Good	2.87	10.32
Degraded	5.04	18.11
Completely Degraded	3.73	13.40
Total	27.80	100



Plate 1 Examples of declining condition

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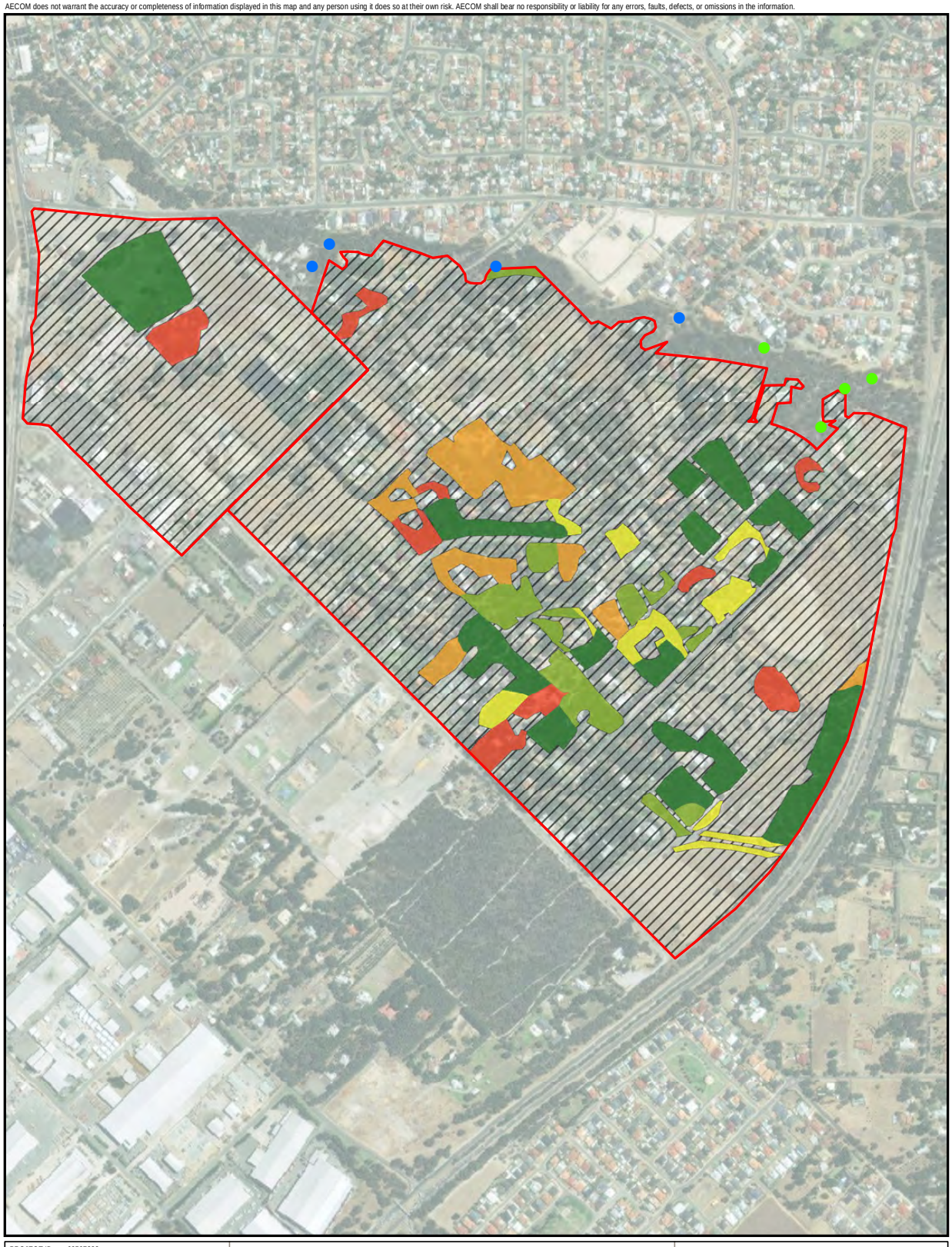

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LEGEND

Survey Area

Declared Pests

- Asparagus asparagoides
- Zantedeschia aethiopica

Vegetation Condition

- Cleared
- Excellent
- Very Good
- Good
- Degraded
- Completely Degraded

Condition Mapping

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure

6

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A4 size

6.2 Flora

6.2.1 Threatened and Priority Flora

One species listed as Threatened under the EPBC Act and WC Act was recorded extensively within the survey area. *Conospermum undulatum* is listed as Vulnerable under the EPBC Act and WC Act, and was known to occur within the survey area.

A recovery plan is available for this species (DEC, 2008), from where the following information was sourced. *C. undulatum* is an erect shrub up to 1.5 m tall (Plate 2). The leaves have three distinct, parallel veins and characteristic wavy margins. The woolly flowers have white hairs and are held well above the leaves. The species occurs on sand and sandy clay soils often over laterite on flat or gently sloping sites between the Swan and Canning Rivers.

One disjointed population was recorded in the survey area. It is considered one population as all individuals are within 100 metres of other individuals and are not considered to be significantly geographically isolated from one another. It is therefore likely that all individuals are breeding and cross-pollinating in the area. A total of 525 individuals were recorded (Table 25), as mapped in Figure 7.

C. undulatum has been historically recorded within the survey area by Shire of Kalamunda (2012) and reported by Strategen (2012). It is known to DPaW as population 4.



Plate 2 ***Conospermum undulatum*** **leaves, flowers and habitat which can vary from Excellent to Good condition**

Table 25 ***C. undulatum*** **population information within and in vicinity of survey area**

Parameter	AECOM		DPaW	
	Populations	Individuals	Populations	Individuals
Within survey area	1	525		
In vicinity of survey area (local context)	NA	NA		
Total in State (regional context)	NA	NA	25	11,453

One Priority 3 species, *Isopogon drummondii*, was recorded in the survey area. At the time of the field survey, this species was not known to be a Priority therefore individual counts were not obtained. The specimen was submitted to DPaW for identification in December 2016.

This species was recorded in nine quadrats (Figure 7). It varied in cover from 0.2% to 3%. There are 19 WA Herbarium records of this species in the local region. It has been recorded in Bush Forever site 123 located directly adjacent to the survey area. It is likely that this Priority 3 species is locally common in patches of native vegetation in the local area.

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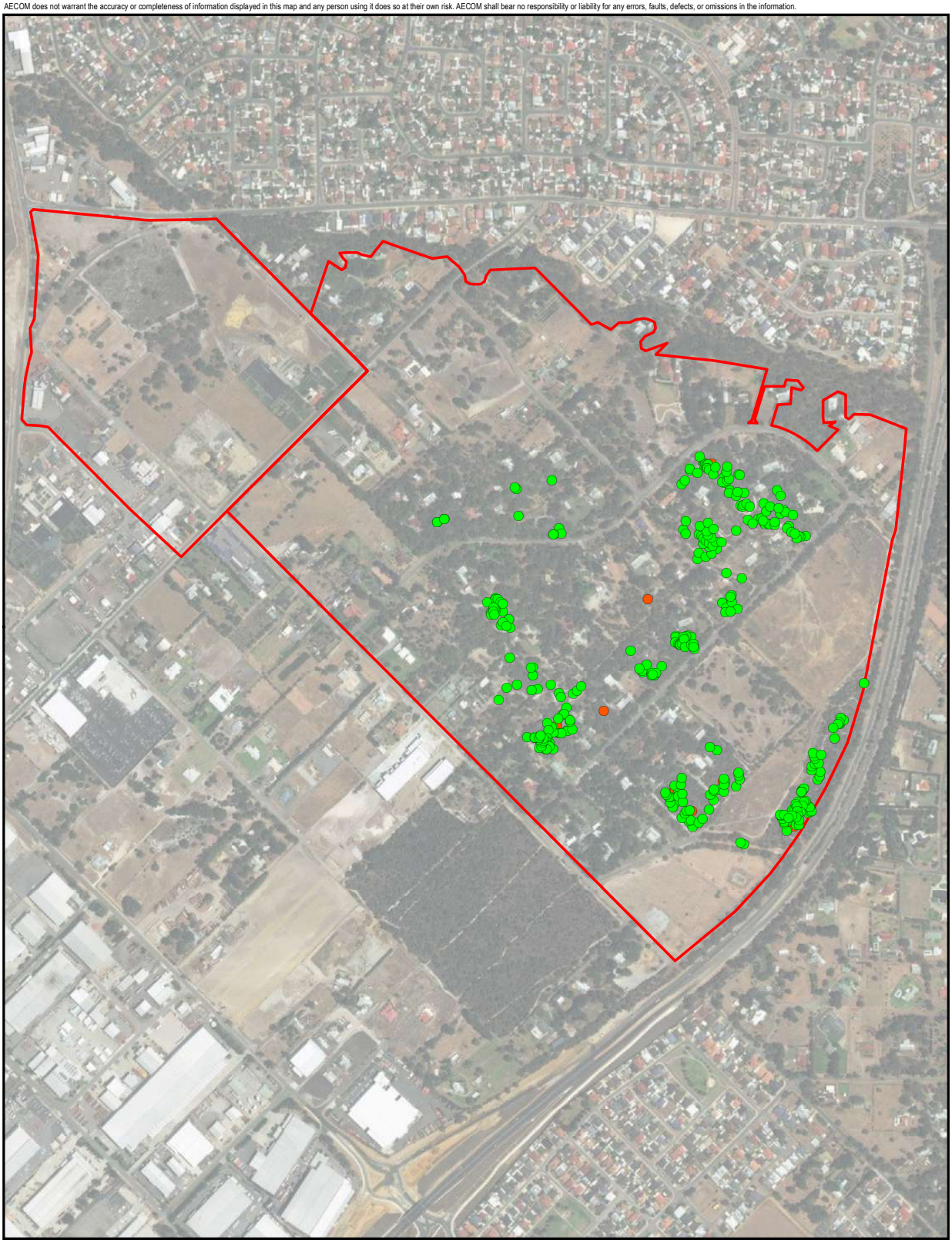

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LEGEND

- *Conospermum undulatum* (T)
- *Isopogon drummondii* (P3)
- Survey Area

Threatened and Priority Flora

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure 7

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6.2.2 Inventory of Flora Species

A total of 142 species from 96 genera and 33 families were recorded within the survey area during the field assessment. The total includes 131 (93%) locally native species.

Families with the highest representation are Proteaceae (24 native taxa), Fabaceae (14 native taxa) and Myrtaceae (11 native taxa).

The full list of vascular flora species recorded and representative communities in which they occur in are presented in Appendix D. Qualitative data recorded from individual quadrats is presented in Appendix E.

6.2.3 Weed Species

In total, nine introduced species were recorded from the survey area and two planted species. It should be noted that quadrats were specifically placed within vegetation in good condition. For this reason weed species count was low. However, there are likely to be more weeds present in the survey area.

Strategen recorded two Declared Pests are listed under the *Biosecurity and Agricultural Management Act 2007* (BAM Act). Pursuant to the BAM Act, these species are subject to restrictions on movement or sale and landholders are obliged to carry out control measures to prevent their spread. These listed species include *Asparagus asparagoides* (Bridal Creeper), and *Zantedeschia aethiopica*. Locations of these are shown on Figure 6.

6.3 Fauna and Fauna Habitat

6.3.1 Threatened, Migratory and Priority Fauna Species

Four species of conservation significance were recorded in the survey area including three birds and one mammal. These include:

- Carnaby's Black Cockatoo listed as Endangered under the EPBC Act and the WC Act
- Forest Red-tailed Black Cockatoo listed as Vulnerable under the EPBC Act and the WC Act
- Rainbow Bee-eater listed as Marine under the EPBC Act
- Quenda listed as Priority 4 by DPaW.

The Rainbow Bee-eater was seen and heard at one location in the survey area. This species is listed as Marine and as such, is not considered protected unless it is in Commonwealth land. All other conservation significant species are discussed below.

6.3.1.1 Carnaby's Cockatoo

Carnaby's Black Cockatoo is endemic to the southwest of Western Australia, extending from the Murchison River to Esperance, and inland to Coorow, Kellerberrin and Lake Cronin (DotEE, 2017). This black cockatoo has a white patch on its cheek, white bands on its tail, and a strong curved bill.

Carnaby's Black Cockatoo feed on seeds, nuts and flowers of a variety of native and exotic plants. Feed plants include the various proteaceous species (e.g. *Banksia, Grevillea* and *Hakea*), *Corymbia calophylla* (Marri*), Eucalyptus* (e.g. Jarrah [*Eucalyptus marginata*]), and seeds from the cones of Pine trees (*Pinus* sp.).

Carnaby's Black Cockatoo display strong pair bonds and nest in the hollows of live or dead mature eucalypts including Salmon Gum (*Eucalyptus salmonophloia*), York Gum (*Eucalyptus loxophleba* subsp. *loxophleba*), Flooded Gum (*Eucalyptus rudis*), Karri (*Eucalyptus diversicolor*), Marri (*Corymbia calophylla*), Wandoo (*Eucalyptus wandoo*) and Tuart (*Eucalyptus gomphocephala* [DSEWPaC, 2012]). Nest hollows generally range from 2.5-12 m above ground, size of entrance from 23-30 cm and depth of hollows from 1-2.5 m (Johnstone & Storr,1998). The species appears to be expanding its current breeding range westward and south into the Jarrah-Marri forests of the Darling Range and into the Tuart forests of the SCP (Johnstone & Kirkby, 2006). After breeding, Carnaby's Black Cockatoo disperse to the higher rainfall coastal areas of the south-west of Western Australia to feed in late December to July (DPaW, 2013). Breeding has been recorded from early July to mid-December.

Carnaby's Black Cockatoo has undergone a dramatic decline of approximately 50 percent in the past 45 years, with the main contributing factors the clearing of core breeding habitat in the Wheatbelt, the deterioration of nesting hollows, and clearing of foraging habitat.

Evidence of the Carnaby, potential breeding trees, and foraging habitat quality is discussed in Section 6.4.

6.3.1.2 Forest Red-tailed Black Cockatoo

The Forest Red-tailed Black Cockatoo (Forest Red-tail) is endemic to the south-west humid and semi-humid zones of Western Australia, where it inhabits dense Jarrah, Karri and Marri forests which receive more than 600 mm average annual rainfall (DSEWPaC, 2012). The species has a pair of black central tail feathers and a bright red, orange or yellow barring on the tail.

This species predominantly feeds in eucalypt forests, preferring Marri (*Corymbia calophylla*) and Jarrah (*Eucalyptus marginata*) seeds, but also feeding in Blackbutt (*Eucalyptus patens*), Albany Blackbutt (*Eucalyptus staeri*), Karri (*Eucalyptus diversicolor*), Sheoak (*Allocasuarina fraseriana*) and Snottygobble (*Persoonia longifolia*) (Johnstone, 2016 pers. comm.). Forest Red-tailed Black Cockatoo are monogamous and pairs nest in tree hollows from 6.5–33 m above ground. Most nests are in very large and very old, mature Marri (*Corymbia calophylla*) Johnstone *et al.*, 2013), though they will nest in other eucalypts such as Tuart (Johnstone, 2016 pers. comm.).

The modelled distribution of Forest Red-Tailed black Cockatoos in the *Referral Guidelines for three threatened black cockatoo species* (DSEWPaC, 2012) ranges from Perth to Albany encompassing the south west of the state. Formerly common, but now rare to uncommon and patchily distributed, the Forest Red-tailed Black Cockatoo has disappeared from about 30% of its former range. It has suffered a marked decline in numbers over the past 60 years because of the destruction and fragmentation of habitat (especially Jarrah-Marri forest), the apparent decline in Marri along the eastern side of the Darling Scarp (possibly due to climate change), logging, the impact of competitors for nest hollows, and fire (Chapman, 2008).

According to Johnstone *et al.* (2013) the foraging ecology of the Forest Red-tail is changing as their range is expanding. New foraging species, including introduced species, are being added to their diet. Lack of food and the discovery of new food sources is leading this change in foraging range. Sedentary flocks are now becoming regular visitors to the Swan coastal Plain, particularly for breeding. Principal foods are Marri and Jarrah with less important foods including Blackbutt, Sheoak, Hakea, introduced eucalypts and cape lilac.

Evidence of the Forest Red-tail, potential breeding trees, and foraging habitat quality is discussed in Section 6.4.

6.3.1.3 Quenda

The Quenda is considered likely to occur in the Survey Area. It is classified as a Priority 4 species. It is found in woodland, heath and shrub communities on the Swan Coastal Plain and prefers a combination of sandy soils and dense heathy vegetation (Van Dyck & Strahan, 2008).

The Quenda is likely to utilise all native (and potentially non-native) vegetation within the survey area. Landowners at Lot 12 Brand Road confirmed numerous Quendas present during their time at the property (20 years).

A total of 22.97 ha of Quenda habitat was mapped in the survey area. Eleven Quenda observations were made during the field survey including diggings and scats shown in Plate 3 and Figure 8.



Plate 3 Quenda evidence a) digging b) digging and scat c) tunnel run

6.3.2 Inventory of Fauna Species

Twelve fauna species were recorded during the field survey. This included nine birds, one mammal and two reptiles (Table 26).

Table 26 Fauna Species recorded within the Survey area

Species	Common Name	Observation Type
Birds		
Acanthorhynchus superciliosus	Western spinebill	Heard/seen
Anthus novaeseelandiae	Australasian pipit	Heard/seen
Anthochaera carunculata	Red Wattlebird	Heard/seen
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	Foraging evidence
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	Heard/seen
Conopophila whitei	Grey honeyeater	Heard/seen
Lichmera indistincta	Brown honeyeater	Heard/seen
Merops ornatus	Raibow Bee-eater	Heard/seen
Rhipidura leucophrys	Willie Wagtail	Heard/seen
Reptiles		
Cryptoblepharus plagiocephalus	Skink	Seen
Tiliqua rugosa rugosa	Southwestern Bobtail	Seen
Mammals		
Isoodon obesulus fusciventer	Quenda	Scats and diggings

6.3.3 Fauna Habitat

Four fauna habitats have been defined and mapped for the survey area based on the results of the field assessment (Figure 8). These habitats are described as follows:

- one woodland habitat
- one heath habitat
- one riparian habitat
- one mixed native and planted trees over gardens.

Table 27 Fauna habitats recorded within the survey area

Description	Photographs
Woodland The most common habitat (excluding cleared area). The woodland habitat is comprised of parcels of land (mostly private property) with an emergent tree stratum of Jarrah, over mixed Banksia and Sheoak low woodland over species rich shrublands including sclerophyllous shrubs, forbs, rushes and sedges. The habitat provides cover in both tree and understorey strata (depending on condition, as condition declines species diversity shifts to perennial grasses). Leaf litter is high and sandy soils provide ideal burrowing and digging substrate. This habitat coincides with vegetation communities AfHhMp, EmToDo, and EmAcMt. Detailed descriptions provided in Section 6.1.2 and Table 23. Area: 19.32 ha Significance: • Quenda habitat • Foraging and potential nesting for Forest Red-tail and Carnaby's Black Cockatoo	 
Heath Isolated to one area (Stage 2). This community is fairly open with isolated trees over approximately 60% heath cover. Areas of bare sand exposed to the sun (and potential predators). This habitat coincides with vegetation community VdCd. As evident in the photographs, bare ground and density of understorey varies across the patch of native vegetation. Area: 2.65 ha Significance: • Quenda habitat • foraging habitat for Forest Red-tail and Carnaby's Black Cockatoo.	 

Description	Photographs
Riparian Restricted to the edge of Poison Gully Creek located on Lot 15A Milner Road. This habitat is comprised of Flooded Gum over introduced species, predominantly grasses. This community is represented by ErApEh in the vegetation community descriptions. Area: 0.18 ha Significance: • Foraging and/or nesting and roosting potential for Forest Red-tail and Carnaby's Black Cockatoo species • Near important water source for all fauna species.	No photographs taken.
Native Trees Extensive in the survey area, native trees with planted vegetation was recorded on private properties including residents backyards, roadsides and paddocks. It includes native trees over grasses, native trees with planted trees, and native trees over planted understorey species. As evident from the photographs, the degree of degradation from clearing, weeds, and general maintenance of private properties varied. This community is represented as 'Trees' in the vegetation community mapping and description. Area: 5.64 ha Significance: • Foraging and potential breeding for Forest Red-tail and Carnaby's Black Cockatoo species.	 

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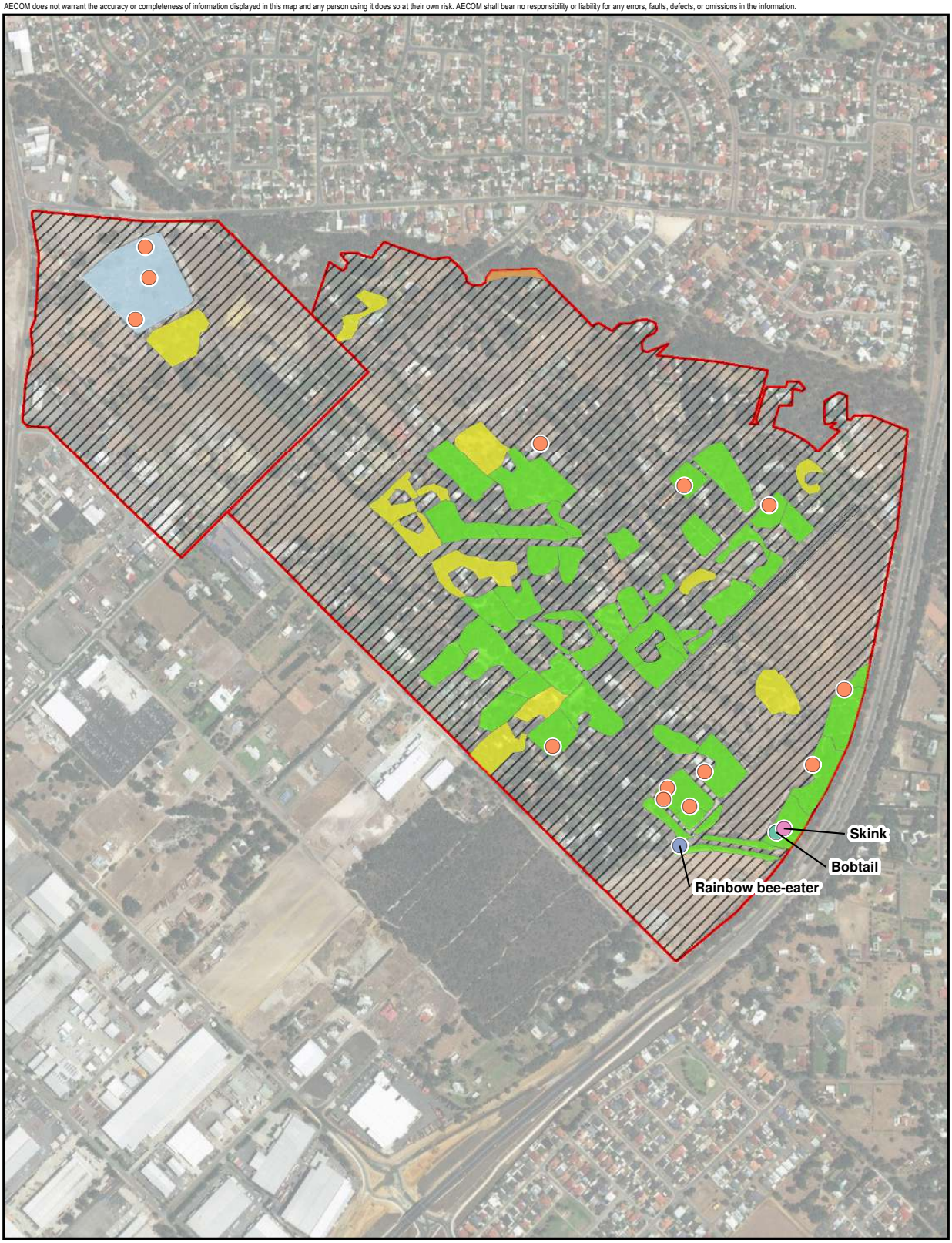

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LEGEND

Survey Area

Fauna Habitat
- Cleared
- Heath
- Jarrah and planted
- Riparian woodland
- Woodland

Fauna Observations
- Bobtail
- Quenda
- Rainbow bee-eater
- Skink

Fauna Habitat

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure 8

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6.4 Black Cockatoos

6.4.1 Breeding

Within the Study area, 458 trees are considered to be potential Black Cockatoo breeding habitat trees, in accordance with the Commonwealth guidelines (DSEWPaC, 2012). This includes Bamford (2012) field survey results and the AECOM field results. Potential breeding trees recorded are shown in Figure 9.

Of the 458 trees, 42 trees had potential suitable breeding hollows. Suitable hollows were defined as those that have an entrance diameter greater than 10cm.

Forty two trees had potential hollows, with 38 hollows recorded that were deemed large enough and did not show signs of occupancy from other fauna species. These are considered potentially suitable for use by Carnaby's and Forest Red-Tailed Black Cockatoo (>10 cm). Further investigation regarding occupancy included recording signs of use by bees and/or galahs. Thirteen bee hives were recorded as occupying hollows. These hollows were excluded from being considered suitable.

6.4.2 Roosting

Black Cockatoo roosting habitat is generally found in or near riparian vegetation, close to fresh water and typically is comprised of the tallest trees in these areas (DSEWPaC, 2012a). A known roosting site is located in the survey area on Lot 47 Brae Road, as provided in DPaW Black Cockatoo observational data.

No additional roosting sites were confirmed during the field survey.

6.4.3 Foraging habitat

6.4.3.1 Carnaby's Black Cockatoo

All native vegetation, including trees with planted vegetation, was considered suitable foraging habitat for Carnaby's. An assessment of floristic data was undertaken to determine the total foliage cover of suitable foraging species present within each quadrat.

Communities AfHhMp, EmAcMt and EmToDo show anywhere between 10-57% foliage cover of suitable foraging species. The variety of cover is directly related to the condition of the vegetation. Degraded vegetation lacks the Proteaceous species in the understorey and has reduced Banksia cover. Suitable Carnaby's foraging species included 24 Proteaceous species and Jarrah trees.

Foraging quality of all native vegetation within the survey area was scored as 12 (rated as 'high') in accordance with the scoring tool (see Section 4.4.2). The area contains suitable foraging species, Jarrah woodlands, there is water available within 2 km, and it supports trees with potential to be used for breeding.

The vegetation comprised of native trees over planted vegetation or cleared paddocks was scored at 6 ('valued'). These areas are originally considered 'low quality' due to lack of suitable foraging plants present (mostly due to lack of complexity in vegetation structure). However additional scores were given for potential breeding tree presence, within 2km of water, and near a known roosting site.

No foraging evidence was recorded for Carnaby's.

In total, 19.32 ha is considered quality foraging habitat with a score of 12 (rated as High) and 8.29 ha was scored at 6 (rated as Valued). This is shown on Figure 10.

6.4.3.2 Forest Red-tailed Black Cockatoo

Similar to the Carnaby's foraging habitat assessment, all native vegetation within the survey area is considered suitable Forest Red-tail foraging habitat. Communities AfHhMp, EmAcMt, EmToDo and VdCd all support suitable foraging species. These are limited to three overstorey species including *Jarrah, Sheoak* and *Snottygobble.* The foliage cover of these species varies from 1.5-53%.

Forest Red-tailed foraging quality for the native vegetation was calculated as 13 ('high'). The survey area supports Eucalypt woodlands dominated by Jarrah, contains trees with potential to become breeding trees, supports a known large roost site (more than 10 birds), and is <2km from a watering point. This evaluation was supported by ten foraging evidence observations.

The trees with planted vegetation or in paddocks were scored at 7. These areas are considered low quality foraging habitat however the score was increased due to the additional context of being near known roosting site, water and other areas of quality foraging habitat.

In total, 19.32 ha is considered quality foraging habitat with a score of 13 (rated as High), and 8.29 ha was scored at 7 (rated as Quality). Foraging evidence records and foraging quality mapping is shown in Figure 10.



Plate 4 Foraging evidence

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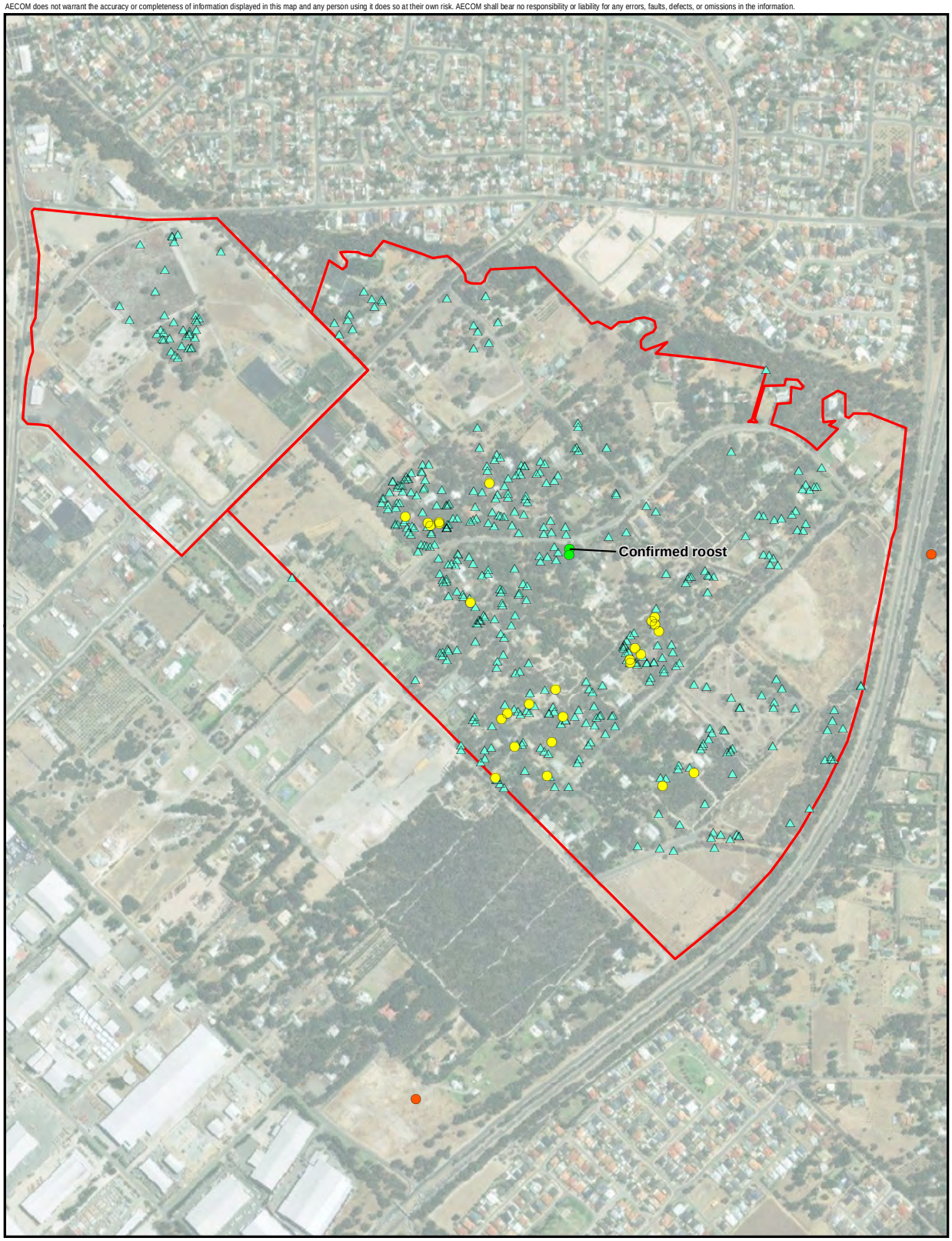

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LEGEND

- Survey Area
- *Calyptorhynchus banksii naso*
- *Calyptorhynchus latirostris*

Potential Black Cockatoo Breeding Trees

- Suitable Hollows
- No Suitable Hollows

Black Cockatoo Potential Breeding Trees

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure

9

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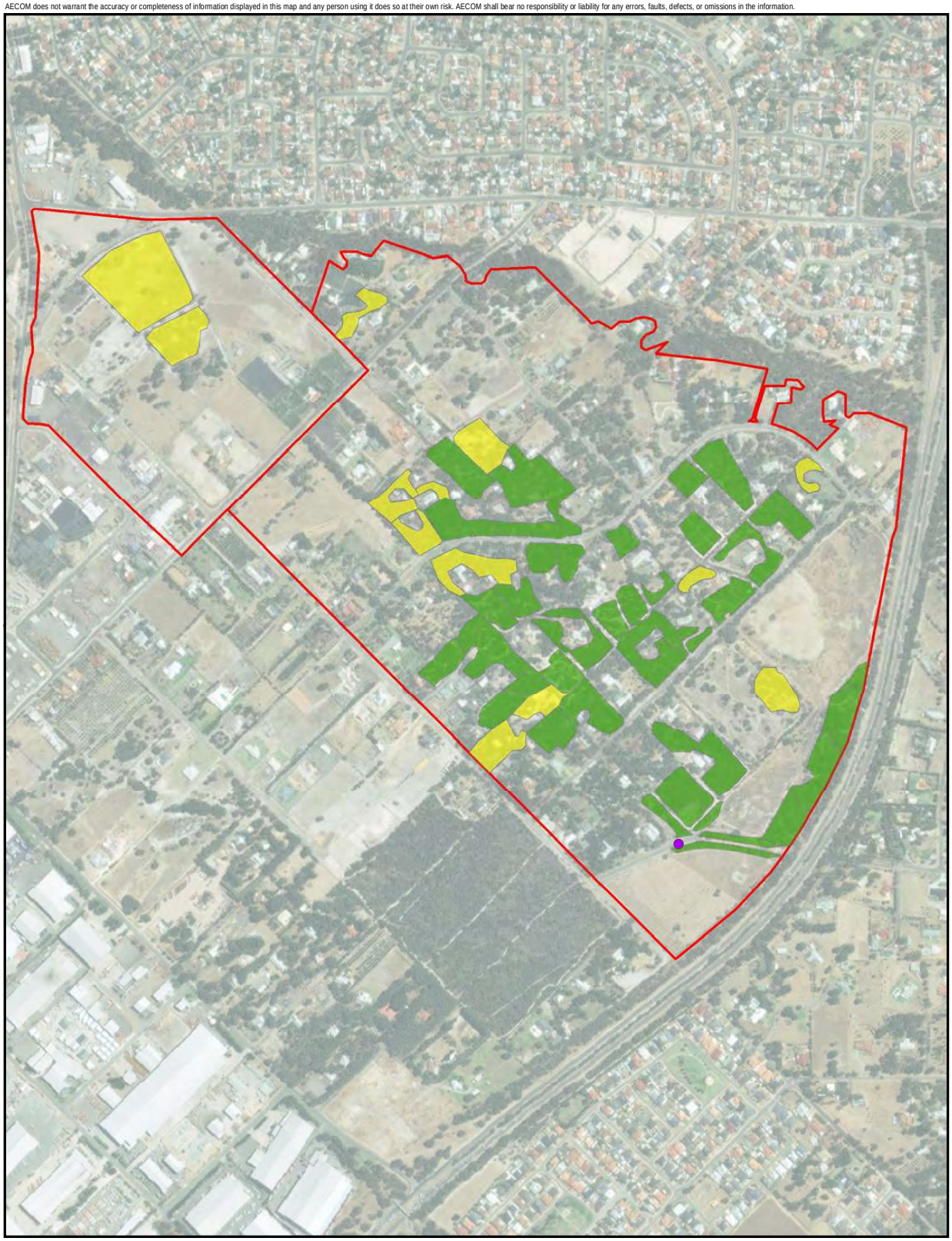

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LEGEND

- Survey Area
- **ENV_FRTBCForaging**
- High Quality Habitat
- Valued Quality Habitat
- **Observations**
- Seen and Heard, Carnaby

Carnaby's Foraging Habitat

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure

10

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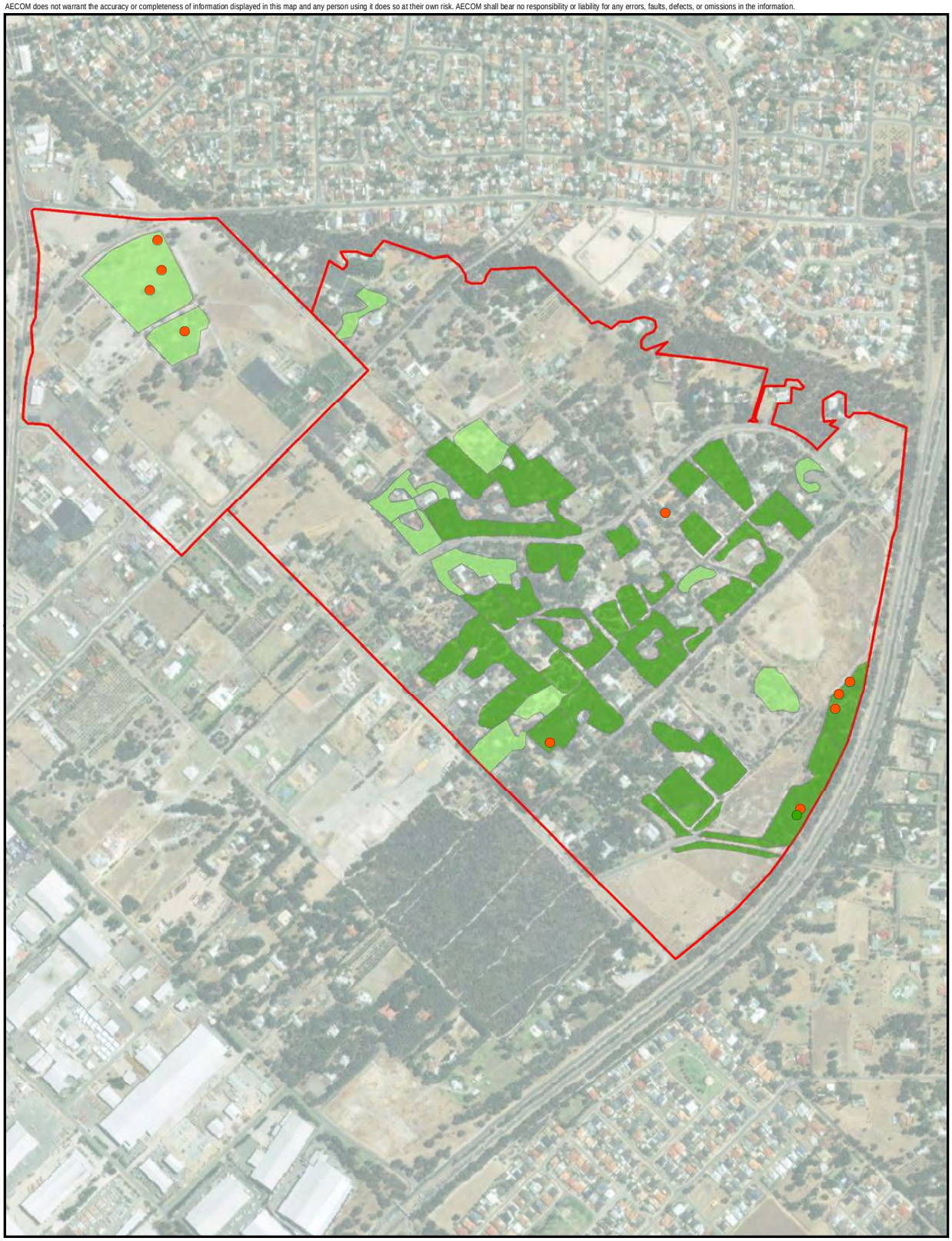

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LEGEND

Survey Area

ENV_FRTBCForaging

Observations

Foraging Evidence, Frtbc

Foraging Evidence, Frtbc Potentially

Forest Red-tail Foraging Habitat

High Quality Habitat

Quality Habitat

Forest Red-tail Foraging Habitat

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure

11

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7.0 Conclusions and Recommendations

The significant ecological findings from the assessment of the survey area are:

- One TEC listed as Endangered under the EPBC Act occurs in the survey area. All native vegetation in 'Good' or better condition within the survey area has met the key diagnostic criteria for the Banksia Woodlands of the Swan Coastal Plain TEC. This TEC extends for 14.22 ha.
- The Banksia Woodlands of the SCP TEC relates to one State-listed TEC *Banksia attenuata* woodlands over species rich dense shrublands, and one DPaW-listed PEC Banksia Woodlands of the SCP. Lack of detailed descriptions for this TEC means it was difficult to accurately delineate these TECs, and therefore all native vegetation in 'Good' or better condition could be considered the State-listed TEC which represents the highest conservation category.
- Five vegetation communities were recorded and mapped. Four of these are considered regionally significant as they represent a federally listed TEC. Many also support populations of the Threatened *Conospermum undulatum.*
- One Threatened flora species, *Conospermum undulatum* (Wavy-leaved Smokebush) was recorded extensively throughout the survey area. This species is listed as Vulnerable under both the EPBC Act and WC Act. One population comprising 525 individuals were recorded within the survey area. Current information shows a total of 25 populations occur on the SCP, comprising approximately 11,453 individuals.
- Two Declared Pest species listed under the BAM Act were recorded, including *Zantedeschia aethiopica* (Arum Lily) and *Asparagus asparagoides* (Bridal Creeper).
- Four conservation significant fauna species were recorded during the survey including the Carnaby's Black Cockatoo listed as Endangered under the EPBC Act and the WC Act, Forest Red-tailed Black Cockatoo listed as Vulnerable under the EPBC Act and the WC Act, Rainbow Bee-eater listed as Marine under the EPBC Act and the Quenda listed as Priority 4 by DPaW.
- Four fauna habitats were mapped within the survey area, including
    - 21.97 ha of suitable Quenda habitat
    - 25.15 ha of Black Cockatoo potential breeding habitat
    - 19.32 ha of High quality foraging habitat for Carnaby's and Forest Red-tailed Black Cockatoos
    - 8.29 ha mapped as Valued for Carnaby's and Quality for Forest Red-tailed Black Cockatoos

The regionally significant ecological values have been captured on the environmental constraints map (Figure 12).

Due to the presence of several Matters of National Environmental Significance, a referral under the EPBC Act is recommended prior to any clearing of native vegetation.

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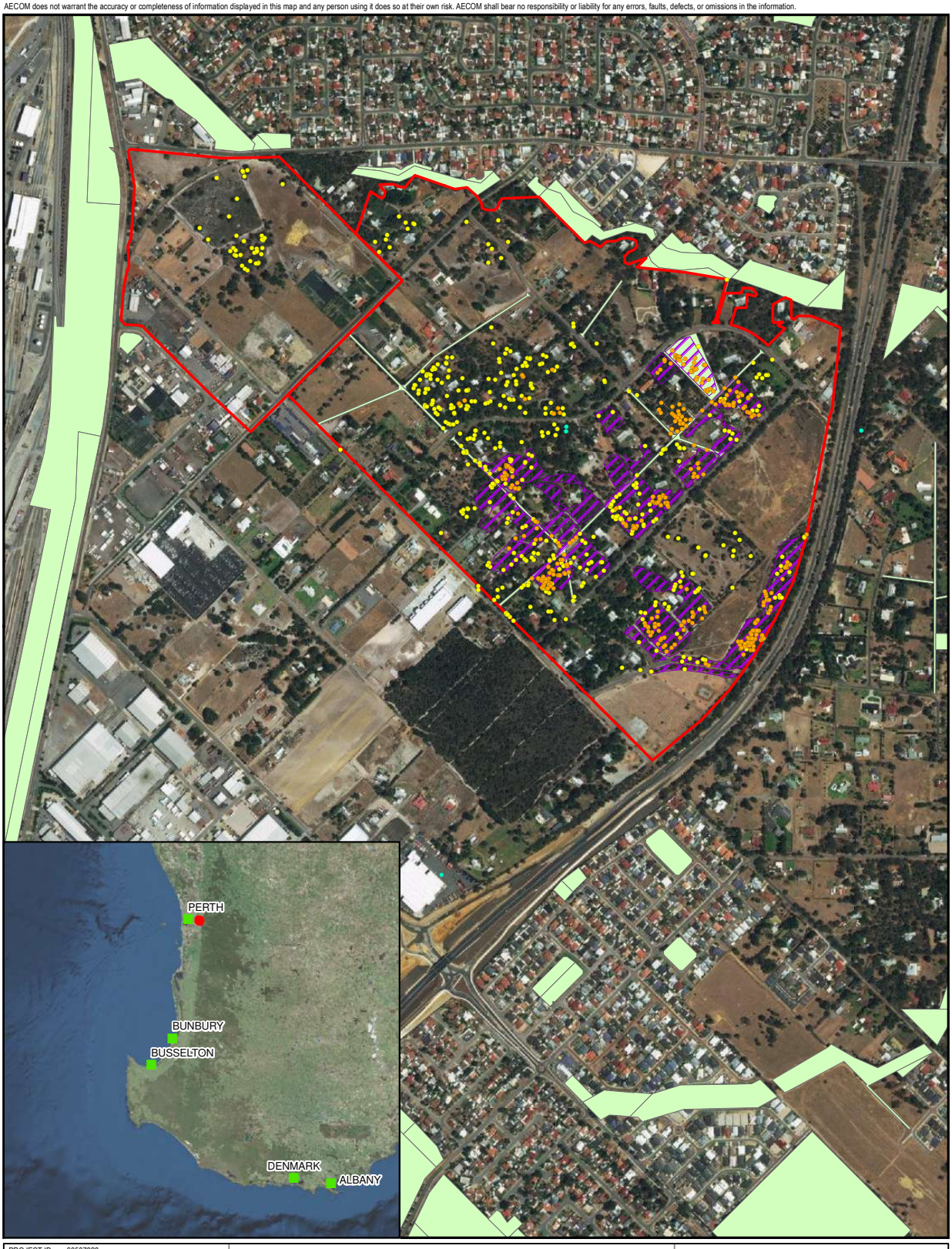

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LEGEND

- *Conospermum undulatum* individuals
- Potential Black Cockatoo Breeding Trees
- *Calyptorrhynchus banksii naso* confirmed roost
- Survey Area
- TEC Extent
- Reserves

Data sources: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Environmental Constraints

Forrestfield North

SHIRE OF KALAMUNDA

VEGETATION AND FAUNA SURVEY

Figure

12

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Appendix A

Desktop Flora Results

Appendix A – Desktop Flora Results

Species	Conservation Code	Habitat[1]	Likelihood of Occurrence in Survey area
Acacia anomala	EPBC Act: V WC Act: VU	Grows on laterite in shallow sand, loam, clay or gravel that is brown, yellow or grey. Found on ridges, slopes and low plains. It grows entangled amongst other low shrubs in dense vegetation. Known from 13 populations including Kalamunda/Bickley, Chittering/Bullsbrook, and Pickering Brook.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Acacia aphylla	EPBC Act: V WC Act: VU	Associated with laterite and granite outcrops on hillsides. Grows in open forest dominated by *Eucalyptus marginata, Corymbia calophylla* or *Eucalyptus loxophleba.*	**Unlikely.** No suitable habitat in survey area. Known from Darling Scarp.
Acacia horridula	DPaW: P3	Gravelly soils over granite, sand. Rocky hillsides.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Andersonia gracilis	EPBC Act: E WC Act: VU	Known from Badgingarra, Dandaragan and Kenwick areas where it is found on seasonally damp, black sandy clay flats near margins of swamps in low open vegetation with species such as *Calothamnus hirsutus, Verticordia densiflora* and *Kunzea recurva*.	**Unlikely**. No suitable habitat in survey area. Known from Darling Scarp.
Anthocercis gracilis	EPBC Act: V WC Act: VU	Known from nine populations growing on steep granite slopes along the Darling Scarp in shallow, humus-rich sandy or loamy soils.	**Unlikely**. No suitable habitat in survey area. Known from Darling Scarp.
Asteridea gracilis	DPaW: P3	Sand, clay, gravelly soils.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Banksia pteridifolia subsp. *vernalis*	DpaW: P3	White/grey sand over laterite. Last record from 1998.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Banksia mimica	EPBC Act: E WC Act: VU	Flat to gentle slopes on grey sand in open woodlands. Known from 14 populations from Mogumber, Darling Range and the Whicher Range.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Beaufortia purpurea	DPaW: P3	Lateritic or granitic soils. Rocky slopes.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.

Species	Conservation Code	Habitat[1]	Likelihood of Occurrence in Survey area
Boronia humifusa	DPaW: P3	Gravelly clay loam over laterite. Mainly in Jarrah-Marri open forest.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Boronia tenuis	DPaW: P4	Laterite, stony soils. Granite. Recorded in 1953.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Byblis gigantea	DPaW: P3	Sandy-peat swamps and seasonally wet areas.	**Unlikely**. No suitable habitat in survey area.
Caladenia huegelii	EPBC Act: E WC Act: CR	Found between Perth and Capel growing in deep sandy soil in *Banksia-Eucalyptus marginata* woodland.	**May occur**. Habitat present, no known records in the vicinity.
Calothamnus accedens	DPaW: P4	Sandy soils over laterite. Road verge.	**Unlikely**. No suitable habitat in survey area.
Calytrix breviseta subsp. *breviseta*	EPBC Act: E WC Act: CR	This species has been recorded in the Kenwick area of Perth where it is restricted to winter-wet clay flats with low shrubs or Jarrah Forest.	**Unlikely**. No suitable habitat in survey area.
Chamelaucium sp. Gingin (N.G. Marchant 6)	EPBC Act: E WC Act: VU	Confined to the Gingin/Chittering area within a 3km range. Occurs on white/yellow sand supporting open low woodlands of *Eucalyptus todtiana, Banksia attenuata* and *Hibbertia* species.	**Unlikely**. No suitable habitat in survey area. Known from Darling Scarp.
Carex tereticaulis	DPaW: P3	Black peaty sand.	**Unlikely**. No suitable habitat in survey area.
Conospermum undulatum	EPBC Act: V WC Act: VU	Grey or yellow-orange clayey sand.	**Known to occur**. Database records within survey area.
Darwinia apiculata	EPBC Act: WC Act: EN	Lateritic soils.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Diuris micrantha	EPBC Act: V WC Act: VU	Recorded between Perth and Boyup Brook growing ins seasonally-wet flats amongst sedges and scattered shrubs.	**Unlikely**. No suitable habitat and no known records.
Diuris purdiei	EPBC Act: E WC Act: EN	Recorded between Perth and Yarloop, gorwing under dense shrubs in seasonally-wet swamps and drainage lines (Brown *et al.,* 2013).	**Unlikely**. No suitable habitat and no known records.
Drakaea elastica	EPBC Act: E WC Act: CR	Found on coastal plain between Ruabon and Cataby growing in sandy soil in *Banksia* woodlands and tall shrubs (Brown *et al.,* 2013).	**May occur**. Suitable habitat present but no known records in vicinity.

Species	Conservation Code	Habitat[1]	Likelihood of Occurrence in Survey area
Eleocharis keigheryi	EPBC Act: V WC Act: VU	Known from north of Eneabba and south-east of Qualeup. Grows in small clumps in a substrate of clay or sandy loam. It is emergent in freshwater creeks and transient waterbodies.	**Unlikely.** No suitable habitat and no known records.
Eucalyptus x balanites	EPBC Act: E WC Act: CE	Recorded on light coloured sandy soils over laterite including gently sloping heathlands, open mallee woodland over shrubland or heathland with emergent mallees. Known from two populations including one in Badgingarra National Park and one in the City of Armadale.	**Unlikely.** No suitable habitat and no known records.
Grevillea curviloba subsp. *incurva*	EPBC Act: E WC Act: EN	Confined to area between Muchea and Badgingarra. Grows in open heath in winter-wet areas on sand over limestone or over ironstone.	**Unlikely.** No suitable habitat and no known records.
Grevillea manglesii subsp. *dissectifolia*	DPaW: P3	Gravelly loam, moist. Roadsides.	**Unlikely**. No suitable habitat in survey area, no records in vicinity.
Grevillea pimeleoides	DPaW: P4	Gravelly soils over granite. Rocky hillsides.	**Unlikely**. No suitable habitat in survey area, no records in vicinity.
Haemodorum loratum	DPaW: P3	Grey or yellow sand and gravel. Record from 1995.	**Likely**. Suitable habitat and record in close proximity to survey area.
Halgania corymbosa	DPaW: P3	Gravelly soils, soils over granite. Records from 1919 and 1977.	**Unlikely**. No suitable habitat in survey area, records on Darling Scarp.
Hibbertia montana	DPaW: P4	Granite rocks, lateritic ridges and boulders, hills. Record from 1985.	**Unlikely**. No suitable habitat in survey area, old record from golf course unlikely to be correct, more likely from Darling Scarp.
Hydrocotyle striata	DPaW: P1	Clay, springs.	**Unlikely**. No suitable habitat in survey area. No records in vicinity.
Hypocalymma sp. Cataby (G.J. Keighery 5151)	DPaW: P2	Grey sand.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Isopogon drummondii	DPaW: P3	No information available on WAH (1998-). Database results describe flats on grey brown sand with or without gravel in Banksia woodlands.	**Likely**. Numerous records in vicinity of survey area.
Jacksonia gracillima	DPaW: P3	No information available on WAH (1998-). No known records in vicinity.	**Unlikely**. No known records in vicinity.

Species	Conservation Code	Habitat[1]	Likelihood of Occurrence in Survey area
Jacksonia sericea	DPaW: P4	Calcareous and sandy soils. Record from 1962.	**May**. Suitable habitat may present, old record in vicinity.
Lasiopetalum bracteatum	DPaW: P4	Sandy clay, clay, lateritic gravel. Along drainage lines, creeks, gullies, and granite outcrops. Record from 1992 and 1997.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Lasiopetalum glutinosum subsp. *glutinosum*	DPaW: P3	No information available on WAH (1998-). Records from 1897.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Lasiopetalum pterocarpum	EPBC Act: E WC Act: CE	Occurs on slopes of Darling Range near Serpentine National Park. Occurs in riparian community with *Eucalyptus rudis.*	**Unlikely.** No suitable habitat and no known records.
Lepidosperma rostratum	EPBC Act: E WC Act: EN	Restricted to two seasonally wet swamps. Grows on peaty sand and clay amongst low heath in winter-wet swamps.	**Unlikely.** No suitable habitat and no known records.
Lepyrodia curvescens	DPaW: P2	Sand, laterite. Seasonally inundated swampland.	**Unlikely**. No suitable habitat present. Two records from Roe/Great Eastern Highway interchange.
Macarthuria keigheryi	EPBC Act: E WC Act: EN	White or grey sand. Records from north of Perth to Dandaragan.	**Likely**. Suitable habitat present, numerous records in close proximity.
Melaleuca viminalis	DPaW: P2	No information available on WAH (1998-). Recorded in 2005 on brown sandy clay over clay.	**May**. Suitable habitat may be present, one record in the vicinity of the survey area.
Ornduffia submersa	DPaW: P4	No information available on WAH (1998-). Records from 1989 and 1995 from shallow claypans with Melaleuca fringing vegetation.	**Unlikely**. No suitable habitat in survey area.
Pimelea rara	DPaW: P4	Lateritic soils.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Pithocarpa corymbulosa	DPaW: P3	Gravelly or sandy loam. Amongst granite outcrops. Recorded in 1996.	**Unlikely**. No suitable habitat in survey area.
Platysace ramosissima	DPaW: P3	Sandy soils.	**Likely**. Suitable habitat present and three records in vicinity.

Species	Conservation Code	Habitat[1]	Likelihood of Occurrence in Survey area
Schoenus griffinianus	DPaW: P4	White sand. One record from 2006.	**Likely**. Suitable habitat present, one record in vicinity.
Schoenus pennisetis	DPaW: P3	Grey or peaty sand, sandy clay. Swamps and winter-wet depressions. Recorded in 1995.	**Unlikely**. No suitable habitat present.
Senecio gilbertii	DPaW: P1	Peaty sand, swamps and slopes. Record from 1957 and 1994.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Stylidium longitubum	DPaW: P4	Sandy clay and clay. Seasonal wetlands.	**Unlikely**. No suitable habitat present.
Stylidium striatum	DPaW: P4	Records from 1897.	**Unlikely**. No suitable habitat in survey area. Records on Darling Scarp.
Synaphea sp. Fairbridge Farm (D. Papenfus 696)	EPBC Act: CE WC Act: CR	Endemic to Pinjarra Plain of WA, known from five subpopulations south of Perth from Serpentine to Dardanup. Occurs on grey, clayey sand with lateritic pebbles in low woodland near winter-wet flats.	**Unlikely.** No suitable habitat and no known records.
Tetratheca sp. Granite (S. Patrick SP1224)	DPaW: P3	Clay, moist loam, clayey sand. Granite boulders. Recorded in 1990.	**Unlikely**. No suitable habitat in survey area.
Thelymitra dedmaniarum	EPBC Act: E WC Act: CR	Recorded near Gidgegannup in Darling Range on granite slopes and in open Wandoo woodland.	**Unlikely**. No suitable habitat in survey area.
Thelymitra magnifica	DPaW: P1	Stony ridges. Recorded on edge of Darling Scarp amongst dense heath in rocky soils surrounding exposed granite outcrops (Brown *et al.*, 2013).	**Unlikely**. No suitable habitat in survey area.
Thelymitra stellata	EPBC Act: E WC Act: EN	Sand, gravel, lateritic loam. Grows in *Eucalyptus marginata* forests or in low heath on rocky tops of small hills (Brown *et al.*, 2013).	**Unlikely**. No suitable habitat in survey area.
Verticordia lindleyi subsp. *lindleyi*	DPaW: P4	Grows in white to grey and yellow sand, often with or over clay and gravel, usually low-lying and winter-wet (George, 2002). Frequently in association with a few other verticordias in heath, shrubland and open woodland (George, 2002). Records from 1990 and 1994.	**Likely**. Suitable habitat present, several records in close proximity.

1. Sourced from Florabase (WAH, 1998-) and DotEE (2016) unless otherwise referenced

Appendix B

Statistical Analysis

Appendix B – Statistical Analysis

1.0 Dendrograms

The following dendrograms justify the survey sample intensity. All vegetation communities are considered suitably represented by quadrats and relevès based on a higher than 70% representation for each community. The estimated total species richness is based on the Chao asymptote which is a nonparametric estimator considered universally valid for all species abundance distributions (Chao & Chiu, 2006).

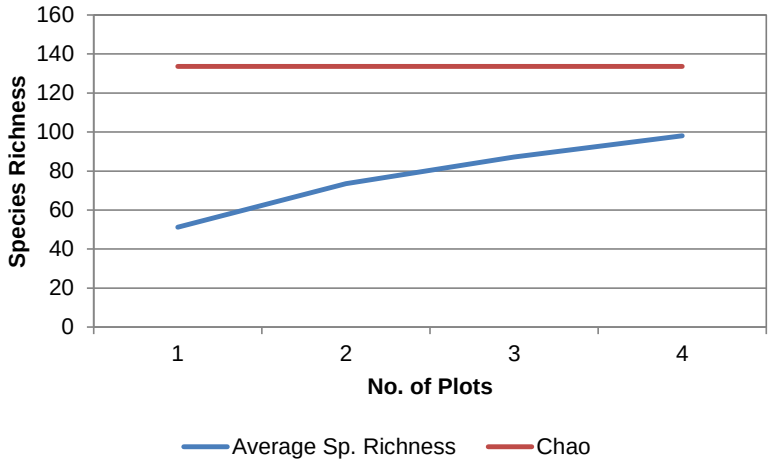
1.1 AfHhMp

Survey effort: 4 quadrats

Species richness: 98 species in total

Chao estimate: 133.64

Percent total species captured: 73.33%



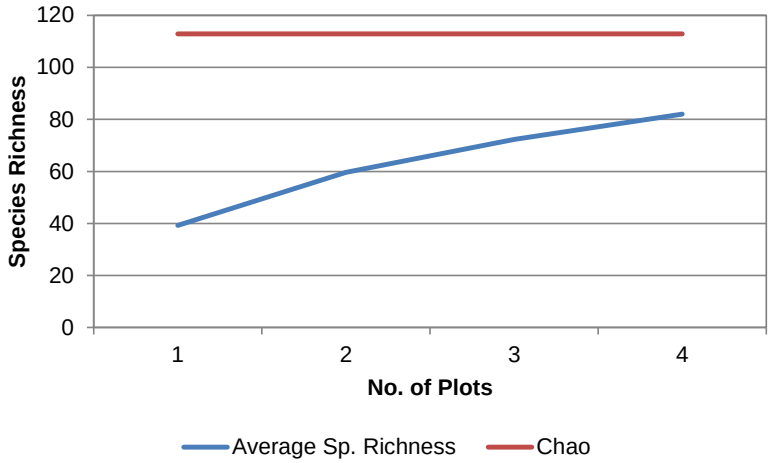
1.2 EmAcMt

Survey effort: 4 quadrats

Species richness: 82 species in total

Chao estimate: 112.87

Percent total species captured: 72.65%



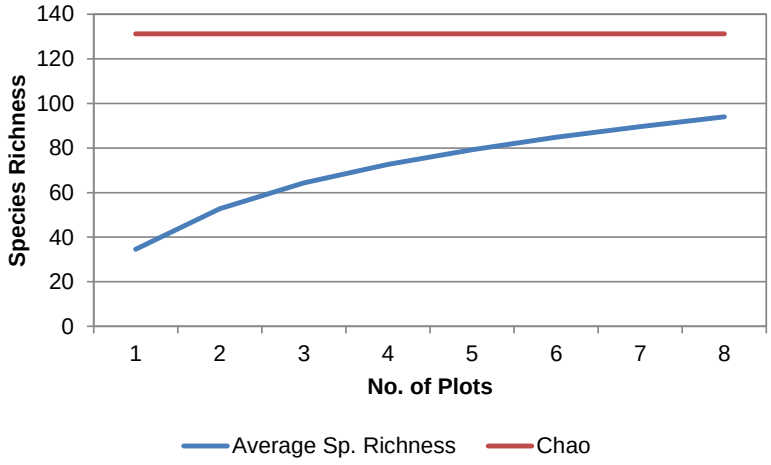
1.3 EmToDo

Survey effort: 8 quadrats

Species richness: 94 species in total

Chao estimate: 131.19

Percent total species captured: 71.65%



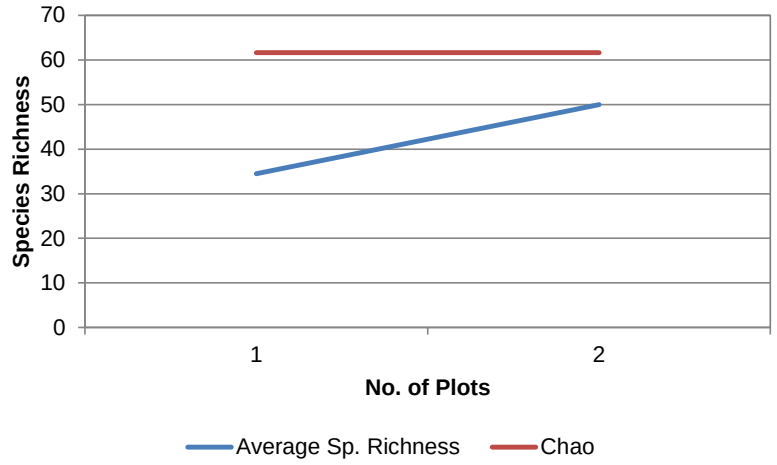
1.4 VdCd

Survey effort: 2 quadrats

Species richness: 50 species in total

Chao estimate: 61.62

Percent total species captured: 81.14%

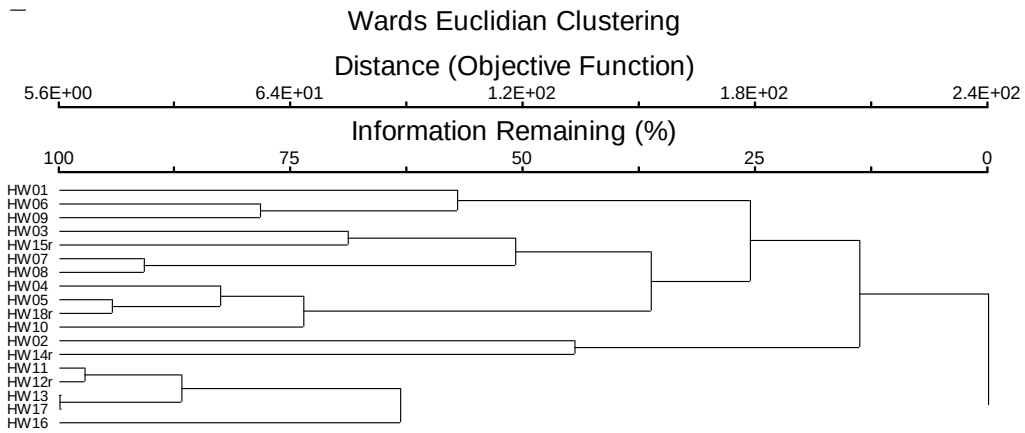


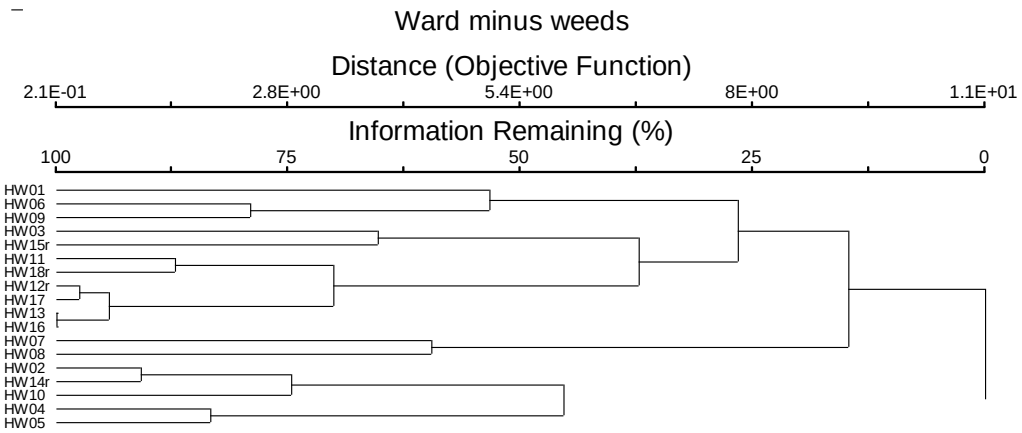
2.0 Dendrograms

Cluster analysis was undertaken using a variety of distance measures. This was done to overcome the cryptic response likely associated with the varying condition of quadrats.

2.1 Ward's Method

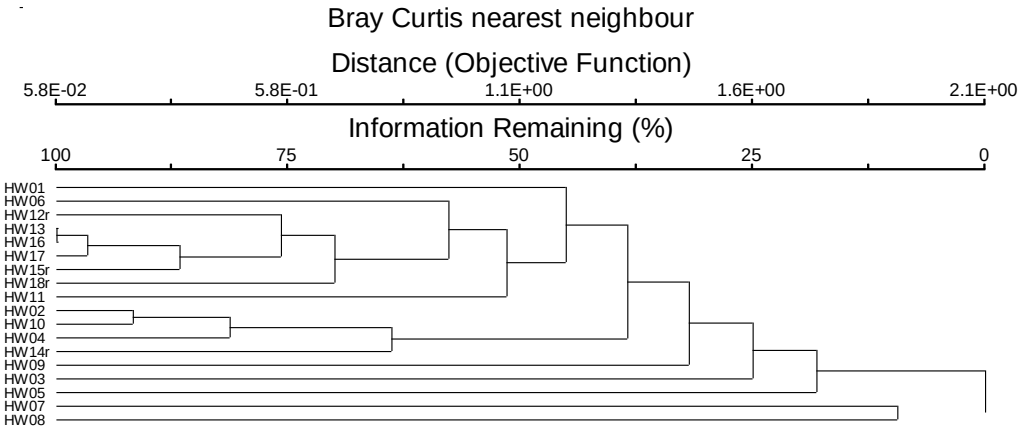
Ward's method using the relative Euclidean distance measure is recommended for ecological community analysis as it avoids distortion (McCune & Grace, 2002).



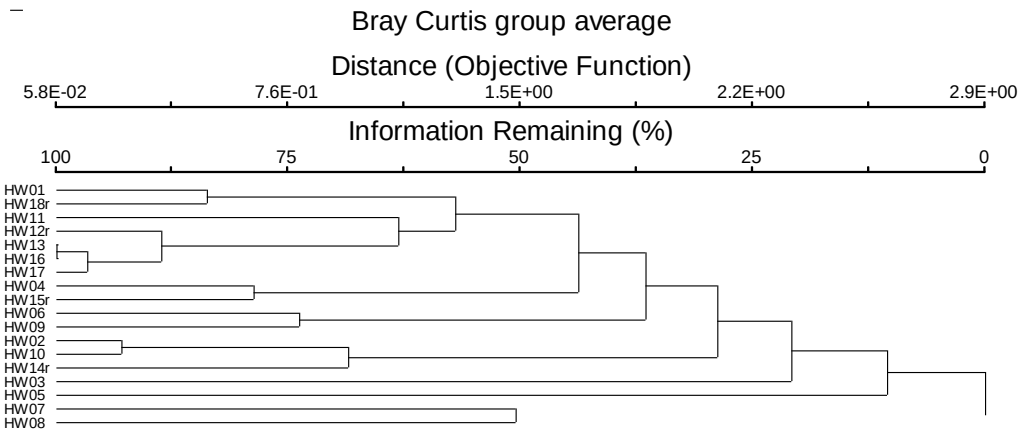


2.2 Bray Curtis

The nearest neighbour measure was used to identify the closest relation for some quadrats not grouping well using Wards method.



The group average distance measure was used as a comparison. Results were similar to nearest neighbour.


Bray Curtis group average
Distance (Objective Function)
5.8E-02
7.6E-01
1.5E+00
2.2E+00
2.9E+00
Information Remaining (%)
100
75
50
25
0
HW01
HW18r
HW11
HW12r
HW13
HW16
HW17
HW04
HW15r
HW06
HW09
HW02
HW10
HW14r
HW03
HW05
HW07
HW08

Appendix C

Banksia Woodlands of the SCP Assessment

Appendix C – Banksia Woodlands of the SCP Assessment

1.0 Banksia Woodlands of the Swan Coastal Plain

1.1 Introduction

The Banksia woodlands of the Swan Coastal Plain encompasses a large natural variation across its range. Furthermore it is subject to varying degrees of disturbance and degradation that have influenced the quality of patches.

The Threatened Species Scientific Committee (TSSC) published the approved Conservation Advice for this community in September 2016. This document details the key diagnostic features applicable for determining the presence of this TEC. Patches must meet the following kei diagnostic characteristics, condition thresholds, and minimum patch sizes:

- Step 1: use key diagnostic characteristics to determine if TEC is present
- Step 2: determine condition of patch
- Step 3: consider if patch meets minimum size threshold
- Step 4: surrounding context of a patch must be taken into account when considering factors that add to the importance of a patch that meets the condition thresholds.

These steps are detailed in the following sections.

1.2 Key Diagnostic Features

Patches are defined as a discreet and mostly continuous area of the ecological community. All native vegetation in Good or better condition has been considered for an assessment against the key diagnostic criteria for the TEC. The native vegetation has been separated into five patches:

- Patch 1 = quadrats 1, 2, 3
- Patch 2 = quadrats 4, 5, 6
- Patch 3 = quadrats 12, 13, 14, 16 and 18
- Patch 4 = quadrats 9, 10, 11, 14, 15
- Patch 5 = quadrat 17

The key diagnostic features have been assessed using patch quadrat data, field observations and mapped vegetation communities in areas under-represented by quadrats (i.e. patch 6).

Table 1 key diagnostic features including location and physical environment, soils and landform, structure, and species composition

Key diagnostic characteristics	1	2	3	4	5
Location and physical environment					
The Banksia Woodlands ecological community primarily occurs on the Swan Coastal Plain IBRA bioregion. Pockets of the community also extent into the adjacent lower parts of the Darling and Whicher escarpments that lie within the Jarrah Forest IBRA bioregion to the immediate east and south of the Swan Coastal Plain.	Y	Y	Y	Y	Y
Soils and landform					
Typically occurs on well drained, low nutrient soils on sandplain landforms, particularly deep Bassendean and Spearwood sands and occasionally on Quindalup sands. Is also common on sandy colluvium and Aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau In other less common scenarios (transitional substrates, sandflats)	Y	Y	Y	Y	Y
Structure					
A distinctive upper sclerophyllous layer of low trees (occasionally large shrubs more than 2 m tall), typically dominated or co-dominated by one or more of the *banksia* species identified below; AND	Y	Y	Y	Y	N – no *Banksia* species dominant
Emergent trees of medium or tall (<10 m) height *Eucalyptus* or *Allocasuarina* species may sometimes be present above the *Banksia* canopy; AND	Y – *E. marginata* and *A. fraseriana*	Y – *E. marginata, A. fraseriana*	Y – *E. marginata, A fraseriana*	Y – *E. marginata, A. fraseriana*	Y – *E. marginata, A. fraseriana*
A often highly species-rich understorey that consists of:	Y – 33 sclerophyllous	Y – 36 sclerophyllous	Y – 36 sclerophyllous	Y – 36 sclerophyllous	N – 12 sclerophyllous

Key diagnostic characteristics	1	2	3	4	5
• A layer of sclerophyllous shrubs of various heights • A herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs that sometimes includes grasses. The development of a ground layer may vary depending on the density of the shrub layer and disturbance history.	shrubs, 11 rushes and sedges, and 35 forbs.	shrubs, 7 sedges and rushes, and 18 forbs.	shrubs, 9 rushes and sedges, and 17 forbs.	shrubs, 10 rushes and sedges, and 28 forbs.	shrubs, 3 sedges, 12 forbs.
Composition					
Canopy is most commonly dominated or co-dominated by *Banksia attenuata* and/or *Banksia menziesii.* Other *Banksia* species that dominate in some examples of the ecological community are *B. prionotes* or *B. ilicifolia*; AND	Y – 6% *B. attenuata*	Y – 8% *B. attenuata,* 3% *B. menziesii*	Y – 2-8% *B. attenuata,* 2-10% *B. menziesii*	Y – *B. menziesii* 0-15%, *B. attenuata* 0-1%	N – No *Banksia* species recorded, predominantly *E. marginata*
Patch must include at least one of the following diagnostic species: • *Banksia attenuata* • *Banksia menziesii* • *Banksia prionotes* • *Banksia ilicifolia*	Y	Y	Y	Y	N
If present, the emergent tree layer often includes *Corymbia calophylla, E. marginata,* or less commonly *E. gomphocephala*; AND	Y – up to 15% *E. marginata*	Y – scattered groups of *E. marginata*	Y – up to 5-40% *E. marginata*	Y – up to 25% *E. marginata*	Y – 20% *E. marginata*
Other trees of a medium height may be present and may be co-dominant with the *Banksia* species across a patch, include *E. todtiana, Nuytsia floribunda, Allocasuarina fraseriana, Callitris arenaria, Callitris pyramidalis* and *Xylomelum occidentale*; AND	Y – *A. fraseriana* trees co-dominate	Y – clusters of *A. fraseriana*	Y – 0-10% *A. fraseriana*	Y – 0-10% *A. fraseriana, 0-2% Nuytsia floribunda*	Y – 10% *A. fraseriana*
Understorey typically contains high to very high diversity of shrub and herb species that often vary from patch to patch.	Y – 92 total species richness (n=3)	Y – 66 total species richness (n=3)	Y – 86 total species richness (n=5)	Y – 83 total species richness (n=5)	Y – 32 total species richness (n=1)

Key diagnostic characteristics	1	2	3	4	5
Contra-indicators					
Patches clearly dominated by *Banksia littoralis* are not part of the TEC	N	N	N	N	N
Patches clearly dominated by *Banksia burdettii* are not the TEC	N	N	N	N	N
FCT 20c – Eastern shrublands and woodlands, corresponds with a separate EPBC ecological community listing, Shrublands and Woodlands of the eastern Swan Coastal Plain. Occurrences of this FCT should be considered under that separate listing.	N	N	N	N	N

1.3 Condition

The condition of vegetation of each patch needs to be determined in accordance with the following:

- The condition assessment of a patch should be centred on the area of highest native floristic diversity and/or cover of the patch.
- Timing of surveys and recent disturbance should be taken into account
- Surrounding context of a patch should be considered
- Certain vegetation components of Banksia Woodlands community merit consideration as critical elements to protect. Three components are recognised as threatened in their own right i.e. Priority Ecological Communities
- A relevant expert may be useful to help identify the ecological community and its condition.
- Vegetation must be in 'Good' or better condition in accordance with Table 2.

Table 2 Condition Table

Keighery (1994) Vegetation Condition Scale	Indicative condition measures/thresholds	
	Typical native vegetation composition	Typical weed cover
Pristine No obvious signs of disturbance	Native plant species diversity fully retained or almost so[1]	Zero or almost no weed cover/abundance
Excellent Vegetation structure intact, disturbance only affecting individual species, weeds are non-aggressive species.	High native plant species diversity[1]	Less than 10%
Very Good Vegetation structure altered, obvious signs of disturbance (e.g. repeated fires, dieback, logging, grazing). Aggressive weeds present.	Moderate native plant species diversity[1]	5 – 20%
Good Vegetation structure altered but retains basic vegetation structure or ability to regenerate it. Obvious signs of disturbance (from partial clearing, dieback, logging, grazing). Presence of very aggressive weeds.	Low native plant species diversity[1]	5 – 50%
Degraded Basic vegetation structure severely impacted by disturbance. Requires intensive management. Disturbance evident such as partial clearing, dieback, logging and grazing. Presence of very aggressive weeds at high density.	Very low native plant species diversity[1]	20 – 70%
Completely Degraded Vegetation structure is no longer intact and the area is completely or almost completely without native flora. Equivalent to 'Parkland Cleared'.	Very low to no native species diversity[1]	Greater than 70%

1. relative to expected natural range of diversity for that vegetation unit e.g. Floristic Community Type where comparative data exists.

1.4 Minimum Patch Size

Different minimum patch sizes apply to different levels of condition, as outlined below:

- Pristine – no minimum patch size
- Excellent – 0.5 ha or 5,000 m^2 (50 x 100 m)
- Very Good – 1 ha or 10,000 m^2 (100 x 100 m)
- Good – 2 ha or 20,000 m^2 (200 x 100 m)

1.5 Further Information

The following information should be taken into consideration when applying the key diagnostic criteria and condition thresholds:

- Land use history and landscape position of patch including position relative to surrounding vegetation
- A patch is a discreet and mostly continuous area of the ecological community and may include small-scale variations (<30 m), gaps and disturbances such as tracks paths or breaks that do not significantly alter the overall functionality of the ecological community.
- Variation in canopy cover, quality or condition of vegetation across a patch should not be considered evidence of multiple patches
- A buffer zone is a contiguous area immediately adjacent to a patch of the ecological community. The recommended minimum buffer zone is 20-50 m. larger buffer zones should be considered for patches of particularly high conservation value, or if patches are down slope of drainage lines or a source of nutrient enrichment, or groundwater drawdown.
- Restored vegetation is not excluded provided it meets the key diagnostic criteria, condition threshold and patch size.
- Sampling protocols includes developing a quick map of the vegetation, landscape qualities and management history. Following this, a thorough sampling exercise must be undertaken to represent the range of variation. At least one hour per plot in early to mid-spring and a second survey in late spring may be required to detect the majority of species. plots to be at least 100 m^2 (10 x 10 m). Search effort (number of person hours per plot across entire patch) and surveyor's level of expertise can be useful for future reference.
- Timing of surveys should allow a reasonable interval after a disturbance. Surveys at least one year post fire may be required to assess a site against the key diagnostic characteristics and minimum condition thresholds.
- Surrounding environment, landscape context and other significance considerations:
    - patches that are more species rich and less disturbed are likely to provide greater biodiversity value.
    - Patches that provide corridors or linkages within a largely modified landscape are particularly important.

The Conservation Advice provides an additional ten indicators to be considered when assessing impacts of actions or proposed actions under the EPBC Act. These are not further listed here.

1.6 Protected in Reserves

The level of protection in reserves has been published based on estimated extent of major and partially corresponding vegetation system associations. This is shown in Table 3.

Table 3 Extent of Banksia Woodlands ecological community estimated to be protected in reserves

Subregion	Current extent (ha)	Extent in reserves (ha)	% Protected
Dandaragan (SWA01)	81,067.8	24,671.2	30.43
Perth (SWA02)	253,540.6	57,054.9	22.50
Jarrah Forests (JAF01/02)	1,881.4	105.9	5.63
TOTAL	**336,489.9**	**81,832.0**	**24.32**

2.0 Results

2.1 Patch 1

Patch 1 incorporates native vegetation along Smokebush Way and Roe Highway. This patch meets all the key diagnostic features as published in the approved conservation advice (TSSC, 2016). There are three vegetation communities mapped within this patch including two *Eucalyptus marginata* and *Banksia* communities and one *Allocasuarina fraseriana* community (EmToDo, EmAcMt and AfHhMp). *E. marginata* and *A. fraseriana* comprise 10-15% of the canopy cover, with *Banksia menziesii* and *Banksia attenuata* representing less than 10%. Despite this co-dominance of other species, the desktop results show the presence of the TEC at this location.

Condition varied from 'Excellent' to 'Very Good'. This patch meets the minimum size requirement, extending 2.33 ha. The condition of the patch is rated at its best mapped condition (Excellent). It therefore is considered to meet the minimum patch size criteria.



Plate 1 Patch 1 photographs

2.3 Patch 2

Patch 2 includes native vegetation on 9, 29, 31 and 37 Brand Road. This patch meets all the key diagnostic features as published in the approved conservation advice (TSSC, 2016). There are three quadrats representing patch 2 including 4, 5 and 6. Two vegetation communities have been mapped within this patch including AfHhMp and EmAcMt. Co-dominant overstorey species include *Allocasuarina fraseriana* and *Eucalyptus marginata* subsp. *marginata*.

One area within patch 2 has been assumed to have been historically cleared. Bare ground is high, and colonising species including *Banksia sessilis* and *Adenanthos cygnorum* dominate the tall shrub stratum. However over time it is likely that this community will regenerate to become a Banksia dominated community as it is surrounded by 'Excellent' condition vegetation all representing the Banksia woodlands TEC.

Condition varied from 'Excellent' to 'Very Good'. This patch meets the minimum size requirement, extending 2.13 ha. The condition of the patch is rated at its best mapped condition (Excellent). It therefore is considered to meet the minimum patch size criteria.



Plate 2 Patch 2 vegetation in 'Excellent' and 'Very Good' condition

2.4 Patch 3

Patch 3 includes native vegetation on 105, 111, 117, 123, and 129 Sultana West Road and 23, 35, 39, and 41 Brae Road and 12, 22, 32 and 42 Brand Road. It was represented by only four quadrats (12, 13, 14, 16 and 18). This patch meets all the key diagnostic features as published in the approved conservation advice (TSSC, 2016). *Eucalyptus marginata* is the dominant to co-dominant overstorey species of this community, in one quadrat representing 40% of the foliage cover. However, this sometimes reflects the small size of a quadrat and importance of quadrat placement.

This patch is in varying condition ranging from 'Good' to 'Excellent' (Plate 3). Areas in 'Good' condition maintained overstorey native species and some understorey species however invasive grasses such as **Ehrharta calycina* and **Avena barbata* dominated on the sandy soils. Patch 3 is 2.76 ha, thereby meeting minimum patch requirements.



Plate 3 Patch 3 vegetation in 'Good' and 'Excellent' condition

2.5 Patch 4

Patch 4 includes native vegetation on Lots 59, 63 and 67 Brae Road and 62, 70, 78 Brand Road. This patch is represented by Quadrats 9, 10, 11, 14, and 15. This patch meets all the key diagnostic features as published in the approved conservation advice (TSSC, 2016). Similar to patch 3, some areas show a high foliage cover of *Eucalyptus marginata*, however the patch is predominantly *Banksia* woodlands.

Vegetation is in 'Good' to 'Excellent' condition (Plate 4). Minimum size thresholds have been met as the patch extends for 29.56 ha, with the majority of area mapped as Very Good. This meets the minimum patch size criteria.



Plate 4 Patch 4 vegetation in 'Good' and 'Excellent' condition

2.6 Patch 5

This patch encompasses Lot 24, 28, 32 and 38 Bray Road and is represented by one quadrat (17) and field observations. The patch is mapped as community EmToDo. This patch does not meet the key diagnostic features and is therefore not considered to represent the Banksia woodlands of the SCP TEC.

The quadrat data and field observations show that *Banksia* species do not form the dominant or co-dominant overstorey species. The overstorey is dominated by *Eucalyptus marginata* and *Allocasuarina fraseriana*.

Appendix D

Flora Species by Family and Community

Appendix D - Flora Species by Family and Community

Family	Cons. Code	Taxon	AfHhMp	EmAcMt	EmToDo	VdCd
Amaranthaceae						
		Ptilotus manglesii		x		
Anarthriaceae						
		Lyginia barbata	x	x	x	x
Apiaceae						
		Xanthosia huegelii	x		x	x
Araliaceae						
		Trachymene pilosa	x			
Asparagaceae						
		Lomandra hermaphrodita	x			
		Lomandra micrantha				x
		Lomandra preissii	x		x	
		Lomandra sericea	x	x	x	
		Lomandra suaveolens	x			
		Thysanotus affinis	x			
		Thysanotus arbuscula	x	x	x	
		Thysanotus patersonii				x
Asteraceae						
	PL	Asteraceae (planted)			x	
		Hyalosperma cotula				x
	*	*Hypochaeris glabra*	x		x	
		Rhodanthe citrina	x			
	*	*Ursinia anthemoides*	x	x	x	x
		Vellereophyton dealbatum	x	x	x	
Casuarinaceae						
		Allocasuarina fraseriana	x	x	x	
		Allocasuarina humilis	x	x	x	x
Colchicaceae						
		Burchardia congesta	x	x	x	x
Cyperaceae						
		Caustis dioica	x		x	x
		Cyathochaeta avenacea	x	x	x	x
		Lepidosperma leptostachyum	x	x	x	
		Lepidosperma sp.			x	
		Mesomelaena pseudostygia	x	x	x	
		Mesomelaena tetragona	x		x	x
		Schoenus brevisetis	x	x	x	x
		Tetraria octandra	x	x	x	x
		Tricostularia exsul	x	x	x	
Dasypogonaceae						
		Dasypogon bromeliifolius	x	x	x	x
		Dasypogon obliquifolius	x	x	x	
Dillenaceae						
		Hibbertia huegelii	x			
		Hibbertia hypericoides	x	x	x	x
Ericaceae						
		Astroloma stomarrhena		x		
		Conostephium pendulum	x	x	x	
		Leucopogon ?conostephioides			x	
		Leucopogon sp.		x		
		Lysinema pentapetalum		x		
Euphorbiaceae						
		Monotaxis grandiflora var. *grandiflora*	x	x	x	
		Stachystemon vermicularis	x		x	

Family	Cons. Code	Taxon	AfHhMp	EmAcMt	EmToDo	VdCd
Fabaceae						
		Acacia pulchella var. *pulchella*	x	x		
	PL	*Acacia* sp.			x	
		Bossiaea eriocarpa	x	x	x	x
		Daviesia angulata	x	x		x
		Daviesia divaricata	x		x	
		Daviesia nudiflora subsp. *nudiflora*	x	x	x	
		Daviesia preissii		x	x	x
		Gastrolobium capitatum	x	x	x	x
		Gompholobium confertum	x	x	x	
		Gompholobium knightianum	x		x	
		Gompholobium tomentosum	x	x	x	
		Jacksonia floribunda	x	x	x	
		Jacksonia lehmannii	x	x		x
		Kennedia prostrata		x		
Goodeniaceae						
		Dampiera alata			x	
		Dampiera linearis	x	x	x	
		Goodenia caerulea				x
		Lechenaultia biloba	x		x	
		Scaevola canescens	x			x
		Scaevola repens var. *repens*	x	x	x	x
Haemodoraceae						
		Anigozanthos manglesii	x		x	x
		Conostylis aurea		x	x	x
		Conostylis juncea	x			x
		Conostylis serrulata		x		
		Conostylis setigera	x	x		
		Conostylis setosa		x		
		Haemodorum laxum	x	x	x	x
		Haemodorum sp.		x	x	
		Haemodorum spicatum	x	x		x
Hemerocallidaceae						
		Agrostocrinum scrabrum				x
		Caesia micrantha	x	x	x	x
		Johnsonia pubescens subsp. *pubescens*		x		
		Tricoryne elatior	x	x	x	x
Iridaceae						
	*	*Gladiolus caryophyllaceus*	x	x	x	x
		Patersonia occidentalis	x	x	x	x
Lamiaceae						
		Hemiandra linearis	x		x	
		Hemiandra pungens	x	x	x	
		Hemiphora bartlingii	x	x	x	
Loranthaceae						
		Nuytsia floribunda	x	x	x	
Malvaceae						
		Thomasia macrocarpa	x			

Family	Cons. Code	Taxon	AfHhMp	EmAcMt	EmToDo	VdCd
Myrtaceae						
		Babingtonia camphorosmae			x	x
		Calothamnus quadrifidus subsp. *quadrifidus*			x	
		Calothamnus torulosus	x	x		
		Calytrix sp.	x			
		Eremaea pauciflora var. *pauciflora*		x		
		Eucalyptus gomphocephala			x	
		Eucalyptus marginata subsp. *marginata*	x	x	x	x
		Hypocalymma angustifolium				x
		Kunzea glabrescens		x		
		Melaleuca trichophylla	x	x	x	
		Verticordia densiflora var. *densiflora*			x	x
Orchidaceae						
		Caladenia sp.		x		
		Microtis media			x	
Phyllanthaceae						
		Phyllanthus calycinus	x			
Pittosporaceae						
		Billardiera fraseri		x		
		Cheiranthera preissiana			x	x
Poaceae						
	*	*Aira caryophyllea*	x			
		Amphipogon strictus		x		
	*	*Avena barbata*	x			
	*	*Briza maxima*	x	x	x	x
	*	*Ehrharta calycina*	x	x	x	x
	*	*Eragrostis curvula*			x	
	*	*Pentameris airoides subsp. airoides*				x
Proteaceae						
		Adenanthos cygnorum subsp. *cygnorum*	x	x	x	
		Banksia armata var. *armata*	x	x	x	
		Banksia attenuata	x	x	x	
		Banksia dallanneyi	x		x	
		Banksia dallanneyi var. *dallanneyi*	x	x	x	x
		Banksia grandis	x		x	
		Banksia menziesii	x	x	x	
		Banksia sessilis var. *sessilis*			x	
		Banksia sphaerocarpa		x	x	
	T	*Conospermum undulatum*	x	x	x	
		Grevillea bipinnatifida subsp. *bipinnatifida*				x
		Hakea conchifolia	x		x	
		Hakea costata			x	
		Hakea incrassata	x			
		Hakea lissocarpha	x			
	P3	*Isopogon drummondii*	x	x	x	
		Lambertia multiflora	x	x	x	
		Persoonia elliptica			x	
		Petrophile macrostachya	x	x	x	
		Petrophile rigida	x			
		Petrophile linearis	x	x	x	
		Stirlingia latifolia	x	x	x	x
		Synaphea sp.	x	x	x	
		Xylomelum occidentale	x		x	

Family	Cons. Code	Taxon	AfHhMp	EmAcMt	EmToDo	VdCd
Restionaceae						
		Alexgeorgea nitens	x	x	x	x
		Desmocladus fasciculatus	x	x	x	x
		Desmocladus flexuosus		x		
		Hypolaena exsulca			x	x
Rubiaceae						
		Opercularia vaginata	x		x	
Rutaceae						
		Boronia ramosa subsp. *anethifolia*	x	x	x	x
		Philotheca spicata	x		x	x
Stylidiaceae						
		Levenhookia pusilla	x			
		Stylidium diuroides subsp. *diuroides*	x			
		Stylidium piliferum	x	x		
Thymelaeaceae						
		Pimelea ciliata subsp. *ciliata*	x	x	x	
Xanthorrhoeaceae						
		Xanthorrhoea acanthostachya	x	x	x	
		Xanthorrhoea gracilis		x	x	
		Xanthorrhoea preissii	x	x	x	x

Appendix E

Quadrat Data

Plot Data

Site No: HW01	Type: Quadrat	Longitude: 116.009195	Latitude: -31.96267
Date: 11/22/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: AfHhMp		Fire History: 10+	
Vegetation Condition: E. Edge Effect			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		250	2
Aira caryophyllea	*	10	0.1
Alexgeorgea nitens		5	2
Allocasuarina fraseriana		800	10 in landscape
Allocasuarina humilis			Oppo
Anigozanthos manglesii		60	0.3
Banksia attenuata			Oppo
Banksia dallanneyi var. *dallanneyi*		10	3
Banksia menziesii		500	2
Bossiaea eriocarpa		20	0.3
Briza maxima	*	30	0.5
Burchardia congesta		30	0.2
Caesia micrantha		70	0.1
Calothamnus torulosus			Oppo
Caustis dioica			Oppo
Conospermum undulatum			
Conostephium pendulum			Oppo
Dampiera linearis		15	0.1
Dasypogon obliquifolius		30	1
Daviesia divaricata			Oppo
Daviesia nudiflora subsp. *nudiflora*		50	0.3
Desmocladus fasciculatus		5	0.1
Ehrharta calycina	*	100	0.3
Eucalyptus marginata subsp. *marginata*		1200	8 in landscape
Gastrolobium capitatum		40	0.1
Gladiolus caryophyllaceus	*	50	0.5
Gompholobium knightianum		2	0.1
Gompholobium tomentosum			Oppo
Haemodorum laxum		120	0.5
Hakea conchifolia			Oppo
Hakea incrassata			Oppo
Hibbertia hypericoides		30	2
Hypochaeris glabra	*	30	0.1
Jacksonia floribunda			Oppo
Lambertia multiflora		100	2
Lepidosperma leptostachyum		80	0.2

Taxon	Cons. Code	Height (cm)	% Alive
Levenhookia pusilla		5	0.1
Lomandra preissii		40	0.3
Lomandra sericea		30	0.1
Lomandra suaveolens		10	0.1
Melaleuca trichophylla		40	4
Mesomelaena pseudostygia		30	10
Mesomelaena tetragona		50	1
Nuytsia floribunda			Oppo
Opercularia vaginata		15	2
Patersonia occidentalis			Oppo
Petrophile macrostachya			Oppo
Petrophile linearis		40	0.5
Philotheca spicata			Oppo
Phyllanthus calycinus			Oppo
Pimelea ciliata subsp. *ciliata*			Oppo
Rhodanthe citrina		10	0.1
Scaevola canescens		3	0.2
Scaevola repens var. *repens*		15	3
Schoenus brevisetis		30	8
Stirlingia latifolia			Oppo
Stylidium diuroides subsp. *diuroides*		10	0.1
Isopogon drummondii	P3	100	0.5
Boronia ramosa subsp. *anethifolia*		30	0.2
Synaphea sp.			Oppo
Tetraria octandra		30	6
Trachymene pilosa		4	0.1
Tricoryne elatior		25	0.2
Tricostularia exsul		80	0.5
Ursinia anthemoides	*	20	0.1
Xanthorrhoea acanthostachya		100	8
Xanthorrhoea preissii			Oppo
Xanthosia huegelii		10	0.1

Site No: HW02	Type: Quadrat	Longitude: 116.009435	Latitude: -31.962045
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmAcMt		Fire History: 10+	

Vegetation Condition: E. Rubbish, Edge effect





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		350	6
Allocasuarina humilis		60	2
Astroloma stomarrhena		5	0.1
Banksia dallanneyi var. *dallanneyi*		30	2
Banksia menziesii		500	6
Bossiaea eriocarpa		15	0.2
Briza maxima	*	30	0.1
Burchardia congesta		30	0.1
Caesia micrantha			oppo
Caladenia sp.		5	0.1
Calothamnus torulosus		40	0.2
Conospermum undulatum		160	0.3
Conostylis aurea		20	0.1
Conostylis serrulata			oppo
Conostylis setigera		15	0.1
Conostylis setosa			oppo
Cyathochaeta avenacea		100	1
Dasypogon bromeliifolius			oppo
Dasypogon obliquifolius		20	1
Daviesia angulata		100	0.6
Daviesia nudiflora subsp. *nudiflora*		40	0.3
Desmocladus fasciculatus		10	0.1
Desmocladus flexuosus		30	0.6
Eucalyptus marginata subsp. *marginata*		600	10
Gastrolobium capitatum		20	0.1
Gastrolobium capitatum		40	0.1
Gladiolus caryophyllaceus	*	50	0.1
Gompholobium tomentosum			oppo
Haemodorum laxum		140	1
Hemiphora bartlingii		20	0.1
Hibbertia hypericoides		30	6
Jacksonia lehmannii		40	0.1
Kennedia prostrata			oppo
Lambertia multiflora		80	1
Lepidosperma leptostachyum		60	1
Lomandra sericea		30	0.2
Lyginia barbata			oppo

Taxon	Cons. Code	Height (cm)	% Alive
Melaleuca trichophylla		40	6
Mesomelaena pseudostygia		50	15
Patersonia occidentalis		30	0.4
Petropile linearis		30	0.2
Pimelea ciliata subsp. *ciliata*		20	0.1
Scaevola repens var. *repens*		10	1
Stirlingia latifolia		50	0.3
Stylidium piliferum		10	0.1
Boronia ramosa subsp. *anethifolia*		30	0.1
Synaphea sp.		40	0.1
Tetraria octandra		60	15
Thysanotus arbuscula		30	0.1
Tricoryne elatior		30	0.1
Tricoryne elatior		30	1
Tricostularia exsul		100	3
Ursinia anthemoides	*	10	0.1
Vellereophyton dealbatum		5	0.1
Xanthorrhoea acanthostachya		230	0.5
Xanthorrhoea gracilis		60	5

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Site No: HW03	Type: Quadrat	Longitude: 116.010158	Latitude: -31.960788
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: E. Weeds			





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Revision A – 17-Dec-2016
Prepared for – Holcim (Australia) Pty Ltd – ABN: 87 099 732 297

Taxon	Cons. Code	Height (cm)	% Alive
Alexgeorgea nitens		30	25
Allocasuarina fraseriana		250	2
Banksia attenuata		500	4
Banksia dallanneyi var. *dallanneyi*		20	2
Bossiaea eriocarpa		30	1.5
Briza maxima	*	30	0.2
Burchardia congesta		60	0.2
Calothamnus quadrifidus subsp. *quadrifidus*			oppo
Conospermum undulatum		50	0.2
Cyathochaeta avenacea		100	4
Dampiera alata		30	0.2
Dasypogon obliquifolius		30	0.2
Daviesia nudiflora subsp. *nudiflora*		40	0.5
Ehrharta calycina	*	100	0.4
Eragrostis curvula	*	130	1
Eucalyptus marginata subsp. *marginata*		1300	15
Gastrolobium capitatum		40	0.1
Gladiolus caryophyllaceus	*	80	0.1
Gompholobium confertum			oppo
Gompholobium knightianum		10	0.1
Haemodorum laxum		130	2
Hemiandra pungens		20	0.3
Jacksonia floribunda		40	0.2
Lepidosperma sp.		30	15
Lomandra sericea		30	0.2
Lomandra sericea		40	0.3
Melaleuca trichophylla		40	0.3
Petrophile linearis		50	0.1
Scaevola repens var. repens		10	4
Schoenus brevisetis		40	1
Stirlingia latifolia		50	0.6
Synaphea sp.		20	1
Thysanotus arbuscula		80	0.1
Tricoryne elatior		40	0.5
Xanthorrhoea preissii		100	5

Site No: HW04	Type: Quadrat	Longitude: 116.006648	Latitude: -31.962009
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: AfHhMp		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		350	15
Allocasuarina fraseriana		300	0.5
Allocasuarina humilis		70	1
Banksia attenuata		500	2
Banksia dallanneyi		30	0.2
Banksia dallanneyi var. *dallanneyi*		20	4
Banksia grandis		500	5
Bossiaea eriocarpa		30	0.4
Burchardia congesta		40	0.2
Caesia micrantha		70	0.1
Calothamnus torulosus		20	0.1
Calytrix sp.			Oppo
Conospermum undulatum		20	0.1
Conostylis juncea		5	0.1
Cyathochaeta avenacea		110	0.2
Dampiera linearis		5	0.1
Dasypogon bromeliifolius		50	3
Dasypogon obliquifolius		20	0.5
Daviesia nudiflora subsp. *nudiflora*		30	0.2
Desmocladus fasciculatus		10	0.1
Eucalyptus marginata subsp. *marginata*		1400	20
Gastrolobium capitatum		30	0.1
Gompholobium confertum			Oppo
Haemodorum laxum		20	0.1
Haemodorum spicatum		100	0.1
Hakea lissocarpha		80	0.5
Hemiphora bartlingii			Oppo
Hibbertia huegelii		20	0.1
Hibbertia hypericoides		40	4
Lambertia multiflora		90	0.5
Lomandra hermaphrodita		20	0.1
Lomandra sericea		30	0.1
Lyginia barbata		60	1
Melaleuca trichophylla		40	0.5
Mesomelaena tetragona		50	10
Patersonia occidentalis		40	0.5
Petrophile linearis		30	0.2

Taxon	Cons. Code	Height (cm)	% Alive
Petrophile macrostachya		50	0.4
Philotheca spicata		100	0.2
Scaevola repens var. *repens*		15	1
Stachystemon vermicularis		40	1
Stirlingia latifolia		50	1.5
Isopogon drummondii	P3	80	1
Thysanotus affinis		20	0.1
Tricoryne elatior		30	0.1
Tricostularia exsul		80	15
Xanthorrhoea acanthostachya		80	4
Xylomelum occidentale		30	0.1

Site No: HW05	Type: Releve	Longitude: 116.007014	Latitude: -31.962401
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition:	
Community: EmAcMt		Fire History:	
Vegetation Condition: VG.			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		400	25
Allocasuarina fraseriana		250	0.5
Allocasuarina humilis		80	0.5
Bossiaea eriocarpa		30	0.2
Conospermum undulatum			Oppo
Cyathochaeta avenacea		120	0.5
Dampiera linearis		10	0.1
Dasypogon obliquifolius		40	0.1
Daviesia nudiflora subsp. *nudiflora*			Oppo
Eremaea pauciflora var. *pauciflora*		50	0.5
Eucalyptus marginata subsp. *marginata*		300	1
Gompholobium confertum		20	0.1
Gompholobium tomentosum		40	0.3
Haemodorum laxum			Oppo
Hemiphora bartlingii		30	0.2
Hibbertia hypericoides		30	1
Johnsonia pubescens subsp. *pubescens*			Oppo
Kunzea glabrescens		250	1
Lambertia multiflora		100	0.5
Lyginia barbata		50	0.2
Lysinema pentapetalum			Oppo
Petrophile linearis			Oppo
Schoenus brevisetis			Oppo
Stirlingia latifolia		40	0.5
Isopogon drummondii	P3	60	0.4
Synaphea sp.			Oppo
Tricostularia exsul		100	20
Xanthorrhoea preissii		80	3

Site No: HW06	Type: Quadrat	Longitude: 116.007671	Latitude: -31.961865
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: AfHhMp		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina fraseriana		700	8
Allocasuarina humilis		60	2
Banksia attenuata		500	8
Banksia dallanneyi var. *dallanneyi*		10	1
Banksia menziesii		400	3
Bossiaea eriocarpa		30	0.2
Briza maxima	*	30	0.1
Burchardia congesta		40	0.1
Calothamnus torulosus		30	1
Caustis dioica		40	0.3
Conostephium pendulum		40	0.1
Cyathochaeta avenacea		100	0.5
Dasypogon bromeliifolius		30	0.5
Dasypogon obliquifolius		30	2
Daviesia nudiflora subsp. *nudiflora*		50	0.2
Ehrharta calycina	*	100	4
Gastrolobium capitatum		20	0.1
Gladiolus caryophyllaceus	*	60	0.2
Gompholobium confertum		25	0.1
Gompholobium tomentosum		30	0.1
Haemodorum laxum		70	0.1
Hemiandra pungens		20	0.2
Hemiphora bartlingii		25	0.1
Hibbertia hypericoides		40	2
Lepidosperma leptostachyum		60	1
Mesomelaena pseudostygia		30	5
Petrophile macrostachya		40	0.3
Petrophile rigida		40	0.2
Scaevola repens var. *repens*		10	0.2
Schoenus brevisetis		40	1
Isopogon drummondii	P3	100	3
Tricoryne elatior		30	0.1
Tricostularia exsul		60	1
Xanthorrhoea preissii		100	6

Site No: HW07	Type: Quadrat	Longitude: 115.995246	Latitude: -31.952148
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: White	
Rocky Type:		Soil Condition: Dry	
Community: VdCd		Fire History: 10+	
Vegetation Condition: VG.			





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Taxon	Cons. Code	Height (cm)	% Alive
Alexgeorgea nitens		15	0.2
Anigozanthos manglesii		30	0.3
Banksia dallanneyi var. *dallanneyi*		10	0.2
Briza maxima	*	30	0.1
Caesia micrantha		25	0.1
Caustis dioica		30	2
Conostylis juncea		20	0.1
Cyathochaeta avenacea		120	0.5
Dasypogon bromeliifolius			Oppo
Daviesia angulata		60	0.3
Ehrharta calycina	*	120	0.3
Eucalyptus marginata subsp. *marginata*		2000	2
Gladiolus caryophyllaceus	*	40	0.1
Grevillea bipinnatifida subsp. *bipinnatifida*		40	0.3
Haemodorum spicatum		100	1
Hypocalymma angustifolium			Oppo
Hypolaena exsulca		25	0.1
Jacksonia lehmannii		15	0.1
Lomandra micrantha		25	0.1
Lyginia barbata		50	1
Mesomelaena tetragona		60	0.5
Patersonia occidentalis		40	1
Pentameris airoides subsp. *airoides*	*	20	0.5
Scaevola canescens		10	0.1
Schoenus brevisetis		50	1
Stirlingia latifolia		60	2
Boronia ramosa subsp. *anethifolia*		20	0.1
Tricoryne elatior		30	0.2
Ursinia anthemoides	*	15	1
Verticordia densiflora var. *densiflora*		50	6
Xanthorrhoea preissii		70	0.5

Site No: HW08	Type: Quadrat	Longitude: 115.995632	Latitude: -31.953041
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: VdCd		Fire History: 10+	
Vegetation Condition: E.			





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Taxon	Cons. Code	Height (cm)	% Alive
Agrostocrinum scabrum		30	0.1
Allocasuarina humilis		60	1
Anigozanthos manglesii		60	0.2
Babingtonia camphorosmae		30	0.2
Banksia dallanneyi var. *dallanneyi*		20	0.1
Bossiaea eriocarpa		30	0.2
Briza maxima	*	30	0.2
Burchardia congesta		40	0.2
Caustis dioica		50	10
Cheiranthera preissiana			0.1
Conostylis aurea		15	0.2
Dasypogon bromeliifolius		30	1
Daviesia angulata		90	8
Daviesia preissii			Oppo
Desmocladus fasciculatus		10	0.1
Eucalyptus marginata subsp. *marginata*		2500	5
Gastrolobium capitatum		20	0.2
Gladiolus caryophyllaceus	*	40	0.2
Goodenia caerulea		15	0.1
Grevillea bipinnatifida subsp. *bipinnatifida*		30	0.6
Haemodorum laxum		80	0.1
Hibbertia hypericoides		50	0.4
Hyalosperma cotula		10	0.1
Hypocalymma angustifolium		50	3
Hypolaena exsulca		20	0.4
Hypolaena exsulca		30	0.2
Lyginia barbata		40	1
Mesomelaena tetragona		70	3
Patersonia occidentalis		30	2
Philotheca spicata		60	0.3
Scaevola repens var. *repens*		10	0.2
Stirlingia latifolia		50	0.5
Boronia ramosa subsp. *anethifolia*		20	0.1

Taxon	Cons. Code	Height (cm)	% Alive
Tetraria octandra		40	2
Thysanotus patersonii			0.1
Tricoryne elatior		20	0.6
Verticordia densiflora var. *densiflora*		50	1
Xanthorrhoea preissii		80	2
Xanthosia huegelii		15	0.2

Site No: HW09	Type: Quadrat	Longitude: 116.007428	Latitude: -31.956075
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: AfHhMp		Fire History: 10+	
Vegetation Condition:			





Taxon	Cons. Code	Height (cm)	% Alive
Acacia pulchella var. pulchella		80	0.6
Adenanthos cygnorum subsp. *cygnorum*		200	
Alexgeorgea nitens		10	0.2
Allocasuarina fraseriana		600	10
Allocasuarina humilis			Oppo
Anigozanthos manglesii		60	0.2
Avena barbata	*		Oppo
Banksia armata var. *armata*			Oppo
Banksia attenuata		400	
Banksia dallanneyi var. *dallanneyi*		20	1
Bossiaea eriocarpa		40	2
Briza maxima	*	20	0.2
Burchardia congesta		50	0.2
Caesia micrantha			Oppo
Calothamnus torulosus		30	0.2
Caustis dioica		50	8
Conostephium pendulum			Oppo
Conostylis setigera		15	0.1
Cyathochaeta avenacea		110	0.4
Dampiera linearis		15	0.1
Dasypogon obliquifolius		30	0.5
Daviesia angulata		60	0.4
Daviesia nudiflora subsp. *nudiflora*			Oppo
Desmocladus fasciculatus		10	1
Ehrharta calycina	*		Oppo
Gastrolobium capitatum		30	0.5
Gladiolus caryophyllaceus	*	50	0.2
Haemodorum laxum		130	2
Haemodorum spicatum			Oppo
Hakea conchifolia		60	0.4
Hemiandra linearis			Oppo
Hemiphora bartlingii			Oppo
Hibbertia hypericoides		60	20
Jacksonia lehmannii		25	0.1
Lambertia multiflora		150	8
Lechenaultia biloba			Oppo
Lepidosperma leptostachyum		40	0.5

Taxon	Cons. Code	Height (cm)	% Alive
Lomandra sericea		30	0.4
Lyginia barbata		40	0.2
Mesomelaena pseudostygia		50	6
Mesomelaena tetragona		50	2
Monotaxis grandiflora var. *grandiflora*			Oppo
Nuytsia floribunda		700	2
Patersonia occidentalis			Oppo
Petrophile macrostachya		50	0.8
Philotheca spicata		60	0.2
Pimelea ciliata subsp. *ciliata*		50	0.1
Scaevola repens var. *repens*		10	0.2
Schoenus brevisetis		40	0.4
Stylidium piliferum		10	0.1
Isopogon drummondii	P3		Oppo
Synaphea sp.			Oppo
Thomasia macrocarpa			Oppo
Thysanotus arbuscula		20	0.2
Vellereophyton dealbatum		5	0.1
Xanthorrhoea preissii		120	1

Site No: HW10	Type: Quadrat	Longitude: 116.008553	Latitude: -31.957151
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmAcMt		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Acacia pulchella var. *pulchella*		100	1.5
Alexgeorgea nitens		10	0.2
Allocasuarina humilis		80	4
Banksia armata var. *armata*			Oppo
Banksia attenuata		400	1
Banksia dallanneyi var. *dallanneyi*		10	1
Banksia menziesii		500	15
Banksia sphaerocarpa		40	1
Bossiaea eriocarpa		30	0.5
Briza maxima	*	30	0.1
Burchardia congesta		40	0.1
Calothamnus torulosus			
Conospermum undulatum		80	0.2
Conostephium pendulum		50	0.2
Conostylis aurea			Oppo
Dasypogon obliquifolius		20	1
Daviesia nudiflora subsp. *nudiflora*		40	0.2
Desmocladus fasciculatus		10	0.1
Eremaea pauciflora var. *pauciflora*		40	2
Eucalyptus marginata subsp. *marginata*		2000	10
Gastrolobium capitatum			Oppo
Gladiolus caryophyllaceus	*	40	0.2
Haemodorum laxum			Oppo
Haemodorum sp.		10	0.1
Hemiandra pungens			Oppo
Hibbertia hypericoides		40	8
Jacksonia floribunda		50	0.2
Lambertia multiflora		100	2
Lepidosperma leptostachyum		40	2
Leucopogon sp.		40	0.1
Lomandra sericea		30	0.1
Lyginia barbata		40	1
Melaleuca trichophylla		40	3
Mesomelaena pseudostygia		40	1
Monotaxis grandiflora var. *grandiflora*		5	0.2
Patersonia occidentalis			Oppo
Petrophile macrostachya		50	1.5

Taxon	Cons. Code	Height (cm)	% Alive
Scaevola repens var. *repens*		15	0.3
Stirlingia latifolia		40	1
Isopogon drummondii	P3	80	3
Synaphea sp.		50	0.5
Tricoryne elatior		30	0.7
Tricostularia exsul		40	10
Xanthorrhoea preissii		90	1

Site No: HW11	Type: Releve	Longitude: 116.009061	Latitude: -31.957063
Date: 11/23/2016		Soil Types:	
Topography: Flat		Soil Colour:	
Rocky Type:		Soil Condition:	
Community: EmToDo		Fire History:	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina fraseriana		1300	15
Allocasuarina humilis		60	0.5
Banksia sphaerocarpa		50	0.5
Bossiaea eriocarpa		30	1
Burchardia congesta		40	0.3
Cheiranthera preissiana			0.1
Eucalyptus marginata subsp. *marginata*		1600	20
Gladiolus caryophyllaceus	*	40	0.1
Gompholobium knightianum		40	0.1
Hakea conchifolia		70	0.2
Hemiandra pungens			Oppo
Lyginia barbata			Oppo
Mesomelaena pseudostygia		40	10
Nuytsia floribunda		200	1
Patersonia occidentalis		30	1
Petrophile macrostachya		200	1
Scaevola repens var. *repens*		10	0.5
Tetraria octandra		30	20
Xanthorrhoea preissii		90	2

Site No: HW12r	Type: Releve	Longitude: 116.005128	Latitude: -31.960586
Date: 11/28/2016		Soil Types: Loam sand	
Topography: Flat		Soil Colour: Dark Brown	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: VG.			





Taxon	Cons. Code	Height (cm)	% Alive
Acacia sp.	Pl		Oppo
Adenanthos cygnorum subsp. *cygnorum*			Oppo
Allocasuarina fraseriana		400	10
Allocasuarina humilis			Oppo
Asteraceae (planted)	Pl	60	2
Banksia attenuata		350	8
Banksia dallanneyi		30	4
Banksia grandis		60	0.1
Banksia menziesii		400	2
Banksia sessilis var. *sessilis*			Oppo
Briza maxima	*	40	2
Conostephium pendulum			Oppo
Dampiera linearis		20	0.2
Dasypogon bromeliifolius		30	0.2
Dasypogon obliquifolius			Oppo
Desmocladus fasciculatus			Oppo
Eucalyptus marginata subsp. *marginata*		700	40
Haemodorum laxum			Oppo
Hibbertia hypericoides			Oppo
Hypochaeris glabra	*		0.5
Lambertia multiflora			Oppo
Lepidosperma leptostachyum		40	2
Mesomelaena tetragona			Oppo
Patersonia occidentalis		40	0.2
Persoonia elliptica		400	3
Petrophile macrostachya			Oppo
Stirlingia latifolia		40	0.2
Isopogon drummondii	P3	80	0.2
Tetraria octandra		40	10
Tricostularia exsul			Oppo
Xanthorrhoea preissii		100	0.5

Site No: HW13	Type: Quadrat	Longitude: 116.006285	Latitude: -31.959895
Date: 11/28/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina fraseriana		400	15
Banksia dallanneyi var. *dallanneyi*		30	10
Banksia grandis			Oppo
Bossiaea eriocarpa		40	1
Briza maxima	*	30	3
Burchardia congesta		40	0.2
Conospermum undulatum		100	0.4
Conostephium pendulum		40	0.1
Cyathochaeta avenacea		70	0.2
Dampiera alata		20	0.1
Dampiera linearis		15	0.2
Dasypogon obliquifolius		40	2
Daviesia divaricata		20	0.1
Daviesia nudiflora subsp. *nudiflora*		50	0.3
Desmocladus fasciculatus		10	1
Ehrharta calycina	*	80	0.1
Eucalyptus marginata subsp. *marginata*		1800	10
Gladiolus caryophyllaceus	*	60	0.1
Gompholobium knightianum		20	0.2
Gompholobium tomentosum		40	0.2
Haemodorum laxum		100	0.2
Hakea conchifolia			Oppo
Hemiandra pungens		20	1
Hemiphora bartlingii			Oppo
Hibbertia hypericoides		20	0.5
Lambertia multiflora		160	8
Lechenaultia biloba		5	0.1
Lepidosperma leptostachyum		50	2
Leucopogon ?conostephioides		30	0.2
Lomandra preissii		20	0.1
Lyginia barbata		40	0.5
Melaleuca trichophylla		50	0.5
Mesomelaena pseudostygia		40	4
Mesomelaena tetragona		40	0.5
Monotaxis grandiflora var. *grandiflora*		20	0.1
Opercularia vaginata		30	0.1
Patersonia occidentalis		30	0.2

Taxon	Cons. Code	Height (cm)	% Alive
Persoonia elliptica			Oppo
Petrophile linearis		15	0.2
Pimelea ciliata subsp. *ciliata*		30	0.2
Scaevola repens var. *repens*		10	0.2
Stirlingia latifolia			Oppo
Boronia ramosa subsp. *anethifolia*		20	0.1
Synaphea sp.		30	0.3
Tetraria octandra		40	8
Tricoryne elatior		20	0.2
Tricostularia exsul		60	2
Vellereophyton dealbatum		5	0.1
Xanthorrhoea acanthostachya		70	0.3
Xanthorrhoea preissii		80	8

Site No: HW14r	Type: Releve	Longitude: 116.007548	Latitude: -31.958775
Date: 11/29/2016		Soil Types:	
Topography: Flat		Soil Colour:	
Rocky Type:		Soil Condition:	
Community: EmAcMt		Fire History:	
Vegetation Condition: G.			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		350	15
Alexgeorgea nitens			Oppo
Allocasuarina fraseriana			Oppo
Allocasuarina humilis		40	0.2
Amphipogon strictus		20	0.5
Banksia attenuata			Oppo
Banksia dallanneyi var. *dallanneyi*		20	0.5
Banksia menziesii		400	5
Billardiera fraseri			0.2
Briza maxima	*	30	5
Cyathochaeta avenacea		130	0.3
Dasypogon obliquifolius			Oppo
Daviesia preissii		60	0.2
Desmocladus fasciculatus			Oppo
Ehrharta calycina	*	100	20
Eremaea pauciflora var. *pauciflora*		30	5
Eucalyptus marginata subsp. *marginata*		700	5
Gladiolus caryophyllaceus	*		Oppo
Haemodorum spicatum		100	0.1
Lambertia multiflora		220	0.5
Lyginia barbata		40	0.5
Melaleuca trichophylla		40	6
Mesomelaena pseudostygia		50	3
Nuytsia floribunda		400	Oppo
Petrophile linearis			Oppo
Ptilotus manglesii		30	0.5
Stirlingia latifolia		40	2
Boronia ramosa subsp. *anethifolia*			Oppo
Tricoryne elatior		30	0.5
Ursinia anthemoides	*		Oppo
Vellereophyton dealbatum			Oppo
Xanthorrhoea preissii		70	1

Site No: HW15r	Type: Releve	Longitude: 116.008478	Latitude: -31.95808
Date: 11/29/2016		Soil Types:	
Topography: Flat		Soil Colour:	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: E.			





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Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina humilis		100	1
Banksia attenuata			Oppo
Banksia dallanneyi var. *dallanneyi*		20	5
Banksia menziesii			Oppo
Bossiaea eriocarpa		30	8
Burchardia congesta		60	0.1
Caustis dioica		30	1
Dasypogon obliquifolius		30	4
Desmocladus fasciculatus		20	0.2
Ehrharta calycina	*	80	1
Eucalyptus marginata subsp. *marginata*		800	25
Gastrolobium capitatum		40	0.2
Gladiolus caryophyllaceus	*	70	0.2
Gompholobium knightianum			Oppo
Hakea costata		220	0.5
Hibbertia hypericoides		30	0.5
Lambertia multiflora		160	1
Lepidosperma leptostachyum		60	2
Melaleuca trichophylla		40	2
Mesomelaena tetragona		50	10
Opercularia vaginata		30	0.3
Patersonia occidentalis		40	1
Petrophile macrostachya		100	1
Petrophile linearis			Oppo
Philotheca spicata		50	0.2
Schoenus brevisetis		30	1
Stirlingia latifolia		40	0.5
Tetraria octandra		30	1
Tricostularia exsul		60	1
Xanthorrhoea acanthostachya		100	1
Xanthorrhoea preissii		100	5

Site No: HW16	Type: Quadrat	Longitude: 116.004122	Latitude: -31.960853

Date: 11/29/2016
Topography: Flat
Rocky Type:
Community: EmToDo
Vegetation Condition: E.

Soil Types: Sand
Soil Colour: Grey
Soil Condition: Dry
Fire History: 10+





Taxon	Cons. Code	Height (cm)	% Alive
Alexgeorgea nitens		10	0.2
Allocasuarina fraseriana		600	10
Allocasuarina humilis		40	0.2
Banksia attenuata		600	5
Banksia dallanneyi var. *dallanneyi*		20	5
Banksia menziesii		300	10
Bossiaea eriocarpa		30	3
Burchardia congesta		40	0.2
Caesia micrantha		30	0.1
Conostephium pendulum		30	0.2
Cyathochaeta avenacea		70	1
Dampiera linearis		20	0.5
Dasypogon obliquifolius		50	4
Daviesia nudiflora subsp. *nudiflora*			Oppo
Daviesia preissii			Oppo
Eucalyptus marginata subsp. *marginata*		800	8
Gastrolobium capitatum		30	1
Haemodorum laxum		80	0.2
Hemiandra pungens		20	2
Hemiphora bartlingii		20	0.3
Hibbertia hypericoides		40	4
Hypolaena exsulca		40	1
Lambertia multiflora		160	6
Lechenaultia biloba		10	0.1
Lomandra preissii		30	0.2
Mesomelaena tetragona		40	10
Patersonia occidentalis		30	0.5
Persoonia elliptica		400	0.5
Petrophile linearis		20	0.1
Pimelea ciliata subsp. *ciliata*		30	0.2
Scaevola repens var. *repens*		10	0.2
Schoenus brevisetis		30	1
Stachystemon vermicularis		60	3
Stirlingia latifolia		50	3
Isopogon drummondii	P3	60	0.5
Synaphea sp.			Oppo

Taxon	Cons. Code	Height (cm)	% Alive
Tetraria octandra		40	5
Thysanotus arbuscula		10	0.1
Tricostularia exsul		60	4
Xanthorrhoea preissii		100	8
Xylomelum occidentale		400	1.5

Site No: HW17	Type: Quadrat	Longitude: 116.001698	Latitude: -31.957207
Date: 11/29/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Dark Brown	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	

Vegetation Condition: VG. Weeds, edge effect





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina fraseriana		600	10
Anigozanthos manglesii		100	0.2
Babingtonia camphorosmae		40	0.5
Banksia dallanneyi var. *dallanneyi*		30	8
Bossiaea eriocarpa		20	1
Briza maxima	*	30	1
Conospermum undulatum		130	0.3
Dampiera alata		10	0.2
Dampiera linearis		10	0.2
Dasypogon obliquifolius			Oppo
Daviesia preissii			Oppo
Ehrharta calycina	*	120	1
Eucalyptus marginata subsp. *marginata*		2000	20
Gastrolobium capitatum		30	1
Gladiolus caryophyllaceus	*	70	0.5
Haemodorum laxum		120	0.5
Hibbertia hypericoides		40	3
Lambertia multiflora		110	0.3
Lepidosperma leptostachyum		40	3
Lomandra sericea		30	0.2
Mesomelaena tetragona		40	4
Monotaxis grandiflora var. *grandiflora*		15	1
Opercularia vaginata		30	0.2
Persoonia elliptica		300	2
Scaevola repens var. *repens*		10	0.2
Stirlingia latifolia		40	1
Boronia ramosa subsp. *anethifolia*		10	0.3
Tetraria octandra		30	5
Thysanotus arbuscula		20	0.1
Tricoryne elatior		20	0.2
Xanthorrhoea gracilis		60	3
Xanthosia huegelii		30	0.3

Site No: HW18r	Type: Releve	Longitude: 116.006067	Latitude: -31.958544

Date: 11/30/2016
Topography: Flat
Rocky Type:
Community: EmToDo
Vegetation Condition: VG.

Soil Types: Sand
Soil Colour: Medium Brown
Soil Condition: Dry
Fire History: 10+





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. cygnorum		300	1
Allocasuarina fraseriana		500	3
Banksia armata var. armata		50	1
Banksia dallanneyi var. *dallanneyi*		20	0.5
Banksia menziesii			Oppo
Bossiaea eriocarpa		20	0.5
Briza maxima	*	40	0.5
Caustis dioica		30	0.4
Conostylis aurea		30	0.1
Cyathochaeta avenacea		120	0.5
Dasypogon obliquifolius		30	1
Daviesia nudiflora subsp. *nudiflora*		40	0.5
Desmocladus fasciculatus		10	0.1
Ehrharta calycina	*	80	4
Eucalyptus gomphocephala		1500	1
Eucalyptus marginata subsp. *marginata*		800	25
Gastrolobium capitatum		30	0.5
Gladiolus caryophyllaceus	*	100	0.3
Gompholobium knightianum		30	0.2
Haemodorum laxum		160	0.2
Haemodorum sp.		30	0.1
Hemiandra linearis		10	0.01
Hibbertia hypericoides		50	1
Lambertia multiflora		120	0.5
Lepidosperma leptostachyum		50	0.1
Lomandra preissii		30	0.5
Lyginia barbata		50	0.2
Mesomelaena pseudostygia		40	4
Microtis media		20	0.01
Patersonia occidentalis		40	0.2
Petrophile linearis		40	0.2
Scaevola repens var. *repens*			Oppo
Isopogon drummondii	P3	100	0.3

Taxon	Cons. Code	Height (cm)	% Alive
Tetraria octandra		40	5
Tricoryne elatior		30	0.1
Tricostularia exsul		80	8
Ursinia anthemoides	*	15	0.02
Verticordia densiflora var. *densiflora*		150	0.5
Xanthorrhoea preissii		100	4

Appendix C AECOM (2017b) Floristic Community Type Analysis

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Shire of Kalamunda
29-Sep-2017

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Floristic Community Type Analysis

Forrestfield North Detailed Flora and Vegetation Assessment



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Floristic Community Type Analysis

Forrestfield North Detailed Flora and Vegetation Assessment

Client: Shire of Kalamunda

ABN: 60 741 095 678

Prepared by

AECOM Australia Pty Ltd
3 Forrest Place, Perth WA 6000, GPO Box B59, Perth WA 6849, Australia
T +61 8 6208 0000 F +61 8 6208 0999 www.aecom.com
ABN 20 093 846 925

29-Sep-2017

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Reviewed by L Kirchner

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Appendix A
Quadrat Data A

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Executive Summary

The Shire of Kalamunda required Floristic Community Type (FCT) analysis to determine the significance of native vegetation at the State level within a defined survey area in Forrestfield. Quadrat data from the 2016 Level 2 Flora and Fauna Assessment (AECOM, 2016) was assessed against the Keighery (2012) Swan Coastal Plain dataset to infer the relevant FCT.

Firstly a review of the desktop study and historical surveys was undertaken. This provided an overview of existing environment and potential State significant vegetation communities that may be present. Four communities listed as Threatened Ecological Communities (TECs) were considered to potentially occur within the survey area, including:

- FCT3a *Corymbia calophylla – Kingia australis* Woodlands on Heavy Soils
- FCT3c *Corymbia calophylla – Xanthorrhoea preissii* Woodlands and Shrublands
- FCT7 Herb-rich Saline Shrublands in Clay Pans
- FCT20a *Banksia attenuata* Woodlands over Species Rich Dense Shrublands.

Another two significant communities listed by Department of Biodiversity, Conservation and Communities (DBCA) were identified:

- FCT2 Southern Wet Shrublands
- Banksia Dominated Woodlands of the Swan Coastal Plain.

Within the survey area three Banksia/Jarrah Woodlands, one heath community, and one riparian community represented native vegetation. These were represented by 12 quadrats. These quadrats were individually compared to the SCP dataset. All quadrats showed the highest similarity to those in the SCP dataset representing FCT20a *Banksia attenuata* Woodlands over Species Rich Dense Shrublands. Similarities differed from 32-52%. The low similarity is likely to be a reflection of the single scoring event and limited time spent at each quadrat (<1 hr). This FCT represents an Endangered TEC at both the State and Federal level.

Verification of the Banksia Woodlands of the SCP was also undertaken. The native vegetation within the survey area was divided into five patches and each assessed against the key diagnostic criteria, condition assessment and minimum patch size. All patches met most of the diagnostic criteria with the exception of the overstorey dominance/co-dominance aspect. The vegetation within the survey area was dominated by *Eucalyptus marginata* and *Allocasuarina fraseriana* with less *Banksia attenuata/Banksia menziesii*, or sometimes these species were absent. Despite this, the desktop study found multiple known locations of the Banksia Woodland TEC within the survey area, indicating that all native vegetation in Good or better condition represents this Federally listed TEC. In this case, the lack of a dominant *Banksia* tree stratum appears to have no effect on the presence of this TEC.

This leads back to the FCT analysis. Perhaps the location of the survey area on the eastern SCP presents a unique composition of overstorey species which has led to the lower similarity of survey quadrats to SCP quadrats representing FCT20a. Furthermore, the desktop study found numerous locations of the Priority 3 Banksia Dominated Woodlands within the survey area. Despite this, all quadrats were aligned with FCT20a. Lacking key diagnostic characteristics for the Priority community, it is uncertain what the differentiating factor is between FCT20a and the Banksia Dominated Woodlands. Consultation with DBCA was undertaken however the response was inconclusive. Both represent the Federally listed Banksia Woodlands.

In conclusion, all native vegetation in Good or better condition within the survey area is considered to represent the Federally listed Banksia Woodlands of the SCP. FCT analysis indicates that this same extent represents the State listed TEC FCT20a.

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1.0 Introduction

1.1 Background

The Shire of Kalamunda is proposing to re-zone an area currently zoned as urban-deferred. Part of this process will require subdivision of properties and clearing of native vegetation for urban development. A detailed flora and vegetation assessment, and a level 1 fauna assessment (including Black Cockatoo survey) was undertaken in November 2016. At this time, the Federally listed Banksia Woodlands of the Swan Coastal Plain Threatened Ecological Community (Banksia Woodland TEC) was identified and mapped, and a number of Floristic Community Types (FCTs) have been referenced as potentially occurring in the survey area.

To further support the Banksia Woodlands TEC mapping, and assess the local and regional significance of vegetation on the Swan Coastal Plain (SCP), FCT analysis is required. FCT analysis is undertaken using a statistical program to assess the similarity of quadrat data obtained from the 2016 survey to the comprehensive SCP dataset. This report includes an overview of the desktop study, the results of the FCT analysis and a more comprehensive Banksia Woodlands assessment. FCT analysis is important on the Swan Coastal Plain as it provides a comparable dataset to determine relative species richness and local and regional significance of the patch at State-level by determining the TEC/PEC status.

1.2 Location

The survey area is located between Maida Vale Road (north), Dundas Road (west), Sultana Road West (south) and Roe Highway (east) in the suburb of High Wycombe. It includes 144 ha of land, of which 116.2 ha is cleared and 27.80 ha is considered native vegetation. The location and extent of the survey area is shown in Figure 1.

1.3 Scope of work

The objective of the FCT analysis is to determine the significance of native vegetation within the survey area at the State level. Specifically:

- Vegetation quadrats from the 2016 Assessment were compared to the SCP dataset
- Analysis in accordance with the draft DPaW statistical analysis methods (2015) was undertaken to identify quadrats in the SCP dataset that are most similar to quadrats within the survey area
- The analysis outcomes were used to identify the FCT most representative of the vegetation types.

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PROJECT ID 60507828 CREATED BY RNM APPROVED BY FdeWit LAST MODIFIED 20 JAN 2017	AECOM www.aecom.com	LEGEND Survey Area Highway Minor Road	**Survey Area**
1:12,500 when printed at A4 DATUM GDA 1994, PERTH COASTAL GRID94 0 100 200 300 400 Meters			**SHIRE OF KALAMUNDA** *FORRESTFIELD NORTH*
Data sources: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community Base Data: (c) Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2019).			**Figure** 1

Map Document: P:\605X\60527304\4. Tech Work Area\4.99 GIS\02_MXDs\Forrestfield_North_Jan2016\G60527304_Fig1_SurveyArea_v2_A4.mxd (fotheringhamd) A4 size

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2.0 Methods

2.1 Floristic Community Type Analysis

A detailed flora and vegetation survey was undertaken in November 2016 (Forrestfield North Level 2 Flora and Fauna Survey; AECOM, 2016). At this time floristic data was collected from 12 quadrats and six relevés. Floristic quadrat data is presented in Appendix A. Relevé data was not further considered as it is not suitable for statistical analysis at this level (DPaW, 2015). Quadrats within the survey area were subject to one scoring event. This deviates from the two events recommended in the DPaW FCT draft analysis methods (2015) and it may cause a low similarity and reduce compatibility of the datasets.

The Keighery (2012) SCP dataset was used for the FCT analysis. A sub-set of this data was defined using a 25 km radius from the survey area. This reduces 'noise' in the data analysis from quadrats located a considerable distance away. It also excludes FCTs that do not occur in the local area. The subset includes 261 SCP quadrats representing 43 FCTs.

The survey area data was reconciled with this dataset and all species coded using the three first letters of the genus and species, reducing infra-specific names. All nomenclature of species followed the WA Plant Census.

The program PC Ord was used to undertake the Bray Curtis distance measure. The Bray Curtis dissimilarity measure was used to quantify the compositional dissimilarity between the quadrats based on presence absence data. Subtracting the results from 1 gives the similarity index, also known as the Bray Curtis index. This method is easily interpretable and provides meaningful results. A sense check was completed incorporating appropriate geology, soils, landscape and the description provided in the Gibson *et al.* (1994) reference material and Bush Forever (Government of WA, 2000).

2.2 Banksia Woodlands of the Swan Coastal Plain verification

Within the survey area native vegetation was separated into five patches. Patches were based on areas that were, at least for the most part, isolated from other areas of native vegetation and in Good or better condition. This approach was used in order to further refine condition categories and potentially inform management actions. Another option would have been to assess the area as one patch. The defined patches comprise of multiple vegetation communities as mapped in the AECOM (2016) report.

The Threatened Species Scientific Committee (TSSC) developed a comprehensive conservation advice document (2016) which provides a detailed description, methods for identifying the community, current threats, research priorities and conservation actions required. Identifying this community is described in detail using four steps:

- Step 1: use key diagnostic characteristics to determine if TEC is present
- Step 2: determine condition of patch
- Step 3: consider if patch meets minimum size threshold
- Step 4: surrounding context of a patch must be taken into account when considering factors that add to the importance of a patch that meets the condition thresholds.

The key diagnostic characteristics summarise the main features that characterise the Banksia Woodland. The condition categories are applied to identify the varying quality of patches, usually as a result of degradation, and ensure that patches of high quality are considered a Matter of National Significance (MNES). The condition of the patch is informed by species richness of quadrat data compared to available datasets, most notably the Gibson *et al.* (1994) and Keighery *et al.* (2012) Swan Coastal Plain datasets, and weed cover. The condition of the patch and size thresholds are then used to determine whether the quality of the patch is suitable to meet MNES standards.

Floristic data collected from permanent quadrats should be used to inform the TEC assessment. This will not only support the condition category assessment, but also identify the associated Floristic Community Type (FCT) that is inferred for these quadrats.

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2.2.1 Key Diagnostic Features

Key diagnostic characteristics
Location and physical environment
Patch on Swan Coastal Plain or adjacent lower parts of the Darling and Whicher escarpments that lie within the Jarrah Forest bioregion to the immediate east and south of the Swan Coastal Plain.
Soils and landform
Typically occurs on: deep Bassendean, Spearwood sands, occasionally on Quindalup sands, sandy colluvium and Aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau. Sometimes on transitional substrates, sandflats.
Structure: The structure of the ecological community is a low woodland to forest with the following features:
Distinctive upper sclerophyllous layer of low trees typically dominated or co-dominated by one or more of the *Banksia* species identified below; AND Emergent trees *Eucalyptus* or *Allocasuarina* species may sometimes be present above the *Banksia* canopy; AND Highly species-rich understorey that consists of a layer of sclerophyllous shrubs of various heights and a herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs that sometimes includes grasses.
Composition
Canopy is most commonly dominated or co-dominated by *Banksia attenuata* and/or *Banksia menziesii.* Other *Banksia* species that dominate in some examples of the ecological community are *B. prionotes* or *B. ilicifolia*; AND Must include at least one of the following diagnostic species: · *Banksia attenuata* · *Banksia menziesii* · *Banksia prionotes* · *Banksia ilicifolia.* Emergent tree layer often includes *Corymbia calophylla, E. marginata,* or less commonly *E. gomphocephala*; AND Other trees of a medium height may be present and may be co-dominant with the *Banksia* species across a patch, include *E. todtiana, Nuytsia floribunda, Allocasuarina fraseriana, Callitris arenaria, Callitris pyramidalis* and *Xylomelum occidentale*.
Contra-indicators
Patches clearly dominated by *Banksia littoralis* are not part of the TEC
Patches clearly dominated by *Banksia burdettii* are not the TEC
FCT 20c – Eastern shrublands and woodlands, corresponds with a separate EPBC ecological community listing, Shrublands and Woodlands of the eastern Swan Coastal Plain. Occurrences of this FCT should be considered under that separate listing.

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2.2.2 Condition assessment

The condition of vegetation of each patch needs to be determined in accordance with the following:

- The condition assessment of a patch should be centred on the area of highest native floristic diversity and/or cover of the patch
- Timing of surveys and recent disturbance should be taken into account
- Surrounding context of a patch should be considered
- Certain vegetation components of Banksia Woodlands community merit consideration as critical elements to protect. Three components are recognised as threatened in their own right i.e. Priority Ecological Communities
- A relevant expert may be useful to help identify the ecological community and its condition
- Vegetation must be in 'Good' or better condition in accordance with Table 1.

Table 1 Condition Table

Keighery (1994) Vegetation Condition Scale	Indicative condition measures/thresholds	
	Typical native vegetation composition	**Typical weed cover**
Pristine No obvious signs of disturbance.	Native plant species diversity fully retained or almost so[1]	Zero or almost no weed cover/abundance
Excellent Vegetation structure intact, disturbance only affecting individual species, weeds are non-aggressive species.	High native plant species diversity[1]	Less than 10%
Very Good Vegetation structure altered, obvious signs of disturbance (e.g. repeated fires, dieback, logging, grazing). Aggressive weeds present.	Moderate native plant species diversity[1]	5 – 20%
Good Vegetation structure altered but retains basic vegetation structure or ability to regenerate it. Obvious signs of disturbance (from partial clearing, dieback, logging, grazing). Presence of very aggressive weeds.	Low native plant species diversity[1]	5 – 50%
Degraded Basic vegetation structure severely impacted by disturbance. Requires intensive management. Disturbance evident such as partial clearing, dieback, logging and grazing. Presence of very aggressive weeds at high density.	Very low native plant species diversity[1]	20 – 70%
Completely Degraded Vegetation structure is no longer intact and the area is completely or almost completely without native flora. Equivalent to 'Parkland Cleared'.	Very low to no native species diversity[1]	Greater than 70%

1. relative to expected natural range of diversity for that vegetation unit e.g. Floristic Community Type where comparative data exists.

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2.2.3 Patch size thresholds

Different minimum patch sizes apply to different levels of condition, as outlined below:

- Pristine – no minimum patch size
- Excellent – 0.5 ha or 5,000 m^2 (50 x 100 m)
- Very Good – 1 ha or 10,000 m^2 (100 x 100 m)
- Good – 2 ha or 20,000 m^2 (200 x 100 m).

2.2.4 Additional information

The following information should be taken into consideration when applying the key diagnostic criteria and condition thresholds:

- Land use history and landscape position of patch including position relative to surrounding vegetation
- A patch is a discreet and mostly continuous area of the ecological community and may include small-scale variations (<30 m), gaps and disturbances such as tracks paths or breaks that do not significantly alter the overall functionality of the ecological community.
- Variation in canopy cover, quality or condition of vegetation across a patch should not be considered evidence of multiple patches
- A buffer zone is a contiguous area immediately adjacent to a patch of the ecological community. The recommended minimum buffer zone is 20-50 m. Larger buffer zones should be considered for patches of particularly high conservation value, or if patches are down slope of drainage lines or a source of nutrient enrichment, or groundwater drawdown.
- Restored vegetation is not excluded provided it meets the key diagnostic criteria, condition threshold and patch size.
- Sampling protocols includes developing a quick map of the vegetation, landscape qualities and management history. Following this, a thorough sampling exercise must be undertaken to represent the range of variation. At least one hour per plot in early to mid-spring and a second survey in late spring may be required to detect the majority of species. plots to be at least 100 m^2 (10 x 10 m). Search effort (number of person hours per plot across entire patch) and surveyor's level of expertise can be useful for future reference.
- Timing of surveys should allow a reasonable interval after a disturbance. Surveys at least one year post fire may be required to assess a site against the key diagnostic characteristics and minimum condition thresholds.
- Surrounding environment, landscape context and other significance considerations:
  - patches that are more species rich and less disturbed are likely to provide greater biodiversity value
  - patches that provide corridors or linkages within a largely modified landscape are particularly important.

The Conservation Advice provides an additional ten indicators to be considered when assessing impacts of actions or proposed actions under the EPBC Act. These are not further listed here.

2.2.5 Protected in reserves

The level of protection in reserves has been published based on estimated extent of major and partially corresponding vegetation system associations. This is shown in Table 2.

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Table 2 Extent of Banksia Woodlands ecological community estimated to be protected in reserves

Subregion	Current extent (ha)	Extent in reserves (ha)	% Protected
Dandaragan (SWA01)	81,067.8	24,671.2	30.43
Perth (SWA02)	253,540.6	57,054.9	22.50
Jarrah Forests (JAF01/02)	1,881.4	105.9	5.63
TOTAL	**336,489.9**	**81,832.0**	**24.32**

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3.0 Summary of Historical Surveys

3.1 Threatened and Priority communities

A desktop review was undertaken as part of this report to provide a comprehensive overview of the potential threatened ecological communities that may occur within the survey area. The desktop study took into account the government database results undertaken as part of the detailed flora and vegetation assessment (AECOM, 2016), the Strategen (2012) Environmental Review document and the Keighery (2012) Floristic Community Type dataset. The Keighery (2012) dataset was consulted within 4km of the survey area to identify potential significant communities that occur in close proximity of the survey area. A summary of the results is presented in Table 3.

Table 3 Threatened communities identified in the desktop study informed by various sources

FCT	Community Name	Cons. Status		Source
		DBCA	EPBC Act	
2	Southern Wet Shrublands	Endangered	-	Keighery
3a	*Corymbia calophylla – Kingia australis* Woodlands on Heavy Soils	Critically Endangered	Endangered	Keighery Strategen
3c	*Corymbia calophylla – Xanthorrhoea preissii* Woodlands and Shrublands	Critically Endangered	Endangered	Strategen
7	Herb-rich Saline Shrublands in Clay Pans	Vulnerable	Critically Endangered	Keighery
20a	*Banksia attenuata* Woodlands over Species Rich Dense Shrublands	Endangered	Endangered	Database, Keighery
?	Banksia Dominated Woodlands of the Swan Coastal Plain.	Priority 3		Database

Southern wet shrublands is listed by DBCA as Endangered. It is known in the vicinity of the survey area from one location on the corner of Roe Highway and Tonkin Highway. This community is described by Gibson *et al.* (1994) as shrublands or open low woodlands occurring on seasonally inundated sandy clay soils.

The ***Corymbia calophylla – Kingia australis* Woodlands TEC** occurs on the eastern side of the Swan Coastal Plain. The floristic composition varies with water regime across its distribution (DotEE, 2017a). The community is associated with areas where groundwater is less than 3m from the natural ground surface, indicating a high level of dependence on groundwater. There are 41 occurrences of this community extending across 192.5 ha between Ruabon and Guildford. There is one occurrence of this community within 1.3km of the survey area, located east of Roe Highway associated with Bush Forever Site 319 Dundas Road Bushland. Due to its restricted distribution, no condition thresholds are applicable to this community, with all areas meeting the description are considered habitat critical to the survival of this community.

The ***C. calophylla – Xanthorrhoea preissii* Woodlands TEC** is not known to occur within 5km of the survey area. It is known to occur on heavy soils of the eastern side of the Swan Coastal Plain. Dominant species include *C. calophylla,* occasionally *Eucalyptus wandoo*. This community is currently known from 115 ha located between Bullsbrook and Capel. Similarity with this community, due to its restricted distribution, no condition thresholds are applicable to this community.

Herb-rich saline shrublands in claypans are listed under “Clay Pans of the Swan Coastal Plain” federally listed Critically Endangered community. This community is unique in its composition of geophytes and annual flora that germinates, grows and flowers sequentially as the areas dry over summer (TSSC, 2012). This community is located within the Perth Airport land tenement.

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The **Banksia Woodlands TEC**, described by the Threatened Species Scientific Committee (TSSC, 2016) incorporates Woodland of *Banksia* species with scattered eucalypts and other tree species over a species rich mix of sclerophyllous shrubs, graminoids, and forbs. The community shows high endemism and considerable local variation in species composition across its range. It is restricted to the southwest of WA on the Swan Coastal Plain. It occurs mainly on deep Bassendean and Spearwood sands or occasionally on Quindalup sands.

At the State level, this Banksia Woodlands community is represented by a number of FCTs as defined in Bush Forever (Government of WA, 2000) and Gibson *et al.* (1994). Within the survey area, the Banksia Woodlands TEC is represented by FCT20a *Banksia attenuata* woodlands over species rich dense shrublands. This community is listed as an Endangered TEC by Department of Biodiversity, Conservation and Attractions (DBCA). In addition, the TEC is also represented by a Priority 3 ecological community (PEC) listed as 'Banksia Dominated Woodlands of the Swan Coastal Plain'. This community is directly aligned with the EPBC Act listed TEC.

3.2 Vegetation communities

Five vegetation communities were described and mapped within the survey area (Table 4). These encompassed:

- Three *Banksia/E. marginata* Woodlands, AfHhMp, EmAcMt, EmToDo
- one Heath community VaCd
- one Riparian community ErApEh
- one significantly disturbed community, mapped as 'Trees'.

For the purpose of the FCT analysis, only the three Woodlands and one Heath community were included.

Table 4 Vegetation community descriptions recorded and mapped in the survey area including survey effort, species richness and total extent

Community Description	Additional Details
AfHhMp *Allocasuarina fraseriana*, *Banksia attenuata, Banksia menziesii* and occasional *Nuytsia floribunda* low woodland over *Xanthorrhoea preissii, Lambertia multiflora, Adenanthos cygnorum* subsp. *cygnorum* and *Xanthorrhoea acanthostachya* mid sparse shrubland over *Hibbertia hypericoides, Banksia dallanneyi* var. *dallanneyi, Bossiaea eriocarpa, Calothamnus torulosus* and *Petrophile macrostachya* low sparse shrubland with *Mesomelaena pseudostygia, Schoenus brevisetis, Lepidosperma leptostachyum*, *Caustis dioica* and *Tricostularia exsul* tall open sedgeland with *Dasypogon obliquifolius*, *Scaevola repens* var. *repens*, *Haemodorum laxum*, *Gladiolus caryophyllaceus**, *Burchardia congesta* and *Anigozanthos manglesii* low sparse forbland.	Survey effort: four quadrats (1, 4, 6, 9) Species richness: 92 native, seven weed species. Area: 5.5 ha
EmAcMt *Eucalyptus marginata* and *Banksia menziesii* low open woodland over *Adenanthos cygnorum* subsp. *cygnorum*, *Lambertia multiflora* and *Xanthorrhoea acanthostachya* mid open shrubland over *Melaleuca trichophylla*, *Hibbertia hypericoides, Eremaea pauciflora* var. *pauciflora, Allocasuarina humilis* and *Stirlingia latifolia* low shrubland with *Mesomelaena pseudostygia*, *Cyathochaeta avenacea, Tricostularia exsul* and *Lepidosperma leptostachyum* mid to low sedgeland over *Tricoryne elatior, Dasypogon obliquifolius, Lyginia barbata, Scaevola repens* var. *repens, Haemodorum laxum* and *Lomandra sericea* low sparse forbland.	Survey effort: three quadrats (2, 5, 10), one relevè (14). Species richness: 79 native, four weed species, Area: 3.51 ha

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Community Description	Additional Details
EmToDo *Eucalyptus marginata* and *Allocasuarina fraseriana* mid woodland over Banksia *attenuata, Banksia menziesii* and *Persoonia elliptica* low woodland over *Lambertia multiflora* and *Xanthorrhoea preissii* mid open shrubland over *Banksia dallanneyi* var. *dallanneyi, Hibbertia hypericoides, Bossiaea eriocarpa*, *Stirlingia latifolia*, and *Gastrolobium capitatum* low shrubland with *Tetraria octandra, Mesomelaena pseudostygia, Mesomelaena tetragona* and *Lepidosperma leptostachyum* low sedgeland over *Dasypogon obliquifolius*, *Patersonia occidentalis, Dampiera linearis, Haemodorum laxum, Scaevola repens* var. *repens* and *Lomandra preissii* low sparse forbland.	Survey effort: five quadrats (3, 11, 13, 16, 17), three relevès (12, 15 and 18). Species richness: 87 native, eight weed species. Area: 10.32 ha
ErApEh *Corymbia calophylla* and *Eucalyptus rudis* tall woodland over *Trymalium odoratissimum* thicket over *Acacia pulchella*, *Hibbertia hypericoides* and *Xanthorrhoea preissii* mid sparse shrubland over **Ehrharta calycina, *Cynodon dactylon, *Gladiolus caryophyllaceus* and *Tetraria octandra* grassland/herbland on clay soils within Poison Gully.	Area: 0.18 ha
VdCd *Eucalyptus marginata* subsp. *marginata* mid isolated trees over *Verticordia densiflora* var. *densiflora, Daviesia angulata, Hypocalymma angustifolium, Stirlingia latifolium* and *Banksia bipinnatifida* subsp. *bipinnatifida* low open shrubland with *Caustis dioica, Mesomelaena tetragona, Tetraria octandra* and *Schoenus brevisetis* tall open sedgeland over *Patersonia occidentalis, Lyginia barbata, Haemodorum spicatum*, *Tricoryne elatior* and *Anigozanthos manglesii* low open forbland.	Survey effort: two quadrats (7, 8) Species richness: 45 native, five weed species. Area: 2.65 ha

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4.0 Results

4.1 FCT Analysis

The FCT analysis results identified FCT20a Banksia Woodlands over Species-rich Dense Shrublands as the most representative FCT to survey area quadrats. This community is listed as Endangered by DBCA and represents the Banksia Woodlands of the Swan Coastal Plain Federally listed TEC.

Communities AfHhMp and EmAcMr showed a 46-52% similarity to FCT20a, with the three top matches all representing quadrats assigned to FCT20a (Table 5). AfHhMp and EmAcMr have a high species richness (34-67 species/quadrat), low historical disturbance and are mapped in Excellent condition.

EmToDo also shows the highest similarity to quadrats representing FCT20a, however results were lower with 32-47% similarity. Survey quadrats had a species richness slightly lower than the other two Banksia communities at 32-50 species/quadrat. Condition was mapped as Very Good to Excellent.

Gibson *et al.* (1994) describes FCT20a as occurring in deep sands at the base of the Scarp in Forrestfield covering the Southern River unit and Karrakatta unit. This woodland is either represented by *B. attenuata* woodlands or *E. marginata-B. attenuata* woodlands and has an average species richness of 67.4 species/quadrat. The description of this FCT matches those of the three Woodland communities mapped in the survey area.

Some factors that should be considered regarding the moderate percentage similarity include:

- survey quadrats were scored once which is a reduced survey effort compared to the SCP dataset
- the survey was undertaken late in the season (November 2016) which may have affected presence of early-flowering annuals
- more time allowed for each quadrat (1 hour) may have allowed for additional species to be recorded, the survey was very time-restricted.

The inference of FCT20a being present at all patches of native vegetation (represented by a quadrat) in the survey area is contradictory to the desktop study. The database results show 26 locations of the Priority 3 “Banksia Dominated Woodlands” community. This P3 community is not associated with a particular FCT and is therefore difficult to identify. The FCT results therefore imply that the native vegetation represents an Endangered State and Federally listed TEC, however the desktop study implies that only one patch represents FCT20a.

DBCA was consulted to ascertain the difference between the Banksia Dominated Woodland to other FCTs however their response was inconclusive.

Community VcCa had cryptic results that varied between several FCTs, with FCT20a showing the closest resemblance. The other two inferred FCTs are associated with wetland communities and were therefore discounted. However, this community lacked any overstorey species and field observations indicate historical clearing followed by potential rehabilitation of native species? The community is very unique in its composition and implies human-disturbance/influence.

None of the quadrats showed any similarity to quadrats representing FCT2, 3a, 3c, 7, or 20c. For this reason, the other TECs can be excluded from being present in the survey area.

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Table 5 Inferred FCT for Forrestfield North including quadrat condition, species richness h the Project quadrat, the SCP FCT quadrat, and % similarity)

Quadrat	Condition	Sp. Richness	Quadrat (FCT; % similarity)	Review of Result	Final FCT
AfHhMp					
HW01	Excellent	67	Activ03 (20a; 52%) Activ01 (20a; 48%) Wire01 (28; 45%)	Consistent results for all quadrats in this community for FCT20a.	According to database records, this represents the P3 Banksia Woodlands.
HW04	Excellent	48	Activ03 (20a; 45%) APBF-1 (20a; 45%) Activ01 (20a; 43%)		According to database records, this represents the P3 Banksia Woodlands.
HW06	Excellent	34	Activ01 (20a; 41%) APBF-2 (20a; 38%)		According to database records, this represents the P3 Banksia Woodlands.
HW09	Excellent	54	Activ01 (20a; 46%) Activ03 (20a; 45%)		FCT20a *Banksia attenuata* woodlands over species rich dense shrublands.
EmAcMt					
HW02	Excellent	54	Activ01 (20a; 46%) M5303 (20a; 40%)	Consistent results for all quadrats in this community for FCT20a.	FCT20a *Banksia attenuata* woodlands over species rich dense shrublands.
HW10	Excellent	43	Activ01 (20a; 49%) APBF-2 (20a; 47%) APBF-1 (20a; 46%)		
EmToDo					
HW03	Excellent	34	Activ03 (20a; 32%) Hart01 (20a; 31%) APBF-1 (20a; 31%) KING-2 (28; 31%)	Consistent results for all quadrats in this community for FCT20a.	According to database records, this represents the P3 Banksia Woodlands.
HW13	Excellent	50	Activ03 (20a; 47%) M5303 (20a; 43%)		According to database records, this represents the P3 Banksia Woodlands.
HW16	Excellent	41	APBF-1 (20a; 44%) Activ03 (20a; 42%)		According to database records, this represents the P3 Banksia Woodlands.
HW17	Very Good	32	Active03 (20a; 38%) M5303 (20a; 35%)		

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Quadrat	Condition	Sp. Richness	Quadrat (FCT; % similarity)	Review of Result	Final FCT
VcCa					
HW07	Excellent	31	FL-1 (4; 37%) M5302 (20a; 37%) Cavs02 (21a; 31%)	Definitely not 4 *Melaleuca preissiana* damplands.	FCT20a *Banksia attenuata* woodlands over species rich dense shrublands – cryptic as this patch appears to represent historically cleared area.
HW08	Excellent	38	M5302 (S11; 46%) M5303 (20a; 42%)	Definitely not S11 Northern *Acacia rostellifera-Melaleuca acerosa* shrublands.	

D R A F T

4.2 Banksia Woodlands Assessment

The three Woodland communities mapped within the survey area all appear to meet the Banksia Woodlands of the Swan Coastal Plain Assessment. It should be noted that in all communities, *Eucalyptus marginata* was the dominant tree species, along with dense patches of *Allocasuarina fraseriana*, often forming a top canopy stratum over *Banksia attenuata* and *Banksia menziesii* in lower percentages. This may reflect the location at the foothills.

4.2.1 Banksia Woodland Patch 1

Location	Patch 1 is located on the eastern border of the survey area, bounded by Roe Highway (east) and cleared paddock (west and north) and Conospermum Way (south).
Key diagnostic characteristics	Meets all key diagnostic characteristics.
Condition	Excellent, 92 species recorded in this patch and less than 2% weed cover. Mean species richness was 52 species/quadrat compared to FCT20a at 67.4 species/quadrat, the mean species richness represents 77% of anticipated species richness.
Patch size	2.33 ha
Additional features	The small size of the patch may imply higher risk of degradation from competing land uses. Patch supports population of Threatened *Conospermum undulatum* species.
Land use history	Unknown.
Any variations in patch	The patch comprises of variable condition native vegetation. The roadside vegetation along the south is in Good condition, comprising of a narrow strip of vegetation between cleared paddocks and the road. Several *C. undulatum* species occur in this corridor and therefore was considered important as a link between this patch and the adjacent patch. The remainder of the patch represents intact Excellent vegetation, dissected by one old track. Some weeds and rubbish was evident as a result of edge effects from Roe Highway and the paddocks adjacent. The northern tip is mapped as Degraded as a result of historical clearing and partial regrowth.
Buffer zone present	This patch has no buffer between adjacent conflicting land uses.
Sampling protocol	Assessed based on one scoring event of three quadrats in November, 2016.
Disturbance history	Unknown.
Surrounding environment	Paddock, minor road, and highway roadside. Paddock is proposed for further development.

Key diagnostic characteristics	**Response**
Location and physical environment	
Patch on Swan Coastal Plain or adjacent lower parts of the Darling and Whicher escarpments that lie within the Jarrah Forest bioregion to the immediate east and south of the Swan Coastal Plain.	Swan Coastal Plain
Soils and landform	
Typically occurs on: deep Bassendean, Spearwood sands, occasionally on Quindalup sands, sandy colluvium and Aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau. Sometimes on transitional substrates, sandflats.	Located on Forrestfield Complex in the foothills.

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Key diagnostic characteristics	Response
Structure: The structure of the ecological community is a low woodland to forest with the following features:	
Distinctive upper sclerophyllous layer of low trees typically dominated or co-dominated by one or more of the *Banksia* species identified below; AND Emergent trees *Eucalyptus* or *Allocasuarina* species may sometimes be present above the *Banksia* canopy; AND Highly species-rich understorey that consists of a layer of sclerophyllous shrubs of various heights and a herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs that sometimes includes grasses.	The overstorey is patchy, varying from 2-20% and includes *E. marginata, A. fraseriana, B. attenuata* and *B. menziesii.* Understorey comprises 41 slerophyllous shrubs and 35 herbaceous species (total), including 3 rushes and 11 sedges.
Composition	
Canopy is most commonly dominated or co-dominated by *Banksia attenuata* and/or *Banksia menziesii.* Other *Banksia* species that dominate in some examples of the ecological community are *B. prionotes* or *B. ilicifolia*; AND Must include at least one of the following diagnostic species: · *Banksia attenuata* · *Banksia menziesii* · *Banksia prionotes* · *Banksia ilicifolia* Emergent tree layer often includes *Corymbia calophylla, E. marginata,* or less commonly *E. gomphocephala*; AND Other trees of a medium height may be present and may be co-dominant with the *Banksia* species across a patch, include *E. todtiana, Nuytsia floribunda, Allocasuarina fraseriana, Callitris arenaria, Callitris pyramidalis* and *Xylomelum occidentale*.	Low trees comprising of *B. menziesii* and *B. attenuata* (4-6%) along with *E. marginata* (10-15%) and *A. fraseriana* (2%).
Contra-indicators	
Patches clearly dominated by *Banksia littoralis* are not part of the TEC	No
Patches clearly dominated by *Banksia burdettii* are not the TEC	No
FCT20c – Eastern shrublands and woodlands, corresponds with a separate EPBC ecological community listing, Shrublands and Woodlands of the eastern Swan Coastal Plain. Occurrences of this FCT should be considered under that separate listing.	No

D R A F T

4.2.2 Banksia Woodland Patch 2

Location	Patch 2 includes 29, 31, and 37 Brand Road.
Key diagnostic characteristics	It meets all key diagnostic characteristics.
Condition	Very Good. Species richness is moderate with 66 species/3 quadrats, a mean species richness of 37 species/quadrat compared to FCT20a with 67.4 species/quadrat. Weed cover was less than 5%. Condition could potentially be Excellent if another quadrat scoring event was undertaken.
Patch size	2.13 ha
Additional features	Large population of *C. undulatum* present in patch.
Land use history	Unknown.
Any variations in patch	Varied from Very Good to Excellent with degradation caused by firebreak clearing and edge effects of adjacent conflicting land use. Patch represented by AfHhMp and EmAcMt which represents the variation in canopy cover of *E. marginata* and *A. fraseriana* and dominance of sedges and shrubs.
Buffer zone present	No buffer zone present, adjacent land predominantly cleared.
Sampling protocol	Represented by three quadrats (HW04, HW05 and HW06) that have been scored once in November 2016.
Disturbance history	Unknown.
Surrounding environment	Adjacent land represents private property and includes open paddock with scattered native trees, and private gardens comprising of introduced/planted species and housing.

Key diagnostic characteristics	**Response**
Location and physical environment	
Patch on Swan Coastal Plain or adjacent lower parts of the Darling and Whicher escarpments that lie within the Jarrah Forest bioregion to the immediate east and south of the Swan Coastal Plain.	Swan Coastal Plain
Soils and landform	
Typically occurs on: deep Bassendean, Spearwood sands, occasionally on Quindalup sands, sandy colluvium and Aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau. Sometimes on transitional substrates, sandflats.	Forrestfield complex on the foothills.

D R A F T

Key diagnostic characteristics	Response
Structure: The structure of the ecological community is a low woodland to forest with the following features:	
Distinctive upper sclerophyllous layer of low trees typically dominated or co-dominated by one or more of the *Banksia* species identified below; AND Emergent trees *Eucalyptus* or *Allocasuarina* species may sometimes be present above the *Banksia* canopy; AND Highly species-rich understorey that consists of a layer of sclerophyllous shrubs of various heights and a herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs that sometimes includes grasses.	Tree stratum varies in co-dominance between *E. marginata* (0-20% at two sample points), *A fraseriana* (0.5-8% at two sample points), *B. attenuata* (2-8% at two sample points), and *B. menziesii* (3% at one sample point). Understorey stratum includes 33 shrub species, 18 herbs and eight ruses and sedges.
Composition	
Canopy is most commonly dominated or co-dominated by *Banksia attenuata* and/or *Banksia menziesii.* Other *Banksia* species that dominate in some examples of the ecological community are *B. prionotes* or *B. ilicifolia*; AND Must include at least one of the following diagnostic species: · *Banksia attenuata* · *Banksia menziesii* · *Banksia prionotes* · *Banksia ilicifolia* Emergent tree layer often includes *Corymbia calophylla, E. marginata,* or less commonly *E. gomphocephala*; AND Other trees of a medium height may be present and may be co-dominant with the *Banksia* species across a patch, include *E. todtiana, Nuytsia floribunda, Allocasuarina fraseriana, Callitris arenaria, Callitris pyramidalis* and *Xylomelum occidentale*.	Canopy is dominated by *E. marginata* and *A. fraseriana* with variable cover of relevant Banksia species. Other tree species included *B. grandis*.
Contra-indicators	
Patches clearly dominated by *Banksia littoralis* are not part of the TEC	No
Patches clearly dominated by *Banksia burdettii* are not the TEC	No
FCT20c – Eastern shrublands and woodlands, corresponds with a separate EPBC ecological community listing, Shrublands and Woodlands of the eastern Swan Coastal Plain. Occurrences of this FCT should be considered under that separate listing.	No

D R A F T

4.2.3 Banksia Woodland Patch 3

Location	63 & 67 Brae Road, and 62, 70 & 78 Brand Road.
Key diagnostic characteristics	Patch is dominated by *E. marginata* and *A. fraseriana* with some areas of *B. menziesii* and very low percent cover of *B. attenuata*.
Condition	Patch is considered in Very Good condition. Species richness was 83 plants/5 sample points. Using quadrat data only, mean species richness was 38 species/quadrat. This is moderate compared to FCT20a at 67.4 species/quadrat. Weeds predominantly below 1% with the exception of one degraded area where Veldt Grass was recorded at 20% cover.
Patch size	2.76 ha
Additional features	Supports population of Threatened *Conospermum undulatum*. Provides linkage from this patch to the adjacent patch (patch 4) separated by degraded vegetation.
Land use history	Unknown.
Any variations in patch	Edge effects have caused minor degradation on edge of Excellent condition vegetation. Patch is represented by all three Banksia woodland communities. Variation is evident in density of *E. marginata, A. fraseriana,* and *Banksia* trees and large variation in understorey dominance between sedges and shrubs.
Buffer zone present	No buffer zone present with the exception of planted road verge and adjacent private property gardens.
Sampling protocol	Patch 3 is represented by thee quadrats including HW9, HW10 and HW11, and two relevés HW14r and HW15r. The quadrats and relevés were scored/sampled once in November 2016.
Disturbance history	Unknown.
Surrounding environment	Patch of vegetation is adjacent to planted gardens, housing infrastructure and roads. In close proximity to Poison Gully riparian vegetation.

Key diagnostic characteristics	**Response**
Location and physical environment	
Patch on Swan Coastal Plain or adjacent lower parts of the Darling and Whicher escarpments that lie within the Jarrah Forest bioregion to the immediate east and south of the Swan Coastal Plain.	Swan Coastal Plain
Soils and landform	
Typically occurs on: deep Bassendean, Spearwood sands, occasionally on Quindalup sands, sandy colluvium and Aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau. Sometimes on transitional substrates, sandflats.	Forrestfield Complex, on the foothills.

D R A F T

Key diagnostic characteristics	Response
Structure: The structure of the ecological community is a low woodland to forest with the following features:	
Distinctive upper sclerophyllous layer of low trees typically dominated or co-dominated by one or more of the *Banksia* species identified below; AND Emergent trees *Eucalyptus* or *Allocasuarina* species may sometimes be present above the *Banksia* canopy; AND Highly species-rich understorey that consists of a layer of sclerophyllous shrubs of various heights and a herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs that sometimes includes grasses.	Dominated by *E. marginata* (8-40% at all sample points) and *A. fraseriana* (3-15% at all sample points) with *B. menziesii* (2-10% at two sample points) and some *B. attenuata* (5-8% at two sample points). Understorey is comprised of 38 sclerophyllous shrubs, ten rushes and sedges of variable dominance, and 28 herbs all less than 2% cover.
Composition	
Canopy is most commonly dominated or co-dominated by *Banksia attenuata* and/or *Banksia menziesii.* Other *Banksia* species that dominate in some examples of the ecological community are *B. prionotes* or *B. ilicifolia*; AND Must include at least one of the following diagnostic species: · *Banksia attenuata* · *Banksia menziesii* · *Banksia prionotes* · *Banksia ilicifolia* Emergent tree layer often includes *Corymbia calophylla, E. marginata,* or less commonly *E. gomphocephala*; AND Other trees of a medium height may be present and may be co-dominant with the *Banksia* species across a patch, include *E. todtiana, Nuytsia floribunda, Allocasuarina fraseriana, Callitris arenaria, Callitris pyramidalis* and *Xylomelum occidentale*; AND	Canopy is dominated by *E. marginata* and *A. fraseriana* at all four sample point locations with patches of relevant *Banksia* species in two of the four sample point locations.
Contra-indicators	
Patches clearly dominated by *Banksia littoralis* are not part of the TEC	No
Patches clearly dominated by *Banksia burdettii* are not the TEC	No
FCT20c – Eastern shrublands and woodlands, corresponds with a separate EPBC ecological community listing, Shrublands and Woodlands of the eastern Swan Coastal Plain. Occurrences of this FCT should be considered under that separate listing.	No

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4.2.4 Banksia Woodland Patch 4

Location	Patch 4 is nestled between Brae Road, Brand Road, and Sultana Road West.
Key diagnostic characteristics	Overstorey is dominated by *E. marginata* and *A. fraseriana* with 0-15% of *Banksia* species present.
Condition	Patch condition is Very Good to Excellent with low species richness accounting for the lower score. There are 80 species within the patch represented by four sample point locations. Mean species richness is 40 species/quadrat which is moderate compared to FCT20a with 67.4 species/quadrat. Species richness may be higher with another quadrat scoring event. Weed cover is less than 5%.
Patch size	7.00 ha
Additional features	Supports population of Threatened *Conospermum undulatum*. Provides linkage between patch 2, 3 and 5. Plays important habitat corridor role for Bush Forever block located nearby and Poison Gully riparian vegetation.
Land use history	Unknown. Semi-rural development in area has created isolated 'backyard' patches of native vegetation separated by firebreaks, fences, roads and backyards.
Any variations in patch	Highly variable condition reflecting landowner maintenance, historical clearing and low-level grazing from livestock. Firebreaks are prone to erosion as highly mobile sand is exposed, exacerbating degradation in some localised areas. Weed invasion is also significant in some areas.
Buffer zone present	No buffer zone is present.
Sampling protocol	Patch is represented by two quadrats (HW13, HW16) and two relevés (HW12r, HW18r). All sample point locations were subject to one scoring event in November 2016.
Disturbance history	Unknown.
Surrounding environment	The area is surrounded by private properties which include some areas of native vegetation and planted gardens as well as infrastructure.

Key diagnostic characteristics	**Response**
Location and physical environment	
Patch on Swan Coastal Plain or adjacent lower parts of the Darling and Whicher escarpments that lie within the Jarrah Forest bioregion to the immediate east and south of the Swan Coastal Plain.	Swan Coastal Plain
Soils and landform	
Typically occurs on: deep Bassendean, Spearwood sands, occasionally on Quindalup sands, sandy colluvium and Aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau. Sometimes on transitional substrates, sandflats.	Crosses from Southern River Complex onto Forrestfield Complex.

D R A F T

Key diagnostic characteristics	Response
Structure: The structure of the ecological community is a low woodland to forest with the following features:	
Distinctive upper sclerophyllous layer of low trees typically dominated or co-dominated by one or more of the *Banksia* species identified below; AND Emergent trees *Eucalyptus* or *Allocasuarina* species may sometimes be present above the *Banksia* canopy; AND Highly species-rich understorey that consists of a layer of sclerophyllous shrubs of various heights and a herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs that sometimes includes grasses.	Dominated by *E. marginata* (8-40%, all sample locations) and *A. fraseriana* (3-15%, all sample locations) with *B. menziesii* (0-10%, two sample locations) and some *B. attenuata* (0-8%, two sample locations). Understorey is comprised of 36 sclerophyllous shrubs, 11 rushes and sedges of variable dominance, and 24 herbs.
Composition	
Canopy is most commonly dominated or co-dominated by *Banksia attenuata* and/or *Banksia menziesii.* Other *Banksia* species that dominate in some examples of the ecological community are *B. prionotes* or *B. ilicifolia*; AND Must include at least one of the following diagnostic species: · *Banksia attenuata* · *Banksia menziesii* · *Banksia prionotes* · *Banksia ilicifolia* Emergent tree layer often includes *Corymbia calophylla, E. marginata,* or less commonly *E. gomphocephala*; AND Other trees of a medium height may be present and may be co-dominant with the *Banksia* species across a patch, include *E. todtiana, Nuytsia floribunda, Allocasuarina fraseriana, Callitris arenaria, Callitris pyramidalis* and *Xylomelum occidentale*.	Canopy is dominated by *E. marginata* and *A. fraseriana* with patches of relevant *Banksia* species at two of the four sample point locations.
Contra-indicators	
Patches clearly dominated by *Banksia littoralis* are not part of the TEC	No
Patches clearly dominated by *Banksia burdettii* are not the TEC	No
FCT20c – Eastern shrublands and woodlands, corresponds with a separate EPBC ecological community listing, Shrublands and Woodlands of the eastern Swan Coastal Plain. Occurrences of this FCT should be considered under that separate listing.	No

D R A F T

4.2.5 Banksia Woodland Patch 5

Location	Patch 5 is located on the north side of Brae Road between Sultana Road West and Stewart Road.
Key diagnostic characteristics	Meets most key diagnostic criteria. As with all other patches in this area, the overstorey is dominated by *E. marginata* with minor areas of *Banksia* if present at all.
Condition	Condition is considered Very Good. Despite the low species richness, this is a direct reflection of sample effort rather than condition of the patch. Species richness is 32 species/quadrat, considered moderate to low compared to FCT20a with 67.4 species/quadrat. Additional quadrats in the patch in Excellent condition vegetation and more scoring events may influence this assessment. Weeds represent less than 3% of total foliage cover, taking into account the quadrat was located away from the edge of the patch.
Patch size	1.08 ha
Additional features	Represents extension of habitat corridor/area between Bush Forever Site, other patches of native vegetation, and Poison Gully.
Land use history	Unknown. Partial clearing for housing and associated infrastructure.
Any variations in patch	Significant variation in condition of native vegetation reflecting landowner use of area and land use history.
Buffer zone present	No buffer zone present.
Sampling protocol	Patch represented by one quadrat, HW17, sampled once in November 2016. Low representation of patch in suitable quadrats is likely to have affected the assessment.
Disturbance history	Unknown.
Surrounding environment	Surrounded by semi-rural urbanisation including gardens, paddocks with livestock, housing and a road.

Key diagnostic characteristics	**Response**
Location and physical environment	
Patch on Swan Coastal Plain or adjacent lower parts of the Darling and Whicher escarpments that lie within the Jarrah Forest bioregion to the immediate east and south of the Swan Coastal Plain.	Swan Coastal Plain
Soils and landform	
Typically occurs on: deep Bassendean, Spearwood sands, occasionally on Quindalup sands, sandy colluvium and Aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau. Sometimes on transitional substrates, sandflats.	Southern River Complex.

D R A F T

Key diagnostic characteristics	Response
Structure: The structure of the ecological community is a low woodland to forest with the following features:	
Distinctive upper sclerophyllous layer of low trees typically dominated or co-dominated by one or more of the *Banksia* species identified below; AND Emergent trees *Eucalyptus* or *Allocasuarina* species may sometimes be present above the *Banksia* canopy; AND Highly species-rich understorey that consists of a layer of sclerophyllous shrubs of various heights and a herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs that sometimes includes grasses.	Patch is dominated by *E. marginata* and *A. fraseriana* with occasional *Banksia* species. Undesrtorey includes 12 sclerophyllous shrubs, 12 herbs and three sedges. Additional survey effort is likely to increase these numbers.
Composition	
Canopy is most commonly dominated or co-dominated by *Banksia attenuata* and/or *Banksia menziesii.* Other *Banksia* species that dominate in some examples of the ecological community are *B. prionotes* or *B. ilicifolia*; AND Must include at least one of the following diagnostic species: · *Banksia attenuata* · *Banksia menziesii* · *Banksia prionotes* · *Banksia ilicifolia* Emergent tree layer often includes *Corymbia calophylla, E. marginata,* or less commonly *E. gomphocephala*; AND Other trees of a medium height may be present and may be co-dominant with the *Banksia* species across a patch, include *E. todtiana, Nuytsia floribunda, Allocasuarina fraseriana, Callitris arenaria, Callitris pyramidalis* and *Xylomelum occidentale*; AND	No, the canopy is dominated by *E. marginata* and *A. fraseriana.*
Contra-indicators	
Patches clearly dominated by *Banksia littoralis* are not part of the TEC	No
Patches clearly dominated by *Banksia burdettii* are not the TEC	No
FCT20c – Eastern shrublands and woodlands, corresponds with a separate EPBC ecological community listing, Shrublands and Woodlands of the eastern Swan Coastal Plain. Occurrences of this FCT should be considered under that separate listing.	No

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1:10,000 when printed at A4
DATUM GDA 1994, PERTH COASTAL GRID94
0 100 200 300 400
Meters

Data sources: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Base Data: (c) Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2016).

LEGEND
Survey Area
Banksia Woodlands of the Swan Coastal Plain
Excellent Condition
Very Good Condition
Good Condition

Threatened Ecological Communities

SHIRE OF KALAMUNDA

FORRESTFIELD NORTH

Figure 2

Map Document: \\AUPER1FP001.AU.AECOMNET.COM\Projects\605X\605273044. Tech Work Area\4.99 GIS\02_MXDs\Forrestfield_North_Jan2016\G60527304_Fig2_ThreatenedCommunities_v5_A4.mxd (fotheringhamd)

A4 size

D R A F T

5.0 Conclusion

The native vegetation mapped as Woodlands in Good or better condition within the Forrestfield North survey area represents the Federally listed Banksia Woodlands of the Swan Coastal Plain. This community extends for 15.30 ha and is considered in Very Good to Excellent condition in accordance with the Banksia Woodlands key diagnostic criteria.

This outcome is further supported by the FCT analysis which showed all quadrats within the survey area represent FCT20a Banksia Woodlands over Species-rich Dense Shrublands. This community is listed as Endangered by DBCA and under the EPBC Act. This is at odds with the desktop study which also showed a considerable presence of the Priority 3 community (as listed by DBCA) named Banksia Dominated Woodlands of the SCP. This community is not associated with a particular FCT and its diagnostic features are undefined.

The similarity of survey quadrats to the SCP dataset was moderate, at 32-52% similarity to SCP quadrats representing FCT20a. This low similarity is likely a factor of survey effort and timing. The description of FCT20a, its known location, and identifying features as published in Gibson *et al.* (1994) match the description of the three Woodlands mapped within the survey area.

D R A F T

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D R A F T

Appendix A

Quadrat Data

Plot Data

Site No: HW01	**Type: Quadrat**	**Longitude: 116.009195**	**Latitude: -31.96267**
Date: 11/22/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: AfHhMp		Fire History: 10+	
Vegetation Condition: E. Edge Effect			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		250	2
Aira caryophyllea	*	10	0.1
Alexgeorgea nitens		5	2
Allocasuarina fraseriana		800	10 in landscape
Allocasuarina humilis			Oppo
Anigozanthos manglesii		60	0.3
Banksia attenuata			Oppo
Banksia dallanneyi var. *dallanneyi*		10	3
Banksia menziesii		500	2
Bossiaea eriocarpa		20	0.3
Briza maxima	*	30	0.5
Burchardia congesta		30	0.2
Caesia micrantha		70	0.1
Calothamnus torulosus			Oppo
Caustis dioica			Oppo
Conospermum undulatum			
Conostephium pendulum			Oppo
Dampiera linearis		15	0.1
Dasypogon obliquifolius		30	1
Daviesia divaricata			Oppo
Daviesia nudiflora subsp. *nudiflora*		50	0.3
Desmocladus fasciculatus		5	0.1
Ehrharta calycina	*	100	0.3
Eucalyptus marginata subsp. *marginata*		1200	8 in landscape
Gastrolobium capitatum		40	0.1
Gladiolus caryophyllaceus	*	50	0.5
Gompholobium knightianum		2	0.1
Gompholobium tomentosum			Oppo
Haemodorum laxum		120	0.5
Hakea conchifolia			Oppo
Hakea incrassata			Oppo
Hibbertia hypericoides		30	2
Hypochaeris glabra	*	30	0.1
Jacksonia floribunda			Oppo
Lambertia multiflora		100	2
Lepidosperma leptostachyum		80	0.2

Taxon	Cons. Code	Height (cm)	% Alive
Levenhookia pusilla		5	0.1
Lomandra preissii		40	0.3
Lomandra sericea		30	0.1
Lomandra suaveolens		10	0.1
Melaleuca trichophylla		40	4
Mesomelaena pseudostygia		30	10
Mesomelaena tetragona		50	1
Nuytsia floribunda			Oppo
Opercularia vaginata		15	2
Patersonia occidentalis			Oppo
Petrophile macrostachya			Oppo
Petrophile linearis		40	0.5
Philotheca spicata			Oppo
Phyllanthus calycinus			Oppo
Pimelea ciliata subsp. *ciliata*			Oppo
Rhodanthe citrina		10	0.1
Scaevola canescens		3	0.2
Scaevola repens var. *repens*		15	3
Schoenus brevisetis		30	8
Stirlingia latifolia			Oppo
Stylidium diuroides subsp. *diuroides*		10	0.1
Isopogon drummondii	P3	100	0.5
Boronia ramosa subsp. *anethifolia*		30	0.2
Synaphea sp.			Oppo
Tetraria octandra		30	6
Trachymene pilosa		4	0.1
Tricoryne elatior		25	0.2
Tricostularia exsul		80	0.5
Ursinia anthemoides	*	20	0.1
Xanthorrhoea acanthostachya		100	8
Xanthorrhoea preissii			Oppo
Xanthosia huegelii		10	0.1

Site No: HW02	Type: Quadrat	Longitude: 116.009435	Latitude: -31.962045
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmAcMt		Fire History: 10+	
Vegetation Condition: E. Rubbish, Edge effect			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		350	6
Allocasuarina humilis		60	2
Astroloma stomarrhena		5	0.1
Banksia dallanneyi var. *dallanneyi*		30	2
Banksia menziesii		500	6
Bossiaea eriocarpa		15	0.2
Briza maxima	*	30	0.1
Burchardia congesta		30	0.1
Caesia micrantha			oppo
Caladenia sp.		5	0.1
Calothamnus torulosus		40	0.2
Conospermum undulatum		160	0.3
Conostylis aurea		20	0.1
Conostylis serrulata			oppo
Conostylis setigera		15	0.1
Conostylis setosa			oppo
Cyathochaeta avenacea		100	1
Dasypogon bromeliifolius			oppo
Dasypogon obliquifolius		20	1
Daviesia angulata		100	0.6
Daviesia nudiflora subsp. *nudiflora*		40	0.3
Desmocladus fasciculatus		10	0.1
Desmocladus flexuosus		30	0.6
Eucalyptus marginata subsp. *marginata*		600	10
Gastrolobium capitatum		20	0.1
Gastrolobium capitatum		40	0.1
Gladiolus caryophyllaceus	*	50	0.1
Gompholobium tomentosum			oppo
Haemodorum laxum		140	1
Hemiphora bartlingii		20	0.1
Hibbertia hypericoides		30	6
Jacksonia lehmannii		40	0.1
Kennedia prostrata			oppo
Lambertia multiflora		80	1
Lepidosperma leptostachyum		60	1
Lomandra sericea		30	0.2
Lyginia barbata			oppo

Taxon	Cons. Code	Height (cm)	% Alive
Melaleuca trichophylla		40	6
Mesomelaena pseudostygia		50	15
Patersonia occidentalis		30	0.4
Petropile linearis		30	0.2
Pimelea ciliata subsp. *ciliata*		20	0.1
Scaevola repens var. *repens*		10	1
Stirlingia latifolia		50	0.3
Stylidium piliferum		10	0.1
Boronia ramosa subsp. *anethifolia*		30	0.1
Synaphea sp.		40	0.1
Tetraria octandra		60	15
Thysanotus arbuscula		30	0.1
Tricoryne elatior		30	0.1
Tricoryne elatior		30	1
Tricostularia exsul		100	3
Ursinia anthemoides	*	10	0.1
Vellereophyton dealbatum		5	0.1
Xanthorrhoea acanthostachya		230	0.5
Xanthorrhoea gracilis		60	5

Site No: HW03	Type: Quadrat	Longitude: 116.010158	Latitude: -31.960788
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: E. Weeds			





Taxon	Cons. Code	Height (cm)	% Alive
Alexgeorgea nitens		30	25
Allocasuarina fraseriana		250	2
Banksia attenuata		500	4
Banksia dallanneyi var. *dallanneyi*		20	2
Bossiaea eriocarpa		30	1.5
Briza maxima	*	30	0.2
Burchardia congesta		60	0.2
Calothamnus quadrifidus subsp. *quadrifidus*			oppo
Conospermum undulatum		50	0.2
Cyathochaeta avenacea		100	4
Dampiera alata		30	0.2
Dasypogon obliquifolius		30	0.2
Daviesia nudiflora subsp. *nudiflora*		40	0.5
Ehrharta calycina	*	100	0.4
Eragrostis curvula	*	130	1
Eucalyptus marginata subsp. *marginata*		1300	15
Gastrolobium capitatum		40	0.1
Gladiolus caryophyllaceus	*	80	0.1
Gompholobium confertum			oppo
Gompholobium knightianum		10	0.1
Haemodorum laxum		130	2
Hemiandra pungens		20	0.3
Jacksonia floribunda		40	0.2
Lepidosperma sp.		30	15
Lomandra sericea		30	0.2
Lomandra sericea		40	0.3
Melaleuca trichophylla		40	0.3
Petrophile linearis		50	0.1
Scaevola repens var. repens		10	4
Schoenus brevisetis		40	1
Stirlingia latifolia		50	0.6
Synaphea sp.		20	1
Thysanotus arbuscula		80	0.1
Tricoryne elatior		40	0.5
Xanthorrhoea preissii		100	5

Site No: HW04	Type: Quadrat	Longitude: 116.006648	Latitude: -31.962009
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: AfHhMp		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		350	15
Allocasuarina fraseriana		300	0.5
Allocasuarina humilis		70	1
Banksia attenuata		500	2
Banksia dallanneyi		30	0.2
Banksia dallanneyi var. *dallanneyi*		20	4
Banksia grandis		500	5
Bossiaea eriocarpa		30	0.4
Burchardia congesta		40	0.2
Caesia micrantha		70	0.1
Calothamnus torulosus		20	0.1
Calytrix sp.			Oppo
Conospermum undulatum		20	0.1
Conostylis juncea		5	0.1
Cyathochaeta avenacea		110	0.2
Dampiera linearis		5	0.1
Dasypogon bromeliifolius		50	3
Dasypogon obliquifolius		20	0.5
Daviesia nudiflora subsp. *nudiflora*		30	0.2
Desmocladus fasciculatus		10	0.1
Eucalyptus marginata subsp. *marginata*		1400	20
Gastrolobium capitatum		30	0.1
Gompholobium confertum			Oppo
Haemodorum laxum		20	0.1
Haemodorum spicatum		100	0.1
Hakea lissocarpha		80	0.5
Hemiphora bartlingii			Oppo
Hibbertia huegelii		20	0.1
Hibbertia hypericoides		40	4
Lambertia multiflora		90	0.5
Lomandra hermaphrodita		20	0.1
Lomandra sericea		30	0.1
Lyginia barbata		60	1
Melaleuca trichophylla		40	0.5
Mesomelaena tetragona		50	10
Patersonia occidentalis		40	0.5
Petrophile linearis		30	0.2

Taxon	Cons. Code	Height (cm)	% Alive
Petrophile macrostachya		50	0.4
Philotheca spicata		100	0.2
Scaevola repens var. *repens*		15	1
Stachystemon vermicularis		40	1
Stirlingia latifolia		50	1.5
Isopogon drummondii	P3	80	1
Thysanotus affinis		20	0.1
Tricoryne elatior		30	0.1
Tricostularia exsul		80	15
Xanthorrhoea acanthostachya		80	4
Xylomelum occidentale		30	0.1

Site No: HW05	Type: Releve	Longitude: 116.007014	Latitude: -31.962401
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition:	
Community: EmAcMt		Fire History:	
Vegetation Condition: VG.			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		400	25
Allocasuarina fraseriana		250	0.5
Allocasuarina humilis		80	0.5
Bossiaea eriocarpa		30	0.2
Conospermum undulatum			Oppo
Cyathochaeta avenacea		120	0.5
Dampiera linearis		10	0.1
Dasypogon obliquifolius		40	0.1
Daviesia nudiflora subsp. *nudiflora*			Oppo
Eremaea pauciflora var. *pauciflora*		50	0.5
Eucalyptus marginata subsp. *marginata*		300	1
Gompholobium confertum		20	0.1
Gompholobium tomentosum		40	0.3
Haemodorum laxum			Oppo
Hemiphora bartlingii		30	0.2
Hibbertia hypericoides		30	1
Johnsonia pubescens subsp. *pubescens*			Oppo
Kunzea glabrescens		250	1
Lambertia multiflora		100	0.5
Lyginia barbata		50	0.2
Lysinema pentapetalum			Oppo
Petrophile linearis			Oppo
Schoenus brevisetis			Oppo
Stirlingia latifolia		40	0.5
Isopogon drummondii	P3	60	0.4
Synaphea sp.			Oppo
Tricostularia exsul		100	20
Xanthorrhoea preissii		80	3

Site No: HW06	Type: Quadrat	Longitude: 116.007671	Latitude: -31.961865
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: AfHhMp		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina fraseriana		700	8
Allocasuarina humilis		60	2
Banksia attenuata		500	8
Banksia dallanneyi var. *dallanneyi*		10	1
Banksia menziesii		400	3
Bossiaea eriocarpa		30	0.2
Briza maxima	*	30	0.1
Burchardia congesta		40	0.1
Calothamnus torulosus		30	1
Caustis dioica		40	0.3
Conostephium pendulum		40	0.1
Cyathochaeta avenacea		100	0.5
Dasypogon bromeliifolius		30	0.5
Dasypogon obliquifolius		30	2
Daviesia nudiflora subsp. *nudiflora*		50	0.2
Ehrharta calycina	*	100	4
Gastrolobium capitatum		20	0.1
Gladiolus caryophyllaceus	*	60	0.2
Gompholobium confertum		25	0.1
Gompholobium tomentosum		30	0.1
Haemodorum laxum		70	0.1
Hemiandra pungens		20	0.2
Hemiphora bartlingii		25	0.1
Hibbertia hypericoides		40	2
Lepidosperma leptostachyum		60	1
Mesomelaena pseudostygia		30	5
Petrophile macrostachya		40	0.3
Petrophile rigida		40	0.2
Scaevola repens var. *repens*		10	0.2
Schoenus brevisetis		40	1
Isopogon drummondii	P3	100	3
Tricoryne elatior		30	0.1
Tricostularia exsul		60	1
Xanthorrhoea preissii		100	6

Site No: HW07	Type: Quadrat	Longitude: 115.995246	Latitude: -31.952148
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: White	
Rocky Type:		Soil Condition: Dry	
Community: VdCd		Fire History: 10+	
Vegetation Condition: VG.			





Taxon	Cons. Code	Height (cm)	% Alive
Alexgeorgea nitens		15	0.2
Anigozanthos manglesii		30	0.3
Banksia dallanneyi var. *dallanneyi*		10	0.2
Briza maxima	*	30	0.1
Caesia micrantha		25	0.1
Caustis dioica		30	2
Conostylis juncea		20	0.1
Cyathochaeta avenacea		120	0.5
Dasypogon bromeliifolius			Oppo
Daviesia angulata		60	0.3
Ehrharta calycina	*	120	0.3
Eucalyptus marginata subsp. *marginata*		2000	2
Gladiolus caryophyllaceus	*	40	0.1
Grevillea bipinnatifida subsp. *bipinnatifida*		40	0.3
Haemodorum spicatum		100	1
Hypocalymma angustifolium			Oppo
Hypolaena exsulca		25	0.1
Jacksonia lehmannii		15	0.1
Lomandra micrantha		25	0.1
Lyginia barbata		50	1
Mesomelaena tetragona		60	0.5
Patersonia occidentalis		40	1
Pentameris airoides subsp. *airoides*	*	20	0.5
Scaevola canescens		10	0.1
Schoenus brevisetis		50	1
Stirlingia latifolia		60	2
Boronia ramosa subsp. *anethifolia*		20	0.1
Tricoryne elatior		30	0.2
Ursinia anthemoides	*	15	1
Verticordia densiflora var. *densiflora*		50	6
Xanthorrhoea preissii		70	0.5

Site No: HW08	Type: Quadrat	Longitude: 115.995632	Latitude: -31.953041
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: VdCd		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Agrostocrinum scabrum		30	0.1
Allocasuarina humilis		60	1
Anigozanthos manglesii		60	0.2
Babingtonia camphorosmae		30	0.2
Banksia dallanneyi var. *dallanneyi*		20	0.1
Bossiaea eriocarpa		30	0.2
Briza maxima	*	30	0.2
Burchardia congesta		40	0.2
Caustis dioica		50	10
Cheiranthera preissiana			0.1
Conostylis aurea		15	0.2
Dasypogon bromeliifolius		30	1
Daviesia angulata		90	8
Daviesia preissii			Oppo
Desmocladus fasciculatus		10	0.1
Eucalyptus marginata subsp. *marginata*		2500	5
Gastrolobium capitatum		20	0.2
Gladiolus caryophyllaceus	*	40	0.2
Goodenia caerulea		15	0.1
Grevillea bipinnatifida subsp. *bipinnatifida*		30	0.6
Haemodorum laxum		80	0.1
Hibbertia hypericoides		50	0.4
Hyalosperma cotula		10	0.1
Hypocalymma angustifolium		50	3
Hypolaena exsulca		20	0.4
Hypolaena exsulca		30	0.2
Lyginia barbata		40	1
Mesomelaena tetragona		70	3
Patersonia occidentalis		30	2
Philotheca spicata		60	0.3
Scaevola repens var. *repens*		10	0.2
Stirlingia latifolia		50	0.5
Boronia ramosa subsp. *anethifolia*		20	0.1

Taxon	Cons. Code	Height (cm)	% Alive
Tetraria octandra		40	2
Thysanotus patersonii			0.1
Tricoryne elatior		20	0.6
Verticordia densiflora var. *densiflora*		50	1
Xanthorrhoea preissii		80	2
Xanthosia huegelii		15	0.2

Site No: HW09	Type: Quadrat	Longitude: 116.007428	Latitude: -31.956075
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: AfHhMp		Fire History: 10+	
Vegetation Condition:			





Taxon	Cons. Code	Height (cm)	% Alive
Acacia pulchella var. pulchella		80	0.6
Adenanthos cygnorum subsp. *cygnorum*		200	
Alexgeorgea nitens		10	0.2
Allocasuarina fraseriana		600	10
Allocasuarina humilis			Oppo
Anigozanthos manglesii		60	0.2
Avena barbata	*		Oppo
Banksia armata var. *armata*			Oppo
Banksia attenuata		400	
Banksia dallanneyi var. *dallanneyi*		20	1
Bossiaea eriocarpa		40	2
Briza maxima	*	20	0.2
Burchardia congesta		50	0.2
Caesia micrantha			Oppo
Calothamnus torulosus		30	0.2
Caustis dioica		50	8
Conostephium pendulum			Oppo
Conostylis setigera		15	0.1
Cyathochaeta avenacea		110	0.4
Dampiera linearis		15	0.1
Dasypogon obliquifolius		30	0.5
Daviesia angulata		60	0.4
Daviesia nudiflora subsp. *nudiflora*			Oppo
Desmocladus fasciculatus		10	1
Ehrharta calycina	*		Oppo
Gastrolobium capitatum		30	0.5
Gladiolus caryophyllaceus	*	50	0.2
Haemodorum laxum		130	2
Haemodorum spicatum			Oppo
Hakea conchifolia		60	0.4
Hemiandra linearis			Oppo
Hemiphora bartlingii			Oppo
Hibbertia hypericoides		60	20
Jacksonia lehmannii		25	0.1
Lambertia multiflora		150	8
Lechenaultia biloba			Oppo
Lepidosperma leptostachyum		40	0.5

Taxon	Cons. Code	Height (cm)	% Alive
Lomandra sericea		30	0.4
Lyginia barbata		40	0.2
Mesomelaena pseudostygia		50	6
Mesomelaena tetragona		50	2
Monotaxis grandiflora var. *grandiflora*			Oppo
Nuytsia floribunda		700	2
Patersonia occidentalis			Oppo
Petrophile macrostachya		50	0.8
Philotheca spicata		60	0.2
Pimelea ciliata subsp. *ciliata*		50	0.1
Scaevola repens var. *repens*		10	0.2
Schoenus brevisetis		40	0.4
Stylidium piliferum		10	0.1
Isopogon drummondii	P3		Oppo
Synaphea sp.			Oppo
Thomasia macrocarpa			Oppo
Thysanotus arbuscula		20	0.2
Vellereophyton dealbatum		5	0.1
Xanthorrhoea preissii		120	1

Site No: HW10	Type: Quadrat	Longitude: 116.008553	Latitude: -31.957151
Date: 11/23/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmAcMt		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Acacia pulchella var. *pulchella*		100	1.5
Alexgeorgea nitens		10	0.2
Allocasuarina humilis		80	4
Banksia armata var. *armata*			Oppo
Banksia attenuata		400	1
Banksia dallanneyi var. *dallanneyi*		10	1
Banksia menziesii		500	15
Banksia sphaerocarpa		40	1
Bossiaea eriocarpa		30	0.5
Briza maxima	*	30	0.1
Burchardia congesta		40	0.1
Calothamnus torulosus			
Conospermum undulatum		80	0.2
Conostephium pendulum		50	0.2
Conostylis aurea			Oppo
Dasypogon obliquifolius		20	1
Daviesia nudiflora subsp. *nudiflora*		40	0.2
Desmocladus fasciculatus		10	0.1
Eremaea pauciflora var. *pauciflora*		40	2
Eucalyptus marginata subsp. *marginata*		2000	10
Gastrolobium capitatum			Oppo
Gladiolus caryophyllaceus	*	40	0.2
Haemodorum laxum			Oppo
Haemodorum sp.		10	0.1
Hemiandra pungens			Oppo
Hibbertia hypericoides		40	8
Jacksonia floribunda		50	0.2
Lambertia multiflora		100	2
Lepidosperma leptostachyum		40	2
Leucopogon sp.		40	0.1
Lomandra sericea		30	0.1
Lyginia barbata		40	1
Melaleuca trichophylla		40	3
Mesomelaena pseudostygia		40	1
Monotaxis grandiflora var. *grandiflora*		5	0.2
Patersonia occidentalis			Oppo
Petrophile macrostachya		50	1.5

Taxon	Cons. Code	Height (cm)	% Alive
Scaevola repens var. *repens*		15	0.3
Stirlingia latifolia		40	1
Isopogon drummondii	P3	80	3
Synaphea sp.		50	0.5
Tricoryne elatior		30	0.7
Tricostularia exsul		40	10
Xanthorrhoea preissii		90	1

Site No: HW11	Type: Releve	Longitude: 116.009061	Latitude: -31.957063
Date: 11/23/2016		Soil Types:	
Topography: Flat		Soil Colour:	
Rocky Type:		Soil Condition:	
Community: EmToDo		Fire History:	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina fraseriana		1300	15
Allocasuarina humilis		60	0.5
Banksia sphaerocarpa		50	0.5
Bossiaea eriocarpa		30	1
Burchardia congesta		40	0.3
Cheiranthera preissiana			0.1
Eucalyptus marginata subsp. *marginata*		1600	20
Gladiolus caryophyllaceus	*	40	0.1
Gompholobium knightianum		40	0.1
Hakea conchifolia		70	0.2
Hemiandra pungens			Oppo
Lyginia barbata			Oppo
Mesomelaena pseudostygia		40	10
Nuytsia floribunda		200	1
Patersonia occidentalis		30	1
Petrophile macrostachya		200	1
Scaevola repens var. *repens*		10	0.5
Tetraria octandra		30	20
Xanthorrhoea preissii		90	2

Site No: HW12r	Type: Releve	Longitude: 116.005128	Latitude: -31.960586
Date: 11/28/2016		Soil Types: Loam sand	
Topography: Flat		Soil Colour: Dark Brown	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: VG.			





Taxon	Cons. Code	Height (cm)	% Alive
Acacia sp.	Pl		Oppo
Adenanthos cygnorum subsp. *cygnorum*			Oppo
Allocasuarina fraseriana		400	10
Allocasuarina humilis			Oppo
Asteraceae (planted)	Pl	60	2
Banksia attenuata		350	8
Banksia dallanneyi		30	4
Banksia grandis		60	0.1
Banksia menziesii		400	2
Banksia sessilis var. *sessilis*			Oppo
Briza maxima	*	40	2
Conostephium pendulum			Oppo
Dampiera linearis		20	0.2
Dasypogon bromeliifolius		30	0.2
Dasypogon obliquifolius			Oppo
Desmocladus fasciculatus			Oppo
Eucalyptus marginata subsp. *marginata*		700	40
Haemodorum laxum			Oppo
Hibbertia hypericoides			Oppo
Hypochaeris glabra	*		0.5
Lambertia multiflora			Oppo
Lepidosperma leptostachyum		40	2
Mesomelaena tetragona			Oppo
Patersonia occidentalis		40	0.2
Persoonia elliptica		400	3
Petrophile macrostachya			Oppo
Stirlingia latifolia		40	0.2
Isopogon drummondii	P3	80	0.2
Tetraria octandra		40	10
Tricostularia exsul			Oppo
Xanthorrhoea preissii		100	0.5

Site No: HW13	Type: Quadrat	Longitude: 116.006285	Latitude: -31.959895
Date: 11/28/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina fraseriana		400	15
Banksia dallanneyi var. *dallanneyi*		30	10
Banksia grandis			Oppo
Bossiaea eriocarpa		40	1
Briza maxima	*	30	3
Burchardia congesta		40	0.2
Conospermum undulatum		100	0.4
Conostephium pendulum		40	0.1
Cyathochaeta avenacea		70	0.2
Dampiera alata		20	0.1
Dampiera linearis		15	0.2
Dasypogon obliquifolius		40	2
Daviesia divaricata		20	0.1
Daviesia nudiflora subsp. *nudiflora*		50	0.3
Desmocladus fasciculatus		10	1
Ehrharta calycina	*	80	0.1
Eucalyptus marginata subsp. *marginata*		1800	10
Gladiolus caryophyllaceus	*	60	0.1
Gompholobium knightianum		20	0.2
Gompholobium tomentosum		40	0.2
Haemodorum laxum		100	0.2
Hakea conchifolia			Oppo
Hemiandra pungens		20	1
Hemiphora bartlingii			Oppo
Hibbertia hypericoides		20	0.5
Lambertia multiflora		160	8
Lechenaultia biloba		5	0.1
Lepidosperma leptostachyum		50	2
Leucopogon ?conostephioides		30	0.2
Lomandra preissii		20	0.1
Lyginia barbata		40	0.5
Melaleuca trichophylla		50	0.5
Mesomelaena pseudostygia		40	4
Mesomelaena tetragona		40	0.5
Monotaxis grandiflora var. *grandiflora*		20	0.1
Opercularia vaginata		30	0.1
Patersonia occidentalis		30	0.2

Taxon	Cons. Code	Height (cm)	% Alive
Persoonia elliptica			Oppo
Petrophile linearis		15	0.2
Pimelea ciliata subsp. *ciliata*		30	0.2
Scaevola repens var. *repens*		10	0.2
Stirlingia latifolia			Oppo
Boronia ramosa subsp. *anethifolia*		20	0.1
Synaphea sp.		30	0.3
Tetraria octandra		40	8
Tricoryne elatior		20	0.2
Tricostularia exsul		60	2
Vellereophyton dealbatum		5	0.1
Xanthorrhoea acanthostachya		70	0.3
Xanthorrhoea preissii		80	8

Site No: HW14r	Type: Releve	Longitude: 116.007548	Latitude: -31.958775
Date: 11/29/2016		Soil Types:	
Topography: Flat		Soil Colour:	
Rocky Type:		Soil Condition:	
Community: EmAcMt		Fire History:	
Vegetation Condition: G.			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. *cygnorum*		350	15
Alexgeorgea nitens			Oppo
Allocasuarina fraseriana			Oppo
Allocasuarina humilis		40	0.2
Amphipogon strictus		20	0.5
Banksia attenuata			Oppo
Banksia dallanneyi var. *dallanneyi*		20	0.5
Banksia menziesii		400	5
Billardiera fraseri			0.2
Briza maxima	*	30	5
Cyathochaeta avenacea		130	0.3
Dasypogon obliquifolius			Oppo
Daviesia preissii		60	0.2
Desmocladus fasciculatus			Oppo
Ehrharta calycina	*	100	20
Eremaea pauciflora var. *pauciflora*		30	5
Eucalyptus marginata subsp. *marginata*		700	5
Gladiolus caryophyllaceus	*		Oppo
Haemodorum spicatum		100	0.1
Lambertia multiflora		220	0.5
Lyginia barbata		40	0.5
Melaleuca trichophylla		40	6
Mesomelaena pseudostygia		50	3
Nuytsia floribunda		400	Oppo
Petrophile linearis			Oppo
Ptilotus manglesii		30	0.5
Stirlingia latifolia		40	2
Boronia ramosa subsp. *anethifolia*			Oppo
Tricoryne elatior		30	0.5
Ursinia anthemoides	*		Oppo
Vellereophyton dealbatum			Oppo
Xanthorrhoea preissii		70	1

Site No: HW15r	Type: Releve	Longitude: 116.008478	Latitude: -31.95808
Date: 11/29/2016		Soil Types:	
Topography: Flat		Soil Colour:	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina humilis		100	1
Banksia attenuata			Oppo
Banksia dallanneyi var. *dallanneyi*		20	5
Banksia menziesii			Oppo
Bossiaea eriocarpa		30	8
Burchardia congesta		60	0.1
Caustis dioica		30	1
Dasypogon obliquifolius		30	4
Desmocladus fasciculatus		20	0.2
Ehrharta calycina	*	80	1
Eucalyptus marginata subsp. *marginata*		800	25
Gastrolobium capitatum		40	0.2
Gladiolus caryophyllaceus	*	70	0.2
Gompholobium knightianum			Oppo
Hakea costata		220	0.5
Hibbertia hypericoides		30	0.5
Lambertia multiflora		160	1
Lepidosperma leptostachyum		60	2
Melaleuca trichophylla		40	2
Mesomelaena tetragona		50	10
Opercularia vaginata		30	0.3
Patersonia occidentalis		40	1
Petrophile macrostachya		100	1
Petrophile linearis			Oppo
Philotheca spicata		50	0.2
Schoenus brevisetis		30	1
Stirlingia latifolia		40	0.5
Tetraria octandra		30	1
Tricostularia exsul		60	1
Xanthorrhoea acanthostachya		100	1
Xanthorrhoea preissii		100	5

Site No: HW16	Type: Quadrat	Longitude: 116.004122	Latitude: -31.960853
Date: 11/29/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Grey	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: E.			





Taxon	Cons. Code	Height (cm)	% Alive
Alexgeorgea nitens		10	0.2
Allocasuarina fraseriana		600	10
Allocasuarina humilis		40	0.2
Banksia attenuata		600	5
Banksia dallanneyi var. *dallanneyi*		20	5
Banksia menziesii		300	10
Bossiaea eriocarpa		30	3
Burchardia congesta		40	0.2
Caesia micrantha		30	0.1
Conostephium pendulum		30	0.2
Cyathochaeta avenacea		70	1
Dampiera linearis		20	0.5
Dasypogon obliquifolius		50	4
Daviesia nudiflora subsp. *nudiflora*			Oppo
Daviesia preissii			Oppo
Eucalyptus marginata subsp. *marginata*		800	8
Gastrolobium capitatum		30	1
Haemodorum laxum		80	0.2
Hemiandra pungens		20	2
Hemiphora bartlingii		20	0.3
Hibbertia hypericoides		40	4
Hypolaena exsulca		40	1
Lambertia multiflora		160	6
Lechenaultia biloba		10	0.1
Lomandra preissii		30	0.2
Mesomelaena tetragona		40	10
Patersonia occidentalis		30	0.5
Persoonia elliptica		400	0.5
Petrophile linearis		20	0.1
Pimelea ciliata subsp. *ciliata*		30	0.2
Scaevola repens var. *repens*		10	0.2
Schoenus brevisetis		30	1
Stachystemon vermicularis		60	3
Stirlingia latifolia		50	3
Isopogon drummondii	P3	60	0.5
Synaphea sp.			Oppo

Taxon	Cons. Code	Height (cm)	% Alive
Tetraria octandra		40	5
Thysanotus arbuscula		10	0.1
Tricostularia exsul		60	4
Xanthorrhoea preissii		100	8
Xylomelum occidentale		400	1.5

Site No: HW17	Type: Quadrat	Longitude: 116.001698	Latitude: -31.957207
Date: 11/29/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Dark Brown	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: VG. Weeds, edge effect			





Taxon	Cons. Code	Height (cm)	% Alive
Allocasuarina fraseriana		600	10
Anigozanthos manglesii		100	0.2
Babingtonia camphorosmae		40	0.5
Banksia dallanneyi var. *dallanneyi*		30	8
Bossiaea eriocarpa		20	1
Briza maxima	*	30	1
Conospermum undulatum		130	0.3
Dampiera alata		10	0.2
Dampiera linearis		10	0.2
Dasypogon obliquifolius			Oppo
Daviesia preissii			Oppo
Ehrharta calycina	*	120	1
Eucalyptus marginata subsp. *marginata*		2000	20
Gastrolobium capitatum		30	1
Gladiolus caryophyllaceus	*	70	0.5
Haemodorum laxum		120	0.5
Hibbertia hypericoides		40	3
Lambertia multiflora		110	0.3
Lepidosperma leptostachyum		40	3
Lomandra sericea		30	0.2
Mesomelaena tetragona		40	4
Monotaxis grandiflora var. *grandiflora*		15	1
Opercularia vaginata		30	0.2
Persoonia elliptica		300	2
Scaevola repens var. *repens*		10	0.2
Stirlingia latifolia		40	1
Boronia ramosa subsp. *anethifolia*		10	0.3
Tetraria octandra		30	5
Thysanotus arbuscula		20	0.1
Tricoryne elatior		20	0.2
Xanthorrhoea gracilis		60	3
Xanthosia huegelii		30	0.3

Site No: HW18r	Type: Releve	Longitude: 116.006067	Latitude: -31.958544
Date: 11/30/2016		Soil Types: Sand	
Topography: Flat		Soil Colour: Medium Brown	
Rocky Type:		Soil Condition: Dry	
Community: EmToDo		Fire History: 10+	
Vegetation Condition: VG.			





Taxon	Cons. Code	Height (cm)	% Alive
Adenanthos cygnorum subsp. cygnorum		300	1
Allocasuarina fraseriana		500	3
Banksia armata var. armata		50	1
Banksia dallanneyi var. *dallanneyi*		20	0.5
Banksia menziesii			Oppo
Bossiaea eriocarpa		20	0.5
Briza maxima	*	40	0.5
Caustis dioica		30	0.4
Conostylis aurea		30	0.1
Cyathochaeta avenacea		120	0.5
Dasypogon obliquifolius		30	1
Daviesia nudiflora subsp. *nudiflora*		40	0.5
Desmocladus fasciculatus		10	0.1
Ehrharta calycina	*	80	4
Eucalyptus gomphocephala		1500	1
Eucalyptus marginata subsp. *marginata*		800	25
Gastrolobium capitatum		30	0.5
Gladiolus caryophyllaceus	*	100	0.3
Gompholobium knightianum		30	0.2
Haemodorum laxum		160	0.2
Haemodorum sp.		30	0.1
Hemiandra linearis		10	0.01
Hibbertia hypericoides		50	1
Lambertia multiflora		120	0.5
Lepidosperma leptostachyum		50	0.1
Lomandra preissii		30	0.5
Lyginia barbata		50	0.2
Mesomelaena pseudostygia		40	4
Microtis media		20	0.01
Patersonia occidentalis		40	0.2
Petrophile linearis		40	0.2
Scaevola repens var. *repens*			Oppo
Isopogon drummondii	P3	100	0.3

Taxon	Cons. Code	Height (cm)	% Alive
Tetraria octandra		40	5
Tricoryne elatior		30	0.1
Tricostularia exsul		80	8
Ursinia anthemoides	*	15	0.02
Verticordia densiflora var. *densiflora*		150	0.5
Xanthorrhoea preissii		100	4

Appendix D Ethnosciences (2018) Report of an Ethnographic Assessment of the Forrestfield North DSP

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Ethnography, Heritage & Cultural Interpretation

Report of an Ethnographic Assessment of the Forrestfield North DSP, Shire of Kalamunda, Western Australia

Prepared for Strategen

By Jan Turner, William Christensen and Edward M. McDonald

April 2018

PO Box 121, MELVILLE WA 6956
Phone (08) 9339 8431; Mobile: 0419 957 140
Email: dredward@iinet.net.au

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Disclaimer

The results, conclusions and recommendations contained within this report are based on information available at the time of its preparation. Whilst every effort has been made to ensure that all relevant data has been collated, the authors can take no responsibility for omissions and/or inconsistencies that may result from information becoming available subsequent to the report's completion.

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PO Box 121, MELVILLE WA 6956
Phone (08) 9339 8431; Mobile: 0419 957 140
Email: dredward@iinet.net.au

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Abbreviations

ACMC:	Aboriginal Cultural Material Committee
AHA:	*Aboriginal Heritage Act 1972*
AHIS:	Aboriginal Heritage Inquiry System
DAA:	Department of Aboriginal Affairs
DPLH:	Department of Planning, Lands & Heritage
DSP:	District Structure Plan
PDA:	Proposed Development Area
LSP:	Local Structure Plans
Strategen:	Strategen Environmental
SWALSC:	South West Aboriginal Land and Sea Council

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Richard Wilkes
Ron Gidjup
Tristan Bergin
Vanessa Corunna

PO Box 121, MELVILLE WA 6956
Phone (08) 9339 8431; Mobile: 0419 957 140
Email: dredward@iinet.net.au

Ethnosciences

ABN 47 065 099 228

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Summary & Recommendations

Ethnosciences was commissioned by Strategen to conduct an ethnographic assessment of the Forrestfield North District Structure Plan (DSP) area in the Shire of Kalamunda, with a particular focus on the Registered Aboriginal Site Poison Gully Creek (DPLH ID 25023). The assessment involved both desktop research and community consultation, the latter involving separate women's and men's on-site meetings in December 2017 with follow-up consultation. No archaeological research was undertaken as part of the assessment.

The search of the online AHIS and other archival sources confirmed that Poison Gully Creek (DPLH ID 25023) is the only Registered Aboriginal Site in the DSP study area. Two 'Other Heritage Places' (DPLH ID 3667 and DPLH ID 3637, both artefact scatters) are also listed. It is highly likely that additional archaeological sites (i.e., artefact scatters) could be found within the study area.

Poison Gully Creek (DPLH ID 25023) was the only place within the study area reported by the Aboriginal consultants that might reasonably be considered to be an Aboriginal Site within the meaning of s5 of the AHA. Both the women's and the men's consultations confirmed the cultural significance of Poison Gully Creek and highlighted its importance to Nyungar women in particular as a 'birthing place' with associated rituals and still seen as a place for teaching and learning about traditional cultural knowledge, both specific to the site and country more generally.

The women in particular strongly expressed a desire to protect the natural bush and creek between Dundas Road and Milner Road and in particular the open space adjacent to the Dundas Road crossing. They wish to have an area where they can continue to teach and support their children and grandchildren in an accessible and nurturing bush environment.

Water is a central aspect of the site which, together with its immediate surrounds, is conceptualised to be a single entity from its source in the high country of Kalamunda to where it joins with the waters of Munday Swamp. Both the surface and the subsurface

PO Box 121, MELVILLE WA 6956
Phone (08) 9339 8431; Mobile: 0419 957 140
Email: dredward@iinet.net.au

waters are seen as integral to the site, which despite various historical impacts is conceptualised as following the path laid down by ancestral beings in the Dreaming. Concerns are expressed with regards to impacts on the creek that might also have flow-on effects on Munday Swamp.

Whereas Nyungars are typically concerned about negative impacts on waterways such as Poison Gully Creek, the community is generally supportive of endeavours to improve and restore water flow and quality to reflect the waterways' original state where these have been degraded through past land use practices.

Such work, however, would require either consent from the Minister of Aboriginal Affairs under s18 of the AHA or approval under Regulation 10 from the Registrar of Aboriginal Sites.

The Nyungar consultants' conceptualisation of Poison Gully Creek as a place and its extent is not two-dimensional, nor do they view the place in isolation from its broader geographical and cultural setting. This perspective was reflected in all the meetings with the Nyungar consultants, with a strong emphasis throughout on its relationship with other places. Of special significance to them in this regard were places, such as Munday Swamp and Allawah Grove, traditionally linked by the flow of water and the *bidi* or tracks and part of a meshwork in which place is to be understood as an outcome of movement, practice and event, which result in the experience of 'biographical entanglements'.

Recommendations

1. It is recommended that the Shire of Kalamunda and its agents continue their consultations with the Nyungar community in respect of the Forrestfield North DSP, particularly as this might impact on Poison Gully Creek (DPLH ID 25023).
2. It is also recommended that the Shire of Kalamunda seek advice from the DPLH as to whether any planned impacts on Poison Gully Creek (DPLH ID 25023) will require consent from the Minister of Aboriginal Affairs under s18 of the AHA or approval under Regulation 10 from the Registrar of Aboriginal Sites.

PO Box 121, MELVILLE WA 6956
Phone (08) 9339 8431; Mobile: 0419 957 140
Email: dredward@iinet.net.au

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3. It is further recommended that the Shire of Kalamunda, in conjunction with Nyungar women, examine ways in which the natural bush and creek between Dundas Road and Milner Road can be enhanced as a Nyungar women's place.
4. It is likewise recommended that the Shire of Kalamunda commemorate the Aboriginal heritage of the Forrestfield North DSP study area, giving particular emphasis to the meshwork of Nyungar places, including the high country in Kalamunda, Munday Swamp and Allawah Grove.
5. It is recommended that Nyungars are invited to engage in any works associated with Poison Gully Creek, including the rehabilitation of the creek and revegetation with native plants.
6. It is also recommended that the Shire of Kalamunda commission an archaeological survey of the Forrestfield North DSP study area prior to the commencement of development.

PO Box 121, MELVILLE WA 6956
Phone (08) 9339 8431; Mobile: 0419 957 140
Email: dredward@iinet.net.au

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Phone (08) 9339 8431; Mobile: 0419 957 140
Email: dredward@iinet.net.au

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PO Box 121, MELVILLE WA 6956

Phone (08) 9339 8431; Mobile: 0419 957 140

Email: dredward@iinet.net.au

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Introduction

Ethnosciences was contracted by Strategen Environmental (Strategen) to conduct an ethnographic assessment of the Forrestfield North District Structure Plan (DSP) area in the Shire of Kalamunda, with a particular focus on Poison Gully Creek which is a Registered Aboriginal Site (DPLH ID 25023). An archaeological survey of the Forrestfield North DSP study area was not part of the current study brief.

In June 2014, the State Government announced the Forrestfield Airport Link, a $2 billion train line connecting with the Midland line near Bayswater Station, servicing the airport and finishing in the Forrestfield/High Wycombe area. The train line is scheduled to be commissioned by 2020. Following this announcement, the State Government requested the Shire of Kalamunda to explore the opportunities that a new train station could bring to the surrounding areas. This meant moving away from the industrial land uses previously proposed and focusing on residential and retail/commercial uses more suitable for a train station precinct.

The new focus resulted in the Forrestfield North District Structure Plan being prepared, which planned for the delivery of high-density residential, a new activity centre and a commercially-focused Transit Oriented Development precinct based around the new train station (Figure 1). The purpose of the DSP is to provide strategic guidance for the preparation of subsequent Local Structure Plans (LSPs) which will support the coordination and implementation of subdivision and development around and feeding into the Forrestfield Train Station.

Scope of Works

Ethnosciences provided the following professional services:

- A review of the Aboriginal Heritage Inquiry System (AHIS) and other relevant archival material;
- Ethnographic consultation, including site inspections with relevant Aboriginal stakeholders nominated by the South West Aboriginal Land and Sea Council (SWALSC);

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- Documentation of the Aboriginal representatives' views and comments with regard to the DSP study area and the provision of an ethnographic assessment of any places identified in the study area and in particular Poison Gully Creek (DPLH ID 25023); and
- Preparation of a report which complies with the standards currently published by the Department of Planning, Lands and Heritage (DPLH) documenting the outcomes of the ethnographic assessment.

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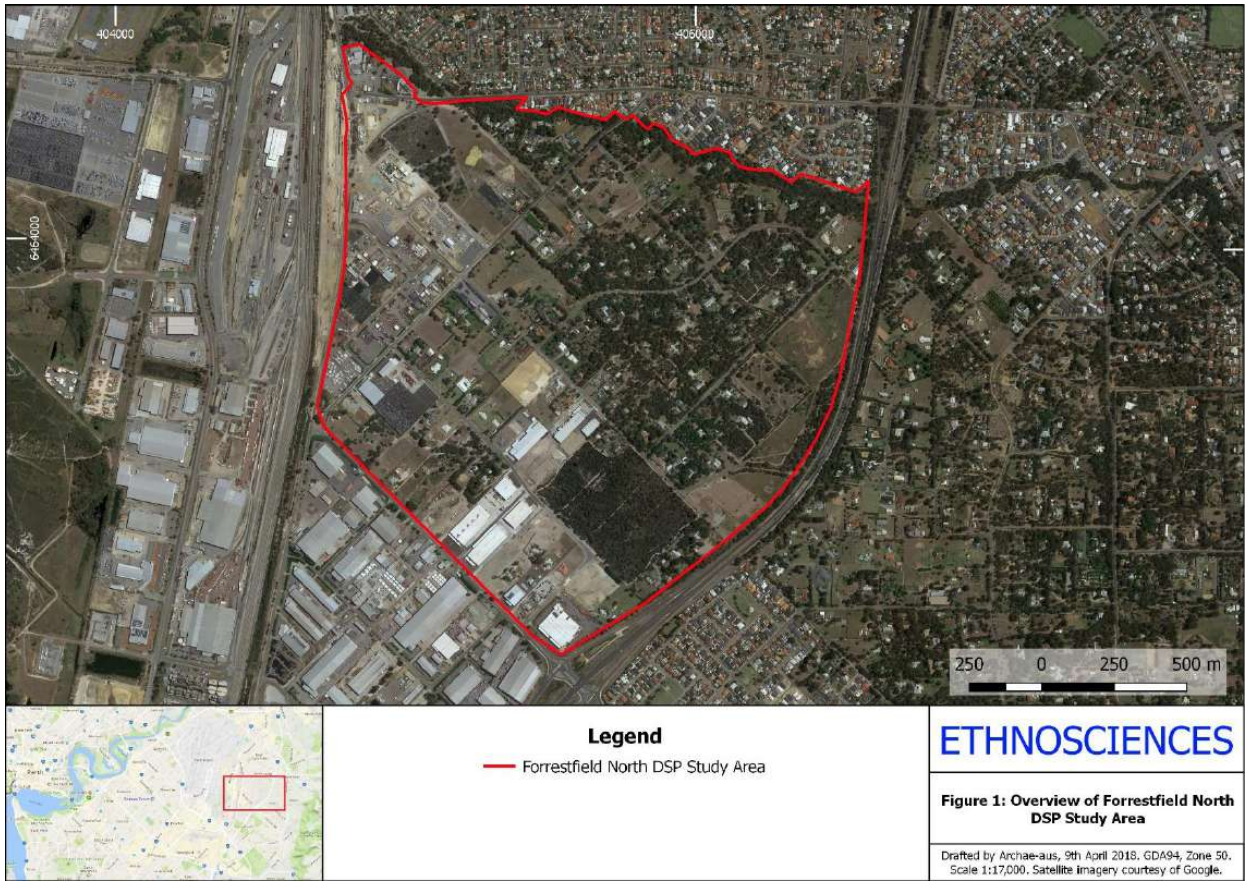

Figure 1: Forrestfield North DSP study area (Source: Strategen)

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Ethnographic Survey/Consultation Methods

The ethnographic survey/consultation was conducted in the following stages:

- Desktop research;
- Preliminary consultation with SWALSC regarding the selection of the 'relevant Aboriginal people' to be consulted about the proposed development;
- Ethnographic consultations on site with female and male representatives of Aboriginal groups and families nominated by SWALSC as having interests in the area (December 2017);
- A second women's consultative meeting (March 2018); and,
- Report preparation.

Edward McDonald and Jan Turner undertook desktop research and Jan Turner and William Christensen conducted the on-site consultations with the female and male Nyungar representatives respectively. The report was jointly prepared by Jan Turner, William Christensen and Edward McDonald.

Desktop Research

The desktop research involved, in the first instance, an examination of the Register of Aboriginal Sites using the DPLH's online Aboriginal Heritage Inquiry System (AHIS). A range of relevant published and unpublished material relating to the ethnohistory and the Aboriginal heritage values of the study area and its environs was also reviewed. The latter included reports of previous heritage surveys conducted in the area. Of particular relevance to the current study is the ethnographic survey carried out by Nicolas Green (Green & Jackson 1995) and that by Jan Turner and her colleagues (Turner, de Gand & Mattner 2014).

Preliminary Consultation

As is required by the DPLH (formerly the DAA), SWALSC was consulted about the selection of a panel of 'relevant Aboriginal people' having associations with, and knowledge of, the Poison Gully site, which in broad terms forms the northern boundary of the DSP area, and its environs. Poison Gully Creek is listed on the Register of Aboriginal

Sites under the classifications "Birth Place" and "Water Source" (see below for further comment). The former classification, reflects the site's particular importance to Nyungar women. Consequently, SWALSC provided a list of eight women whom their internal research showed were of relevance to the consultation. To this list we added two additional women who are the daughters of two of the site's listed informants on the DPLH register and several men who also have reported associations with the Forrestfield area and who had been consulted in previous surveys.

Ethnographic Consultations

The ethnographic consultations were undertaken on site on December 7, 2017 and December 19, 2017, for the women's and men's group respectively. In the end, six of the ten women invited, or their proxies attended the consultative meeting. Three are members of the registered Native Title Claim over the Metropolitan Area (the Whadjuk People, which is a party to the South West Settlement) [1] and three are members of the unregistered claim, the Swan River People 2. In addition, a second women's consultation was held off-site in March 2018 which was attended by six women, most notably Gwen Corunna who had not been included in the original panel selected by SWALSC.

[1] The South West Settlement signed in June 2015 between the WA Government and SWLASC, which includes six identical Indigenous Land Use Agreements (ILUAs) in respect of the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip and Southern Noongar groups and the passing of the Noongar (Koorah, Nitja, Boordahwan) (Past, Present, Future) Recognition Act 2016. [

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Table 1: Aboriginal people attending the December 2017 consultations and their group affiliation

Aboriginal Group	December 7, 2017 Women's Consultative Meeting	December 19, 2017 Men's Consultative Meeting
Whadjuk People	Kezia Jacobs-Smith Myrtle Yarran Marion Collard	Ron Gidjup Cedric Jacobs
Swan River People	Bella Bropho Vanessa Corunna Marlene Rose Warrell	Albert Corunna Richard Wilkes

Women's Consultative Meetings

The first ethnographic consultation with female consultants was conducted by anthropologist Jan Turner on site on December 7, 2017 with follow-up phone calls made during December to confirm details. Jan Turner, having consulted with Nyungar women in 2014 at Poison Gully Creek, knew of or had met several of the participants previously. However, the selection of women attendees was determined by SWALSC and women's availability on the day.

Locking in a date when women were able to attend proved difficult and several dates were mooted. Unfortunately, the date agreed to subsequently coincided with the afternoon funeral of a Nyungar elder (a woman who had been deferred to by other women in the 2014 consultations). A minute's silence was requested to honour her memory. No photographs of the women were taken during the December 2017 consultations out of respect for the deceased. However, they gave their permission for prior photographs of Poison Gully Creek to be included in this report.

The on-site consultations were divided between a group discussion in the morning and two independent consultations with one woman attending each in the afternoon. There was no overlap in attendance. The morning consultation was held upstream at the Milner Road crossing and both afternoon interviews were held at the well-shaded Dundas Road

crossing. Consultation times were flexible to accommodate the maximum number of respondents. Keywords, concepts and observations were recorded at Poison Gully Creek. Photographs of Poison Gully Creek, its banks and nearby vegetation were taken in the lunchbreak between sessions. These photographs provide an environmental context for the discussion that follows. The contents of this report were elaborated and consented to in March 2018.

The follow-up meeting in March 2018 was held at a private home in Maddington and provided the opportunity for women to expand further on their cultural knowledge of Poison Gully Creek and Munday Swamp, reminisce about their residency at Allawah Grove, and give their consent as to what could be included in this report in the more general context of Nyungar women's cultural discussions. The women involved included among others: Vanessa Corunna, Gwen Corunna, Bella Bropho and Marion Kickett. Of these, Vanessa Corunna and Bella Bropho were participants in the December consultative process.

The women consulted ranged in age from a woman in her twenties through to a woman of eighty years, including an adult with young children to grandmothers and great-grandmothers, providing a range of women's knowledge and views. This breadth of the group consulted provided opportunities for observations of intra-group behaviours of respect, ritual and the public demonstration of cultural knowledge. These women currently reside locally in the Perth metropolitan area, Quairading and Wyalkatchem.

Men's Consultative Meeting

Anthropologist Dr Will Christensen consulted the male representatives on December 19, 2017. The consultation group comprised Mr Ron Gidjup and Mr Cedric Jacobs, both of the Whadjuk People Native Title Claim, together with Mr Albert Corunna and Mr Richard Wilkes from the unregistered Swan River People 2 Native Title Claim. Christensen also had the opportunity to consult with two of the men as he drove them from their residences in Rockingham and Pinjara to the meeting and back again in the afternoon.

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Ethnographic Background

Bates (1985) was the first researcher to systematically collect information regarding the social organisation, language and customs of the Aboriginal people of the Southwest of Western Australia. She was engaged in anthropological research on behalf of the Western Australia Government from 1904-1911, undertaking pioneering ethnographic fieldwork in 1905 on the Maamba Reserve (see below) (McDonald, Coldrick & Christensen 2008b discuss her research within the context of the development of modern ethnographic practice).

Bates (1985: 39) referred to the Aboriginal people occupying this region as the 'Bibbulmun Nation'. She reports (1985, 1992) that the Bibbulmun comprised of a number of related 'tribal' groupings. She notes similar customs and beliefs among the groups, though she also reported that regional differences, including forms of descent and dialectic terms, applied to various local communities (Bates 1985: 46–54). The Bibbulmun were part of what Berndt (1979:19) would later refer to as part of the 'Old Australian Tradition' of Law and male initiatory practices including, among other practices, the piercing of the septum and the insertion of a 'nose-bone'. Unlike in other parts of Western Australia circumcision was not practiced.

Bates (1985: 48) identified the local group located in the country in which the Forrestfield North DSP area is located as the *Yabbaru Bibbulmun* [northern Bibbulmun]. She reports that they were also known by neighbouring groups as the *Illa kuri wongi* after the dialect which they spoke. Later researchers, however, provide a vastly different perspective to that of Bates. Berndt (1979), following Tindale (1974), suggests that, at the time of British colonisation, the Southwest was occupied by thirteen 'tribes' or socio-dialectal groups, to use Berndt's term, that formed a discrete socio-cultural bloc referred to as 'Nyungar'. Tindale (1974) recorded the socio-dialectal group who inhabited the region in which the DSP area is located as the *Whadjug* or *Whadjuk* (Figure 2).

More recently, Keen (1997:261) has suggested that anthropologists "get away from the idea of discrete Aboriginal 'societies' 'cultures', 'groups' or 'communities' as basic elements, and to substitute a more regional perspective." He (1997:261, 273) notes that

most ethnography is based on the assumption that Australia was divided into a number of discrete 'cultures', 'societies' or 'tribes' and that the 'tribe' model "has been found wanting". The works of Tindale and Berndt are clearly based on such a model, though the latter presents a different picture with respect to the Western Desert. Keen's (1997) concept of 'focused networks' and 'regional system(s)' in contrast focuses on:

> *A nexus of adjacencies, of chains of connection, and of a dynamic, open, and transforming systemic network, broken here and there by fissures and lesions. A 'local system' becomes defined in a relative way. It is possible that somewhat uniform and reproduced systems on interconnected practices might be detected, but on the other hand, what might be found is a pattern of continuous variations in one place, or a mosaic of overlapping differences in another. Whatever the pattern, any local system must be seen in its wider context.*

The differences between the 'tribal' system in the Southwest provided by Bates (1985) and Tindale (1974) has perplexed many researchers, including the present consultants. McDonald and Christensen (1999) have previously noted that these differences may be due to a number of reasons, such as:

- different data collection periods (Bates, 1905–12; Tindale 1930s–60s);
- a focus on different levels of social organisation;
- variations in use of anthropological terminology; and,
- common Aboriginal practice for groups to be known by several names.

The differences may reflect Bates' appreciation of the 'focused networks' which characterised Nyungar social organisation. While Bates (1985) uses the term 'tribe' to discuss the social organisation of the Southwest and other parts of the State, her actual description would seem to be broadly consistent with the model outlined by Keen with all its apparent contradictions of 'continuous variations' and 'mosaic of overlapping differences'.[2] Bates also had a particular interest in movement and interconnectivity, investigating individual's 'runs' (see below), country, roads and tracks (called *bidi* in

[2] McDonald & Christensen (1999) and Edwards & McDonald (1999) explore in more detail some of the possible reasons for the differences between Bates' and other researchers' findings.

Nyungar country), along which people, myth, ceremony and objects moved and were exchanged (McDonald, Coldrick and Christensen 2008b). [3]

Journals and records by early settlers describe various influential Aboriginal 'leaders' in the early days of the Swan River colony and the 'territories' in which they were principally located. According to Lyon (1833 cited in Green 1979: 176), the area in which the DSP is located was, at the time of colonisation, *Beeloo* territory whose leader was Munday or Monday. Lyon described Munday's territory as extending south from the Swan to the Canning River, north to the Upper Swan and Ellen's Brook and east into the mountains (i.e. the forested uplands east of the Darling Scarp). Hallam and Tilbrook (1990: 234) note that "Monday seems usually to be found south of Guildford on the Helena River, moving between west and east of the Swan" (Figure 3).

Other early commentators (e.g., Armstrong and Symmons) paint a somewhat different picture of land holdings and band composition shortly after colonisation (Hallam & Tilbrook 1990). Armstrong (1836, in Green 1979), for example, wrote of the "Canning Tribe" occupying the country Lyon allocates to Munday and Munday's group holding land north of the Swan River (see Brown 1983, his Figures 1, 2 & 3). These differences may have resulted from a lack of understanding of the complex nature and fluidity of Nyungar social organisation on the one hand and changes due to Aboriginal adjustments to the usurpation by colonists on the other. Hallam (1975) and Hallam & Tilbrook (1990) point out that this emerging picture of Aboriginal life contradicted European observers' focus on geographical areas and patrilineal relationships. A more accurate description, Hallam suggests, is that of a system of overlapping sets of ritual and social connections with land usage rights based on membership of both matrifilial and patrifilial groups. Individuals, families and bands moved between areas, generating a fluid local population size and

[3] Baines (1988) and Birdsall (1988) discuss the contemporary significance of 'runs' and 'lines'in Nyungar life and sociability. The word *bidi* in Nyungar also means 'vein' as well as 'track' (Bindon & Chadwick 1992: 13) metaphorically referring to the flow of people, ideas and objects, a similar metaphor is typically used in respect of the flow of water (McDonald, Coldrick and Christensen 2008a).

composition and suggesting that boundaries between territories were permeable (Hallam & Tilbrook 1990).

Bates (1985; nd(i) and nd(ii)) provides data which indicates that the present survey area was part of Joobaitch's (died 1907) run or country which he inherited from his father and uncles. The Swan, Helena and Canning Rivers, according to Bates, marked boundaries of his country. Bates (1985: 49) reports that Joobaitch*:*

> *[S]eemed to lay special claim to some springs in what is now the Canning district, where he was born, and was so eager to die upon his own special ground that he managed to evade the civilised comforts of the Public Hospital and died near one of his own springs while he was being brought into Perth for medical attention.*

Despite the massive disruptions to traditional activities caused by European settlement, Nyungars have continued to use areas in and around Forrestfield for camping, hunting and rural-based employment (see Baines 1988; Biskup 1973; Bourke 1987; and Green 1979 amongst others). Of particular interest is the old Welshpool Reserve or Maamba (DPLH ID 3773) located in Forrestfield to the south of the study area. The old reserve(s), which is a Registered Aboriginal Site, is depicted on the AHIS as continuous with the boundaries of the present-day Hartfield Park, Forrestfield/Wattle Grove, Kalamunda, though the exact boundaries of the place are problematic as there seems to have been at least two Aboriginal reserves in the area with different reserve numbers and which may have overlapped (Wall 1976).Ancestors of a number of key Nyungar families lived on the reserve in the late 1890s and early 1900s. One of the key Nyungar men involved with the 1995 survey in Forrestfield (see Green & Jackson 1995), Mr Corrie Bodney, reports that his mother was born at Maamba and that his grandmother, Berrigan, after whom Berrigan Drive is named, lived there for several years. Mr Bodney also reported that he had camped at what is now Fleming Reserve in High Wycombe to the north of the study area in the 1960s after he was evicted from Allawah Grove (Green & Jackson 1995: 16).

The former Allawah Grove Reserve (# 12720; partially captured by DPLH ID 3771), located at the Perth Airport to the west of the study area, is a place of major significance to Perth Nyungars (Plate 1). O'Connor (1997: 18) suggests, based on his assessment, "… that the

Allawah Grove site is, to Aboriginal people, one of the most important historic/human/mundane sites in the Perth Metropolitan area". Members of many of the key families who have been involved with heritage surveys in the Forrestfield area have at some stage resided at Allawah Grove, either before it was requisitioned for military use during World War II,[4] or in the 1950s and 1960s when it was re-established as an Aboriginal reserve (O'Connor, Bodney & Little 1985: 96; Carter 1986: 241–43; Delmege 2015; Lapham 2002; Smith Walley & Pushman 2005).

A brief glimpse of life at Allawah Grove is crucial to understanding the contemporary significance of Poison Gully Creek. A readily-available source of materials with good photographic evidence is in the 2005 University of Western Australia publication by Smith Walley and Pushman (2005). Many of the comments obtained during the current consultations are substantiated by reference to this publication, in particular the six o'clock curfew referred to by women informants with regard to the birthing associations of Poison Gully Creek (Smith Walley & Pushman 2005: 14), customary hunting and gathering practices and the inter-generational passing on of cultural knowledge. In 1959, according to official reports, there were 134 'residents' and 13 'authorised visitors' in Allawah Grove but it was also home for a large number of 'unofficial' residents and a number of fringe camps were located in the surrounding bush. Indeed, families evicted from Allawa Grove often ended up camping nearby (J. Wilson, 1958 and Makin 1970).

From its gazettal in 1910 as an Aboriginal Reserve until it was acquired by the Commonwealth during the Second World War, Allawah Grove families lived in lean-to shelters made of salvaged tin and timber cut and bark stripped from the paperbark trees growing in the nearby swamps (see Plate 2). This use of wetland resources was extensive and in 1962 the young mothers of Allawah Grove began using different barks to create layered artworks, or bark paintings, which became saleable, creative products enabling

[4] Ironically, the Reserve's requisitioning occurred shortly after Aboriginal families camping in various locations around Guildford and the Swan Valley were forced by authorities to move to the reserve. Several of the Aboriginal families removed the during WWII were relocated to a temporary reserve at Widgie Road, Beechboro, (1942–52). Others moved in with families in Eden Hill, some of whom owned their own blocks (for more on Widgie Road, see Robinson 1978 and Delmege 2015).

women to generate a reliable income. These artworks were sold domestically and overseas (Lapham 2002: 47–48; Smith Walley & Pushman 2005: 35, 41; Gare 1967). During the second consultative meeting in March 2018, two women were singled out in the presence of others as being bark artists, initially as residents of Allawah Grove. Interest was expressed in resuming this artwork style and the necessity of conserving stands of living paperbark trees such as those found at Munday Swamp and Poison Gully Creek as natural resource materials for future generations.

In 2014, women told Turner of being children at Allawah Grove and assisting in the gathering of bark materials for artworks whilst hunting turtle at nearby Munday Swamp (Turner 2014). A similar conversation between Vicky Bandry and Donna Kickett details hunting techniques and the gathering of edible seed pods, tubers, roots, tree sap and bardie grubs (Turner 2014: 36–37) and also details strict cultural protocols that applied to the hunting, cooking, dismemberment and sharing of turtle (Turner 2014:43; see also Lapham 2002: 42). What becomes apparent from listening to oral recollections of life at Allawah Grove is that it functioned as a community of Indigenous interest where opportunities abounded for the transmission of cultural knowledge both within and between resident families and visiting family members, and provided one of the last opportunities in the metropolitan area for Nyungar people to live as a community to an extent that challenged the mainstream policies of Assimilation.

The ethnohistorical evidence shows that rivers, creeks and wetlands in the Perth metropolitan region and beyond were most intensively occupied by Aborigines, given the availability of fresh water and food resources (see, for example, Hammond 1980/1933; Hallam 1975; see also O'Connor, Quartermaine & Bodney 1989; McDonald, Coldrick & Christensen 2008). This conclusion is supported by the archaeological data. In particular, the alluvial plains and the associated *warran* or native yam grounds were of crucial subsistence importance (Hallam 1975).

A number of wetlands located in the vicinity of the Allawah Grove Reserve are recorded as focal points of Nyungar activity from pre-colonial to recent times as food resource areas (see, for example, O'Connor, Bodney & Little 1985; O'Connor, Quartermaine & Bodney

1989; McDonald, Hales & Associates 1988; Smith, McDonald & Machin 1990). Several of these are listed on the AHIS as registered sites or 'Other Heritage Places', including Munday Swamp (DPLH ID 3719), Soldier Swamp (DPLH ID 3718), Airport: Tonkin Highway, Wullemarra Spring (ID 3495) and the Hazelmere Lakes (DPLH ID 17501, known as 'Leghorn Lakes' to Nyungars). Ongoing heritage investigations in and around the airport indicate that Munday Swamp is still being used for hunting and foraging (e.g., Terra Rosa 2015; Turner 2014).

Langton (2006) notes that in Aboriginal Australia waterscapes are construed not only as physical domains, but also as spiritual, social and jural spaces, according to the same fundamental principles as places in the landscape. She also suggests that "the dialogic relationship in Indigenous thought between the ancestral past and its effect on human existence derives from the Aboriginal understanding of the transformative powers of the spiritual beings that inhabit those places". For this reason, waterscapes are frequently associated with ancestral beings, in particular in the South West with the *Waugal*. Many major waterscapes in the Perth Metropolitan region are listed as mythological sites, including the Swan River (DPLH ID 3536), the Helena River DPLH ID 3758, the Ellen Brook (DPLH ID 3525), the Canning River (DPLH ID 3538), the Southern River (DPLH ID 3511), the Wungong River (DPLH ID 3512) and so on. These have been reported to be associated with the creative activities of the Waugal.

Bates (1985:221) notes in respect of the 'woggal' [Waugal]: "It made all the big rivers of the Southwest" and "wherever it travelled it made a river". She also reports that the Waugal travelled through "certain districts" and "left traces of its journeys at certain places" in the Southwest; for example, "certain hills and other features [are] sacred through their being the homes of these fabulous snakes" (Bates 1985:219). The Waugal, therefore, is associated with other topographical features besides waterscapes including hills, rocks, trees, caves, sand dunes, ridges, etc. These places are the "traces of its journeys". [5] Bates (1985:221) adds

[5] In broaching the notions of the "traces of its journeys" and the Waugal's "home", Bates (1985) is referring to the process where the mythic being metamorphoses into the topographic feature which forever contains its spiritual essence (see Berndt & Berndt 1988).

that "The places where it camped in these travels were always sacred." Indeed, the Waugal is reported to be associated with Poison Gully Creek (DPLH ID 25023).

Modern Nyungar cosmological writings place *Waakarl* [Waugal], the creation being, as belonging to the *Nyetting,* the cold or dark time (i.e., the Dreamtime), 'Era 1' which is associated with the single continent Pangea in the Earth's formation 300 million years ago (Robertson, Nannup, et. al 2017: 10–12). "The Waakarl of the Nyoongar [Nyungar] narrative is described as the rhythm of the earth. It can be understood to be an embodiment of the energy generated by persistent friction between ice and land." Robertson, Nannup, et. al (2017) view the *Waakarl* as the primary spiritual being, forced down onto and into the earth by the crushing sky, emerging again and again, and in so doing creating the waterways and swamps and forging the environment where other spiritual beings would settle. "[M]any of the spiritual ancestors followed the trail left by the Waakarl and selected the places where they would one day flourish" (ibid: 10).

As with other groups in Aboriginal Australia, the notion that 'water is life' underpins Nyungar conceptualisations of surface and subsurface hydrological systems (see McDonald, Coldrick & Villiers 2005 and McDonald, Coldrick & Christensen 2008 for discussions of Nyungar concerns; for more general discussions of Aboriginal views, see Rose 2004 and Strang 2002 and 2008). The key ancestral being associated with water is the Waugal or water serpent, described in various parts of Australia as the 'rainbow serpent', whose actions highlight the interconnectedness of water with the wider environment, including earth and the sky and human beings. As Rose (2004:39) remarks:

> *One set of connectivities articulated by the Rainbow Serpent is thus the flow of water from inside the earth, across the surfaces, into the sky and back to earth. On the face of it, Rainbow Serpent connectivities parallel ecological analysis of water dynamics and energy flow. However, the internal forces and sources of water that the Rainbow Serpent is, and accesses, are deep matters in Indigenous metaphysics.*

Water and water sources are immensely important to Nyungar identity and social being. As Strang (2002) notes in another context, water metaphorically frames social and environmental relationships and is an important source of cultural identity. Metaphors of

blood figure centrally in Aboriginal, including Nyungar, conceptualisations of water and its flow (Strang 2002; McDonald, Coldrick & Christensen 2008).

Munday Swamp (DPLH ID 3719) and other wetlands generally have also been reported to be associated with the creative activities of the Waugal (Terra Rosa 2015, for example). O'Connor, Bodney & Little (1985: 98–100) report that the late Mrs Ollie Worrell was probably the last Nyungar to know "the ritual invocation specific to the area" [Munday Swamp]. O'Connor (1997: 18) concludes that "to Nyungars the Munday Swamp site is one of the most important mythological/sacred sites in the same [airport] region". This statement might be somewhat hyperbolic; however, it does draw attention to the potential significance of this wetland, and by extension to others in the area, to Nyungars (see below for further comment).

Wetlands and rivers were connected by a series of pads (*bidi*) for example, *bidi* extended from the present-day Perth area south to Mandurah and Pinjarra on the Murray River and north to Cockleshell Gully and beyond (Bates 1985; McDonald & Venz 2002). A number of major roads in the South West generally follow the alignment of these original Aboriginal pads. For example, Popham (1980:17) notes that Albany Highway follows a route surveyed by Hillman in 1836 which "followed the worn pathways of the Aboriginals (sic) and the course of the Neerigen Brook". Coy (1984:4) reports that "[t]he South Western Highway, known originally as the Foothills Track, vaguely follows a major Nyungar walking pad, which ran from the Perth Causeway to Pinjarra, then southwards to the Blackwood."

Ethnohistorical data suggest that local groups undertook a great deal of movement along these pads (Bates 1992). Individuals, families and bands moved between areas, generating a fluid local population in terms of size, location and composition, suggesting that boundaries between territories were permeable. Hallam (1975) points out that this emerging picture of Aboriginal life contradicted European observers' focus on geographic areas and patrilineal relationships. A more accurate description is that of a system of overlapping sets of ritual and social connections with land usage rights based on membership of both matrilineal and patrilineal groups.

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European colonisation heralded the destruction of traditional Aboriginal social organisation, beginning in the Perth area and expanding steadily across the South West. Epidemics, shootings by Europeans, and draconian policies introduced by the colonial administration (e.g., forced exclusion from urban areas, concentration on reserves, and restrictions on movement and labour) resulted in the decimation of the Nyungar population as well as the attenuation of traditional ties with the land and sites (Berndt 1979; Hammond 1933). As a result of this dislocation, there has been a loss of traditional mythological and ceremonial associations with the land along with the knowledge underpinning these connections. However, there is still some mythological knowledge available in the Nyungar community.

While there is a paucity of information regarding Aboriginal occupation in the area post European contact, information gleaned from local histories and other sources indicates that Aboriginal people continued to play a significant, albeit marginal, role in local social and economic life. Nyungars were employed seasonally on farms or in local industry or were engaged in marginal economic activities such as bean stick cutting (for clothes line props and crayfish pots). Popham (1980:120) reports that Aborigines in the Armadale area exchanged "the scraped-off wood of zamia palms, which were used as pillow filling in exchange for tea and flour" at the turn of the twentieth century. Aboriginal involvement in the local economy also meant that Aboriginal people lived in or on the fringes of the local community. In the 1950s men were walking from Allawah Grove to Bentley for work and to the Swan Valley for extended periods of seasonal vine cutting (Lapham 2002).

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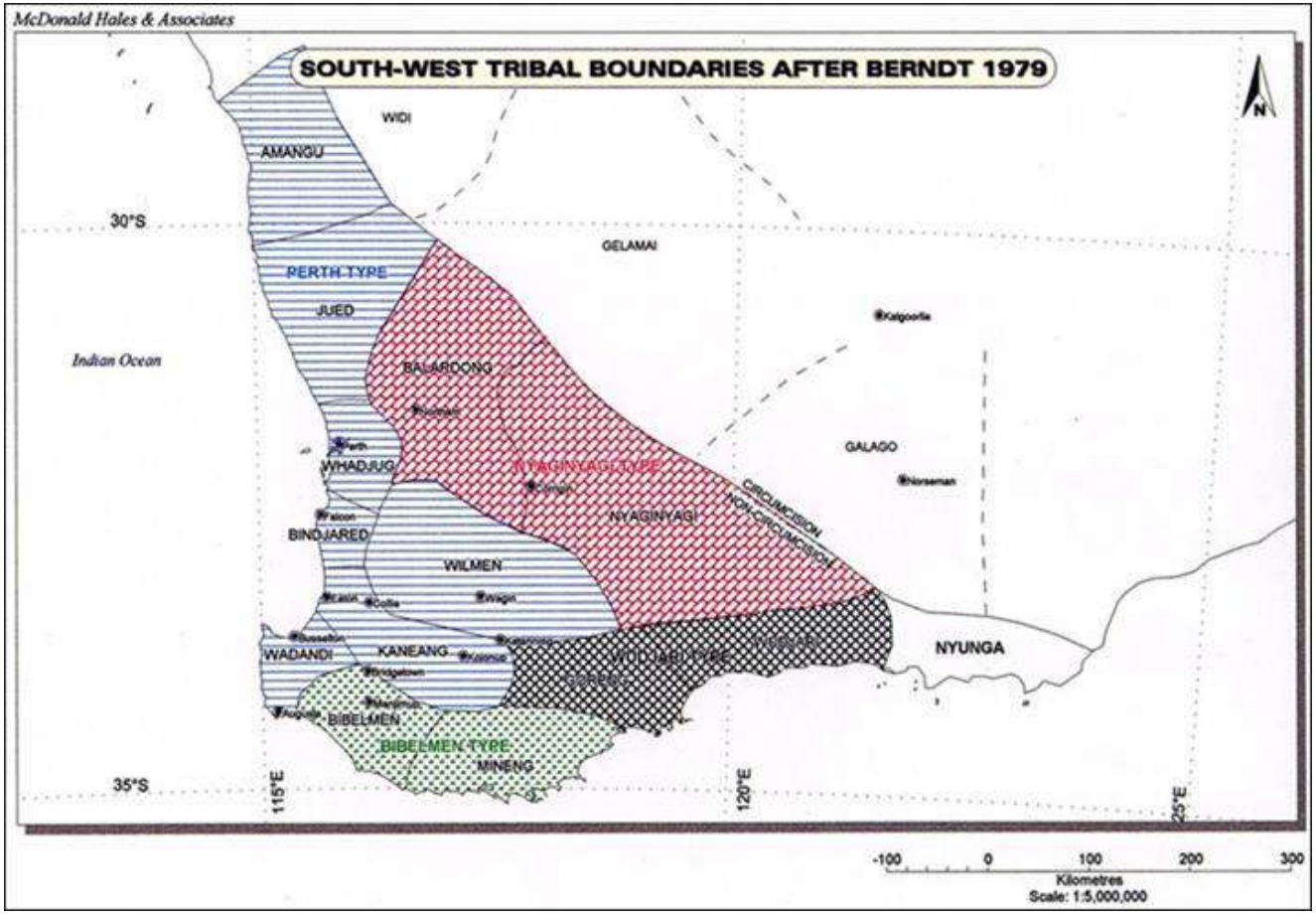

Figure 2: South-West tribal boundaries and social types (after Berndt 1979)

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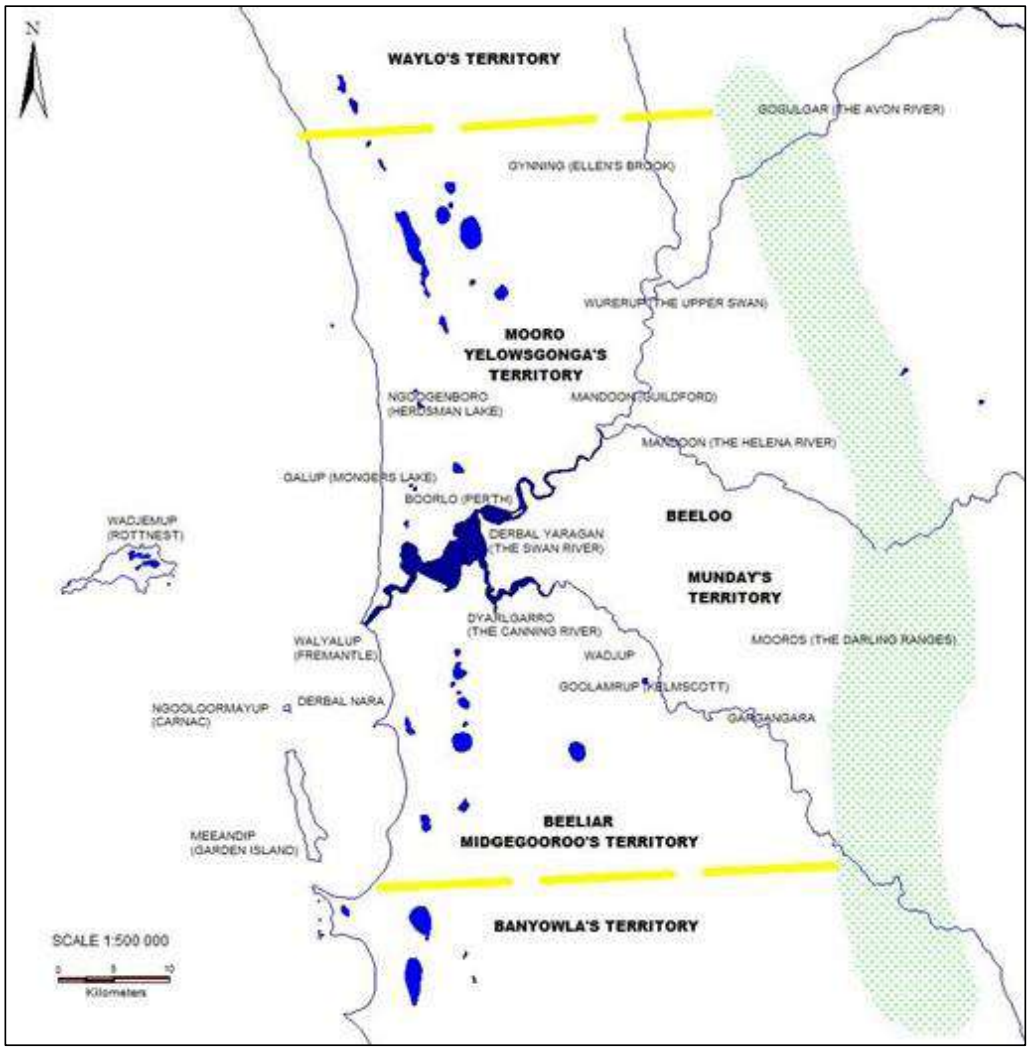

Figure 3: Place names and territories recorded by Robert Lyon after Green 1979

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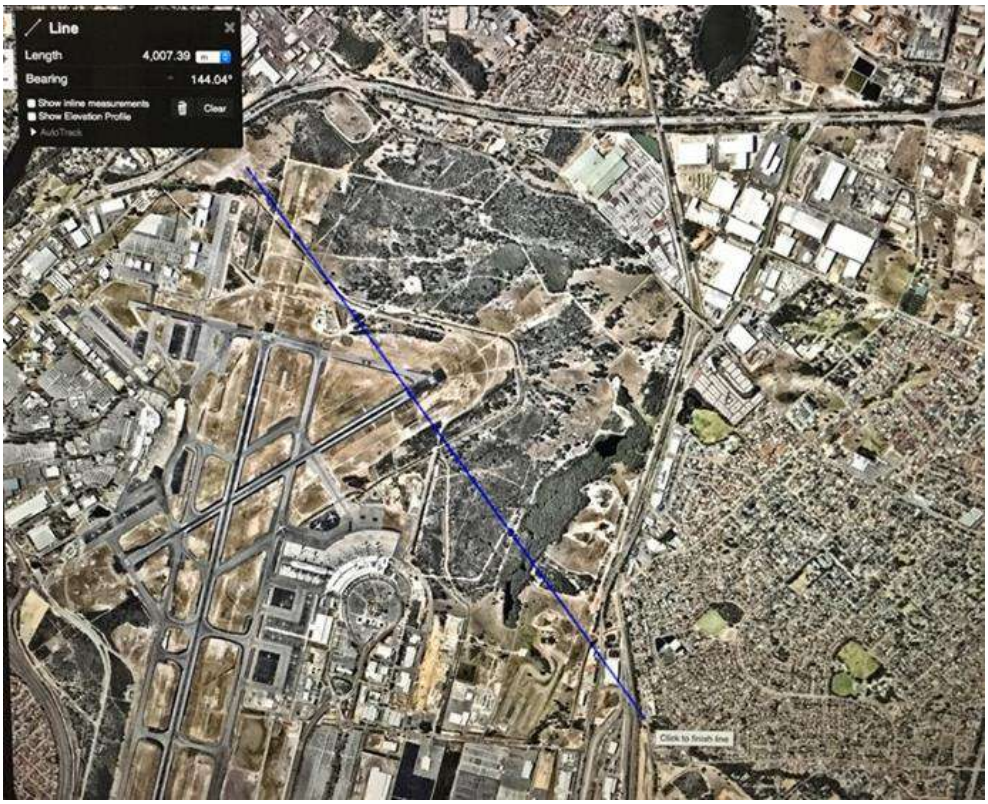

Figure 4: Aerial photograph showing distance between Allawah Grove and Poison Gully Creek as being 4km (courtesy T. Bergin).

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Plate 1: Allawah Grove settlement (Source: Smith Walley & Pushman 2005)



Plate 2: Typical fringe camp at Allawah Grove (Source: Smith Walley & Pushman 2005)

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Plate 3: Poison Gully Creek, Dundas Rd Crossing, summer 2017 (Photo: J. Turner)

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Plate 4: Ducks on Poison Gully Creek, Dundas Rd Crossing, winter 2014 (Photo: J. Turner)

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Plate 5: Poison Gully Creek, Dundas Rd Crossing, winter 2014 (Photo: J. Turner)

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Plate 6: 'Soap Bush', plant associated with human bathing in general and Nyungar women's post birth practices in particular (Photo: J. Turner)

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Ethnographic Survey Results

Desktop Research Findings

Registered Aboriginal Sites

The search of the Register of Aboriginal Sites confirmed that Poison Gully Creek (DPLH ID 25023), which is currently listed on the DPLH Register of Aboriginal Sites under the classifications "Birth Place" and "Water Source", is located within the study area. The following summary comes from Turner (2014: 4–5).

Poison Gully Creek was not formally reported as an ethnographic site in its own right until specific ethnographic research was undertaken by Nicolas Green in 1995 associated with the installation of a sewerage system (Green & Jackson 1995). Subsequent heritage research by Chown et. al. was undertaken in 2008 in response to a proposal by Western Power to install cables across Poison Gully Creek. Background research at this time revealed that although the Green and Jackson report of 1995 had been lodged with the Department of Indigenous Affairs, Poison Gully Creek had not been registered as an Aboriginal site.

The initial research of May 2008 undertaken by Bob Chown reinforced the earlier findings that not only was Poison Gully Creek a significant cultural site, it was associated specifically with "women's business" and secondly that Nyungar women, with the support of men, requested a female anthropologist be engaged to consult with them (Chown et al. 2008: 1). Their request was recognised and three weeks later a female anthropologist, Jeanne Hohnen, was engaged to undertake site documentation research for Poison Gully Creek, now also referred to by its Site Register identifier, DPLH ID 25023. Ms Hohnen met with 16 Nyungar women over two on-site consultations at Poison Gully Creek and in one home visit. She was able to include a considerable amount of cultural information in the subsequent report (Hohnen & Bergin 2008).

The site was assessed by the Aboriginal Cultural Material Committee (ACMC) during deliberations of a Section 18 Notice on August 6, 2008 (Resolution Number 2008/093) and

was determined to be a place to which Section 5(b) of the AHA applies (i.e., a sacred site) on the basis of Sections 39(2)(b): "any former or reputed use or significance which may be attributed upon the basis of tradition, historical association, or Aboriginal sentiment" and 39(2)(c): "any potential anthropological, archaeological or ethnographical interest".

Access to the site file is restricted and only available to females. Ironically, though a 'female only' site, two of the place's listed informants or knowledge holders are men, the late Ken Colbung and Corrie Bodney. The other informant is the now defunct organisation, the Nyungar Circle of Elders. Another layer of irony is added when it is noted that both the late Ken Colbung and Corrie Bodney reported to Green (Green & Jackson 1995: 16 & 19) that Poison Gully Greek was not in their opinion an Aboriginal Site (that is, they were unaware of any mythological or ritual significance).

As the site file is 'Closed', the boundaries on the AHIS are 'restricted' and therefore 'dithered'; i.e., the spatial representation published on the AHIS website is broader than the actual boundary, because of the site's reported significance and hence confidentiality regarding the place's precise boundaries. [6]

In 2014, the specific services of a female anthropologist were deemed necessary by Waru Consulting as part of their Section 18 consultations for the Public Transport Authority's proposed rail link. Jan Turner was engaged to do this work. Her gender-specific report to Waru was then incorporated into a final report which included reporting on both women's and men's consultations (Turner et al 2014).

Turner has noted a consistency in the nuanced gendered knowledge and the right to speak publicly about Poison Gully Creek across her consultations from 2014, 2017 and 2018. Women are standing up as spokespersons but also deferring to the wishes of senior men

[6] The DPLH website notes in respect of restricted boundaries: "To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least 4km²) provides a general indication of where the place is located."

as to what information can be divulged publicly. These nuances are further illuminated in the Women's section of this report.

Munday Swamp (DPLH ID 3719), into which Poison Gully Creek (DPLH ID 25023) originally flowed, is located on Perth Airport land to the west of the study area. Nyungars previously have expressed concerns about impacts on Poison Gully Creek having downstream negative impacts on Munday Swamp. DPLH ID 3719 is a Registered Aboriginal Site under the categories of ceremonial and mythological significance (Waugal associations) as well as being a camp, an artefact scatter and a place associated with hunting and plant resources. The site file is 'Closed' and therefore the site is depicted on the AHIS with a dithered 2km x 2km boundary. However, information on the site file would indicate that its actual boundary follows the fringe of riparian vegetation around the swamp (see Bergin & Mattner 2009: 34).

The notion of ceremonial/mythological has to be read with caution. Although clear, albeit quite generalised, mythological associations have been reported for the wetland, no 'ceremonial' activities per se seem to have been recorded. The AHA s5(b) recognises sacred, ritual and ceremonial sites ("any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent") and s39(3) gives primacy to sacred beliefs and ritual or ceremonial usage in the evaluation of places and objects. In practice, however, the DPLH conflate 'ritual' and 'ceremonial' sites and 'ritual' or 'ceremonial usage'. The term 'ritual' for example, in our experience does not appear on the AHIS or other DPLH documentation. However, though 'ritual' and 'ceremony' are two closely related concepts, they do need to be distinguished. What O'Connor, Bodney & Little (1985: 98–100) originally described was a 'ritual' observance: "the ritual invocation specific to the area". Similarly, Turner observed ritual behaviour at Poison Gully Creek in 2014. The term "specific" would suggest that it is in some way different from the general (though probably similar) invocation of the Waugal described by Baines (1988) and others which involve the sprinkling of sand in the water and calling out to the Waugal (see below for further comment). Possibly specific wording was used at Munday Swamp. Regardless, such rituals need to be distinguished from larger 'ceremonies' involving large groups of

people, such as those typically associated with initiation ceremonies or *mulyapin*, which refers to both initiation process and an initiation or corroboree ground. These are the sort ceremonies that Bates (1985) records having occurred at *Wardawardong* (DPLH ID 3796) on the eastern bank of the Swan River near its original junction with Blackadder Creek. Mr Bodney, who is one of the listed informants for Munday Swamp reports that his maternal grandmother, Berrigan, participated in the last corroboree at *Wardawardong* around 1907.

Munday Swamp was a place that Nyungars gathered in both prehistoric and historical times (Bropho n.d.). It was the location for evidence being heard by the Federal Court in the first Nyungar Native Title Claim where customary activities such as the cooking and eating of swamp turtles and other bush foods were demonstrated to the Court. Unfortunately, it would seem that the notation of 'ceremonial' on the AHIS and site file has given rise to the perception that large-scale religious ceremonies took place at Munday Swamp:

> *Munday Swamp, in particular, is a known ceremonial and mythological site which would have regularly drawn large numbers and/or groups of people to the area* (Terra Rosa 2015: 44).

This notion of Munday Swamp being the location of large scale 'ceremonies' then gets fed into the interpretation of the area's archaeology:

> *As no raw material sources suitable for tool making exist in the immediate Munday Swamp area, past people would have had to bring with them all the lithic items they would require in preparation for a potentially extended visit to this important ceremonial and mythological site* (Terra Rosa 2015: 45).

Nevertheless, regardless of the apparent misinterpretation of the term 'ceremonial' in relation to the place, Munday Swamp is a place of importance and significance to Nyungars and in a sense its significance frames the attribution of significance to other heritage places within the Forrestfield North DSP study area's environs and is directly linked to Poison Gully Greek and its status as an Aboriginal Site.

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Other Heritage Places

Two 'Other Heritage Places', both artefact scatters, are listed in the Forrestfield North DSP study area: DPLH ID 3667 Crumpet Creek, Forrestfield and DPLH ID 3637 High Wycombe: Brooklands Estate. The former has been deemed not to be an Aboriginal Site within the meaning of Section 5 of the AHA and information regarding the place is archived in 'Stored Data'. The latter is a 'Lodged' place which has not as yet been assessed by the ACMC.

As noted, an archaeological survey of the Forrestfield North DSP study area was not part of the current brief. Areas around the present study area, such as the Perth Airport land and the Newburn Marshalling Yards, have been intensively surveyed and as a result dozens of archaeological sites, typically artefact scatters, have been recorded (see Archae-aus 2016, for example). It is reasonable to assume, therefore, that an archaeological survey of the Forrestfield North DSP study area would without doubt result in the recording of archaeological sites in addition to DPLH ID 3667 and DPLH ID 3637. This prediction is also supported by previous regional-scale research (see, for example, Hallam 1986; see also Figure 5 below

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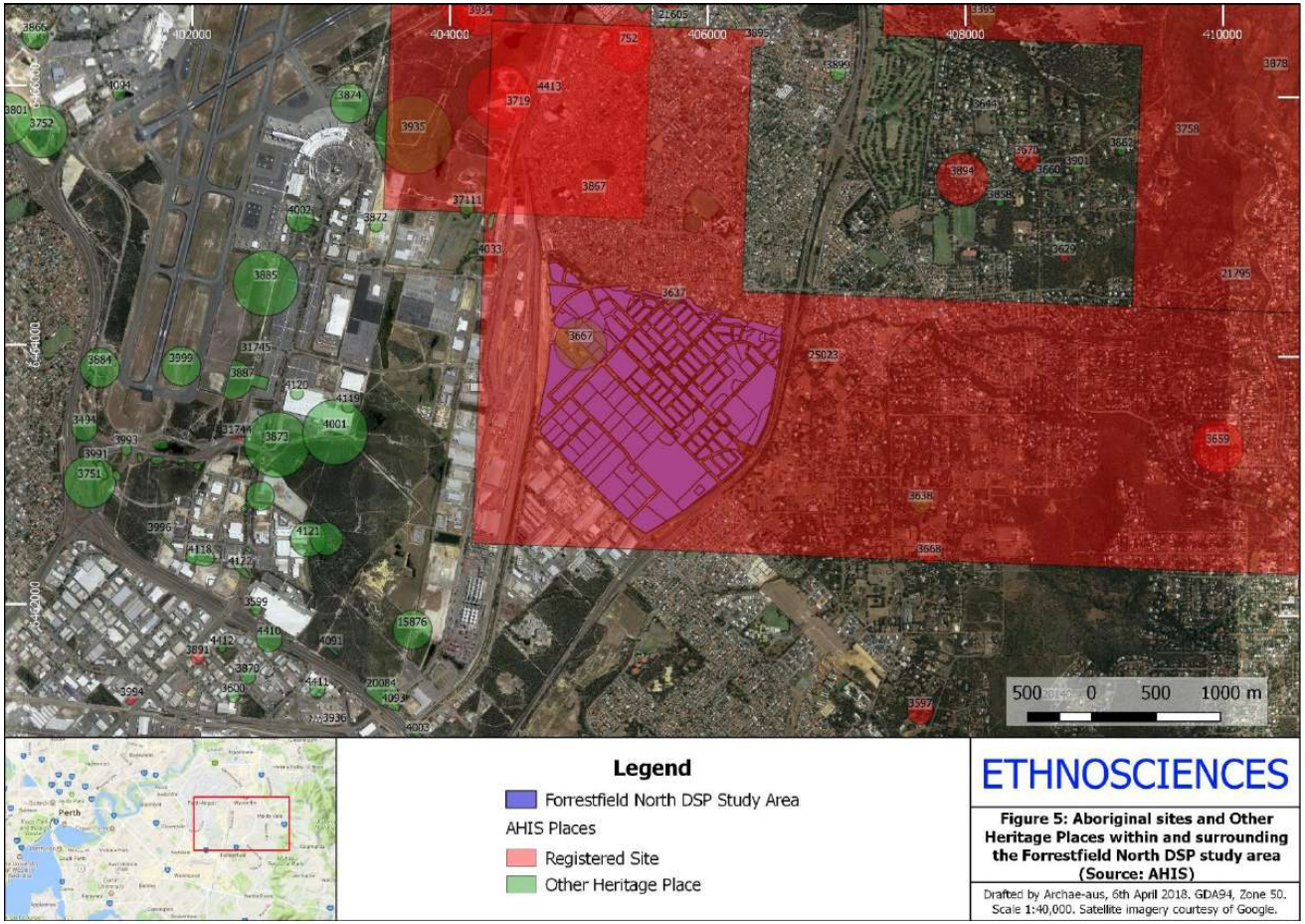

Figure 5: Aboriginal sites and Other Heritage Places within and surrounding the Forrestfield North DSP study area (Source: AHIS)

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Outcomes of the Ethnographic Consultation

Both the women's and men's consultative meetings confirmed the presence and the importance and significance of Poison Gully Creek (DPLH ID 25023) in the Forrestfield DSP study area. No other places that might reasonably be considered to be Aboriginal Sites were identified by the Aboriginal consultants in the study area.

Results of the Women's Consultative Meetings

Nature and Extent of the Poison Gully Creek Site

The December 2017 consultations were consistent with those of 2014 with regard to the women's understanding of the nature and extent of the Poison Gully Creek site (DPLH ID 25023) (Turner 2014: 11–12). These can be summarised as follows:

The Nyungar women regard Poison Gully Creek and the immediate surrounds to be a single site from its source in the high country of Kalamunda to where it joins with the waters of Munday Swamp. They speak of the site as if it still follows its original path prior to European disturbance, insisting that water flows as a 'life force' both above and below ground. Above ground the creek rises and falls in depth, narrows and widens in breadth and flows, remains in still water pools or dries out according to the six Nyungar seasons.[7] Below ground the water is in continuous motion, following the path laid down by ancestral beings, the flow occurring irrespective of the seasonal conditions experienced above ground. The ever-present underground water is said to sustain life for the turtles, frogs and micro-aquatic life in the dry seasons and be simultaneously available for the root systems of even the tallest trees. It is also home to spiritual beings and is, in itself, direct proof of their existence.

[7] The Nyungar seasons are *Birak* (December - January), *Bunuru* (February – March), *Djeran* (April – May), *Makuru* (June – July), *Djilba* (August – September) and *Kambarang* (October – November) (see, for example, Australian Bureau of Metrology http://www.bom.gov.au/iwk/nyoongar/index.shtml [Accessed March 2018]).

At the time of the consultation for the Forrestfield North DSP, it was difficult to determine the land area included within the Poison Gully Creek site (DPLH ID 25023) but it appeared to vary for a distance of between 30 to 50 metres from the creek banks where they are clearly defined. In 2014, Nyungar consultant Rebecca Hume stated that a greater land area should be included where the waters broadened out in the vicinity of Munday Swamp and the differences between high and low watermarks were more pronounced (Turner 2014), which accords with Hohnen's findings (Hohnen & Bergin 2008: 10).

The Nyungar women's construction of the extent of the Poison Gully Creek site is challenging to Western perceptions of sites, which underlie the AHA, as stationary and two dimensional, i.e., having a defined area. In the case of DPLH ID 25023, these aspects are augmented by concepts of vertical depth and volume. The women defined the site as including the water below ground, the natural surface of the land and the airspace above the creek and its banks up to and including the tallest vegetation. Additionally, the Noongar women forcefully stated a cultural notion of water movement both east–west and in descending altitude from Kalamunda to Monday Swamp (see also Turner 2014: 11–12).[8]

Whilst the women consulted state that the entire length of Poison Gully Creek should be considered a site — from Kalamunda to Munday Swamp, consistent with the findings contained within heritage consultation reports from 1995 to 2017 (e.g., Green & Jackson 1995; Hohnen & Bergin 2008: 10; Turner 2014: 17) — there is a strong emphasis on the need to protect the natural bush and creek between Dundas Road and Milner Road and in particular the open space adjacent to the Dundas Road crossing. The women cite the aesthetic value of this area as being integral to their own, and indeed Nyungar, wellbeing in general. [9] They wish to have this area given full 'legal protection' to enable them to

[8] During Aboriginal heritage consultations, Nyungars frequently articulate four principles in respect of impacts on waterways: 'Do not interfere with (a) the riverbed, (b) the watercourse, (c) the quality of the water and (d) the foreshore areas' and are concerned that riverine sites ought to be left in their 'natural state' (McDonald 2017 and McDonald, Coldrick & Christensen n.d.).

[9] Aesthetic values are one of the evaluative criteria of the AHA (s39(2)(d)) that have to be addressed in respect of the assessment of the importance and significance of places and objects.

activate the spiritual wellbeing and nurturing forces of this women's place in the future. They wish to use this site as a place where Nyungar women can bring younger women to talk about sexual health, respect for their developing bodies, child rearing practices and the naming of children. Quietly, they express their opinions that it is only in these remnant pockets of bushland that older people can assist younger ones to turn away from drugs, despair, depression and thoughts of suicide. This desire is expressed in the following quotation:

> *… these sites where there is natural bush and where we can feel our spiritual connections need to be protected. It gives us a place to get away from the violence, sickness and sadness in our lives. Too many young people in trouble.*

The aesthetic qualities of the bush were noted many times over during the current consultations. This accords with the 2014 consultations:

> *The importance of the remaining bushland associated with the Poison Gully Creek site was endorsed by Gwen Corunna who spoke of the peacefulness of the natural environment and Poison Gully Creek in particular and its importance for women's wellbeing, particularly female youth, in direct contrast to youth problems of suicide and despair, the issuing of 'Move On' notices and the high imprisonment rates of Noongar youth.*

These sentiments were endorsed by those present in December 2017 and March 2018.

In the December 2017 consultation, an extra dimension was raised by reference to the inclusion of archaeological materials. One of the women, Kezia Jacobs-Smith, had participated in the Terra Rosa survey (2015) and was able to speak knowledgeably to others of the numbers of artefacts found during archaeological surveys in the adjacent Airport land area, including contemporary archaeological theories of land usage over prehistoric time. Of particular note was the introduction of lithic material such as quartz artefacts from the Darling Range and fossiliferous chert from what is now off the coast to the swampy coastal plain, reinforcing Indigenous oral histories of movement between the hinterland and the coast via *bidi* (tracks) that typically followed the waterways. The other women present acknowledged and concurred with Kezia's statements. As noted above, the Forrestfield North DSP study area has not been specifically surveyed archaeologically.

This archaeological dimension requires ethnographic attention.[10] It reflects not only recent Nyungar participation in archaeological surveys at the nearby Airport lands, but the development and deployment of a research method used in modern Nyungar collaborative writings associated with scientific research called "Koodjal jinnung" (looking both ways). This method has allowed Nyungar writers to integrate different concepts of time, deep geological history, pre-colonisation, post-colonisation and contemporary oral memories with Nyungar cultural concepts of time (see Robertson, Nannup et. al. 2017 and Robertson, Barrow et. al. 2017). It has allowed for the synchronisation of Western and Nyungar science perspectives and is integral to an understanding of the contemporary importance of Poison Gully Creek to the women.

Customary Behaviour

During the December 2017 consultation, one of the women was observed to speak quietly to a perceived spiritual force (possibly the Waugal) after she alighted from her vehicle and before we began discussions. Wandering to the banks of the creek bed, she paused, her gaze including the tree canopy before directing her words in the direction of a small patch of damp earth surrounded by reeds. This accords with the actions of two different women in the 2014 consultations observed by Turner and with those reported by Green (1995). Such behaviour forms part of what Rose (1996) refers to as 'rituals of wellbeing'. These, she notes, may occur in a formal ritual or ceremonial context or may involve such things as 'talking to', 'singing out' or 'calling out' to country, to Dreamtime beings, to other living things, or to the 'Old People' [ancestors] on visits to country. [11]

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[10] Archaeological sites are typically of concern to contemporary Aboriginal people and the AHA requires that such sites are evaluated with respect to 'relevant Aboriginal custom' (s39(2)(a)); Aboriginal tradition, historical association and sentiment (s39(2)(b)), and potential anthropological and ethnographical interest in addition to potential archaeological interest (s39(2)(c). For a discussion of the contemporary significance of archaeological sites see, McDonald & Coldrick (forthcoming).

[11] As noted above, the typical ritual associated with waterways is the throwing or sprinkling of sand/dirt in the water and invoking the Waugal to propitiate the spirit (see, for example, Baines 1988:247–48). This ritual has its correspondence in the Pilbara and other parts of the Northwest, where Aboriginal people squirt water from their mouths into the pool or other 'living waters' occupied by the mythic water snake or Rainbow Serpent and call out telling him that they are

The oldest woman consulted, Myrtle Yarran, was heard to speak to her female driver and asked that freshly fallen gumnuts be collected from beneath the trees, to be taken back to their home in Quairading, patterned with paint and distributed among family members as part of Christmas gift giving. Mrs Yarran attributed gifts created from this site as having positive family influences because they originated from a women's site.

Significance to Women

There is now a significant number of Nyungar women who speak of Poison Gully Creek, more particularly the vegetated shaded flat with pool access near Dundas Road, as a site where women came in the past to give birth. They speak of the conducive features: the shallow depth of the pool, privacy afforded by vegetation, easily obtainable small-sized firewood and slow-burning bark for practical and ritual purposes, the presence of the white flowering 'soap bush' that produces a sudsy cleansing substance when rubbed in the hands and specific plants known for their medicinal values such as red gum sap.

Women are aware of the knowledge of previous women spokespersons for the site and endorse their words. Of particular relevance are the oft-referred to words of deceased elder Dorothy Winmar as quoted in the Hohnen and Bergin report (2008: 12):

> *… [birthing places] could be close to Banksia trees, as these when burnt, gave the softest ash for babies. [She] explained that babies were covered in a layer of goanna fat and then Banksia ash to provide an insulating layer to keep them warm in the same way as a blanket.*

Winmar's words were selected and brought by Rebecca Hume to be read aloud to a women's consultative group in 2014 (Turner 2014: 13). They were also referred to in the 2017 consultation.

The proximity of Poison Gully Creek to the residential community of Allawah Grove and the resource-rich Munday Swamp was noted by the women. Marion Collard spoke of extended stays with her mother's family at the Allawah community and the opportunities that this provided for the transmission of cultural knowledge between named families.

countrymen; otherwise there is a danger, they believe, that the snake might harm those approaching the water source.

Marlene Warrell continues to eat 'long neck turtle' and actively transmits cultural knowledge to younger people. She is one of a group of sisters whose grandmother Ollie Warrell lived for many years at Allawah Grove and was so closely identified with this area that 2.5km from the Dundas Road crossing of Poison Gully Creek there is gazetted public open space named the 'Ollie Warrell Reserve'. Ollie Warrell was known to walk the *bidi,* the network of Nyungar walking trails that connected Aboriginal residential reserves and camps with the natural resource-rich swamps and watercourses of the coastal plain. At times, she was accompanied by her granddaughters (Turner 2014: 14).

It is clear from the preceding discussions that Poison Gully Creek is of contemporary significance to women and is held to be a woman's place. In the 2017 consultations there was much discussion about the role of women and which women in particular had responsibility for teaching/transmitting cultural knowledge, learning/receiving and capacity to speak for the site in the face of continuing development issues and their associated threats to the physical and spiritual integrity of the site. In the morning session, Bella Bropho was encouraged to take on this knowledge and "speak for this place". Rather than speak as a small group or as individuals about the specifics of women's cultural knowledge in December, all women consulted endorsed the idea of a specially convened women's meeting to be held at Matagarrup (Heirisson Island) in 2018. At the core of the discussion was dissatisfaction with the current heritage process. In the words of Vanessa Corunna: "What do we women want from heritage talks? How can we do this? How can we embrace our culture and overcome the [heritage] system of oppression?" The proposed Matagarup meeting was endorsed as an initiative of the women themselves rather than triggered by heritage processes of site identification and the associated process of obtaining consents to alter and too often impact or destroy the identified sites, referred to frequently by the women consulted as "section 18s". At the proposed Matagarup meeting, women intend to discuss establishing a women's cultural project to both gather and transmit knowledge to younger women — to raise, discuss and incorporate the words of now-deceased women elders or those too frail to attend on-site consultations.

The proposed project would document famous Nyungar midwives, ante and post-natal ritual practices and women's spiritual health and responsibilities. Gwen Corunna and her daughter Vanessa wished to have noted in this report that they have documentary evidence of six generations of their family being born in the metropolitan area from Adeline Wilkes' birth in 1898 beside the river at Success Hill, to the youngest of the "grannies" (i.e., grandchildren). It was also proposed that named "bush babies" (that is, living persons born in the bush or on community reserves in the Perth area rather than in a hospital) be approached to have their stories documented. This is in keeping with Nyungar-based community artwork honouring Bush Babies elsewhere in the Southwest and Pilbara regions of Western Australia. One Nyungar art exhibition on Bush Babies, installed in the WA Museum in Perth in 2014, was visited by over 72,000 people before it toured regional WA. This exhibition will have been continuously viewed until September 2018.[12]

Of particular relevance to this report were statements made relating specifically to gender and the transmission of gendered knowledge. In the morning session, women discussed previous practices whereby Nyungar men "spoke up" for Poison Gully Creek. It was posited that the men may have been protecting women and women's knowledge by allowing women to remain supportively in the background. However, it was also noted that many heritage surveys in Nyungar country are undertaken by male anthropologists with whom women do not easily wish to discuss women's sites. Two of the women present for the December 2017 consultation, Vanessa Corunna and Kezia Jacobs Smith, have studied the subjects of anthropology and archaeology at university level. However, they observe that they are not asked by heritage consultancy companies to participate as anthropologists. The paucity of female anthropologists working with Nyungar women on heritage surveys was noted, as was the inability of any single female anthropologist to gain familiarity and knowledge due to the multiplicity of heritage companies operating

[12] See, for example: , https://www.waitoc.com/fast-find/latest-news/bush-babies-exhibition-coming-perth; https://www.cacwa.org.au/advocacy-policy/stories/can---goomalling-ush-babies.

in the metropolitan area each with their preferred staff or consultants. In the March 2018 consultation/discussions, specific known birthing practices were referred to that involved natural births beside water sources such as Poison Gully Creek. However, it was requested that this knowledge not be made public as it was believed to be held by specific families and specific family members and was not open for general discussion in either the Nyungar or mainstream Western Australian communities.

Request for Documentation

There was general agreement that funds be sought to document from a Nyungar perspective the entirety of the Poison Gully Creek site from Kalamunda to Munday Swamp. Bella Bropho raised filming as an option that has been deployed on other cultural recording projects.

Results of the Men's Consultative Meeting

All four Nyungar men involved with the consultation spoke knowledgeably about the present survey area, drawing in this respect upon long and continuing individual and family associations with the survey area itself and with its broader social, cultural and geographic context.

One man, for example, spoke of early childhood experiences walking with his parents along a well-defined traditionally-important track (*bidi*) from the foothills to the Poison Creek Gully site, where they camped before progressing further along that track to other places of special significance to them on the coastal plain. He recounted how, in the context of these experiences, he had learned from both his parents about his "country", its resources, its special places and their relationship to each other, and about the responsibilities its owners had toward its upkeep and renewal. He further recounted how, growing toward adulthood, he acquired more and more knowledge about his country, including Poison Creek Gully, allowing him in later years to speak authoritatively about his country and to instruct younger generations about it, just as his parents and other relatives had done in earlier times.

The other three consultants had not had the same width of early childhood experience in regard to Poison Creek Gully per se, but all were able to point to similar experiences as youths and young adults learning first-hand from their parents and older relatives about Poison Gully Creek and its associations with surrounding "country". They too have subsequently taken on responsibilities in speaking and caring for "country" and for imparting the required knowledge to the younger generations.

In all essential respects, the men spoke with a single voice as it were in relation to the issues of concern to them raised by the proposed Forrestfield DSP.

The men acknowledged that Poison Gully Creek (DPLH ID 25023), a Registered Aboriginal Site with which all are familiar, is the only place lying within the present survey area which is currently recognised as an Aboriginal Site under the terms of the AHA. They reported that they were not aware of any other place within the survey area for which similar recognition had been sought, nor of any other place for which such recognition could or should now be sought.

They pointed out that in Nyungar culture, the senior women in their families were the holders of special knowledge and cultural responsibilities in relation to Poison Gully Creek, including speaking up for the site in relation to any potential disturbance or degradation. They noted approvingly in this regard that a prior Women's Meeting had been held in relation to the Project Area and that consultation had been led by Jan Turner, a female anthropologist with extensive research and consultation experience, including earlier work in relation to Poison Creek Gully itself (Turner 2014). Envisaging that further consultation would be necessary as the Forrestfield DSP proceeds, the men nominated two other women they want included in any follow-up meetings.

The Nyungar male consultants provided further information that they believed would complement and extend that provided by the women at the earlier consultation meeting. The key points made concern:

(i) their continuing access to and control of the land as its traditional owners and custodians;

(ii) cultural precepts and practices seen as sustaining both "country" and community;

(iii) complementary male and female knowledge and responsibilities; and,

(iv) linkages between the Forrestfield North DSP study area and the surrounding landscape.

The viewpoints expressed in each of these regards are summarised below.

The men reported that they were traditional owners and custodians of the broader area embracing Poison Gully Creek (DPLH ID 25023). As such, they carry broad responsibilities for the upkeep of the land based upon their unbroken inheritance of that land as its traditional owners. They acknowledged ruefully that the traditional ownership they assert in relation to this particular place is not recognised in current governmental legislation, administrative arrangements or formal agreements, other than to the limited extent allowed by current heritage legislation (i.e., the AHA). Extending this theme, they expressed their frustration at continually being asked to approve developments that 'chip away' at their inheritance. "It's death by a thousand cuts" is how one of the consultants expressed their shared sentiment in this regard. Putting aside that sense of inevitability, the consultants expressed their desire to explore whatever avenues might still be available to them to gain formal recognition of their customary rights via existing Native Title processes. [13]

As discussion turned more toward the specifics of the Forrestfield North DSP area, the consultants spoke in terms of both custodianship and ownership. One consultant expressed his annoyance at "whitefellas" who use "custodian" as an alternative to "owner" when discussing traditional relationships to land, especially when they think they are being more culturally sensitive by doing so. The two terms, he asserted, need to go together, to encompass the complementary dimensions of their relationship to land—the inextinguishable rights that have come to them from time immemorial, including

13 These concerns were raised despite the signing of the South West Settlement between the WA Government and SWLASC, which includes the Whadjuk People, and the passing of the *Noongar (Koorah, Nitja, Boordahwan) (Past, Present, Future) Recognition Act 2016*.

rights to control what others might do on their territory; and their culturally-defined responsibilities to care for and renew the land. "We look after the land and the land looks after us." Another consultant added that the health of their people depended upon them continuing to look after their country.

Without in any way retreating from their recognition of the primacy of senior women in sustaining specific cultural belief and practice in relation to Poison Gully Creek, the consultants pointed out that men also have an essential role to play in its protection and care, and more generally in sustaining their links to country. Special rights and responsibilities are not sole rights and responsibilities, they said. Men, they reported, must protect and "back up" women's special rights and responsibilities without intruding upon them, just as women are expected to do in relation to men's corresponding activities in other places. "We work together" is how one consultant described the underlying relationship.

The consultants also spoke of how specific sites exist within a broader geographic and cultural context, and, therefore, should not be viewed in isolation either from other sites in the area, especially those along particular "tracks" (*bidi*), or from traditional "country" generally. Each site, they emphasised, constitutes one part of a much bigger picture shaped and defined by beliefs about how the land and its features were initially shaped in the distant past (as often conveyed in conceptions of the Dreaming as a transformative era in the remote past); and sustained in the eons since by successive generations playing their vital part in renewing the life and order instituted and ordained during that original heroic era, invoking the wider sense of the Dreaming as an "everywhen", to use Stanner's (1979) now familiar term, unifying past, present and future.

Against this background, the men expressed the desire to know more about the possible consequences for other areas outside the present Forrestfield North DSP study area of the plans now being prepared for the wider Forrestfield redevelopment. Possible downstream consequences for Munday Swamp (DPLH ID 3719) were cited as of particular concern in this respect.

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Discussion

The women's and men's conceptualisation of Poison Gully Creek as a place and its dimensions are not easily shoehorned into the two-dimensional provisions of the AHA. The focus is on the dynamics of the place. In this regard, Poison Gully Creek was not discussed by either the women or men as an isolated place. Rather, the focus of discussions was on its relationship with other places, traditionally linked by the flow of water and by *bidi* or tracks. The creek and its *bidi* form part of a 'meshwork' (Ingold 2007 and 2011) in which place is to be understood as an outcome of movement, practice and event, which result in the experience of 'biographical entanglements'. As Pink (2012: 27) notes: "movement is integral to the constitution of place". Ingold (2007: 81) observes: "the lines of a meshwork are the trails along which life is lived …. It is the entanglement of lines, not in the connecting of points, that the mesh is constituted." Discussing the Walbiri of Central Australia, Ingold (2007: 79, 100) suggests that their life is laid out on the ground as the sum of their trails. Low (2017: 102) drawing on Munn's ethnography of the Walbiri notes that place and its significance can be defined out of "transient but repeatable boundaries out of the moving body". A similar point could be made regarding Nyungars.

Ingold's observations regarding 'meshwork' has a resonance is Baines (1988) and Birdsall's (1988) ethnographies which highlight the importance of movement along 'runs' and 'lines' and the resulting 'biographical entanglements' to Nyungar identity and sociability. As Sansom (1983: 120-121) remarks on Baines Nyungar ethnography on family stories: "the ancestral figures who move across country progress on the site-and-track pattern of the mythical ancestors of traditional Dreaming stories. … Nyungar stories ae stories of arrivals and departures, of human travels that cover country to take it into walkabout embrace." The sort of meshwork described by Ingold (2007) is evident in the present Aboriginal consultants' discussion of the place and its connections with Munday Swamp and Allawah Grove. The point here is that Poison Gully Creek has to be understood not as an isolated place but part of a meshwork that connects Nyungar lives with places in an ongoing and emergent fashion.

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Conclusions and Recommendations

This report has presented the process and findings of ethnographic assessment in respect of the Forrestfield North District Structure Plan (DSP) area in the Shire of Kalamunda, with a particular focus on Poison Gully Creek, a Registered Aboriginal Site (DPLH ID 25023). The assessment involved desktop research and community consultation, the latter involving separate women's and men's meetings in December 2017. Because of the reported importance of Poison Gully Creek (DPLH ID 25023) to Nyungar women, the on-site consultation was followed up with telephone calls and an additional consultation with several Perth-based women in March 2018 in order to review the results of the research and to confirm the contents of the report.

The search of the online AHIS and other archival sources confirmed that Poison Gully Creek (DPLH ID 25023) is the only Registered Aboriginal Site in the DSP study area. Two 'Other Heritage Places' (DPLH ID 3667 and DPLH ID 3637, both artefact scatters) are also listed in the study area. The desktop research indicates that is highly likely that additional archaeological sites in the form of artefact scatters would be located within the Forrestfield North DSP study area.

With the exception of Poison Gully Creek (DPLH ID 25023), no other places were reported within the study area that might reasonably be considered to be an Aboriginal Site within the meaning of Section 5 of the AHA. Both the women's and the men's consultative meetings confirmed the cultural significance of Poison Gully Creek and highlighted its importance to Nyungar women in particular. Indeed, the site is a focal point in Nyungar women's assertion of their rights with respect to country and heritage practices. Discussions regarding the importance and significance of Poison Gully Creek are part of a broader concern among Nyungar women to document and support traditional birthing practices.

The site is confirmed by the women consultants to have been a 'birthing place' with associated rituals and is still seen as a place for teaching/transmitting cultural knowledge, learning/receiving. The women in particular strongly expressed a desire to protect the

natural bush and creek between Dundas Road and Milner Road and in particular the open space adjacent to the Dundas Road crossing. The women cite the aesthetic value of this area as being integral to their own, and indeed Nyungar, wellbeing in general. They wish to have an area where they can continue to teach and support their children and grandchildren in an accessible nurturing bush environment.

Water is a central aspect of the site which, together with its immediate surrounds, is conceptualised to be a single site from its source in the high country of Kalamunda to where it joins with the waters of Munday Swamp. Both the surface and the subsurface waters are seen as integral to the site, which despite various historical impacts is conceptualised as following the path laid down by ancestral beings in the Dreaming. In keeping with the Nyungar worldview, the creek's water is seen as a 'life force' that requires protection and ongoing attention. Concerns were expressed with regards to impacts on the creek that might also have flow-on effects on Munday Swamp.

Though Nyungars are typically concerned about negative impacts on waterways such as Poison Gully Creek, the community is generally supportive of endeavours to improve and restore water flow and quality to mirror the waterways' original state where these have been degraded through past land use practices. This support typically extends to endeavours to rehabilitate waterways through the removal of introduced floral species and revegetation with native plants. Such work, however, would require either consent from the Minister of Aboriginal Affairs under Section 18 of the AHA or approval under Regulation 10 from the Registrar of Aboriginal Sites.

The Nyungar consultants' conceptualisation of Poison Gully Creek as a place and its extent is not two-dimensional, nor do they view the place in isolation from its broader geographical and cultural setting. This perspective was reflected in all the meetings with the Nyungar consultants, with a strong emphasis throughout on its relationship with other places. Of special significance to them in this regard were places, such as Munday Swamp and Allawah Grove, traditionally linked by the flow of water and the bidi or tracks and part of a meshwork in which place is to be understood as an outcome of movement, practice and event, which result in the experience of 'biographical entanglements'.

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Recommendations

1. It is recommended that the Shire of Kalamunda and its agents continue their consultations with the Nyungar community in respect of the Forrestfield North DSP, particularly as this might impact on Poison Gully Creek (DPLH ID 25023).
2. It is also recommended that the Shire of Kalamunda seek advice from the DPLH as to whether any planned impacts on Poison Gully Creek (DPLH ID 25023) will require consent from the Minister of Aboriginal Affairs under s18 of the AHA or approval under Regulation 10 from the Registrar of Aboriginal Sites.
3. It is further recommended that the Shire of Kalamunda, in conjunction with Nyungar women, examine ways in which the natural bush and creek between Dundas Road and Milner Road can be enhanced as a Nyungar women's place.
4. It is likewise recommended that the Shire of Kalamunda commemorate the Aboriginal heritage of the Forrestfield North DSP study area, giving particular emphasis to the meshwork of Nyungar places, including the high country in Kalamunda, Munday Swamp and Allawah Grove.
5. It is recommended that Nyungars are invited to engage in any works associated with Poison Gully Creek, including the rehabilitation of the creek and revegetation with native plants.
6. It is also recommended that the Shire of Kalamunda commission an archaeological survey of the Forrestfield North DSP study area prior to the commencement of development.

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A	D White, K Cooper	D Newsome	D Newsome		25/10/2017
B	K Cooper	D Newsome	D Newsome		13/04/2018
0	K Cooper	D Newsome	D Newsome		23/04/2018
1	J Hunt	D Newsome	D Newsome		03/06/2020
B	H Sullivan/R Mason	J Blitz	J Blitz		24/09/2021


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element.

Technical Appendix B -BMP

FPA AUSTRALIA | Fire Protection Association Australia | Life. Property. Environment.

BPAD Bushfire Planning & Design

Bushfire Management Plan Coversheet

This Coversheet and accompanying Bushfire Management Plan has been prepared and issued by a person accredited by Fire Protection Association Australia under the Bushfire Planning and Design (BPAD) Accreditation Scheme.

Bushfire Management Plan and Site Details

Site Address / Plan Reference: Forrestfield North Residential Precinct

Suburb: High Wycombe **State:** WA **P/code:** 6057

Local government area: City of Kalamunda

Description of the planning proposal: Structure Plan application

BMP Plan / Reference Number: 60690/140,968 **Version:** R01 Rev2 **Date of Issue:** 04/10/2021

Client / Business Name: Element on behalf of City of Kalamunda

Reason for referral to DFES	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 BPC elements)?	☐	☒
Is the proposal any of the following special development types (see SPP 3.7 for definitions)?		
Unavoidable development (in BAL-40 or BAL-FZ)	☐	☒
Strategic planning proposal (including rezoning applications)	☒	☐
Minor development (in BAL-40 or BAL-FZ)	☐	☒
High risk land-use	☐	☒
Vulnerable land-use	☐	☒

If the development is a special development type as listed above, explain why the proposal is considered to be one of the above listed classifications (E.g. considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

Structure Plan application

Note: The decision maker (e.g. local government or the WAPC) should only refer the proposal to DFES for comment if one (or more) of the above answers are ticked "Yes".

BPAD Accredited Practitioner Details and Declaration

Name	Accreditation Level	Accreditation No.	Accreditation Expiry
Louisa Robertson	Level 3	BPAD 36748	28/02/2022
Company		**Contact No.**	
Strategen-JBS&G		08 9792 4797	

I declare that the information provided within this bushfire management plan is to the best of my knowledge true and correct

Signature of Practitioner LM Robertson **Date** 04/10/2021

Forrestfield North Residential Precinct Local Structure Plan

Bushfire Management Plan

Prepared for
Element
by Strategen-JBS&G

October 2021

61690/140,968 (Rev 2)

BPAD Bushfire Planning & Design Accredited Practitioner Level 3

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Forrestfield North Residential Precinct Local Structure Plan

Bushfire Management Plan

Strategen-JBS&G is a trading name of
JBS&G Australia Pty Ltd
Level 1, 50 Subiaco Square Road Subiaco WA 6008
ABN: 62 100 220 479

October 2021

Limitations

Scope of services

This report ("the report") has been prepared by Strategen-JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen-JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

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In preparing the report, Strategen-JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen-JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen-JBS&G has also not attempted to determine whether any material matter has been omitted from the data. Strategen-JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen-JBS&G. The making of any assumption does not imply that Strategen-JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen-JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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Document control

Client: Element

Report Version	Revision No.	Purpose	Strategen-JBS&G author/reviewer and accreditation details	Submitted to Client	
				Form	Date
Draft Report	Rev A	For review by client	L Robertson (BPAD36748) / Z Cockerill (BPAD37803)	Electronic (email)	11/04/2018
Final Report	Rev 0	Issued for use: to accompany Local Structure Plan submission	L Robertson (BPAD36748) / Z Cockerill (BPAD37803)	Electronic (email)	24/04/2018
Final Report	Rev 1	Revised with updated Local Structure Plan	L Robertson (BPAD36748) / Z Cockerill (BPAD37803)	Electronic (email)	26/06/2020
Final Report	**Rev 2**	**Revised with updated Structure Plan**	**L Robertson (BPAD36748, Level 3)**	**Electronic (email)**	**04/10/2021**

Filename: 61690 R01 Forrestfield North Res LSP BMP (Rev 2) - 4 October 2021

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Appendix 4 Town Park Concept Plan (Element 2021)
Appendix 5 Guideline standards for Asset Protection Zones (APZs)

1. Proposal details

1.1 Background

Element, on behalf of City of Kalamunda (the City), intends to lodge a Structure Plan over a 123.05 ha area of land known as the Forrestfield North Residential Precinct (hereafter referred to as the Residential Precinct/project area). The Residential Precinct is located in the suburb of High Wycombe and is bound by Roe Highway to the east, Sultana Road West to the south, Milner Road to the west and Poison Gully Creek to the north. The Structure Plan is depicted in Figure 1 and shows the proposed development as comprising the following elements:

- eight separate development cells (Cells 01 to 08)
- nine public open space (POS) areas (POS-01 to POS-09)
- thirteen environmental conservation reserves (EC-01 to EC-13)
- Town Park
- six drainage basins (DB-01 to DB-06)
- public road network
- potential future fly-over Roe Highway
- three connections to the TOD Precinct at the northwest site boundary
- Public Purposes – Primary School site
- residential lots (R30 to R100)
- re-vegetation area adjacent to Roe Highway overpass.

The Forrestfield North Residential Precinct forms part of the overall Forrestfield North District Structure Plan (DSP), which also includes an adjacent 61.02 ha parcel of land directly to the north, which is known as the Forrestfield North Transport Oriented Development (TOD) Precinct. A separate Activity Centre Plan application is currently in progress for the TOD Precinct.

The City has engaged in significant stakeholder consultation throughout the early planning stages and the resulting LSP has been designed to maximise retention of key environmental assets.

1.2 Site description

Rural residential properties form the predominant existing land use within the Residential Precinct and commercial zoned properties are also present in the south. The site includes Brae Road Reserve Bush Forever site in the north and the Brand Road old tip site in the east. The Residential Precinct is surrounded by the following, as depicted in Figure 2:

- Bush Forever site 123 adjacent to the southwest corner of the site
- Industrial properties abutting the southern site boundary, including a number of logistics businesses
- Commercial and Rural Residential properties to the north/northwest
- Bush Forever site 45, which includes the Poison Gully Creek foreshore area that transects the northern site boundary.

1.3 Purpose

The Residential Precinct is situated within a designated bushfire prone area according to the DFES State Map of Bush Fire Prone Areas (DFES 2019; refer to Plate 1), which triggers bushfire planning requirements under Policy Measure 6.2 and 6.3 of *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7; WAPC 2015).

This Bushfire Management Plan (BMP) has been prepared in accordance with Section 5.2.5 of *Guidelines for Planning in Bushfire Prone Areas* (the Guidelines; WAPC 2017), which requires LSP submissions to be accompanied by a BMP that includes the results of a strategic level Bushfire Hazard Level (BHL) assessment.

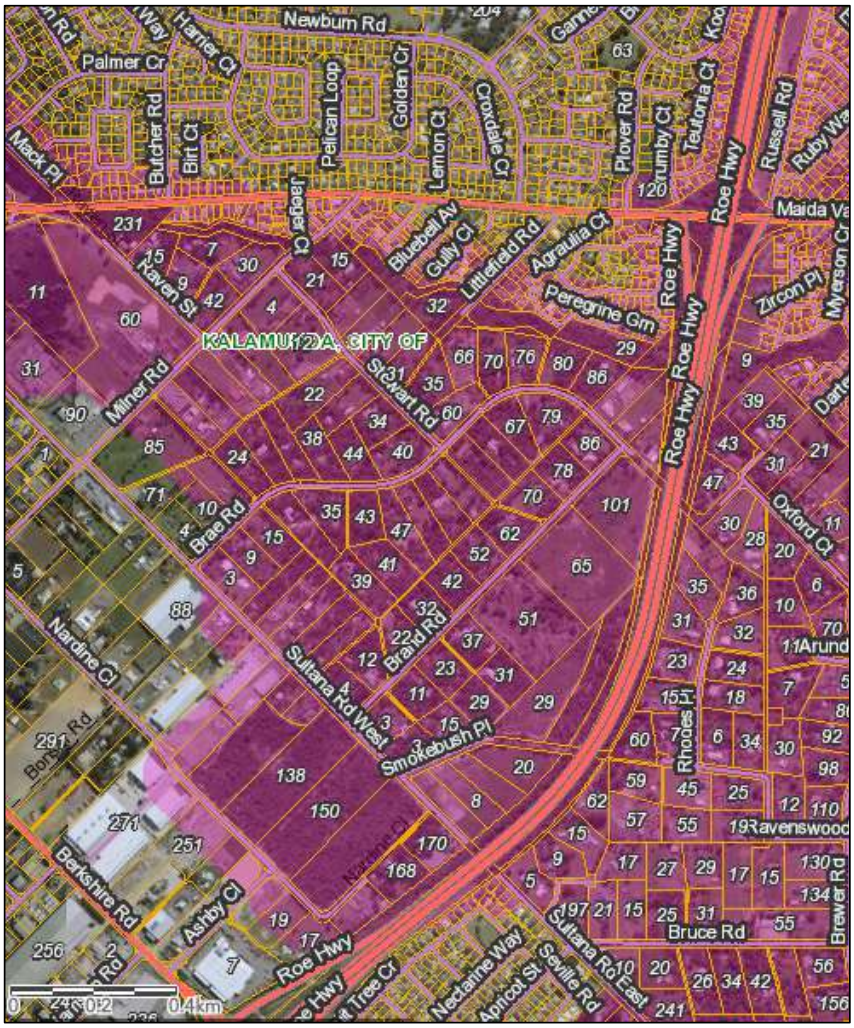

Plate 1: Map of bushfire prone areas (DFES) 2019

1.4 Other plans/reports

The first version of this BMP (Revision 0) was prepared in 2018 and has undergone several revisions in response to amendments to the Structure Plan design. This current BMP is Revision 2 and considers a Structure Plan design that was amended in 2021.

Other relevant reports that have been prepared for the project area include:

- Bushfire Management Plan in respective of the adjacent Forrestfield North TOD Precinct Activity Centre Plan(Strategen-JBS&G 2021a).
- Environmental Assessment and Management Strategy (EAMS) in respect of:
    - Forrestfield North Residential Precinct (Strategen-JBS&G 2021b); and
    - Forrestfield North TOD Precinct (Strategen-JBS&G 2021c).
- Local Water Management Strategy in respect of:
    - Forrestfield North Residential Precinct (Urbaqua 2020); and
    - Forrestfield North TOD Precinct (Strategen-JBS&G 2021c).



Figure 1: Structure Plan (Element 2021)



Legend

- Project area
- 100m assessment area
- 150m assessment area
- Existing cadastral boundary
- Bush Forever
- Poison Creek Gully
- Roads (MRWA)

strategen JBS&G

0 200 metres

Job No: 61690		Scale 1:6,500 at A3		**Forrestfield North Residential Precinct, WA**
Client: Element		Coord. Sys. GDA 1994 MGA Zone 50		**SITE OVERVIEW**
Drawn By: cthatcher	Checked By: LR	Version: A	Date: 30-Sep-2021	**FIGURE: 2**

Document Path: \\008PMPMR004V001.jbsg.aust\JBS Perth\Projects\1)Open\Element (TPG)\61690 Forrestfield North Res Precinct BMP Update\GIS\Maps\R01_Rev_A\61690_02_SiteOverview.mxd
Image Reference: www.nearmap.com© - Imagery Date: 25 August 2021

2. Environmental considerations

2.1 Native vegetation – modification and clearing

An extensive consultative process has resulted in various updates to the LSP and driven design changes in response to agency issues in order to maximise retention of key environmental assets while reducing the bushfire impacts on future development as far as is reasonably practicable. The resulting LSP layout allows for retention of a vegetation corridor to maintain linkages to the Bush Forever sites to the north and south of the site and prevent further fragmentation within the area. The proposed design provides for the retention of the Threatened Wavy-leaved Smokebush within the corridor as well as individual environmental conservation reserves throughout the Residential Precinct.

The proposed development will require removal of remnant native vegetation to accommodate construction of roads and other built form and to establish various low threat landscaped POS areas throughout the residential precinct area. No clearing is proposed within the environmental conservation reserves or existing Bush Forever site. It is understood that various levels of vegetation thinning and some clearing will be conducted throughout some proposed POS areas to address bushfire impacts and to accommodate drainage requirements as well as for public amenity purposes. The recommended pathway for clearing approvals at the state and/or federal is yet to be determined; however, this will likely be achieved in consultation with relevant agencies via strategic assessment for individual proponents at future development stages as required. In consideration of the exhaustive design process that has been undertaken and current advice from leading environmental agencies, Strategen-JBS&G (formerly Strategen Environmental) considers the potential environmental impacts of proposed development have been carefully considered and are manageable, as documented in the *Environmental Assessment and Management Strategy* (EAMS; Strategen-JBS&G 2020), provided as part of the LSP submission.

A search of publicly available environmental data concluded that:

- the western portion of the Residential Precinct contains a mapped Multiple Use Wetland (MUW)
- a Resource Enhancement Wetland (REW) is mapped in the northwest corner of the Residential Precinct
- Bush Forever site 45, encompassing the Poison Gully Creek foreshore area, intersects the northern site boundary and partially extends into the Residential Precinct
- Bush Forever site 123 lies adjacent to the southern boundary of the Residential Precinct
- Brae Road Reserve located within the Residential Precinct is a Bush Forever site
- the Banksia Woodland EPBC listed Threatened Ecological Community (TEC) is mapped as occurring within the Residential Precinct
- the Residential Precinct is within the Perth Regional Ecological Linkage network.

The EAMS (Strategen-JBS&G 2021) should be read concurrently with this BMP. The report identifies the following additional environmental considerations in relation to native vegetation modification and clearing:

- five vegetation communities ranging from ‘Degraded’ to ‘Excellent’ condition were mapped within the Residential Precinct
- the Threatened Wavy-leaved Smokebush (*Conospermum undulatum*), which is listed as Vulnerable under the EPBC Act and WC Act, was extensively recorded within the Residential Precinct
- *Isopogon drummondii* (a Priority 3 species) was recorded in the Residential Precinct
- Four species of conservation significance including Carnaby’s Black Cockatoo, Forest Red-tailed Black Cockatoo, Rainbow Bee-eater and Quenda were recorded within the Residential Precinct.

2.2 Revegetation / Landscape Plans

A Concept Landscape Plan has been prepared to support the LSP application by Place Laboratory (2021) and is included at Appendix 1. The plan provides a conceptual design for landscaping throughout the Residential Precinct and is consistent with the environmental, visual amenity, drainage and bushfire requirements for the site. This BMP takes into account areas of low threat landscaping and classified vegetation from the high-level landscaping design concepts.

The following areas of vegetation retention and revegetation are expected to occur within the Residential Precinct:

1. The Concept Landscape Plan designates “Ecological Protection Zones” that comprise a combination of environmental conservation (EC) reserves supporting classified vegetation as well as passive recreation zones (POS). The POS areas are expected to include low threat landscaping such as turf and manicured plantings as well as areas containing denser canopy coverage that would likely constitute classified vegetation.
2. The EAMS outlines requirements for the development of a POS revegetation management plan to identify the EC and POS zones and any areas of revegetation during future planning applications.
3. The EAMS requires that a POS interface plan is to be prepared for future planning stages to address revegetation of the POS and EC areas within the REW and associated buffer along Poison Gully Creek. This may include the provision for low threat landscaping adjacent to the residential lots to reduce potential bushfire impacts on future development.
4. The Concept Landscape Plan identifies low threat landscaped buffers within POS and drainage basins at key development interfaces to account for potential APZ requirements. The width of the buffers is to be determined at future planning stages to ensure that APZs are sufficient to achieve ratings of BAL-29 or lower for all proposed development.
5. Drainage basins are proposed to be developed throughout the Residential Precinct and it is likely these areas will be revegetated with classified vegetation. The design and species composition of the drainage basins will be determined at future planning stages, but it is expected that the vegetation will comprise a combination of Class B Woodland, Class C Shrubland and Class G Grassland. The drainage basins are to be assigned a precautionary effective downslope of >0 to 5 degrees at future planning stages to account for slope requirements in drainage area.
6. The Concept Landscape Plan includes the provision of revegetation within POS-01 which is adjacent to the school site, as part of the Ecological Protection Zone. Existing vegetation fringing the northern boundary of the school site is also proposed to be retained.
7. Revegetation is proposed to occur adjacent to the Roe Highway flyover to provide a vegetative link between the EC reserves abutting Roe Highway and the two EC reserves either side of the future TOD connecter road (POS-02). It is expected that the vegetation would comprise Class B Woodland which is consistent with existing vegetation within the adjoining EC reserves.
8. Significant trees are proposed to be retained within the Town Park (POS-08) as detailed within the Town Park Concept Plan (see Appendix 4).
9. Street tree plantings are proposed along the major roads with the Residential Precinct. Streetscapes have been designed to account for potential APZ requirements.
10. No re-vegetation is expected to occur within the Brae Road Reserve Bush Forever site.

3. Bushfire assessment results

3.1 Assessment inputs

3.1.1 Vegetation classification

Strategen-JBS&G assessed classified vegetation and exclusions within 150 m of the Residential Precinct through on-ground verification on 12 September 2017 in accordance with *AS 3959—2009 Construction of Buildings in Bushfire-Prone Areas* (AS 3959; SA 2009) and the *Visual Guide for Bushfire Risk Management* in *Western Australia* (DoP, 2016). Georeferenced site photos are contained in Appendix 2.

Figure 3 illustrates the existing (pre-development) vegetation classifications within the Residential Precinct. Figure 4 shows the post-development vegetation classifications following completion of construction works and implementation the POS, drainage basins, environmental conservation reserves and low threat landscaping.

Pre-development vegetation classification

A summary of the assessed pre-development classified vegetation are as follows (refer to Figure 3):

- Class A Forest occurs within:
  - the Poison Gully creek foreshore area that transects the northern cadastral boundary
  - the internal rural residential properties abutting the northern site boundary and within Lots 2 and 92 Milner Road, which are partially mapped as an REW
  - Lot 50 Smokebush Place, which forms part of the Brand Road old tip site and within the adjoining Roe Highway road reserve
  - both the western and eastern sides of Roe Highway.
- Class B Woodland vegetation occurs:
  - across a large proportion of the Residential Precinct with the majority of the rural residential lots supporting remnant banksia woodland with minimal land cleared for building footprints and Asset Protection Zones (APZs)
  - within the Brae Road Reserve (existing Bush Forever)
  - within Bush Forever site 123 (abutting the southern cadastral boundary) and extending into the neighbouring properties to the east
  - within other external rural residential properties to the west and east of the Residential Precinct
- Class G Grassland (grass greater than 100mm in height) occurs within:
  - the Brand Road old tip site and adjacent Lot 15 Brand Road
  - vacant lots to the south of Smokebush Place
  - a number of rural residential properties within and external to the Residential Precinct.

The City's Fire Hazard Reduction Notice (refer to Appendix 3) requires that all vacant and occupied land of any size is to "slash, mow, or trim dead grasses, dead shrubs, and dead plants to a height no greater than 50mm and remove cuttings/swath across the entire property". Although all lots within the 150m assessment area are legally required to maintain grassland in a low threat state, lots that were not maintained at the time of the inspection were classified as Class G Grassland.

A summary of the assessed pre-development exclusions are as follows (refer to Figure 3):

- Clause 2.2.3.2 (e) occurs across the assessment area and includes all permanently non-vegetated areas such as roads, footpaths, building footprints, carparks, hardstand areas and private driveways
- Clause 2.2.3.2 (f) occurs across the assessment area and includes all land maintained in a low threat state, including cultivated gardens, maintained lawns within residential properties and grassland managed below 50mm in accordance with the City's Firebreak and Fuel Load Notice (refer to Appendix 3).

Post-development vegetation classification

On completion of development, the majority of the Residential Precinct area will be modified to a low threat state. Classifiable vegetation remaining within the site will be located within the EC reserves, POS areas, Brae Road Bush Forever site and drainage basins. Roe Highway has a vegetated verge and is adjacent to the Residential Precinct, however, the development does not propose any modification of vegetation within this corridor.

The post-development vegetation assessment that development of the TOD Precinct will not occur prior to development of the Residential Precinct and the remaining vegetation classifications external to the Residential Precinct are expected to remain the same as per pre-development classifications. Any changes to vegetation within the 150m assessment prior to development of the Residential Precinct will be captured in an updated Bushfire Hazard Level (BHL) assessment and/or future BAL contour assessment at future planning stages.

A summary of the expected post-development classified vegetation within the Residential Precinct is as follows (refer to Figure 4):

- Class A Forest vegetation will occur within:
    - the EC reserves sited along the northern site boundary identified as EC-09, EC-10, EC-12 and EC-13
    - the reserve identified as EC-01, which is existing Lot 50 Smokebush Place
    - POS-08, which lies within the Town Park site
    - a portion of DB-04, located along the northern site boundary
    - both the western and eastern sides of Roe Highway
- Class B Woodland vegetation will occur within:
    - the EC reserves sited adjacent to the future TOD connector boulevard, identified as EC-02 and EC-03
    - the EC reserves sited within the central corridor linkage, identified as EC-04 to EC-08
    - the POS areas located within the central corridor linkage and throughout the Residential Precinct, identified as POS-01, POS-03, POS-04, POS-05 and POS-07
    - POS-02, situated adjacent to the future TOD connector boulevard
    - POS-06, located on Brae Road, within the northeast of the site
    - POS-07, situated along the northern site boundary
    - Brae Road Reserve (existing Bush Forever site; BF-01)
    - Drainage basins (DB) 01 and 02, a portion of 03, 04 and 06– these drainage basins have been classified as Class B Woodland as a precautionary measure given that the majority will lie immediately adjacent to external Bush Forever sites or internal EC reserves; however, the likely classification will be a combination of Class B Woodland, Class C Shrubland and Class G Grassland and any exclusions identified at the detailed landscape planning stage.

A summary of the expected post-development exclusions within the Residential Precinct are as follows (refer to Figure 4):

- Clause 2.2.3.2 (b) will occur within POS-09/EC-11 in the centre-west of the Residential Precinct. This area is less than 1 ha and not located within 100 m of any other classified vegetation

- Clause 2.2.3.2 (e) will occur throughout the Residential Precinct and will include all permanently non-vegetated areas such as roads, footpaths, building footprints, carparks, hardstand areas and private driveways
- Areas of Clause 2.2.3.2 (f) exclusions will occur within the POS areas, which will include low threat turf, manicured plantings and low threat buffers to residential development
- DB-05 (Town Park) will comprise managed turf and parkland trees and will meet exclusion Clause 2.2.3.2 (f)
- All street tree plantings are assumed to meet the low threat criteria of AS 3959 Clause 2.2.3.2 (f)
- Clause 2.2.3.2 (f) will occur throughout the Residential Precinct and will include all land maintained in a low threat state, including cultivated gardens and maintained lawns within residential properties, the community purpose site, portions of the school site and associated playing fields and all other actively maintained POS areas (including a portion of POS-01).

On completion of development, maintenance of all land in a low threat state will be enforceable under the City's Firebreak and Fuel Load Notice (refer to Appendix 3), which requires that all vacant and occupied land is to "have all flammable matter slashed, mowed or trimmed down by other means to a height no greater than 50mm across the entire property".

3.1.2 Effective slope

Strategen-JBS&G assessed effective slope under classified vegetation through on-ground verification 12 September 2017 in accordance with AS 3959. Results are depicted in Figure 3 and Figure 4.

Site observations indicate that the Residential Precinct is predominantly flat, with little variation in relief. The terrain inclines very gradually from 35 mAHD in the west to 45 mAHD in the northeast over an approximate distance of 1.2 km.

Class B Woodland vegetation within Bush Forever site 123 to the south of the site has an effective downslope of >0 to 5 degrees. Class A Forest vegetation within the Poison Gully Creek foreshore area transecting the northern cadastral boundary has an effective downslope ranging from >0 to 10 degrees. The remainder of the external classified vegetation is located on land that is predominantly flat in relation to the Residential Precinct.

On completion of the development, the retained areas of classified vegetation within the Residential Precinct would be predominantly flat in relation to areas supporting habitable development. The drainage basins are to be assigned a precautionary effective downslope of >0 to 5 degrees to account for a slight slope required for drainage purposes.



Legend

- Residential Precinct
- 100m wide assessment area
- 150m wide assessment area
- Cadastral boundary
- Poison Creek Gully
- Topographic contours (mAHD)
- Roads (MRWA)

Vegetation classification

- Class A Forest
- Class B Woodland
- Class G Grassland
- Excluded Clause 2.2.3.2 (e) and (f) of AS3959-2009

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0 200 metres

Job No: 57806		Scale 1:6,500 at A3	
Client: Element		Coord. Sys. GDA 1994 MGA Zone 50	
Drawn By: hsullivan	Checked By: CT	Version: A	Date: 21-May-2020

Forrestfield North Residential Precinct, WA

PRE-DEVELOPMENT VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE

FIGURE: 3

Document Path: W:\Projects\1)Open\Element (TPG)\57806 - FF North TOD & Res LWMS\GIS\Maps\BMP\57806_03_PreDev_VegClassSlope.mxd
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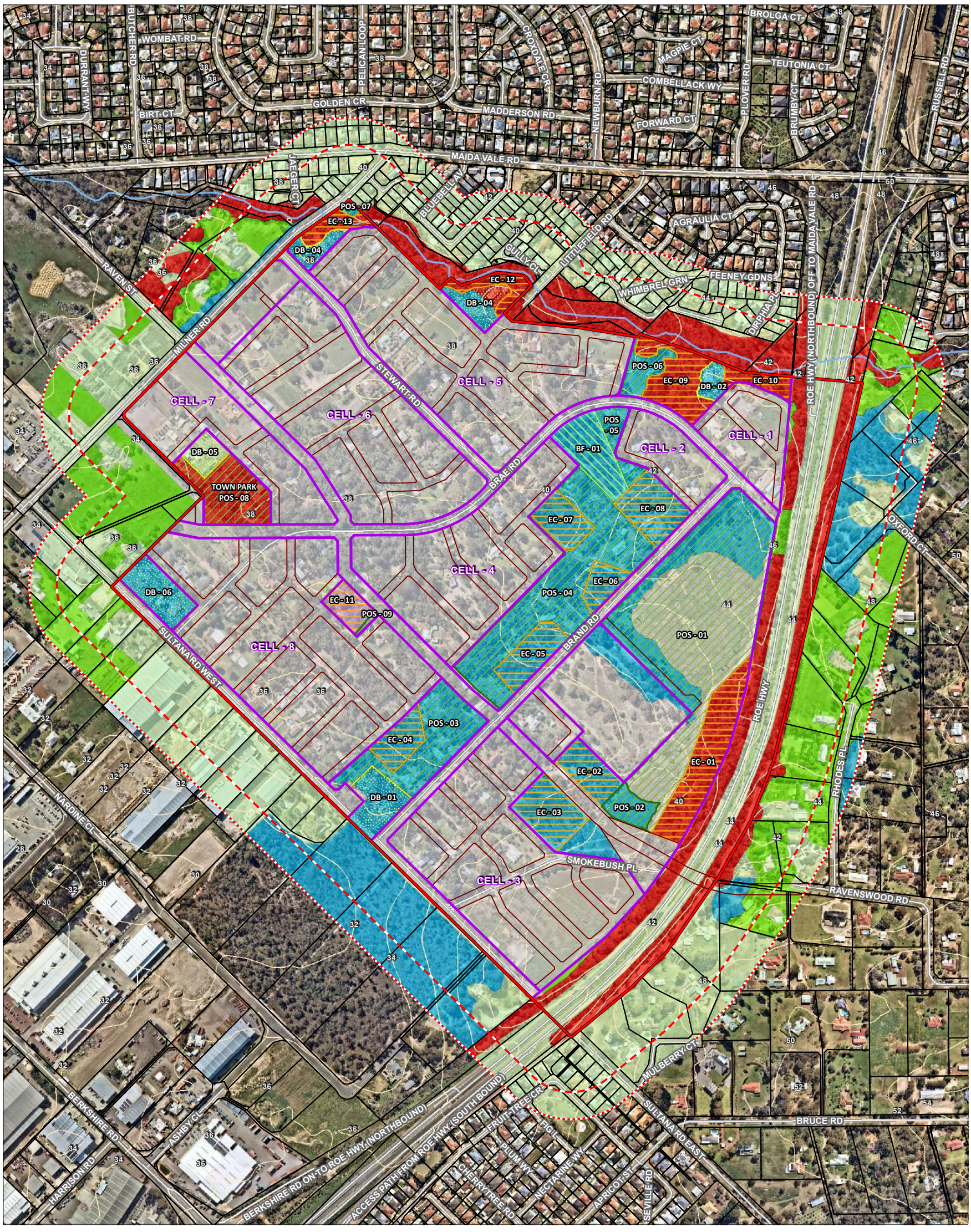


Legend

- Project area
- 100m assessment area
- 150m assessment area
- Existing cadastral boundary
- Bush Forever
- Drainage basin
- Environmental Conservation Reserve
- POS
- Proposed lot
- Development cell

Vegetation classification

- Class A Forest
- Class B Woodland
- Class G Grassland
- Area to be modified to low threat state
- Excluded Clause 2.2.3.2 (b)
- Excluded Clause 2.2.3.2 (e) and (f)
- Poison Creek Gully
- Topographic contours (mAHD)
- Roads (MRWA)

strategen JBS&G

0 200 metres

Job No: 61690		Scale 1:6,500 at A3	
Client: Element		Coord. Sys. GDA 1994 MGA Zone 50	
Drawn By: cthatcher	Checked By: LR	Version: A	Date: 30-Sep-2021

Forrestfield North Residential Precinct, WA

POST-DEVELOPMENT VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE

FIGURE: 4

Document Path: \\008PMPMR004V001.jbsg.aust\JBS Perth\Projects\1)Open\Element (TPG)\61690 Forresfield North Res Precinct BMP Update\GIS\Maps\R01_Rev_A\61690_04_PostDev_VegClassSlope.mxd
Image Reference: www.nearmap.com© - Imagery Date: 25 August 2021

3.2 Assessment outputs

3.2.1 Bushfire Hazard Level (BHL) assessment

Pre-development bushfire hazard levels

Strategen-JBS&G has mapped the pre-development bushfire hazard levels within the Residential Precinct and the 150 m wide assessment area. The bushfire hazard levels have been assessed on the basis of the vegetation discussed in Section 3.1.1 and the current pre-development extent of vegetation within and surrounding the Residential Precinct.

A summary of results is provided below and depicted in Figure 5:

- all Class A Forest has been assigned a bushfire hazard level of Extreme
- all Class B Woodland has been assigned a bushfire hazard level of Extreme
- all Class G Grassland has been assigned a bushfire hazard level of Moderate
- in accordance with the bushfire hazard level assessment methodology detailed in Appendix 2 of the Guidelines, vegetation that has a Low hazard level but is within 100 m of Extreme or Moderate hazard level vegetation has been assigned a Moderate hazard level
- all remaining areas have been assigned a bushfire hazard level of Low.

The pre-development BHL assessment shows that based on the existing vegetation, the Residential Precinct contains land with Moderate and Extreme bushfire hazard levels.

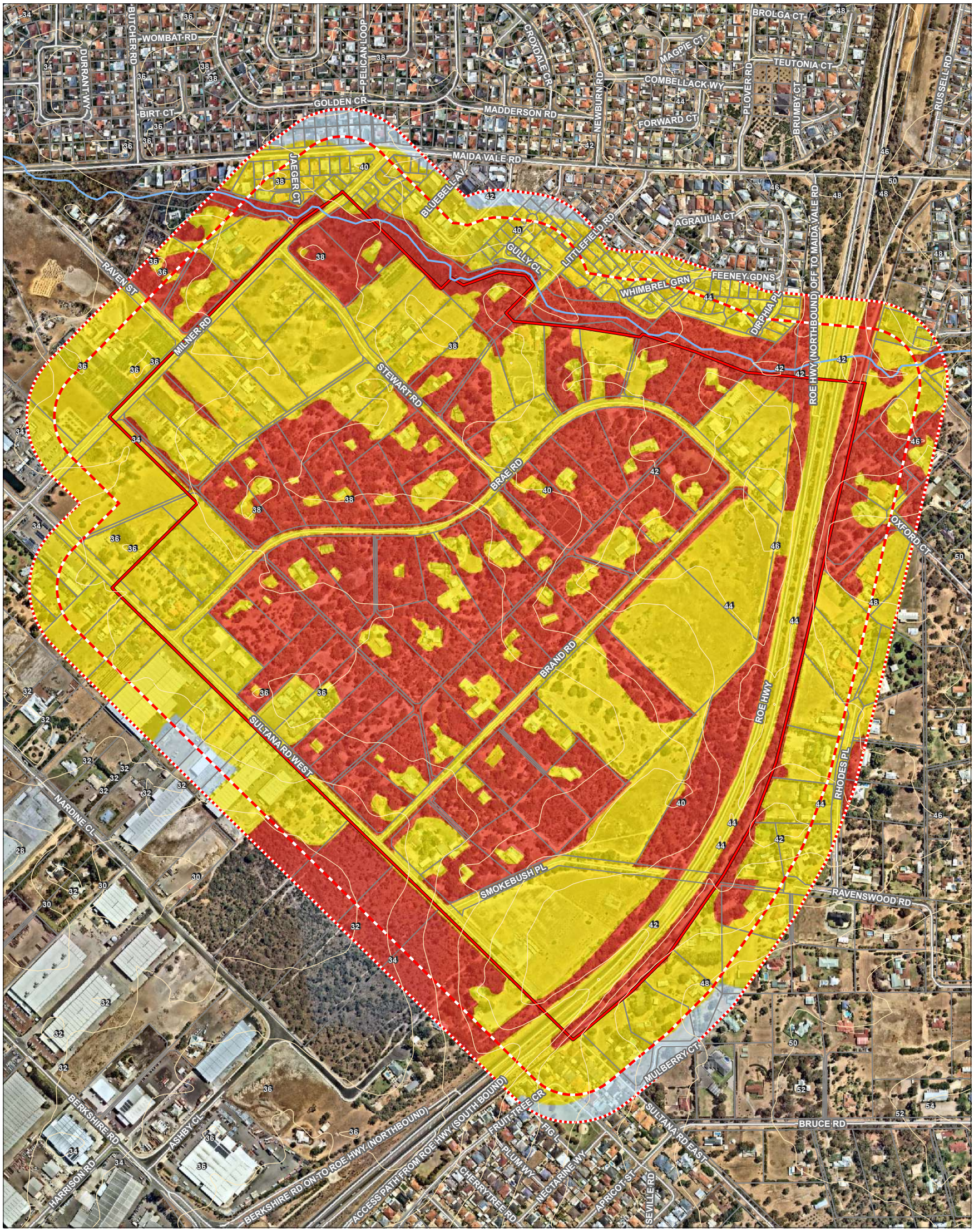
Post-development bushfire hazard levels

Strategen-JBS&G has mapped the post-development bushfire hazard levels to demonstrate that the future bushfire hazard levels will be acceptable for future development to occur within the Residential Precinct. The bushfire hazard levels have been assigned on the basis of the vegetation discussed in Section 3.1.1 and the future expected vegetation within and surrounding the Residential Precinct.

A summary of results is provided below and depicted in Figure 6:

- all Class A Forest has been assigned a bushfire hazard level of Extreme
- all Class B Woodland has been assigned a bushfire hazard level of Extreme
- all Class G Grassland has been assigned a bushfire hazard level of Moderate
- in accordance with the bushfire hazard level assessment methodology detailed in Appendix Two of the Guidelines, vegetation that has a Low hazard level but is within 100 m of Extreme or Moderate hazard level vegetation has been assigned a Moderate hazard level
- all remaining areas have been assigned a bushfire hazard level of Low.

The post-development BHL assessment demonstrates that on completion of the development, areas of the Residential Precinct supporting habitable development will be within an area of Low or Moderate hazard level and all future development will avoid Extreme bushfire hazard level areas, meeting acceptable solution A1.1 of the Guidelines.



Legend

- Residential Precinct
- 100m wide assessment
- 150m wide assessment
- Cadastral boundary
- Poison Creek Gully
- Topographic contours (mAHD)
- Roads (MRWA)

Bushfire Hazard Level

- Extreme
- Moderate
- Low

strategen JBS&G

0 200 metres

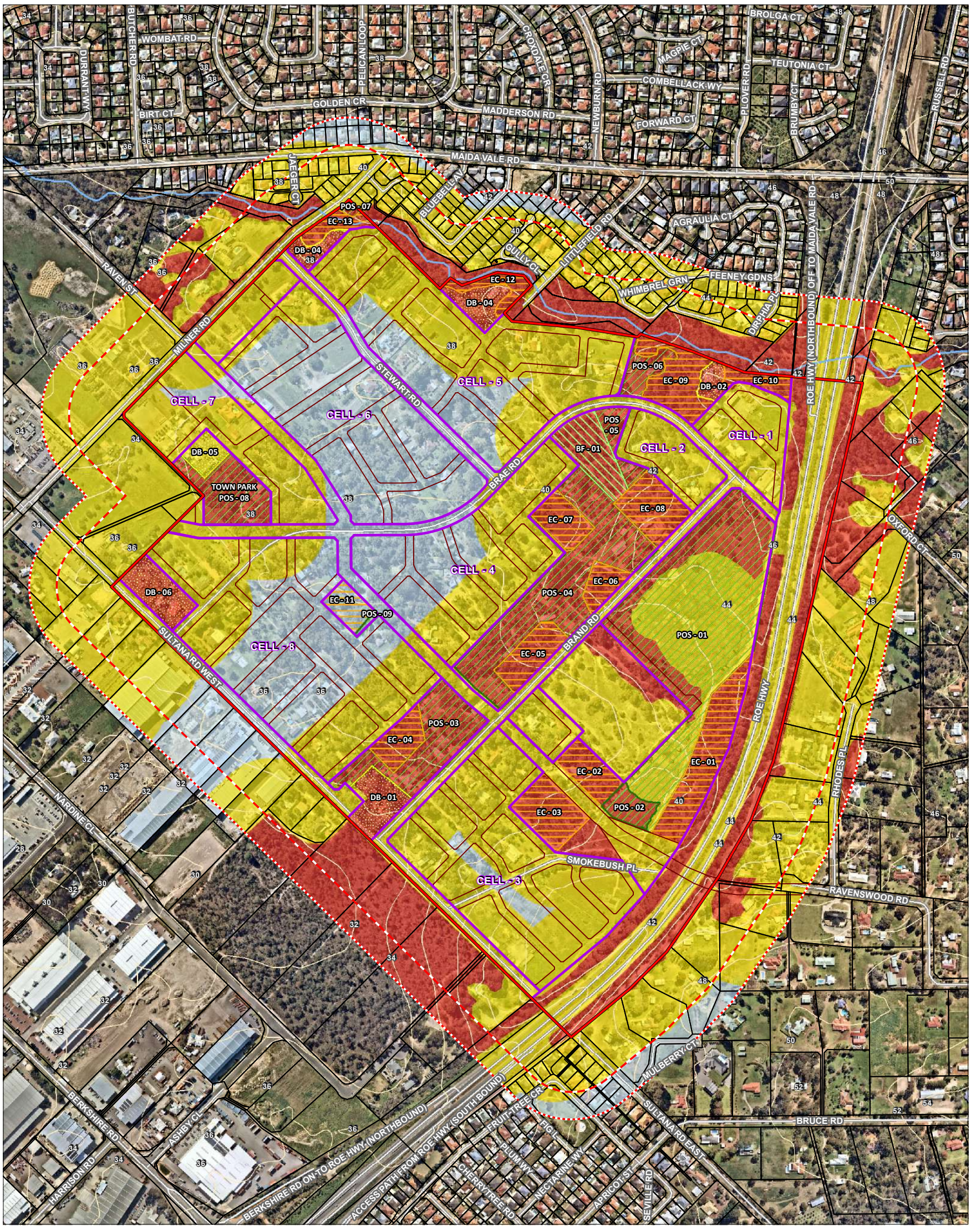
Job No: 57806		Scale 1:6,500 at A3	
Client: Element		Coord. Sys. GDA 1994 MGA Zone 50	
Drawn By: hsullivan	Checked By: CT	Version: A	Date: 21-May-2020

Forrestfield North Residential Precinct, WA

PRE-DEVELOPMENT BUSHFIRE HAZARD LEVEL

FIGURE: 5

Document Path: W:\Projects\1)Open\Element (TPG)\57806 - FF North TOD & Res LWMS\GIS\Maps\BMP\57806_05_PreDevBHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 17 February 2020.



Legend

- Project area
- 100m assessment area
- 150m assessment area
- Existing cadastral boundary
- Bush Forever
- Drainage basin
- Environmental Conservation Reserve
- POS

Hazard level

- Extreme
- Moderate
- Low
- Proposed lot
- Development cell
- Poison Creek Gully
- Topographic contours (mAHD)
- Roads (MRWA)

strategen JBS&G

0 200 metres

Job No: 61690		Scale 1:6,500 at A3	
Client: Element		Coord. Sys. GDA 1994 MGA Zone 50	
Drawn By: cthatcher	Checked By: LR	Version: A	Date: 04-Oct-2021

Forrestfield North Residential Precinct, WA

POST-DEVELOPMENT VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE

FIGURE: 4

Document Path: \\008PMPMR004V001.jbsg.aust\JBS Perth\Projects\1)Open\Element (TPG)\61690 Forrestfield North Res Precinct BMP Update\GIS\Maps\R01_Rev_A\61690_06_PostDevBHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 25 August 2021

4. Identification of bushfire hazard issues

4.1.1 Bushfire context

Strategen-JBS&G considers that the Residential Precinct is unlikely to be impacted by a landscape scale bushfire as the surrounding vegetation is largely fragmented and not of a sufficient size to support fire runs of any great length.

Intact vegetation adjacent to the Residential Precinct includes banksia woodland within Bush Forever site 123 to the south; narrow strips of forest vegetation adjacent to the Roe Highway in the east; and a narrow band of forest vegetation associated with Poison Gully Creek in the north. Land directly to the west comprises rural-residential development predominantly managed as low threat development, with some areas of unmanaged grassland.

Under predominant afternoon summer weather conditions for the location, the likely prevailing winds are from the east in the morning and southwest in the afternoon. Summer winds from the north are less common and can occur during the bushfire season when a low-pressure trough forms off the west coast and strong winds develop from the north or northeast. These conditions have the potential to direct a bushfire towards the site and contribute elevated levels of radiant heat and ember attack on the proposed development.

Strategen-JBS&G therefore considers a fire front approaching the Residential Precinct from the south, east and north to be the worst-case bushfire scenarios due to the presence of fragmented but intact bushfire fuels in these directions.

During summer afternoon southwest winds, a bushfire within Bush Forever site 123 has the potential to support fire runs of up to 350 m; however, Strategen-JBS&G considers that the isolated nature of the vegetation would restrict potential impacts to moderate levels of radiant heat and ember attack. A bushfire occurring in forest vegetation within the western side of Roe Highway would most likely impact the site in the morning during prevailing easterly winds. The fire would be severely restricted in fire run potential; however, future residential development abutting this vegetation could be impacted by radiant heat and ember attack if sufficient setbacks are not employed. The forest vegetation associated with Poison Gully Creek is similarly restricted in fire run potential; however, with an effective downslope of up to 10°, adjacent development has the potential to be impacted by a bushfire in this vegetation

The retained vegetation within the EC reserves and POS serve the purpose of linking remnant native vegetation with the adjacent Bush Forever sites. In this regard, there is potential for an external bushfire to spread into the site from the surrounding vegetation. Strategen-JBS&G considers that the narrow width and likely fragmented nature of the vegetation corridor would not support extended bushfire behaviour; however, setbacks and/ or APZs sufficient to achieve BAL-29 do need to be adopted at future planning stages.

4.1.2 Bushfire hazard issues

Examination of strategic development design as per the LSP, conceptual landscaping design and existing and post-development bushfire hazard levels has identified the following bushfire hazard issues to be considered at future planning stages:

- The Residential Precinct contains Extreme bushfire hazard level areas not suitable for habitable development. However, the post-development BHL assessment demonstrates that on completion of the development all habitable development areas will be located on land with a Low or Moderate bushfire hazard level. Therefore, the development is able to comply with A1.1 of the Guidelines.
- Development design will include the retention of native vegetation within the Brae Road Reserve Bush Forever site, EC reserves, POS and drainage basins, which are classified as Extreme hazard level vegetation. Where habitable development is proposed within proximity to the retained vegetation, setbacks and/ or APZs sufficient to achieve BAL-29 are to be employed. Given the size of the proposed development cells adjacent to these hazard areas, appropriate setbacks are expected to be easily achieved.
- The development is sited adjacent to bushfire prone vegetation within Bush Forever Site 123 in the south, Roe Highway road reserve in the east and Poison Gully Creek in the north. Although the conceptual lot layout has been designed to avoid direct interfaces with external vegetation wherever possible, consideration should be given to areas of the Residential Precinct where the proximity of habitable development to external vegetation could result in BAL impacts exceeding BAL-29.
- The applicable habitable building setbacks from internal and external bushfire prone vegetation required to achieve BAL-29 are to be determined through site-specific BAL Contour map analysis at future planning stages but are likely to be:
    - Class A Forest, Flat/ Upslope: 21 m
    - Class A Forest, Downslope >0 to 5 degrees: 27 m
    - Class A Forest, Downslope >5 to 10 degrees: 33 m
    - Class B Woodland, Flat/ Upslope: 14 m
    - Class B Woodland, Downslope >0 to 5 degrees: 17 m
    - Class C Shrubland, Downslope >0 to 5 degrees: 10 m
    - Class G Grassland, Downslope >0 to 5 degrees: 9 m.
- The design and species composition of the drainage basins have not yet been finalised but it is expected that the vegetation will comprise a combination of Class B Woodland, Class C Shrubland and Class G Grassland. The Concept Landscape Plan (Appendix 1) depicts the drainage areas as containing trees with substantial canopy coverage. On this basis, the BHL assessment has taken a precautionary approach to classify the entirety of each drainage basin as Class B Woodland, however, it is likely that vegetation with a lower classification will be planted in these areas. The drainage basins are to be assigned a precautionary effective downslope of >0 to 5 degrees at future planning stages.
- The Concept Landscape Plan (Appendix 1) includes low threat managed buffers around the perimeter of the POS and drainage basin areas that abut residential development. The purpose of the buffers is to accommodate the APZs for future residential development and to ensure that a minimum of BAL-29 is able to be achieved. The final design of the POS and drainage areas, including the required width of the low threat buffers, will be determined at the subdivision stage of planning.
- For the purposes of this high-level BHL assessment, the entire area of POS-02, POS-03, POS-04, POS-05, POS-06, POS-7 and POS-8 has been assigned an Extreme bushfire hazard level which is based on the presence of Class B Woodland (and Class A Forest for POS-08). This precautionary classification does not take into consideration the low threat buffers mentioned above or other low threat areas such as maintained turf, paving, footpaths and landscaped gardens. Low threat areas can be incorporated into the BAL Contour assessment at the subdivision stage of planning, once the landscaping design has been finalised.

- As mentioned above, POS-08 has been classified as Class A Forest as a precaution due the proposed canopy cover and potential understorey vegetation which is detailed in the Town Park Concept Plan (Appendix 4), which will be finalised at the subdivision stage of planning. However, this vegetation will most likely be excluded in a future BAL Contour assessment on the basis that it is less than 1 ha in area and not within 100 m of any other classifiable vegetation. At the time this assessment was carried out, there was unmanaged grassland identified within adjacent Lot 1563, which is outside of the Structure Plan area. As management of the grassland is enforceable under the firebreak notice, there is grounds for this vegetation to be excluded in the future. The effect of excluding this vegetation will be that there will be no setback requirements from this vegetation.
- The Concept Landscape Plan (Appendix 1) identifies street tree landscaping throughout the Residential Precinct. It is assumed that the design of the street tree landscaping would meet the low threat exclusion criteria of AS 3959 Clause 2.2.3.2 (f). A sparser tree canopy has been considered to occur at key development interfaces to account for potential APZ requirements.
- The development has been designed to provide perimeter roads at the interface with both internal and external bushfire prone vegetation where possible. Although the perimeter roads have been sited to reduce the BAL impacts on adjacent residential lots, in instances where the roads are not of a sufficient width for the lots to achieve BAL-29 or lower, habitable building setbacks may be required.
- The Concept Landscape Plan (Appendix 1) includes the retention of vegetation within the school site and revegetation within POS-01 directly to the northeast. Future planning stages are to consider the potential bushfire impact of this vegetation on the school, in particular, ensuring that future buildings can achieve a minimum of BAL-29.
- The LSP includes a primary school site that is considered to be a Vulnerable Land Use under Policy Measure 6.6 of SPP 3.7. The future school will be subject to a development application and will need to be accompanied by an updated BMP that includes a Bushfire Attack Level (BAL) assessment and a bushfire emergency evacuation plan (BEEP). Any other Vulnerable Land Uses in an area greater than BAL-LOW will need to address Policy Measure 6.6 at the DA stage of planning.
- Development of the LSP is expected to occur in stages with each cell being constructed independently. Staging of development is to ensure that at least two access routes are provided at all times in accordance with acceptable solution A3.1 of the Guidelines (see Section 5).
- As the Residential Precinct contains relatively large amounts of bushfire prone vegetation, staged construction at the subdivision stage of planning is to consider the BAL impacts from adjacent future stages that have not yet been developed. Low threat buffers may need to be implemented around the current stage of development to ensure there is no residual impact from vegetation that has not yet been cleared or landscaped to achieve a low threat state.
- Fire service access routes (FSARs) may be required to provide access around the perimeter of the Residential Precinct where public roads are not proposed. Temporary FSARs may also be required during staged development to ensure firefighters are able to gain access to the site perimeter prior to future subdivision roads being constructed. Emergency access ways (EAWs) may also be required to link public roads during staging of development.

Strategen-JBS&G considers the bushfire hazards within and adjacent to the Residential Precinct and the associated bushfire risks are readily manageable through standard management responses outlined in the Guidelines and AS 3959 and the strategic level bushfire management strategies outlined in this BMP. These responses will be factored in to proposed development early in the planning process to ensure a suitable, compliant and effective bushfire management outcome is achieved for protection of future life and property assets.

5. Assessment against the bushfire protection criteria

5.1 Compliance table

In response to the requirements of SPP 3.7 and the Guidelines, strategic level bushfire management measures have been devised to demonstrate how the bushfire protection criteria will be met at subsequent stages of the planning process.

Table 1: Compliance table

Bushfire protection criteria	Method of compliance Acceptable solutions	Proposed bushfire management strategies
Element 1: Location	A1.1 Development location	The post-development BHL assessment (Figure 6) identifies areas of land within the Residential Precinct with that will have a moderate bushfire hazard level on completion of the development. All habitable development is to be avoided on land with an extreme bushfire hazard level.
Element 2: Siting and design	A2.1 Asset Protection Zone	APZs sufficient to achieve BAL-29 are to be implemented for all lots subject to a BAL rating above BAL-LOW. The required APZs are to be identified at future planning stages based on future subdivision/ development design and following a BAL assessment. APZs are to be implemented and maintained in accordance with Schedule 1 of the Guidelines (Appendix 5) and the City's Firebreak and Fuel Load Notice (see Appendix 3).
Element 3: Vehicular access	A3.1 Two access routes	On completion of development, the Residential Precinct will be serviced by multiple access routes leading to destinations in all directions. The new main connecting road proposed as part of the development will provide an arterial linkage to the existing surrounding public road network. During staged development, each stage is to be provided with two access routes.
	A3.2 Public road	All public roads are to be constructed to comply with requirements of A3.2 (see Table 2 for technical details).
	A3.3 Cul-de-sac (including a dead-end-road)	The LSP does not include any dead-end roads. Temporary dead-end roads may be required during staged development, in which case they will need to comply with the requirements of A3.2 (see Table 2 for technical details). Sultana Road West is proposed to be closed near DB-01 which will result in a 70 m long dead-end that terminates with a carparking area. The road is unable to be constructed though because of the drainage basin and ecological link and is therefore considered to be unavoidable. As the dead-end portion of the road is relatively short and does not service any habitable development, it is not considered to be prohibitive of development or subject to any significant bushfire risk.
	A3.4 Battle-axe	N/A.
	A3.5 Private driveway longer than 50 m A private driveway is to meet detailed requirements (refer to the Guidelines for detailed private driveway requirements)	Where habitable development in an area above BAL-LOW requires a driveway longer than 50 m, the driveway is to comply with the requirements of A3.5 (see Table 2 for technical details).

Bushfire protection criteria	Method of compliance Acceptable solutions	Proposed bushfire management strategies
	A3.6 Emergency access way	Temporary EAWs may be required to provide through access to a public road during staged development (see Table 2 for technical details). Based on the conceptual development design, the development is not considered to require any permanent EAWs.
	A3.7 Fire service access routes (perimeter roads)	FSARs may be required to provide firefighter access to the perimeter of the site and/ or development cells where public roads are not proposed (see Table 2 for technical details). Temporary FSARs may be required during staging of development to provide firefighter access to undeveloped areas of the Residential Precinct.
	A3.8 Firebreak width	Each stage of development is required to comply with the requirement of the City's Firebreak and Fuel Load Notice as amended (refer to Appendix 3). On completion of the development, the residential portions of the Residential Precinct will be fully managed and firebreaks would not be required for residential lots. Consultation with the City may be required to determine whether perimeter firebreaks would be applicable to the Brae Road Bush Forever site and the EC reserves abutting the northern and eastern boundaries, as these areas have significant environmental value.
Element 4: Water	A4.1 Reticulated areas	The Residential Precinct is serviced by an existing reticulated hydrant network. Future development will be provided with a reticulated supply compliant with Water Corporation DS-63 requirements.
	A4.2 Non-reticulated areas	N/A.
	A4.3 Individual lots within non-reticulated areas (Only for use if creating 1 additional lot and cannot be applied cumulatively)	N/A.

Table 2: Vehicular access technical requirements

Technical requirement	Public road	Cul-de-sac	Battle-axe legs and private driveways longer than 50 m	Emergency access ways	Fire service access routes
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal distance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	N/A	4.5	4.5	4.5
Maximum grade <50 m	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	8.5	8.5	8.5	8.5	8.5

* Refer to E3.2 Public roads: Trafficable surface

Source: WAPC 2017

6. Responsibilities for implementation and management

This BMP has been prepared as a strategic guide to demonstrate how development compliance will be delivered at future planning stages in accordance with the Guidelines. Aside from the preparation of future BMPs to accompany future subdivision and development applications where appropriate, there are no further items to implement, enforce or review at this strategic stage of the planning process.

Future BMPs prepared for subsequent subdivision and development applications are to meet the relevant commitments outlined in this strategic level BMP, address the relevant requirements of SPP 3.7 (i.e. Policy Measures 6.4 and 6.5 respectively) and demonstrate in detail how the proposed development will incorporate the relevant acceptable solutions to meet the performance requirements of the Guidelines. Future BMPs are to include the following detailed information:

- proposed lot layout and detailed POS, reserve and drainage basin design
- post development classified vegetation extent, effective slope and separation distances
- post development BAL application requirements
- BAL contour map demonstrating that proposed development areas will achieve a rating of BAL–29 or lower
- width and alignment of compliant APZs
- confirmation of how bushfire management will be addressed during development staging
- confirmation of how bushfire management will be addressed with regards to temporary bushfire hazards on adjacent future development stages, including staging buffers or temporary quarantining of lots where required
- proposed approach to fuel management or AS 3959 application in response to on-site POS or easements (if and where required)
- vehicular access provisions, including demonstration that a minimum of two access routes will be achieved for each stage of development in accordance with acceptable solution A3.1
- water supply provisions with regards to reticulated water
- future requirements for any identified vulnerable land uses, such as provision of a Bushfire Emergency Evacuation Plan at the DA or building permit stage for the proposed school site
- provisions for notification on Title for any future lots with a rating of BAL-12.5 or greater as a condition of subdivision
- compliance requirements with the current City annual firebreak notice
- acceptable solutions assessment against the bushfire protection criteria
- proposed audit program outlining all measures requiring implementation and the appropriate timing and responsibilities for implementation.

On the basis of the information contained in this BMP, Strategen-JBS&G considers the bushfire hazards within and adjacent to the Residential Precinct and the associated bushfire risk is readily manageable through standard management responses outlined in the Guidelines and AS 3959. Strategen-JBS&G considers that on implementation of the proposed management measures, the Residential Precinct will be able to be developed with a manageable level of bushfire risk whilst maintaining full compliance with the Guidelines and AS 3959.

7. References

Department of Fire and Emergency Services (DFES) 2019, *Map of Bush Fire Prone Areas*, [Online], Government of Western Australia, available from: h*ttps://maps.slip.wa.gov.au/landgate/bushfireprone/* [28/09/2021].

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Appendix 1
Concept Landscape Plan (Place Laboratory, 2021)



PLACE LABORATORY

HIGH WYCOMBE SOUTH

© placelaboratory 2021

Client	Revision	Date
Element/City of Kalamunda	C	September 2021

Appendix 2
Georeferenced site photos



Photo 1: Class A Forest sited along the western side of Roe Highway. Vegetation has a tiered structure and >30% canopy cover.



Photo 2: Vegetation in distance is Class A Forest vegetation along the eastern side of Roe Highway.



Photo 3: Vegetation within Poison Gully reserve bordering the northern site boundary. Vegetation has a grassy understorey with a canopy cover greater than 30% and has been classified as Class A Forest.



Photo 4: Vegetation within Poison Gully reserve bordering the northern site boundary. Vegetation has a grassy and shrubby understorey with a canopy cover greater than 30% and has been classified as Class A Forest.



Photo 5: Vegetation within Poison Gully reserve bordering the northern site boundary. Vegetation has a grassy and shrubby understorey with a canopy cover greater than 30% and has been classified as Class A Forest



Photo 6: Vegetation within Poison Gully reserve bordering the northern site boundary. Vegetation has a grassy and shrubby understorey with a canopy cover greater than 30% and has been classified as Class A Forest



Photo 7: Class B Woodland vegetation in northwest corner of Residential Precinct. Comprises trees with canopy cover <30% and an unmanaged grassland understorey.



Photo 8: Class B Woodland bordering the northern side of Milner Road has a grassy understorey.



Photo 9: Vegetation within Poison Gully reserve to the north of Milner Road. Vegetation has a grassy and shrubby understorey with a canopy cover greater than 30% and has been classified as Class A Forest.



Photo 10: Class G Grassland vegetation within the northwest of the Residential Precinct. Grassland is unmanaged (>10 cm) and includes areas of Open Woodland (<10% canopy cover).



Photo 11: Class B Woodland within Brae Road Reserve. Vegetation comprises banksia woodland.



Photo 12: Vegetation within rural residential lots abutting the northern site boundary. Photo depicts banksia woodland classification. Area has been classified as Class A Forest as a precautionary measure due to connectivity to the Poison Gully Creek forest vegetation.



Photo 13: Class G Grassland vegetation within the east of the Residential Precinct. Grassland is unmanaged (>10 cm) and includes areas of Open Woodland (<10% canopy cover).



Photo 14: Class A Forest sited along the western side of Roe Highway. Vegetation has a tiered structure and canopy cover >30%.



Photo 15: Class A Forest sited along the western side of Roe Highway. Vegetation has a tiered structure and canopy cover >30%.



Photo 16: Class B Woodland located within the Brand Road old tip site. Vegetation comprises trees within canopy cover <30% and grassy understorey.



Photo 17: Class B Woodland within rural residential properties in east of Residential Precinct. Vegetation comprises trees with canopy cover <30% and grassy understorey.



Photo 18: Class G Grassland vegetation within Brand Road old tip site. Grassland is unmanaged (>10 cm) and includes areas of Open Woodland (<10% canopy cover).



Photo 19: Class B Woodland within rural residential properties in centre of Residential Precinct. Vegetation comprises banksia woodland.



Photo 20: Class B Woodland within Bush Forever site 123 south of the Residential Precinct. Vegetation comprises banksia woodland.



Photo 21: Class G Grassland vegetation in southeast of Residential Precinct. Grassland is unmanaged (>10 cm) and includes areas of Open Woodland (<10% canopy cover).



Photo 22: Class B Woodland within Bush Forever site 123 south of the Residential Precinct. Vegetation comprises banksia woodland.



Photo 23: Class A Forest sited along the western side of Roe Highway. Vegetation has a tiered structure and canopy cover >30%.



Photo 24: Class A Forest sited along the western side of Roe Highway. Vegetation has a tiered structure and canopy cover >30%.



Photo 25: Class B Woodland within rural residential properties in centre of Residential Precinct. Vegetation has a grassy understorey and canopy cover <30%.



Photo 26: Class B Woodland within rural residential properties in centre of Residential Precinct. Vegetation has a grassy understorey and canopy cover <30%.



Photo 27: Class B Woodland within rural residential properties in centre of Residential Precinct. Vegetation has a grassy/ shrubby understorey and canopy cover <30%.



Photo 28: Class G Grassland vegetation in northwest of Residential Precinct. Grassland is unmanaged (>10 cm) and includes areas of Open Woodland (<10% canopy cover).



Photo 29: Low threat maintained lots excluded in accordance with AS 3959 Clause 2.2.3.2 (f).



Photo 30: Low threat public road and maintained verge vegetation excluded in accordance with AS 3959 clauses 2.2.3.2 (e) & (f).

Appendix 3
City of Kalamunda 2021/22 Firebreak and Fuel Load Notice

City of Kalamunda

FIRST AND FINAL NOTICE

FIRE HAZARD REDUCTION NOTICE 2021/2022

COMPLIANCE DUE BY: 1 NOV 2021

ASSESSMENTS COMMENCE FROM: 1 NOV 2021

Important: The works outlined below must be completed by 1 November 2021 and maintained in this state up to and including 31 March 2022.

NOTICE TO ALL OWNERS AND OCCUPIERS OF LAND WITHIN THE CITY OF KALAMUNDA

Pursuant to Section 33 of the *Bush Fires Act 1954* (WA), the City of Kalamunda (City) gives written notice to act as specified in this notice to land that you own and/or occupy and with respect to any matter which is upon the land that you own and/or occupy within the City. Failure or neglect to comply with this notice is an offence and can result in a penalty of up to $5000. The City advises that its officers, servants, workmen, contractors, vehicles, machinery, and appliances (as the officers deem fit) may carry out the requisitions of this notice that are not complied with by the date specified above, and any costs and expenses incurred may be recovered from you as the owner and/or occupier of the land.

ALL LAND WITH A TOTAL AREA OF 4000m² OR MORE

❑ FIRE BREAKS

Install or upgrade a **3-metre-wide** by **4-metre-high clearance**, **bare mineral earth**, **continuous** (no dead ends) **trafficable** fire break as close as possible inside the entire perimeter of the land. Maintained, reticulated living lawns that are kept completely green is acceptable in conjunction with, or in lieu of, a mineral earth fire break/s (see definition FIRE BREAK).

❑ DEAD FLAMMABLE MATERIAL (DFM)

Reduce and/or maintain all dead flammable material below 8 tonne per hectare (see definition FUEL LOAD).

❑ SLASHING

Slash, mow, or trim dead grasses, dead shrubs, and dead plants to a height no greater than 50mm and remove cuttings/swath across the entire property.

❑ ASSET PROTECTION ZONE (APZ)

Maintain a fuel reduced zone around all buildings or assets which extends 20 metres from the outermost point of the building or asset.

- Gutters, roofs, and walls of all buildings to be free of flammable matter and maintained.
- Fuel load within the 20-metre zone is reduced and maintained to no more than 2 tonne per hectare.
- Trees over 5 metres in height within the 20-metre zone to be under pruned up to 2 metres.
- Trees or shrubs within 2 metres of the asset shall be pruned to a height no greater than 2 metres and/or pruned away from the asset to a distance no greater than 2 metres.

ALL LAND WITH A TOTAL AREA LESS THAN 4000m²

❑ DEAD FLAMMABLE MATERIAL

Reduce and/or maintain all dead flammable material below 8 tonne per hectare (see definition FUEL LOAD).

❑ SLASHING

Slash, mow, or trim dead grasses, dead shrubs, and dead plants to a height no greater than 50mm and remove cuttings/swath across the entire property.

❑ CLEAN GUTTER DEBRIS

Gutters, roofs, and walls of all buildings to be free of flammable matter and maintained.

VARIATION TO THE FIRE HAZARD REDUCTION NOTICE

If you consider it impractical to meet a requirement/s of this Notice, you may apply to the City for a variation **no later than 1 October 2021.**

Note: A variation is not an exemption but an application to employ other methods of property preparedness to land that you own and/or occupy.

An administration fee of $150 applies for applications received after 1 October 2021.

If your application is not granted you must comply with all requirements outlined in the Fire Hazard Reduction Notice 2021/2022.

Variation request application forms are available before 1 October 2021 on the City's website at:

www.kalamunda.wa.gov.au/fire

ADDITIONAL WORKS

You may be required to carry out further bushfire property preparedness works on your land to reduce any fire hazards considered necessary by a Fire Officer. If required, these will be outlined in a 'work order' and sent to the address of the owner and/or occupier.

EMERGENCY MANAGEMENT PLANS AND CITY APPROVED TREATMENT PLANS

All properties and/or land subject to a Bushfire Management Plan, Emergency Management Plan, or an approved Bushfire Attack Level assessment (BAL), as a result of subdivision, development application or a City approved treatment plan, must comply with the listed requirements in their entirety. **Compliance with any additional plans does not constitute compliance with this Notice**.

ENVIRONMENTAL CONDITIONS

Any property subject to environmental value such as, but not limited to, Threatened Ecological Communities (TEC), Bush Forever sites, Declared Rare Flora and Fauna (DRF) sites etc, should seek further information about what can or cannot be done prior to carrying out requirements under this Notice.

DEFINITIONS

FIRE BREAK: A strip of land free of all flammable material with the intention of minimising the spread or extension of a bushfire and provide safe access on the property for emergency vehicles and other firefighting operations.

- Clearance must be no less than 3-metres wide and 4-metres in height inside and along all boundaries (including boundaries adjacent to roads, rail and drain reserves and all public open space reserves).
- Must not be more than 4-metres wide (further width extensions may be considered upon written application for approval to the City).
- Maintained, reticulated living lawns are lawns considered to be kept completely green. Driveways may be acceptable in conjunction with, or in lieu of, mineral earth fire breaks. Contact a City Fire Officer for further assistance.
- Must have a corner turning radius of up to 10 metres.
- Must be a mineral earth break with a continuous trafficable surface for a 4WD vehicle, be clear of any obstructions and must not terminate in a cul-de-sac (dead end).

FUEL LOAD: Can be live and dead vegetation that accumulates over time.

This Notice refers only to dead vegetation.

Fine fuels include = leaf litter, grasses, twigs (up to 6mm diameter), bark etc.

Heavy (course) fuels include = branches, logs, stumps etc.

- A fuel load depth of 15mm (fine fuels) to the mineral earth is indicative of approximately 8 tonne per hectare. The more fuel load, the higher the flame height and increased fire intensity.
- Mulch piles, stored firewood and burn piles can contribute to fuel loading on land and must be stored safely away from assets, removed from the property, or actioned as directed by a Fire Officer.

If you require any further information, please contact the City of Kalamunda Community Safety team on (08) 9257 9999, email at enquiries@kalamunda.wa.gov.au or visit www.kalamunda.wa.gov.au/fire

Rhonda Hardy
CHIEF EXECUTIVE OFFICER

kalamunda.wa.gov.au

T 9257 9999 F 9293 2715 E enquiries@kalamunda.wa.gov.au
2 Railway Road KALAMUNDA WA 6076 PO Box 42, KALAMUNDA WA 6926
ABN 60 741 095 678

Appendix 4
Town Park Concept Plan (Element 2021)



Town Park Concept Plan

High Wycombe South Residential Precinct

Date: 21 Sep 2021 Scale: 1:1000 @ A3 1:500 @ A1 File: **17-527 ST-13 A** Staff: MC GW Checked: MC

0 10 20m

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

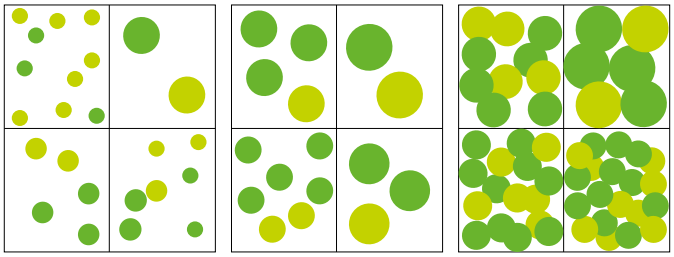
Appendix 5
Guideline standards for Asset Protection Zones (APZs)

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.

element.

Technical Appendix C – Transportation Noise Assessment

Lloyd George Acoustics
PO Box 717
Hillarys WA 6923
T: 9401 7770
www.lgacoustics.com.au

Transportation Noise Assessment

Forrestfield North Residential Precinct – Local Structure Plan

Reference: 21046304-01

Prepared for:
element

Report: 21046304-01

Lloyd George Acoustics Pty Ltd

ABN: 79 125 812 544

PO Box 717
Hillarys WA 6923

www.lgacoustics.com.au

Contacts	General	Daniel Lloyd	Terry George	Matt Moyle
E:	info@lgacoustics.com.au	daniel@lgacoustics.com.au	terry@lgacoustics.com.au	matt@lgacoustics.com.au
P:	9401 7770	0439 032 844	0400 414 197	0412 611 330
Contacts	**Ben Hillion**	**Rob Connolly**	**Daryl Thompson**	**Hao Tran**
E:	ben@lgacoustics.com.au	rob@lgacoustics.com.au	daryl@lgacoustics.com.au	hao@lgacoustics.com.au
P:	0457 095 555	0410 107 440	0420 364 650	0438 481 207

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

Date:	Rev	Description	Prepared By	Verified
01-Jul-21	-	Issued to Client as Preliminary Draft	Terry George	Matt Moyle
20-Sep-21	0	Issued as Final – Minor Change from Draft	Terry George	-

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1 INTRODUCTION

The subject of this report is transportation noise impacts to the Forrestfield North Residential Precinct as shown in *Figure 1-1* and generally bound by Roe Highway, Sultana Road West, Milner Road and Poison Gully.

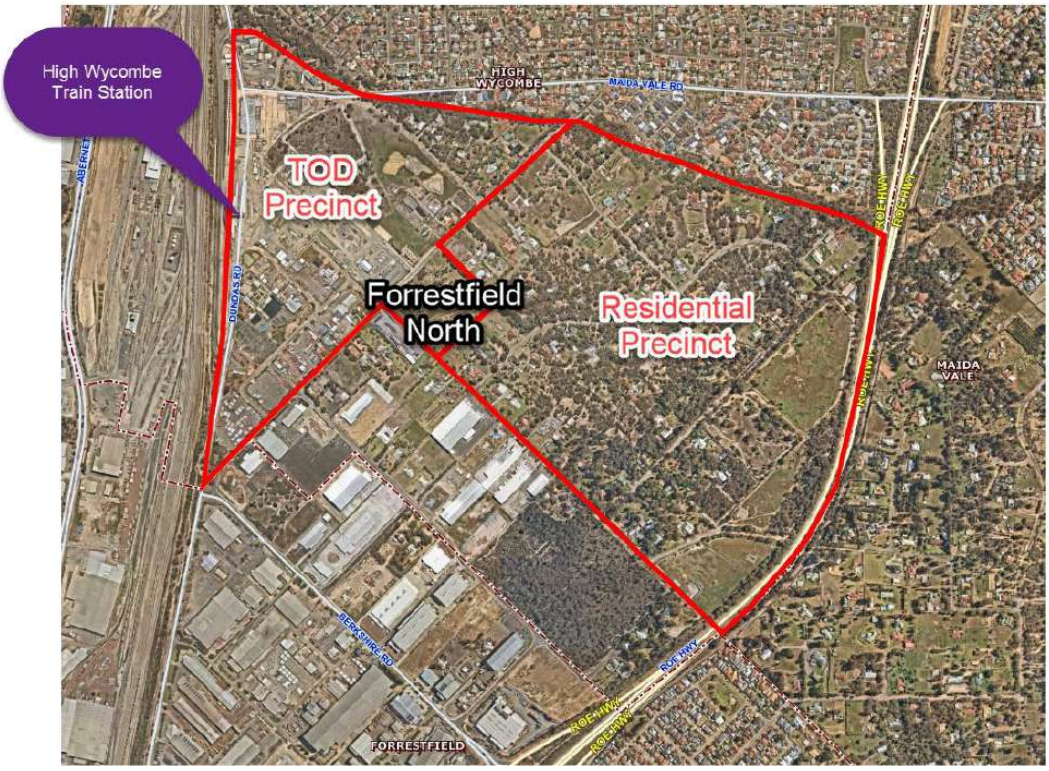


Figure 1-1 Locality of Residential Precinct

The Local Structure Plan is provided in *Figure 1-2*.

The most significant noise impact to the Residential Precinct is from Roe Highway road traffic. Aircraft noise is also discussed although is a lesser impact. Noise and vibration from the freight and passenger railway is also touched upon briefly, although determined to be of negligible impact to the Residential Precinct area.

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



Figure 1-2 Local Structure Plan

2 CRITERIA

2.1 Road and Rail Noise

The criteria relevant to this assessment is provided in *State Planning Policy No. 5.4 Road and Rail Noise* (hereafter referred to as SPP 5.4) produced by the Western Australian Planning Commission (WAPC). The objectives of SPP 5.4 are to:

- Protect the community from unreasonable levels of transport noise;
- Protect strategic and other significant freight transport corridors from incompatible urban encroachment;
- Ensure transport infrastructure and land-use can mutually exist within urban corridors;
- Ensure that noise impacts are addressed as early as possible in the planning process; and
- Encourage best practice noise mitigation design and construction standards

Table 2-1 sets out noise targets that are to be achieved by proposals under which SPP 5.4 applies. Where the targets are exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.

Table 2-1 Noise Targets for Noise-Sensitive Land-Use

Outdoor Noise Target		Indoor Noise Target	
55 dB $L_{Aeq(Day)}$	50 dB $L_{Aeq(Night)}$	40 dB $L_{Aeq(Day)}$ (Living and Work Areas)	35 dB $L_{Aeq(Night)}$ (Bedrooms)

Notes:

- Day period is from 6am to 10pm and night period from 10pm to 6am.
- The outdoor noise target is to be measured at 1-metre from the most exposed, habitable[1] facade of the noise sensitive building.
- For all noise-sensitive land-use and/or development, indoor noise targets for other room usages may be reasonable 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.
- Outdoor targets are to be met at all outdoor areas as far as is reasonable and practicable to do so using the various noise mitigation measures outlined in the Guidelines.

The application of SPP 5.4 is to consider anticipated traffic volumes for the next 20 years from when the noise assessment is undertaken.

[1] A habitable room is defined in State Planning Policy 3.1 as a room used for normal domestic activities that includes a bedroom, living room, lounge room, music room, sitting room, television room, kitchen, dining room, sewing room, study, playroom, sunroom, gymnasium, fully enclosed swimming pool or patio.

In the application of the noise targets, the objective is to achieve:

- indoor noise levels specified in *Table 2-1* in noise-sensitive areas (e.g. 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 childcare 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.

2.2 Aircraft Noise

The relevant planning policy in Western Australia in relation to aircraft noise is *State Planning Policy 5.1: Land Use Planning in the Vicinity of Perth Airport*; July 2015, Western Australian Planning Commission (hereafter referred to as SPP 5.1). SPP 5.1 applies to any land within Aircraft Noise Exposure Forecast (ANEF) 20 and separates land into three zones:

- Areas below 20 ANEF;
- Areas between 20 ANEF and 25 ANEF; and
- Areas above 25 ANEF.

There is no restriction on zoning or development below 20 ANEF.

Separate to the ANEF contours, which are used as a planning tool, Perth Airport has also produced N65 contours which show the average expected number of times a day an aircraft event above 65 dB(A) will occur. A level of 65 dB(A) is considered to be the point at which aircraft noise may be considered intrusive.

3 METHODOLOGY

3.1 Road and Rail Noise

State Planning Policy No. 5.4 Road and Rail Noise provides the trigger distances shown in *Table 3-1*.

Figure 3-1 shows these trigger distances across the subject site, with the image taken from the PlanWA Maps. On the western side are the trigger distances associated with the existing freight railway (grey) and the new passenger railway (green). On the eastern side is the trigger distance associated with Roe Highway (red).

It can be seen that the Residential Precinct is outside of the trigger distances for the trains and therefore this is no longer considered. With regard to road traffic noise, the site is within the trigger distance of Roe Highway and therefore warrants more detailed noise management.

Table 3-1 Transport Corridor Classification and Trigger Distances

Transport Corridor Classification	Trigger Distance	Distance Measured From
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 meets the criteria of either ≥ 100 Class 7 to 12 Austroads vehicles daily or ≥ 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

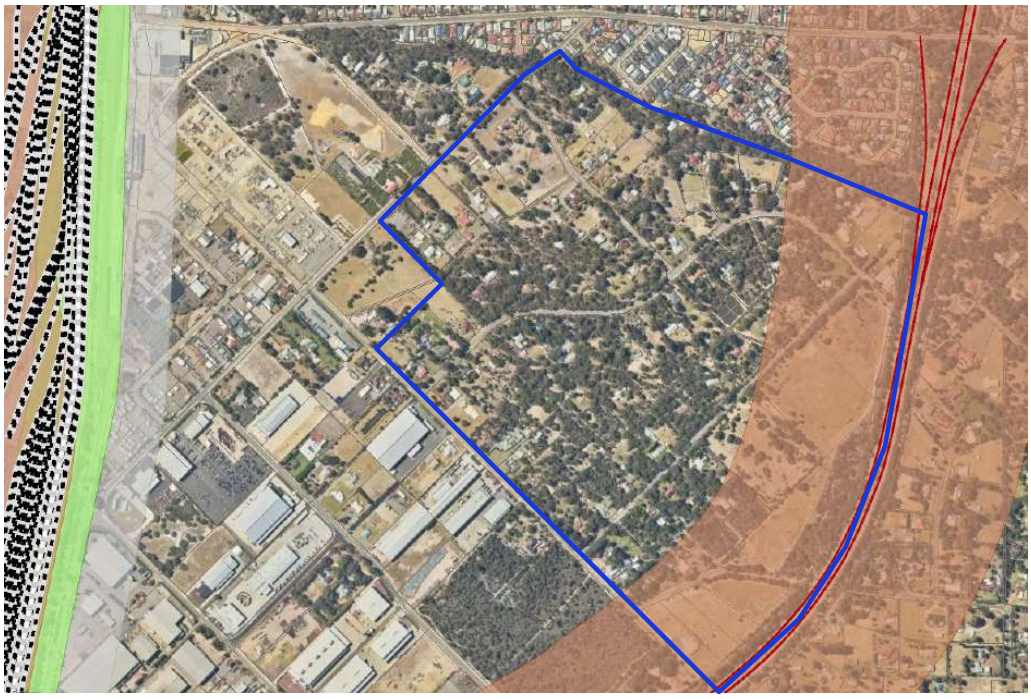


Figure 3-1 Locality of Residential Precinct in Relation to Road and Rail Triggers

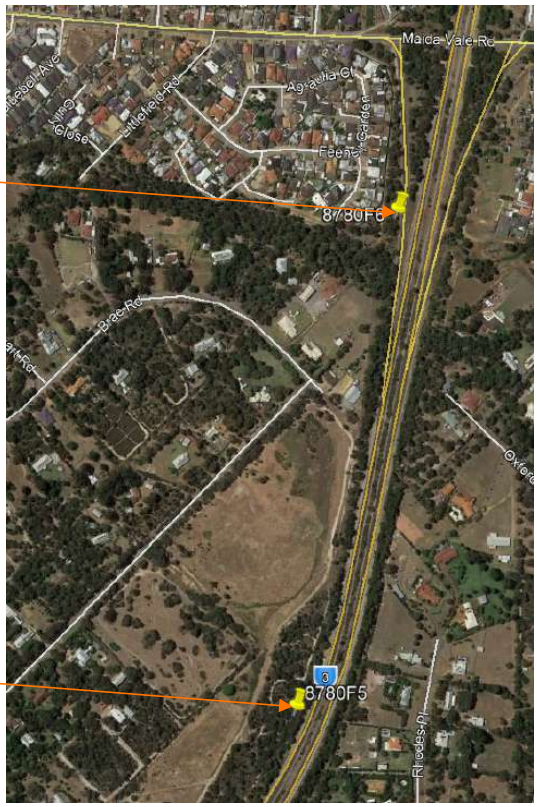
3.1.1 Site Measurements

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

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

The instruments used and their locations are provided in *Table 3-2*.

Table 3-2 Noise Monitoring Information

On Site Photo and Description	General Locality
	
Alongside Maida Vale Northbound Off Ramp Ngara Noise Logger (S/N: 8780F6)	
	
South of Maida Vale Northbound Off Ramp Ngara Noise Logger (S/N: 8780F5)	

The microphones are 1.4 metres above ground level with the loggers programmed to record hourly L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels. The instruments comply with the requirements of *Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise*. The loggers were field calibrated before and after the measurement session and found to be accurate to within +/- 1 dB. Lloyd George Acoustics also holds current laboratory calibration certificate for the loggers.

3.1.2 Noise Modelling

The computer programme *SoundPLAN 8.2* was utilised incorporating the *Calculation of Road Traffic Noise* (CoRTN) algorithms, modified to reflect Australian conditions. The modifications included the following:

- Vehicles were separated into heavy (Austroads Class 3 upwards) and non-heavy (Austroads Classes 1 & 2) with non-heavy vehicles having a source height of 0.5 metres above road level and heavy vehicles having two sources, at heights of 1.5 metres and 3.6 metres above road level, to represent the engine and exhaust respectively. By splitting the noise source into three, allows for less barrier attenuation for high level sources where barriers are to be considered;
- Note that a -8.0 dB correction is applied to the exhaust and -0.8 dB to the engine (based on Transportation Noise Reference Book, Paul Nelson, 1987), so as to provide consistent results with the CoRTN algorithms for the no barrier scenario;
- Adjustments of -0.8 dB and -1.7 dB have been applied to the predicted levels for the 'free-field' and 'at facade' cases respectively, based on the findings of *An Evaluation of the U.K. DoE Traffic Noise Prediction*; Australian Road Research Board, Report 122 ARRB – NAASRA Planning Group (March 1983).

Predictions are made at heights of 1.4 m above ground floor level for single storey houses and 4.2 m for double storey houses. The noise is predicted at 1.0 metre from an assumed building facade resulting in a + 2.5 dB correction due to reflected noise.

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

3.1.2.1 Ground Topography

Topographical and road design data for this project was taken from Landgate data on file. At this stage information on subdivision levels are unknown and therefore the modelling uses the existing topography. For the future scenario, it is assumed Roe Highway will increase to 3 lanes in each direction, with the widening assumed to occur outside the existing lanes (i.e. northbound lane added to the west, southbound carriageway added to the east).

Buildings have also been included as these can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. For the future scenario with buildings, these have been incorporated as indicative blocks only, to be further refined as the subdivision design progresses. However, within the R30-R60, houses are assumed single storey at 3.5 metres high and within R60-R100 assumed to be double storey at 7.0 metres high.

3.1.2.2 Traffic Data

Traffic data includes:

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

Table 3-3 Noise Relationship Between Different Road Surfaces

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

On/Off ramps are generally dense graded asphalt in the vicinity of the interchange, nominally 150 metres and as such this has also been assumed in this project. The ramps then change to match that of the main carriageway. Closer to the Berkshire interchange, the existing road surface is open graded asphalt with the rest mostly stone mastic asphalt although there is some areas incorporating slurry seal and chip seal. In the future scenario, it is assumed this will change to open graded asphalt throughout.

- Vehicle Speed – The existing and future posted speeds for Roe Highway is 100km/hr, with the on/off ramps modelled as 70km/hr and then increasing to or decreasing from 100 km/hr.

- Traffic Volumes – Existing (2016) and forecast (2041) traffic volumes were provided by Main Roads WA (Thomas Ng, Traffic Modelling Analyst, Reference: #41867). A validation plot was also provided allowing the Main Roads WA traffic volume model to be calibrated against actual counts. More recent existing volumes were obtained from the Main Roads WA Traffic Map and these have been used to calibrate the noise model to the noise loggers. Note that the existing counts for Maida Vale on/off ramps were relatively old (2015/16) so that these were increased by the percentage growth shown on Roe Highway between 2015/16 and 2019/20. *Table 3-4* provides the traffic volume input data in the model based on the information provided.

Table 3-4 Traffic Information Used in the Modelling

Road / Parameter	Scenario			
	Existing – 2019/20		Future - 2041	
	Northbound	Southbound	Northbound	Southbound
Berkshire Av On/Off Ramps				
24 Hour Volume	2845	2896	6700	5300
% Heavy	14.7	14.1	15	6
Maida Vale Road On/Off Ramps				
24 Hour Volume	6416	6689	8347	10024
% Heavy	11.7	17.0	11	11
Roe Highway, North of Berkshire				
24 Hour Volume	27055	26523	53800	57000
% Heavy	16.3	17.8	13	12

3.1.2.3 Ground Attenuation

The ground attenuation has been assumed to be 0.0 (0%) for the road, 0.5 (50%) throughout the subdivision, except for the public open space, which was set to 1.00 (100%). Note 0.0 represents hard reflective surfaces such as water and 1.00 represents absorptive surfaces such as grass.

3.1.2.4 Parameter Conversion

The CoRTN algorithms used in the *SoundPlan* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. SPP 5.4 however uses $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$. The relationship between the parameters varies depending on the composition of traffic on the road (volumes in each period and percentage heavy vehicles).

As noise monitoring was undertaken, the relationship between the parameters is based on the results of the monitoring – refer *Section 4.1*.

3.2 Aircraft Noise

Figure 3-2 shows the relationship of the site to the ANEF contours. It can be seen that the Residential Precinct is located outside the ANEF 20 zone and therefore there are no restrictions on residential development.

In addition to the ANEF Contours, Perth Airport also provide N65 Contours. These have been extracted from the Perth Airport 2020 Master Plan as shown in *Figure 3-3* showing that there are small areas of the site where there may be an average of 5 or more aircraft events above 65 dB(A).



Figure 3-2 Locality of Residential Precinct in Relation to ANEF Contours

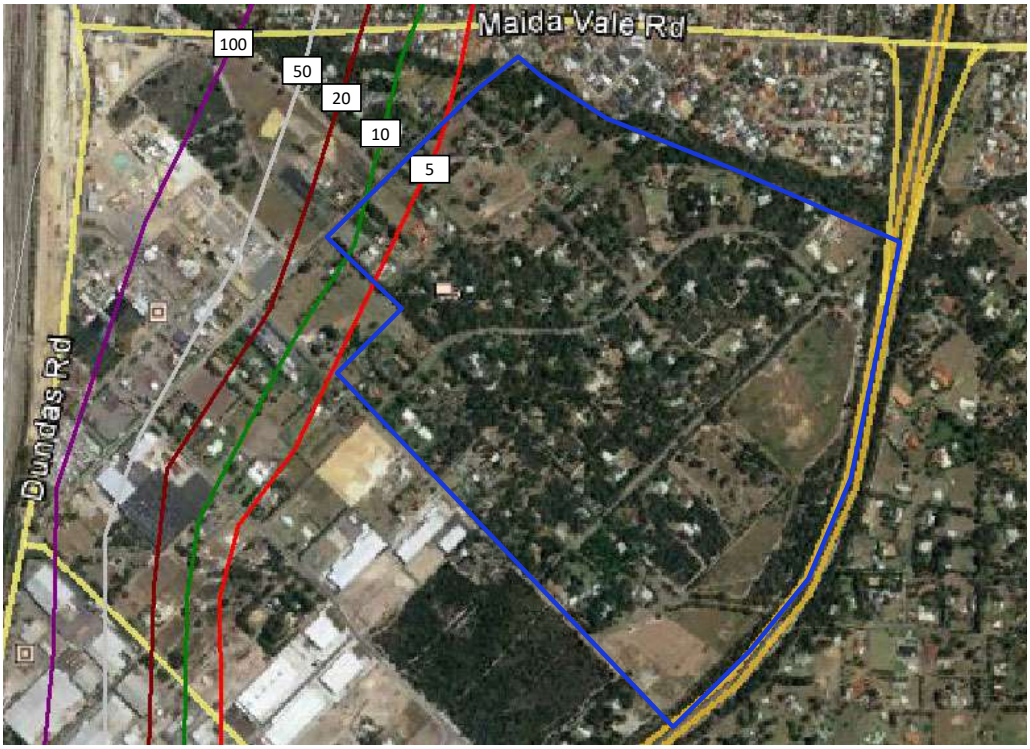


Figure 3-3 Locality of Residential Precinct in Relation to N65 Contours

4 RESULTS

4.1 Road Traffic

4.1.1 Road Traffic Measurements

The results of the noise monitoring at the two locations are provided in *Table 4-1* and *Table 4-2* and graphically in *Figure 4-1* and *Figure 4-2*.

Table 4-1 Measured Average Noise Levels: Alongside Northbound Off Ramp

Date	Average Weekday Noise Level, dB			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Monday 17-May-21	69.8	67.1	68.4	62.0
Tuesday 18-May-21	70.2	67.2	68.5	62.2
Wednesday 19-May-21	70.1	67.1	68.4	62.0
Thursday 20-May-21	70.3	67.4	68.6	62.9
Friday 21-May-21	70.3	67.3	68.5	62.8
Average	**70.1**	**67.2**	**68.5**	**62.4**

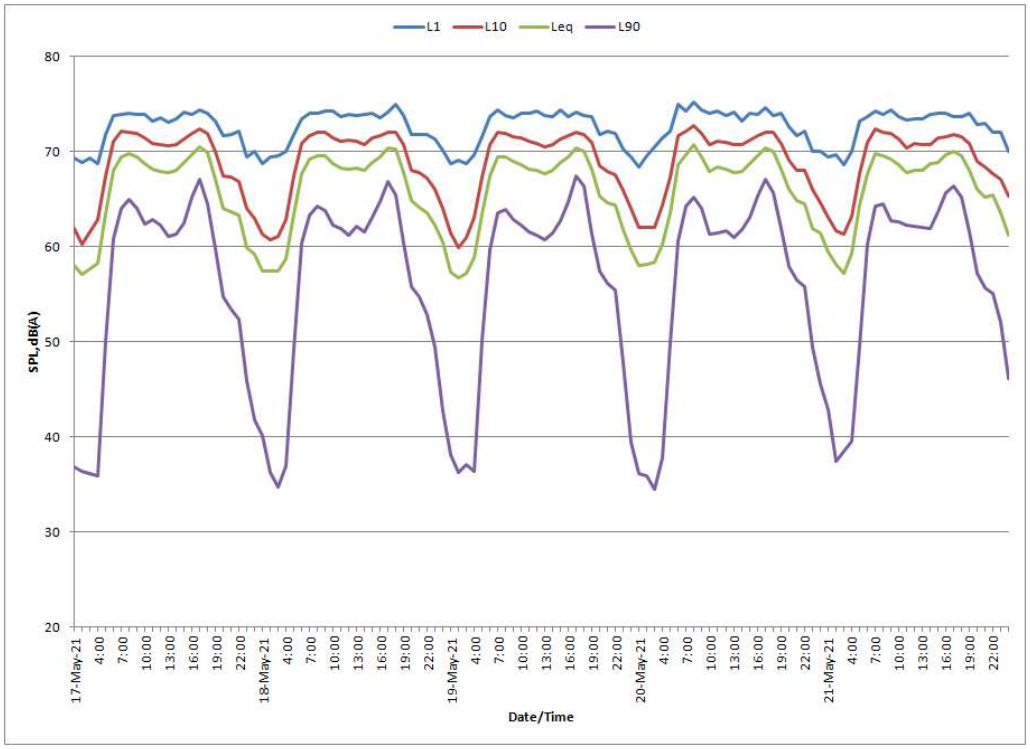


Figure 4-1 Noise Monitoring Results: Alongside Northbound Off Ramp

Table 4-2 Measured Average Noise Levels: Alongside Roe Highway

Date	Average Weekday Noise Level, dB			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Monday 17-May-21	67.9	65.1	66.4	60.0
Tuesday 18-May-21	68.3	65.4	66.6	60.5
Wednesday 19-May-21	68.2	65.3	66.6	60.0
Thursday 20-May-21	68.3	65.4	66.6	60.8
Friday 21-May-21	68.4	65.6	66.8	60.7
Average	**68.2**	**65.3**	**66.6**	**60.4**

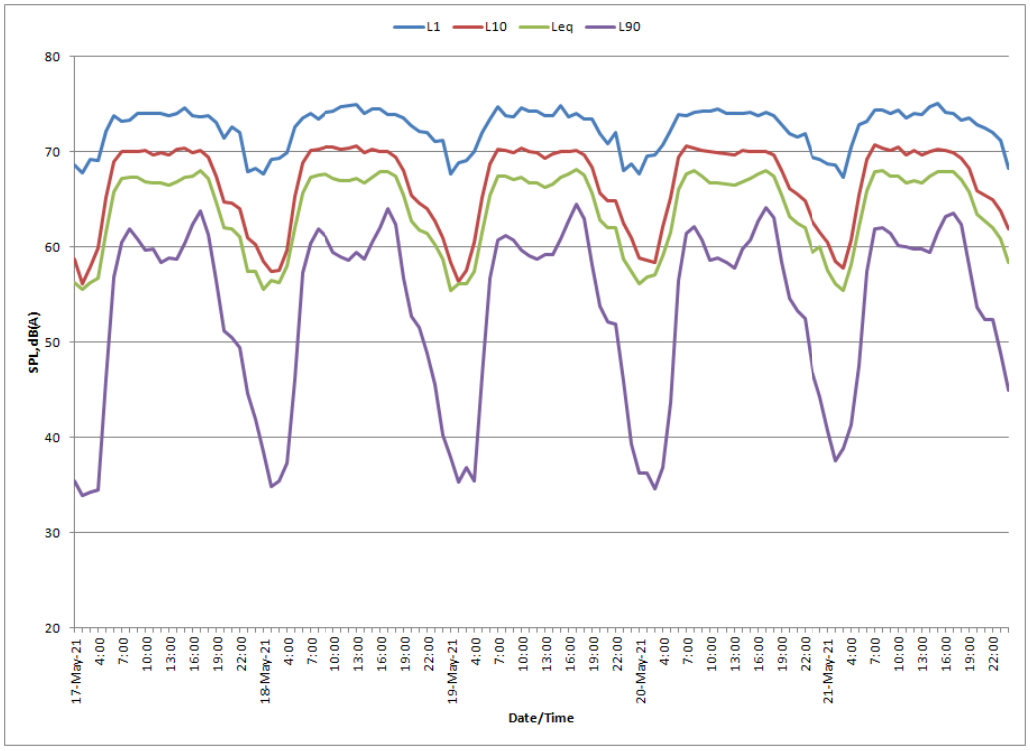


Figure 4-2 Noise Monitoring Results: Alongside Roe Highway

The difference between the weekday $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ at both sites is around 6 dB, such that it is the daytime noise levels that will dictate compliance since these are at least 5 dB more than night-time levels.

4.1.2 Road Traffic Modelling

The noise model is initially set-up for existing conditions and calibrated against the results of the noise logging. The model is then modified for future conditions (increased traffic volumes and proposed development) using the same calibration. The results of this modelling are provided in *Figure 4-3*.

4.2 Aircraft Noise

The Residential Precinct is outside the ANEF 20 zone and therefore there are no restrictions on residential development. Aircraft noise will be audible at times with parts of the site exposed to an average of 5 or more events per day above 65 dB(A). This is considered a relatively minor impact, only warranting notifications on title for any noise sensitive premises to the west of the 5 events N65 contour line shown in *Figure 3-3*. Suggested wording from SPP No. 5.1 is:

This property is situated in the vicinity of Perth Airport and is currently affected, or may be affected in the future by aircraft noise. Noise exposure levels are likely to increase in the future as a result of an increase in aircraft using the airport, changes in aircraft type or other operational changes. Further information regarding noise insulation requirements for noise-affected property is available on request from the relevant local government offices.



Figure 4-3

Noise levels
$L_{Aeq(Day)}$ dB

<= 55	
<= 56	Exposure A
<= 57	
<= 58	
<= 59	Exposure B
<= 60	
<= 61	
<= 62	
<= 63	Exposure C
<= 64	
<= 65	
<= 66	
> 66	Exposure D

SPP 5.4 (Sep 2019)

Signs and symbols
- Road
- Block of Buildings
- Residential Precinct

Length Scale 1:10000
0 50 100 200 300 400 m

Forrestdale North Residential Precinct -
Future (2041) $L_{Aeq(Day)}$ Noise Level Contours: Ground Level

Road Traffic Noise: Roe Highway Widened to 6 Lanes / 100 km/hr and Open Graded Asphalt

SoundPLAN v8.2
CoRTN Algorithms

1 July 2021

Lloyd George Acoustics
PO Box 717
HILLARYS WA 6923
(08) 9401 7770

5 ASSESSMENT

5.1 Road Traffic

The objectives of SPP 5.4 are to achieve:

- indoor noise levels specified in *Table 2-1* in noise-sensitive areas (e.g. bedrooms and living rooms of houses and school classrooms); and
- a reasonable degree of acoustic amenity for outdoor living areas on each residential lot.

Where the outdoor noise targets of *Table 2-1* are achieved, no further controls are necessary.

With reference to the predicted noise levels in *Figure 4-3*, it is evident the outdoor noise target will be exceeded. As such, the following is recommended:

- Noise wall to be constructed. Such a wall may be constructed by Main Roads WA or the developer as part of subdivision approval process and can be negotiated between the two parties. At this stage, the outcome of an indicative 5-metre high wall has been provided on *Figure 5-1*. Any noise wall is to be solid, free of gaps and of minimum surface mass 15 kg/m^2 (or approved equivalent).
- Where lots are still above the outdoor noise target (refer *Figure 5-1*), the following Packages (refer *Appendix A*) are required:
    - Package A where noise levels are between 56 dB and 58 dB $L_{Aeq(Day)}$;
    - Package B where noise levels are between 59 dB and 62 dB $L_{Aeq(Day)}$;
    - Package C where noise levels are between 63 dB and 66 dB $L_{Aeq(Day)}$;

      Alternative constructions from the deemed to satisfy packages may be acceptable if supported by a report undertaken by a suitably qualified acoustical consultant (member firm of the Association of Australasian Acoustical Consultants (AAAC)), once the lots specific building plans are available.
- Where houses are to be double storey, the noise impacts extend further into the development due to less ground absorption and barrier attenuation. Noise contours for the first floor are provided in *Figure 5-2*. Where a double storey residence is constructed, the same packages described above are applicable.
- All affected lots are to have notifications on lot titles as per SPP 5.4 requirements – refer *Appendix A*.

As the project progresses through to subdivision the findings and recommendations will need to be reviewed in more detail.

5.2 Aircraft Noise

Noise from aircraft to the Residential Precinct is considered to be of minimal impact. Any noise sensitive premises located west of the 5 events N65 contour line shown on *Figure 3-3* are to incorporate notifications on lot title.



Figure 5-1

Noise levels
$L_{Aeq(Day)}$ dB

<= 55	
<= 56	Exposure A
<= 57	
<= 58	
<= 59	Exposure B
<= 60	
<= 61	
<= 62	
<= 63	Exposure C
<= 64	
<= 65	
<= 66	
> 66	Exposure D

SPP 5.4 (Sep 2019)

Signs and symbols
- Road
- Block of Buildings
- 5m High Wall
- Residential Precinct

Length Scale 1:10000
0 50 100 200 300 400 m

Forrestdale North Residential Precinct -
Future (2041) $L_{Aeq(Day)}$ Noise Level Contours: Ground Level
Includes 5m High Noise Walls

Road Traffic Noise: Roe Highway Widened to 6 Lanes / 100 km/hr and Open Graded Asphalt

SoundPLAN v8.2
CoRTN Algorithms

1 July 2021

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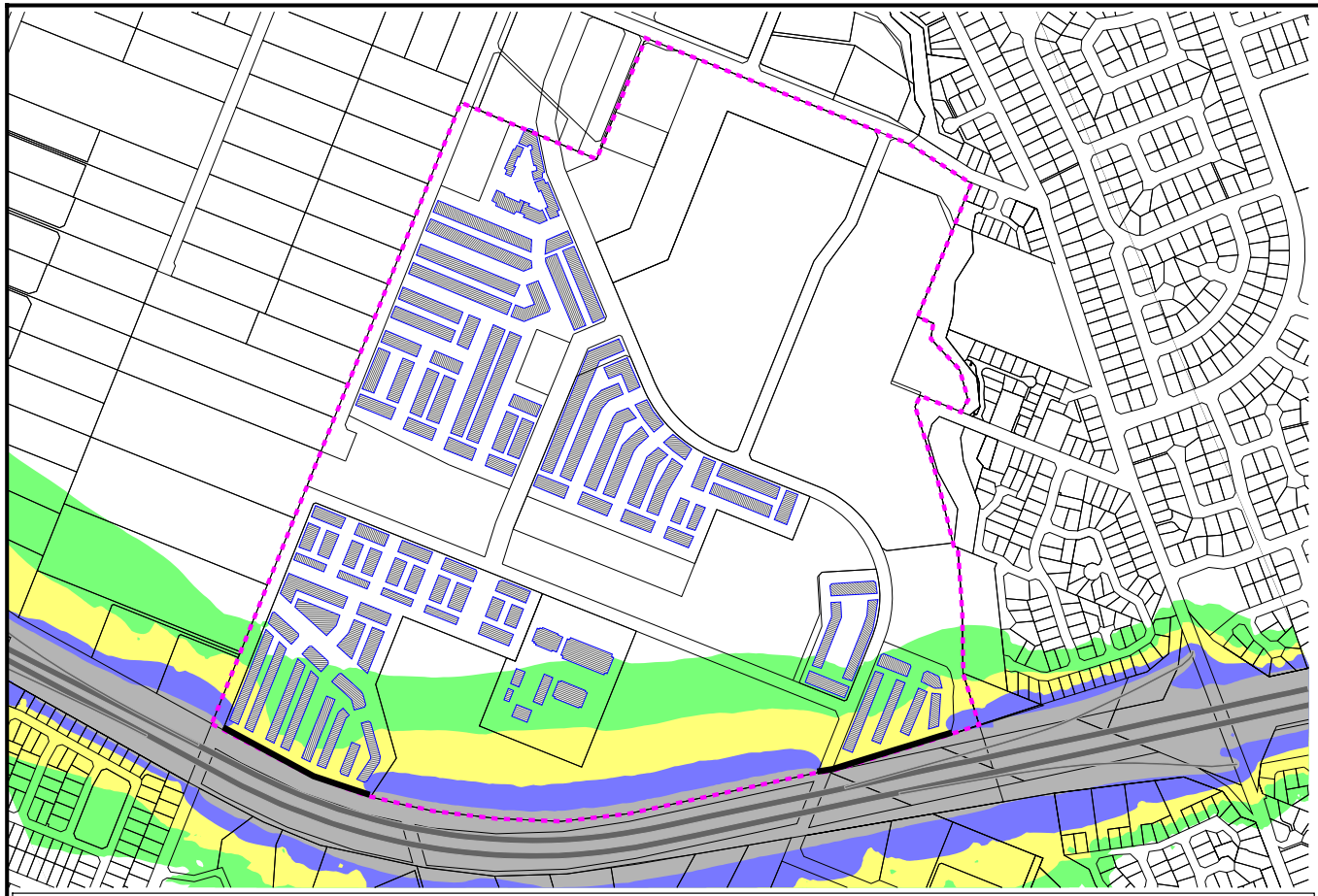

Figure 5-2

Noise levels
$L_{Aeq(Day)}$ dB

<= 55	
<= 56	Exposure A
<= 57	
<= 58	
<= 59	Exposure B
<= 60	
<= 61	
<= 62	
<= 63	Exposure C
<= 64	
<= 65	
<= 66	
> 66	Exposure D

SPP 5.4 (Sep 2019)

Signs and symbols
- Road
- Block of Buildings
- 5m High Wall
- Residential Precinct

Length Scale 1:10000
0 50 100 200 300 400 m

Forrestdale North Residential Precinct -
Future (2041) $L_{Aeq(Day)}$ Noise Level Contours: First Floor Level
Includes 5m High Noise Walls

Road Traffic Noise: Roe Highway Widened to 6 Lanes / 100 km/hr and Open Graded Asphalt

SoundPLAN v8.2
CoRTN Algorithms

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HILLARYS WA 6923
(08) 9401 7770

Lloyd George Acoustics

Appendix A

Quiet House Packages

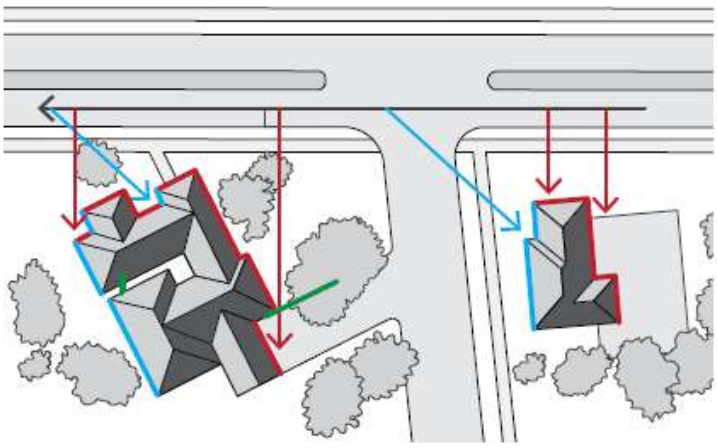
The packages and information provided on the following pages are taken from *Road and Rail Noise Guidelines* (September 2019).

Where outdoor and indoor noise levels received by a noise-sensitive land-use and/or development exceed the policy's noise target, implementation of quiet house requirements is an acceptable solution.

The quiet house packages are not the only solution to achieving acceptable internal transport noise levels. A suitably qualified acoustical engineer or consultant may also determine more tailored acoustic design requirements for buildings in a transport noise corridor by carrying out acoustic design in accordance with relevant industry standards. This includes the need to meet the relevant design targets specified in AS/NZS 2107:2016 for road traffic noise.

With regards to the packages, the following definitions are provided:

- **Facing** the transport corridor (red): Any part of a building façade is 'facing' the transport corridor if any straight line drawn perpendicular (at a 90 degree angle) to its nearest road lane or railway line intersects that part of the façade without obstruction (ignoring any fence).
- **Side-on** to transport corridor (blue): Any part of a building façade that is not 'facing' is 'side-on' to the transport corridor if any straight line, at any angle, can be drawn from it to intersect the nearest road lane or railway line without obstruction (ignoring any fence).
- **Opposite** to transport corridor (green): Neither 'side on' nor 'facing', as defined above.



Quiet House Package A

56-58 dB $L_{Aeq(Day)}$ & 51-53 dB $L_{Aeq(Night)}$

Element	Orientation	Room	
		Bedroom	Indoor Living and Work Areas
External Windows	Facing	• Up to 40% floor area ($R_w + C_{tr} \geq 28$): ○ Sliding or double hung with minimum 10mm single or 6mm-12mm-10mm double insulated glazing; ○ Sealed awning or casement windows with minimum 6mm glass. • Up to 60% floor area ($R_w + C_{tr} \geq 31$): ○ Sealed awning or casement windows with minimum 6mm glass.	• Up to 40% floor area ($R_w + C_{tr} \geq 25$): ○ Sliding or double hung with minimum 6mm single or 6mm-12mm-6mm double insulated glazing; • Up to 60% floor area ($R_w + C_{tr} \geq 28$); • Up to 80% floor area ($R_w + C_{tr} \geq 31$).
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	No specific requirements	
External Doors	Facing	• Fully glazed hinged door with certified $R_w + C_{tr} \geq 28$ rated door and frame including seals and 6mm glass.	• Doors to achieve $R_w + C_{tr} \geq 25$: ○ 35mm Solid timber core hinged door and frame system certified to R_w 28 including seals; ○ Glazed sliding door with 10mm glass and weather seals.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less.	
	Opposite	No specific requirements	
External Walls	All	• $R_w + C_{tr} \geq 45$: ○ Two leaves of 90mm thick clay brick masonry with minimum 20mm cavity; or ○ Single leaf of 150mm brick masonry with 13mm cement render on each face; or ○ One row of 92mm studs at 600mm centres with: ▪ Resilient steel channels fixed to the outside of the studs; and ▪ 9.5mm hardboard or fibre cement sheeting or 11mm fibre cement weatherboards fixed to the outside; ▪ 75mm thick mineral wool insulation with a density of at least 11kgkg/m^3; and ▪ 2 x 16mm fire-rated plasterboard to inside.	
Roofs and Ceilings	All	• $R_w + C_{tr} \geq 35$: ○ Concrete or terracotta tile or metal sheet roof with sarking and at least 10mm plasterboard.	
Outdoor Living Areas		At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2 metres height above ground level.	

Quiet House Package B

59-62 dB $L_{Aeq(Day)}$ & 54-57 dB $L_{Aeq(Night)}$

Element	Orientation	Room	
		Bedroom	Indoor Living and Work Areas
External Windows	Facing	• Up to 40% floor area ($R_w + C_{tr} \geq 31$): ○ Fixed sash, awning or casement with minimum 6mm glass or 6mm-12mm-6mm double insulated glazing. • Up to 60% floor area ($R_w + C_{tr} \geq 34$): ○ Fixed sash, awning or casement with minimum 10mm glass or 6mm-12mm-10mm double insulated glazing.	• Up to 40% floor area ($R_w + C_{tr} \geq 28$): ○ Sliding or double hung with 6mm-12mm-10mm double insulated glazing; ○ Sealed awning or casement windows with minimum 6mm glass. • Up to 60% floor area ($R_w + C_{tr} \geq 31$); • Up to 80% floor area ($R_w + C_{tr} \geq 34$).
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Doors	Facing	• Fully glazed hinged door with certified $R_w + C_{tr} \geq 31$ rated door and frame including seals and 10mm glass.	• Doors to achieve $R_w + C_{tr} \geq 28$: ○ 40mm Solid timber core hinged door and frame system certified to R_w 32 including seals; ○ Fully glazed hinged door with certified $R_w + C_{tr} \geq 28$ rated door and frame including seals and 6mm glass.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Walls	All	• $R_w + C_{tr} \geq 50$: ○ Two leaves of 90mm thick clay brick masonry with minimum 50mm cavity between leaves and 25mm glasswool or polyester (24kg/m^3). Resilient ties used where required to connect leaves. ○ Two leaves of 110mm clay brick masonry with minimum 50mm cavity between leaves and 25mm glasswool or polyester insulation (24kg/m^3). ○ Single leaf of 220mm brick masonry with 13mm cement render on each face. ○ 150mm thick unlined concrete panel or 200mm thick concrete panel with one layer of 13mm plasterboard or 13mm cement render on each face. ○ Single leaf of 90mm clay brick masonry with: ▪ A row of 70mm x 35mm timber studs or 64mm steel studs at 600mm centres; ▪ A cavity of 25mm between leaves; ▪ 50mm glasswool or polyester insulation (11kg/m^3) between studs; and ▪ One layer of 10mm plasterboard fixed to the inside face.	
Roofs and Ceilings	All	• $R_w + C_{tr} \geq 35$: ○ Concrete or terracotta tile or metal sheet roof with sarking and at least 10mm plasterboard ceiling with R3.0+ fibrous insulation.	
Outdoor Living Areas		At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2.4 metres height above ground level.	

Quiet House Package C

63-66 dB $L_{Aeq(Day)}$ & 58-61 dB $L_{Aeq(Night)}$

Element	Orientation	Room	
		Bedroom	Indoor Living and Work Areas
External Windows	Facing	• Up to 20% floor area ($R_w + C_{tr} \geq 31$): ○ Fixed sash, awning or casement with minimum 6mm glass or 6mm-12mm-6mm double insulated glazing. • Up to 40% floor area ($R_w + C_{tr} \geq 34$): ○ Fixed sash, awning or casement with minimum 10mm glass or 6mm-12mm-10mm double insulated glazing.	• Up to 40% floor area ($R_w + C_{tr} \geq 31$): ○ Fixed sash, awning or casement with minimum 6mm glass or 6mm-12mm-6mm double insulated glazing. • Up to 60% floor area ($R_w + C_{tr} \geq 34$): ○ Fixed sash, awning or casement with minimum 10mm glass or 6mm-12mm-10mm double insulated glazing.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Doors	Facing	• Not recommended.	• Doors to achieve $R_w + C_{tr} \geq 30$: ○ Fully glazed hinged door with certified $R_w + C_{tr} \geq 31$ rated door and frame including seals and 10mm glass; ○ 40mm Solid timber core side hinged door, frame and seal system certified to R_w 32 including seals. Any glass inserts to be minimum 6mm.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Walls	All	• $R_w + C_{tr} \geq 50$: ○ Two leaves of 90mm thick clay brick masonry with minimum 50mm cavity between leaves and 25mm glasswool or polyester insulation (24kg/m^3). Resilient ties used where required to connect leaves. ○ Two leaves of 110mm clay brick masonry with minimum 50mm cavity between leaves and 25mm glasswool or polyester insulation (24kg/m^3). ○ Single leaf of 220mm brick masonry with 13mm cement render on each face. ○ 150mm thick unlined concrete panel or 200mm thick concrete panel with one layer of 13mm plasterboard or 13mm cement render on each face. ○ Single leaf of 90mm clay brick masonry with: ▪ A row of 70mm x 35mm timber studs or 64mm steel studs at 600mm centres; ▪ A cavity of 25mm between leaves; ▪ 50mm glasswool or polyester insulation (11kg/m^3) between studs; and ▪ One layer of 10mm plasterboard fixed to the inside face.	
Roofs and Ceilings	All	• $R_w + C_{tr} \geq 40$: ○ Concrete or terracotta tile roof with sarking, or metal sheet roof with foil backed R2.0+ fibrous insulation between steel sheeting and roof battens; ○ R3.0+ insulation batts above ceiling; ○ 2 x 10mm plasterboard ceiling or 1 x 13mm sound-rated plasterboard affixed using steel furring channel to ceiling rafters.	
Outdoor Living Areas		At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2.4 metres height above ground level.	

Mechanical Ventilation requirements

In implementing the acceptable treatment packages, the following mechanical ventilation / air-conditioning considerations are required:

- Acoustically rated openings and ductwork to provide a minimum sound reduction performance of R_w 40 dB into sensitive spaces;
- Evaporative systems require attenuated ceiling air vents to allow closed windows;
- Refrigerant based systems need to be designed to achieve National Construction Code fresh air ventilation requirements;
- Openings such as eaves, vents and air inlets must be acoustically treated, closed or relocated to building sides facing away from the corridor where practicable.

Notification

Notifications on title advise prospective purchasers of the potential for noise impacts from major transport corridors and help with managing expectations.

The Notification is to state as follows:

This lot is in the vicinity of a transport corridor and is affected, or may in the future be affected, by road and rail transport noise. Road and rail transport noise levels may rise or fall over time depending on the type and volume of traffic.

Appendix B

Terminology

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

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

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

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

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

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

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

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

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

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

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

Noise-sensitive land use and/or development
Land-uses or development occupied or designed for occupation or use for residential purposes (including dwellings, residential buildings or short-stay accommodation), caravan park, camping ground, educational establishment, child care premises, hospital, nursing home, corrective institution or place of worship.

About the Term 'Reasonable'

An assessment of reasonableness should demonstrate that efforts have been made to resolve conflicts without comprising on the need to protect noise-sensitive land-use activities. For example, have reasonable efforts been made to design, relocate or vegetate a proposed noise barrier to address community concerns about the noise barrier height? Whether a noise mitigation measure is reasonable might include consideration of:

- The noise reduction benefit provided;
- The number of people protected;
- The relative cost vs benefit of mitigation;
- Road conditions (speed and road surface) significantly differ from noise forecast table assumptions;
- Existing and future noise levels, including changes in noise levels;
- Aesthetic amenity and visual impacts;
- Compatibility with other planning policies;
- Differences between metropolitan and regional situations and whether noise modelling requirements reflect the true nature of transport movements;
- Ability and cost for mobilisation and retrieval of noise monitoring equipment in regional areas;
- Differences between Greenfield and infill development;
- Differences between freight routes and public transport routes and urban corridors;
- The impact on the operational capacity of freight routes;
- The benefits arising from the proposed development;
- Existing or planned strategies to mitigate the noise at source.

About the Term 'Practicable'

'Practicable' considerations for the purposes of the policy normally relate to the engineering aspects of the noise mitigation measures under evaluation. It is defined as "reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge" (*Environmental Protection Act 1986*). These may include:

- Limitations of the different mitigation measures to reduce transport noise;
- Competing planning policies and strategies;
- Safety issues (such as impact on crash zones or restrictions on road vision);
- Topography and site constraints (such as space limitations);
- Engineering and drainage requirements;
- Access requirements (for driveways, pedestrian access and the like);
- Maintenance requirements;
- Bushfire resistance or BAL ratings;
- Suitability of the building for acoustic treatments.

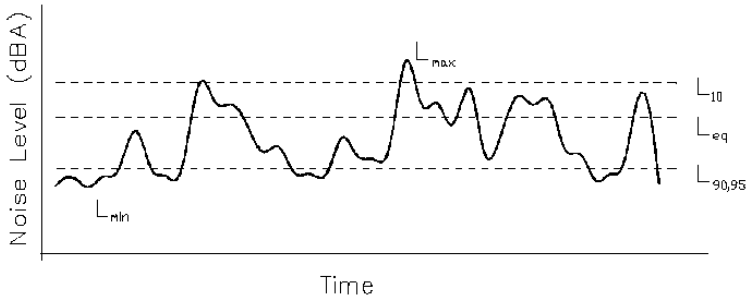
R_w

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

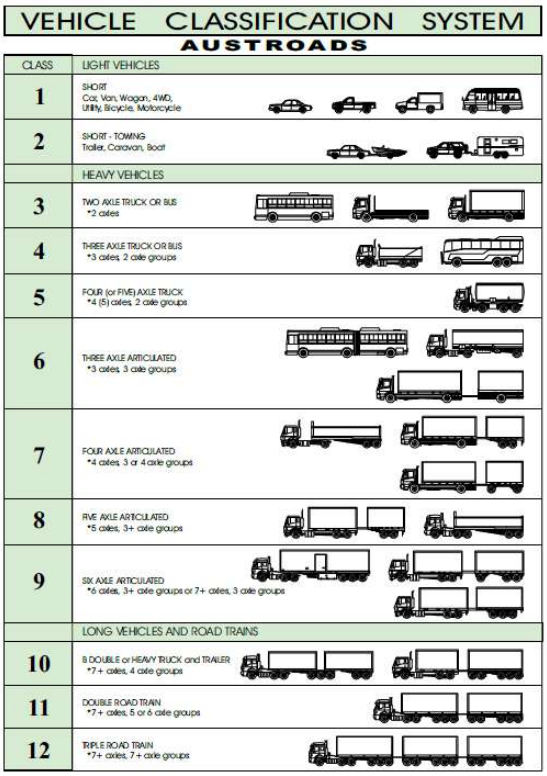
C_{tr}

This is a spectrum adaptation term for airborne noise and provides a correction to the R_w value to suit source sounds with significant low frequency content such as road traffic or home theatre systems. A wall that provides a relatively high level of low frequency attenuation (i.e. masonry) may have a value in the order of –4 dB, whilst a wall with relatively poor attenuation at low frequencies (i.e. stud wall) may have a value in the order of -14 dB.

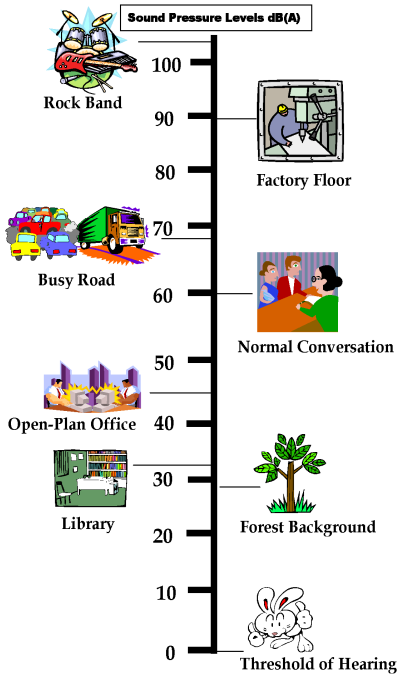
Chart of Noise Level Descriptors



Austroads Vehicle Class

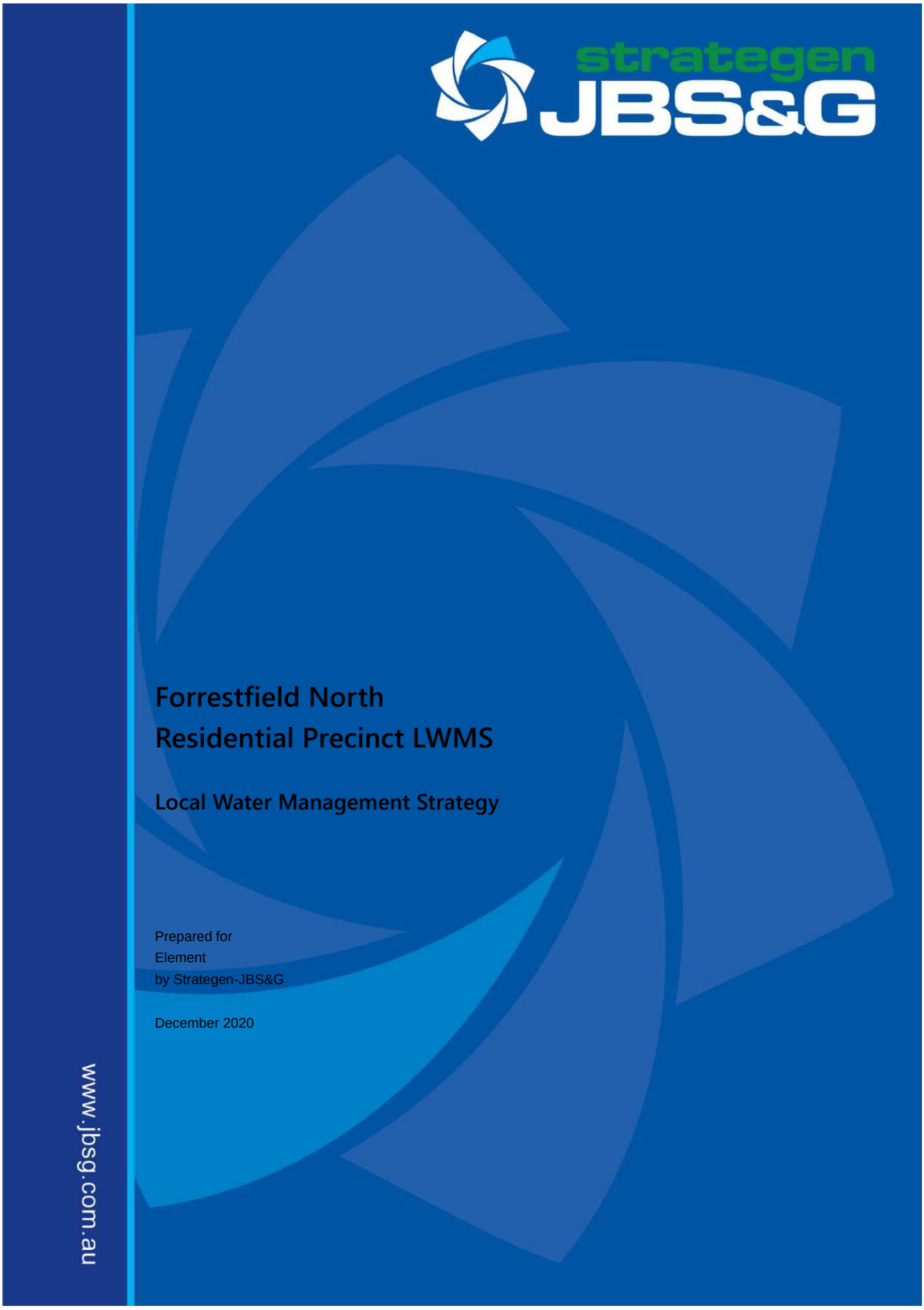


Typical Noise Levels



element.

Technical Appendix D - LWMS


strategen
JBS&G
Forrestfield North
Residential Precinct LWMS
Local Water Management Strategy
Prepared for
Element
by Strategen-JBS&G
December 2020
www.jbsg.com.au

Forrestfield North Residential Precinct LWMS

Local Water Management Strategy

Strategen-JBS&G is a trading name of
JBS&G Australia Pty Ltd
Level 1, 50 Subiaco Square Road Subiaco WA 6008
ABN: 62 100 220 479

December 2020

Limitations

Scope of services

This report ("the report") has been prepared by Strategen-JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen-JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen-JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen-JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen-JBS&G has also not attempted to determine whether any material matter has been omitted from the data. Strategen-JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen-JBS&G. The making of any assumption does not imply that Strategen-JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen-JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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This report has been prepared for use by the client who has commissioned the works in accordance with the project brief only, and has been based in part on information obtained from the client and other parties.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

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Sampling and chemical analysis of environmental media is based on appropriate guidance documents made and approved by the relevant regulatory authorities. Conclusions arising from the review and assessment of environmental data are based on the sampling and analysis considered appropriate based on the regulatory requirements.

Limited sampling and laboratory analyses were undertaken as part of the investigations undertaken, as described herein. Ground conditions between sampling locations and media may vary, and this should be considered when extrapolating between sampling points. Chemical analytes are based on the information detailed in the site history. Further chemicals or categories of chemicals may exist at the site, which were not identified in the site history and which may not be expected at the site.

Changes to the subsurface conditions may occur subsequent to the investigations described herein, through natural processes or through the intentional or accidental addition of contaminants. The conclusions and recommendations reached in this report are based on the information obtained at the time of the investigations.

This report does not provide a complete assessment of the environmental status of the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown sources of contamination, Strategen-JBS&G reserves the right to review the report in the context of the additional information.

Client: Element

Report Version	Revision No.	Purpose	Strategen-JBS&G author/reviewer	Submitted to Client	
				Form	Date
Preliminary Draft Report	A	Client review	M Dunlop/ D Newsome	Electronic	13/04/18
Draft Report	1	Public Review	M Dunlop/ D Newsome	Electronic	20/04/18
Final Report	2	Final for advertising	M Dunlop/ D Newsome	Electronic	24/04/18
Revised final	C	Client endorsement	M Dunlop/ D Newsome	Electronic	01/04/19
Revised final	3	Final	J Hunt/ D Newsome	Electronic	26/06/20
Revised final	4	Final	J Hunt/ D Newsome	Electronic	24/09/20
Revised final	5	Final	J Hunt/ D Newsome	Electronic	10/12/20

Document originally prepared by Strategen Environmental Pty Ltd (now Strategen-JBS&G).

Filename: R02 57806-128960 LWMS (Rev 5)

Executive Summary

In response to the State Government's Forrestfield-Airport Link Project, the City of Kalamunda (the City) is facilitating the design and subsequent implementation of the development of the Forrestfield North Area. To coordinate the development, an Activity Centre Plan (ACP) and a Local Structure Plan (LSP) are being developed for two designated precincts:

- ACP for the TOD Precinct (TODP) (55 ha)
- LSP for the Residential Precinct (RP) (123 ha) (Figure 1).

The TODP is a METRONET project whereas the RP is not a METRONET Project. These areas combined are referred to as the LSP Precinct Areas.

This document provides the Local Water Management Strategy (LWMS) for the RP and has been developed to inform and support the lodgement of the LSP for the Forrestfield North RP (the site) prepared by the City. A copy of the LSP is presented in Figure 2.The principal objective of this LWMS is to achieve better urban water management outcomes by guiding development within the precinct which incorporates and manages the total water cycle in a sustainable manner and meets objectives for water sensitive urban design. This includes consideration of:

- water conservation and efficiency (water use)
- water quantity management (groundwater levels and surface water flows)
- water quality management (groundwater and surface water quality).

Potential water sustainability measures have been assessed against the sustainability principles outlined in the *Water Resources Statement of Planning Policy 2.9* (WAPC 2004). This requires that an integrated approach is needed to address these issues and achieve sustainable outcomes and an acceptable 'prioritisation and balance' between competing interests (WAPC 2004) with consideration of the District Water Management Strategy prepared for the Forrestfield North Area (Strategen 2014). This requires that sustainability is pursued through integration of:

- environmental protection (including protection of water resources)
- social advancement
- economic prosperity (WAPC 2004).

Table ES 1 below summarises how the water management principles and objectives for the site will be met.

Table ES 1: Compliance with water management principles and objectives

Category	Principles	Objectives	Methods for achievement
Water use	• consider all potential water sources in water supply planning • integration of water and land use planning • sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	• minimise the use of potable water where drinking water quality is not essential • achieve a significant reduction in water use below the 100 kL/person/year State Water Plan (Government of Western Australia 2007) target • mandate Water Efficiency Labelling and Standards rated water efficient products, water efficient irrigation, waterwise landscaping and rainwater storage tanks for individual green title lots.	• potable water use estimated at 66 kL/day through mandating water efficient fittings and appliances and reduced garden areas • irrigation volumes for POS and schools will be kept within the current City of Kalamunda licenced allocation volume • POS design will maximise retention of native bushland, include extensive rehabilitation and minimise the use of turf in POS where not required • trials of soil amendments and/or irrigation measures to reduce turf water and fertiliser use will be undertaken in the first two POS areas containing turf and result used to inform POS design.
Groundwater and surface water quantity	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and waterlogging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles • for flood management, manage up to the 1% AEP event within the development area to pre-development flows and the requirements of Water Corporation (Water Corporation 2010). • adopt ‘at source’ stormwater management approach and consider reducing pit and pipe drainage system significantly. Treat polluted runoff by installing appropriate treatment systems where required. • Consider managing stormwater runoff by providing overland flow paths and opportunities for infiltration of runoff on lots, road reserves and public open space where site conditions permit • Pre-development flow rates will be maintained for events up to the 1% AEP event at discharges from the site, including Poison Gully • Design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.	• control of groundwater levels on the site is not proposed and thus impacts on groundwater regimes will be limited • maintain pre-development flows off the site through detention and retention on site, while minimising land take for drainage to improve public amenity.

Category	Principles	Objectives	Methods for achievement
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater • where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	• maintain surface water and groundwater quality • retain and/or detain and treat (if required) — stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.	• use of raingardens, including roadside raingardens to retain and treat the 1-year, 1-hour event through use of raingardens and tree pits • minimisation of turf areas and POS fertiliser use to reduce nutrient discharge to the environment • investigation and redevelopment of Brand Road landfill to manage and mitigate potential impacts to groundwater.

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1. Introduction

In response to the State Government's Forrestfield-Airport Link Project, the City of Kalamunda (the City) is facilitating the design and subsequent implementation of the development of the Forrestfield North Area. To coordinate the development, an Activity Centre Plan (ACP) and a Local Structure Plan (LSP) are being developed for two designated precincts:

- ACP for the TOD Precinct (TODP) (55 ha)
- LSP for the Residential Precinct (RP) (123 ha) (Figure 1).

The TODP is a METRONET project whereas the RP is not a METRONET Project. These areas combined are referred to as the LSP Precinct Areas.

This document provides the Local Water Management Strategy (LWMS) for the RP and has been developed to inform and support the lodgement of the LSP for the Forrestfield North RP (the site) prepared by the City as presented in Figure 2. The principal objective of this LWMS is to achieve better urban water management outcomes by guiding development within the precinct which incorporates and manages the total water cycle in a sustainable manner and meets objectives for water sensitive urban design. This includes consideration of:

- water conservation and efficiency (water use)
- water quantity management (groundwater levels and surface water flows)
- water quality management (groundwater and surface water quality).

This LWMS is presented in support of the LSP to fulfil the requirements of *Planning Bulletin 92: Better Urban Water Management* (WAPC 2008).

1.1 Proposed development

The LSP proposes a medium to high density residential precinct (R40 to R100) with an estimated yield of approximately 3500 dwellings. The precinct also includes:

- Primary School
- Approximately 22 ha of public open space, approximately 10 ha reserved for conservation purposes, and approximately 1 hectare of bush forever (Figure 2)

1.2 Statutory framework

This LWMS has been prepared in accordance with *Better Urban Water Management* guidelines (WAPC 2008) on advice from Department of Water and Environment Regulation (DWER). The document is consistent with regional and district scale urban water management planning, including the *State Water Plan* (DPC 2007) as well as *State Planning Policy 2.9 Water Resources* (WAPC 2006). The document aims to meet the principles and objectives of stormwater management in Western Australia, as detailed in the *Decision Making Process for Stormwater in Western Australia* (DWER 2017) and *Decision Making Process for Stormwater in Western Australia* (DWER 2017). Section 2 provides more information on the key policies. The LWMS is consistent with the District Water Management Strategy (DWMS) prepared for the Forrestfield North Area. A completed copy of the LWMS checklist is presented in Appendix 1.

1.3 District Water Management Strategy

A DWMS was prepared by Strategen (now Strategen-JBS&G) (2015) for the broader Forrestfield North area and approved by the then Department of Water (DoW, now DWER) and the then Shire of Kalamunda (now the City of Kalamunda).

The LWMS addresses the RP and provides a refinement of surface water and groundwater management presented in the DWMS. The LWMS has been developed with regard to the water management needs of the TODP, with consideration given to stormwater flows in the broader Forrestfield North Area.

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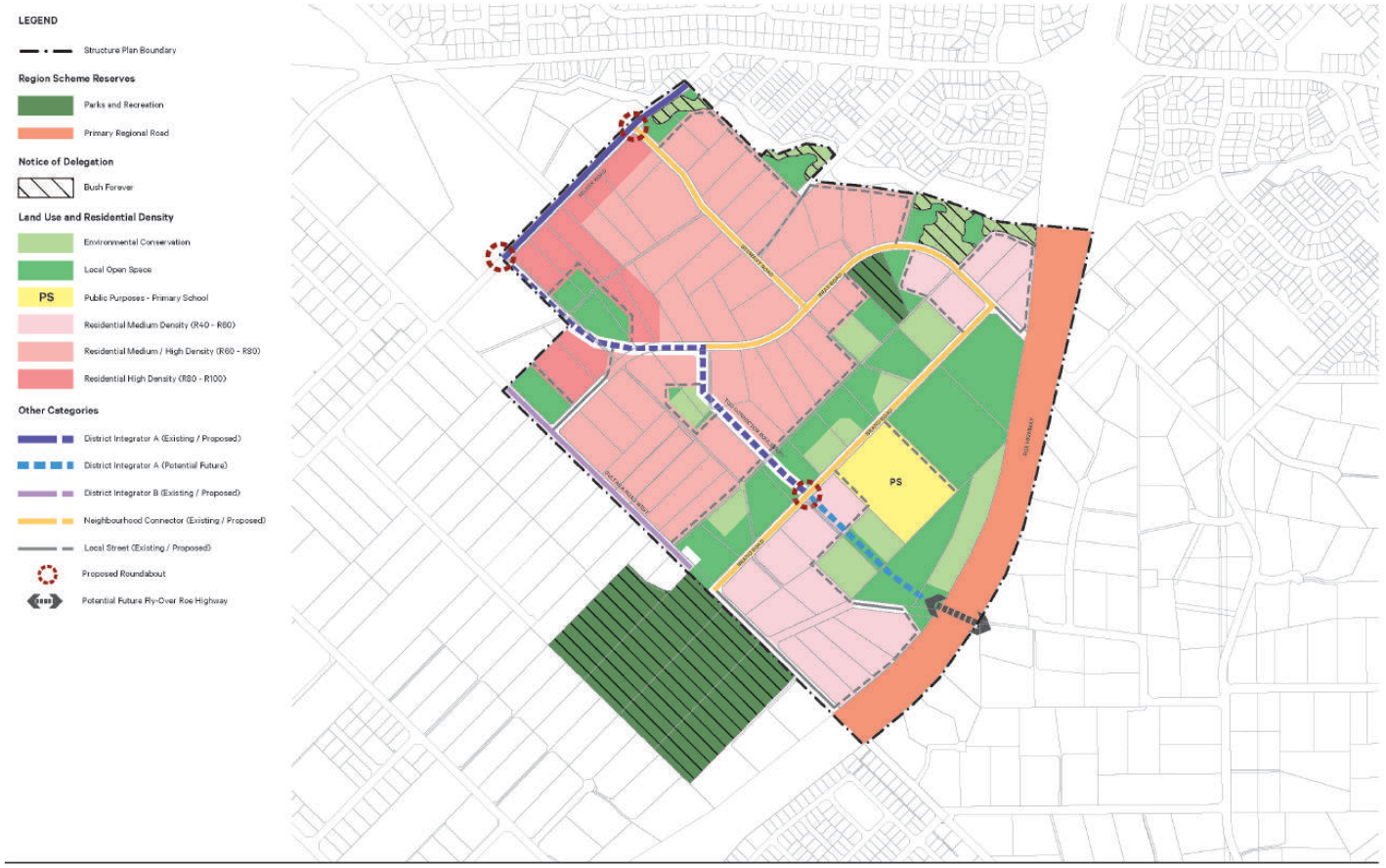
Legend:
- Residential precinct
- Roads (MRWA)

Scale 1:15,000 at A4 (0 100 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**SITE LOCATION**
Job No: 57806		
Client: Element		**FIGURE 1**
Version: A	Date: 23-Sep-2020	strategen JBS&G
Drawn By: cthatcher	Checked By: JH	

File Name: W:\Projects\1)Open\Element (TPG)\57806 - FF North TOD & Res LWMS\GIS\Maps\R02_Rev_A\57806_01_SiteLocation.mxd
Image Reference: www.nearmap.com© - Imagery Date: 30 August 2020



strategen JBS&G

Job No: 57806	
Client: Element	
Version: A	Date 16/04/2020
Drawn By: hsullivan	Checked By: CT
Image reference: Element, 2020	

Forrestfied North Residential Precinct, WA

STRUCTURE PLAN

FIGURE 2

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2. Key principles and objectives

The LWMS uses the following documents to define its key principles and objectives for sustainable water management:

- *Liveable Neighbourhoods Edition 4* (WAPC 2009)
- *Water Resources Statement of Planning Policy 2.9* (WAPC 2004)
- *Stormwater Management Manual for WA* (Department of Water 2007)
- *Decision Making Process for Stormwater in Western Australia* (Decision Process, DWER 2017)
- *Better Urban Water Management* (WAPC 2008)
- *Interim: Developing a Local Water Management Strategy* (DoW 2008)
- *Forrestfield North District Water Management Strategy* (Strategen 2015).

The sections below outline the application of key policies in relating to this LWMS. The key points of these policies are discussed below. A summary of the key design principles and objectives from these documents is provided in Table 2 1.

Table 1: Water management principles and objectives

Category	Principles	Objectives
Water use	• consider all potential water sources in water supply planning • integration of water and land use planning • sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	• minimise the use of potable water where drinking water quality is not essential • achieve a significant reduction in water use below the 100 kL/person/year State Water Plan (Government of Western Australia 2007) target • mandate Water Efficiency Labelling and Standards rated water efficient products, water efficient irrigation, waterwise landscaping and rainwater storage tanks for individual green title lots.
Groundwater and surface water quantity	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and waterlogging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles • for flood management, manage up to the 1% AEP event within the development area to pre-development flows and the requirements of Water Corporation (Water Corporation 2010) • adopt 'at source' stormwater management approach and consider reducing pit and pipe drainage system significantly. Treat polluted runoff by installing appropriate treatment systems where required • consider managing stormwater runoff by providing overland flow paths and opportunities for infiltration of runoff on lots, road reserves and public open space where site conditions permit • pre-development flow rates will be maintained for events up to the 1% AEP event at discharges from the site, including Poison Gully • design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.

Category	Principles	Objectives
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater • where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	• maintain surface water and groundwater quality • retain and/or detain and treat (if required) — stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.

2.1 Water Resources Statement of Planning Policy 2.9 and Liveable Neighbourhoods

The LWMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water, including promotion of water conservation measures, reuse and recycling of water and best practice in stormwater management (WAPC 2004). These objectives are consistent with Liveable Neighbourhoods (WAPC and DPI 2007).

2.2 Stormwater Management Manual and Decision Process

The DoW position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: *Understanding the Context of the Stormwater Management Manual for Western Australia* (DoW 2004-2007), which details the management objectives, principles, and a stormwater delivery approach for WA. Principal objectives for managing urban water in WA are stated as:

- Water Quality: to maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions
- Water Quantity: to maintain the total water cycle balance within development areas relative to the pre-development conditions
- Water Conservation: to maximise the reuse of stormwater
- Ecosystem Health: to retain natural drainage systems and protect ecosystem health
- Economic Viability: to implement stormwater systems that are economically viable in the long term
- Public Health: to minimise the public risk, including risk of injury or loss of life to the community
- Protection of Property: to protect the built environment from flooding and waterlogging
- Social Values: to ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater
- Development: to ensure the delivery of best practice stormwater management through planning and development of high-quality developed areas in accordance with sustainability and precautionary principles Australia (DoW 2004-2007).

DWER revised the *Decision Process for Stormwater Management in WA* in 2017 to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above. The Decision Process is a component of Chapter 4 of the Stormwater Management Manual for WA and focuses on achieving desired stormwater outcomes by:

- designing urban stormwater management systems that reduce risk to people and property from flooding to within acceptable levels
- designing urban stormwater management systems that mimic natural hydrological processes for that catchment
- retaining natural water bodies as the receiving environments for runoff of suitable quality from minor and major rainfall events

- retaining and planting vegetation (preferably local native species) wherever possible to reduce stormwater runoff volumes and peak flow rates, reduce urban temperatures, improve water quality, increase urban biodiversity, and improve aesthetics and urban amenity
- implementing stormwater management systems and site management, maintenance and other practices to prevent, reduce and treat pollutants
- designing urban stormwater management systems that achieve good urban amenity and provide multiple functions (DWER 2017).

2.3 Better Urban Water Management

The guideline 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.

2.4 City of Kalamunda drainage guidelines

The City has prepared the Stormwater Design Guidelines for Subdivisional and Property Development (City of Kalamunda, 2018) to assist "developers, builders and consulting engineers to produce consistent designs for Stormwater Management Systems for residential, commercial, and industrial developments within the City of Kalamunda. This guideline should also be referenced when preparing an Urban Water Management Plan or Stormwater Management Strategy" (City of Kalamunda, 2018).

This document was provided after the stormwater modelling was completed for the LWMS and therefore some requirements in the document have not been included in the LWMS. However, the approach taken in the LWMS is more conservative in terms of sizing the drainage infrastructure than in the drainage guidelines, and as such provides a worst case scenario to provide proof on concept The drainage infrastructure sizing will be refined at subdivision stage and will take into consideration the requirements outlined in the guidelines.

2.5 Agency consultation

Consultation was undertaken with DWER (meeting held 29 September 2017) and Water Corporation (meeting held 6 December 2017) confirming the adequacy of the Water Corporation (2007 and 2010) documents to provide information on the regional drainage network and provide advice on modelling parameters to be used and stormwater volumes to be considered. Copies of these meeting minutes are provided in Appendix 5.

Ongoing consultation has been undertaken with DWER and the City as the proponent of the project.

3. Pre-development environment

This section provides a summary of information presented in the DWMS approved by DoW in June 2015 and additional studies where relevant. In accordance with the DWMS, this LWMS is informed by data from provided in the DWMS, including on groundwater and surface water monitoring was undertaken by Strategen over 2011/12 (Strategen 2015) which was considered to adequately cover the LSP area. The DWMS did not identify the need for further studies or monitoring prior to the preparation of the LWMS.

3.1 Climate

The RP area exhibits a Mediterranean climate, characterised by hot dry summers and mild wet winters, similar to that of other coastal areas in the Perth Metropolitan region.

The closest Bureau of Meteorology (BoM) monitoring station to the RP area is situated at Perth Airport, approximately 4 km away (BoM 2015). Temperature and rainfall data from this station are summarised in Table 2.

Summer months extend from October to April, with maximum daily temperatures of between 22 and 32°C. The winter months extend from May to September, with mean minimum temperatures of approximately 18°C.

Rainfall at Perth Airport mainly occurs during winter with a mean monthly rainfall of 155.9 mm in June and 10 mm in January. The mean annual rainfall for the area is 766.1 mm.

Table 2: Climate statistics for Perth Airport (1944 to 2017) (BoM Station 9021) (BoM 2018)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Max Temp (°C)	31.8	32.0	29.7	25.5	21.8	19.0	17.9	18.6	20.2	22.7	26.0	29.0	24.5
Mean Min Temp (°C)	17.1	17.5	15.9	13.0	10.4	9.0	8.0	8.1	8.9	10.3	12.8	14.9	12.2
Mean Rainfall (mm)	10.0	15.3	16.4	40.5	98.9	155.9	155.7	118.2	73.2	43.3	25.9	11.2	766.1

3.2 Land use

The RP predominantly consists of semi-rural /residential and horticultural uses.

3.3 Topography

The topography of the precinct ranges from approximately 46 m Australian Height Datum (AHD) in the north-eastern section to approximately 35 m AHD in the south-western corner. Topographic contours for the precinct are shown in Figure 3.

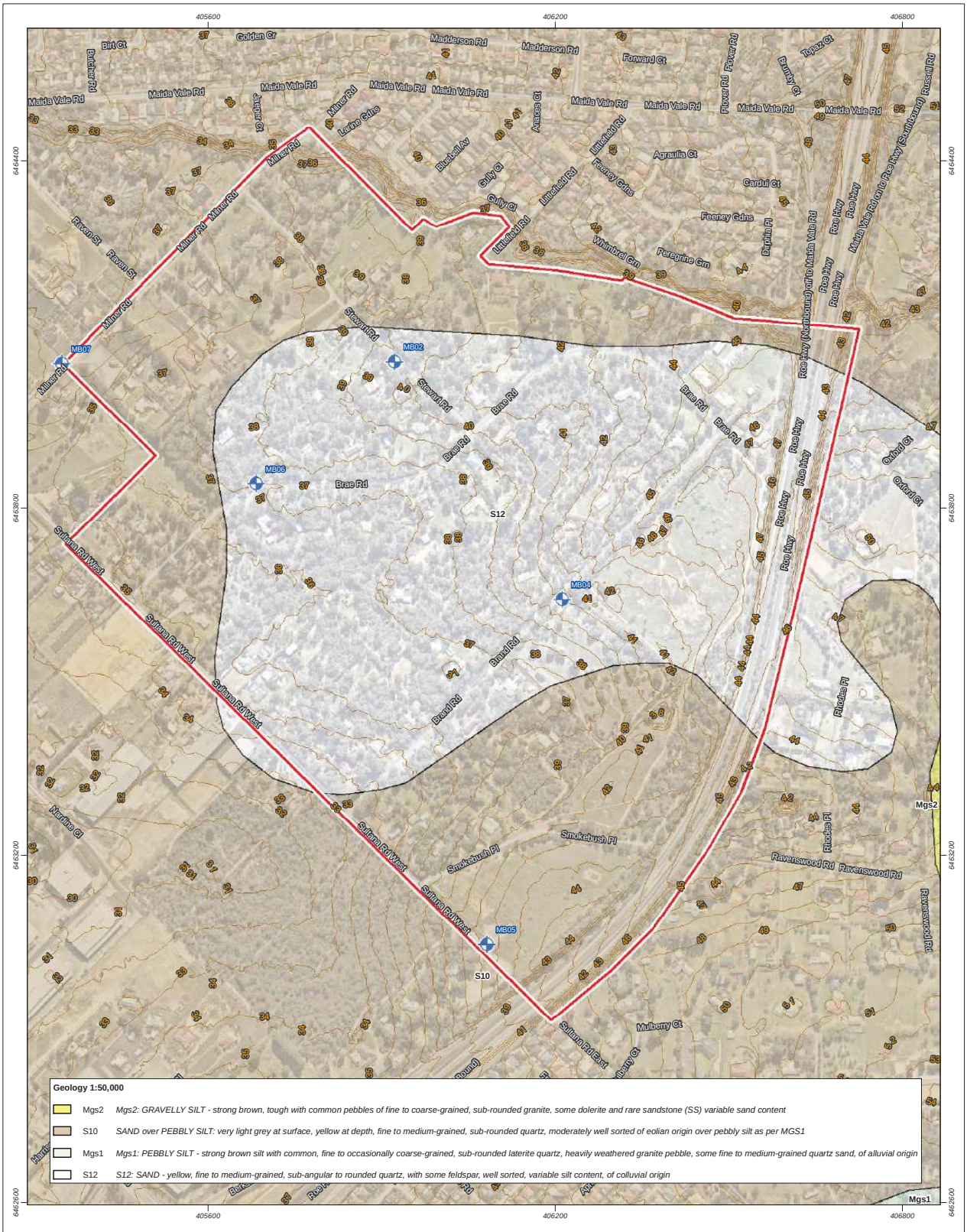

Figure 3: Topography and soils

Scale 1:6,000 at A3

0 60 120 180 m

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 9/04/2018
Author: vd
Source: Nearmap: Aerial imagery - 04/06/2017.

Legend

- Monitoring bore location (Strategen 2012)
- Contour (mAHD)
- Residential Precinct

strategen JBS&G

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3.4 Geology and soils

Regional Mapping indicates that the geology of the RP consists of a mixture of Bassendean Sands over Guildford Formation (S10) and sands of the Yoganup Formation (S12) (Gozzard 1986) (Figure 3). The Yoganup Formation predominantly occurs in the east of the precinct and consists of yellow, fine to medium grained quartz sand with some feldspar and variable silt content of colluvial origin (Gozzard 1986). EMRC (2013) reports that the eastern portion of the RP is underlain by superficial deposits of Bassendean Sand and Guildford Formation which comprise approximately 25-30 metres of saturated thickness of the superficial aquifer.

Geological soil unit mapping indicates that the site is characterised by sand at the surface, consisting of:

- S10: Thin layer of SAND – very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz, moderately well sorted, of eolian origin over alluvial silts and sands of the Guildford formation
- S12: SAND – yellow, fine to medium grained, sub-angular to rounded quartz, with some feldspar, well sorted, variable silt content, of colluvial origin (Gozzard 1986).

3.4.1 Depth to low permeability material

As discussed in the DWMS, several bores were drilled across the precinct by Strategen in September 2011. The lithology of the bores within the RP were:

- MB02: predominantly sand with clayey sand at 6.5 m depth
- MB04: gravelly sand at surface with sand at depth
- MB05: predominantly sand (coarse to medium grained)
- MB06: sand with clayey sand at 13.5 m depth
- MB07: sand with clayey sand at 2.5 m depth (Strategen 2012a).

Depths to the interpolated low permeability material varied from 2.5 m to greater than 5 m, with the shallowest depths in the east of the site (Figure 4). Low permeability material is not anticipated to be of concern over the majority of the RP Area. The presence of low permeability material should be confirmed through geotechnical investigations at the subdivision stage.

3.4.2 Hydraulic conductivity

Hydraulic conductivity testing was undertaken at proposed basin and storage tank locations on 23 October 2018 based on Australian Standard methodology (AS 1547:2012). Further details of the testing are presented in Appendix 7. These values were used to derive hydraulic conductivities to be used in stormwater modelling (Table 3).

Table 3: Hydraulic conductivity test results

Basin	Soil type	Conductivity measured(m/day)	Recommended conductivity for model (m/day)
AS1	Clayey Sand	1.2	0.6
AS1B	Clayey Sand	0.7	0.3
AS3	Clayey Sand	0.8	0.4
MV5	Fine to medium SAND	2.7	1.3
PG4	Fine to medium SAND	6.3	3.1
PG5	Clayey gravelly SAND	0.9	0.4
PG6	Clayey gravelly SAND	0.8	0.4
PG6B	Fine to medium SAND	>10	3.0

3.4.3 Acid sulfate soils

Acid Sulfate Soils (ASS) are naturally occurring, iron-sulphide rich soils, sediments or organic substrates, formed under waterlogged conditions. If exposed to air, these sulphides can oxidise and release sulphuric acid and heavy metals. This process can potentially occur due to a change in drainage conditions, lowering of the water table (dewatering) and/ or excavation.

Review of regional mapping indicates that the precinct has a low to moderate risk of ASS occurring within 3 m of natural soil surface (Class 2) (DER 2015). The nearest area of high to moderate risk of ASS occurring within 3 m of natural soil surface is approximately 400 m south east of the precinct (Figure 5).

During bore installation in 2011, samples were collected at 25 cm intervals from the surface to a depth of 4 m and results analysed. Results indicate relatively neutral pH and pHf_{ox} results, with minimal difference between these indicators. ASS are not considered likely to be a significant risk in the RP.

3.4.4 Contaminated sites

The DWER (2017) Contaminated Site Database was searched and there are currently no registered contaminated sites within the precinct. The closest registered contaminated site is associated with the Marshalling Yards located approximately 0.8km south west of the RP.

Previous land uses

Brand Road Landfill

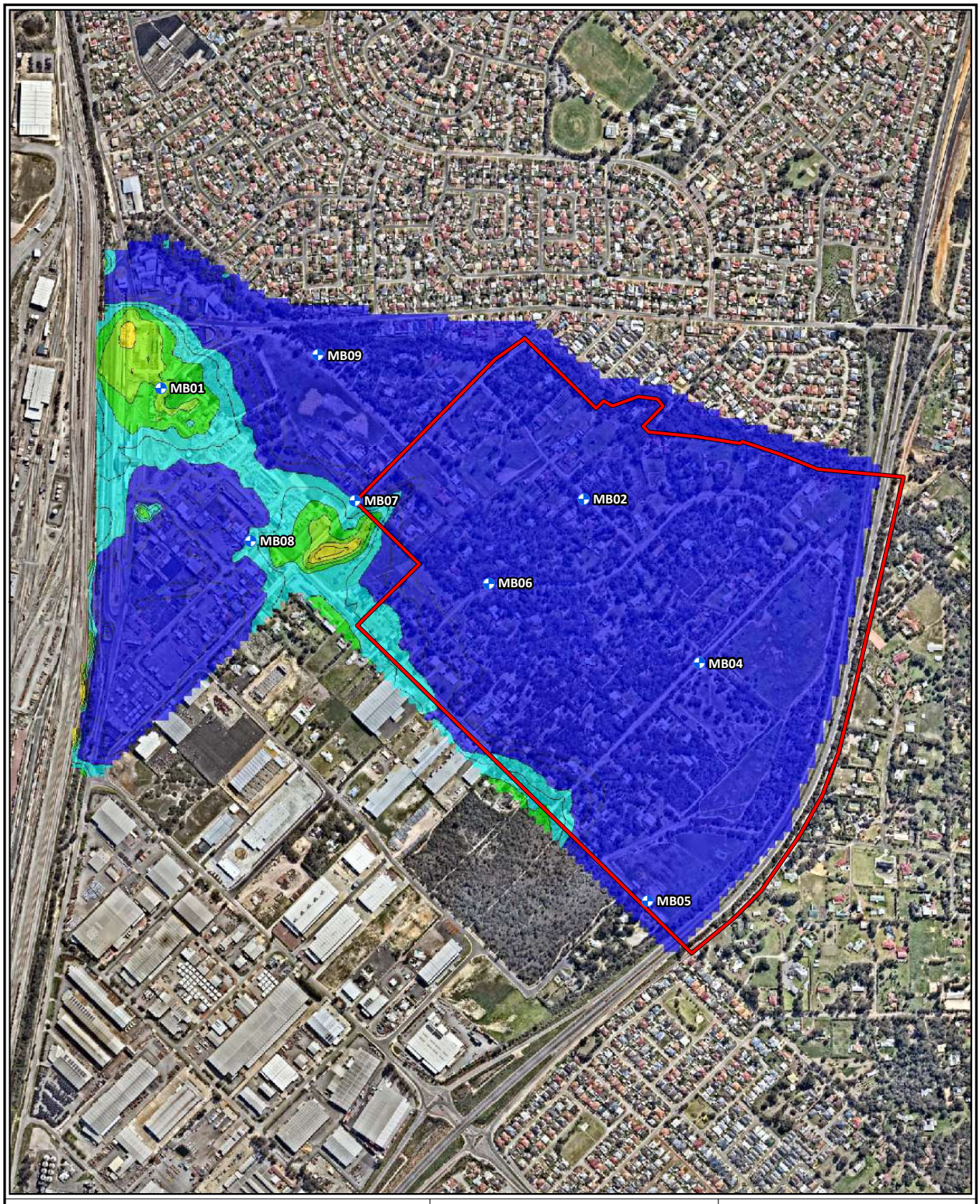
Brand Road landfill operations (Lot 13, 14 and 18 on Plan 24292) commenced in approximately 1978. It was operated by Western Excavating from the beginning of the sand mining activities until 1989. The sanitary landfill operations started in 1989.

The former Brand Road landfill is located on the eastern boundary of the Precinct (Figure 5). A Preliminary Site Investigation (PSI) for the former landfill was completed in 2010 (GHD 2010). This site is considered '*Possibly Contaminated – Investigation Required*' under the *Contaminated Sites Act 2003* (Reference: DEC10015). A series of site investigations and reporting has been completed for the former landfill. Land use planning for the RP has incorporated the landfill within the design of the LSP.

Orchards

Based on historical aerial photography, there have been several hobby farms and/or orchards within Lots 94 and 98 Brae Road and Lots 100, 101, 102 and 103 Smokebush Place High Wycombe (Figure 5). These land uses and their associated activities are potentially contaminating due to the use of metals, organochlorine pesticides, organophosphate pesticides, carbamate and fuels (DoE 2004).

Investigations consistent with the requirements of the *Contaminated Sites Act 2003* are anticipated to be required prior to the redevelopment of these areas.



Legend:
- Residential precinct
- Monitoring bore location (2012)

Depth to low permeability material
- 5.0
- 4.5
- 4.0
- 3.5
- 3.0
- 2.5
- 2.0
- 1.5
- 1.0
- 0.5
- 0.0

Scale 1:12,500 at A4 (0 100 200 metres)

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57806

Client: Element

Version: A | Date: 23-Sep-2020

Drawn By: cthatcher | Checked By: JH

Forrestfield North Residential Precinct, WA

DEPTH TO LOW PERMEABILITY MATERIAL

FIGURE 4

strategen JBS&G

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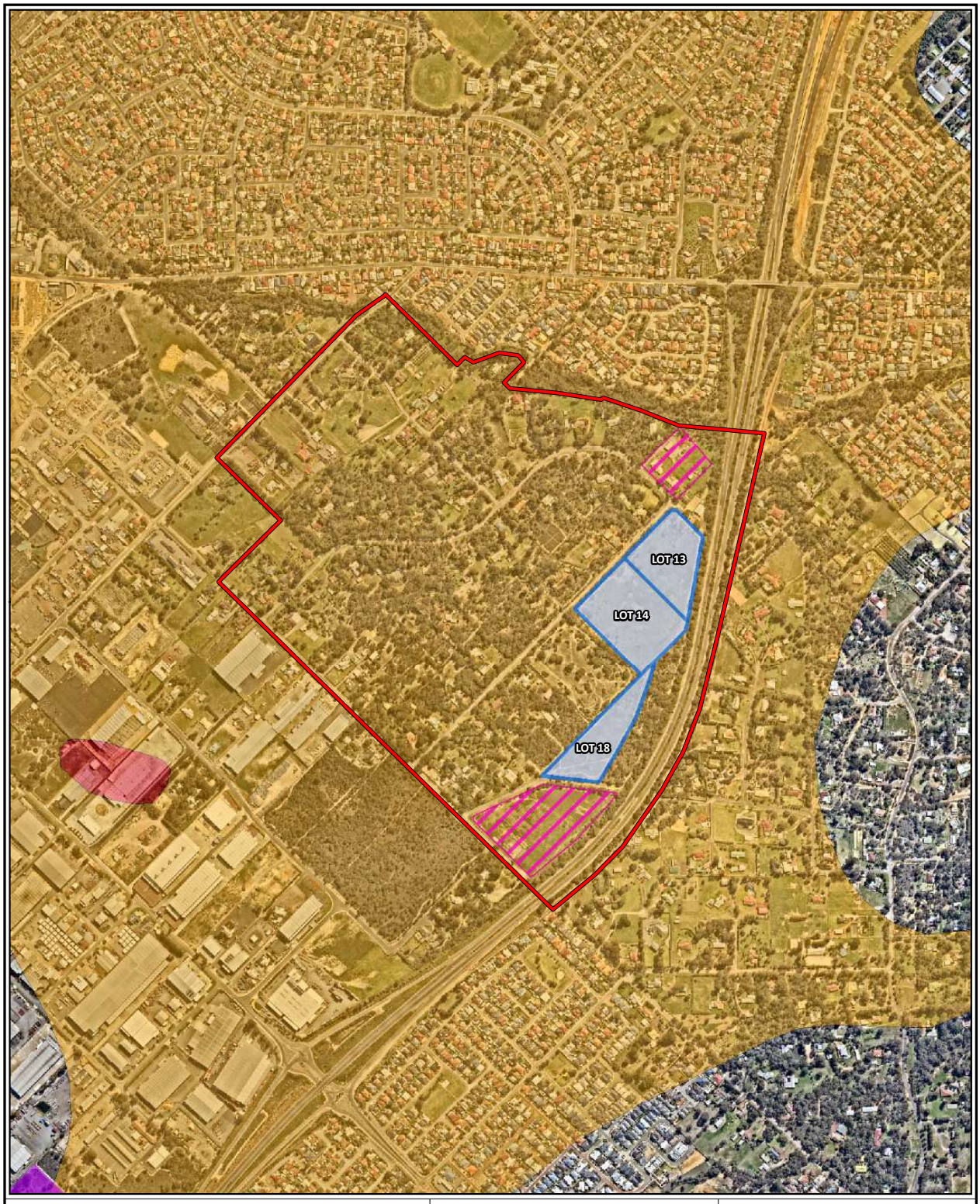
Image Reference: www.nearmap.com© - Imagery Date: 30 August 2020



Legend:

- Residential precinct
- Indicative landfill (source: GHD 2010)
- Historical orchard activity

Acid sulfate soil (DWER)

- High to moderate risk
- Moderate to low risk

DWER registered contaminated sites

- Contaminated - remediation required

Scale 1:12,500 at A4	0 100 200 metres
Coord. Sys. GDA 1994 MGA Zone 50	
Job No: 57806	
Client: Element	
Version: A	Date: 23-Sep-2020
Drawn By: cthatcher	Checked By: JH

Forrestfield North Residential Precinct, WA

ACID SULPHATE SOILS AND POTENTIALLY CONTAMINATED SITES

FIGURE 5

strategen JBS&G

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3.5 Groundwater

3.5.1 Groundwater monitoring

Strategen installed bores in the LSP precinct areas in September 2011 as part of the preparation of a DWMS (Figure 2). Bore details are presented in Table 4 and Appendix 2. Groundwater levels were monitored for water level monthly between September 2011 and December 2012 (Appendix 3). The highest groundwater levels to date were recorded in October 2011 (Table 4).

Groundwater appeared to flow in a generally south easterly direction. This is consistent with the work of ENV (2012) for the area to the south of Sultana Road West and monitoring in the TODP by Strategen for a confidential client which indicates that Poison Gully is a losing stream (i.e. discharges surface water to groundwater) in the TODP area.

3.5.2 Maximum groundwater levels

Available groundwater level data was reviewed for October 2011, April 2012 and October 2012 for monitoring bores MB01 to MB09. Comparisons were made to historic groundwater levels from the nearest DWER bore 61610508 and other available historical groundwater level data to provide an estimate of short-term perched MGL following high rainfall periods. The estimated maximum groundwater levels for each bore location is provided in Table 4. The maximum groundwater level contours are presented in Figure 6. The depth to maximum groundwater levels is presented in Figure 7.

The groundwater levels for 2011 and 2012 were compared along with the DoW bore (61610508) to allow an assessment of the perching that occurs where the clay layer is known to be present west of Milner Rd (Table 5). Groundwater monitoring results obtained by PTA between 2014 and 2016 (Appendix 8) were also considered as part of the review process.

Table 4: Groundwater levels

Bore	Easting	Northing	Ground level (mAHD)	Screened depth (mbgl)	October 2011 (mbgl)	Oct 2011 (mAHD)	Oct 2012 (mAHD)	Difference	Max groundwater level (mAHD)
MB01	404861	6464332	30.04	6 - 9	3.79	26.427	24.690	1.737	30.027
MB02	405922	6464054	38.45	14 - 18	14.22	24.235	23.990	0.245	31.235
MB04	406211	6463643	39.73	15 - 19	15.73	23.876	23.800	0.076	30.876
MB05	406081	6463047	40.77	15 - 19	16.99	23.776	23.570	0.206	30.776
MB06	405683	6463843	36.24	13 - 16	11.92	24.319	23.970	0.349	31.319
MB07	405347	6464050	34.49	9 - 13	9.61	24.876	24.230	0.646	31.876
MB08	405086	6463948	31.84	6 - 9	3.97	27.873	25.750	2.123	30.873
MB09	405255	6464415	33.36	2 - 5.5	0.95	32.411	28.350	4.061	33.411

Table 5: Rainfall, DWER Bore (61610508) and groundwater levels data summary

	2011	2012	Difference (m)	Comment
DoW bore (61610508)	~ 14.5 mAHD	~ 14 mAHD	~ 0.5	2017 (Oct) levels ~15.2 mAHD (0.7 m higher than 2011, 1.2 m higher than 2012).
Rainfall (Jan-Sept)	666.4 mm	526 mm	0.14	Higher rainfall for Jan-Sept 2011.
Rainfall (Oct)	63.4 mm	13.8 mm	0.496	High Oct 2011 rainfall periods immediately prior to groundwater level measurement.
Oct groundwater levels East of Milner Rd	23.776 - 24.319 mAHD	23.570 - 23.990 mAHD	0.076 - 0.349 m	no significant perching is evident east of Milner Rd (absence of clay layer).
Oct groundwater levels West of Milner Rd	26.427 - 32.411 mAHD	24.690 - 28.350 mAHD	1.737 - 4.061 m	Significant perching to the northwest near MB09 due to clay layer west of Milner Rd.

Perching of groundwater was not observed in the RP.

3.5.3 Groundwater quality

Groundwater and surface water quality monitoring was undertaken by Strategen on six occasions between October 2011 and November 2012.

Water quality monitoring results for the RP and TODP are summarised below with all results provided in Appendix 3.

Monitoring data for pH ranged from 4.62 (MB4) to 7.21 (MB9) with a median across all bores of 5.84 (Appendix 4). This indicates that groundwater is generally neutral to acidic. Groundwater is fresh with a median electrical conductivity (EC) level of 0.438 mS/cm (Appendix 4). EC levels were less than 1.1 mS/cm for all bores (Appendix 4).

Total nitrogen (TN) levels varied from 0.31 mg/L to 25 mg/L throughout the monitoring period with a median of 2.1 mg/L (Table 6). This median exceeds the Swan Canning Water Quality Improvement Plan's (SCWQIP) long-term and short-term target for TN (1 mg/L and 2 mg/L respectively) (Swan River Trust 2009). The Australian Drinking Water Guidelines for nitrate of 30 mg/L nitrate as nitrogen were exceeded in MB07 and MB08 on two occasions each. Groundwater within the RP may require treatment if mobilised due to installation of subsoil drainage.

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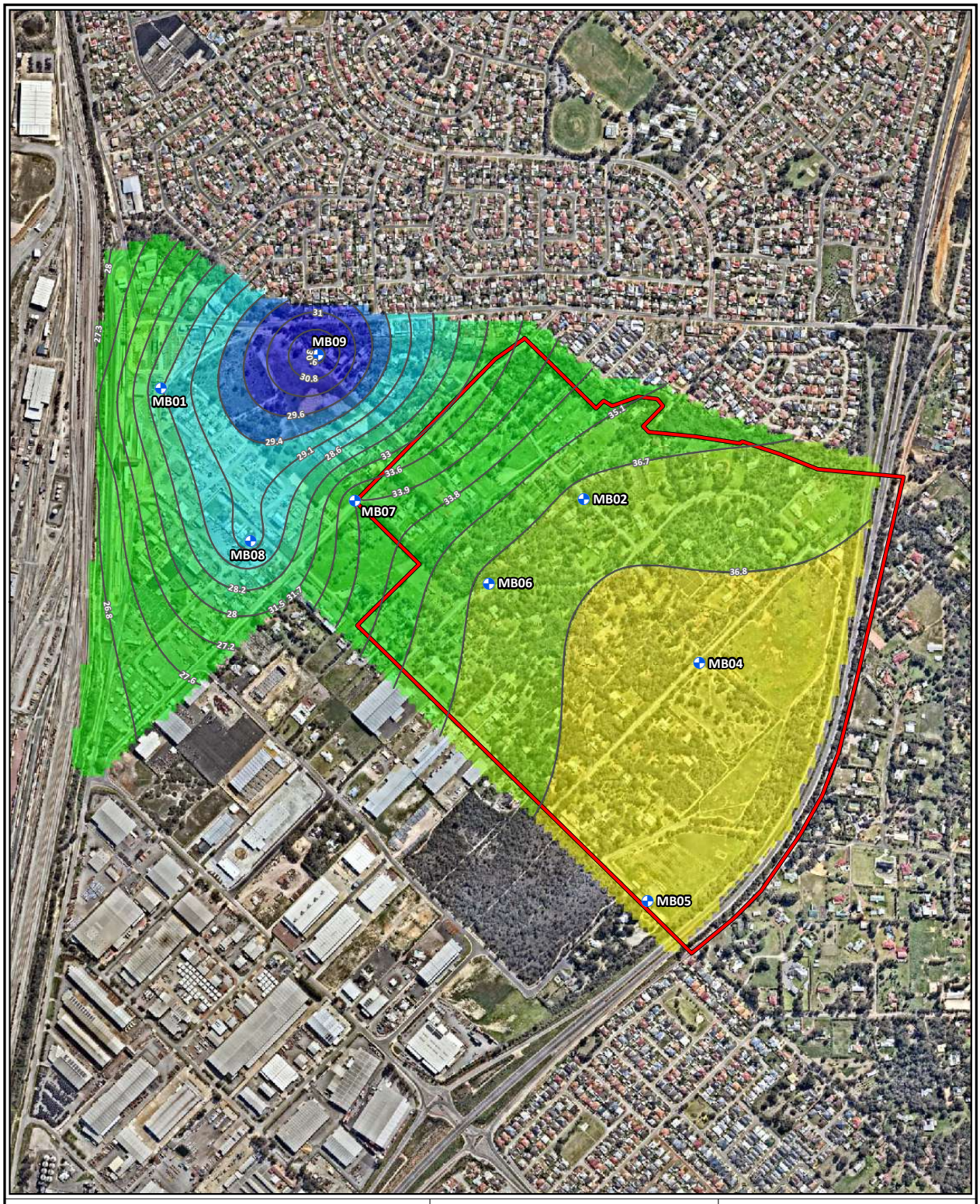

Legend:

- Residential precinct
- Groundwater contour (mAHD)
- Monitoring bore location (2012)

Maximum groundwater level (mAHD)

- 33.0
- 32.0
- 31.0
- 30.0
- 29.0
- 28.0
- 27.0
- 26.0
- 25.0
- 24.0
- 23.0

Scale 1:12,500 at A4

0 100 200 metres

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57806

Client: Element

Version: A | Date: 23-Sep-2020

Drawn By: cthatcher | Checked By: JH

Forrestfield North Residential Precinct, WA

GROUNDWATER LEVELS

FIGURE 6

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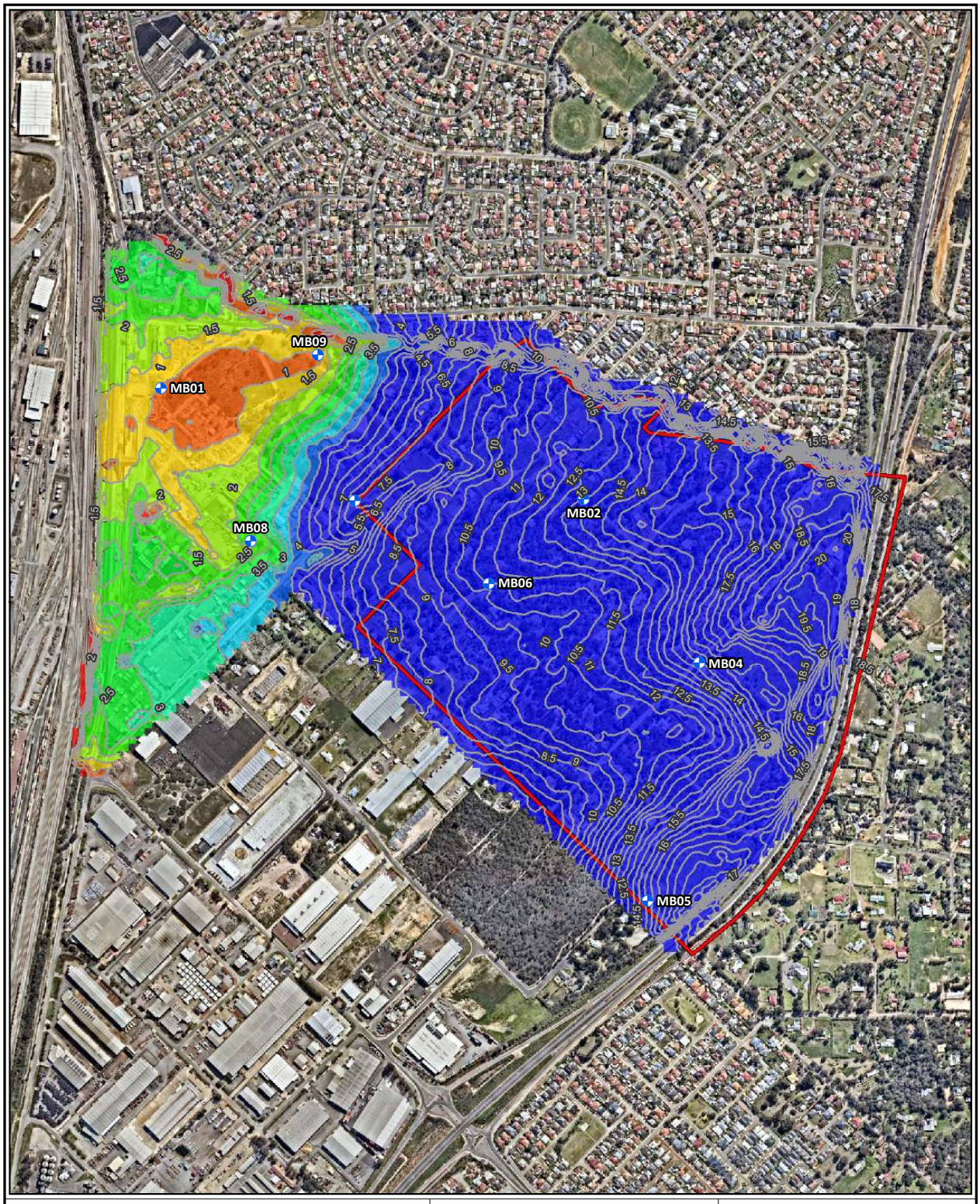

Legend:
- Residential precinct
- Topography
- Monitoring bore location (2012)

Depth to maximum groundwater level (mAHD)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

Scale 1:12,500 at A4 — 0 100 200 metres

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57806

Client: Element

Version: A | Date: 23-Sep-2020

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Forrestfield North Residential Precinct, WA

DEPTH TO GROUNDWATER

FIGURE 7

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Image Reference: www.nearmap.com© - Imagery Date: 30 August 2020

Table 6: Groundwater nutrient summary

Bore	Statistic	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
MB01	Min	0.93	0.21
	Max	5.90	1.70
	Average	2.43	0.72
MB02	Min	0.55	0.12
	Max	1.20	0.82
	Average	0.82	0.37
MB04	Min	0.62	0.84
	Max	2.30	2.40
	Average	1.24	1.33
MB05	Min	5.10	2.30
	Max	6.90	5.70
	Average	5.76	4.14
MB06	Min	0.31	0.12
	Max	5.30	1.90
	Average	2.38	0.90
MB07	Min	7.10	0.20
	Max	10.00	1.60
	Average	8.08	0.81
MB08	Min	18.00	0.18
	Max	25.00	1.20
	Average	21.50	0.66
MB09	Min	-	-
	Max	-	-
	Average	1.30	0.08

Total phosphorus (TP) results varied from 0.12 to 5.76 mg/L, with an average of 0.72 mg/L (Table 6). These levels are above the SCWQIP long-term and short-term target for TP (0.1 mg/L and 0.2 mg/L respectively).

3.5.4 Groundwater availability

The RP area is located in the 'Shire of Kalamunda' subregion of the Perth Groundwater Area. The superficial, Leederville and Yarragadee Aquifers in this area are identified by the DWER Water Register as being fully allocated, with groundwater not being available for new licences (accessed 2 October 2017).

A total of 137.4 ML is allocated for private use within the TODP and RP areas (Table 7). The timing of development of these areas will depend on the landowners, who may choose to retain their allocations for other purposes rather than providing these to the City. As such these allocations have not been relied on for the future irrigation of Public Open Space (POS) and landscaping.

Table 7: Groundwater licences within the TOD and RP areas

Licence Number	Licence Allocation (kL)	Licence Address
63807	89390	Lot 22 On Diagram 71134 Volume/Folio 1791/535 Lot 22 Dundas Rd High Wycombe; Lot 23 On Diagram 71134 Volume/Folio 1791/536 Lot 23 Milner Rd High Wycombe; Lot 551 On Plan 4684 Volume/Folio 365/181a Lot 551 Dundas Rd High Wycombe
152091	3500	Lot 89 on Plan 13420; Certificate of Title Volume 1581 Folio 996 Lot 89 on Stewart Road High Wycombe
152215	23120	Lot 1 on Diagram 17430; Certificate of Title Volume 1324 folio 130 Lot 1 Milner Road High Wycombe
154669	3500	Lot 4 on Diagram 69590; Certificate of Title 1723, Folio 473 Lot 4 Brand Road High Wycombe
155694	7625	Lot 3 On Diagram 69590 Volume/Folio 1723/472 Lot 3 Brand Rd High Wycombe
167016	7280	Lot 92 On Plan 13420 Volume/Folio 1581/969 Lot 92 Milner Rd High Wycombe
167785	3000	Lot 220 On Plan 31169 Volume/Folio 2526/471 Lot 220 Nardine Cl Forrestfield
Total	**137415**	

The City currently operates a managed aquifer recharge (MAR) scheme at Hartfield Park for irrigation of POS. MAR is the intentional recharge of water to suitable aquifers for subsequent recovery. The MAR scheme at Hartfield Park pumps water from an adjacent drain into the Leederville Aquifer during the winter months. During the summer months, this water is abstracted from the aquifer for irrigation of POS.

A preliminary 'entry-level' assessment of potentially incorporating a MAR to supply irrigation water for LSP area based on the *Australian Guidelines for Water Recycling* (AGWR) (NRMMC, EPHC and NHMRC 2006) has been undertaken to inform decision making on this issue. The MAR option would have involved injection of stormwater into the Leederville Aquifer during the winter wet season and abstraction during the summer dry season for irrigation. As previously discussed, the City currently operates a MAR scheme for irrigation at Hartfield Park, approximately 4 km south of the site. The findings of the review and subsequent discussions with DWER and hydrogeologists indicated:

1. Volumes of stormwater within the two LSP precinct areas (RP and TODP) may not be adequate to support a MAR scheme. MAR using wastewater or greywater would require the installation of complex treatment units.
2. Uncertainty regarding the depth and presence of the Leederville Aquifer – estimated to be greater than 80 m in the LSP precinct areas, compared to approximately 40 m at Hartfield Park. This would increase the cost of investigations and installation of any MAR bores.
3. Uncertainty regarding water quality in the Leederville Aquifer in the area as limited information is available.
4. A bore has been installed by PTA into the Leederville Aquifer near Forrestfield North Train Station as a temporary source of construction water with a temporary, non-transferrable groundwater allocation. Subject to further investigation, this bore may be suitable in the longer term to be used as a Leederville Aquifer MAR injection bore.
5. Water quality in the Leederville Aquifer under the site may not be suitable for irrigation of turf.

The review identified that, based on the above, the LSP precinct area conditions were not favourable for a MAR scheme compared to other locations within the City. The City is strategically considering opportunities to install MAR schemes within the City, pending more detailed future assessment.

The City currently has an allocation for irrigation of POS in the superficial aquifer which covers the POS currently irrigated by the City. Review of groundwater use by the City indicates that this allocation is not being fully utilised. The City has identified that 100,000 kL/year from the existing allocation can be made available for irrigation within the LSP precinct areas (Varelis P [City of Kalamunda] 2017, pers. comm. 12 October). As the RP is the larger precinct with more residential development and contains playing fields, the school and extensive POS, a total of 48,000 kL/yr has been allocated to this precinct, and 30,000 kL/yr to the TODP.

3.6 Surface water

The site is located within two drainage catchments, referred to as 'Poison Gully' (PG, northern portion of the site) and 'Airport South' (AS, southern portion of the site) (Figure 8). Poison Gully drains into the Perth Airport Northern Main Drain. The Airport South catchment drains into the Peth Airport Southern Main Drain.

Within the RP, drainage infrastructure is limited to open drains within road reserves where required.

The majority of the RP has:

- sandy soils
- significant depth to groundwater
- limited areas of hardstand.

Consequently, runoff is currently infiltrated on site in smaller events, with flows offsite occurring in larger events.

The Main Drains are currently operated by Water Corporation. Both Main Drains drain into the Swan River. Arterial drainage planning for these drainage systems are documented in:

- *Limestone Creek (Perth Airport Northern Main Drain) Stage 1 Capacity Review 2010* (Water Corporation 2010)
- *Perth Airport Southern Main Drain Scheme Review (2006),* Water Corporation 2007.

3.6.1 Poison Gully

Poison Gully, which collects water from elevated areas to the east of the LSP precinct areas and flows in a westerly direction via the Perth Airport Northern Main Drain and Limestone Creek into the Swan River (Figure 9). Poison Gully is an ephemeral creek that flows during the winter months. Water monitoring in Poison Gully commenced in September 2011, with water only present in September and October 2011. Poison Gully is located largely to the north of the RP boundary (Figure 9). Poison Gully also has Aboriginal Heritage significance as it is a water source and a historical birthplace (Ethnosciences 2018).

Water Corporation has undertaken hydraulic and hydrological modelling of Poison Gully as part of the *Limestone Creek (Perth Airport Northern Main Drain) Capacity Review* (2010). Flood levels and extent of flooding were interpolated from the Water Corporation (2010) modelling (Appendix 4). Extents of flooding and levels shown have been estimated for a previous foreshore assessment based on this modelling (Appendix 4). Development within the Poison Gully floodplain is not proposed.

The width of the mapped 1% Annual Exceedance Probability (AEP, equivalent to 100-year Average Return Interval) flood plain is variable, ranging from less than 10 m to approximately 40 m at the widest point. The Water Corporation (2010) modelling does not identify a separate floodway (area of fast flow) and flood fringe (area of slower water movement).

Road culverts for Poison Gully are as follows:

- Roe Highway – four 1500 mm diameter culverts
- Littlefield Road – 2000 x 3000 mm box culvert
- Milner Road – one 1350 mm diameter culvert
- Maida Vale Road – two 1350 mm diameter culverts (Water Corporation 2010).

Water Corporation (2010) considered that these culverts were adequate for the current flows in Poison Gully, based on the level of development. Should overtopping of surface water at Milner Road be considered unacceptable from a serviceability perspective, the current design of the road and culverts may need to be reviewed.

The Water Corporation monitored surface water quality in Poison Gulley at Littlefield Rd from 1981 to 2011. Strategen Environmental performed surface water monitoring downstream of the Site near Dundas Rd in 2015 (Appendix 8). The Water Corporation surface water quality results for 2011 and the are provided in Table 8.

Table 8: Predevelopment surface water quality results

Analyte	TN (mg/L)	TP (mg/L)	TKN (mg/L)	NH4 (mg/L)	NOX (mg/L)	pH	EC (mS/cm)
Dundas Rd (3-6-2015)	0.8	2.2	0.5	>0.02	0.25	7.2	-
Littlefield Rd 2011 average	1.0	0.05	0.4	0.04	0.6	7.1	-

Foreshore assessment and management

A foreshore assessment and boundary delineation for Poison Gully was included in the approved DWMS (Strategen 2012, Appendix 4). The foreshore boundary has been delineated based on consideration of bank steepness, presence of native vegetation and the 1% AEP floodway (Appendix 4). The most important factor has generally been the floodway and the presence of native vegetation that stabilises the banks and strips nutrients.

The Poison Gully foreshore area consists largely of retained vegetation. The management of foreshore areas and other retained vegetation which extends into the site will be addressed through preparation of a POS Revegetation Management Plan as identified in the *Forrestfield North Residential Precinct Environmental Assessment Report and Management Strategy* (Strategen 2018).

3.6.2 Airport South catchment

The Airport South catchment includes approximately 114 ha of land to the west of Roe Highway in Maida Vale (MV1 and MV2) (Figure 8). Historically, any water not infiltrated in MV1, MV2 or the RP would have run through the AS4/AS5 and Nardine Catchments and discharged to the west of Dundas Road as shown in Figure 8. Recent industrial development in the Nardine Catchment has impeded the flow path from AS3 to the Dundas Road area, where filling of low-lying areas identified as flow paths in the 1% AEP event by Water Corporation (2007) has occurred.

Catchments MV1 and MV2 which drains into an approximately 2400 m^3 basin (Bartlett D [CoK] 2017, pers. comm. 3 November) on the site via one 600 mm diameter Main Roads culvert (Figure 8). Because of industrial development in the Nardine Catchment, the basin no longer has a clear discharge pathway (i.e. no drain or delineated creek line) and is located on the former Brand Road Landfill.

The LWMS has reviewed the current situation with respect to these catchments and catchment Forrest2, which is similarly affected by development in the Nardine Catchment.

Flows into the Nardine Catchment are anticipated to occur in larger events only (e.g. 5205 AEP event and larger). As the southern portion of the Nardine Catchment has not been developed, it is possible that localised flooding has occurred but has not been in a location or of a scale to cause concern.

3.7 Wetlands and groundwater dependent ecosystems

A search of the Geomorphic Wetlands of the Swan Coastal Plain Database shows that the western section of the precinct is mapped as a Multiple Use Wetland (MUW), and a portion of Poison Gully Creek and an area to the south, both outside of the RP boundary, are classified as a Palusplain Resource Enhancement Wetland (REW) (UFI 13997) (DWER 2017, Figure 9).

REW's are considered as priority wetlands where they have been partially modified but still support substantial ecological attributes and function. The ultimate objective is to manage, restore and protect towards improving their conservation value. No unauthorised development is permitted within a REW. A generic wetland buffer to protect the wetlands ecosystem is usually associated with REW, site buffer assessment can be undertaken to determine the buffer widths (EPA 2008). The existing buffer (generic 30m) associated with REW (UFI 15880) (Poison Gully) is semi developed (i.e. residential properties, cleared footprints and sheds).

MUW's are the lowest management category assigned to wetlands by the DWER, and are generally considered appropriate for development, provided the hydrological regime is not disturbed (EPA 2008).

Based on the depth to groundwater, the wetlands in the RP are not considered to be dependent on groundwater.

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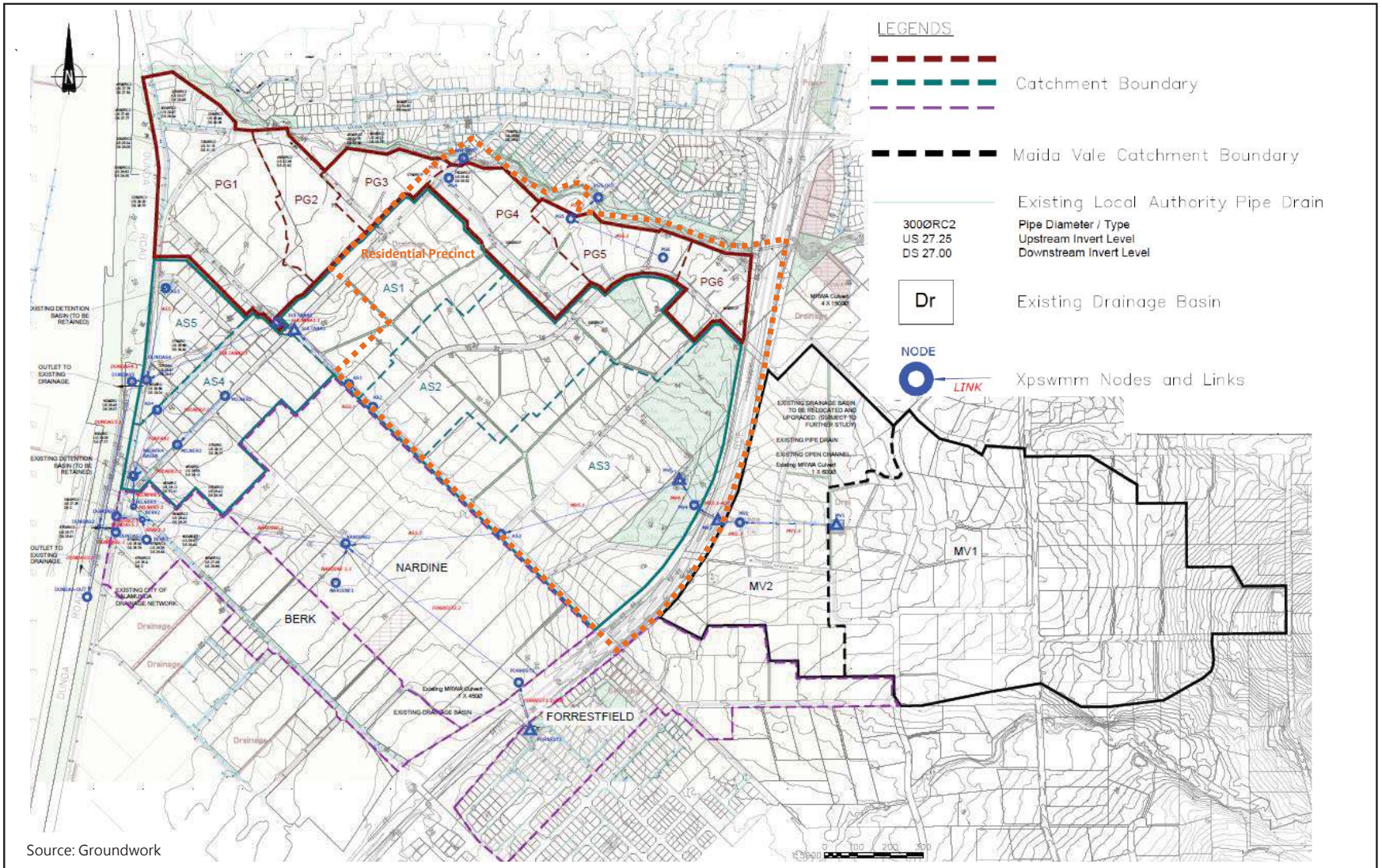

Source: Groundwork

Figure 8: Surface Water Catchments

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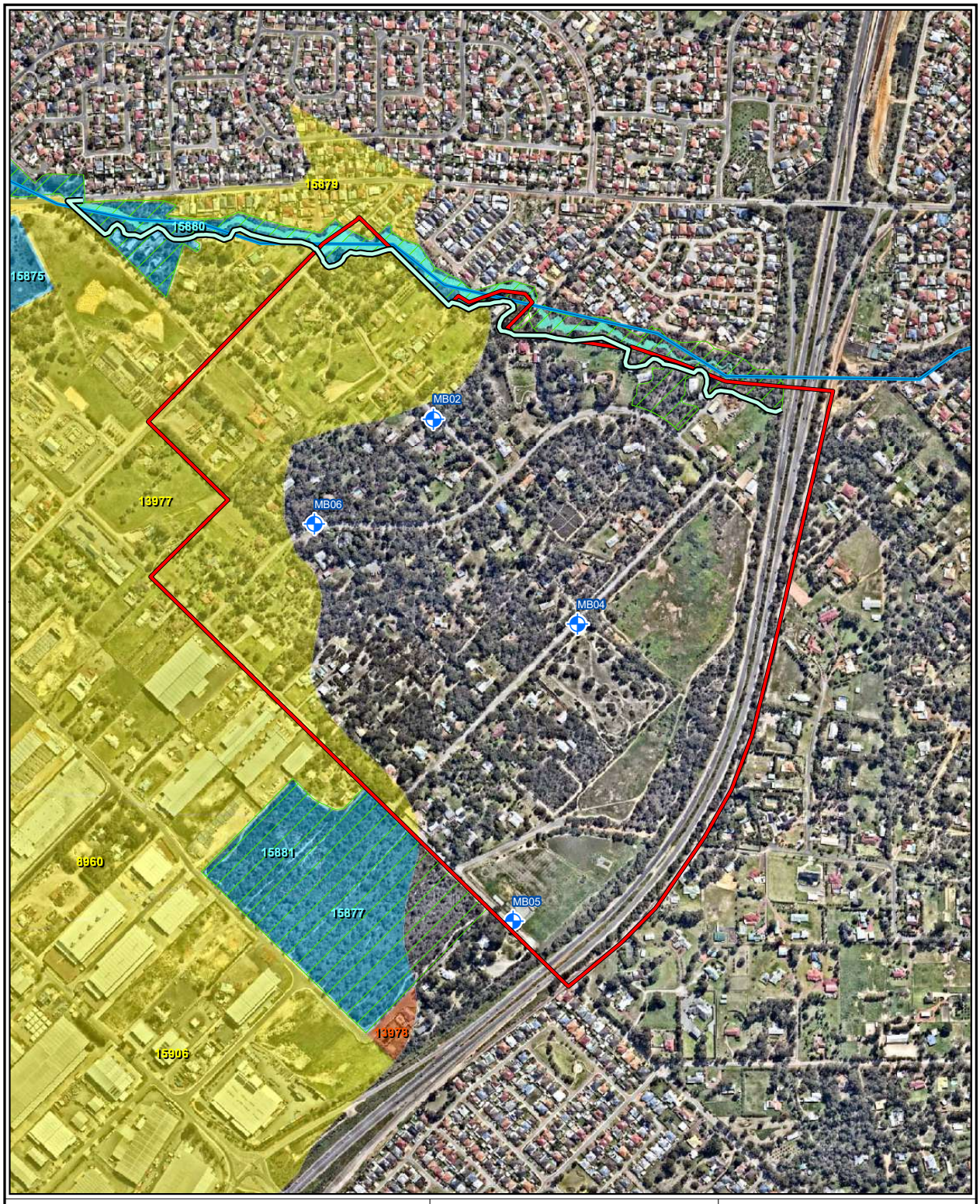

Legend:

- Residential precinct
- Estimated 100 year flood area
- Bush Forever site
- Geomorphic Wetlands (DBCA)
  - Resource Enhancement
  - Multiple Use
  - Not Applicable
- Foreshore boundary
- Poison Gully Creek
- Groundwater monitoring bore

Scale 1:10,000 at A4 (0 100 200 metres)		**Forrestfield North Residential Precinct, WA**
Coord. Sys. GDA 1994 MGA Zone 50		**WETLANDS AND SURFACE WATER**
Job No: 57806		
Client: Element		**FIGURE 9**
Version: A	Date: 24-Sep-2020	strategen JBS&G
Drawn By: cthatcher	Checked By: JH	

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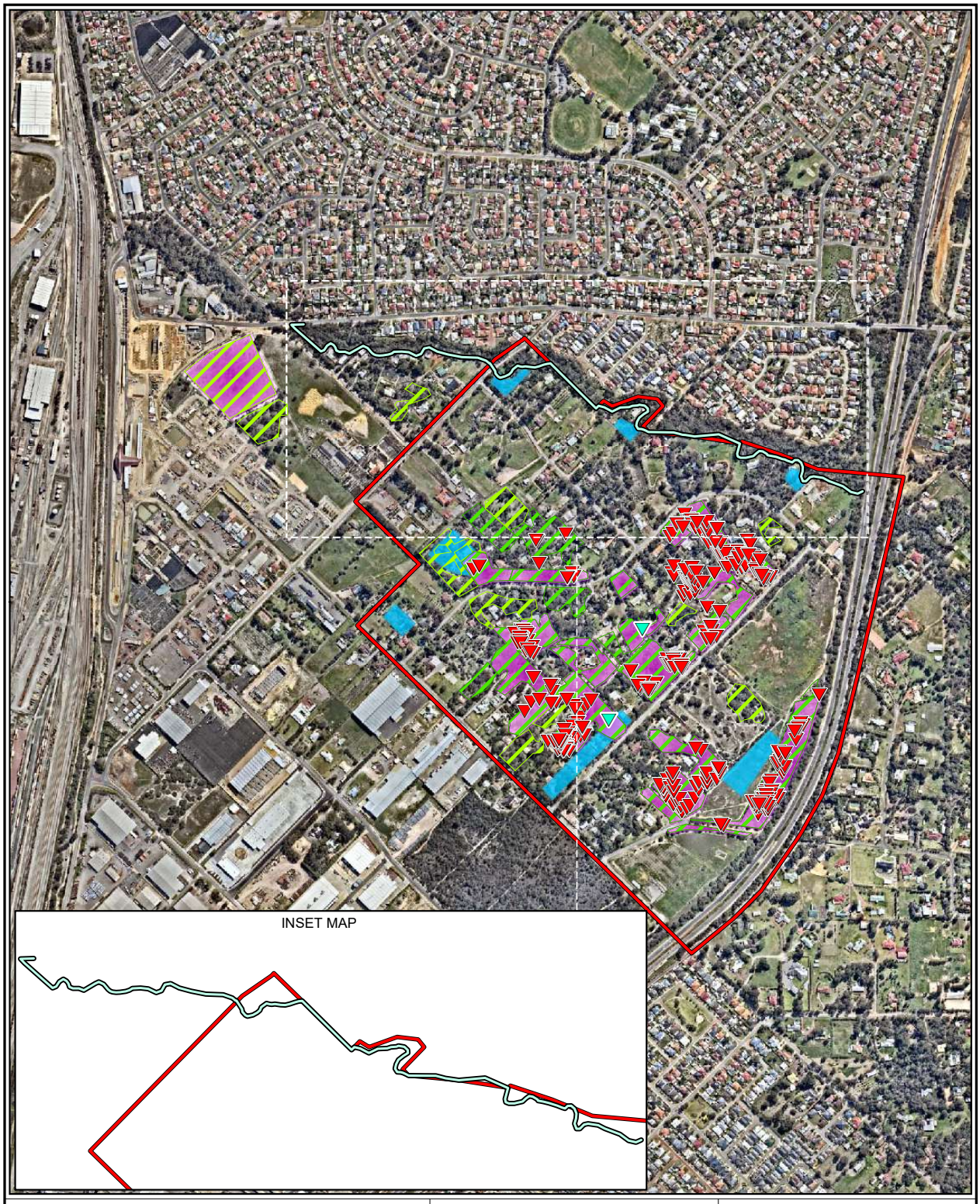

Legend:
- Residential precinct
- 1% AEP drainage basin
- TEC extent / Banksia woodland TEC

Black cockatoo habitat
- High quality habitat
- Valued quality habitat

- Foreshore boundary
- *Isopogon drummondii* (P3)
- *Conospermum undulatum* (T)

Scale 1:12,500 at A4 — 0 100 200 metres

Coord. Sys. GDA 1994 MGA Zone 50

Job No: 57806

Client: Element

Version: A | Date: 24-Sep-2020

Drawn By: cthatcher | Checked By: JH

Forrestfield North Residential Precinct, WA

ENVIRONMENTAL PLAN

FIGURE 10

strategen JBS&G

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3.8 Biodiversity and natural assets

A detailed discussion of the vegetation, flora and fauna of the RP is provided in the *Residential Precinct Environmental Assessment and Management Strategy* (EAMS, Strategen 2018). The EAMS discussed that remnant vegetation on site has been fragmented through semi-rural land development and clearing for building footprints. The key environmental assets for the site include the:

- Banksia Woodlands of the Swan Coastal Plain Threatened Ecological Community
- *Conospermum undulatum* (Wavy-leaved Smokebush) – threatened species
- Black Cockatoo foraging and habitat trees (Figure 10).

A Strategic Conservation Management Plan (SCMP) (Emerge, 2020) was prepared in order to "provide an overarching framework that will support the implementation of the LSP and ensure the long-term preservation of biodiversity values through:

- Specifying and guiding the required impact avoidance and conservation gain outcomes for identified biodiversity values in the LSP area.
- Providing greater certainty regarding conservation outcomes and management requirements for Kal (the City), government departments (state and commonwealth), the local community and future developers of land within the LSP area."

The above documents have informed the design of the site such that it aims to:

- consolidate existing fragmented environmental areas and to retain and conserve viable significant flora, threatened ecological communities and fauna habitat
- create a planning outcome which will ensure the long-term protection and management of the 'ecology retention area' (new Bush forever /conservation area).

To achieve these objectives, the land take for drainage has been minimised and extensive areas of bushland have been maintained, with a focus on retaining and rehabilitating key environmental assets and providing biological linkages. This includes commitments to the retention and rehabilitation of bushland in new environmental conservation areas as shown in Figure 2.

4. Water sustainability initiatives

The scope of works for the RP involved the assessment of potential water sustainability initiatives for use at a precinct and lot level. Because of the relatively high density of development proposed (R40 to R100), the development is anticipated to consist of a mixture of small individual lots and groups of apartments and/or townhouses constructed and operated by a strata body. The water sustainability measures proposed are cognisant of the type of development proposed in the RP.

4.1 Principles

Potential water sustainability measures have been assessed against the sustainability principles outlined in the *Water Resources Statement of Planning Policy 2.9* (WAPC 2004). This requires that an integrated approach is needed to address these issues and achieve sustainable outcomes and an acceptable 'prioritisation and balance' between competing interests (WAPC 2004). This requires that sustainability is pursued through integration of:

- environmental protection (including protection of water resources)
- social advancement
- economic prosperity (WAPC 2004).

Initiative options have consequently been evaluated against environmental, social and economic criteria.

4.2 Initiative options

The RP development is anticipated to consist of a mixture of single dwellings and strata developments in the form of apartments and townhouses. Consideration was given to both precinct and lot/strata scale options.

Precinct scale options considered were:

1. Stormwater Managed Aquifer Recharge (MAR).
1. Wastewater recycling.
2. Improved water and fertiliser efficiency in POS irrigation through installation of soil amendments or water efficient irrigation systems at construction.
3. Use of pervious pavements to increase infiltration in paved areas of POS, car parks and pedestrian pavements.

Lot/strata options considered were:

1. Water efficient gardens at a lot/strata scale.
2. Installation of water efficient fixtures.
3. Rainwater tanks for in-house water use.
4. Rainwater tanks for ex-house water use.
5. On-lot greywater/wastewater recycling.
6. Roof gardens.

Initiative options have consequently been evaluated against environmental, social and economic criteria consistent with the principles outlined in SPP 2.9 (WAPC 2004) with consideration given to practicability (Table 9). Where initiatives show benefits but may have significant costs or logistical issues (such as pervious pavements), trials have been recommended to assess the suitability of these initiatives for use in the RP.

4.3 Evaluation of options

The evaluation of options is presented in Table 9.

Table 9: Sustainability option evaluation

Option	Economic	Social	Environmental	Recommendation
Precinct scale options				
Stormwater Managed Aquifer Recharge (MAR).	1. High capital cost. 2. High operating cost. 3. Cost per kilolitre anticipated to be higher than scheme water and groundwater.	1. May allow for increased irrigation of POS.	1. Benefit to water dependent ecosystems because of reduced groundwater abstraction for POS irrigation.	Not a preferred option. Investigation identified likely high cost and significant uncertainties around site suitability for MAR (Section 3.5.4). The City undertaking identification and evaluation of potential MAR sites within the City.
Wastewater/greywater recycling (with or without MAR).	1. High capital cost. 2. High operating cost. 3. Cost per kilolitre anticipated to be higher than scheme water and groundwater.	1. May allow for increased irrigation of POS. 2. Challenges in finding a suitable long-term manager for the scheme if it is not economically viable.	1. Treated wastewater/greywater contains high concentrations of nutrients which can impact on groundwater and surface water quality. These nutrients must either be removed as part of the treatment process or the wastewater used in locations where this is not of concern (i.e. away from creeks and wetlands).	Not a preferred option.
Improved water and fertiliser efficiency in POS irrigation through soil amendment or installation of extremely water efficient below ground irrigation at construction.	1. Low to moderate capital cost compared to MAR, but higher than a conventional POS. 2. Operational cost similar to or higher than standard POS. The use of soil amendments are not anticipated to result in any additional operating costs. 3. May lower operating costs if less water is required.	1. Neutral – not anticipated to result in a perceptible difference to standard POS.	1. Benefits in reduction in nutrient loads to groundwater/surface water and groundwater abstraction.	All POS landscaping will be water efficient. Trial recommended for soil amendment and below ground irrigation. Preferred methods to be trialled on the first two POS areas containing turf to be developed with consideration given to expanding use after the trial (Section 7.2.1).

Option	Economic	Social	Environmental	Recommendation
Use of pervious pavements to increase infiltration in paved areas of POS, car parks and pedestrian pavements.	1. Typically, higher capital cost than traditional paving. 2. Typically, higher maintenance requirements and costs than conventional paving because of need to prevent clogging (Section 5.1.4).	1. Potential reduction in POS land take for drainage will increase the useability of POS. 2. Limited benefit in urban heat island effect. Permeable pavements can be cooler than other pavements when wet but little or no benefit during the drier (summer) months (USEPA 2008).	1. Potential to infiltrate water on site may reduce requirements for drainage areas. 2. Removal of sediment and nutrients from stormwater compared to conventional pavement (DPLG 2010).	Trial proposed for future potential adoption. To be included in design guideline. Pervious paving to be trialled by the City at either the Community Purpose (Community Hub) site or District Open Space for use in car parks and/or low traffic areas (e.g. laneways) (Section 5.1.4).
Large scale community storage rainwater in underground tanks for reuse in irrigation	1. High capital cost. 2. High operating cost. 3. Cost per kilolitre anticipated to be higher than scheme water, groundwater and MAR (because of need to install large tanks).	1. May allow for increased irrigation of POS.	2. Benefit to water dependent ecosystems because of reduced groundwater abstraction for POS irrigation.	Not a preferred option. Investigation identified likely high cost and significant uncertainties. The City undertaking identification and evaluation of potential MAR sites within the City.
Lot/strata scale options				
Water efficient gardens at a lot/strata scale (i.e. low water use landscaping and water efficient irrigation).	1. Low capital cost. 2. No significant difference in operating (maintenance) costs to householders anticipated. 3. Limited operating cost benefits. The higher density housing proposed in the RP results in small garden areas, so irrigation is anticipated to be only 11% of household water use (Section 7.1). Operating costs for household irrigation will be low regardless of whether development areas are low.	1. Additional agency approvals for dwelling construction not required.	1. Limited water use reduction as irrigation is only a small portion of potable water demand. Reducing potable water demand reduces groundwater abstraction from the environment and greenhouse emissions from pumping and desalination. 2. Water efficient gardens are more likely to include local species that benefit native birds and wildlife.	Encouraged. To be included in design guideline. Use of water efficient landscaping at a household level is encouraged as best practice.
Installation of water efficient fixtures (e.g. taps, toilets).	1. Small increase in capital cost compared to standard fixtures (perhaps $200-$300 per house). 2. Reduction in household water bills with limited operating costs (maintenance cost).	1. Additional agency approvals for dwelling construction not required.	1. The use of water efficient fixtures in all buildings for toilets, showers and taps could reduce potable water demand by approximately 12%.	Preferred option. To be included in design guideline. The use of water efficient fixtures will be mandated for all new buildings.

Option	Economic	Social	Environmental	Recommendation
Rainwater tanks for in-house water use (e.g. toilets, washing machines).	1. Capital cost estimated at $3000 for an individual house. 2. Householder operating costs higher than scheme water because of need for pumping to maintain water pressure and maintenance of tank. 3. Overall cost per kilolitre higher than scheme water (Section 7.1).	1. Feel good factor. 2. Requires additional householder or strata company maintenance to keep tank clean and pump operational. 3. Additional agency approvals for dwelling construction not required.	1. Potential benefit in reduction in scheme water use by 17%, reducing water abstraction from the environment and greenhouse gas emissions.	Preferred option. To be included in design guideline. Installation of rainwater tanks for in-house water use is supported for individual green title lots. The use of rainwater tanks for multi-dwelling strata lots will require additional management considerations by the corporate body management such as the legal and compliance issues to ensure the tanks provide acceptable quality water and equitable distribution of costs.
Rainwater tanks for ex-house water use.	1. Capital cost estimated at $1500 for a 1000L tank for individual house. 2. Overall cost per kilolitre higher than scheme water (Section 7.1). 3. Larger tanks for strata scale may be more viable.	1. Feel good factor. 2. Requires additional householder or strata company maintenance to keep tank clean and pump operational. 3. Additional agency approvals for dwelling construction not required.	1. Limited benefit if used only for irrigation, unless very large tanks are provided. Reasonably sized rainwater tanks in Perth cannot provide water over the dry summer months when irrigation is required. 2. Scheme water may be replaced/augmented if there is a non-potable, wet season water demand.	Not recommended in isolation. Advantages are at best marginal unless coupled with in-house rainwater water use.
On-lot greywater/wastewater recycling.	1. Requires each house to install a treatment system. High capital cost. 2. As external (irrigation) water use is anticipated to be low, benefits can only be realised if systems are plumbed into internal water uses (e.g. toilets, washing machines), a high level of treatment is required. 3. Operating costs higher than scheme water because of need for treatment, pumping and maintenance. 4. Overall cost per kilolitre typically higher than scheme water.	1. Feel good factor. 2. Regulatory complexity. Requirement for approval from Department of Health for individual households and/or strata companies for each building with a greywater or wastewater recycling system. 3. Requires additional householder or strata company maintenance to keep treatment and pump operational. 4. Potential for health risks if system is not properly installed and maintained.	1. Potential benefit in reduction in scheme water use similar to or greater than rainwater tanks, reducing water abstraction from the environment and greenhouse gas emissions.	Not recommended. Installation of domestic greywater or rainwater recycling systems are encouraged but not mandated because of the regulatory complexities, potential health risks and high capital and operating costs.

Option	Economic	Social	Environmental	Recommendation
Roof gardens.	1. Requires strong rooves designed to: • manage the weight of the soil and plants, which may be 0.1 - 1 tonne/m^2 • provide effective drainage for the above garden bed, including drainage layers and waterproof membranes to protect the house residents below (City of Sydney, undated). 2. Designing to these standards is anticipated to result in significant additional construction costs, particularly for single dwellings which typically have lightweight, lower strength metal or tile roofs. 3. Higher maintenance costs and requirements than a typical roof (e.g. weeding, inspection of membranes and drainage layers).	1. Feel good factor. 2. Reduces urban heat island effect by absorbing heat and providing roof insulation (and consequently energy costs). 3. May provide additional green space and amenity to residents within their lots where gardens can be made accessible. 4. Requires regular maintenance by strata or lot owner.	1. Provides stormwater treatment. 2. Roof gardens are similar to pot plants with respect to soil depth and will require regular irrigation over the summer months. Systems with thinner soil layers ('extensive' green rooves) may also require irrigation during periods of infrequent rain. This may increase potable water demand.	For developer consideration at UWMP stage. Trial recommended on public building if appropriate site available. To be included in design guideline. Roof gardens can have a significant benefit in terms of water treatment, reducing urban heat island effects. Where buildings are designed to have heavier roof loads (e.g. apartment blocks which typically have air-conditioning and water tanks on rooves), roof gardens may be able to be constructed with limited additional cost. For single storey residential dwellings, the cost of installing a roof garden may be prohibitive.

5. Surface water management strategy

5.1 Surface water management system

The stormwater drainage system has been designed using a major/minor approach. The major drainage system includes the use of roads, swales, detention storages and open spaces to provide safe passage of stormwater runoff from major storm events greater than 18% AEP and up to the 1% AEP. The minor system will focus on treatment of the 63% AEP, 1 hour event and involves the use of raingardens within some road reserves and areas of POS identified for drainage purposes, outside of the areas of POS identified for Environmental Conservation purposes (Figure 2).

5.1.1 Minor drainage system

The minor drainage system is defined as the series of raingardens, kerbs (flush or no kerb), pipes and gutters designed to convey runoff generated by minor storms up to and including the 1 hour duration, 63% AEP storm event. The minor drainage system incorporates best management practice (BMP) water quality structural controls such as vegetated raingardens and bioretention storages that provide water quality treatment in the RP area. Proposed locations of POS storages for the 63% AEP event are shown on Figure 11. Storage details are presented in Table 10.

Key points of the minor drainage system strategy are as follows:

1. Treatment of stormwater from roads in vegetated storages within detention storages sized to treat the first 16 mm of rainfall from the roads. Storages will be located in car parks, streets and POS. This is approximately the 1 hour duration, 63% AEP storm event, which comprises 99% of the total annual runoff volume (DoW 2011).
2. Lots and laneways will be required to retain the first 16 mm, approximately equivalent to the 1 hour duration, 63% AEP storm event at source using methods as described in Section 5.1.3.
3. The following major streets have been designed to include roadside swales, with additional raingarden volume provided in drainage storage areas (DSAs), areas of public open space identified for drainage purposes (Figure 15):
   - New Main Connecting Road
   - Milner Road
   - Stewart Road
   - Brae Road
   - Brand Road
   - Sultana Road West.

   The use of raingardens/swales and tree pits on all roads to manage stormwater will be employed for minor roads adjacent to the Poison Gully POS and encouraged for all other roads with a preference for median swales where possible. Finalised swale/raingarden designs and locations will be presented in the Urban Water Management Plans. Minimum design guidelines for raingardens are presented in Section 5.3.

   Opportunities for overland flow paths will be considered at a Subdivision stage where these are consistent with structure plan requirements (e.g. Bush Forever, land ownership).
4. Kerb breaks and flush kerbing to be utilised around POS and raingardens to encourage overland flow.
5. An outlet pipe of 600mm diameter is required from the corner of Sultana and Milner Rd (AS1) through to the basin at the corner of Milner and Berkshire Roads. This pipe is required along Sultana Rd, Milner Rd and across Dundas Rd to the existing outlet channel.

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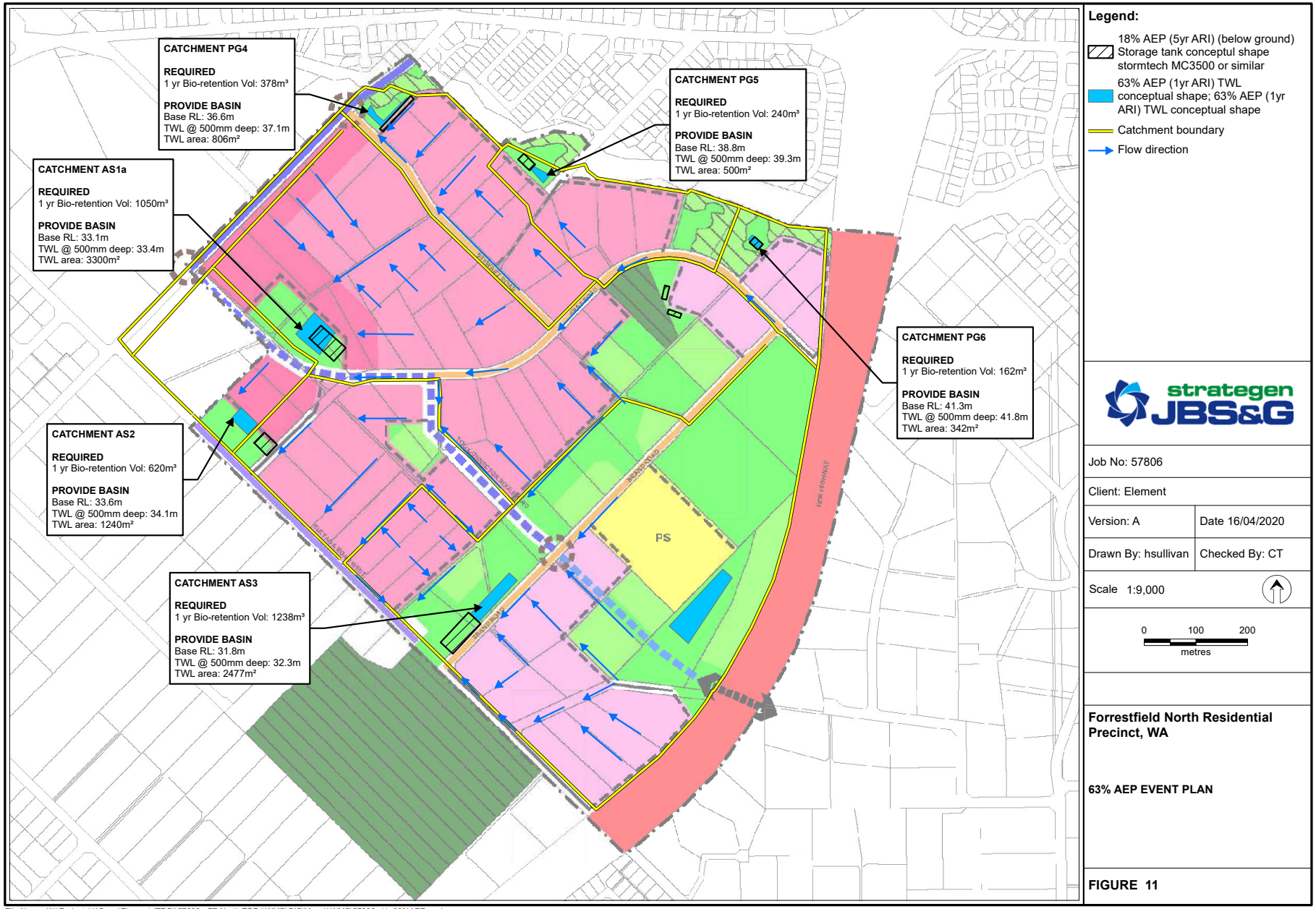

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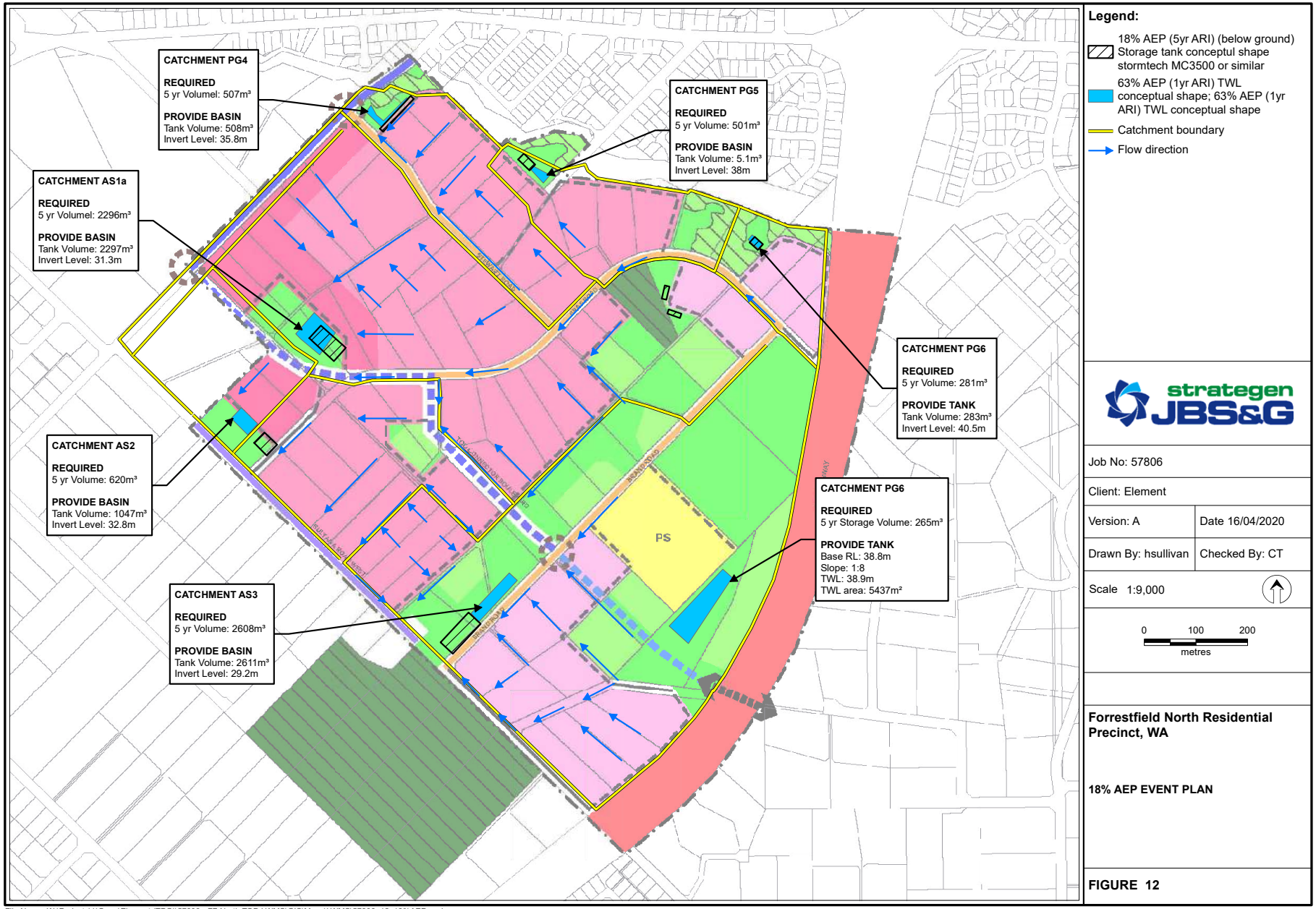

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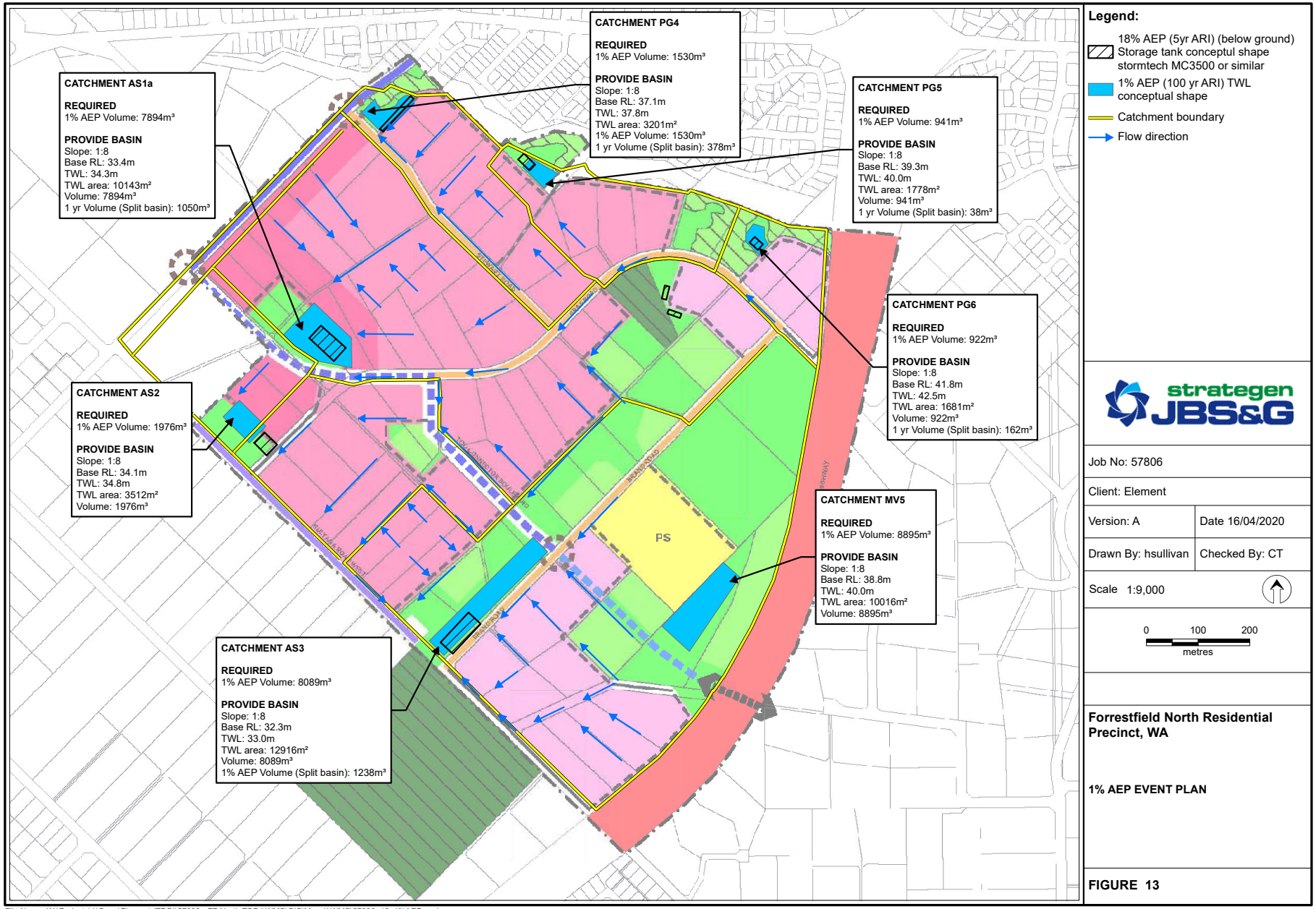

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Table 10: Storage details - 63% AEP, 1 hour event*

Catchment	Above ground storage provided (m^3)	Above ground storage TWL area (m^2)	Above ground storage invert (mAHD)	Above ground storage TWL (mAHD)	Above ground storage depth (m)	Outflow (m^3/s)
PG4	378	806	37.1	37.6	0.5	0
PG5	240	500	38.8	39.3	0.5	0
PG6	162	342	41.3	41.8	0.5	0
MV5	-	0	38.8	-	-	0
AS1a	1,050	3300	33.1	33.4	0.3	0
AS2	620	1240	33.6	34.1	0.5	0
AS3	1,238	2477	31.8	32.3	0.5	0

*All values are indicative and must be reviewed at subdivision stage

Table 11: Total storage for 1% AEP*

Catchment	Modelled hydraulic conductivity (m/day)	Below ground storage provided (m^3)	Above ground storage provided (m^3)	Total storage provided (m^3)	100 year storage base area (m^2)	Above ground storage TWL area (m^2)	Below ground storage invert (mAHD)	Above ground storage invert (mAHD)	Above ground storage TWL (mAHD)	Total above ground storage depth (m)	Outflow (m^3/s)	Outlet diameter (mm)	Side Slopes 1 in x
PG4	3.1	507	1,908	2,415	1,799	3201	35.8	36.6	37.8	1.2	0.076	225	8
PG5	0.4	501	1,181	1,682	915	1778	38	38.8	40.0	1.2	0.059	225	8
PG6	0.4	281	1,084	1,365	874	1681	40.5	41.3	42.5	1.2	0.037	225	8
MV5	1.3	0	8,895	8,895	5,437	10,016	-	38.8	40.0	1.2	0	N/A	8
AS1a	0.3	2296	8,944	11,240	1,681	10,143	31.3	33.1	34.3	1.2	0.081	300	8
AS2	0.6	1049	2,596	3,645	10,143	3,512	32.8	33.6	34.8	1.2	0.055	300	8
AS3	0.4	2,608	9,327	11,935	9,269	12,916	29.2	31.8	33.0	1.2	0	N/A	8

*All values are indicative and must be reviewed at subdivision stage

Table 12: Storage details– 5% AEP event*

Catchment	Below ground storage provided (m^3)	Above ground storage provided (m^3)	Total storage capacity (m^3)	Above ground storage TWL area (m^2)	Above ground storage invert (mAHD)	Above ground storage TWL (mAHD)	Above ground storage depth (m)	Outflow (m^3/s)	Outlet diameter (mm)	Side Slopes 1 in x	POS Area	% of POS area inundated
PG4	507	378	885	806	37.6	37.1	0.5	0.053	225	8	7,751	10
PG5	501	240	741	500	39.3	38.8	0.5	0.052	225	8	3,669	14
PG6	281	162	443	342	41.8	41.3	0.5	0.037	225	8	7,725	4
MV5	0	-	265	5437	38.9	38.8	0.1	0	N/A	8	105,072	5
AS1a	2296	1050	3,346	3300	33.4	33.1	0.3	0.068	300	8	10,522	31
AS2	1049	620	1,669	1240	34.1	33.6	0.5	0.045	300	8	6,917	18
AS3	2,608	1238	3,846	2477	32.3	31.8	0.5	0	N/A	8	23,021	11

*All values are indicative and must be reviewed at subdivision stage

5.1.2 Major drainage system

The major drainage system has been designed to maintain the pre-development flow off the site in events up to the 1% AEP, 48-hour event as requested by Water Corporation (Kanagaratnam K, 2017, pers. comm. 12 December). In most catchments, the critical storm duration is the 6-hour event and larger storages are required for this event.

Key points of the major drainage system strategy are as follows:

1. Minor roads will be graded to direct flow overland to the lowest point in each catchment. The ultimate road low point will be adjacent to POS, with overflow flood storage provided within the drainage storage area, an area of POS being prioritised for drainage, rather than conservation or recreation, purposes. The POS design will aim to create flood storage in an informal manner, minimising formal drainage storage areas. Major event storages are anticipated to be turfed to form useable POS areas.
2. To maximise POS amenity and minimise the impact of inundation on POS areas, a mixture of below and above ground storage is proposed.
3. All lot finished levels will have a minimum 0.3 m clearance above the estimated 1% AEP flood level in the road and POS.
4. All lot finished levels will have a minimum 0.5 m clearance above the estimated 1% AEP flood level of the detention storages and Poison Gully.
5. Overland flow pathways are proposed to Poison Gully in consultation with appropriate stakeholders, including Aboriginal communities.
6. Top water levels in a major event will be no greater than 1.2 m for safety and amenity reasons. Major event basins have been designed with a batter of 1 in 8.
7. The Storage layout and locations shown are conceptual and will be reviewed at the UWMP stage based on the detailed earthworks and civil designs.
8. To prevent building and critical infrastructure, commercial and industrial building habitable floor levels with the following minimum clearances above the 1% annual exceedance probability (AEP) flood level:
   - road drainage systems: 0.3 m
   - terminal retention or detention areas with no overflow relief: 0.5 m
   - major drainage system and waterways: 0.5 m.

   These clearances will be demonstrated through detailed design at the UWMP stage.

Details of storages are presented in Figure 12, Figure 13, Table 11 and Table 12. Figure 14 provides a conceptual cross section of the proposed major event storage.

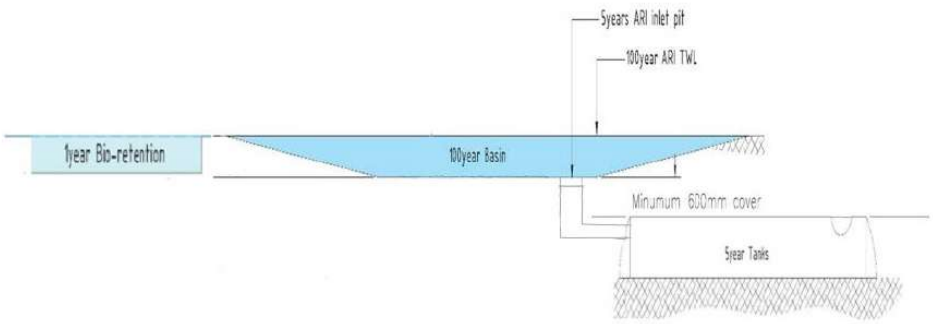

Figure 14: Conceptual storage design

5.1.3 Lot scale water management

Lots (including strata developments) and laneways will be required to retain and infiltrate the first 16 mm of rainfall within the lot or strata development (equivalent to the 1 hour, 63% AEP event) prior to the water entering the road drainage system.

Lot scale water management systems should aim to include a treatment element in the form of a lot scale bioretention system (Plate 1), biofiltration tree pits or a planted roof garden to clean stormwater prior to infiltration. The use of pervious pavements for outdoor spaces and driveways is encouraged to reduce stormwater volumes, consistent with *Decision Process for Stormwater Management in Western Australia,* November 2017. Water may be infiltrated through soak wells and subsurface soakage tanks and cells if required. Pervious pavements may also be used for driveways and outdoor paving to reduce the amount of runoff produced on the lot (Section 5.1.4).



Plate 1: Lot scale bioretention systems

Source: newwaterways.org.au

5.1.4 Pervious pavement

Pervious pavement (otherwise known as permeable and porous pavement) is a load bearing pavement structure that is permeable to water.

Pervious pavements fall into two broad categories:

1. Permeable pavements, which comprise a layer of paving blocks typically impervious, specially shaped to allow the ingress of water by way of vertical 'slots' or gravel-filled 'tubes'. There are generally large gaps between impervious paved areas for infiltration (Plate 2).
2. Porous pavements, which comprise a layer of highly porous material (DPLG 2010).



Plate 2: Permeable pavement with tree pits
Source: Place Lab

Pervious pavements can potentially be used in:

- private paved areas such as courtyards
- areas with low traffic volumes and light traffic weight (e.g. laneways, driveways)
- car parks
- pedestrian pavements
- public open space (DPLG 2010).

Pervious pavements can have advantages compared to traditional pavements because of:

- increased infiltration of stormwater and reduced runoff
- reductions in sediment and nutrient loads (DPLG 2010).

Pervious pavements can be cooler than other pavements when wet due to evaporation but offer little or no benefit when dry (USEPA 2008). Pervious pavements are unlikely to reduce the urban heat island effect in the dry summer months when this effect is most needed.

The disadvantages of pervious pavements are:

- pervious pavements can become clogged with oil and sediment over time
- to remove or prevent clogging, maintenance is required in terms of:
  - high pressure hosing, sweeping or vacuuming to remove sediments and maintain infiltration rates
  - periodic replacement of aggregate layers (approximately every 20 years) and replacement of geotextile fabric
  - maintenance of surface vegetation (if present, permeable pavements only).

Such maintenance is higher and potentially more costly than that which is required for a conventional pavement. For these reasons, pervious pavements are not commonly installed in Western Australia.

The largest areas for potential use of pervious pavements in the RP are laneways, and car parks associated with the District Open Space (DOS) (Figure 15). Primary School and Community Purpose (CP) site. Laneways and car parks constructed by the City such as the CP site and DOS, offer an opportunity to trial the use of permeable pavement in the RP. As part of the construction of the CP site and the DOS, the City should undertake a trial of the use of permeable paving for low traffic areas and/or car parks.

Design of the lot scale bioretention systems, pervious paving and soak wells will be mandated through the Design Guidelines that form part of the Structure Plan.

5.2 Surface water modelling

The pre-development XP-SWMM model was used based on the land uses presented in Table 13 and the modelling parameters and assumptions presented in Table 14. Modelling assumptions and critical durations were developed in consultation with Water Corporation. Pre-development catchment boundaries and land uses are presented in Table 13 and Figure 8. Hydraulic conductivities are presented in Table 11.

Table 13: Pre-and post-development land use*

Catchment	Land use	Pre-development area (m^2)	Post-development area (m^2)	Catchment
PG4	Lots	82,074	59,558	PG4
	Road	12,884	30,097	
	POS	-	5,118	
PG5	Lots	62,010	32,043	PG5
	Road	4,906	18,904	
	POS	-	15,969	
PG6	Lots	45,120	20,059	PG6
	Road	7,509	12,738	
	POS	-	12,047	
AS1a	Lots	167,430	180,769	AS1a
	Road	17,480	78,058	
	POS	-	61,462	
AS1b	Lots	22,356	34,555	AS1b
	Road	2,334	8,211	
	POS	-	-	
AS2	Lots	265,045	72,677	AS2
	Road	29,173	45,994	
	POS	-	12,870	
AS3	Lots	419,893	159,595	AS3
	Road	36,036	93,610	
	POS	-	182,117	
MV1	Lots	749,294	749,294	MV1
	Road	63,770	63,770	
MV2	Lots	319,889	319,889	MV2
	Road	12,222	12,222	

*All values are indicative and must be reviewed at subdivision stage

Table 14: Catchment runoff parameters

Land use	Impervious fraction	Surface roughness (Manning's n)		Initial loss (mm)	Continuous loss (mm/hr)
		Impervious	Pervious		
Rural lots	0.1	0.014	0.025	Horton's equation, Medium well drained, AMC3	
Rural roads	0.5	0.014	0.025	16	6
Urban lots	0.9	0.014	0.025	26	6
Urban roads	0.9	0.014	0.025	1.5	0
Urban roads with biofilter	0	0.014	0.025	26	6
POS - bush	0	0.014	0.4	26	7
Commercial /industrial (existing)	0.9	0.014	0.025	Horton's equation, Medium well drained, AMC3, assumed to contain 1% AEP event onsite.	

5.2.1 Pre-development flows

Pre-development flows for key locations in critical events are presented in Table 15.

Table 15: Pre-development flows for critical events*

Catchment	Peak flow (m^3/s)				
	63% AEP, 1 hour	18% AEP, 6 hours	10% AEP, 6 hours	1% AEP, 6 hours	1% AEP, 48 hours
PG4	0	0.316	0.073	0.24	0.058
PG5	0	0.043	0.297	0.287	0.061
PG6	0	0.025	0.038	0.142	0.033
MV5	0	0	0	0.507	0.028
AS1	0	0.064	0.109	0.318	0.157
AS2	0	0.174	0.144	0.817	0.165
AS3	0	0.108	0.032	0.835	0.159
AS - Dundas Road Outlet (DUNDAS-OUT)	0	0.247	0.382	2.547	0.565

*All values are indicative and must be reviewed at subdivision stage

5.2.2 Post-development flows

Post-development flows for key locations in critical events are presented in Table 16.

Table 16: Post-development flows for critical events*

Catchment	Peak flow (m^3/s)				
	63% AEP, 1 hour	18% AEP, 6 hours	10% AEP, 6 hours	1% AEP, 6 hours	1% AEP, 48 hours
PG4	0	0.056	0.062	0.076	0.067
PG5	0	0.052	0.056	0.063	0.059
PG6	0	0.037	0.037	0.037	0.037
MV5	0	0	0	0	0
AS1a	0	0.068	0.074	0.238	0.081
AS2	0	0.045	0.05	0.388	0.055
AS3	0	0	0	0	0
AS - Dundas Road Outlet (DUNDAS-OUT)	0	0.224	0.299	0.46	0.154

*All values are indicative and must be reviewed at subdivision stage

5.2.3 Flows from outside the Precinct

Maida Vale

The Airport South catchment includes approximately 114 ha of land to the west of Roe Highway in Maida Vale which drains into a basin on the site via a Main Roads culvert, referred to as MV1 and MV2 (Figure 11). Prior to development, any water not infiltrated in MV1 and MV2 or the small basin located on the site would have run through the Nardine Catchment to the south of Sultana Road West in larger events (anticipated greater than the 63% AEP event) (Figure 11). The development of the Forrestfield-High Wycombe Industrial Area south of Sultana Road West has removed this historic flow path. This matter was discussed with the City who advised that their preferred option to manage this was installation of an infiltration basin within the RP to infiltrate stormwater from MV1 and MV2 until the infrastructure can be rectified (Bartlett D [CoK] 2017, pers. comm. 3 November).

Surface water modelling undertaken as part of this project has identified that the current storage at MV5 is not adequately sized. A total volume of 10,0012 m^3 of storage is required for the 1% AEP event compared to the 2400 m^3 currently available. With the current basin, a 1% AEP event in the MV area would result in flooding of the RP. Storage will be retained at this location until the school and associated sporting facilities are constructed.

The current storage is not considered suitable for long term infiltration because of its' location. The storage is located at a topographic low point and there is no obvious location within RP for relocation without construction of considerable additional pipework. Relocating this basin to an area east of Roe Hwy will be required.

Stormwater modelling for the Maida Vale area shall be undertaken as part of future structure planning for the Maida Vale South Area. This modelling should allow for the relocation of the basin at MV5.

The Nardine St catchment is assumed to retain the 1% AEP event (all durations).

East Forrestfield

The discharge pathway for East Forrestfield Catchment (referred to as "Forrest1") is via a Main Roads culvert and has likewise been affected by the development of the Forrestfield/High Wycombe Industrial Area. A 1% AEP event in this area would result in flooding of the Industrial Area. This matter was not addressed in the LWMS for the Industrial Area (ENV 2012). To address this matter and ensure pre-development flows are maintained, stormwater storage is required to be constructed. A suggested basin location and sizing is 3561 m^3. This design and location are indicative and should be subject to more detailed investigation by the City.

Works for the East Forrestfield and Maida Vale South areas will be excluded from the Developer Contribution Scheme is there is no nexus with the development of the precinct.

5.3 Surface water quality management

The effective implementation of the structural and non-structural controls as part of the urban development will enhance water quality from the RP area as a result of the land use change. Non-structural source controls to reduce nutrient export from the RP area will focus on reducing the need for nutrient inputs into the landscape. The following non-structural strategies are proposed:

- species will be selected for drought tolerance and low fertiliser requirements
- street sweeping.

The UWMPs will outline the schedule and cleaning requirements for street sweeping, which will be co-ordinated with the City.

Structural source controls are proposed to compliment the non-structural source controls and provide a complete treatment train for stormwater movement through the RP area. The following structural controls are considered appropriate for the RP area:

- the use of bio-retention storages and raingardens to treat road runoff in events up to and including the 63% AEP, 1-hour event
- a trash rack installed downstream of each vegetated treatment area or at the upstream end of the storage overflow to manage gross pollutants.

The minimum specifications for all bio-retention systems (raingardens and storages, including on lot bioretention systems) are presented in Table 17.

Table 17: Minimum specifications for bio-retention systems

Item	specifications
Amended soil media	• minimum 300 mm thickness • saturated hydraulic conductivity of 3 m/day • PRI ≥10 • light compaction only • infiltration testing prior to installation and again following completion of construction. Ongoing testing to be undertaken as required by monitoring program.
Species selection and planting density	• species to be in accordance with *Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia* (Monash University 2014) • densities to be in accordance with *Adoption Guidelines for Stormwater Biofiltration Systems* (CRC for Water Sensitive Cities 2015) • planting density appropriate to species selection.

The bio-retention systems should be sized to function correctly with a saturated hydraulic conductivity, ksat, of 3 m/day. The *Adoption Guidelines for Stormwater Biofiltration Systems* (CRC for Water Sensitive Cities 2015) indicate that the desired ksat is in the range of 2.5 to 7 m/day, to fulfil the drainage requirements as well as retain sufficient moisture to support the vegetation. The CRC for Water Sensitive Cities (2015) also identifies 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 bio-retention systems is recent and largely based on laboratory testing. 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.

6. Groundwater management strategy

6.1 Groundwater level management

Based on the depth to MGL within the precinct it is not anticipated that control of groundwater will be required in the RP. Should control be determined to be required at the UWMP stage, then this shall be discussed with DWER and groundwater monitoring and/or modelling undertaken if required. Any subsoil drainage modelling shall consider the potential impact of subsoil drainage on any Environmentally Sensitive Areas (ESAs) and the need for treatment to remove nutrients from mobilised groundwater.

6.2 Groundwater quality management

Groundwater quality will be managed through:

- effective treatment of stormwater to reduce nutrient loads (Section 5.2.1)
- sustainable landscaping practice, including use of soil amendments and minimisation of fertiliser use in POS (Section 7.2).
- post development monitoring (Section 8.4).

7. Water conservation and efficiency

7.1 Potable water consumption

A water balance was undertaken for the RP to estimate potable water consumption at Forrestfield North based on the Water Corporation Water Use Calculator and the Alternative Technology Association (2010) rainwater tank calculator for individual, household scale rainwater tanks. In summary:

1. The total water use is 518,986 kL/yr or 85.4 kL/yr without water conservation measures. Of this, 12% or 10.6 kL/person/year is groundwater for irrigation of POS. The remaining 74.8 kL/person/year is potable water use. This volume is 25% below the State Water Plan potable use target of 100 kL/person/year. This is considered a favourable outcome and reflects the comparatively high density of the development, with limited external water use.
2. Of the 74.8 kL/person/year potable use, approximately 73.5 kL/yr is for domestic use.
3. An estimated 11% of potable use is for residential irrigation (approx. 8.5 kL/person/year) compared to perhaps 40% in a lower density development. Consequently, in-house water use (e.g. showers, toilets) reductions need to be targeted to reduce water use.
4. Water efficient fixtures are generally the most cost-effective way of reducing water use as there is a small upfront cost difference and there is unlikely to be a difference in maintenance costs when compared to traditional fixtures. The use of water efficient fixtures in all buildings for toilets, showers and taps could reduce potable water demand by approximately 12% to approximately 66 kL/yr.
5. Providing rainwater tanks and plumbing these in for in-house use (toilet flushing and washing machines) alone would reduce potable water demand by approximately 17% to 62.3 kL/year. It is recommended that rainwater tanks should provide a minimum of 1000 L of storage capacity connected to a minimum roof area of 55 m^2 per dwelling. If rainwater tanks are provided, these should be plumbed in for internal use as:
   - ex-house water use is a small component of the domestic demand (11%)
   - rainwater is available over the winter months (April to October) and domestic irrigation occurs predominantly over the summer months (October to March).

Installation of internally plumbed rainwater tanks is proposed for individual green title lots. The use of rainwater tanks for multi-dwelling strata lots is not considered feasible because of the legal and compliance issues with maintenance required to ensure tanks provide acceptable quality water.

On the basis of these findings:

1. It is proposed that the use of water efficient fixtures will be mandated for new developments in the RP to minimise water use in a sustainable manner. This will include the use of water efficient fixtures to the following standards in all buildings:
   - showerheads and taps that use ≤6 L/min in kitchens, bathrooms and laundries
   - dishwashers, where installed, that use ≤14 L per use
   - toilets that use ≤4.7 L per full flush.
2. The use of rainwater tanks for in-building water use is recommended, however not mandated. Where provided, rainwater tanks shall be plumbed in for in-building water use and provide a minimum of 1000 L of storage capacity and connected to a minimum roof area of 55 m^2 per dwelling.
3. Use of water efficient residential landscaping incorporating local species is encouraged as best practice.

With these measures, it is estimated that potable water demand will be approximately 66 kL/person/year, approximately one third less than the State Water Plan target of 100 kL/person/year. This is considered to be a sustainable outcome.

7.2 Public open space water efficiency

POS design will be undertaken to ensure that sustainable outcomes which reduce water and fertiliser use, are implemented through the following principles:

- improvement of the existing soil with 50 mm of soil conditioner certified to Australian Standard (AS) 4454 mixed into the native soil or fill to a depth of 100 mm in turf and 250 mm in garden beds
- landscape plantings primarily based on native Waterwise plant species with a focus on native species
- planting design based on watering requirements to allow for hydrozoning
- garden beds to be mulched to 75 mm or in accordance with Bushfire Management Plan requirements
- turf areas to be focussed around facilities such as play spaces and picnic facilities, to ensure turf is located where it will be best utilised
- implementation of an appropriate management and maintenance program for POS that reduces irrigation rates and fertiliser use over the long term to promote future water savings.

For all areas, efficiencies will be sought during landscaping design at the subdivision stage to target a reduction in fertiliser and irrigation water use while maintaining a high standard of POS, including:

- retaining natural bushland where feasible
- reduce irrigated areas by minimising turf through prioritising turf in active areas
- utilise low water use vegetation and hard surfaces where feasible to reduce irrigation demand
- utilise efficient irrigation systems to reduce water use
- utilising establishment only irrigation for streetscapes and landscaping.

7.2.1 Water and fertiliser use reduction trials

The first two areas of POS that contain turf to be developed will be used as trial areas for soil improvements or irrigation systems that can significantly reduce irrigation water use without affecting the quality of turf and thus provide a more sustainable POS outcome without impacting upon amenity.

The sandy soils, such are present in the surface of the Residential Precinct, have poor water retention and high infiltration rates. Loam and sandy loam textured soils are more suitable for turf growth because these contain a higher portion of clays, silts and organic matter that retain soil water and nutrients much more efficiently than sand. Soil amendments that add silt and clay to soil, such as Eclipse Aquamor Soil Improver and Soil Solver can be mixed into sands to achieve a sandy loam or loam soil classification. Other options for trials may include subsoil irrigation systems which reduce irrigation losses through evaporation, but these are less likely to reduce fertiliser use than soil amendments.

As technologies will develop over time, the methods to be trialled in each POS will be identified by COK at the time of subdivision, identifying the preferred methods. The trial construction, monitoring and reporting methods will be developed at the UWMP stage through consultation between the City and the developer. Findings of these studies will inform the future stages of POS development within the precinct.

7.2.2 Water use requirements

Water for the POS will be sourced from the existing City groundwater allocation (Section 3.5.4).

POS irrigation water use has been based on the following assumptions:

- permanent irrigation of turf with an average irrigation rate of 6,750 kL/ha/yr
- establishment irrigation of planted areas (POS and landscaped verges) at an average rate of 6,750 kL/ha/yr for two years.

The projected long-term irrigation demand is 38,652 kL/yr excluding the school. With allowance of 9,678 kL/yr for the school, this brings the total volume to 48,330 kL/yr. This volume is within the 100,000 kL/year allocated by the City from their existing superficial irrigation allocation (Section 3.5.4). The temporary establishment irrigation rate will vary depending on the development cycle, but an estimated total of 299,000 kL will be required for all establishment irrigation (based on a two-year establishment period). Estimated water use volumes for each POS and the street plantings are provided in Appendix 6.

Projected irrigation volumes include allowances for irrigation of the school and community purpose sites. The City has confirmation from the Department of Education that the allocated volume is sufficient for their requirements. This volume will be provided by the City to the Department of Education on construction of the school site.

7.2.3 Landscaping concept

The landscape plan (Figure 15 and Figure 16) is based on the ambition to create a 'Forest Neighbourhood', a medium density area with a bush character. This would provide Forrestfield North with a competitive difference in regard to other medium density developments around the Perth Metropolitan Area.

To realise the forest neighbourhood, the landscape plan works on two main ingredients:

- spaces for people - creating an attractive public realm for people of all demographics, with a comfortable microclimate, safe paths and an abundance of elements that support activation
- forest character - creating a continuous urban forest that supports the bush character, provides a suitable microclimate for people, connects to nature and contributes to the biodiversity.

The landscape plan translates the framework of the Local Structure Plan to the public realm design guide, incorporating the technical demands of the Local Water Management Strategy, the Bushfire Management Plan, the Transport Impact Assessment and the Community Infrastructure Strategy.



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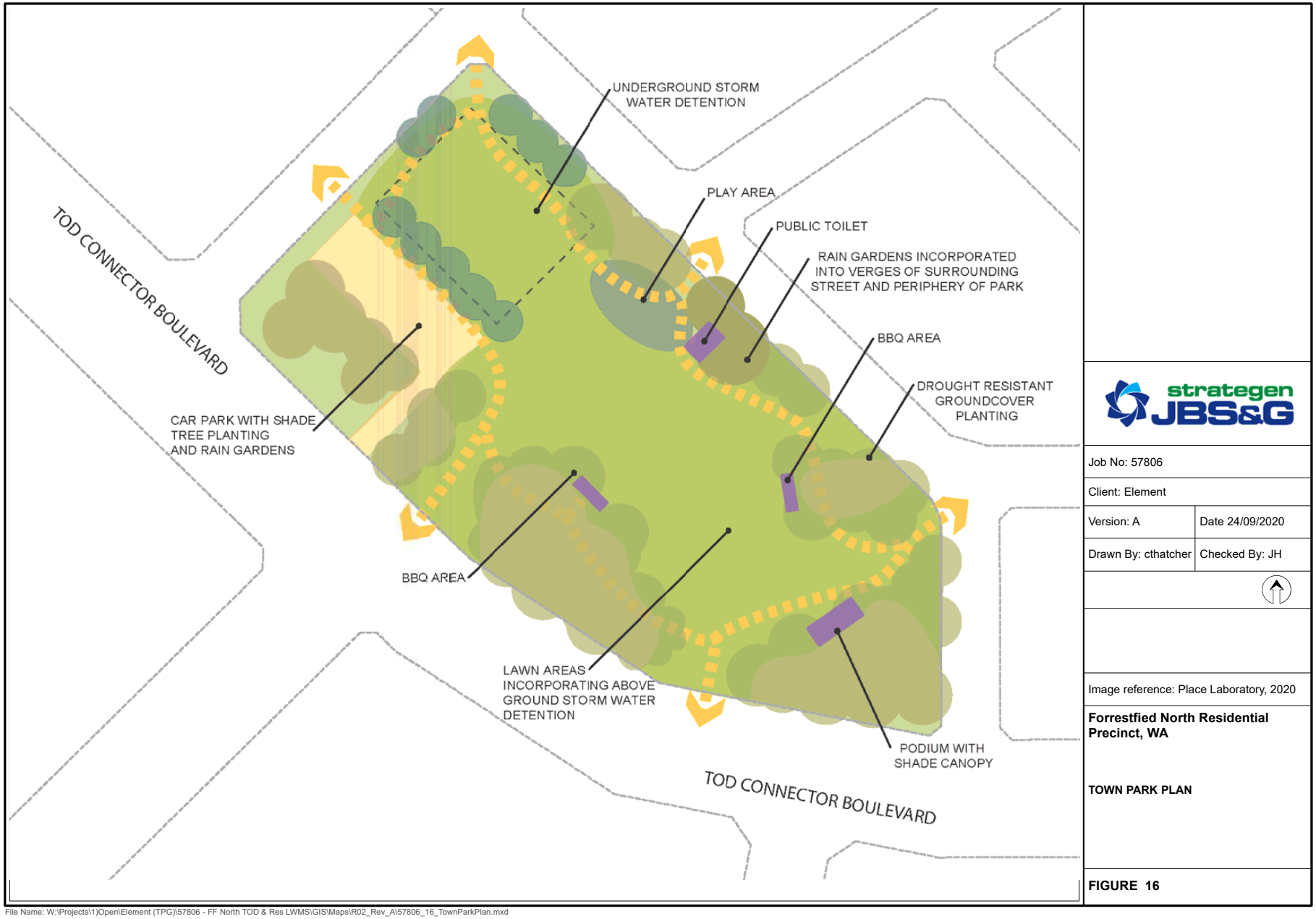
UNDERGROUND STORM WATER DETENTION
PLAY AREA
PUBLIC TOILET
RAIN GARDENS INCORPORATED INTO VERGES OF SURROUNDING STREET AND PERIPHERY OF PARK
BBQ AREA
DROUGHT RESISTANT GROUNDCOVER PLANTING
TOD CONNECTOR BOULEVARD
CAR PARK WITH SHADE TREE PLANTING AND RAIN GARDENS
BBQ AREA
LAWN AREAS INCORPORATING ABOVE GROUND STORM WATER DETENTION
PODIUM WITH SHADE CANOPY
TOD CONNECTOR BOULEVARD
strategen JBS&G
Job No: 57806
Client: Element
Version: A
Date 24/09/2020
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Image reference: Place Laboratory, 2020
Forrestfied North Residential Precinct, WA
TOWN PARK PLAN
FIGURE 16
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8. Implementation

Responsibility for the development of the RP will be divided between the City and individual developers. The City will be responsible for development of:

- POS (including drainage structures in POS)
- District Integrator and Neighbourhood Connector Roads, including drainage structures and any upgrades required to these roads and associated drainage infrastructure (Figure 2).

These works will be funded through a Developer Contribution Plan (DCP) and are referred to as 'DCP infrastructure'.

Construction of all other roads and drainage structures will be the responsibility of the developer and will be developed through a subdivision or development application process. These are referred to as 'Subdivision infrastructure'.

8.1 Urban Water Management Plans

Processes defined in Better Urban Water Management (WAPC, 2008) require an Urban Water Management Plan (UWMP) at subdivision stage. With an approved LWMS, a UWMP is required to be prepared by the developer or proponent:

- as a condition of subdivision
- for any strata development or a Development Application for a site greater than 2000 m^2.

Further work that is identified for inclusion in the UWMP:

- results of geotechnical investigations, including measurement of hydraulic conductivity at locations where underground storages are proposed as part of the subdivision infrastructure
- present design of treatment structures, including tree pits, biofilters, median vegetated swales and vegetated swales at public car parks, streets and public open spaces
- present design stormwater management systems that provide serviceability, amenity and road safety during minor rainfall events with consideration of the City of Kalamunda's Stormwater Design Guidelines for Subdivisional and Property Development (City of Kalamunda, 2018)
- consideration of art within stormwater management structures
- refinement of the final configuration (storage side slopes, type and invert level of underground storages etc) and exact location of the flood detention storage areas dependent on final earthworks, drainage and road design levels for the RP area
- construction details inverts and diameters of stormwater pipes
- confirmation of groundwater design levels
- confirmation of subsoil location and levels (if any)
- confirmation of finished levels and demonstration of adequate clearance to the 1% AEP flood levels to residential, commercial and industrial building habitable floor levels
- landscaping design and POS water use
- Foreshore Management Plan will be a required condition of subdivision approval for all development areas adjacent to Poison Gully
- identify any eroded areas within the Poison Gulley foreshore reserve and commit to upgrading or repairing as required
- identify any direct discharge piped into Poison Gulley and commit to replacing with overland flow paths where practical
- review surface water quality trigger levels in consideration of any additional pre-development monitoring results.

8.2 Construction management

8.2.1 Dewatering

Dewatering may be required for some elements of subdivision construction, including servicing infrastructure. Given the depth of construction, dewatering is anticipated to occur in the Superficial Aquifer only.

Prior to the commencement of any dewatering, the developer must apply for and obtain a "Licence to Take Water" from DWER. All dewatering should be carried out in accordance with the conditions of this licence. Where possible, construction should be timed to minimise impacts on groundwater and any dewatering requirement.

Dewatering will be managed through re-infiltration on site where feasible.

8.2.2 Acid sulphate soils and contaminated sites

Management of ASS and contaminated sites will be addressed as a separate process to the urban water management document approvals process.

ASS and potentially contaminated sites will be investigated and managed in accordance with the applicable DWER guidance and requirements of dewatering licences as they arise. Investigations and mapping indicate a low risk of ASS within the site (Section 3.4.3).

8.2.3 Stormwater outlets to Poison Gully

Poison Gully is not within a proclaimed Surface Water Area under the Rights in Water and Irrigation Act 1914 and therefore a bed and banks permit from the DWER will not be required for works within Poison Gully.

8.3 Stormwater system operation and maintenance

The operation and maintenance of DCP Infrastructure will be the responsibility of the City.

The operation and maintenance of Subdivision Infrastructure installed in roads will initially be the responsibility of the developer, ultimately reverting to the local authority, being the City.

The drainage system will require regular maintenance to ensure its efficient operation. It is considered 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 surfaces and gutters.
- maintenance of vegetation in bio-retention systems/ storages
- cleaning of sediment build-up and litter layer on the bottom of storages
- undertake education campaigns regarding source control practices to minimise pollution runoff into stormwater drainage system
- checking and maintenance of subsoil drainage function.

8.4 Monitoring and contingency planning

The objective of this section is to provide guidance on the future post-development monitoring based on the pre-development monitoring for the RP area. The monitoring will focus on comparing post-development conditions to baseline conditions, as well as monitoring the BMPs to assess their effectiveness and that these structures are fulfilling their function. Prior to handover to the City, any BMPs constructed by developers must be assessed to confirm that these are in satisfactory condition and functioning appropriately.

8.4.1 Hydraulic performance monitoring

Hydraulic performance monitoring aims to determine if stormwater infiltration through basins and swales is consistent with the intended design.

Where amended soils profiles have been installed, infiltration testing will be completed to test the hydraulic conductivity of the media. Testing will be completed annually during the monitoring period.

Infiltration testing will be completed using a permeameter. Permeameter tests will be completed once per year in each basin.

8.4.2 Water quality and level monitoring

Post development monitoring will be undertaken by the City on the basis of the monitoring schedule outlined in Table 18 at monitoring bores to be installed during POS construction. Water quality assessment criteria and contingency actions will be undertaken as outlined in Table 18. Monitoring will be undertaken at the time of construction of the BMPs by the developer associated with the construction of each BMP.

Table 18: Monitoring schedule

Monitoring type	Location	Method	Frequency and timing	Parameters
Groundwater level	Four locations (one adjacent to each main basin for AS1/2, AS3, PG4 and PG5)	Electrical depth probe or similar	Monthly for two years (February, May, August, October)	Water level (m AHD).
Surface water quantity	Outlets of basins for AS1/2, PG4 and PG5	Continuous logger	Downloaded three times per year for two years	Stage (flow inferred).
Groundwater quality	Four locations (one adjacent to each main basin for AS1/2, AS3, PG4 and PG5)	Pumped bore samples	Quarterly for two years (February, May, August, October)	In situ: pH, EC, temperature Laboratory: TN, Kjeldahl nitrogen, ammonia, nitrate, nitrite, TP, filterable reactive phosphorus, total dissolved salts, selected heavy metals
Surface water quality	Outlets of basins for AS1/2, PG4 and PG5	Collected via grab sampler	Three times per year while flowing for two years	

Annual monitoring reports will be prepared by the City for review by DWER a period of two years following construction of the relevant storages. At the end of the two-year period, the monitoring results will be reviewed against the criteria identified in Table 19. If performance is not considered satisfactory and the criteria are not met, remedial actions may be required, and additional two years' monitoring may be required.

Table 19: Criteria for assessment and contingencies

Monitoring type	Criteria for assessment	Criteria assessment frequency	Contingency action
Groundwater levels	Water levels not to increase above predevelopment MGL	Monthly review of water levels against MGLs	1. Assess if depth to groundwater is reaching levels of concern for natural assets or infrastructure 2. Investigate subsoil drainage
Surface water quantity	Flow discharging from storage basins to be within peak flows established in LWMS.	Annual review of water quantity targets	1. Review design and operation of stormwater drainage system. 2. Perform maintenance as required.

Monitoring type	Criteria for assessment	Criteria assessment frequency	Contingency action
Groundwater quality	Nutrient levels within the RP area should not exceed the maximum recorded pre-development level.	Annual review	1. Identify and remove any point sources. 2. Review operational and maintenance measures. 3. Consider modifications to stormwater system. 4. Consider reinforcement of community education/awareness programs. 5. Consider initiation of community-based projects.
Surface water quality	Assess performance of vegetated storages in nutrient reduction. Water quality discharging from the RP area should not exceed the maximum recorded pre-development level.	Annual review	1. Review design and operation of stormwater drainage system. 2. Perform maintenance as required.

Proposed water quality trigger values for the site have been determined considering existing concentrations recorded on site and trigger values recommended in the National Water Quality Management Strategy (NWQMS) (ANZECC 2000). Site specific trigger values are provided in Table 20 and are suitable for both surface and ground water. The NWQMS guideline default trigger values (ANZECC 2000) are intended to be for slightly disturbed ecosystems, not highly modified environments such as the site, and are designed to be used when no pre-development monitoring has been carried out to inform site specific trigger values. As such, trigger values should be reviewed at UWMP stage in consideration of any additional pre-development monitoring results available for the site and should be reviewed post-construction as water quality across the site changes to reflect the new land use.

Table 20: Post-development surface and groundwater trigger values

Analyte	TN (mg/L)	TP (mg/L)	TKN (mg/L)	NH4 (mg/L)	NOX (mg/L)	pH	EC (mS/cm)
Dundas Rd (3-6-2015)	0.8	2.2	0.5	>0.02	0.25	7.2	-
Littlefield Rd 2011 average	1.0	0.05	0.4	0.04	0.6	7.1	-
ANZECC Guideline Trigger Value[1]	1.2	0.065	-	0.8	0.15	6.5-8	0.12-0.3
Site trigger values	5	0.3	3	0.08	4	5.0-8.0	0.8

1. Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) - Trigger values for freshwater for a 95% level of protection (slightly to moderately disturbed ecosystem), values adopted for Lowland River, South West Australia.

8.4.3 Contingency action plan

If results from the initial monitoring occasion indicate that nutrient concentrations exceed the nominated trigger values, a number of contingency measures will be employed. The first action that will be undertaken is to repeat the monitoring to remove the potential for sampling error. If the repeat monitoring still shows results which breach the trigger value, the next action will be to compare the upstream (incoming) nutrient concentrations with the outgoing (downstream) nutrient concentrations.

If the downstream nutrient concentrations are >40% higher than the upstream nutrient concentrations, the following actions will be undertaken:

1. Review POS nutrient application practices to identify source if possible.
2. Conduct surveillance of subdivision area to determine any other potential and obvious nutrient inputs.

3. Remove source of nutrients if possible (e.g. fertiliser input, etc.).
4. Manual removal of excess plant material to facilitate further nutrient uptake.

In the case of total phosphorus in Poison Gulley, this approach is not suitable given the high level of downstream TP. In this situation the monitoring results should be compared with predevelopment results to initiate the above actions.

8.5 Responsibilities and funding

Responsibilities for funding, construction and maintenance are presented in Table 21.

Table 21: Table of responsibilities

Management Issue	Responsibility and funding	
	Developer	The City
DCP Infrastructure		
Construction and management of irrigation system.		✓
Construction of planted raingardens, street drainage and detention storages.		✓
Detention storages and planted raingardens.		✓
Management of stormwater storage landscaping.		✓
Post-development monitoring • Monitoring over a two-year period, commencing immediately after the Practical Completion of the storage.		✓
Street sweeping		✓
Installation of low water use fixtures and fittings and rainwater tanks (where required) • selection of fittings and tanks • demonstration of compliance • review of compliance (as required).	 ✓ ✓	 ✓
POS water and fertiliser use reduction trials (first two POS areas developed that contain turf) • selection of methods to be trialled • trial design and materials funding (in consultation with developer) • POS construction implementing trial methods • trial monitoring (two years) and reporting • implementation of findings (as required).		 ✓ ✓ ✓ ✓ ✓
Pervious paving trial by the City at either the Community Purpose site or District Open Space for use in car parks and/or low traffic areas • selection of methods to be trialled • trial design and materials funding (in consultation with developer) • POS construction implementing trial methods • trial monitoring (two years) and reporting • implementation of findings (as required).		 ✓ ✓ ✓ ✓ ✓
Subdivision infrastructure		
Construction of planted raingardens, street drainage and any detention storages.	✓	
Street drainage maintenance • between successful Practical Completion Inspection and written confirmation of the City's acceptance (12 month defects liability period) • after the City's acceptance.	✓	 ✓
Detention storages and planted raingardens • between successful Practical Completion Inspection and written confirmation of the City's acceptance (12-month defects liability period) • after the City's acceptance.	✓	 ✓

Management Issue	Responsibility and funding	
	Developer	The City
Street sweeping	✓	
• up to the successful Practical completion of civil works		
• after the City's acceptance.		✓
Installation of low water use fixtures and fittings		
• selection of fittings	✓	
• demonstration of compliance	✓	
• review of compliance (as required).		✓

9. Summary of compliance

Table 22 below summarises how the water management principles and objectives for the site will be met.

Table 22: Compliance with water management principles and objectives

Category	Principles	Objectives	Methods for achievement
Water use	• consider all potential water sources in water supply planning • integration of water and land use planning • sustainable and equitable use of all water sources having consideration for the needs of all users, including community, industry and the environment.	• minimise the use of potable water where drinking water quality is not essential • achieve a significant reduction in water use below the 100 kL/person/year State Water Plan (Government of Western Australia 2007) target • mandate Water Efficiency Labelling and Standards rated water efficient products, water efficient irrigation, waterwise landscaping and rainwater storage tanks for individual green title lots.	• Potable water use estimated at 66 kL/day through mandating water efficient fittings and appliances, mandating rainwater tanks for green title development and reduced garden areas • Irrigation volumes for POS and schools will be kept within the current City of Kalamunda licenced allocation volume • POS design will maximise retention of native bushland, include extensive rehabilitation and minimise the use of turf in POS where not required • Trials of soil amendments and/or below ground irrigation measures to reduce turf water and fertiliser use will be undertaken in the first two POS areas containing turf and result used to inform POS design.
Groundwater and surface water quantity	• to retain natural drainage systems and protect ecosystem health • to protect from flooding and waterlogging • to implement economically viable stormwater systems • post development annual discharge volume and peak flow rates to remain at pre-development levels or defined environmental water requirements.	• where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles • for flood management, manage up to the 1% AEP event within the development area to pre-development flows and the requirements of Water Corporation (Water Corporation 2010). • adopt 'at source' stormwater management approach and consider reducing pit and pipe drainage system significantly. Treat polluted runoff by installing appropriate treatment systems where required • consider managing stormwater runoff by providing overland flow paths and opportunities for infiltration of runoff on lots, road reserves and public open space where site conditions permit • pre-development flow rates will be maintained for events up to the 1% AEP event at discharges from the site, including Poison Gully • design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.	• control of groundwater levels on the site is not proposed and thus impacts on groundwater regimes will be limited • maintain pre-development flows off the site through detention and retention on site, while minimising land take for drainage to improve public amenity • at source stormwater management will be adopted through retention of the first 26mm of water on lots and use of biofilters and tree pits within road reserves where feasible • the 63% AEP event (including the first 15 mm) will be treated through vegetated structures prior to discharge to receiving water bodies • pre-development flow rates will be maintained for events up to the 1% AEP event at discharges from the site, including Poison Gully • design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.

Category	Principles	Objectives	Methods for achievement
Groundwater and surface water quality	• to maintain or improve groundwater and surface water quality • where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater • where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterways and maintain water quality in the specified environment.	• maintain surface water and groundwater quality • retain and/or detain and treat (if required) — stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.	• use of raingardens, including roadside raingardens to retain and treat the 1-year, 1-hour event through use of raingardens and tree pits • minimisation of turf areas and POS fertiliser use to reduce nutrient discharge to the environment • investigation and redevelopment of Brand Road landfill to manage and mitigate potential impacts to groundwater. • the 63% AEP event (including the first 15 mm) will be treated through vegetated structures prior to discharge to receiving water bodies.

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Appendix 1
LWMS checklist

Checklist for assessment of local structure plan or local planning scheme amendment

1. Tick the status column for items for which information is provided.
2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column.
3. Provide brief comments on any relevant issues.
4. Provide a brief description of any proposed best management practices, e.g. multi-use corridors, community based-social marketing, water re-use proposals.

LWMS item	Deliverable	Included?	Location in text
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMPs and critical control points	✓	Table ES-1
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		✓	Sections 1 and 2
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	✓ ✓	Section 1.1 and 3.2 Figures 2 and 3
Landscape - proposed POS areas, water source, bore(s), lake details, irrigation areas (if applicable)	Landscape Plan	✓	Section 7.2.3 Appendices 7 and 8
Design criteria			
Agreed design objectives and source of objectives		✓	Section 2
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		✓	Section 3
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	✓	Section 3.3 Figures 1, 3
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	✓	Section 3.4, Figures 3 to 5.
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	✓	Sections 3.7 and 3.8 Figures 9 and 10
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	✓	Section 3.6, Figures 8 and 9
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus site investigation	✓	Section 3.6, Figures 6 and 7
Water sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		✓	Section 7
Water supply (fit-for-purpose), agreed actions and implementation		✓	Section 7
Wastewater management		✓	Section 7

LWMS item	Deliverable	Included?	Location in text
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detention storage areas	100yr event plan Long section of critical points	✓ ✓	Section 5.1.2 Figure 11
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5 yr event plan	✓	Section 5.1.2 Figure 11
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan Typical cross sections	✓ ✓	Section 5.1.1 Figure 11
Groundwater management strategy			
Post development groundwater levels, existing and likely final surface levels, outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil plan	✓	Section 6
Actions to address acid sulfate soils or contamination		✓	Section 3.4, 8.2.2
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before to detailed design.		✓	Section 8.1
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		✓	Section 8.4
Implementation			
Developer commitments		✓	Section 8.5
Roles, responsibilities, funding for implementation		✓	Section 8.5
Review		✓	Section 8.5

Appendix 2
Bore logs

3

Soil Log

Page No:	**1 of 3**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**11 m bgl**
Borehoe ID:	**MB01**	**GPS:**	**E 404861.05**
Logged by:	**CJ**		**N 6464332.42**

Depth (m)	Graphic log	Description of soil type	Additional observations
0		Sandy GRAVEL/ Gravelly SAND, brown/grey, fine to coarse sand	no smell
0.1			
0.2			
0.3			
0.4			
0.5			
0.6			
0.7			
0.8			
0.9			
1			
1.1			
1.2			
1.3			
1.4			
1.5			
1.6			
1.7			
1.8			
1.9			
2			
2.1			
2.2			
2.3			
2.4			
2.5			
2.6			
2.7			
2.8			
2.9			
3			

3

Soil Log

Page No:	**2 of 3**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**11 m bgl**
Borehoe ID:	**MB01**	**GPS:**	**E 404861.05**
Logged by:	**CJ**		**N 6464332.42**

Depth (m)	Graphic log	Description of soil type	Additional observations
3		Clayey SAND, orange-brown to orange, medium to coarse sand	no smell
3.2			
3.4			
3.6			
3.8			
4			
4.2			
4.4			
4.6			
4.8			
5			
5.2			
5.4			
5.6			
5.8			
6			bore slotted 6 m to 9 m
6.2			
6.4			
6.6			
6.8			
7			
7.2			
7.4			
7.6			
7.8			
8			
8.2			
8.4			
8.6			
8.8			
9			

3

Soil Log

Page No:	**3 of 3**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**11 m bgl**
Borehoe ID:	**MB01**	**GPS:**	**E 404861.05**
Logged by:	**CJ**		**N 6464332.42**

Depth (m)	Graphic log	Description of soil type	Additional observations
9.2		Clayey SAND, orange-brown to orange, medium to coarse sand	no smell
9.4			
9.6			
9.8			
10			
10.2			
10.4			
10.6			
10.8			
11		**EOH - 11 m BGL**	
11.2			
11.4			
11.6			
11.8			
12			
12.2			
12.4			
12.6			
12.8			
13			
13.2			
13.4			
13.6			
13.8			
14			
14.2			
14.4			
14.6			
14.8			
15			
15.2			

3

Soil Log

Page No:	**1 of 2**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**18 m bgl**
Borehoe ID:	**MB02**	**GPS:**	**E 405921.6**
Logged by:	**CJ**		**N 6464053.81**

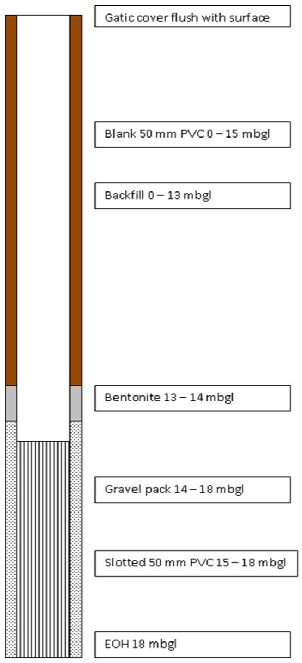
Depth (m)	Graphic log	Description of soil type	Additional observations
0 – 0.5		SAND, medium grained, subrounded, grey-black. Becoming grey below 0.5 m	no smell
1 – 3.5		SAND, grey, medium grained, becoming orange below 1m	
4 – 6		Gravelly SAND orange, medium sand, low to no plasticity	
6.5 – 15		clayey SAND, red, medium sand, moderate plasticity, becoming grey below 14.5 m	no smell, slow drilling

3

Soil Log

Page No:	**2 of 2**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**18 m bgl**
Borehoe ID:	**MB02**	**GPS:**	**E 405921.6**
Logged by:	**CJ**		**N 6464053.81**

Depth (m)	Graphic log	Description of soil type	Additional observations
15		clayey SAND, grey, medium sand, moderate plasticity **Water at 15.5 - 16 m**	no smell, slotted from 15 m.
15.5			
16		SAND, medium, subrounded, orange/red, moist	
16.5			
17			
17.5			
18		EOH - 18 m	
18.5			
19			
19.5			
20			
20.5			
21			
21.5			
22			
22.5			
23			
23.5			
24			
24.5			
25			
25.5			
26			
26.5			
27			
27.5			
28			
28.5			
29			
29.5			
30			



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Soil Log

Page No:	**1 of 1**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	**not encountered, not installed as bore**
Date of works:	**9/09/2011**	**End of hole:**	**19.8 m BGL**
Borehoe ID:	**MB03**	**GPS:**	**corner Brae Rd and Brand Rd**
Logged by:	**CJ**		**Not surveyed as bore not installed**

Depth (m)	Graphic log	Description of soil type	Additional observations
0		0 - 0.25 m gravelly SAND, medium to coarse material, black to grey topsoil,	no smell
1		then 0.25 -2.5 m SAND, grey to yellow/orange, medium grained	
2		2.5 m - 7 m, SAND, yellow/orange, medium to coarse grained, subrounded, darker than above	
3			
4			
5			
6			
7		Clayey SAND, fine to medium sand, grey-orange, moderately sorted	
8			
9			
10			
11			
12			
13		SAND, fine to medium, orange- grey, moderately sorted	
14			
15		becoming grey	
16			
17			
18			
19		EOH 19.8 m	
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			

3

Soil Log

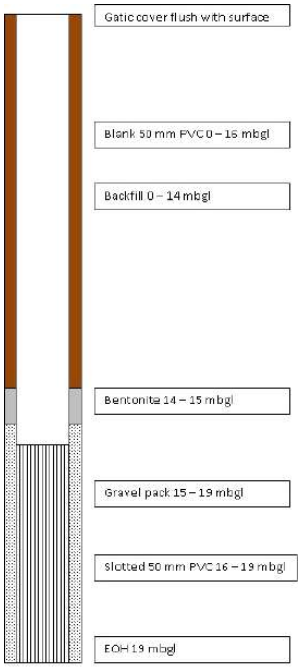
Page No:	**1 of 2**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**19 m bgl**
Borehoe ID:	**MB04**	**GPS:**	**E 406211.14**
Logged by:	**CJ**		**N 6463642.55**

Depth (m)	Graphic log	Description of soil type	Additional observations
0		Gravelly SAND, medium to coars, subangular, black/orange, moderately sorted	
0.5		SAND, medium grained, subrounded, orange, moderately sorted	
1			
1.5			
2			
2.5			
3			
3.5			
4			
4.5			
5			
5.5			
6			
6.5			
7		SAND, medium/coarse grained, brown/orange, subangular, moderately sorted	
7.5			
8			
8.5			
9			
9.5			
10		SAND, coarse, yellow, subangular, moderately sorted	
10.5			
11			
11.5			
12			
12.5			
13			
13.5			
14			
14.5			
15			

3

Soil Log

Page No:	**1 of 2**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**19 m bgl**
Borehoe ID:	**MB04**	**GPS:**	**E 406211.14**
Logged by:	**CJ**		**N 6463642.55**

Depth (m)	Graphic log	Description of soil type	Additional observations
15.5		SAND, coarse, yellow, subangular, moderately sorted	
16			
16.5			
17			
17.5			
18		SAND, medium to coarse, yellow/grey, subrounded, moderately sorted	
18.5			
19		EOH at 19 m	
19.5			
20			
20.5			
21			
21.5			
22			
22.5			
23			
23.5			
24			
24.5			
25			
25.5			
26			
26.5			
27			
27.5			
28			
28.5			
29			
29.5			
30			
30.5			

3

Soil Log

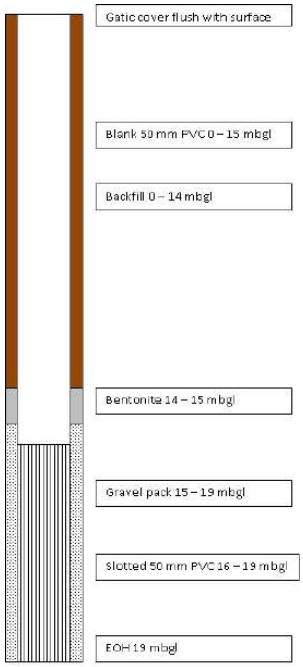
Page No:	**1 of 2**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**19 m BGL**
Borehoe ID:	**MB05**	**GPS:**	**E 406081.39**
Logged by:	**CJ**		**N 6463046.74**

Depth (m)	Graphic log	Description of soil type	Additional observations
0		SAND, medium to fine grained, subangular, grey, poorly sorted	
0.5			
1			
1.5			
2			
2.5			
3			
3.5			
4		Sand, medium grained, orange, subangular, moderately sorted	
4.5			
5			
5.5			
6			
6.5			
7			
7.5			
8			
8.5			
9		SAND, coarse, yellow, subrounded, poorly sorted,	
9.5			
10		SAND, coarse, grey, subrounded moderately sorted	
10.5			
11		SAND, medium grained, brown'grey, subrounded, moderately sorted	
11.5			
12			
12.5			
13			
13.5			
14			
14.5			
15			

3

Soil Log

Page No:	**2 of 2**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**19 m BGL**
Borehoe ID:	**MB05**	**GPS:**	**E 406081.39**
Logged by:	**CJ**		**N 6463046.74**

Depth (m)	Graphic log	Description of soil type	Additional observations
15.5		SAND, medium grained, brown-grey, subrounded, moderately sorted	
16			
16.5			
17			
17.5			
18			
18.5			
19		EOH	
19.5			
20			
20.5			
21			
21.5			
22			
22.5			
23			
23.5			
24			
24.5			
25			
25.5			
26			
26.5			
27			
27.5			
28			
28.5			
29			
29.5			
30			
30.5			

3

Soil Log

Page No:	**1 of 2**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	**13.9 m BGL**
Date of works:	**9/09/2011**	**End of hole:**	**16 m bgl**
Borehoe ID:		**GPS:**	**E 405683.24**
Logged by:	**CJ**		**N 6463843.04**

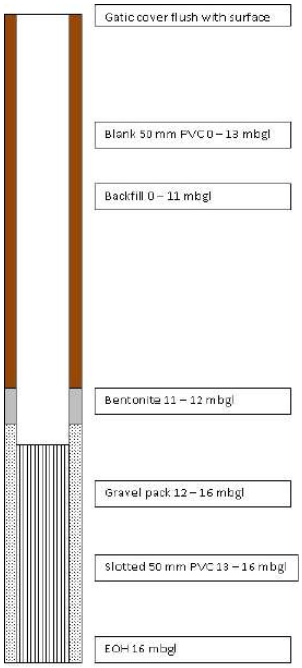
Depth (m)	Graphic log	Description of soil type	Additional observations
0		SAND, medium grained, subrounded, brown, moderately sorted	
0.5		becoming yellow from 0.75 m	
1		SAND, fine to medium grained, subrounded, orange, moderately sorted	
1.5			
2			
2.5			
3			
3.5			
4			
4.5			
5		SAND, fine to medium grained, orange, subrounded, moderately sorted	
5.5			
6			
6.5			
7			
7.5			
8			
8.5			
9			
9.5			
10			
10.5			
11			
11.5			
12			
12.5			
13			
13.5		clayey SAND medium grained, subrounded, orange/grey, moderately sorted	
14		Groundwater at 13.9 m BGL	
14.5			
15		clayey SAND, medium grained, subrounded, grey, moderately sorted, moist	

3

Soil Log

Page No:	**2 of 2**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	**13.9 m BGL**
Date of works:	**9/09/2011**	**End of hole:**	**16 m bgl**
Borehole ID:		**GPS:**	**E 405683.24**
Logged by:	**CJ**		**N 6463843.04**

Depth (m)	Graphic log	Description of soil type	Additional observations
15.5		clayey SAND, medium grained, subrounded, grey, moderately sorted, moist	
16			
16.5			
17			
17.5			
18			
18.5			
19		EOH 19 m	
19.5			
20			
20.5			
21			
21.5			
22			
22.5			
23			
23.5			
24			
24.5			
25			
25.5			
26			
26.5			
27			
27.5			
28			
28.5			
29			
29.5			
30			
30.5			



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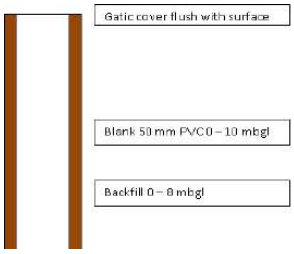
3

Soil Log

Page No:	**1 of 1**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**13 m BGL**
Borehoe ID:	**MB07**	**GPS:**	**E 405347.43**
Logged by:	**CJ**		**N 6464050.07**

Depth (m)	Graphic log	Description of soil type	Additional observations
0 – 0.5		Gravelly SAND, medium to coarse, subangular, grey, moderately sorted	
1 – 2.5		SAND, medium grained, subrounded, orange/yellow, moderately sorted	
3 – 7.5		Clayey SAND, orange, subrounded, moderately sorted	
8 – 9.5		Clayey SAND, brown/grey, subrounded, moderately sorted	
10 – 12.5		Clayey SAND, medium grained, grey, subrounded, moderately sorted	
12.5		EOH - 13 m	
13 – 15			



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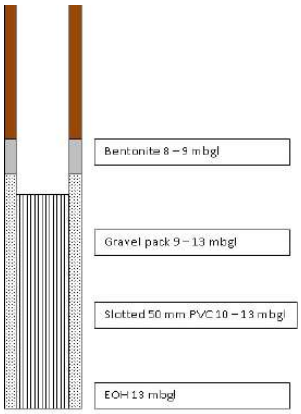
Bentonite 8 – 9 mbgl
Gravel pack 9 – 13 mbgl
Slotted 50 mm PVC 10 – 13 mbgl
EOH 13 mbgl

3

Soil Log

Page No:	**1 of 1**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**9 m**
Borehoe ID:	**MB08**	**GPS:**	**E 405086.11**
Logged by:	**CJ**		**N 6463948.16**

Depth (m)	Graphic log	Description of soil type	Additional observations
0		SAND, medium grained, subrounded, black/grey, moderately sorted	
0.5			
1			
1.5		SAND, medium grained, subrounded, brown-orange, moderately sorted	
2			
2.5			
3		SAND, medium to coarse grained, subrounded, orange-brown, moderately sorted	
3.5			
4		Clayey SAND, medium grained, subrounded, light brown/orange	
4.5			
5			
5.5			
6			
6.5			
7			
7.5			
8			
8.5			
9		Clayey SAND, fine-medium grained, subrounded, grey, well sorted	
9.5			
10			
10.5		Bore screened 6 m to 9m BGL	
11			
11.5			
12			
12.5			
13			
13.5			
14			
14.5			
15			

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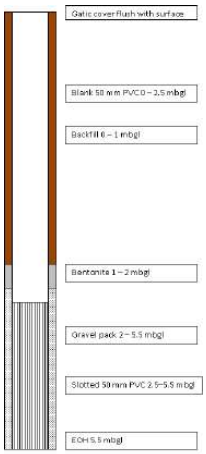
Page: 15 of 17

3

Soil Log

Page No:	**1 of 1**	**Drill method:**	**Auger - Strataprobe**
Job Number:	**SKA11193.02**	**Hole diameter:**	**50 mm**
Project:	**Forrestdale**	**Groundwater at:**	
Date of works:	**9/09/2011**	**End of hole:**	**7 m**
Borehoe ID:	**MB09**	**GPS:**	**E 405255.15**
Logged by:	**CJ**		**N 6464414.64**

Depth (m)	Graphic log	Description of soil type	Additional observations
0		Sand, medium grained, subrounded black to 0.1 m and then grey	
0.5			
1			
1.5		1.5 -2.25 m, SAND, medium grained, subrounded, grey, moist	
2			
2.5		2.25 m on, clayey SAND, meidum grained, subrounded, orange, poorly sorted	
3			
3.5			
4			
4.5			
5			
5.5			
6			
6.5		EOH, slotted to 5.5 m	
7			
7.5			
8			
8.5			
9			
9.5			
10			
10.5			
11			
11.5			
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13.5			
14			
14.5			
15			

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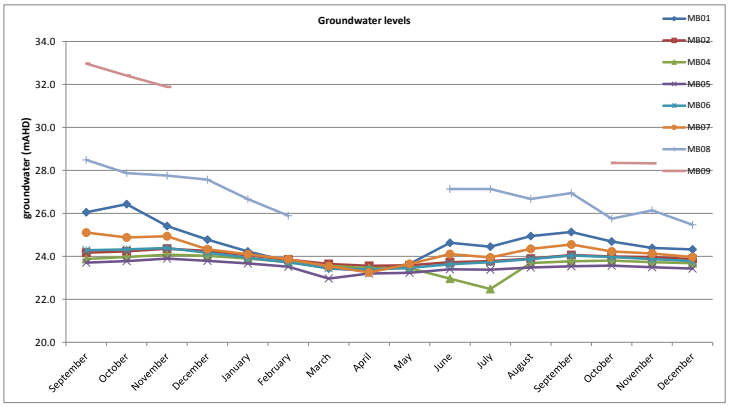
Appendix 3
Water monitoring summary

GROUNDWATER FIELD OBSERVATIONS

					These may not always be required							
Sample Identification Number	Sample Date	Depth to groundwater (mbtoc)	Groundwater level (m AHD)	Depth from ground level	pH	Change in pH	Electrical Conductivity	Temp	Dissolved Oxygen	Dissolved Oxygen	Redox	Comments
Units					pH Unit	pH Unit	mS/cm	oC	mg/L	%	mV	
MB01 - TD = 9.028 mbtoc, RL = 30.64 mAHD												
September	28/09/2011 12:25	4.590	26.050		6.61		0.311	21.3	3.420	39.10	187.6	bailed 30 L, bore still not dry
October	19/10/2011 11:40	4.213	26.427		6.62	0.01	0.452	21.5	2.760	31.40	188.0	bailed 10 L, bore still not dry, samples taken
November	14/11/2011 8:45	5.228	25.412									
December	22/12/2011 9:25	5.863	24.777									
January	16/01/12	6.412	24.228		5.87	-0.75	0.319	23.2	2.780	87.30	133.0	Bailed 15L, Bore still not dry, samples taken
February	22/02/12	6.874	23.766									
March	27/03/12	7.202	23.438									
April	23/04/12	7.306	23.334		5.68	-0.19	0.246	22.2	2.720	32.10	67.0	Bailed 10L,Bore still not dry, samples taken
May	24/05/12	6.998	23.642									
June	27/06/12	6.010	24.630									
July	26/07/12	6.190	24.450		5.84	0.16	0.239	22.2	2.240	25.70	113.8	Bailed 10L,Bore still not dry, samples taken
August	29/08/12	5.700	24.940									
September	26/09/12	5.510	25.130									
October	24/10/12	5.950	24.690									
November	21/11/12	6.250	24.390		6.07	-0.23	0.230	22.3	3.100	31.60	145.3	Bailed 10L,Bore still not dry, samples taken
December	20/12/12	6.320	24.320									
MB02 - TD = 16.835 mbtoc, RL = 39.05 mAHD												
September	28/09/11	14.878	24.172		5.03		0.150	20.20	3.390	38.10	261.8	bailed 20 L, bore still not dry
October	19/10/11	14.815	24.235		4.84	-0.19	0.253	20.60	4.100	46.60	260.2	bailed 10 L, bore still not dry, samples taken
November	14/11/11	14.696	24.354									
December	22/12/11	14.795	24.255									
January	16/01/12	15.004	24.046		4.85	0.01	0.336	21.50	13.750	158.20	270.0	bailed 15 L, bore still not dry, samples taken
February	22/02/12	15.201	23.849									
March	27/03/12	15.407	23.643									
April	23/04/12	15.491	23.559		4.63	-0.22	0.286	20.40	3.870	43.20	197.0	Bailed 10L, bore still not dry, samples taken (red colour)
May	24/05/12	15.467	23.583									
June	27/06/12	15.325	23.725									
July	26/07/12	15.270	23.780		4.91	0.28	0.253	20.40	4.440	49.20	178.5	bailed 15 L, bore still not dry, samples taken
August	29/08/12	15.160	23.890									
September	26/09/12	14.990	24.060									
October	24/10/12	15.060	23.990									
November	21/11/12	15.090	23.960		4.85	0.06	0.156	22.80	4.030	47.30	221.5	Bailed 10L, bore still not dry, samples taken (red colour)
December	20/12/12	15.180	23.870									
MB04 - TD = 18.1 mbtoc, RL = 40.33 mAHD												
September	28/09/11	16.454	23.876		5.03		0.530	22.30	2.600	30.10	234.9	bailed 10 L, bore still not dry
October	19/10/11	16.364	23.966		4.82	-0.21	0.650	21.80	3.040	37.30	246.2	bailed 10 L, bore still not dry, samples taken
November	14/11/11	16.251	24.079									
December	22/12/11	16.305	24.025									
January	16/12/11	16.434	23.896		4.62	-0.20	0.608	22.89	6.430	68.20	240.0	bailed 15 L, bore still not dry, samples taken
February	22/02/12	16.597	23.733									
March	27/03/12	16.765	23.565									
April	23/04/12	16.881	23.449		4.28	-0.34	0.820	21.50	1.850	20.40	-12.6	Bailed 10L, bore still not dry, samples taken. Sulphur smell and metal smell - ant nest also in bore
May	24/05/12	16.876	23.454									
June	27/06/12	17.371	22.959									
July	26/07/12	17.850	22.480		4.57	0.29	0.840	21.40	24.900	2.18	157.8	Bailed 10L, bore still not dry, samples taken. Sulphurous smell - ant nest also in bore
August	29/08/12	16.640	23.690									
September	26/09/12	16.560	23.770									
October	24/10/12	16.530	23.800									
November	21/11/12	16.600	23.730		4.38	0.19	0.830	22.80	4.350	52.10	154.7	bailed 15 L, bore still not dry, samples taken
December	20/12/12	16.650	23.680									
MB05 - TD = 18.776 mbtoc, RL = 41.37 mAHD												
September	28/09/11	17.663	23.707		5.73		0.345	20.90	5.800	65.31	176.8	bailed 15 L, bore still not dry
October	19/10/11	17.594	23.776		6.06	0.33	0.267	20.80	6.450	71.50	176.2	bailed 10L, bore still not dry, samples taken
November	14/11/11	17.475	23.895									
December	22/12/11	17.581	23.789									
January	16/01/11	17.697	23.673		5.03	-1.03	0.268	21.95	18.640	195.20	258.0	bailed 15 L, bore still not dry, samples taken
February	22/02/12	17.851	23.519									
March	27/03/12	18.405	22.965									
April	23/04/12	18.166	23.204		5.42	0.39	0.354	20.50	6.360	70.30	221.8	8L, bore dry and recharged in 20 minutes, samples taken.
May	24/05/12	18.139	23.231									
June	27/06/12	17.975	23.395									
July	26/07/12	17.990	23.380		5.75	0.33	0.346	20.40	7.560	84.00	203.5	bailed 15 L, bore still not dry, samples taken
August	29/08/12	17.890	23.480									
September	26/09/12	17.830	23.540									
October	24/10/12	17.800	23.570									
November	21/11/12	17.880	23.490		5.32	0.43	0.306	22.10	7.060	81.60	176.9	bailed 10L, bore still not dry, samples taken
December	20/12/12	17.940	23.430									
MB06 - TD = 15.72 mbtoc, RL = 36.84 mAHD												
September	28/09/11	12.559	24.281		5.18		0.910	20.20	1.460	16.30	-1.7	bailed 25 L, bore still not dry. Sulfur smell
October	19/10/11	12.521	24.319		4.94	-0.24	1.070	19.80	1.780	19.80	-7.5	bailed 10 L, bore still not dry, sulfur smell, samples taken
November	14/11/11	12.451	24.389									
December	22/12/11	12.678	24.162									
January	16/01/11	12.902	23.938		4.84	-0.10	1.002	21.26	8.430	129.30	-38.0	bailed 10 L, bore still not dry, sulfur smell, samples taken
February	22/02/12	13.120	23.720									
March	27/03/12	13.386	23.454									
April	23/04/12	13.456	23.384		4.55	-0.29	1.150	20.10	1.910	21.00	-38.6	Bailed 10L, bore still not dry, sulfur smell, samples taken
May	24/05/12	13.376	23.464									
June	27/06/12	13.210	23.630									
July	26/07/12	13.110	23.730		4.93	0.38	1.130	19.50	2.000	21.80	85.8	bailed 10 L, bore still not dry, sulfur smell, samples taken
August	29/08/12	12.970	23.870									
September	26/09/12	12.800	24.040									
October	24/10/12	12.870	23.970									
November	21/11/12	12.970	23.870		5.15	-0.22	1.260	21.60	4.200	49.00	90.6	Bailed 10L, bore still not dry, sulfur smell, samples taken
December	20/12/12	13.060	23.780									
MB07 - TD = 13.407 mbtoc, RL = 35.09 mAHD												
September	28/09/11	9.982	25.108		6.20		0.256	21.20	5.660	63.20	235.1	bailed 30 L, bore still not dry
October	19/10/11	10.214	24.876		6.15	-0.05	0.293	21.00	6.690	75.80	183.5	bailed 10 L, bore still not dry, samples taken
November	14/11/11	10.151	24.939									
December	22/12/11	10.763	24.327									
January	16/01/11	10.998	24.092		5.84	-0.31	0.245	21.75	15.180	134.10	188.0	bailed 15 L, bore still not dry, samples taken
February	22/02/11	11.226	23.864									
March	27/03/12	11.545	23.545			0.00						
April	23/04/12	11.841	23.249		6.05	0.21	0.310	21.90	6.600	74.80	158.8	Bailed 8L, slow recharge, samples taken
May	24/05/12	11.446	23.644									
June	27/06/12	10.985	24.105									

					These may not always be required							
Sample Identification Number	Sample Date	Depth to groundwater (mbtoc)	Groundwater level (m AHD)	Depth from ground level	pH	Change in pH	Electrical Conductivity	Temp	Dissolved Oxygen	Dissolved Oxygen	Redox	Comments
Units					pH Unit	pH Unit	mS/cm	oC	mg/L	%	mV	
July	26/07/12	11.140	23.950		6.34	0.29	0.137	20.80	4.520	49.90	164.2	bailed 15 L, bore still not dry, samples taken
August	29/08/12	10.740	24.350									
September	26/09/12	10.540	24.550									
October	24/10/12	10.860	24.230									
November	21/11/12	10.960	24.130		6.25	0.09	0.195	21.40	4.530	48.50	155.6	bailed 10 L, bore still not dry, samples taken
December	20/12/12	11.120	23.970									
MB08 - TD = 7.47 mbtoc, RL = 32.44 mAHD												
September	28/09/11	3.950	28.490		6.15		0.690	20.40	6.880	76.60	228.9	bailed 30 L, bore still not dry
October	19/10/11	4.567	27.873		6.03	-0.12	0.920	20.10	6.650	76.00	201.7	bailed 10 L, bore still not dry, samples taken
November	14/11/11	4.681	27.759									
December	22/12/11	4.872	27.568									
January	16/01/11	5.775	26.665		5.83	-0.20	0.710	22.81	24.730	270.60	204.0	Bailed 6 L and bore ran dry, replenished in 15-20 minutes, sample taken
February	22/02/12	6.549	25.891									
March	27/03/12	dry										dry
April	23/04/12	dry										dry
May	24/05/12	dry										dry
June	27/06/12	5.310	27.130									
July	26/07/12	5.310	27.130		Not enough sample for Physio-Chem analysis							Bailed 1 L and bore ran dry, replenished in 25 mins, samples taken
August	29/08/12	5.770	26.670									
September	26/09/12	5.500	26.940									
October	24/10/12	6.690	25.750									
November	21/11/12	6.300	26.140		6.58	-0.75	0.014	23.00	6.230	73.30	115.3	bailed 10 L, bore still not dry, samples taken
December	20/12/12	6.970	25.470									
MB09 - TD = 5.64 mbtoc, RL = 33.96 mAHD												
September	28/09/11	0.990	32.970		6.02		0.174	16.80	4.180	43.90	232.3	bailed 30 L, bore still not dry
October	19/10/11	1.549	32.411		6.68	0.66	0.191	17.30	5.890	62.30	204.8	bailed 10 L, bore still not dry, samples taken
November	14/11/11	2.075	31.885									
December	22/12/11	dry										dipper muddy ?may just be moisture at bottom of bore
January	16/12/11	dry										Bore was dry, water level obtained by moist mud level, no sample taken
February	22/02/12	dry										Bore was dry, water level obtained by moist mud level
March	27/03/12	dry										dry
April	23/04/12	dry										dry
May	24/05/12	dry										dry
June	27/06/12	dry										dry
July	26/07/12	dry										dry
August	29/08/12	dry										dry
September	26/09/12	dry										Bore was dry, water level obtained by moist mud level, no sample taken
October	24/10/12	5.610	28.350									water level obtained by moist mud level, no sample taken
November	21/11/12	5.630	28.330									water level obtained by moist mud level, no sample taken
Poison Gully Creek (at Milner Road)												
September	28/09/11				7.21		0.640	14.80	9.030	87.30	181.4	
October	19/10/11	<0.20cm			6.75	-0.46	0.700	16.60	8.700	89.10	208.9	Less flow than September
November	14/11/11	<0.20cm										Similar flow to October
December	22/12/11											Creek is dry
January	16/01/12											Creek is dry
February	22/02/12											Creek is dry
March	27/03/12											dry
April	23/04/12											dry
May	24/05/12											dry
June	27/06/12	50 cm										no samples taken
July	26/07/12	25 cm										no samples taken
August	29/08/12	50 cm										no samples taken
September	26/09/12	50 cm										no samples taken
October	24/10/12	45 cm										Samples taken
November	21/11/12	Dry										Creek is dry
December	20/12/12											
Water Corporation Bore off Noble street (near railway tracks in bushland area)												
May	24/05/12	3.041										Depth to Ground: 5.570
June	27/06/12	2.970										
July	26/07/12	2.910										
August	29/08/12	2.870										
September	26/09/12	2.750										
October	24/10/12	2.450										
November	21/11/12	2.330										
December	20/12/12	2.590										



GROUNDWATER LABORATORY ANALYTICAL RESULTS

Sample Identification Number	Sample Date	Physio-chem	Metals and Metaloids							Nutrients							
		pH	Arsenic	Cadmium	Copper	Chromium	Nickel	Lead	Zinc	Ammonia as N	Nitrite as N	Nitrate as N	Nitrite + Nitrate as N	Total Kjeldahl Nitrogen as N	Total N	Total Phosphorus (Kjeldahl Digestion)	Reactive Phosphorus as P
Units		pH Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
The Swan Canning Water Quality Improvement Plan (short term limits)															2	0.2	
The Swan Canning Water Quality Improvement Plan (Long term limits)															0.5	0.05	
ANZECC & ARMCANZ (2000) guidelines for slightly disturbed ecosystems in South West Australia		6.5 - 8.5															
ANZECC & ARMCANZ (2000) guidelines for fresh and marine water quality - 95% trigger value (Freshwater)			24	0.2	1.4	1	11	3.4	8								
Australian Drinking Water Guideline (2000)												11.3					
MB01	28/09/2011	6.61															
	19/10/2011	6.62	9	<0.1	24	2	11	62	170	0.65	0.27	1.2	1.47	1	2.4	0.61	0.003
	16/01/2012	5.87	7	<0.1	44	7	22	100	520	1.9	0.029	0.97	0.999	4.9	5.9	1.7	<0.002
	23/04/2012	5.68								0.066	<0.05	1.12	5.25	0.66	1.8	0.41	<0.002
	26/07/2012	5.84								0.09	<0.05	0.63	0.66	0.45	1.1	0.21	0.008
	21/11/2012	6.07								0.0464	0.2	0.25	0.45	0.66	0.93	0.68	<0.005
MB02	28/09/2011	5.03															
	19/10/2011	4.84	<1	<0.1	<1	<1	<1	3	19	0.046	<0.005	0.13	0.1325	0.42	0.55	0.22	<0.002
	16/01/2012	4.85	<1	<0.1	7	5	2	10	31	0.14	<0.05	0.2	1.125	0.92	1.2	0.46	<0.002
	23/04/2012	4.63								0.047	<0.05	0.22	1.005	0.43	0.65	0.82	<0.002
	26/07/2012	4.91								0.05	0.006	0.22	0.23	0.51	0.74	0.23	0.008
	21/11/2012	4.85								0.175	<0.005	0.018	0.018	0.96	0.98	0.12	<0.005
MB04	28/09/2011	5.03															
	19/10/2011	4.82	<1	<0.1	<1	1	3	4	46	0.15	0.012	0.11	0.122	0.92	1	2.4	<0.002
	16/01/2012	4.62	<1	<0.1	9	3	1	9	18	0.20	<0.05	0.02	0.115	1.1	1.1	1.1	<0.002
	23/04/2012	4.28								<0.005	<0.05	<0.05	0.05	0.62	0.62	1	<0.002
	26/07/2012	4.57								0.12	<0.05	<0.005	NR	1.2	1.2	1.3	0.006
	21/11/2012	4.38								0.035	<0.005	0.069	0.069	2.3	2.3	0.84	<0.005
MB05	28/09/2011	5.73															
	19/10/2011	6.06	<1	<0.1	1	2	3	50	20	0.120	0.014	4.5	4.514	0.88	5.4	5.7	<0.002
	16/01/2012	5.03	<1	<0.1	5	7	2	48	30	0.026	<0.05	4.74	21.025	0.041	5.1	2.3	0.003
	23/04/2012	5.42								0.037	<0.05	5.41	24.025	0.62	6	4.8	<0.002
	26/07/2012	5.75								0.06	<0.05	4.5	4.5	0.91	5.4	3.4	0.002
	21/11/2012	5.32								0.065	<0.005	4.8	4.8	2.1	6.9	4.5	<0.005
MB06	28/09/2011	5.18															
	19/10/2011	4.94	<1	<0.1	16	1	4	89	56	0.047	<0.005	0.13	0.1325	1.5	1.7	0.69	<0.002
	16/01/2012	4.84	2	<0.1	36	12	4	270	75	0.27	<0.05	0.022	0.1025	2.8	2.8	1.9	<0.002
	23/04/2012	4.55								0.038	<0.05	<0.05	0.05	0.31	0.31	0.12	<0.002
	26/07/2012	4.93								0.13	<0.05	0.012	0.037	1.8	1.8	0.58	0.005
	21/11/2012	5.15								0.052	<0.005	0.058	0.058	5.2	5.3	1.2	<0.005
MB07	28/09/2011	6.20															
	19/10/2011	6.15	<1	<0.1	13	2	4	6	66	0.037	<0.005	7.5	7.5025	0.43	8	0.38	<0.002
	16/01/2012	5.84	<1	<0.1	18	8	3	7	58	0.10	<0.05	6.32	28.0025	0.91	7.3	0.77	<0.002
	23/04/2012	6.05								0.098	<0.05	7.67	34.025	0.25	8	0.2	<0.002
	26/07/2012	6.34								0.08	<0.05	1.6	1.6	5.5	7.1	1.6	0.003
	21/11/2012	6.25								<0.005	<0.005	6.1	6.1	4.1	10	1.1	<0.005
MB08	28/09/2011	6.15															
	19/10/2011	6.03	<1	<0.1	6	<1	<1	8	14	0.023	<0.005	22	22.0025	0.81	23	0.18	<0.002
	16/01/2012	5.83	2	<0.1	47	10	5	240	170	0.19	<0.005	20.32	90.0025	4.3	25	0.72	<0.002
	23/04/2012	IS								IS	IS	IS	IS	IS	IS	IS	IS
	26/07/2012	IS								0.03	<0.05	18	18	2.5	20	0.52	0.017
	21/11/2012	6.58								0.15	<0.005	13	13	5.7	18	1.2	0.013
MB09	28/09/2011	6.02															
	19/10/2011	6.68	<1	<0.1	4	<1	<1	3	20	0.03	<0.005	0.54	0.5425	0.76	1.3	0.08	<0.002
	16/01/2012	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS
	23/04/2012	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS
	26/07/2012	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS
	21/11/2012	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS	IS
Posion Gully	28/09/2011	7.21															
	19/10/2011	6.75	<1	<0.1	<1	<1	<1	<1	22	0.024	<0.005	0.15	0.1525	0.28	0.42	<0.01	<0.002
	16/01/2012	IS								IS	IS	IS	IS	IS	IS	IS	IS
	23/04/2012	IS								IS	IS	IS	IS	IS	IS	IS	IS
	24/10/2012	IS								<0.005	<0.005	<0.005	<0.005	0.36	0.36	0.01	<0.02
Groundwater statistics	max	7.21												max	25	5.7	
	min	4.28												min	0.31	0.08	
	median	5.71												median	2.35	0.77	

nr - not recorded
NA - Not analysed
IS -Insufficient sample

Shire of Kalamunda – Mapping



FORRESTFIELD/HIGH WYCOMBE PROPOSED INDUSTRIAL AREA – STAGE 3

Appendix 4
Foreshore assessment

STRATEGEN
environmental consultants

Mr Andrew Fowler-Tutt
Manager Development Services
Shire of Kalamunda
PO Box 42
KALAMUNDA WA 6926

Reference: SKA11210.02

Dear Mr Fowler-Tutt

POISON GULLY CREEK FORESHORE ASSESSMENT

A foreshore assessment of Poison Gully Creek has undertaken by Strategen to support an Environmental Review of the proposed rezoning of the Forrestfield Industrial Area (FIA) Stage 3 (the Project) from 'Rural' to 'Light Industrial', under the Metropolitan Region Scheme. The foreshore assessment is intended to inform the establishment of an appropriate foreshore reserve on the northern boundary of the Project.

A foreshore is the land that adjoins or directly influences a waterway (WRC 2001). More specifically, it is the area of transition between the edge of the waterway and the furthest extent of riparian vegetation, flood prone land, and riverine landform or simply the adjacent upland (WRC 2001). Where human activities have affected the waterway, the foreshore area may be the land between the waterway and the area actively being used (WRC 1999, *Statewide Foreshore Policy – Policy Update No. 2*).

The FIA Stage 3 will be located to the south of Poison Gully (the creek) between Roe Highway and Maida Vale Road (Figure 1). Discussions with the Department of Water (Mackintosh J [Department of Water] 2011, pers. comm. 22 November) indicated that assessment of the southern boundary of the Poison Gully foreshore between Roe Highway in the east and Maida Vale Road in the west would be adequate to support development of FIA Stage 3.

The foreshore assessment involved a desktop review of existing information and a site visit. The site visit was completed on 28 May 2012 by Strategen. The creek was predominantly dry at the time of the site visit, with pools of standing water present at Littlefield Road and areas to the west of this. The assessment considered the following biophysical criteria; vegetation, hydrology, soil type, geology, topography, habitat, land use and heritage, based on the guidelines in *Determining Foreshore Reserves* (WRC 2001).

The channel of the creek is predominantly located within an existing foreshore reserve that is zoned for 'public recreation and drainage' (ID&A 2001). The creek runs though private property at locations near Maida Vale Road and immediately to the east of Milner Road. The boundary of private property is shown as the 'Project boundary' on the figures.

Topography

The creek is deeply incised along its length adjacent to FIA Stage 3, with the steepest gradient occurring on the eastern extent of the creek. The level of the base of the creek varies from approximately 41 meters Australian Height Datum (mAHD) at Roe Highway in the east to approximately 32 mAHD at Maida Vale Road (Figure 2). The creek flows in a westerly direction. Figure 2 illustrates 0.2 m topographical contours of the creek.

The form of the creek changes from east to west. East of Littlefield Road, the creek comprises a 1-2 m deep low flow channel with a top width of approximately 2 m, contained within a larger 3-6 m deep incised channel with a 20 to 30 m top width (ID&A 2001). In some isolated points, the low flow channel abuts the sides of the larger incised channel, resulting in a vertical exposed bank of 3 to 5 m in

Level 2, 322 Hay Street, Subiaco, WA 6008 P.O. Box 243 Subiaco, WA 6904 Phone: (08) 9380 3100 Fax: (08) 9380 4606
Podium Level, Bunbury Tower, 61 Victoria Street, Bunbury, WA 6230 P.O. Box 287, Bunbury, WA 6231 Phone: (08) 9792 4797 Fax: (08) 9792 4708
Email: info@strategen.com.au Web: www.strategen.com.au ABN: 32 056 190 419

height(Plate 1). Further west (downstream), the creek becomes less incised and shallower, with an approximately 0.5 m deep low flow channel with a width of approximately 1-2 m, with the outer incised channel reducing to a depth of 2 to 3 m and becoming less steep at the far western end, near Maida Vale Road.



Plate 1 Photograph taken from low flow channel of Gully, showing steep banks of approximately 4 m in height (photo taken between Roe Highway and Littlefield Road)

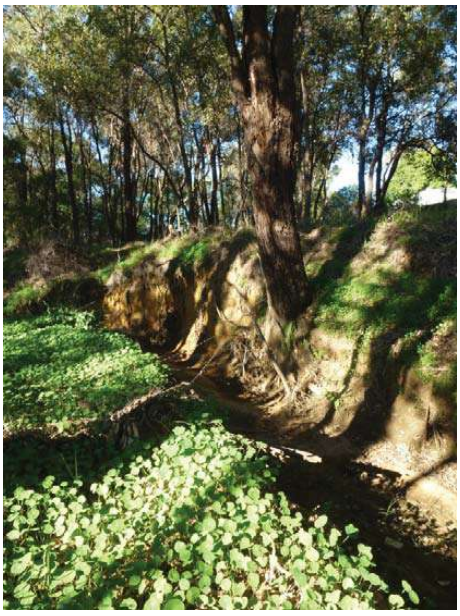


Plate 2 Exposed tree roots on bank of low flow channel, east of Milner Road

The steeper banks of the stream are often vertical or close to vertical and are potentially quite dangerous to persons who may access the area. At many locations, these banks are very close to property boundaries or are within the properties themselves (Figure 2). Where steep banks abut property boundaries, the removal of trees and other vegetation and the construction of large structures may increase the risk of erosion, with impacts on both Poison Gully and the structures involved.

Soil type and geology

The geology of Poison Gully in this area is described in the regional mapping as Bassendean Sands (light grey fine to medium grained quartz sands of eolian origin) over the sands and silts of the Guildford Formation soils (Gozzard 1986). This geological unit extends over Poison Gully and the surrounding Forrestfield area (Gozzard 1986). The soils of the creek were predominantly sand to sandy clay in the west of the site, becoming more consolidated, cemented and clayey to the east.

A small patch (less than 0.5 m by 0.5 m) of rock was observed at the bottom of the creek at one location to the east of Littlefield Road. This rock appeared to be limestone-like in nature.

Hydrology

1 in 100 year Average Return Interval (ARI) flood level modelling for Poison Gully was undertaken by Water Corporation (2010). This flood modelling indicates a 1 in 100 year ARI flood level ranging between 39.81 mAHD at Roe Highway and 32.36 mAHD at Maida Vale Road (Figure 3). The flood height at Roe Highway is considered likely to be underestimated, as the invert level of the creek at this point is greater than 40 mAHD, above the Water Corporation Flood level (Figure 3). Based on the Water Corporation modelling, Poison Gully will overtop the road at Milner Road in the 1 in 100-year ARI event (Figure 3).

Flood levels and extent of flooding were interpolated from the Water Corporation modelling by Strategen along Poison Gully (Figure 3). Extents of flooding and levels shown have been estimated for the purpose of the foreshore assessment based on this modelling. The accuracy and results of this modelling have not been checked by Strategen. The mapping is therefore considered indicative and persons undertaking construction or other works adjacent to Poison Gully should make their own assessments of the flooding risks involved.

The width of flooding is variable, ranging from less than 10 m to approximately 40 m at the widest point. The Water Corporation modelling does not identify a separate floodway (area of fast flow) and flood fringe (area of slower water movement). For the purposes of this study, it has been assumed that the whole width of the inundated area is floodway.

Erosion

Evidence of erosion was observed to varying degrees along the length of Poison Gully Creek at the time of the site visit. The outer vertical banks are comprised of a consolidated and lightly cemented alluvium. These banks appear relatively stable and the rates of erosion are anticipated to be very low (ID&A 2001). However, other vertical eroding banks were evident in the low flow channel, as identified by IDA (2001). ID&A (2001) considered that the erosion was consistent with a stream in 'good to high physical condition'.

Vegetation

Vegetation mapping of lots, but not the existing foreshore reserve, was undertaken by Shire of Kalamunda as part of the works for the Project. Vegetation within the lots is predominantly cleared, but some patches of Marri woodland and Jarrah/Banksia woodland in good condition occur near Maida Vale Road and at one location between Roe Highway and Littlefield Road (Figure 4, Maps 1 and 4).

Formal mapping of vegetation within the existing foreshore reserve was not undertaken as part of this study. Because of the steepness of the banks and narrow nature of the main flow channel, there is little classical wetland vegetation such as sedges or rushes present.

Vegetation condition within the Foreshore Reserve varied between completely degraded and good to very good. The best vegetation within the Foreshore Reserve was located adjacent to and within the good vegetation mapped on lots near Maida Vale Road and between Littlefield Road and Roe Highway. A variety of introduced plant species are present along the creek, including watsonia (*Watsonia bulbillifera*) and Spanish bamboo (*Arundo donax*). The area immediately to the east of Milner Road is heavily infested with morning glory (*Ipomoea indica*) (Plate 3). Native and introduced vegetation plays an important role in terms of bank stabilisation.



Plate 3 Morning glory infestation of Poison Gully on private land at Milner Road.

This section of Poison Gully, including most of the foreshore reserve and some surrounding bush is recognised as a Bush Forever site, because of its regional significance (Figure 4, Maps 1-5). Poison Gully and the surrounding areas west of Littlefield Road are also identified as a Resource Enhancement Category Wetland (REW) (Figure 3, Maps 1-3).

The upland vegetation is considered important for the maintenance of the health of Poison Gully as the root systems assist in bank stabilisation, and also for nutrient stripping and habitat purposes. The Bush Forever site is considered to represent the minimum area of vegetation requiring protection. Where areas of good vegetation extend beyond this, the extent of this bushland has been taken into account in delineating the vegetation boundary (Figure 4, Maps 1 and 4). Mapping of native vegetation has been undertaken based on aerial photography.

Habitat

Waterways are important for conservation as they can provide important breeding and feeding sites for fauna. Poison Gully Creek is an ephemeral waterway. At the time of the site visit, a small pool of standing water was present near Littlefield Road and a few other minor pools were observed to the east of Littlefield Road. Rain had not occurred for more than a week prior to the survey.

The vegetation in the foreshore area may provide habitat for species including Quenda and black cockatoo (Bamford 2012).

Land use

The proposed FIA Stage 3 lies to the south of Poison Gully Creek. This area is currently zoned 'Rural' and is predominantly rural residential. To the north of the creek lies residential development.

Protecting existing residential and future proposed Light Industrial land uses from inundation and erosion must be considered in establishing a foreshore reserve.

Heritage

Poison Gully Creek is a registered Aboriginal heritage site (Site 25023) and is considered a birthplace and water source.

Rationale for foreshore boundary

The foreshore boundary has been delineated based on consideration of bank steepness, presence of native vegetation and the extent of the 1 in 100 year flood (Figure 5). These factors have been considered through:

- bank steepness- assessment of topographic mapping provided in Figure 2, to determine where steep banks occur and ensure that these are protected
- 1 in 100 year flood mapping based on interpolation of Water Corporation modelling (Figure 3)
- presence of quality native vegetation based on retention of vegetation identified as being in good condition from Bush Forever, Shire mapping of quality vegetation within the Project Area and observations of vegetation undertaken during the site inspection, as identified by the vegetation boundary in Figure 4.

The foreshore boundary represents the outer limits of these three boundaries. Where good quality vegetation identified by the Shire mapping extends well beyond the foreshore into Stage 3, a compromise has been made to ensure a practical boundary.

The most important factor has generally been the floodway and the presence of native vegetation that stabilises the banks and strips nutrients. The steep banks that may require stabilisation are generally within this area, as these banks are difficult to clear and generally avoided. The 1 in 100 year floodway rarely extends beyond the vegetation boundary at few locations, most notably to the east of Milner Road (Figure 5). The recommended foreshore boundary for the site is presented in Figure 5.

Buffers

The lower sections of Poison Gully are categorised as a Resource Enhancement Category wetland. The use of a 30-50 m buffer is recommended to areas of REW.

The area within the foreshore boundary is anticipated to remain as a REW. The foreshore to the east of this area is considered to be of a similar or better quality to the foreshore within the REW area. The foreshore should therefore be afforded a similar buffer to that applied to a REW. This buffer should be assessed at the LSP stage.

Yours sincerely



Darren Walsh
SENIOR PRINCIPAL

19 October 2012

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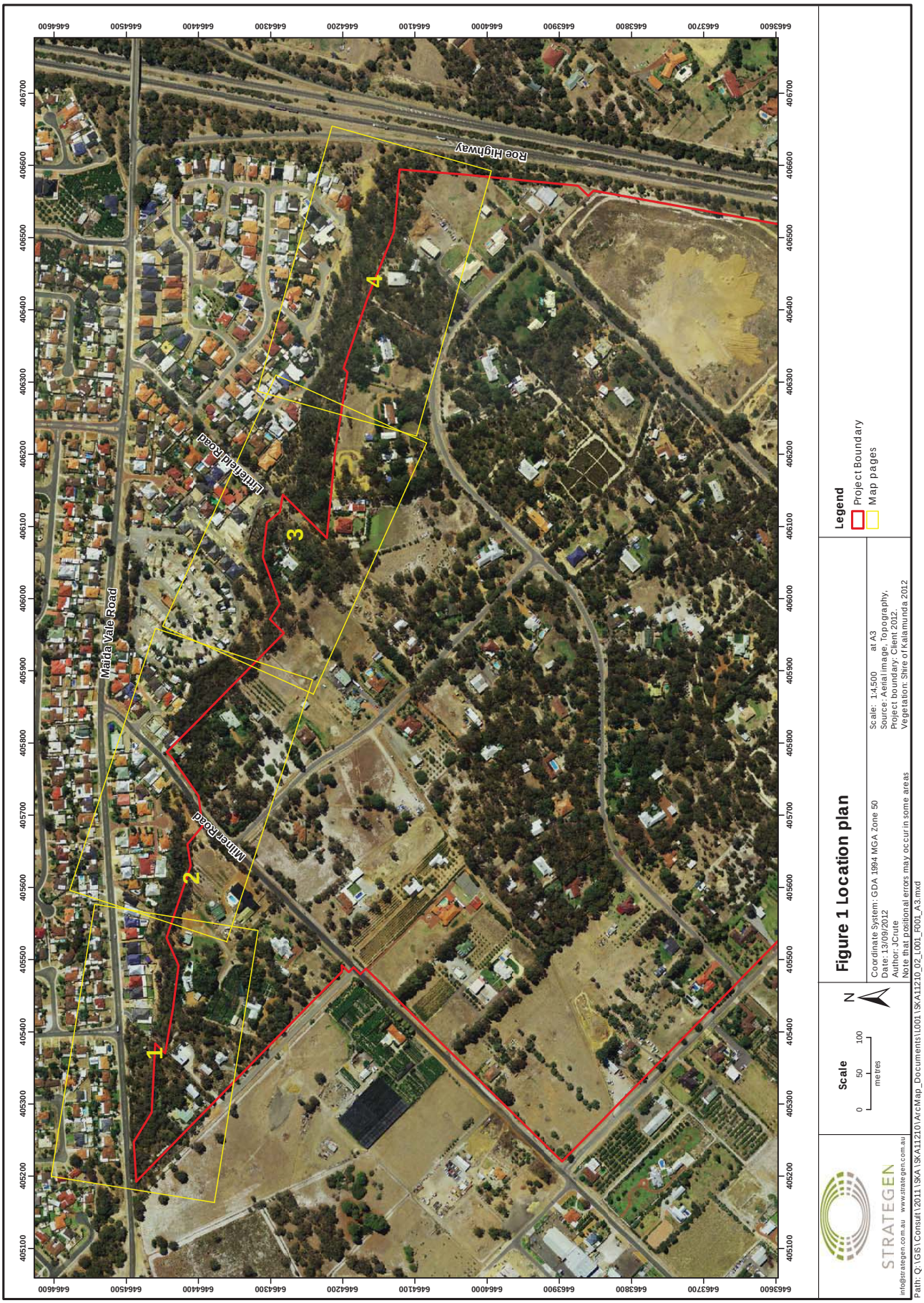
Figure 1 Location plan
Figure 2 Aerial and detailed topography
Figure 3 1 in 100 year flood mapping
Figure 4 Vegetation
Figure 5 Foreshore boundary


Roe Highway
Littlefield Road
Miner Road
Maida Vale Road
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2
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Legend
Project Boundary
Map pages
Figure 1 Location plan
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Scale: 1:4,500 at A3
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Note that positional errors may occur in some areas
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Overview
Legend
Elevation 1 m (mAHD)
Elevation 20cm (mAHD)
Project Boundary
Figure 2 Map 1
Scale
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Overview
Minter Road
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Elevation 1 m (mAHD)
Elevation 20cm (mAHD)
Project Boundary
Figure 2 Map 2
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Date: 13/09/2012
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Overview
Littlefield Road
Legend
Elevation 1 m (mAHD)
Elevation 20cm (mAHD)
Project Boundary
Figure 2 Map 3
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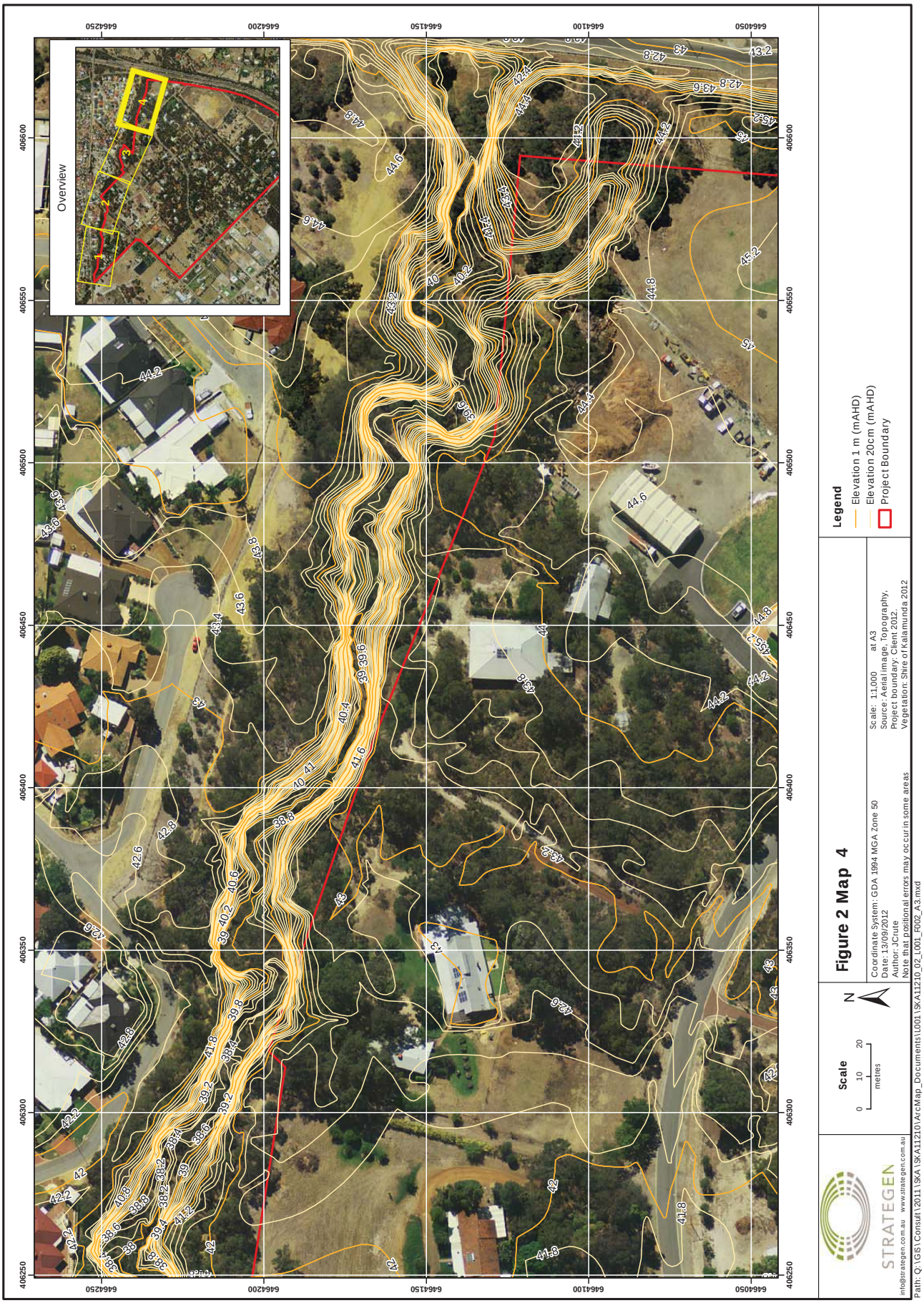
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Elevation 1 m (mAHD)
Elevation 20cm (mAHD)
Project Boundary
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Figure 2 Map 4
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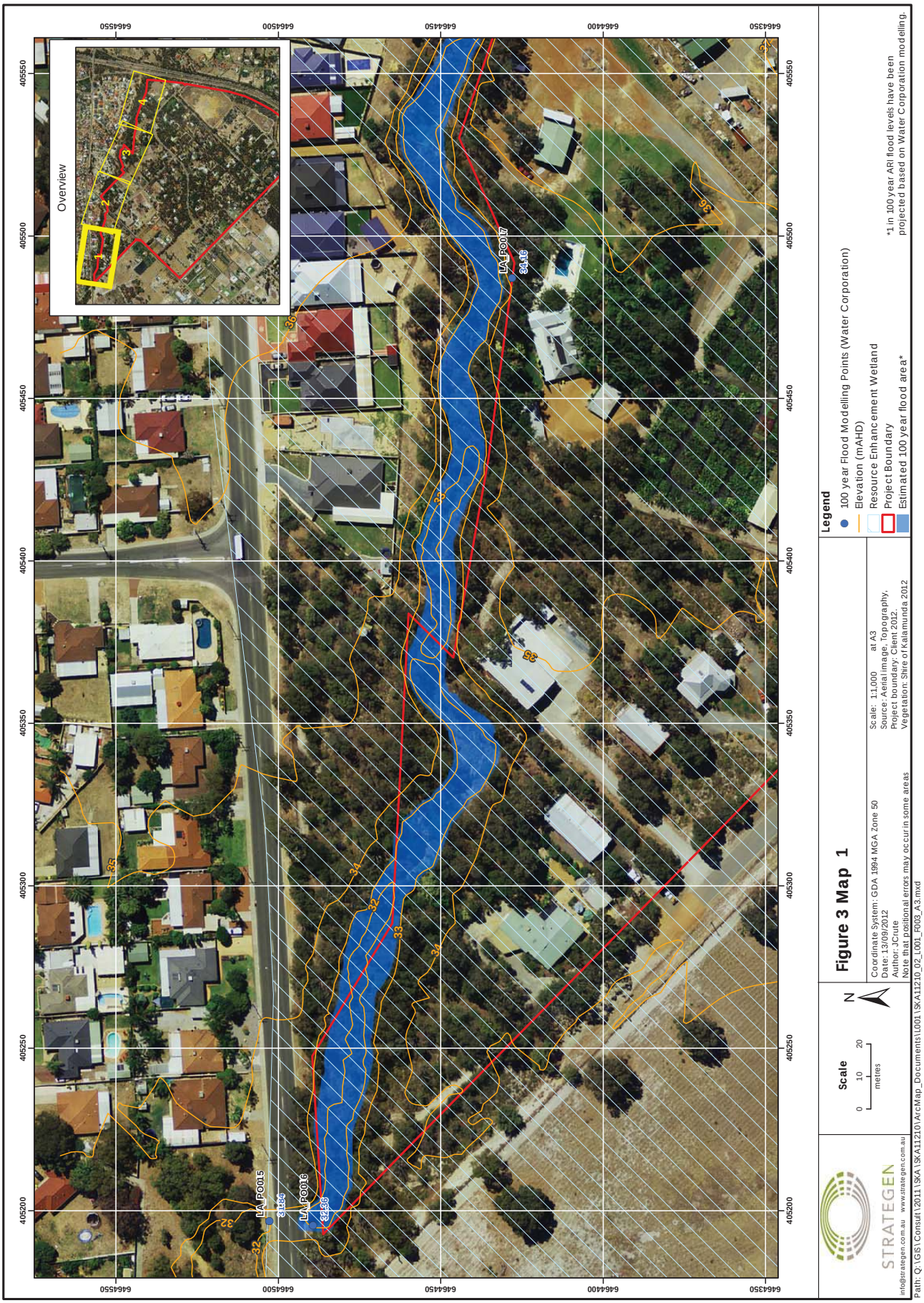
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LA_PO016
LA_PO017
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100 year Flood Modelling Points (Water Corporation)
Elevation (mAHD)
Resource Enhancement Wetland
Project Boundary
Estimated 100 year flood area*
*1 in 100 year ARI flood levels have been projected based on Water Corporation modelling.
Figure 3 Map 1
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Author: JCrute
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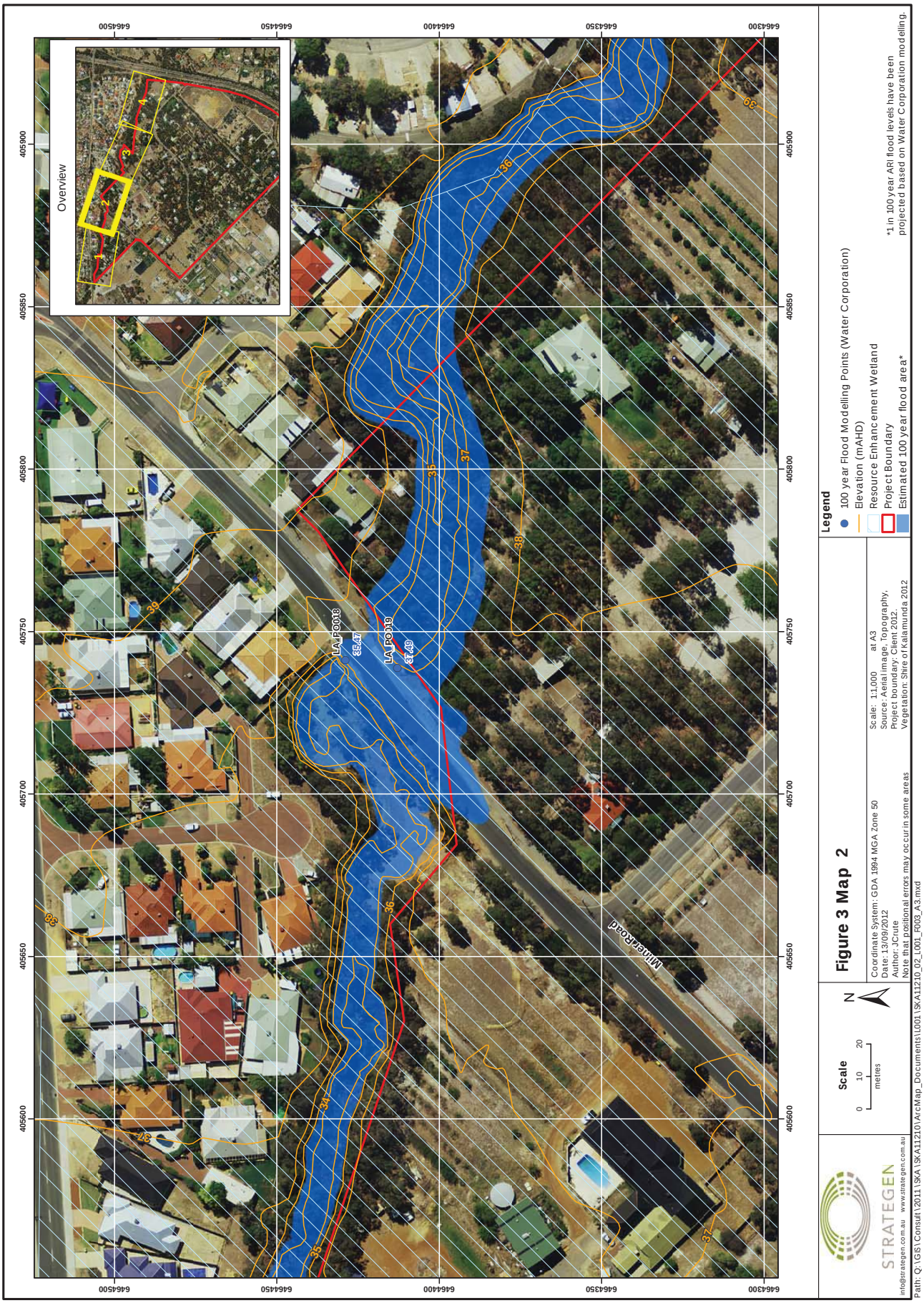
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100 year Flood Modelling Points (Water Corporation)
Elevation (mAHD)
Resource Enhancement Wetland
Project Boundary
Estimated 100 year flood area*
*1 in 100 year ARI flood levels have been projected based on Water Corporation modelling.
Figure 3 Map 2
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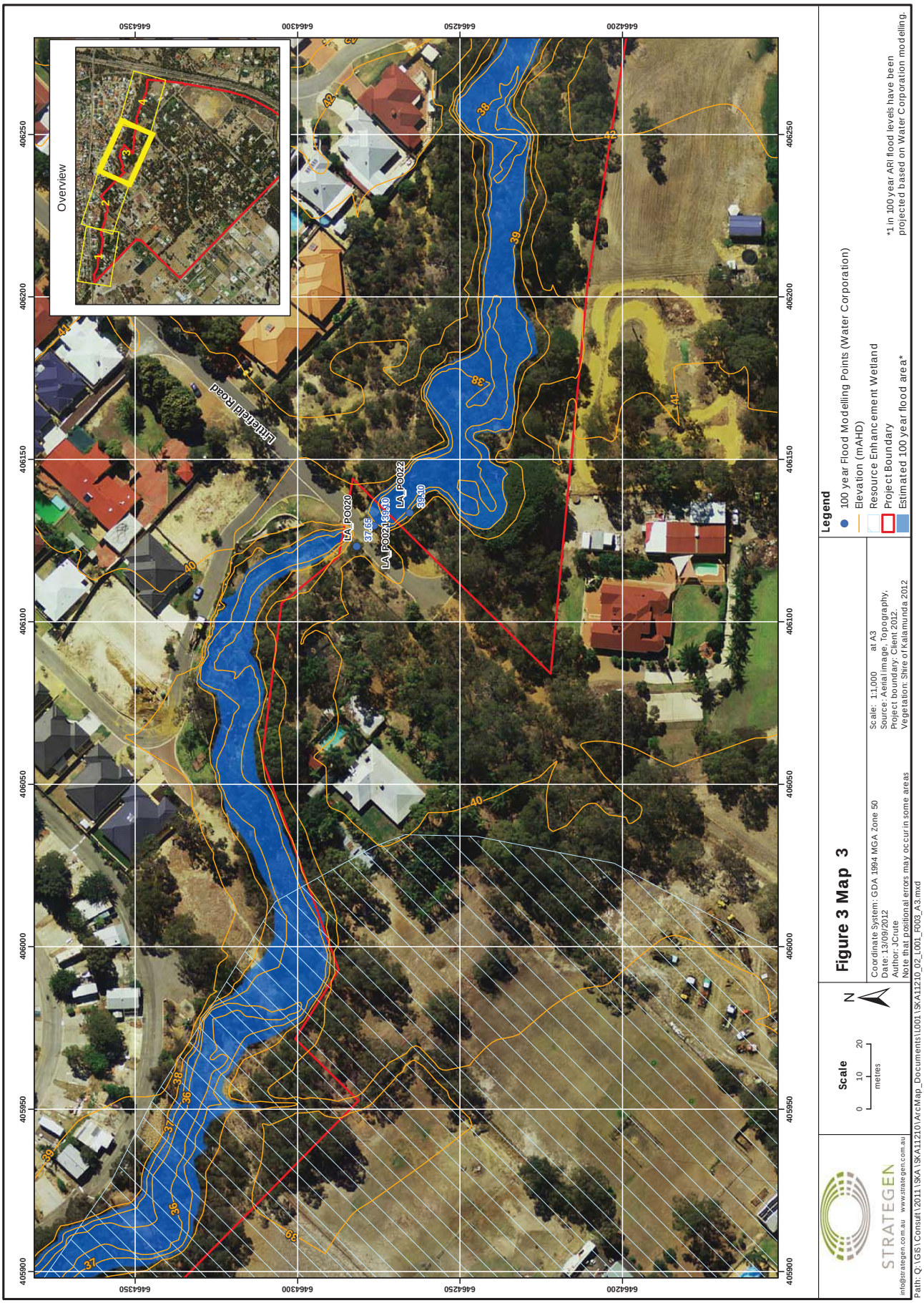
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100 year Flood Modelling Points (Water Corporation)
Elevation (mAHD)
Resource Enhancement Wetland
Project Boundary
Estimated 100 year flood area*
*1 in 100 year ARI flood levels have been projected based on Water Corporation modelling.
Figure 3 Map 3
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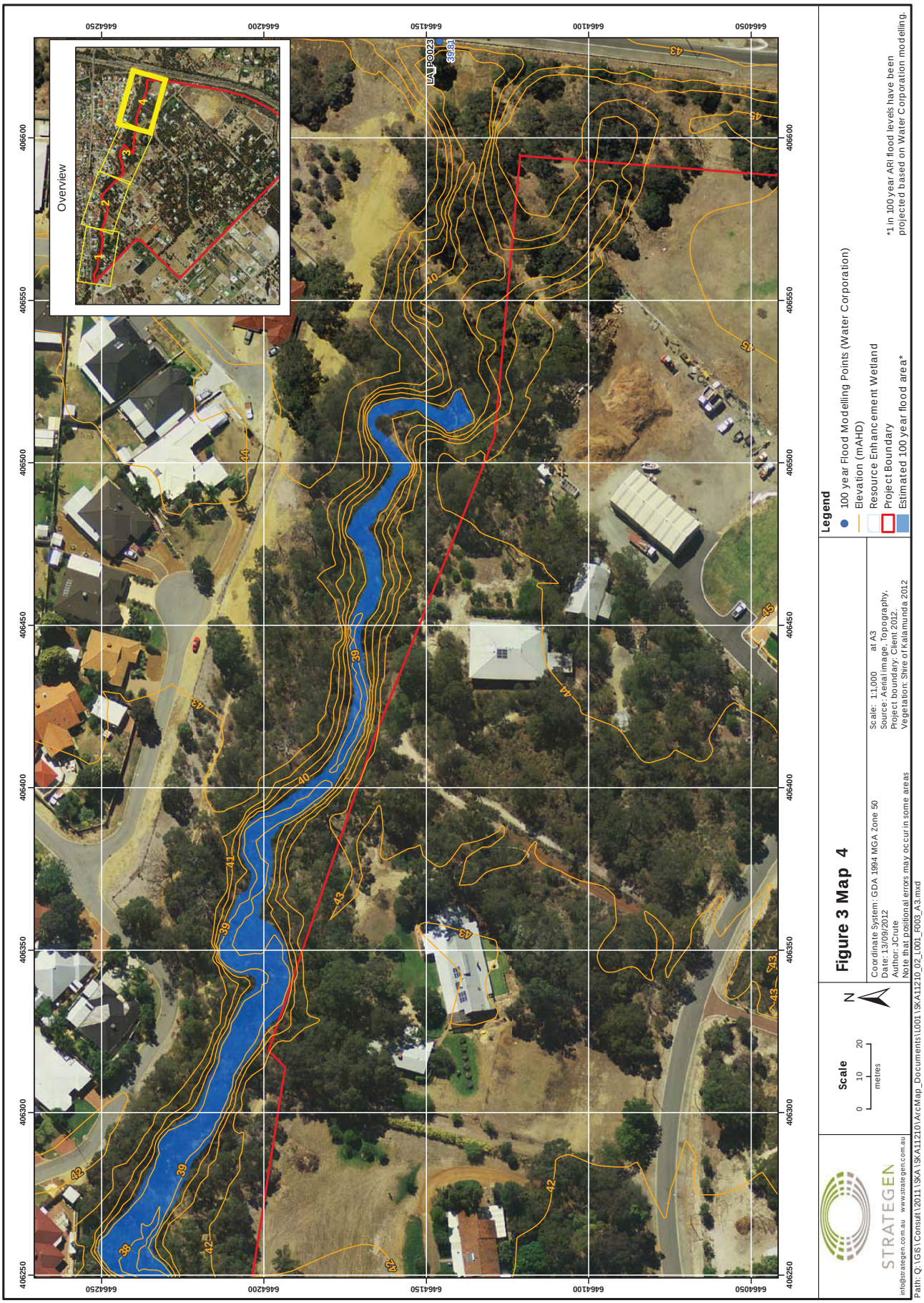
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Elevation (mAHD)
Resource Enhancement Wetland
Project Boundary
Estimated 100 year flood area*
*1 in 100 year ARI flood levels have been projected based on Water Corporation modelling.
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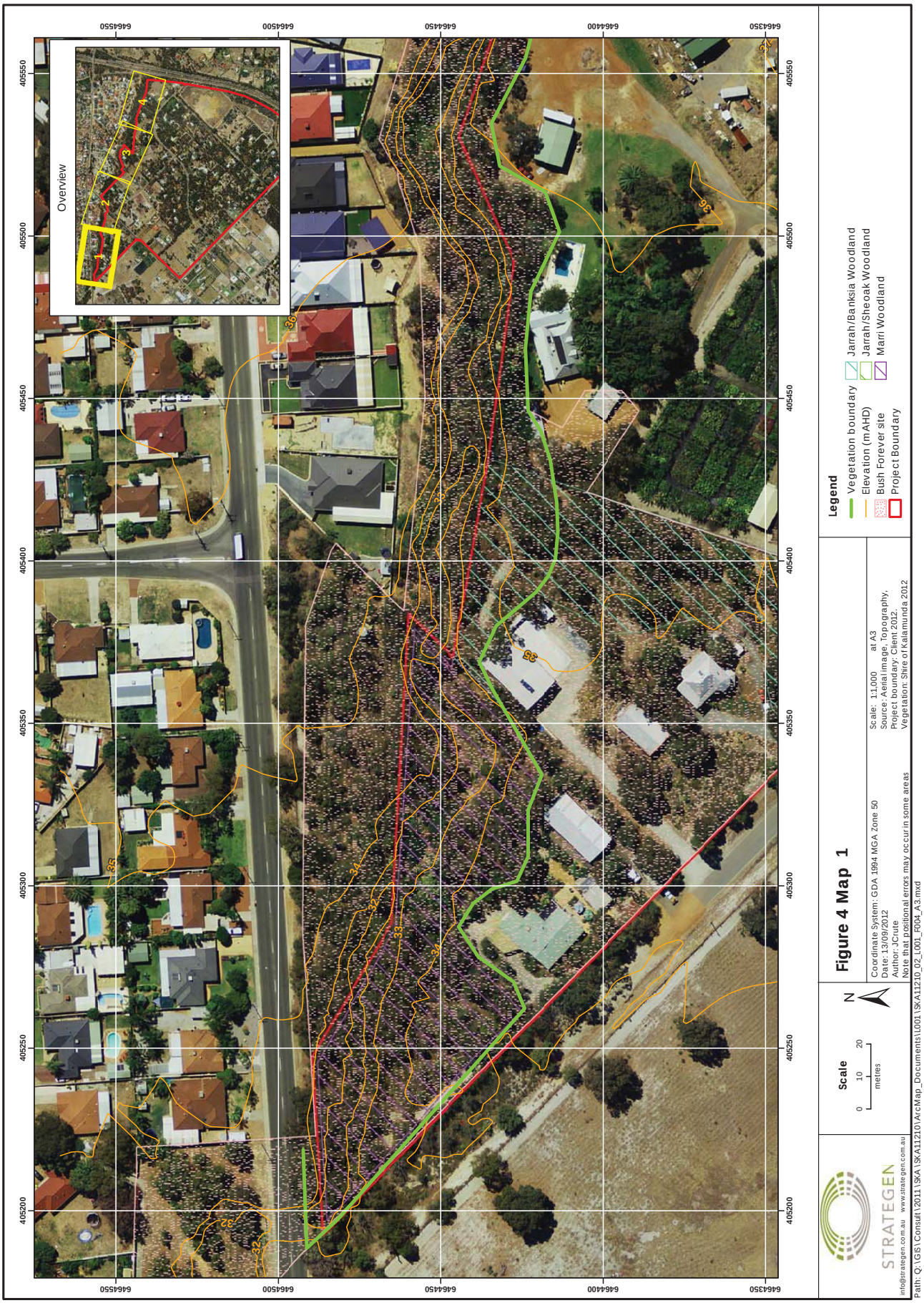
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Jarrah/Sheoak Woodland
Marri Woodland
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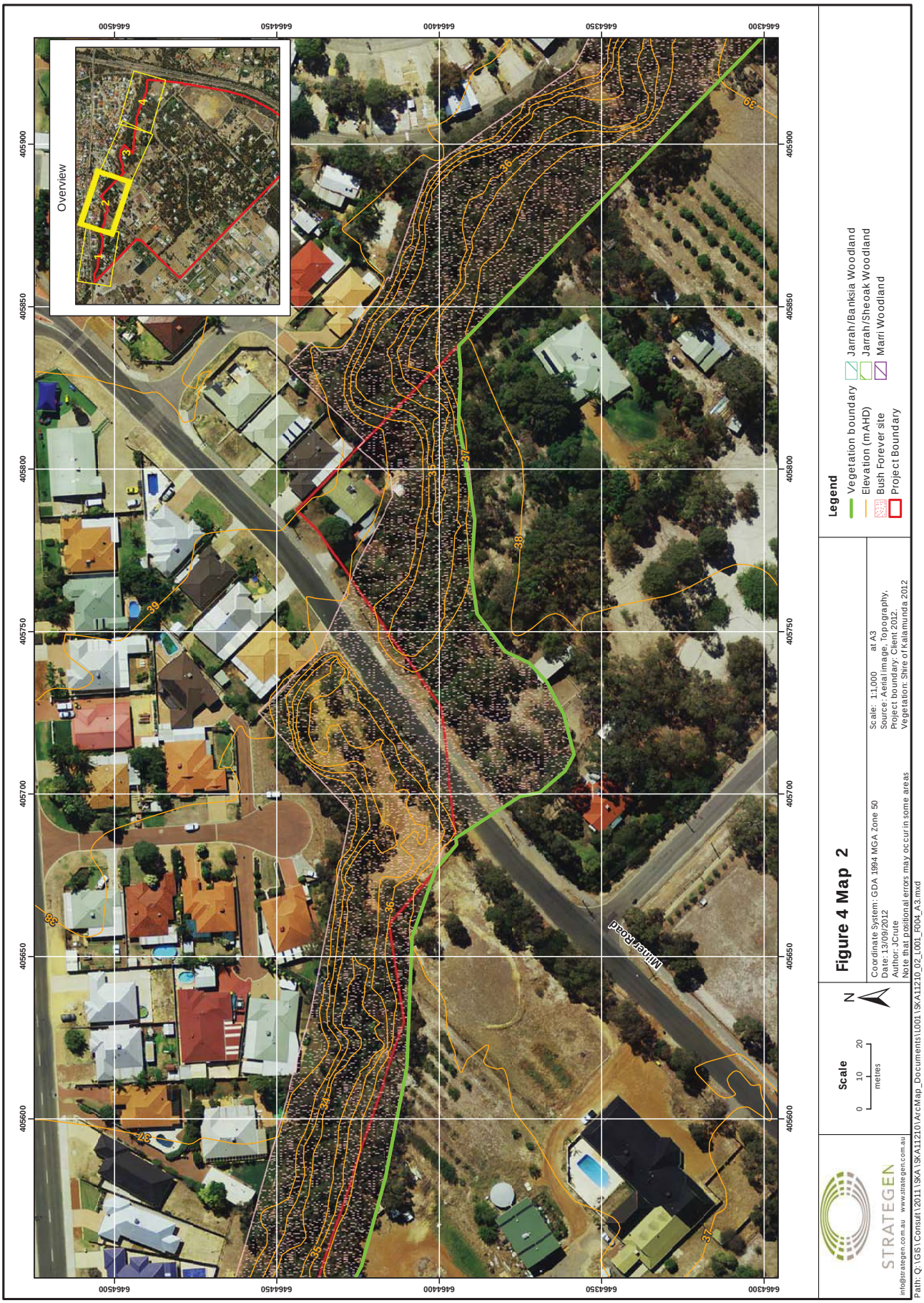
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Jarrah/Sheoak Woodland
Marri Woodland
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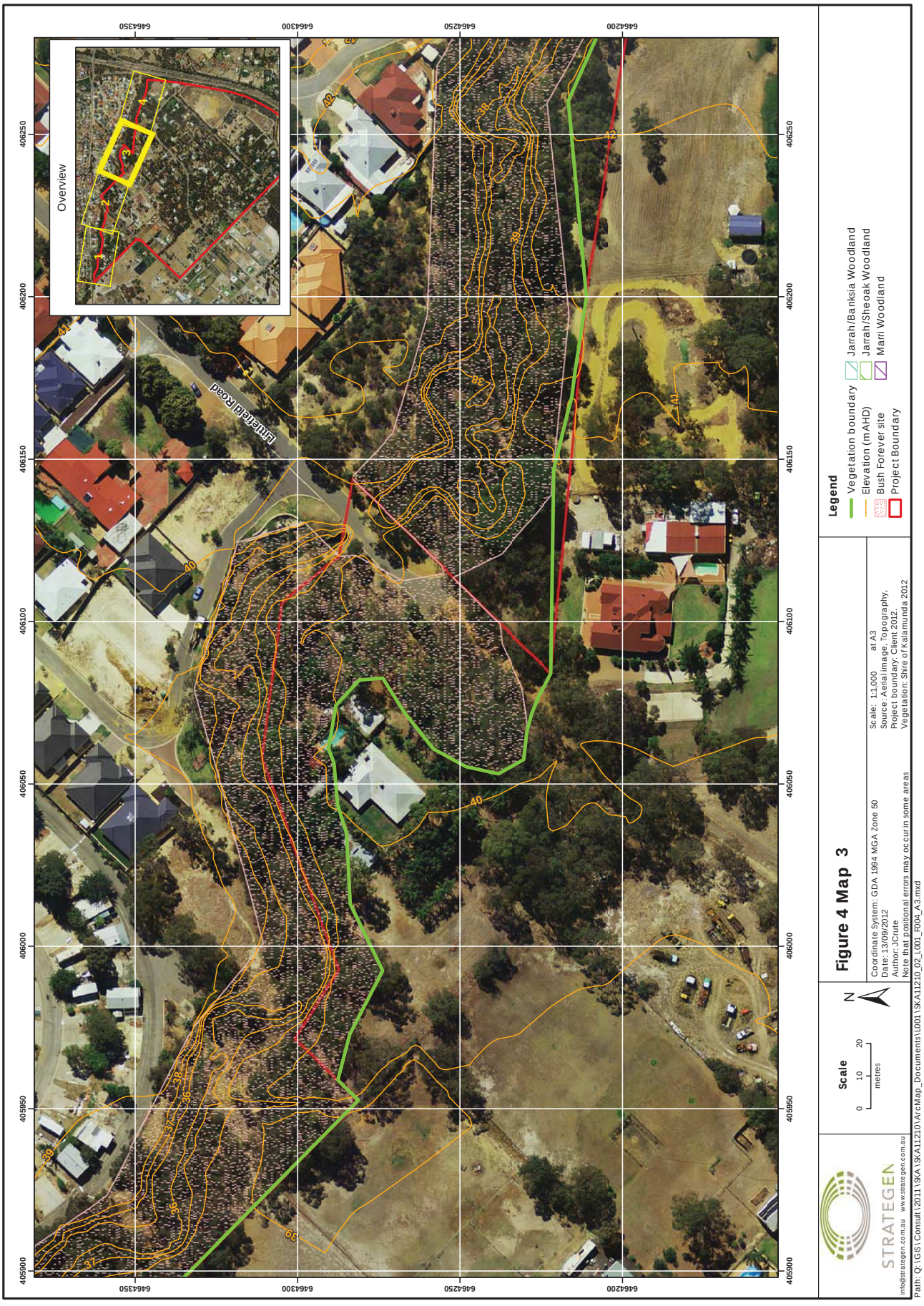
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Jarrah/Sheoak Woodland
Marri Woodland
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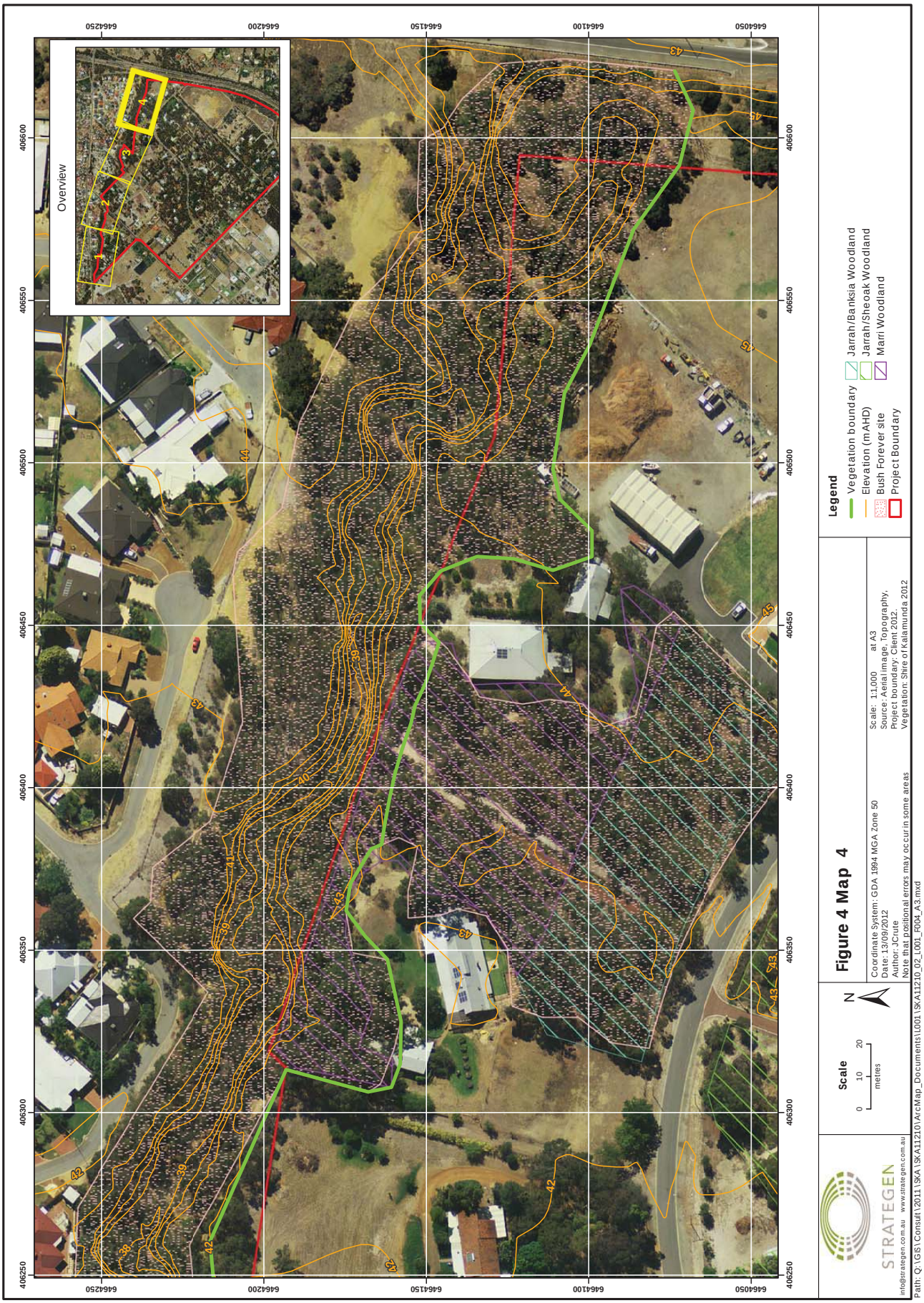
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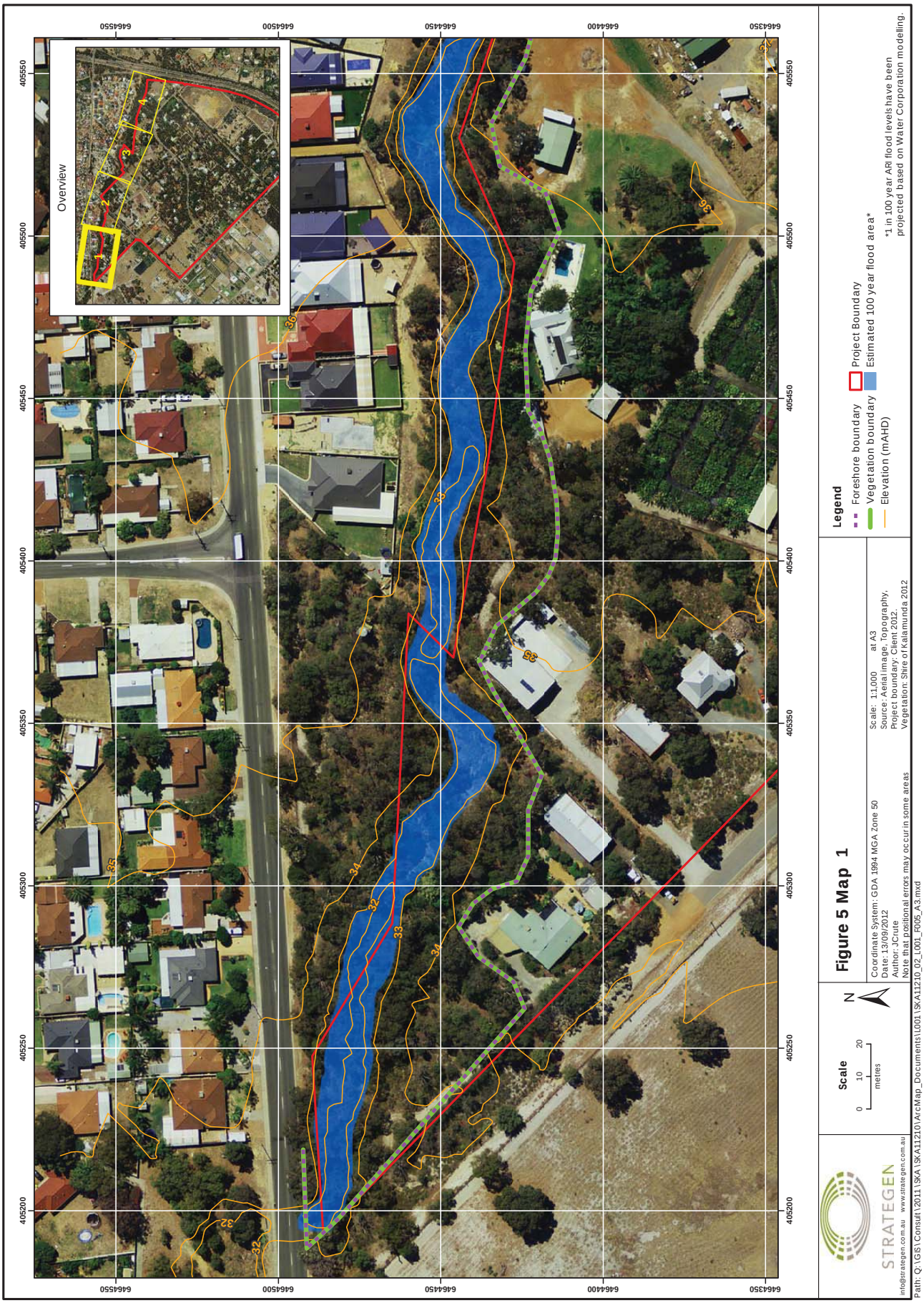
Overview
Legend
Foreshore boundary
Vegetation boundary
Elevation (mAHD)
Project Boundary
Estimated 100 year flood area*
*1 in 100 year ARI flood levels have been projected based on Water Corporation modelling.
Figure 5 Map 1
Scale
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Source: Aerial image, Topography.
Project boundary: Client 2012
Vegetation: Shire of Kalamunda 2012
Note that positional errors may occur in some areas
STRATEGEN
info@strategen.com.au www.strategen.com.au
Path: Q:\GIS\Consult\2011\SKA\SKA11210\ArcMap_Documents\L001\SKA11210_02_L001_F005_A3.mxd


Overview
Legend
Foreshore boundary
Vegetation boundary
Elevation (mAHD)
Project Boundary
Estimated 100 year flood area*
*1 in 100 year ARI flood levels have been projected based on Water Corporation modelling.
Figure 5 Map 2
Coordinate System: GDA 1994 MGA Zone 50
Date: 13/09/2012
Author: JCrute
Note that positional errors may occur in some areas
Scale: 1:1,000 at A3
Source: Aerial image, Topography,
Project boundary: Client 2012.
Vegetation: Shire of Kalamunda 2012
Scale
0 10 20
metres
N
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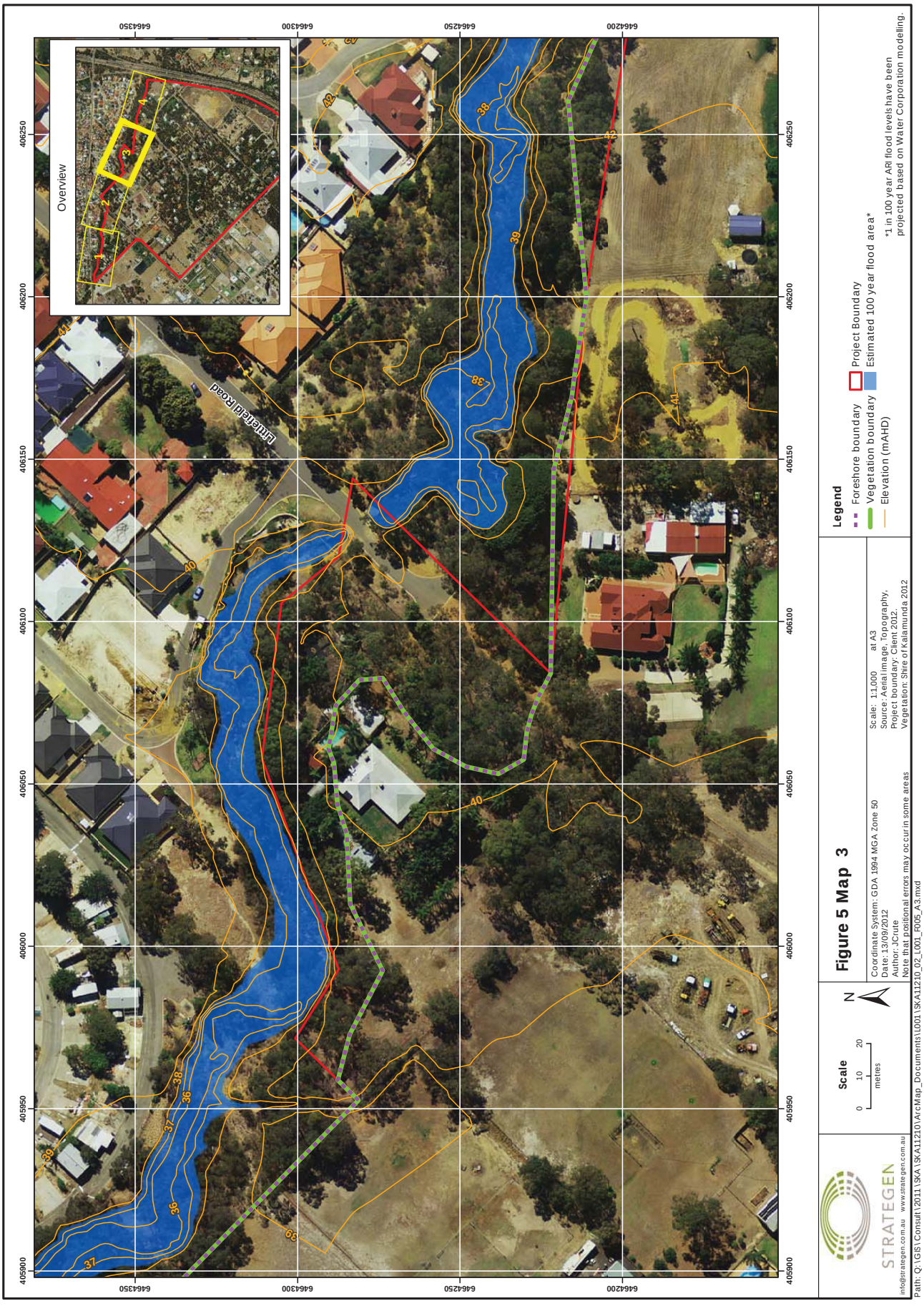
Path: Q:\GIS\Consult\2011\SKA\SKA11210\ArcMap_Documents\L001\SKA11210_02_L001_F005_A3.mxd
Miner Road
405600
405650
405700
405750
405800
405850
405900
6464500
6464450
6464400
6464350
6464300


Overview
Littlefield Road
Legend
Foreshore boundary
Vegetation boundary
Elevation (mAHD)
Project Boundary
Estimated 100 year flood area*
*1 in 100 year ARI flood levels have been projected based on Water Corporation modelling.
Figure 5 Map 3
Scale
0 10 20
metres
N
Coordinate System: GDA 1994 MGA Zone 50
Date: 13/09/2012
Author: JCrute
Scale: 1:1,000 at A3
Source: Aerial image, Topography.
Project boundary: Client 2012
Vegetation: Shire of Kalamunda 2012
Note that positional errors may occur in some areas
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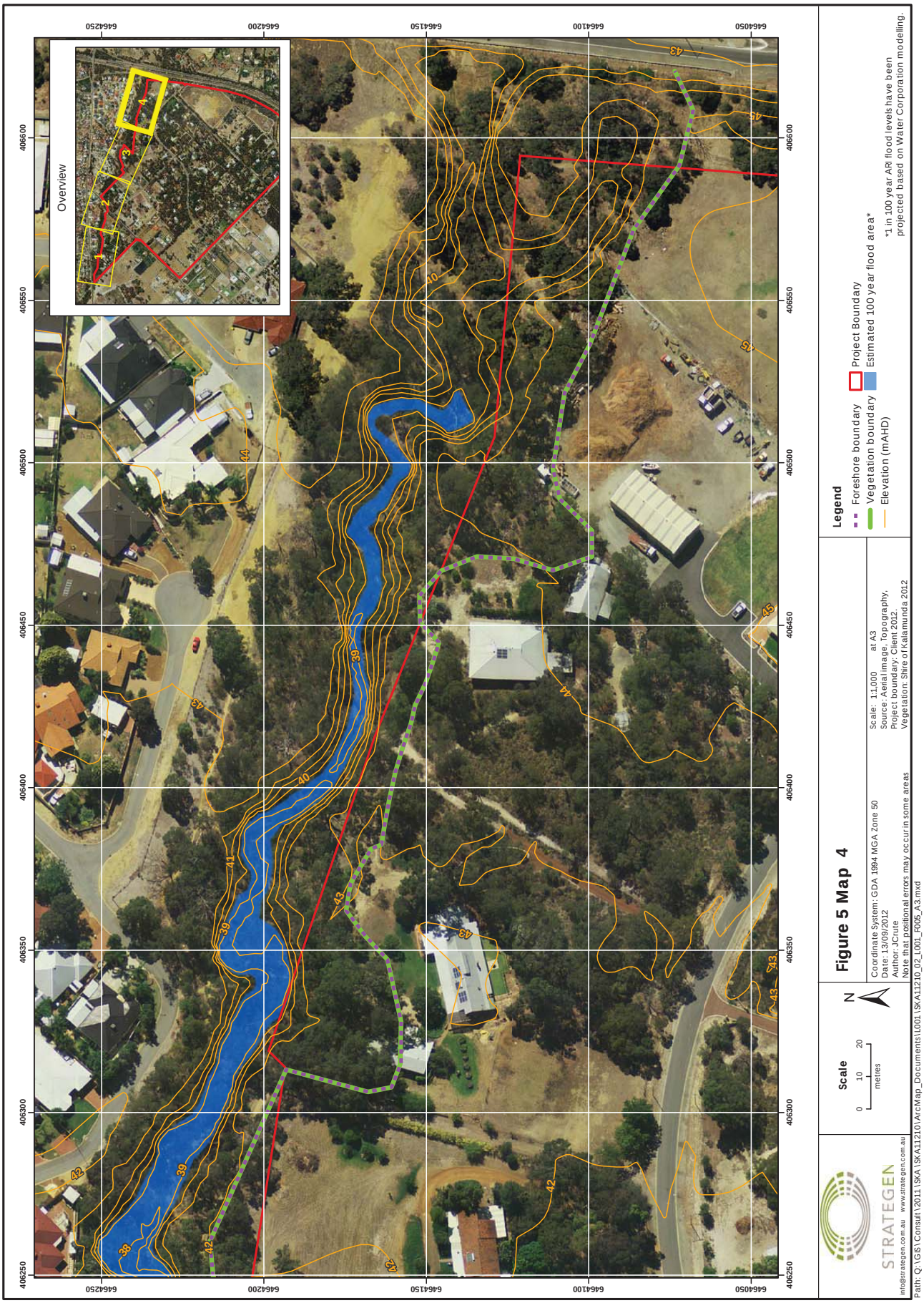
info@strategen.com.au www.strategen.com.au
Path: Q:\GIS\Consult\2011\SKA\SKA11210\ArcMap_Documents\L001\SKA11210_02_L001_F005_A3.mxd


Overview
Legend
Foreshore boundary
Vegetation boundary
Elevation (mAHD)
Project Boundary
Estimated 100 year flood area*
*1 in 100 year ARI flood levels have been projected based on Water Corporation modelling.
Figure 5 Map 4
Scale
0 10 20
metres
N
Coordinate System: GDA 1994 MGA Zone 50
Date: 13/09/2012
Author: JCrute
Scale: 1:1,000 at A3
Source: Aerial image, Topography.
Project boundary: Client 2012
Vegetation: Shire of Kalamunda 2012
Note that positional errors may occur in some areas
STRATEGEN
info@strategen.com.au www.strategen.com.au
Path: Q:\GIS\Consult\2011\SKA\SKA11210\ArcMap_Documents\L001\SKA11210_02_L001_F005_A3.mxd

Appendix 5
Agency meeting minutes

Level 1, 50 Subiaco Square Road Subiaco WA 6008 PO Box 243 Subiaco WA 6904
Phone (08) 9380 3100 Fax (08) 9380 4606
177 Spencer Street Bunbury WA 6230 PO Box 287 Bunbury WA 6231
Phone (08) 9792 4797 Fax (08) 9792 4708

Forrestfield North – meeting with Department of Environment and Water Regarding MAR

Time	1:30 pm	Job code	TPG16528.01
Date of meeting	29/09/17	**Client**	City of Kalamunda
		Scribe	M. Dunlop
Purpose of meeting	Discussion of the potential for MAR and drainage design at Forrestfield North		

Attendees

Name	**Organisation**	**Name**	**Organisation**
Peter Varelis	City of Kalamunda	Steve O'Brien	DWER
Doug Bartlett	City of Kalamunda	Chris O'Boy	DWER
Murray Casselton	TPG	Matt Viskovich	DWER
Dale Newsome	Strategen	Carlie Slodecki	DWER
Margaret Dunlop	Strategen	Steve Watson	DWER

Minutes / Notes

1. Strategen advised the project team is investigating MAR as one option for water supply for POS at Forrestfield North. This will be put into the two LWMSes for Forrestfield North (TOD Precinct and Residential Precinct). Other options include water trading with other users within the sub-area or reallocation of water within existing City of Kalamunda (COK) water licences to allow for flexibility. Forrestfield North is anticipated to be a joint COK/Metronet project.
2. TPG advised Forrestfield North will be a high density development (approx. 6,700 dwellings) with a focus on innovation and sustainability. There is also a high percentage POS (approx. 20%) with 10% being retained natural spaces. District Playing Fields are proposed on top of the former Brand Road Landfill to meet the shortfall of Playing Fields in the broader COK. The City is planning to undertake a Detailed Site Investigation and Geotechnical Investigation to confirm the suitability of the former landfill for this use.
3. DWER advised that PTA had installed a Leederville Aquifer abstraction bore to provide water for the Forrestfield Airport Link project near the future Forrestfield Station. The bore is approximately 100 m deep and has a temporary allocation for dewatering (i.e. allocation cannot be transferred for POS use). A H2 level hydrogeological report for the Leederville abstraction licence was prepared by PTA, which includes pump test and geological results. This would be useful to better assess the feasibility of MAR. The bore may be suitable for future MAR use but is not located in the vicinity of proposed POS. Resolving this issue is not likely to be in the timeframe required for the Structure Plan and consequently LWMS. **Action:** COK to request hydrogeological reporting for the bore.
4. DWER accepts that the LWMSes may present a Plan A/Plan B approach as the funding for MAR is uncertain (would require financial support from outside COK) provided that the non-MAR option could be demonstrated to work. A MAR Pre-feasiblity report is not required for the LWMSes provided that there is another feasible option for POS water supply.
5. DWER advised that the use of MAR based on stormwater should not prevent Water Sensitive Urban Design criteria being met – i.e. treat first 15 mm of rainfall, maintain pre-development flows off the site.
6. COK advised that because this was a Metronet project, there is an emphasis on showcasing WSUD including structures such as tree pits and roadside swales. **Action:** TPG/Creative Direction to provide conceptual cross sections for roads showing WSUD structuresin consultation with Strategen

7. DWER suggested rechecking the Water Register for potential licence transfers from other users within the superficial, as this was last checked for the DWMS and there were large licences within the Structure Plan area. **Action:** Strategen to review Water Register.
8. DWER requested a landscape concept plan and irrigation breakdown to be provided with the LWMSes, in a similar matter to what is required for the North West Corridor (i.e. includes areas and volumes for establishment and ongoing irrigation in each POS). The use of reduced irrigation areas is supported. It was noted by Strategen that (a) a high standard of POS is expected given the high density nature of the area, (b) turf or low fuel landscaping areas will be required for separation of buildings from high fire risk retained bush. **Action:** Strategen to include breakdown tables in LWMSes, with assistance from Creative Direction (landscaper).
9. DWER advised that a draft MAR policy was out for public consultation.
10. DWER (Steve Watson) asked whether there was adequate regional information regarding the drainage system to develop a drainage strategy for the LWMS. Strategen advised that regional drainage planning for the area had been undertaken by Water Corporation in the form of the Perth Airport North and Perth Airport South Arterial Drainage Scheme Reviews. **Action:** DWER to review the ADS reports and advise whether additional regional level work is required. COK would request this information within two weeks of provision of draft meeting minutes.

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Phone (08) 9792 4797 Fax (08) 9792 4708

Forrestfield North – meeting with Water Corporation regarding Forrestfield North drainage

Time	10:30 am	Job code	TPG16528.01
Date of meeting	06/12/17	**Client**	City of Kalamunda
		Scribe	M. Dunlop
Purpose of meeting	Discussion of the drainage design and allowable discharges for Forrestfield North project		

Attendees

Name	**Organisation**	**Name**	**Organisation**
Katrina Cooper	Strategen	Brett Coombes	Water Corporation
Margaret Dunlop	Strategen	Kanex Kanagaratnam	Water Corporation
Peter Golder	Groundwork	Martin Daniels	Water Corporation

Minutes / Notes

1. Strategen advised the project team is undertaking drainage planning for Forrestfield North. This will be put into the two LWMSes for Forrestfield North (western TOD Precinct and eastern Residential Precinct). Other options include water trading with other users within the sub-area or reallocation of water within existing City of Kalamunda (COK) water licences to allow for flexibility. Forrestfield North will be a high density residential and commercial development. There is also a high percentage POS, which is predominantly being retained for conservation or as playing fields. As a consequence, stormwater storage is proposed to be largely underground.
2. The site covers parts of the Airport North (AN) and Airport South (AS) catchments. The main drainage systems for AN and AS are managed by Water Corporation (WC).
3. Department of Water and Environmental Regulation (DWER) have advised that WC is the main advising body regarding drainage design for Forrestfield North because of the AN and AS drainage. The purpose of this meeting is to seek advice from WC regarding the allowable discharge rates and any other EC requirements with respect to drainage on the sites.
4. WC emphasised the requirement for post-development flows to be the same as or less than pre-development flows for the critical duration, partially due to commitments made to Perth Airport. **Action:** WC to confirm critical duration for AN and AS. Likely to be the 24 or 36 hour event. **Timeframe:** TBC by WC
5. WC advised that a pre-development loss model would need to be developed for the site and endorsed by WC. This comment notes that:
   - Historic modelling has not used a consistent loss model for AN and AS.
   - The 6 L/s/ha quoted in the WC AN report is an average over the catchment rather than a prescriptive value as pre-development flow rates depend on factors such as soil type and land use
   - The pre-development model should consider the extent of any pre-development storages on the site – e.g. significant natural low points that hold stormwater after rainfall events.
   - The pre-development loss model and the critical duration will determine the pre-development flows from the project area.
   - **Action:** Addendum 1 provided subsequent to meeting showing proposed parameters and loss model **Timeframe:** WC advises a likely 3 week period to review the model.
6. The project team advised that flows will be balanced across the two LWMS areas – i.e. flows may be lower from the eastern sandy area and higher from the western clayey, higher density area – but predevelopment flows will be maintained. WC advised that this approach was acceptable

provided the catchment divides were largely maintained. Some flexibility is allowed to match the proposed road layout.

7. The project team is aiming to avoid new outlets to Poison Gully but it is possible these will be required. In terms of invert levels for new outlets into Poison Gully, WC advised that they do not have a policy on this matter. Invert levels in Poison Gully are consequently at the discretion of the City of Kalamunda as owners. Any new outflows should be designed in the context of the WC Main Drain manual. **Action:** Project team to confirm with the City regarding invert levels of any new outlets to Poison Gully if required.
8. WC were advised of the presence of the basin adjacent to Roe Hwy which compensates flows from the east of Roe Hwy and that the overland flow path for this basin has been blocked by industrial development. The City's preferred approach has been to enlarge the basin to contain the total volume of flow from this area. WC advised that the area to the east is identified for urban development and that the basin will need to accommodate the flows from this basin as an urbanised catchment. The flow out of this basin in the pre-development scenario can be used to offset increases in flows in other areas. **Action**: Project team to confer with City regarding post-development flow volumes from the catchment to the east of Roe Hwy.
9. Project team advised that stormwater based Managed Aquifer Recharge was being considered by City of Kalamunda at a whole of local government level. This includes consideration of the Forrestfield North and other sites identified by the City. Superficial groundwater from existing City allocations is being proposed for POS irrigation at this stage.

Addendum 1: Proposed parameters and loss model (information subsequent to meeting)

Land Use	% Impervious	Manning n	
		Pervious	Impervious
Urban Roads	80%	0.04	0.025
R5-R12 Lots	10%	0.05	0.025
R60/80 Lots	90%	0.04	0.025
Retain flows on site or detain initial 16mm – depending on soil/groundwater conditions			
Rural Lots	5%	0.04	0.025
Industrial	90%	0.04	0.025
POS	0%	0.04	0.025

Soil Type	Initial	Continuing
Impervious	1.5mm	0mm/hr
BoM - Forrestfield	26mm	6mm/hr (orange sandy surface soils)
Rural Road imp	16mm	6mm/hr
Silty Sand	16mm	6mm/hr
Guildford with some vegetation	10mm	3mm/hr

In the pre-development scenario the assumptions are

- Silty sand within the Perth Airport North catchment
- Forrestfield soil conditions within the Airport South catchment
- Allowance will be made for rural roads and pre-development storage.

Appendix 6
Irrigation schedule

Forrestfield North - Residential Area

Note: Park pavement & turf areas: based on high-level assumptions on path length + play / seating areas

Blocks with irrigation requirements

	Community Use (m2)	Existing Bush Forever (m2)	Environmental Conservation (m2)	POS (m2)	Drainage (m2)	TOTAL (m2)	Pavement / Built Up (m2)	# Trees in pavement (establishment)	Planting (irrigation for establishment (m2)	Turf (permanent irrigation) (m2)	TOTAL (m2)	Temporary irrigation (kL/a)	Permanent irrigation (kL/a)
POS-01				70,222		70,222	8,693	60	13,167	48,363	70,222	8,887	32,645
POS-02				34,942		34,942	550		33,592	800	34,942	22,675	540
POS-03				19,646		19,646	1,251		17,595	800	19,646	11,877	540
POS-04				40,884		40,884	1,920		37,764	1,200	40,884	25,491	810
POS-05				4,699		4,699	690		3,209	800	4,699	2,166	540
POS-06				12,150		12,150	100		11,350	700	12,150	7,661	473
POS-07				608		608	0		208	400	608	140	270
POS-08				647		647	0		47	600	647	32	405
POS-09				481		481	0		481	0	481	325	0
EC-01			19,015			19,015					0	0	0
EC-02			7,017			7,017					0	0	0
EC-03			10,495			10,495					0	0	0
EC-04			6,108			6,108					0	0	0
EC-05			8,082			8,082					0	0	0
EC-06			4,610			4,610					0	0	0
EC-07			6,468			6,468					0	0	0
EC-08			10,449			10,449					0	0	0
EC-09			11,908			11,908					0	0	0
EC-10			3,843			3,843					0	0	0
EC-11			4,866			4,866					0	0	0
EC-12			3,991			3,991					0	0	0
EC-13			3,833			3,833					0	0	0
DB-01					8,441	8,441	690		7,751		8,441	5,232	0
DB-02					2,828	2,828	312		2,116	400	2,828	1,428	270
DB-03					4,860	4,860	550		3,910	400	4,860	2,639	270
DB-04					5,620	5,620	550		4,270	800	5,620	2,882	540
DB-05					3,510	3,510	480		2,630	400	3,510	1,775	270
DB-06					3,964	3,964	84		3,080	800	3,964	2,079	540
DB-07					8,886	8,886	700		7,386	800	8,886	4,986	540
BF-01		10,412				10,412					0	0	0
						333,485	**16,570**	**60**	**148,556**	**57,263**	**222,388**	**100,275**	**38,652**

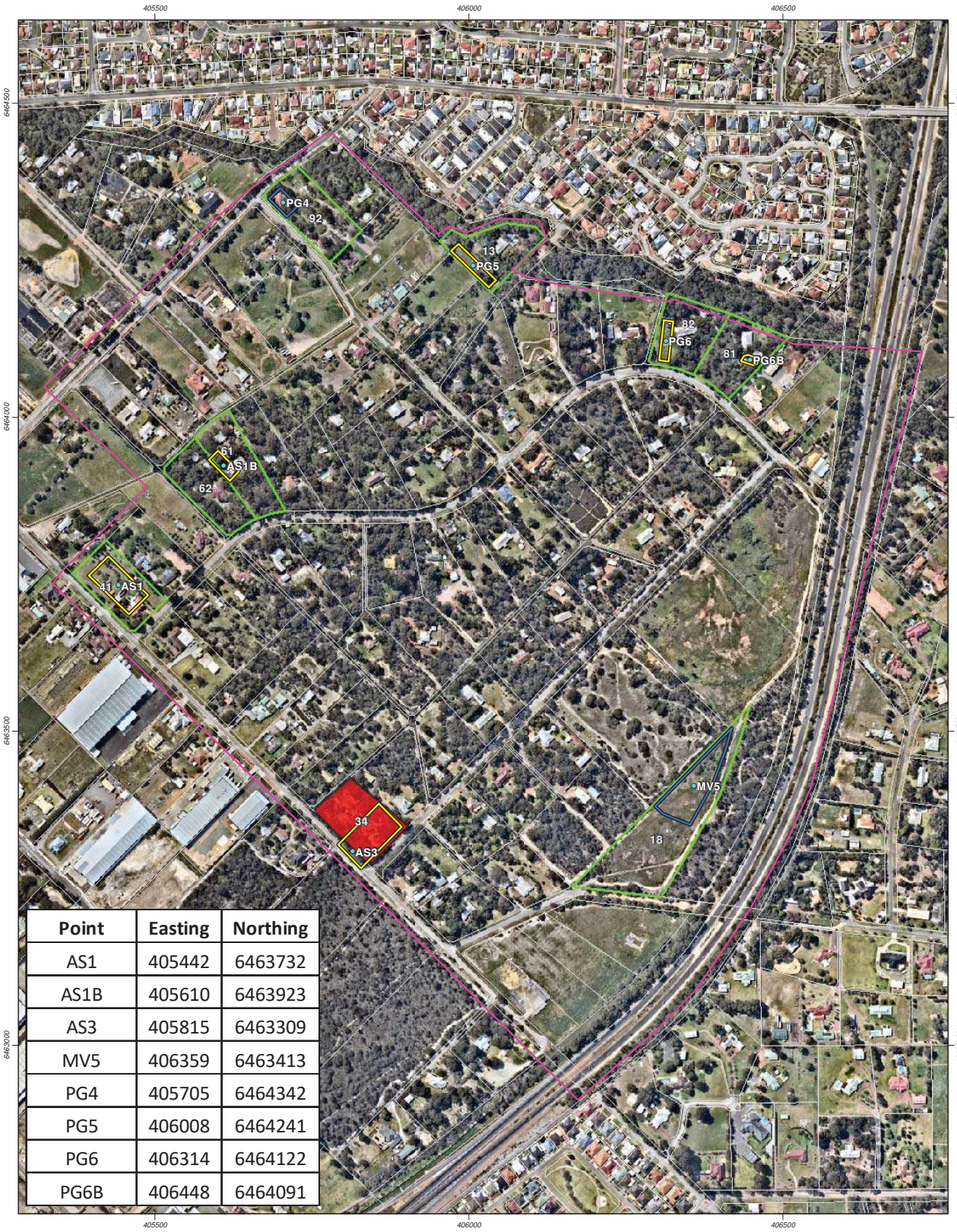
Forrestfield North - Residential Area

Data source: from KC00604.000 E05 Street Trees Rev B.xlsx
Widths from Publ. Realm Guide sections
Tree amounts based on Publ.Realm Guide sections

Structure Plan Streets - DCS

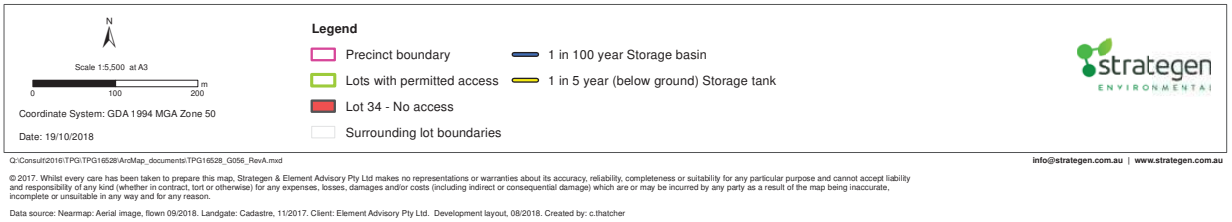
Street	Section	Length	Width	Typology	# Trees in pav.	# Trees in plant.	Tree sizes			Width verges / median (m)	m2 planting (incl. trees)	Temporary tree irrigation demand (kL/a)	Swale width within verges (m)	Swale area (m2)	Temporary swale irrigation demand (kL/a)	Total temporary irrigation demand (kL/a)
							220lt	100lt	45lt							
TOD Connector Boulevard																
	Milner - Activity Centre	533	30	FF Boulevard	213	187	133	160	107	5.8	3,091	2,087	3	1,524	1,029	3,115
	Activity Centre to Roe Hwy	840	30	FF Boulevard	336	294	210	252	168	5.8	4,872	3,289	3	2,145	1,448	4,736
Milner Road																
	TOD Connector to Raven	200	30	Urban Boulevard	40	70	50	20	40	5.8	1,160	783	3	525	354	1,137
	Raven to Stewart	235	30	Urban Boulevard	47	82	59	24	47	5.8	1,363	920	3	630	425	1,345
	Stewart to Maide Vale	150			30	53	38	15	30	5.8	870	587	0	0	0	587
Stewart Road																
	East of Milner to Brea	566	20	Forest Ave		425	28	94	302	9	5,094	3,438	1	416	281	3,719
Connector Road																
	TOC Connector to Sultana Road West	240	20	Forest Ave		180	24	80	336	18	4,320	2,916	5	825	557	3,473
	(According to Long. Drawing this is only Raven to Poison Gully)															0
Brea Road																
	TOD Connector to Roe Hwy	915	20	Forest Ave		686	46	153	488	9	8,235	5,559	1	715	483	6,041
Brand Road																
	Brea to Sultana Road West	910	20	Forest Ave (bush edge)		516	23	174	319	12.5	11,375	7,678	3	2,655	1,792	9,470
Sultana Road West																
	Activity Centre Frontage	760	25	Industrial Boulevard		228		228		9.7	7,372	4,976	3	2,205	1,488	6,464
	Brand Road to Roe Hwy	412	20	Industrial Boulevard		124		124		9.7	3,996	2,698	3	1,011	682	3,380
			(in Civil drawings this seems 25m)													
	Turn Around	45				14		14		9.7	437	295	3	60	41	335
TOTAL					666						52,185	35,225		12,711	8,580	43,805

Appendix 7
Hydraulic conductivity testing



Point	Easting	Northing
AS1	405442	6463732
AS1B	405610	6463923
AS3	405815	6463309
MV5	406359	6463413
PG4	405705	6464342
PG5	406008	6464241
PG6	406314	6464122
PG6B	406448	6464091

Figure X: Field map



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Data source: Nearmap: Aerial image, flown 09/2018. Landgate: Cadastre, 11/2017. Client: Element Advisory Pty Ltd. Development layout, 08/2018. Created by: c.thatcher

Basin	Easting	Northing	Soil type	Ksat measured(m/day)	Recommended Ksat for model (m/day)
AS2	405442	6463732	Clayey Sand	1.2	0.6
AS1B	405610	6463923	Clayey Sand	0.7	0.3
AS3	405815	6463309	Clayey Sand	0.8	0.4
MV5	406359	6463413	Fine to medium SAND	2.7	1.3
PG4	405705	6464342	Fine to medium SAND	6.3	3.1
PG5	406008	6464241	Clayey gravelly SAND	0.9	0.4
PG6	406314	6464122	Clayey gravelly SAND	0.8	0.4
PG6B	406448	6464091	Fine to medium SAND	>10	3.0

DEPTH FALLEN IN 1 min METHOD

LOCATION: AS2

Taslma-Hallam Method

Date: 22/10/2018

Soil type: Clayey Sand (fine to medium)

Instrument parameters					**Test parameters**				
Area of infiltration	A	17.72002	cm2		Depth of auger hole	D		50 cm	
Volume for 10 cm	V10	177.2002	cm3		Depth of water in hole	H		25 cm	
					Average radius of hole	r		3.5 cm	
					Depth to any impermeable layer	S	N/A	cm	Should be greater than 2H
Depth fallen in 1 min	Z1	6.5	cm						last measurement
	Z2	7	cm	last measurement					previous measurement
	Q1	115.1802	cm3/min	previous measurement					
	Q2	124.0402	cm3/min						

Use equation from AS1547:2012

$$Ksat = \frac{4.4*Q*(0.5\sinh^{-1}((H/2r)-SQRT((r/h^2)+0.25))+r/H)}{2*pi*H^2}$$

Q1		**Q2**	
Bottom line		**Bottom line**	
2*pi*H^2	3926.990817	2*pi*H^2	3926.990817
Top line		**Top line**	
Sinh-1 bit	0.992580246	**Sinh-1 bit**	0.992580246
square root term	0.519230199	**square root term**	0.519230199
r/H	0.14	**r/H**	0.14
Top line	310.841308	**Top line**	334.7521779

Ksat, Q1	**0.079**	**cm/min**	**Ksat**	**0.085**	**cm/min**
	1.140	**m/day**		**1.228**	**m/day**

Test Ks 1.2 m/day

DEPTH FALLEN IN 1 min METHOD

LOCATION: AS1B

Taslma-Hallam Method

Date: 22/10/2018

Soil type: Clayey Sand (fine to medium)

Instrument parameters					**Test parameters**				
Area of infiltration	A	17.72002	cm2		Depth of auger hole	D		50 cm	
Volume for 10 cm	V10	177.2002	cm3		Depth of water in hole	H		25 cm	
					Average radius of hole	r		3.5 cm	
					Depth to any impermeable layer	S	N/A	cm	Should be greater than 2H
Depth fallen in 10s	Z1	5	cm						last measurement
	Z2	3.5	cm	last measurement					previous measurement
	Q1	88.60012	cm3/min	previous measurement					
	Q2	62.02008	cm3/min						

Use equation from AS1547:2012

$$Ksat = \frac{4.4*Q*(0.5\sinh^{-1}((H/2r)-SQRT((r/h^2)+0.25))+r/H)}{2*pi*H^2}$$

Q1		**Q2**	
Bottom line		**Bottom line**	
2*pi*H^2	3926.990817	2*pi*H^2	3926.990817
Top line		**Top line**	
Sinh-1 bit	0.992580246	**Sinh-1 bit**	0.992580246
square root term	0.519230199	**square root term**	0.519230199
r/H	0.14	**r/H**	0.14
Top line	239.1086985	**Top line**	167.3760889

Ksat, Q1	**0.061**	**cm/min**
	0.877	**m/day**

Ksat	**0.043**	**cm/min**
	0.614	**m/day**

Test Ks 0.7 m/day

DEPTH FALLEN IN 1 min METHOD

LOCATION: AS3

Taslma-Hallam Method

Date: 22/10/2018

Soil type: Clayey Sand (fine to medium)

Instrument parameters					**Test parameters**				
Area of infiltration	A	17.72002	cm2		Depth of auger hole	D		50 cm	
Volume for 10 cm	V10	177.2002	cm3		Depth of water in hole	H		25 cm	
					Average radius of hole	r		3.5 cm	
					Depth to any impermeable layer	S	N/A	cm	Should be greater than 2H
Depth fallen in 10s	Z1	6	cm						last measurement
	Z2	3	cm	last measurement					previous measurement
	Q1	106.3201	cm3/min	previous measurement					
	Q2	53.16007	cm3/min						

Use equation from AS1547:2012

$$Ksat = \frac{4.4*Q*(0.5\sinh^{-1}((H/2r)-SQRT((r/h^2)+0.25))+r/H)}{2*pi*H^2}$$

Q1		**Q2**	
Bottom line		**Bottom line**	
2*pi*H^2	3926.990817	2*pi*H^2	3926.990817
Top line		**Top line**	
Sinh-1 bit	0.992580246	**Sinh-1 bit**	0.992580246
square root term	0.519230199	**square root term**	0.519230199
r/H	0.14	**r/H**	0.14
Top line	286.9304382	**Top line**	143.4652191

Ksat, Q1	**0.073**	**cm/min**	**Ksat**	**0.037**	**cm/min**
	1.052	**m/day**		**0.526**	**m/day**

Test Ks 0.8 m/day

DEPTH FALLEN IN 1MIN METHOD

LOCATION: MV5

Taslma-Hallam Method

Date: 9/12/16

Soil type: Fine to med sand

Instrument parameters					**Test parameters**				
Area of infiltration	A	17.72002	cm2		Depth of auger hole	D		50 cm	
Volume for 10 cm	V10	177.2002	cm3		Depth of water in hole	H		25 cm	
					Average radius of hole	r		3.5 cm	
					Depth to any impermeable layer	S	N/A	cm	Should be greater than 2H
Depth fallen in 1min	Z1	15	cm						last measurement
	Z2	16	cm	last measurement					previous measurement
	Q1	265.8004	cm3/min	previous measurement					
	Q2	283.5204	cm3/min						

Use equation from AS1547:2012

$$K_{sat} = \frac{4.4Q(0.5\sinh^{-1}((H/2r)-\sqrt{((r/h^2)+0.25)})+r/H)}{2\pi H^2}$$

Q1		**Q2**	
Bottom line		**Bottom line**	
2*pi*H^2	3926.990817	2*pi*H^2	3926.990817
Top line		**Top line**	
Sinh-1 bit	0.992580246	**Sinh-1 bit**	0.992580246
square root term	0.519230199	**square root term**	0.519230199
r/H	0.14	**r/H**	0.14
Top line	717.3260954	**Top line**	765.1478351

Ksat, Q1	**0.183**	**cm/min**	**Ksat**	**0.195**	**cm/min**
	2.630	**m/day**		**2.806**	**m/day**

Test Ks 2.7 m/day

DEPTH FALLEN IN 10 SEC METHOD

LOCATION: PG6b

Taslma-Hallam Method >15L infiltrates in <5s

Date: 9/12/16

Soil type: Fine to med sand

Instrument parameters					**Test parameters**				
Area of infiltration	A	17.72002344	cm2		Depth of auger hole	D		50 cm	
Volume for 10 cm	V10	177.2002344	cm3		Depth of water in hole	H		25 cm	
					Average radius of hole	r		3.5 cm	
					Depth to any impermeable layer	S	N/A	cm	Should be greater than 2H
Depth fallen in 1min	Z1		cm						last measurement
	Z2		cm	last measurement					previous measurement
	Q1	0	cm3/min	previous measurement					
	Q2	0	cm3/min						

Use equation from AS1547:2012

$$K_{sat} = \frac{4.4*Q*(0.5\sinh^{-1}((H/2r)-SQRT((r/h^2)+0.25))+r/H)}{2*pi*H^2}$$

Q1		**Q2**	
Bottom line		**Bottom line**	
2*pi*H^2	3926.990817	2*pi*H^2	3926.990817
Top line		**Top line**	
Sinh-1 bit	0.992580246	**Sinh-1 bit**	0.992580246
square root term	0.519230199	**square root term**	0.519230199
r/H	0.14	**r/H**	0.14
Top line	0	**Top line**	0

Ksat, Q1	**0.000**	**cm/min**	**Ksat**	**0.000**	**cm/min**
	0.000	**m/day**		**0.000**	**m/day**

Test Ks >10 m/day

DEPTH FALLEN IN 10 SEC METHOD

LOCATION: PG4

Taslma-Hallam Method

Date: 9/12/16

Soil type:

Instrument parameters					**Test parameters**				
Area of infiltration	A	17.72002	cm2		Depth of auger hole	D		50 cm	
Volume for 10 cm	V10	177.2002	cm3		Depth of water in hole	H		25 cm	
					Average radius of hole	r		3.5 cm	
					Depth to any impermeable layer	S	N/A	cm	Should be greater than 2H
Depth fallen in 10s	Z1	6	cm						last measurement
	Z2	6	cm	last measurement					previous measurement
	Q1	637.9208	cm3/min	previous measurement					
	Q2	637.9208	cm3/min						

Use equation from AS1547:2012

$$Ksat = \frac{4.4*Q*(0.5\sinh^{-1}((H/2r)-SQRT((r/h^2)+0.25))+r/H)}{2*pi*H^2}$$

Q1		**Q2**	
Bottom line		**Bottom line**	
2*pi*H^2	3926.990817	2*pi*H^2	3926.990817
Top line		**Top line**	
Sinh-1 bit	0.992580246	**Sinh-1 bit**	0.992580246
square root term	0.519230199	**square root term**	0.519230199
r/H	0.14	**r/H**	0.14
Top line	1721.582629	**Top line**	1721.582629

Ksat, Q1	**0.438**	**cm/min**
	6.313	**m/day**

Ksat	**0.438**	**cm/min**
	6.313	**m/day**

Test Ks 6.3 m/day

DEPTH FALLEN IN 1 min METHOD

LOCATION: PG5

Taslma-Hallam Method

Date: 9/12/16

Soil type: Clayey gravelly SAND, Coarse sand, lateritic gravels with some clay content

Instrument parameters					**Test parameters**				
Area of infiltration	A	17.72002	cm2		Depth of auger hole	D		50 cm	
Volume for 10 cm	V10	177.2002	cm3		Depth of water in hole	H		25 cm	
					Average radius of hole	r		3.5 cm	
					Depth to any impermeable layer	S	N/A	cm	Should be greater than 2H
Depth fallen in 1min	Z1	6	cm						last measurement
	Z2	4	cm	last measurement					previous measurement
	Q1	106.3201	cm3/min	previous measurement					
	Q2	70.88009	cm3/min						

Use equation from AS1547:2012

$$K_{sat} = \frac{4.4Q(0.5\sinh^{-1}((H/2r)-\sqrt{((r/h^2)+0.25)})+r/H)}{2\pi H^2}$$

Q1		**Q2**	
Bottom line		**Bottom line**	
2*pi*H^2	3926.990817	2*pi*H^2	3926.990817
Top line		**Top line**	
Sinh-1 bit	0.992580246	**Sinh-1 bit**	0.992580246
square root term	0.519230199	**square root term**	0.519230199
r/H	0.14	**r/H**	0.14
Top line	286.9304382	**Top line**	191.2869588

Ksat, Q1	**0.073**	**cm/min**	**Ksat**	**0.049**	**cm/min**
	1.052	**m/day**		**0.701**	**m/day**

Test Ks 0.9 m/day

DEPTH FALLEN IN 1 min METHOD

LOCATION: PG6

Taslma-Hallam Method

Date: 9/12/16

Soil type: Clayey Gravelly SAND, Coarse sand, lateritic gravels with some clay content

Instrument parameters					**Test parameters**				
Area of infiltration	A	17.72002	cm2		Depth of auger hole	D		50 cm	
Volume for 10 cm	V10	177.2002	cm3		Depth of water in hole	H		25 cm	
					Average radius of hole	r		3.5 cm	
					Depth to any impermeable layer	S	N/A	cm	Should be greater than 2H
Depth fallen in 1min	Z1	5	cm						last measurement
	Z2	3.7	cm	last measurement					previous measurement
	Q1	88.60012	cm3/min	previous measurement					
	Q2	65.56409	cm3/min						

Use equation from AS1547:2012

$$Ksat = \frac{4.4*Q*(0.5\sinh^{-1}((H/2r)-SQRT((r/h^2)+0.25))+r/H)}{2*pi*H^2}$$

Q1		**Q2**	
Bottom line		**Bottom line**	
2*pi*H^2	3926.990817	2*pi*H^2	3926.990817
Top line		**Top line**	
Sinh-1 bit	0.992580246	**Sinh-1 bit**	0.992580246
square root term	0.519230199	**square root term**	0.519230199
r/H	0.14	**r/H**	0.14
Top line	239.1086985	**Top line**	176.9404369

Ksat, Q1	**0.061**	**cm/min**
	0.877	**m/day**

Ksat	**0.045**	**cm/min**
	0.649	**m/day**

Test Ks 0.8 m/day

Appendix 8
Forrestfield Groundwater Level Monitoring – Forrestfield Airport Link



Forrestfield Groundwater Level Monitoring - Forrestfield -Airport Link

Desktop Review

Prepared for
Public Transport Authority
by Strategen

May 2016

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Forrestfield Groundwater Level Monitoring - Forrestfield -Airport Link

Desktop Review

Strategen is a trading name of
Strategen Environmental Consultants Pty Ltd
Level 1, 50 Subiaco Square Road Subiaco WA 6008
ACN: 056 190 419

May 2016

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Limitations

Scope of services

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In preparing the report, Strategen has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen has also not attempted to determine whether any material matter has been omitted from the data. Strategen will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen. The making of any assumption does not imply that Strategen has made any enquiry to verify the correctness of that assumption.

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Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

Client: Public Transport Authority

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
				Form	Date
Preliminary Draft Report	A	Client review	M Dunlop, D Jarvis/ P Bourgault	Electronic	3/3/2016
Draft Report	B	Client submission	M Dunlop, D Jarvis/ P Bourgault	Electronic	4/4/2016
Final Report	C	Client submission	M Dunlop, D Jarvis/ P Bourgault	Electronic	7/4/2016
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1. Introduction

The Forrestfield-Airport Link Project (the Project) is a new rail line to the eastern suburbs of Perth. The project will be delivered by a lead contractor who will be appointed in early to mid-2016.

Preliminary groundwater modelling of the Forrestfield Development Envelope (FDE) identified that the cone of depression from dewatering activities at the FDE (Dive Structure) potentially extends into surrounding Threatened Ecological Community (TEC) vegetation within Poison Gully and Lot 12 Ibis Place (Figure 1-1, Figure 1-2). The drawdown shown on Figure 1-2 is considered to represent the current worst case scenario (Golder 2015b). The more likely scenario is shown in Figure 1-3.

Advice from Department of Parks and Wildlife (DPaW) suggests that a shallow perched water table is present within Ibis Place and potentially the Poison Gully TEC.

Following the Environmental Protection Authority (EPA) assessing and recommending approval of the Project, the Minster for Environment approved the project on 13 November 2015 with the issue of Ministerial Statement 1022.

Condition 6-2 of Ministerial Statement 1022 requires that a Flora and Vegetation Monitoring Plan be prepared that "shall…

- detail baseline groundwater levels as close as practicable to Poison Gully and Lot 12 Ibis Place
- attach the results of the groundwater level baseline survey, include a report on the extent of perched groundwater levels at Poison Gully Creek and Lot 12 Ibis Place…"

Groundwater level monitoring is recommended to determine the level of connectivity between the regional aquifer, which will be subject to temporary construction dewatering, and any perched groundwater in the immediate surrounds of the dive structure at Forrestfield. The objective of this report is to review the existing geological and hydrogeological information and develop a baseline groundwater level monitoring program. This report forms Phase 1 of the Scope of Services set out in RFQ160300.

1.1 Scope

This report presents a desktop review of the existing bore network and site investigation data for the FDE and surrounds, specifically surrounding the proposed dive structure (site of dewatering works) and the neighbouring TECs at Poison Gully and Ibis Place.

Based on the Scope of Services, this desktop review:

- assesses the existing information, including available geotechnical and hydrogeological data, to determine the existence or potential presence of perched groundwater within the Forrestfield Development Envelope and adjacent areas of TEC
- assess the suitability of the monitor bore network with regard to well distribution and depth
- where perched groundwater is identified, determine whether sufficient information is currently available to determine connectivity between the regional groundwater table and perched groundwater, and assess the potential for the dewatering to draw down the perched groundwater
- where insufficient information is available, develop a monitoring program to identify the existence/absence of shallow perched groundwater in the zone of influence of dewatering.

The Scope of Services requires that the proposed monitoring program includes:

- location of existing wells and access constraints
- location of new wells to ensure adequacy of data
- the specifications required for the installation of the wells
- post installation survey of the wells
- frequency and type of monitoring, e.g. bore loggers or frequency of dipping.



Figure 1-1: Site location and Threatened Ecological Communities

Scale 1:6,500 at A4

0 100 200 m

N

Coordinate System: GDA 1994 MGA Zone 50

Note that positional errors may occur in some areas

Date: 26/02/2016

Author: DWhite

Source: Aerial image: ESRI online , approx. 2010.
All other data: Client 2015.

Path: Q:\Consult\2016\PTA\PTA16057\ArcMap_documents\R001\Rev A\PTA16057_01_R001_RevA_F001_1.mxd

Legend

- Poison Gully Creekline
- Development Envelope
- Stations
- Surface disturbance

Threatened Ecological Community

- Poison Gully TEC
- Ibis Place TEC

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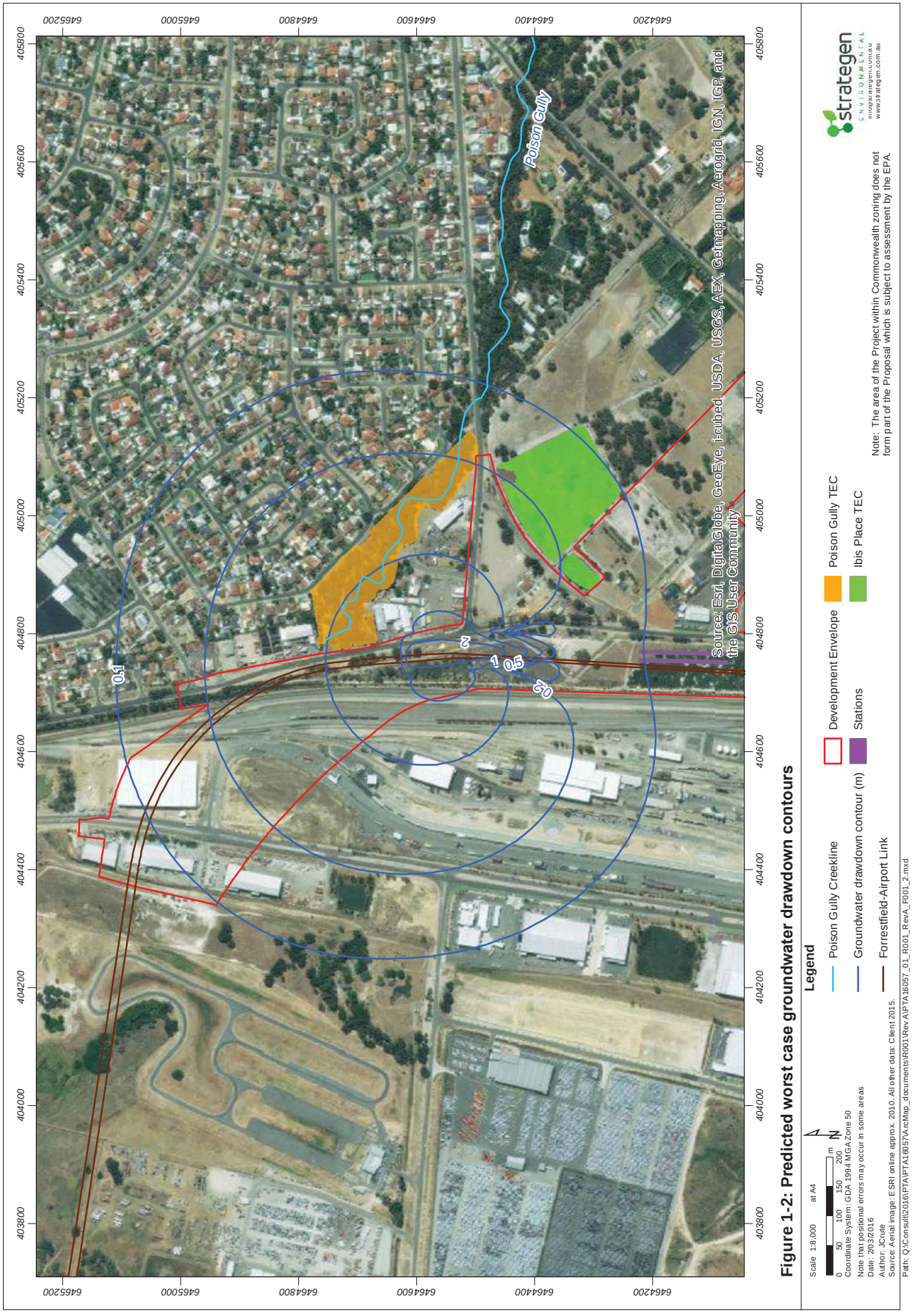
info@strategen.com.au
www.strategen.com.au


Poison Gully
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community
0.1
2
1
0.5
0.25
405800
405600
405400
405200
405000
404800
404600
404400
404200
404000
403800
646200
646400
646600
646800
646500
646520
Figure 1-2: Predicted worst case groundwater drawdown contours
Legend
Poison Gully Creekline
Groundwater drawdown contour (m)
Forrestfield-Airport Link
Development Envelope
Stations
Poison Gully TEC
Ibis Place TEC
Scale 1:8,000 at A4
0 50 100 150 200 m
Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 2/03/2016
Author: JCrute
Source: Aerial image: ESRI online approx. 2010. All other data: Client 2015.
Path: Q:\Consult\2016\PTA\PTA16057\ArcMap_documents\R001\Rev A\PTA16057_01_R001_RevA_P001_2.mxd
Note: The area of the Project within Commonwealth zoning does not form part of the Proposal which is subject to assessment by the EPA.
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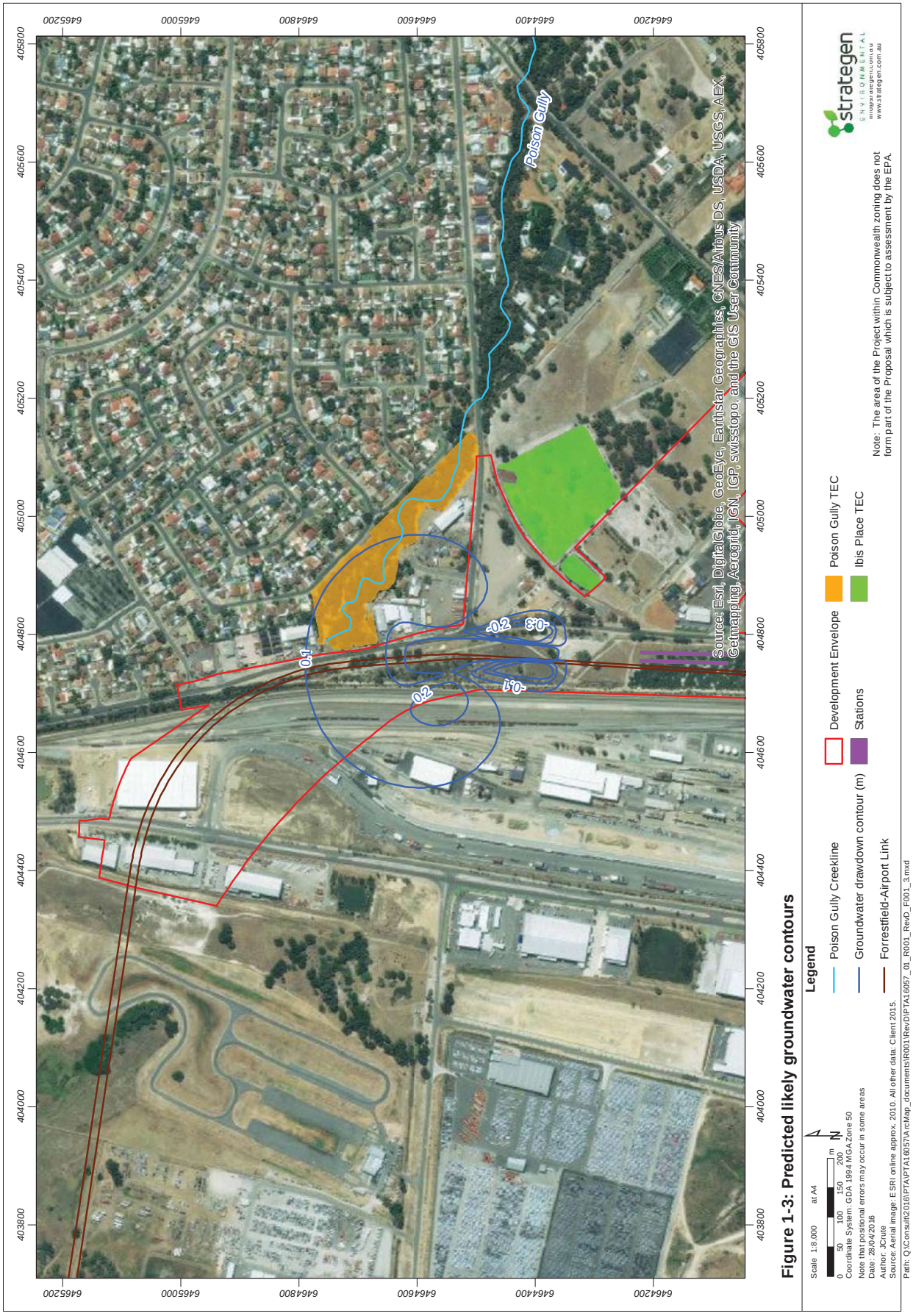

Figure 1-3: Predicted likely groundwater contours

1.2 Documents reviewed

Documents reviewed for this report include:

- *Contamination and Acid Sulphate Soils Investigation* (Golder 2015a)
- *Groundwater Conditions Report* (Golder 2015b)
- *Geotechnical Baseline Report* (PTA 2015)
- *Stage 2 Geotechnical Investigations - Factual Geotechnical Report* (Golder 2015c)
- *Stage 2 Geotechnical Investigations - Factual Geological and Hydrogeological Model Report* (Golder 2015d)
- *Stage 3 Geotechnical Investigation - Monthly Vibrating Wire Piezometer Monitoring Report no. 06* (Worley Parsons 2016)
- *FAL Project: Forrestfield Station Groundwater Levels Investigation* (Western 2015)
- *Summary of advice from other agencies* 25 February 2015 (OEPA 2015)
- *Forrestfield Airport Link Assessment on Proponent Information - Environmental Review Document* (Strategen 2015a)
- *Forrestfield Airport Link Surface Water Monitoring Report* (Strategen 2016)
- *Forrestfield North District Structure Plan – District Water Management Strategy* (Strategen 2015b).

DPaW has raised questions about the presence of perched groundwater at Ibis Place and in the surrounding areas to the Office of the Environmental Protection Authority (OEPA 2015). The evidence of perched groundwater is based on a report by Ecoscape (2010) titled *Threatened Ecological Community (TEC) Assessment of Lot 12 Ibis Place, High Wycombe.* This report included information obtained from installing five piezometers in the Ibis Place TEC. DPaW has provided PTA with a one page extract of this report but this does not include information regarding piezometer installation and geology.

2. Desktop review

2.1 Conditions required for perched groundwater

Rainfall infiltrating into a soil profile will percolate downwards with gravity at a rate governed by the permeability of the surface soils. In circumstances where the percolating rainfall encounters a soil layer of lower permeability, the downward movement of water is impeded and it is possible the soil above the layer of lower permeability becomes saturated. If a borehole or equivalent is placed into this zone of saturation, free water will flow into the void made by the hole. In many instances this free water is referred to as perched groundwater. Figure 2.1 illustrates this concept.

Perched groundwater can occur at any point in the soil profile where an impeding layer occurs above the permanent superficial aquifer. When present the perched groundwater reflects a localised zone of saturation within the vadose (unsaturated) zone above the permanent watertable. In some circumstances where there is sufficient recharge and sufficient thickness of permeable soils over less permeable soils the presence of perched groundwater can be semi-permanent to permanent. Soils beneath the impeding layer remain unsaturated and are not directly hydraulically connected to the underlying permanent superficial aquifer.

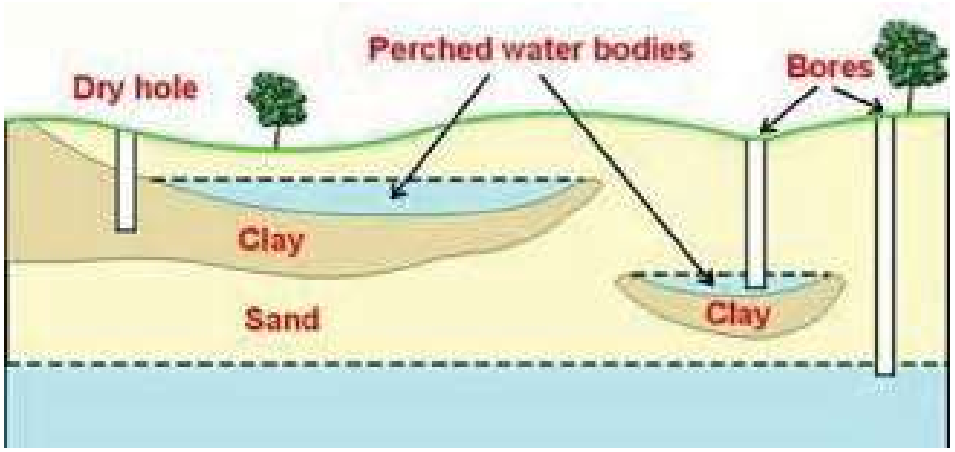

Figure 2-1: Conceptual cross section of perched water body

The presence of perched water can be seasonal. In this case, perched water may be present during the wetter months but dried out during summer as a result of evapotranspiration by vegetation and slow percolation of water through the impeding layer into the regional aquifer.

Understanding the potential for perched water requires an understanding of the soil type, soil texture, underlying geology and hydrology of a site. For the purposes of this report, the term 'impeding layer' has been used to describe less permeable layers in the soil profile above which perched groundwater may occur. Until information regarding the relative hydraulic conductivities of soil strata has been gathered, it is difficult to determine if any soil layers are sufficiently impermeable to impede the vertical percolation of infiltrating rainwater to allow saturation above the impeding layer to occur and perched groundwater to be present.

2.2 Soil investigations

2.2.1 Surface environmental geology mapping

Surface environmental geology mapping for the Perth Metropolitan Region (Gozzard 1986) indicates that the soils at the site are from the S_{10} soil unit, being thin Bassendean Sand over Guildford Formation (Qpb/Qpa) (Figure 2-2). Bassendean Sand is defined as the S_8 soil unit, very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz, moderately well sorted of eolian origin.

The upper profile of soils from the S_{10} soil unit are typically layers of Bassendean Sand with interbedded lenses of clay derived from the Guildford Formation. The sands from the Guildford Formation may also be expressed at the top surface of the soil profile. Seasonal perched groundwater is common in this soil type.

2.2.2 Soil investigations

Geological investigations have been undertaken within the area of surface disturbance and have included test pitting and the construction of bores at the locations shown on Figure 2-3. The following represents a summary of the geological conditions based on the bore logs provided to Strategen for the MW 3 series of bores shown in Figure 2-3 and test pits as presented in Appendix 2. Information was available for 22 bores installed between 20 October 2014 and 11 May 2015. Bore logs are presented in Appendix 1.

Surficial fill

At MW3-001, MW3-009, MW3-034 and MW3-038 a layer of sand to sandy gravel fill has been placed on the site. The Golder logs identify that the fill depth ranges from 0.8 m at MW3-034 to 4 m at MW3-009. On review of the logs following observations of soils in the TEC, Strategen considers that the brown orange and yellow orange sands to sandy gravel in the Golder logs are natural soils and represent the surficial layer of the Guildford Formation. On this basis, Strategen considers the actual fill depth at these bores to be more likely 0.2 m (MW 3-001) to 0.9 m (MW 3-009) with the possibility that some of the grey sands above these layers being misidentified Bassendean Sand.

Bassendean Sand

A layer of sand is present at the top of the profile at most locations. This sand was confirmed as being from the S_{10} Formation, being “light grey, yellow, dark brown, fine to medium grained sand, loose to dense” (Golder 2015d). Some of this sand layer contains gravel or had orange to red colouring, indicating that these gravels may actually be derived from the reworked Guildford Formation that occurs below the sand. For the purposes of this report, this sand layer with intermittent gravels is referred to as Bassendean Sand. Where present, the material ranges from 0.3 to 3.5 m in thickness, with base levels between 24.18 mAHD (MW 3-001) and 29.67 mAHD (MW 1-01 A).

This top layer of sand was not present at MW 3-013, MW3 -038, MW 3-044, MW 3-051, MW 3-052 or MW 3-055 (Table 2-1). Apart from MW 3-013, these are all located in the north of the Site near Poison Gully (Figure 2-3). MW 3-013 is located near Milner Road, to the south of Ibis Place.

Guildford Formation

The gravelly and clayey soils of the Site are primarily associated with the Guildford Formation. Golder 2015 (d) described the Guildford Formation in the Forrestfield portion of the Project as consisting of “pale grey and brown, fine to coarse grained, rounded to sub-angular, medium dense to very dense sand, silty sand and clayey sand with trace quartz gravel generally less than 5 mm of size. The Guildford Formation also contains a sequence of mottled orange, low plasticity, stiff to hard clays in the Forrestfield area that are generally present within 10 m of ground surface and being up to 6 m thick”.

Table 2-1: Summary of geology and potential for perched groundwater

Name	Ground level (mAHD)	Bottom of sand and fill (mbgl)	Bottom of sand (mAHD)	Top of potentially impeding layer (mbgl)	Top of potentially impeding layer (mAHD)	Type of impeding material	Moisture present over dry soil?	Top of screen (mbgl)
MW 3-001	27.78	3.60	24.18	Not present	Not present	Not present, clayey sand only	No	3.00
MW 3-004	30.00	2.10	27.90	Not present	Not present	Not present, silty clayey sand only	No	5.00
MW 3-009	30.20	5.50	24.70	5.50	24.70	sandy clay	No	3.90
MW 3-012	29.24	0.30	28.94	0.30	28.94	silt then silty clay at 4.8 mbgl	No	7.50
MW 3-013	34.68	Not present	Not present	2.00	32.68	clayey silt	No	16.30
MW 3-019	30.61	1.00	29.61	Not present	Not present	Not present, clayey sand only	No	3.50
MW 3-026	28.39	0.60	27.79	3.00	25.39	sandy gravelly clay, then sandy clay	No	5.00
MW 3-034	31.23	2.20	29.03	2.20	29.03	clayey silt	No	4.00
MW 3-038	29.33	1.50	27.83	1.50	27.83	sandy clay	No	4.50
MW 3-044 D	29.54	Not present	Not present	1.40	28.14	clayey silt	No	11.00
MW 3-044 S	29.50	Not present	Not present	1.40	28.14	clayey silt	No	3.30
MW 3-047	30.36	1.50	28.86	1.50	28.86	clayey silt	No	9.00
MW 3-051 D	29.41	Not present	Not present	2.40	27.01	clayey silt	No	15.50
MW 3-051 S	29.39	Not present	Not present	2.40	28.19	clayey silt	No	4.00
MW 3-052	28.35	Not present	Not present	2.00	26.35	clayey silt	No	7.00
MW 3-055	28.81	Not present	Not present	1.50	27.31	silty clay	No	4.00
MW 1-01 A	30.47	3.50	26.97	5.30	25.17	Clay	Moisture not logged	8.00
MW 1-01B	29.33	1.00	28.33	Not present	Not present	Not present	Moisture not logged	8.50
MW 1-01 C	30.47	2.15	28.32	Not present above 0 mAHD (i.e. above sea level)	Not present above 0 mAHD	Not present above 0 mAHD	Moisture not logged	7.00
MW 1-01 D	30.19	5.00	25.19	Not present above 0 mAHD (i.e. above sea level)	Not present above 0 mAHD	Not present above 0 mAHD	Moisture not logged	7.00
MW 1-05	28.42	1.00	27.42	Not present	Not present	Not present	Moisture not logged	7.00
PW 1-01	30.32	2.00	28.32	Not present	Not present	Not present	Moisture not logged	7.00

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Attachment 10.5.3.2

The geology of the Guildford Formation as present in the bore logs is highly variable and includes units from sandy gravel to clays. From a perched groundwater perspective, the key factors are the presence of fine grained layers which may impede downward percolation of water. Where the majority component of a soil unit is described as silt or clay and the material above is predominantly sand, the difference in permeability may be sufficient for seasonal perched groundwater to occur. A silty or clayey sand was not considered to offer adequate difference in permeability to significantly impede the downwards movement of water and thus cause perched groundwater on top of the layer.

Test pits

The test pits along the south-western edge of the Ibis Place TEC indicate:

- TP 1-46: sand then sandy clayey gravel 'weakly to very weakly iron cemented mass' at 0.4 m then refusal at 1.3 m (no groundwater encountered, excavated on 2/12/14)
- TP1-49: sand over moist gravelly clayey sand 'weakly to well cemented' at 0.7 m then refusal at 2.4 m (no groundwater encountered, excavated on 2/12/14)
- TP1-20: sand then moist interbedded sand and clayey sand 'weakly to well cemented lateritic gravel at 1.3m, no refusal (no groundwater encountered, excavated on 12/12/14) (Appendix 2).

The material causing refusal at TP1-46 and TP1-49 could possibly be a cemented perching layer, but there no evidence of actual perching (i.e. no saturation was encountered).

TP1-28 and TP1-29 are located in the vicinity of Poison Gully

- TP1-28: gravelly sand, then sand over clayey sand and then sandy clay at 1.5 mbgl. No evidence of groundwater to 2.1 mbgl during excavation on 15/10/14. Base of hole at approximately 27.15 mAHD
- TP1-29: sandy clay over sandy gravel then clayey sand to 2.6 m. No evidence of groundwater to this depth during excavation on 27/10/14. Base of hole at approximately 26.62 mAHD (Appendix 2).

The bases of the holes appear to be above the invert of the creek at this location. As such, this does not provide any indication of whether the creek is intersecting perched groundwater, which could be present below the base of the holes.

Data gaps for the assessment of perched groundwater

Based on the observed soil profiles, layers with the potential to impede flow were considered to occur in 14 of the 22 bores. Where impeding layers were present, the top of the impeding layer varied from 0.3 m (MW 3-012) to 5.5 mbgl (MW 3-009), with the majority being less than 2.5 m below the surface. The elevation (in mAHD) of these impeding layers varied from 24.7mAHD (MW 3-009) to 32.68 mAHD (MW 3-013). In all cases, the bores were only screened below the impeding layer (Table 2-1).

Logs from four bores installed by Strategen in September 2011 for the Shire of Kalamunda (SoK) in the broader Forrestfield area (MB01, MB07, MB08 and MB09) did not record any potential impeding layers, with sand or gravelly sand/sandy gravel at the surface and then clayey sand at depths between 2.25 and 3.5 mbgl to the end of the hole (Strategen 2015b). Locations of these bores are shown on Figure 2-3.

The geology quoted by DPaW for Ibis Place is consistent with very shallow Bassendean Sand over the Guildford Formation, however the bore logs for these bores have not been provided to Strategen.

The bores and test pits are focussed on investigating the upper soil profile of the regional superficial aquifer along the proposed alignment. One bore (MW 3-034) has been located adjacent to Ibis Place and one on Milner Road (MW 3-013) (Figure 2-3). Only MW 3-055 is located to the north of Poison Gully. Given the complex geology of the subject area, the current geological information is considered limited within and surrounding the TECs. Information in bore logs is variable and determining the presence or otherwise of impeding layers is difficult. Additional geological information would be beneficial.

2.3 Hydrogeology

Ecoscape (2010) report

Ecoscape (2010) reported a depth to groundwater in August 2008 of less than 0.4 m in five piezometers installed within the Ibis Place TEC. The soil samples taken from the installation of the bores showed a "shallow layer of wet sand approximately 10 cm thick over a wet clayey sand, to wet sandy clay, with dry mottled clay at a depth of approximately 1 m" (Ecoscape 2010, quoted in DPaW undated). These readings were taken in winter and it is possible that the perched water was ephemeral and resulted from a period of rain that occurred leading up to the monitoring event. The exact date of the monitoring event has not been provided to allow comparison to rainfall records.

These water levels are in contrast to the groundwater levels at the adjacent PTA bore MW 3-034, which was dry during monitoring by Western Environmental in July and October 2015 (Western 2015). MW 3-034 was installed to a depth of 6.3 metres below ground level (mbgl) and was screened between 3.3 and 6.3 mbgl. Water may have been present as a perched layer above this screened depth.

Evidence from bore installation and test pits

If perched groundwater was present during bore installation or test pitting, a layer of wet soil would have been found over a dry impeding layer. Such perched groundwater conditions were not encountered during drilling or test pitting, indicating that permanent perched groundwater is unlikely to be present. Bore logs were available to Strategen for the bores listed in Table 2-1 and four bores installed for SoK by Strategen (Figure 2-3). Test pit logs were available for locations in the vicinity of both the Ibis Place TEC and Poison Gully (Appendix 2).

These bore logs show that perched groundwater was not present during bore or test pit installation. Groundwater levels on the Swan Coastal Plain generally peaks in October, and as such perched groundwater would be more likely to be present at this time of year. In terms of timing of installation:

1. Installation of the Golder bores for which soil moisture was logged occurred during January and February 2015, when ephemeral perching would be unlikely to be present.
2. Strategen bores were installed in September 2011, close to peak groundwater when ephemeral perching would be more likely to be expressed.
3. Of the Golder test pits, two were installed in October 2014 (around peak groundwater) and three in December 2014. Perched groundwater is likely to be found if present during October but is less likely to be present in December.

The lack of perching in the pits and bores constructed in September and October indicates that perching is not present at these locations.

Screened depth

Of the bores installed to date, none have been screened in the top 3 m of the profile. Top of screen levels vary from 3.0 mbgl at MW 3-001 to 16.3 mbgl at MW 3-013 with bottoms of screens located from 5.9 to 32.5 mbgl. All of the bores that had intersected impeding layers were screened below the top of the impeding material.

Groundwater levels encountered during the summer installation period were below this level and thus the shallowest bores were screened across the groundwater table, as is standard practice. A minimum of 0.5 m of bentonite was placed above the screens to ensure that water from aquifers above the aquifer being monitored did not affect water levels in the bore. Assuming this process was effective and the top of all screens are located below the top of potentially impeding layers, groundwater levels in these bores will not accurately reflect water levels occurring above the impeding layer.

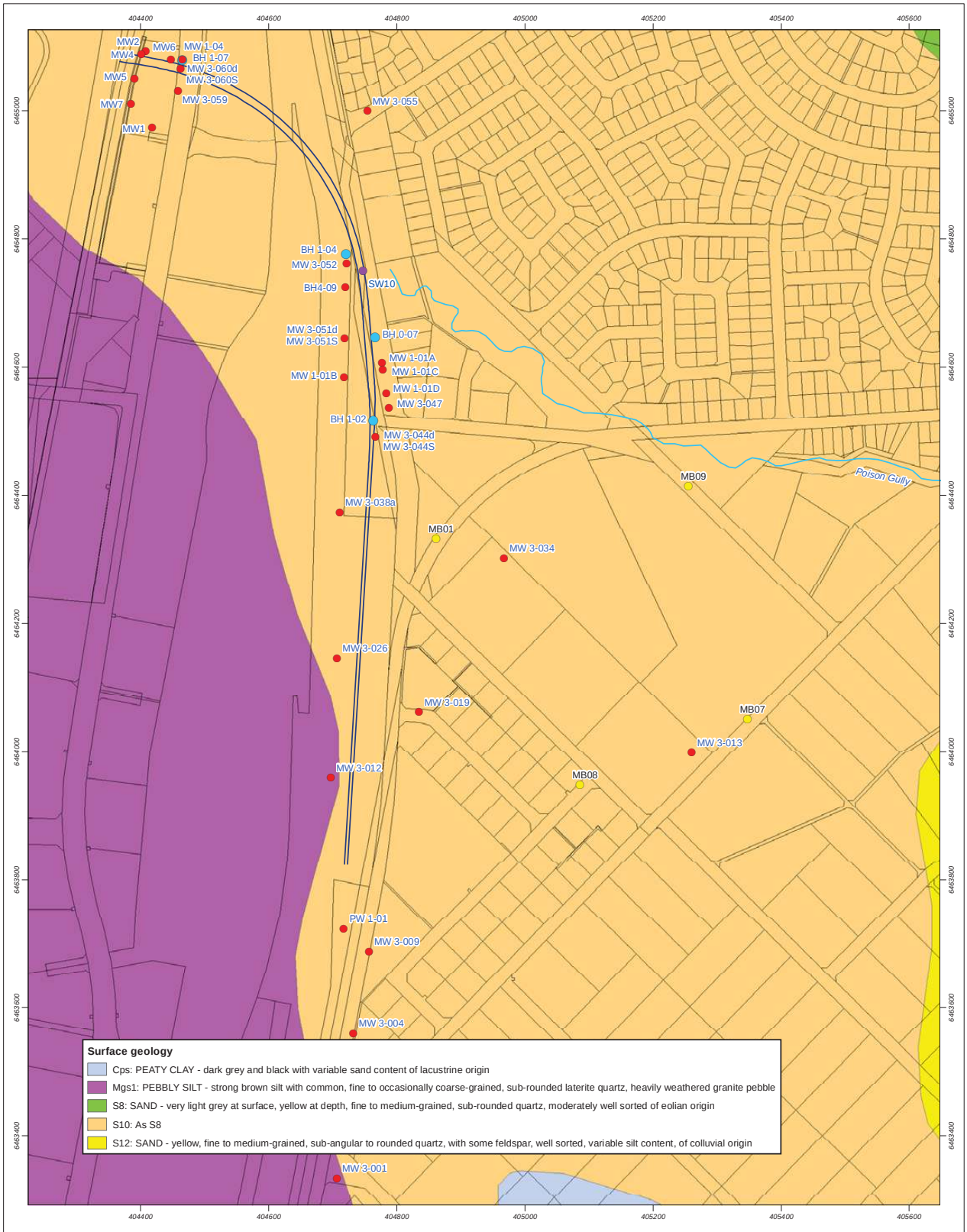

Figure 2-2: Regional geology

Scale 1:5,414 at A3

0 50 100 150 200 250 m

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 1/03/2016
Author: JCrute
Source: Aerial image: ESRI online , approx. 2010. Bores: Client 2015/2016. Geology: Map sheet Perth, 1:50,000, DMP 2012.

Legend

- Monitoring Bore (Shire of Kalamunda)
- Surface Water Monitoring Location
- Vibrating Wire Piezometer
- Monitoring Bore (PTA)
- Poison Gully Creekline
- Forrestfield-Airport Link
- Development Envelope

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Path: Q:\Consult\2016\PTA\PTA16057\ArcMap_documents\R001\Rev A\PTA16057_01_R001_RevA_F002_3_A3.mxd

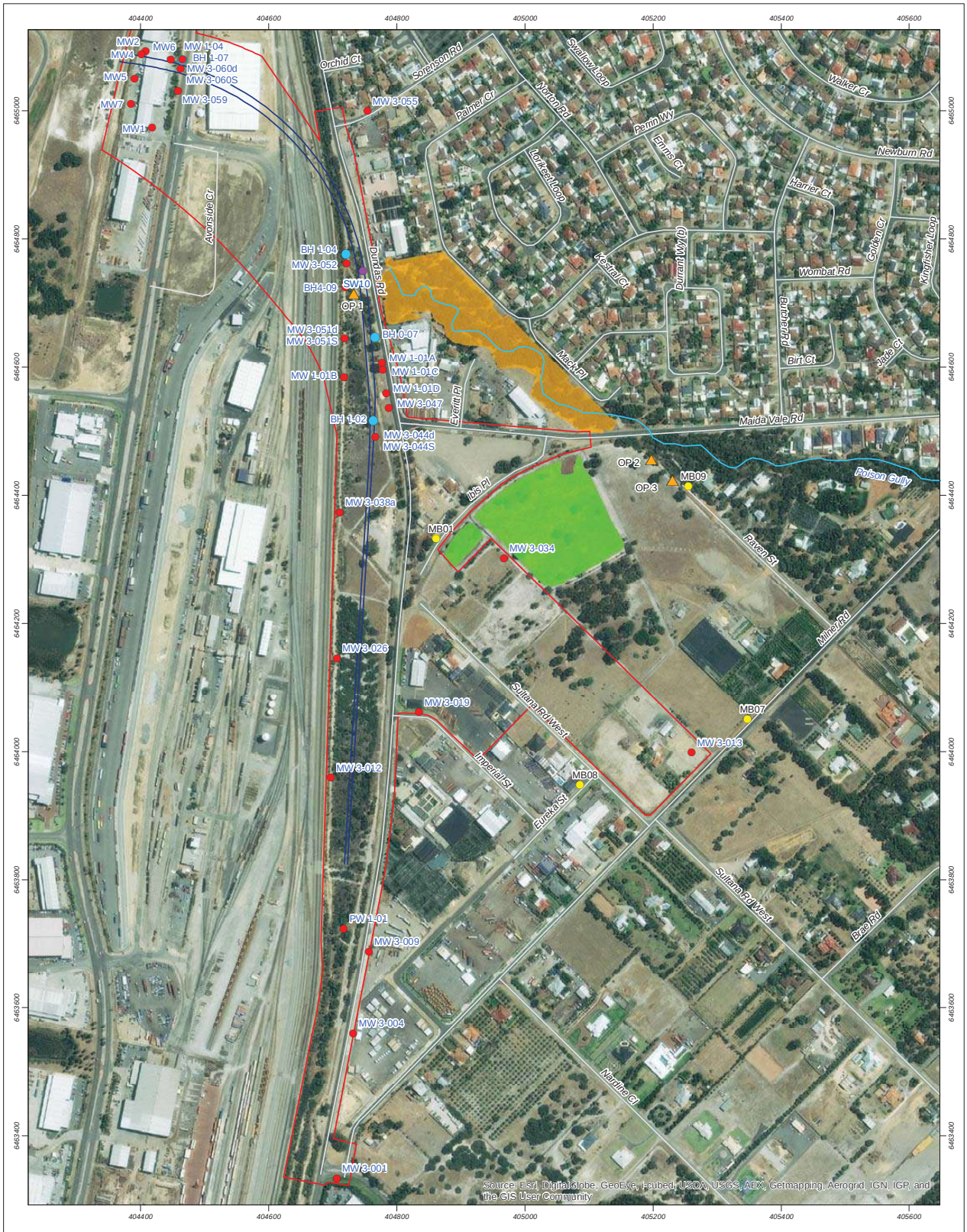

Figure 2-3: Groundwater and surface water monitoring locations

Scale 1:5,414 at A3

0 50 100 150 200 250 m

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 31/03/2016
Author: JCrute
Source: Aerial image: ESRI online , approx. 2010. All other data: Client 2015/2016.

Legend

- Monitoring Bore (Shire of Kalamunda)
- Surface Water Monitoring Location
- Vibrating Wire Piezometer
- Monitoring Bore (PTA)
- Open Pit Observations
- Poison Gully Creekline
- Forrestfield-Airport Link
- Development Envelope
- Poison Gully TEC
- Ibis Place TEC

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Vibrating wire piezometers

Vibrating wire piezometers (VWPs) have been installed at three locations to monitor groundwater pressure/levels at depth (Figure 2-3). The VWPs record water levels on a minimum of daily frequency. VWPs are located at:

- BH0-07 contains at 12.5 mbgl, monitored since April 2014
- BH1-02 at 12.5 mbgl and 24.5 mbgl, monitored since October 2014
- BH1-04 at 9.8 mbgl and 13.7 mbgl, monitored since October 2014.

Strategen understands that the VWP monitoring program will continue until May/June 2016. The VWPs have been installed too deep to represent any perched groundwater but will provide useful historical water level data.

Groundwater levels

The PTA bores were monitored for groundwater levels on:

- 10 March 2015 by Golder
- 23 July 2015 by Western Environmental
- 20 October 2015 by Western Environmental
- 26 February 2016 by Strategen.

The SoK bores were monitored on 12 October 2015 by Gecko Environmental. The only SoK bore located by Gecko (MB09) was dry. Strategen attempted to locate the SoK bores on 26 February 2016, but only MB09 could be located. The SoK bores were installed in the road reserve, so it is likely that these have been either destroyed or covered over with material (e.g. concrete) where flush covers were used.

The only bore showing water levels clearly above an impeding layer is MW 3-009. The water level on 20 October 2015 was 24.86 mAHD, with an impeding layer logged as being present at 24.70 mAHD. Groundwater levels at this bore varied from 24.54 mAHD to 24.86 mAHD during the monitoring events, and thus has been both above and below the top of the impeding layer. This is consequently not considered to be evidence of consistent perching.

Data gaps for assessment of perched groundwater

The bores installed by Golder have been designed to monitor the deeper parts of the superficial aquifer that will be directly affected by dewatering, close to the proposed alignment. Additional monitoring is recommended in the vicinity of the TECs to better understand the hydrology of these areas.

2.4 Surface water

Poison Gully (Plate 1 to Plate 3) is an ephemeral creek which collects water from elevated areas to the east of the Site including parts of Kalamunda and flows in a westerly direction via the Perth Airport Northern Main Drain and Limestone Creek into the Swan River. Between Maida Vale Road and the location to the west of Dundas Road, where Poison Gully becomes a piped drain, the creek is incised up to approximately 2 m below the normal ground surface. No surface water was observed in this section of Poison Gully during a site visit on 26 February 2016. During 2015, the creek was dry at SW10 in the vicinity of the Site during two of four surface water monitoring events (March and December) (Strategen 2016). The location of SW10 is shown on Figure 2-3.

Groundwater monitoring undertaken by Strategen for Shire of Kalamunda in the Forrestfield area indicated a southerly regional groundwater flow direction in the area to the south of Poison Gully in October 2011 (Strategen 2014). The study area and bores for this project were predominantly located to the east of FDE, with the easternmost bore located in Ibis Place. The implication of this flow direction is that Poison Gully may be a losing stream (i.e. one that recharges groundwater) during the period over which it flows. In saying this, the study was undertaken at a regional level and the majority of the project area was located to the east of the area of interest for this study, within soils mapped as deep Yoganup Sands rather than the Guildford Formation.



Plate 1: Poison Gully, February 2016



Plate 2: Poison Gully, February 2016



Plate 3: Poison Gully, February 2016 showing erosion

Surface water levels recorded by Strategen (2016) at SW10 were approximately 26.5 mAHD on 3 June and 3 September 2015. The maximum groundwater level recorded by Western Environmental during their July and October 2015 groundwater monitoring events was 25.31 mAHD in MW 1-01A on 23 June. This implies that the water level in Poison Gully when flowing is generally above the regional groundwater level. This implies that the general direction of water flow when Poison Gully is flowing would be from Poison Gully to the regional groundwater (i.e. this section of Poison Gully is a losing stream).

Poison Gully has previously been surveyed by Water Corporation (2010) as part of a drainage study of the area. Strategen has been provided with this information for another job under the condition that it is used for that purpose. Permission to use this information should be obtained by PTA to assist in determining the interaction between Poison Gully and any perched groundwater.

2.5 Observation of open pits

On the 24 March, Strategen inspected several open pits ranging in depth from 1-2.5m to assess the textural differences within the soil profile. Two pits to approximately one metre depth where inspected along Raven Road on the north-eastern side of the Ibis Road TEC (Plate 4). Another large excavation along the alignment of the gas pipeline running parallel with Dundas Road on the western side was inspected (Plate 5). This excavation was close to the culvert on Dundas Road, through which Poison Gully flows. The approximate locations of the observation pits are shown on Figure 2-3.

The soil profile along Raven Road was found to be grey fine-medium sand to about 0.3m depth over yellow to orange clayey sand (~5% clay) with weathered coffee rock. This soil, which also contains a large percentage of gravel, is unlikely to retard downward percolation of rainwater sufficient to result in perching during normal flows. High intensity rainfall may be sufficiently retarded above the clayey sand for short periods to cause isolated pockets of water saturation, but this would be of very short duration.

The soil profile along the gas pipeline alignment had three distinct horizons. The surface 0.3-0.4m is grey fine-medium sand, typical of Bassendean sand. The underlying 0.4-1.0m of soil profile textured as a clayey sand and was similar to the soil encountered in Raven Road. At a depth of ~0.8m there is a distinct textural change from the clayey sand to sandy clay. The sandy clay is quite plastic but the sand grains are obvious. Based on the bolus formed by wetting some of the sandy clay material and manipulating it in the hand and forming a ribbon by squeezing between the thumb and forefinger (The National Committee on Soil and Terrain, 2009), it is estimated there is about 25% clay. During normal rainfall events, this textural difference at about 1m is possibly sufficient to retard downward percolation of rainfall for long enough to result in minor amounts of water saturation within the soil profile (perched groundwater). However it was noticed there were regular macropores (cracks and old root channels greater than 2 mm in diameter) that would conduct any perched groundwater deeper into the soil profile (Plate 6). Macropores can rapidly convey water through the unsaturated zone of the soil profile, draining areas of temporary saturation (Beven and Germann 1982; Bourgault Du Coudray 1996).

At all inspected locations, the soil profile was dry and showed no evidence of perching. It is highly unlikely there is any connectivity between potential perched groundwater layers and the regional superficial groundwater table.



Plate 4: Soil profile at OP2



Plate 5: Soil observations at OP1

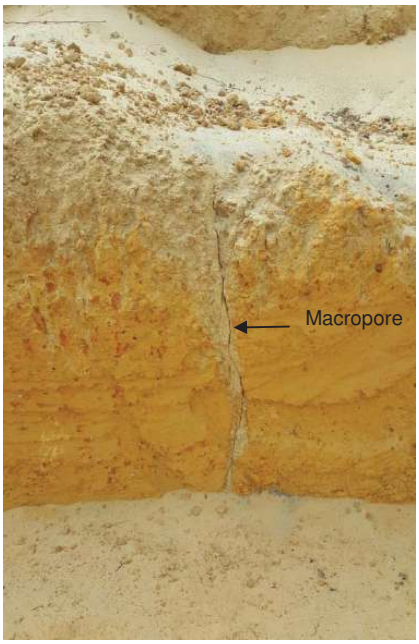

Plate 6: Macropore through sandy clay layer at OP1 and natural gravel within the profile

2.6 Potential for perched groundwater

Apart from the Ecoscape (2010) report, there is no conclusive evidence that perched water occurs near the proposed Forrestfield area. It is possible that the perched groundwater seen by Ecoscape is temporary perched groundwater following the retardation of percolating rainfall by a impeding soil layer of lower hydraulic conductivity, following a short period of relatively high intensity rainfall. Based on the inspection of the soil profile near Raven Road and adjacent to Dundas Road, there is sufficient textural difference between overlying sands and underlying sandy clay to give rise to the possibility of localised temporary perched groundwater following rainfall. The refusal in test pits adjacent to Ibis Place TEC is also indicative of a cemented layer that may cause perching.

Soil logs show potential impeding layers that may cause perched groundwater after rainfall are present at 13 out of 16 Golder bores and at TP 1-46 and TP 1-49 on the southwestern boundary of the Ibis Place TEC. However, perched water was not encountered during bore installation in January/February 2015 or test pitting. This suggests that if there is any perched groundwater, it is not permanent. A potentially impeding layer was noted at a depth of 2.2 mbgl at the bore closest to Ibis Place and in the form of refusal during test pitting at 1.3 m and 2.4 mbgl at TP1-46 and TP 1-49 respectively. There is no evidence of hydraulic connection between the perching layers and the underlying superficial aquifer.

Where potential impeding layers were found, they were of variable texture, depth and thickness. This implies that temporary perched groundwater may exist in some areas but not others.

If permanent perched groundwater occurred and was above the level of Poison Gully, springs or seeps where lateral flow of the perched water intercepted the creek would be expected. If significant volumes of perched water were present and seeping into Poison Gully permanent to semi-permanent pools would be expected along the creek line. There is no evidence of subsurface seepage into Poison Gully from perched groundwater, even in areas where the creek is deeply incised.

2.7 Conclusions

The groundwater level monitoring to date has been focussed on the regional superficial aquifer. While more information regarding the hydrology of the TECs would be beneficial, the evidence available indicates that any perched groundwater that may occur is likely to be ephemeral and limited to isolated areas. Hence temporary lowering of the regional groundwater table is unlikely to impact the TECs adjacent to the FDE.

3. Proposed future works program

3.1 Groundwater monitoring

3.1.1 Bore specifications

The proposed additional monitoring bore locations are shown in Figure 3-1. Bore depth will depend on the geology and presence of groundwater at the drilling location.

Monitoring bores will be installed as a pair or shallow bore only on the following basis:

1. As a pair of monitoring bores, typically 2 to 5 metres apart, where a deep bore is not currently present and a better understanding of the interaction between the shallower and regional (deeper) superficial aquifer is required. The shallow bore will be screened so that it is above the first impeding layer that is encountered in the profile (typically from 0 to 3 mbgl) to intersect any seasonal perched groundwater that may occur in that location. The deepest of the pair will be screened below any confining layer (typically at depths of more than 4 mbgl, but not more than 8 mbgl) so as to intersect the regional groundwater table. If no impeding layer is identified, the shallow bore will still be installed to a depth of 2mbgl.
2. As a shallow bore on top of the impeding layer at a location where a deeper bore already exists or as a supplementary shallow bore located adjacent to the TEC. Where this is not located adjacent to a deeper bore, the hole will extend a minimum of 300 mm into the potential impeding layer to confirm that perched groundwater is likely to be present and then the hole refilled to the top of the impeding layer. If no impeding layer is identified, then the bore will be installed to depth of 2mbgl.

Bores will be constructed in accordance with the requirements outlined in the Land and Water Biodiversity Committee (2003) guidance document *Minimum Construction Requirements for Water Bores in Australia.* Minimum bore internal diameter shall be 50 mm based on this guidance and to allow installation of 41 mm diameter data loggers in any bore.

The screening intervals for all bores will be carefully selected based on the soil profiles encountered at each location. A screened interval of 2-3 m will be installed either completely above (shallow bores) or completely below (deep bores) any impeding layer that is identified.

The soil lithology will be logged for all new bores proposed for installation at the locations shown in Figure 3-1 and Table 3-1 by a suitably qualified environmental scientist. Where bores are paired as a deep and shallow set, logging is required for both bores. The deep bore shall be installed first and this geological information will be used to determine the depth of the shallow well. This will include logging of soil type, texture and moisture status at a minimum of every 20 cm down the hole. Bores will be installed using a push core drilling rig to ensure a clean core is obtained for accurate geological logging.

The proposed locations for the additional bores are provided in Table 3-1. A deep bore screened below the perching layer to access the regional groundwater table will be paired with MW3-009 as a potential control bore set (Figure 3-1). This location has been selected as a control bore as:

- a perched groundwater layer is known to occur in this area
- the bores are located outside the drawdown area shown on Figure 1-2.

Table 3-1: Additional monitoring bore locations

Label	Type	E (MGA94z50)	N (MGA94z50)
MW 8-001	A, D, K	404846.2	6464670
MW 8-002	B	404918.1	6464733.1
MW 8-003	A	404929.3	6464604.2
MW 8-004	B, K	405114.4	6464477.6
MW 8-005	A	405021.3	6464444.5
MW 8-006	A, D, K	404874.8	6464295.5
MW 8-007	A, D	405144.3	6464305.7
MW 3-009 (D)	R	404846.2	6464670

A: New Bore Pair
B: Shallow Bore Only
D: Data Logger Pair
K: Permeability Test
R: Deeper bore to Access Regional Groundwater Table

All new monitoring bores will be surveyed for Easting, Northing and Elevation (surface and top of casing in mAHD) to allow accurate assessment of the groundwater at the site.

3.1.2 Proposed monitoring program

Groundwater water levels will be measured on a monthly basis for all bores shown on Figure 3-1. It is anticipated that monitoring will commence in May 2016 and be ongoing. The amount of data collected should be maximised.

In addition to the monthly measurements, opportunistic monitoring immediately following daily rainfall greater than 10 mm, or following high-intensity rainfall, such as following a thunderstorm, even though the duration and total amount of rainfall is relatively modest. It may be necessary to visit the shallow bores several times following a rain event to ensure any temporary perched groundwater is captured.

The period from March to July is associated with seasonal low groundwater levels (typically March/April) followed by the subsequent rise of the watertable as the winter months approach. Heavy falls are likely to occur in the proposed monitor period, and the monthly and opportunistic monitoring of the shallow bores during these periods should provide sufficient data to help assess any potential impact to the TECs from drawdown in the regional water table.

Data loggers

Data loggers will be installed in three paired sets (i.e. six loggers in total) at the locations shown on Figure 3-1 (two associated with the Ibis Place TEC and one with the Poison Gully TEC). If possible, a data logger should be placed in one of the Ecoscape piezometers. These data loggers will log water levels on an hourly basis to observe the behaviour of water levels following rain. At this logging frequency, a battery life of at least four months is anticipated.

Ecoscape bores

Access to the Ibis Place piezometers installed by Ecoscape should be obtained if possible for monitoring purposes. These piezometers would need to be assessed prior to use to determine that they are still present and in a suitable condition for monitoring. If these bores are accessible and suitable, they should be included in the monitoring program and a data logger placed in one of the bores.

Vibrating wire piezometers

Strategen understands that the VWPs are intended to be monitored until May/June 2016. If possible, this program should be continued as long as practical up until the period of maximum groundwater levels (typically September). Data from the data loggers and dipping program should be compared to data from the VWPs to assist in investigating interactions between any perched and deeper superficial groundwater.

3.2 Soil investigations

3.2.1 Permeability testing

Permeability testing will be undertaken adjacent in hand augered holes adjacent to bores where impeding layers are identified using a falling head (Talsma-Hallam) permeameter based on methodology described in Appendix G of Australian Standard AS/NZS 1547:2012. The permeability tests will be undertaken in hand augered holes:

- within the permeable layer
- within the potentially impeding layer.

3.2.2 Poison Gully creekline

Obtaining soil logs from the Poison Gully creekline could be useful to determine the interaction between surface water in Poison Gully and groundwater. The creek is highly incised (approximately 2 m) and provides a useful geological cross section. During high flow periods, the sides of the creek are covered in clayey sediment, which sticks to the soil and can make such observations difficult. This section of Poison Gully is a significant site to Aboriginal people, and as such the sides of the creek should not be altered or damaged. Visual inspection should be undertaken and logging undertaken where it is considered that this will provide useful data (e.g. freshly eroded areas). This should ideally be done at a minimum of six locations between where the creek becomes a drain to the west of Dundas Road and Maida Vale Road, with the locations recorded by GPS and surveyed.

For safety reasons, any work in Poison Gully creek line should be done when the creek is dry.

3.3 Surface water

Monitoring of surface water levels in Poison Gully should continue at SW10 on the same frequency as the groundwater monitoring (Section 3.1.2). Data loggers are not proposed for Poison Gully.

As discussed in Section 2.4, survey information for Poison Gully should be obtained from Water Corporation to assist in determining the interaction between Poison Gully and any perched groundwater.

3.4 Potential ethnographic constraints

Investigations should be undertaken at the locations shown on Figure 3-1. Strategen notes that cultural reasons may prevent ground disturbing activities within vegetation areas adjacent to Poison Gully as well as the creek line itself. The cultural sensitivity of these areas should be confirmed with PTA prior to work commencing.

Should this be the case, locations shall be moved to a nearby location without such sensitivities. The movement of locations may impact on the relevance of the data obtained to the Poison Gully TEC. Where such movement of locations is required, this shall be identified within subsequent reporting and the reason for such movements identified.



Figure 3-1: Proposed monitoring locations

Scale 1:5,500 at A3

0 50 100 150 200 250 m

Coordinate System: GDA 1994 MGA Zone 50
Note that positional errors may occur in some areas
Date: 6/05/2016
Author: JCrute
Source: Aerial image: ESRI online , approx. 2010.
All other data: Client 2015/2016.

Legend

- New Monitoring Location
- Monitoring Bore (Shire of Kalamunda)
- Existing Surface Water Monitoring Location
- Vibrating Wire Piezometer monitored by Worley Parsons
- Existing Monitoring Bore (PTA) to be monitored
- Poison Gully Creekline
- Forrestfield-Airport Link
- Development Envelope
- Poison Gully TEC
- Ibis Place TEC

A: New Bore Pair
B: Shallow Bore Only
D: Data Logger Pair
K: Hydraulic Conductivity Testing
R: Deeper Bore to Access Regional Groundwater Table

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4. Conclusion

The groundwater level monitoring to date has been focussed on the regional superficial aquifer. While more information regarding the hydrology of the TECs would be beneficial, the evidence available indicates that any perched groundwater that may occur is likely to be ephemeral and limited to isolated areas. Hence temporary lowering of the regional groundwater table is unlikely to impact the TECs adjacent to the FDE.

The data gathered from the additional groundwater level monitoring program outlined in this report will form the basis of further assessment of the seasonal behaviour of the Superficial Aquifer and localised areas of perched groundwater. This assessment will assist in the investigation of potential impacts to TECs in the area due to temporary drawdown of the regional watertable due to dewatering.

5. References

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Appendix 1
Bore logs

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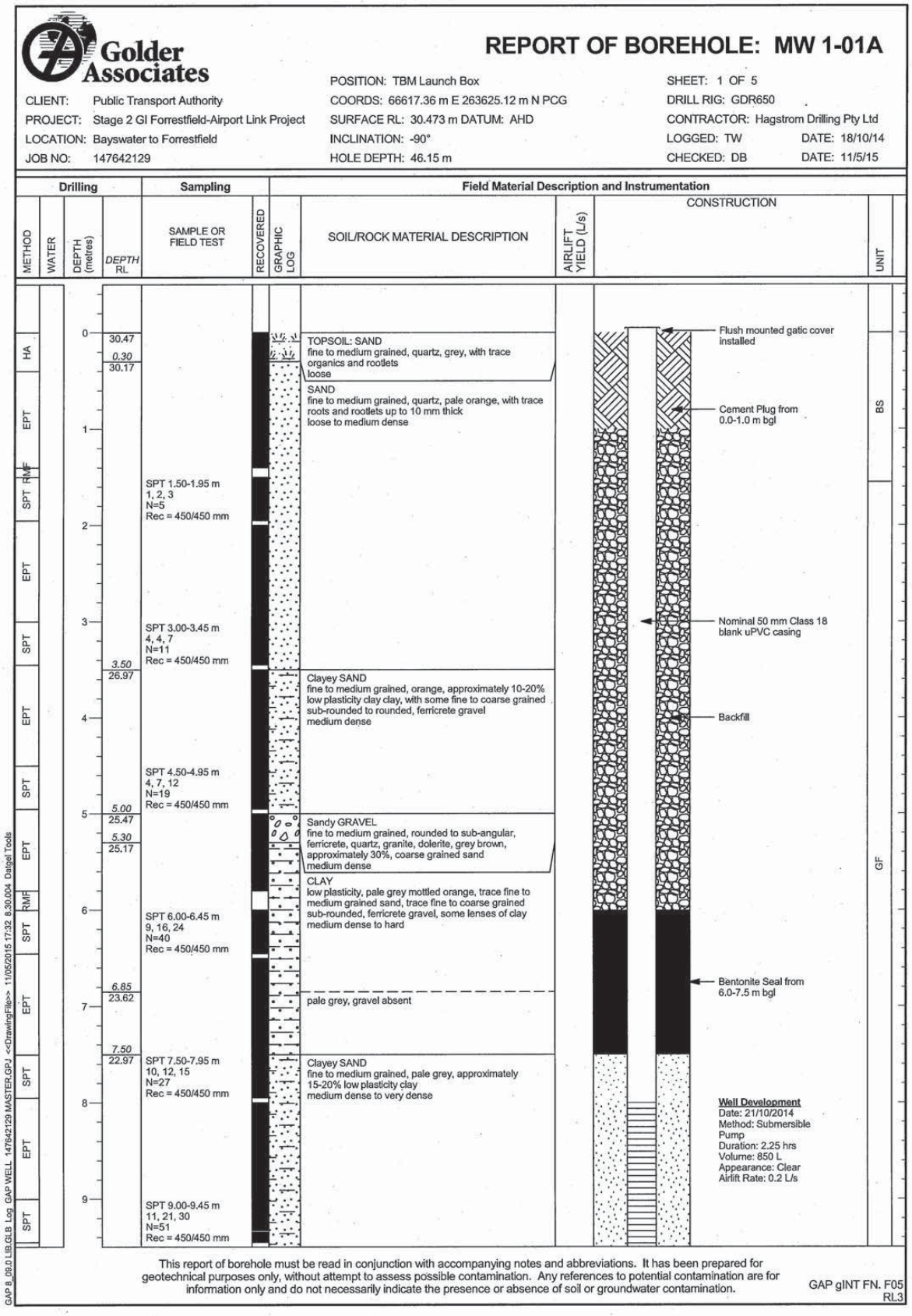
Golder Associates
REPORT OF BOREHOLE: MW 1-01A
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
POSITION: TBM Launch Box
COORDS: 66617.36 m E 263625.12 m N PCG
SURFACE RL: 30.473 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 46.15 m
SHEET: 1 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 18/10/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
30.47
0.30
30.17
TOPSOIL: SAND
fine to medium grained, quartz, grey, with trace organics and rootlets
loose
SAND
fine to medium grained, quartz, pale orange, with trace roots and rootlets up to 10 mm thick
loose to medium dense
SPT 1.50-1.95 m
1, 2, 3
N=5
Rec = 450/450 mm
SPT 3.00-3.45 m
4, 4, 7
N=11
Rec = 450/450 mm
3.50
26.97
Clayey SAND
fine to medium grained, orange, approximately 10-20% low plasticity clay clay, with some fine to coarse grained sub-rounded to rounded, ferricrete gravel
medium dense
SPT 4.50-4.95 m
4, 7, 12
N=19
Rec = 450/450 mm
5.00
25.47
5.30
25.17
Sandy GRAVEL
fine to medium grained, rounded to sub-angular, ferricrete, quartz, granite, dolerite, grey brown, approximately 30%, coarse grained sand
medium dense
CLAY
low plasticity, pale grey mottled orange, trace fine to medium grained sand, trace fine to coarse grained sub-rounded, ferricrete gravel, some lenses of clay
medium dense to hard
SPT 6.00-6.45 m
9, 16, 24
N=40
Rec = 450/450 mm
6.85
23.62
pale grey, gravel absent
7.50
22.97
SPT 7.50-7.95 m
10, 12, 15
N=27
Rec = 450/450 mm
Clayey SAND
fine to medium grained, pale grey, approximately 15-20% low plasticity clay
medium dense to very dense
SPT 9.00-9.45 m
11, 21, 30
N=51
Rec = 450/450 mm
Flush mounted gatic cover installed
Cement Plug from 0.0-1.0 m bgl
Nominal 50 mm Class 18 blank uPVC casing
Backfill
Bentonite Seal from 6.0-7.5 m bgl
Well Development
Date: 21/10/2014
Method: Submersible Pump
Duration: 2.25 hrs
Volume: 850 L
Appearance: Clear
Airlift Rate: 0.2 L/s
BS
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.
GAP gINT FN. F05 RL3
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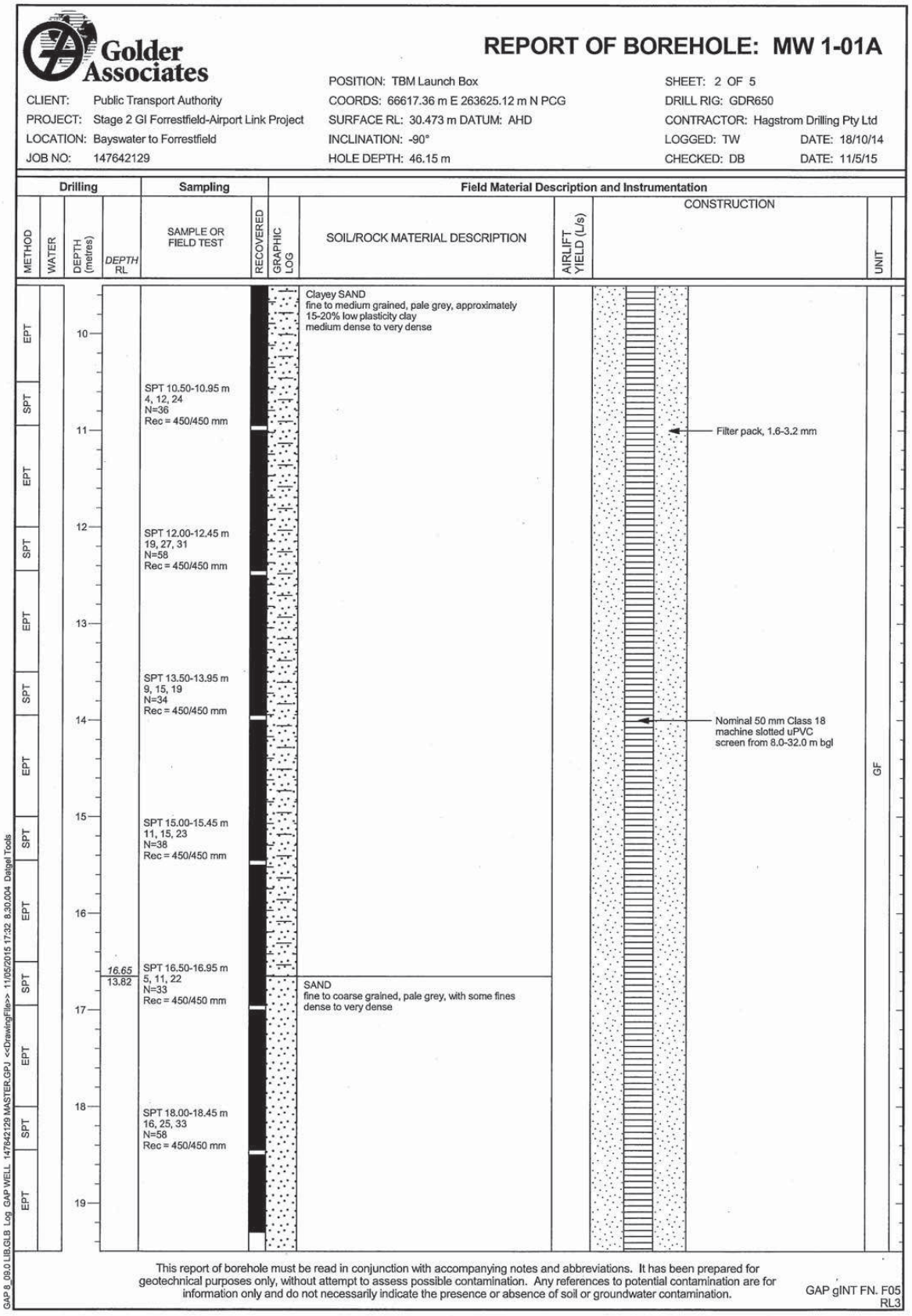
Golder Associates
REPORT OF BOREHOLE: MW 1-01A
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
POSITION: TBM Launch Box
COORDS: 66617.36 m E 263625.12 m N PCG
SURFACE RL: 30.473 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 46.15 m
SHEET: 2 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 18/10/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
Clayey SAND
fine to medium grained, pale grey, approximately 15-20% low plasticity clay
medium dense to very dense
SPT 10.50-10.95 m
4, 12, 24
N=36
Rec = 450/450 mm
SPT 12.00-12.45 m
19, 27, 31
N=58
Rec = 450/450 mm
SPT 13.50-13.95 m
9, 15, 19
N=34
Rec = 450/450 mm
SPT 15.00-15.45 m
11, 15, 23
N=38
Rec = 450/450 mm
16.65
13.82
SPT 16.50-16.95 m
5, 11, 22
N=33
Rec = 450/450 mm
SAND
fine to coarse grained, pale grey, with some fines
dense to very dense
SPT 18.00-18.45 m
16, 25, 33
N=58
Rec = 450/450 mm
Filter pack, 1.6-3.2 mm
Nominal 50 mm Class 18 machine slotted uPVC screen from 8.0-32.0 m bgl
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.
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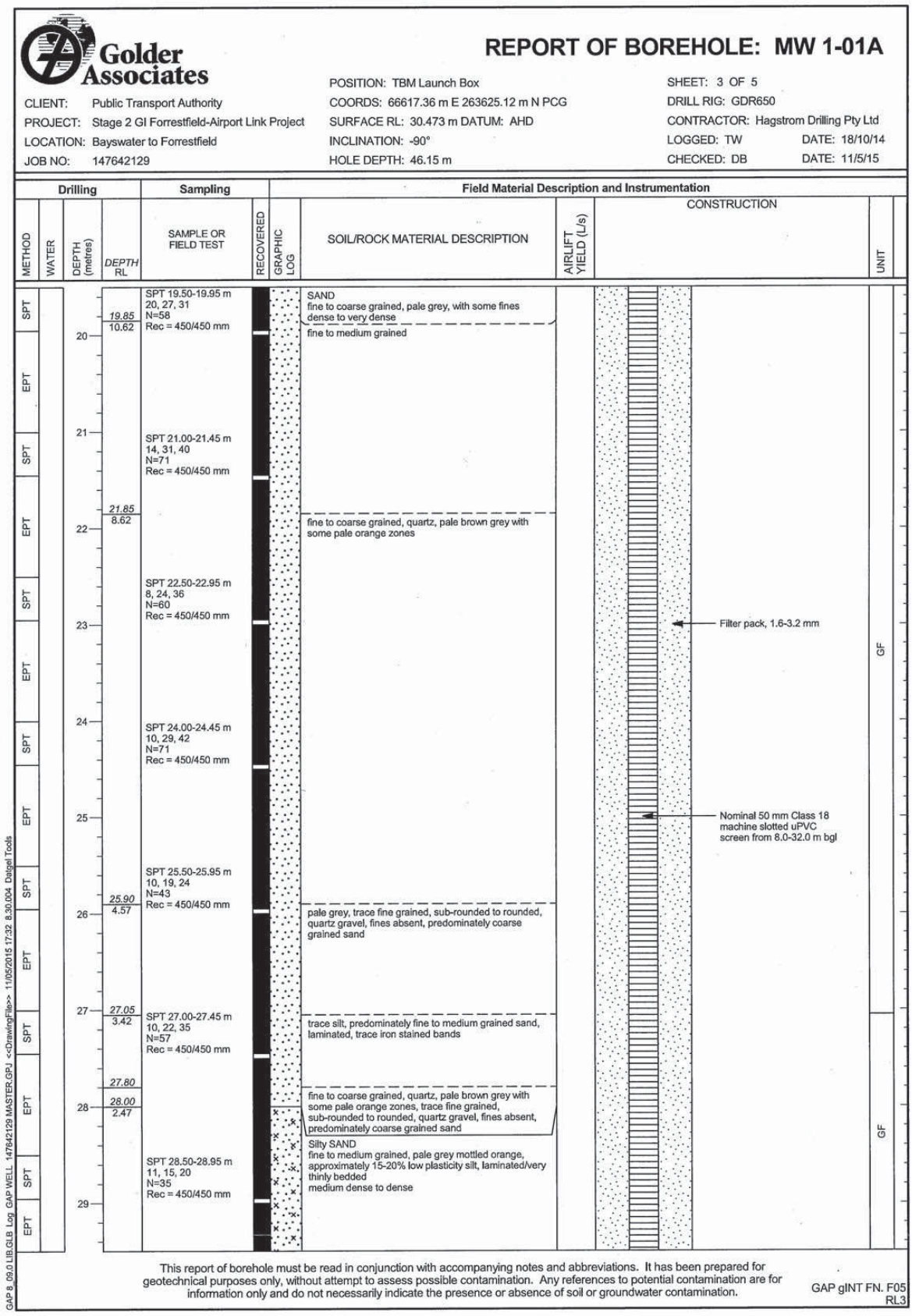
GAP 8_09.0 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:32 8.30.004 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 1-01A
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
POSITION: TBM Launch Box
COORDS: 66617.36 m E 263625.12 m N PCG
SURFACE RL: 30.473 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 46.15 m
SHEET: 3 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 18/10/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
SPT 19.50-19.95 m
20, 27, 31
N=58
Rec = 450/450 mm
SAND
fine to coarse grained, pale grey, with some fines
dense to very dense
19.85
10.62
fine to medium grained
SPT 21.00-21.45 m
14, 31, 40
N=71
Rec = 450/450 mm
21.85
8.62
fine to coarse grained, quartz, pale brown grey with some pale orange zones
SPT 22.50-22.95 m
8, 24, 36
N=60
Rec = 450/450 mm
Filter pack, 1.6-3.2 mm
SPT 24.00-24.45 m
10, 29, 42
N=71
Rec = 450/450 mm
Nominal 50 mm Class 18 machine slotted uPVC screen from 8.0-32.0 m bgl
SPT 25.50-25.95 m
10, 19, 24
N=43
Rec = 450/450 mm
25.90
4.57
pale grey, trace fine grained, sub-rounded to rounded, quartz gravel, fines absent, predominately coarse grained sand
27.05
3.42
SPT 27.00-27.45 m
10, 22, 35
N=57
Rec = 450/450 mm
trace silt, predominately fine to medium grained sand, laminated, trace iron stained bands
27.80
28.00
2.47
fine to coarse grained, quartz, pale brown grey with some pale orange zones, trace fine grained, sub-rounded to rounded, quartz gravel, fines absent, predominately coarse grained sand
Silty SAND
fine to medium grained, pale grey mottled orange, approximately 15-20% low plasticity silt, laminated/very thinly bedded
medium dense to dense
SPT 28.50-28.95 m
11, 15, 20
N=35
Rec = 450/450 mm
GF
GF
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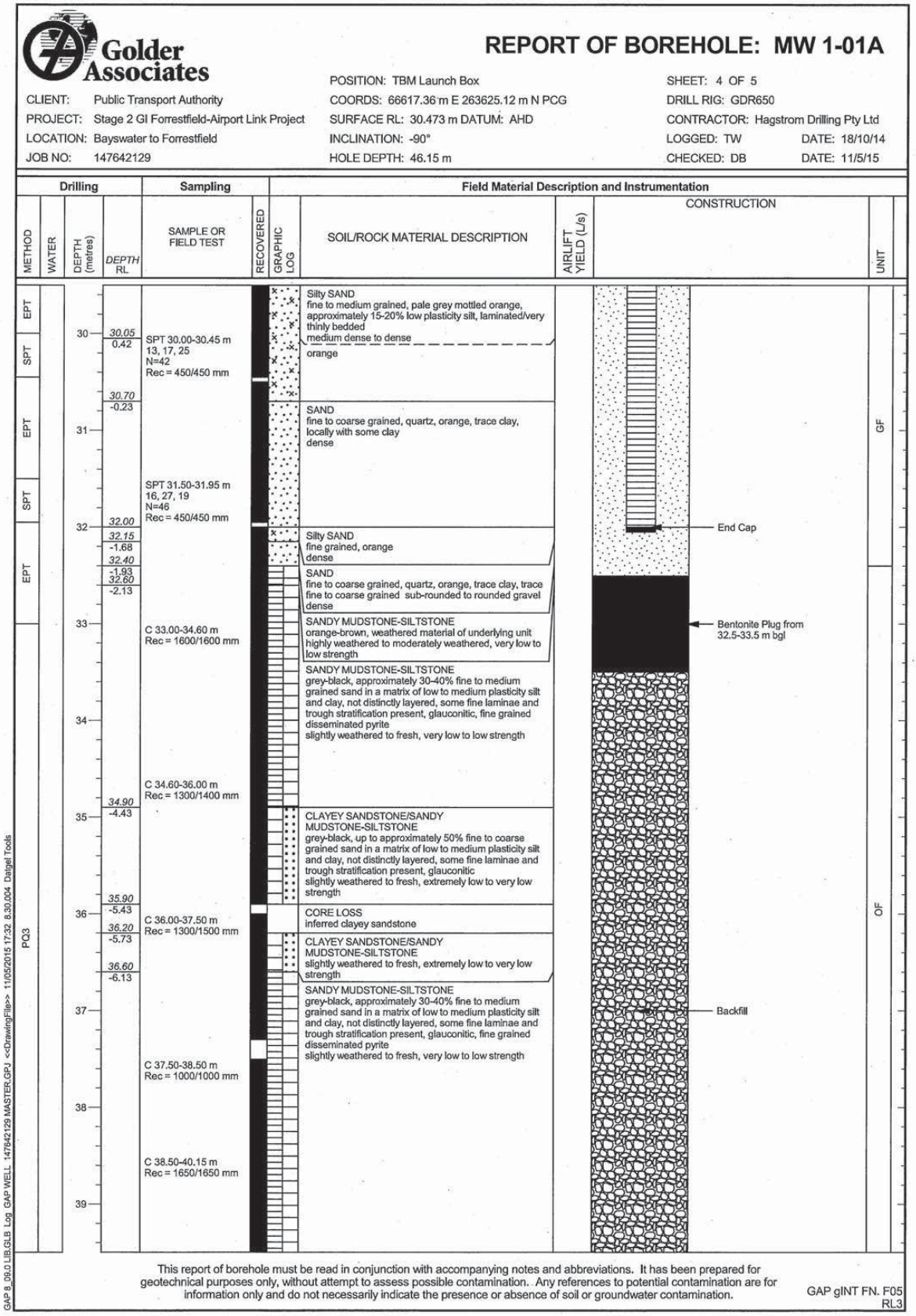
Golder Associates
REPORT OF BOREHOLE: MW 1-01A
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
POSITION: TBM Launch Box
COORDS: 66617.36 m E 263625.12 m N PCG
SURFACE RL: 30.473 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 46.15 m
SHEET: 4 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 18/10/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
EPT
SPT
EPT
SPT
EPT
PQ3
30.05
0.42
SPT 30.00-30.45 m
13, 17, 25
N=42
Rec = 450/450 mm
30.70
-0.23
SPT 31.50-31.95 m
16, 27, 19
N=46
Rec = 450/450 mm
32.00
32.15
-1.68
32.40
-1.93
32.60
-2.13
C 33.00-34.60 m
Rec = 1600/1600 mm
C 34.60-36.00 m
Rec = 1300/1400 mm
34.90
-4.43
35.90
-5.43
C 36.00-37.50 m
Rec = 1300/1500 mm
36.20
-5.73
36.60
-6.13
C 37.50-38.50 m
Rec = 1000/1000 mm
C 38.50-40.15 m
Rec = 1650/1650 mm
Silty SAND
fine to medium grained, pale grey mottled orange, approximately 15-20% low plasticity silt, laminated/very thinly bedded
medium dense to dense
orange
SAND
fine to coarse grained, quartz, orange, trace clay, locally with some clay
dense
Silty SAND
fine grained, orange
dense
SAND
fine to coarse grained, quartz, orange, trace clay, trace fine to coarse grained sub-rounded to rounded gravel
dense
SANDY MUDSTONE-SILTSTONE
orange-brown, weathered material of underlying unit
highly weathered to moderately weathered, very low to low strength
SANDY MUDSTONE-SILTSTONE
grey-black, approximately 30-40% fine to medium grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic, fine grained disseminated pyrite
slightly weathered to fresh, very low to low strength
CLAYEY SANDSTONE/SANDY MUDSTONE-SILTSTONE
grey-black, up to approximately 50% fine to coarse grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic
slightly weathered to fresh, extremely low to very low strength
CORE LOSS
inferred clayey sandstone
CLAYEY SANDSTONE/SANDY MUDSTONE-SILTSTONE
slightly weathered to fresh, extremely low to very low strength
SANDY MUDSTONE-SILTSTONE
grey-black, approximately 30-40% fine to medium grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic, fine grained disseminated pyrite
slightly weathered to fresh, very low to low strength
End Cap
Bentonite Plug from 32.5-33.5 m bgl
Backfill
GF
OF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.
GAP gINT FN. F05 RL3
GAP 8_08.0 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:32 8.30.004 Datgel Tools

Golder Associates

REPORT OF BOREHOLE: MW 1-01A

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

POSITION: TBM Launch Box
COORDS: 66617.36 m E 263625.12 m N PCG
SURFACE RL: 30.473 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 46.15 m

SHEET: 5 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 18/10/14
CHECKED: DB DATE: 11/5/15

Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION / UNIT
PQ3		40		C 38.50-40.15 m Rec = 1650/1650 mm			SANDY MUDSTONE-SILTSTONE grey-black, approximately 30-40% fine to medium grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic, fine grained disseminated pyrite slightly weathered to fresh, very low to low strength		
		41		C 40.15-41.60 m Rec = 1450/1450 mm					
		42		C 41.60-41.70 m Rec = 100/100 mm C 41.70-43.35 m Rec = 1650/1650 mm					Backfill
		43							OF
		44		C 43.35-44.40 m Rec = 1050/1050 mm					
		45	44.50 -14.03	C 44.40-46.00 m Rec = 1600/1600 mm			SAND fine to coarse grained, quartz, grey, with some clay		
SPT		46	46.15 -15.68	SPT 46.00-46.15 m 72/150mm N=R Rec = 150/150 mm			END OF BOREHOLE @ 46.15 m TARGET DEPTH GROUNDWATER NOT OBSERVED GROUNDWATER MONITORING WELL INSTALLED, SCREENED FROM 8 TO 32 m BELOW GROUND LEVEL		
		47							
		48							
		49							

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F05 RL3

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Golder Associates

REPORT OF BOREHOLE: MW 1-01B

SHEET: 1 OF 2

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

COORDS: 66558.46 m E 263603.72 m N PCG
SURFACE RL: 29.326 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 32.50 m

DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 3/11/14
CHECKED: DB DATE: 11/5/15

Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION
WB		0	29.33				SAND fine to medium grained		Flush mounted lockable steel cover Cement Plug from 0.0-1.0 m bgl
			1.00						
			28.33				Clayey SAND fine to medium grained		
		2							Backfill: Cuttings
		4							Nominal 50 mm Class 18 blank uPVC casing
			4.50						
			24.83				Sandy CLAY low plasticity, fine to medium grained sand		**Well Development** Date: 5/11/2014 Method: Airlift Duration: 1 hr Removed Volume: 850 L Appearance: Clear Airlift Rate: 0.24 L/s
		6							
			7.00						
			22.33				SAND fine to medium grained		Bentonite Seal from 6.5-7.5 m bgl
			7.50						
			21.83				Silty SAND fine to medium grained		
		8							
		10							Filter Pack, 1.6-3.2 mm
		12							
			13.50						Nominal 50 mm Class 18 machine slotted uPVC screen from 8.5-32.5 m bgl
			15.83				SAND fine to coarse grained		
		14							
		16							
		18							

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GAP gINT FN. F05 RL3

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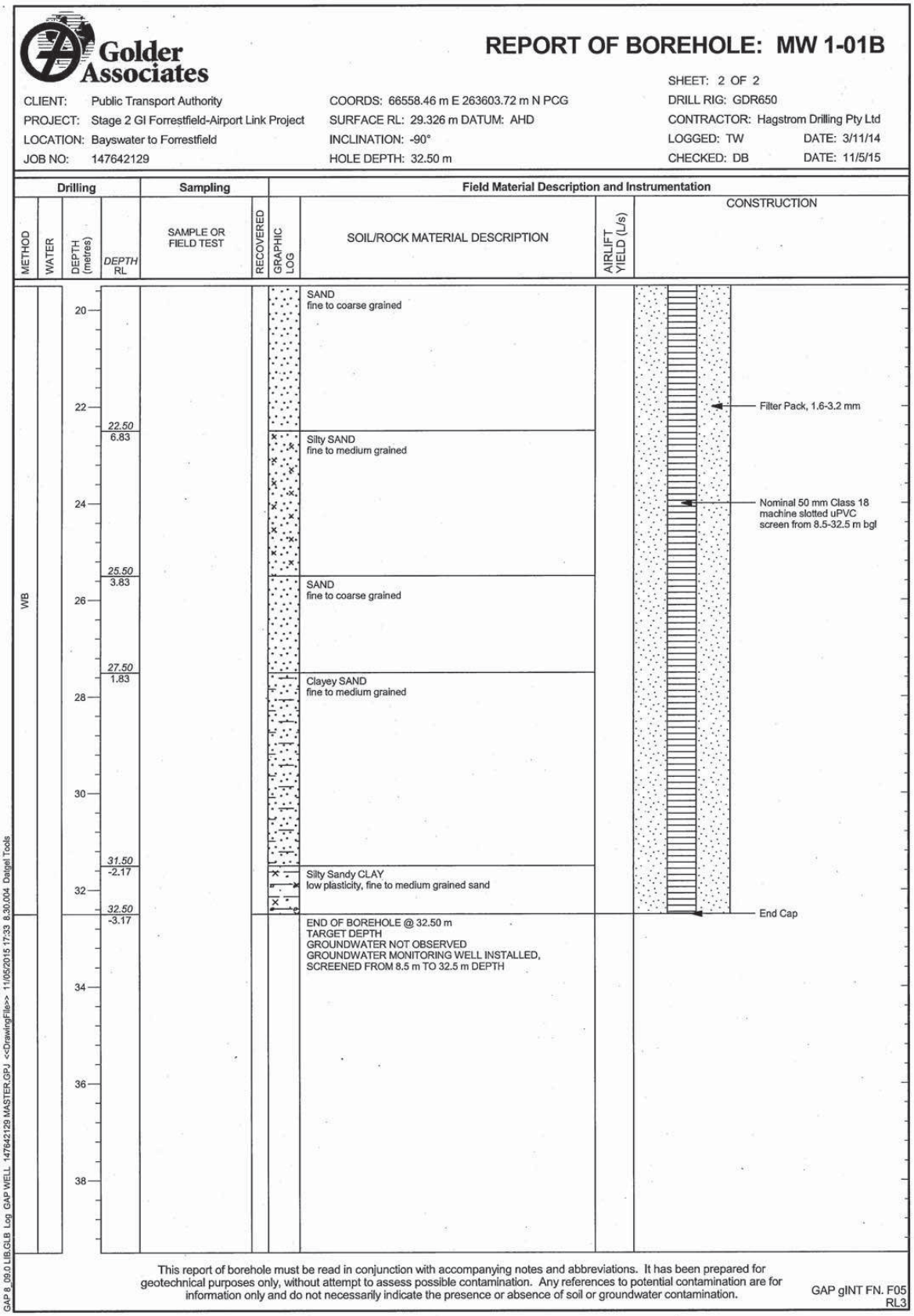
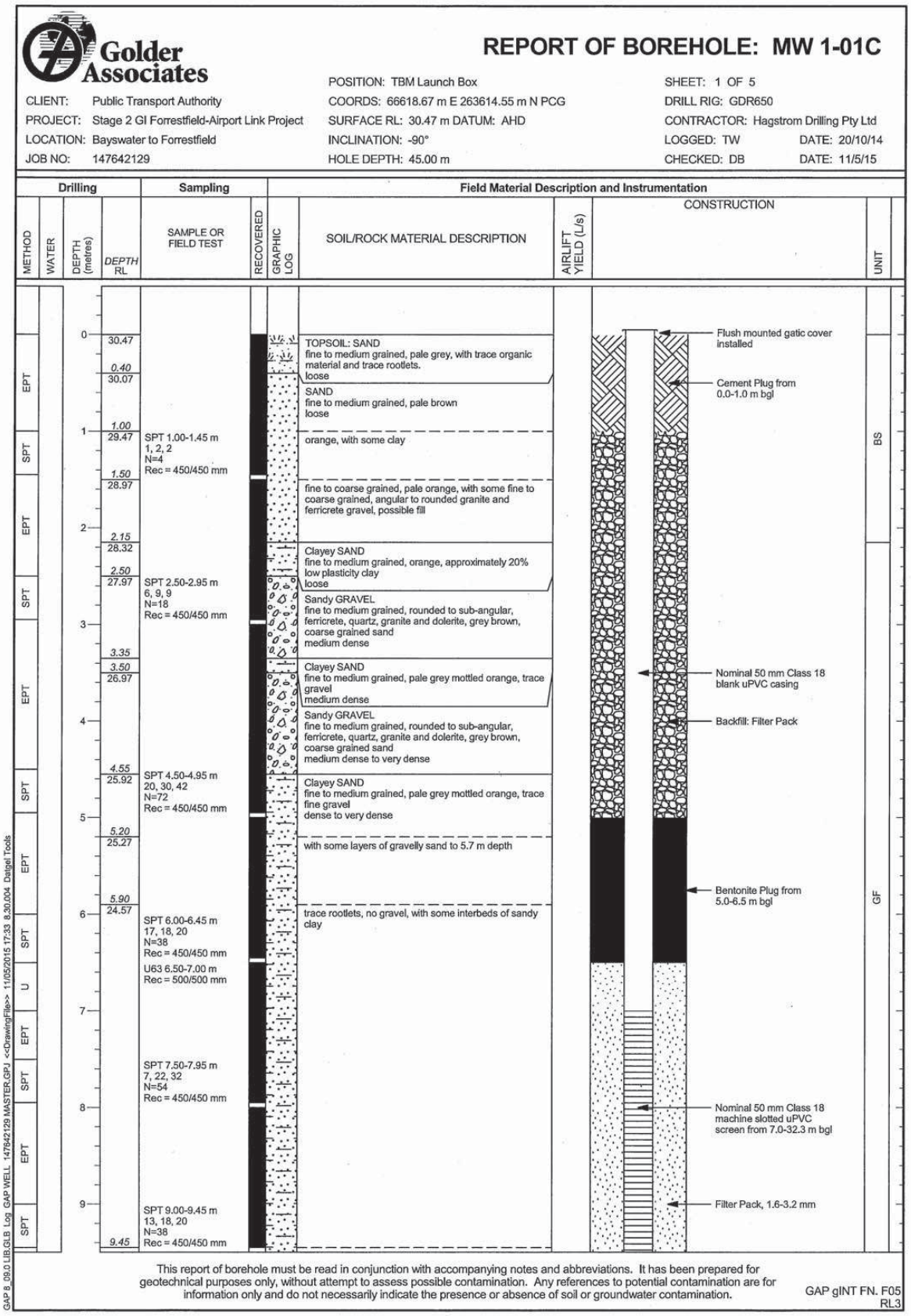
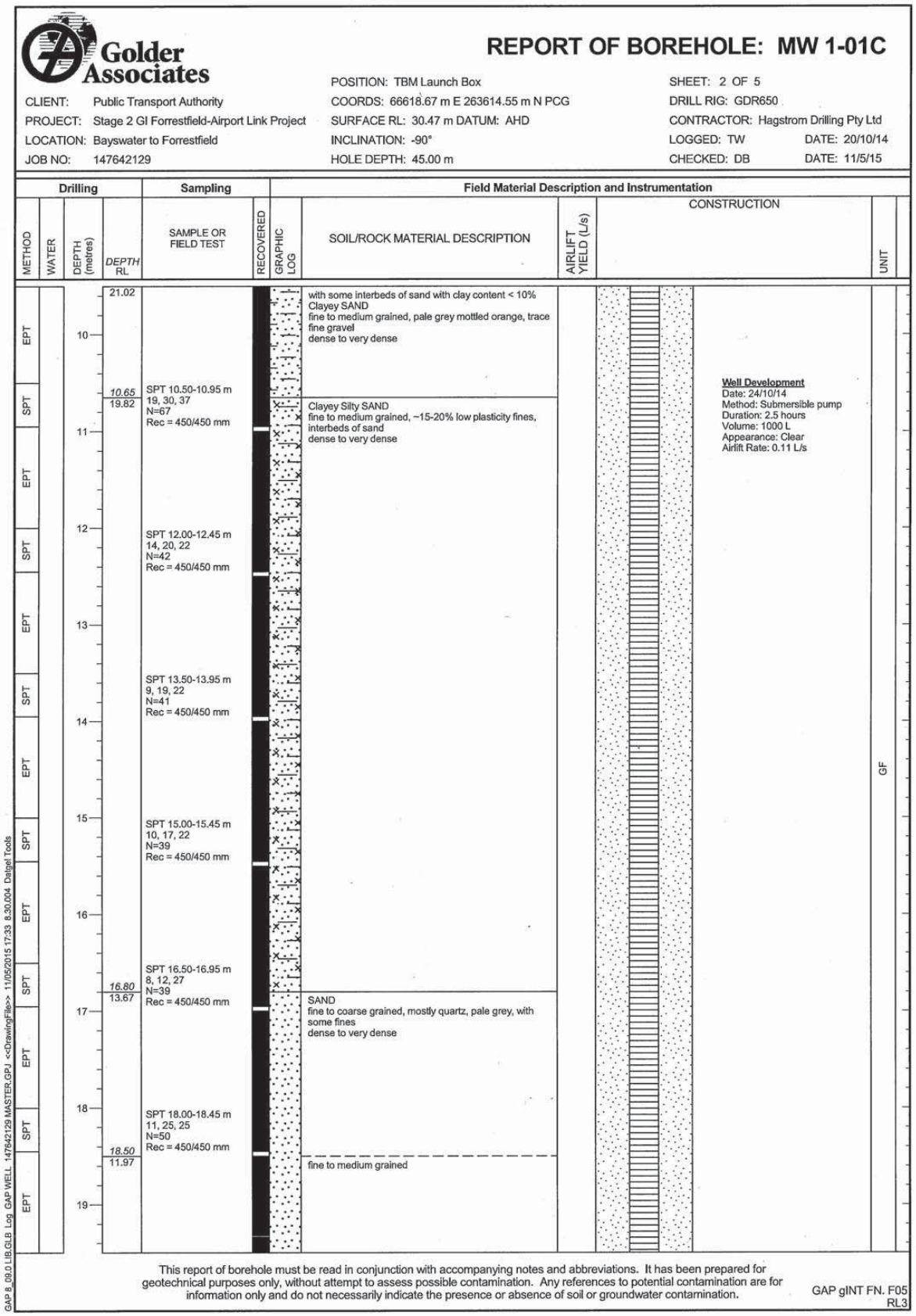

Golder Associates
REPORT OF BOREHOLE: MW 1-01B
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
COORDS: 66558.46 m E 263603.72 m N PCG
SURFACE RL: 29.326 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 32.50 m
SHEET: 2 OF 2
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 3/11/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
WB
SAND
fine to coarse grained
22.50
6.83
Silty SAND
fine to medium grained
25.50
3.83
SAND
fine to coarse grained
27.50
1.83
Clayey SAND
fine to medium grained
31.50
-2.17
Silty Sandy CLAY
low plasticity, fine to medium grained
32.50
-3.17
END OF BOREHOLE @ 32.50 m
TARGET DEPTH
GROUNDWATER NOT OBSERVED
GROUNDWATER MONITORING WELL INSTALLED,
SCREENED FROM 8.5 m TO 32.5 m DEPTH
Filter Pack, 1.6-3.2 mm
Nominal 50 mm Class 18 machine slotted uPVC screen from 8.5-32.5 m bgl
End Cap
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.
GAP gINT FN. F05 RL3
GAP 8_09.0 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:33 8.30.004 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 1-01C
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
POSITION: TBM Launch Box
COORDS: 66618.67 m E 263614.55 m N PCG
SURFACE RL: 30.47 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 45.00 m
SHEET: 1 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 20/10/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
30.47
0.40
30.07
TOPSOIL: SAND
fine to medium grained, pale grey, with trace organic material and trace rootlets.
loose
SAND
fine to medium grained, pale brown
loose
1.00
29.47
SPT 1.00-1.45 m
1, 2, 2
N=4
Rec = 450/450 mm
orange, with some clay
1.50
28.97
fine to coarse grained, pale orange, with some fine to coarse grained, angular to rounded granite and ferricrete gravel, possible fill
2.15
28.32
Clayey SAND
fine to medium grained, orange, approximately 20% low plasticity clay
loose
2.50
27.97
SPT 2.50-2.95 m
6, 9, 9
N=18
Rec = 450/450 mm
Sandy GRAVEL
fine to medium grained, rounded to sub-angular, ferricrete, quartz, granite and dolerite, grey brown, coarse grained sand
medium dense
3.35
3.50
26.97
Clayey SAND
fine to medium grained, pale grey mottled orange, trace gravel
medium dense
Sandy GRAVEL
fine to medium grained, rounded to sub-angular, ferricrete, quartz, granite and dolerite, grey brown, coarse grained sand
medium dense to very dense
4.55
25.92
SPT 4.50-4.95 m
20, 30, 42
N=72
Rec = 450/450 mm
Clayey SAND
fine to medium grained, pale grey mottled orange, trace fine gravel
dense to very dense
5.20
25.27
with some layers of gravelly sand to 5.7 m depth
5.90
24.57
trace rootlets, no gravel, with some interbeds of sandy clay
SPT 6.00-6.45 m
17, 18, 20
N=38
Rec = 450/450 mm
U63 6.50-7.00 m
Rec = 500/500 mm
SPT 7.50-7.95 m
7, 22, 32
N=54
Rec = 450/450 mm
SPT 9.00-9.45 m
13, 18, 20
N=38
Rec = 450/450 mm
9.45
Flush mounted gatic cover installed
Cement Plug from 0.0-1.0 m bgl
Nominal 50 mm Class 18 blank uPVC casing
Backfill: Filter Pack
Bentonite Plug from 5.0-6.5 m bgl
Nominal 50 mm Class 18 machine slotted uPVC screen from 7.0-32.3 m bgl
Filter Pack, 1.6-3.2 mm
BS
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.
GAP gINT FN. F05 RL3
GAP 8_09.0 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:33 8.30.004 Datgel Tools



Golder Associates

REPORT OF BOREHOLE: MW 1-01C

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

POSITION: TBM Launch Box
COORDS: 66618.67 m E 263614.55 m N PCG
SURFACE RL: 30.47 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 45.00 m

SHEET: 2 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 20/10/14
CHECKED: DB DATE: 11/5/15

Drilling				Sampling		Field Material Description and Instrumentation				
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION	UNIT
EPT		10	21.02				with some interbeds of sand with clay content < 10% Clayey SAND fine to medium grained, pale grey mottled orange, trace fine gravel dense to very dense			
SPT			10.65 19.82	SPT 10.50-10.95 m 19, 30, 37 N=67 Rec = 450/450 mm			Clayey Silty SAND fine to medium grained, ~15-20% low plasticity fines, interbeds of sand dense to very dense		**Well Development** Date: 24/10/14 Method: Submersible pump Duration: 2.5 hours Volume: 1000 L Appearance: Clear Airlift Rate: 0.11 L/s	
EPT		11								
SPT		12		SPT 12.00-12.45 m 14, 20, 22 N=42 Rec = 450/450 mm						
EPT		13								
SPT				SPT 13.50-13.95 m 9, 19, 22 N=41 Rec = 450/450 mm						
EPT		14								
SPT		15		SPT 15.00-15.45 m 10, 17, 22 N=39 Rec = 450/450 mm						GF
EPT		16								
SPT			16.80 13.67	SPT 16.50-16.95 m 8, 12, 27 N=39 Rec = 450/450 mm			SAND fine to coarse grained, mostly quartz, pale grey, with some fines dense to very dense			
EPT		17								
SPT		18		SPT 18.00-18.45 m 11, 25, 25 N=50 Rec = 450/450 mm						
EPT			18.50 11.97				fine to medium grained			
		19								

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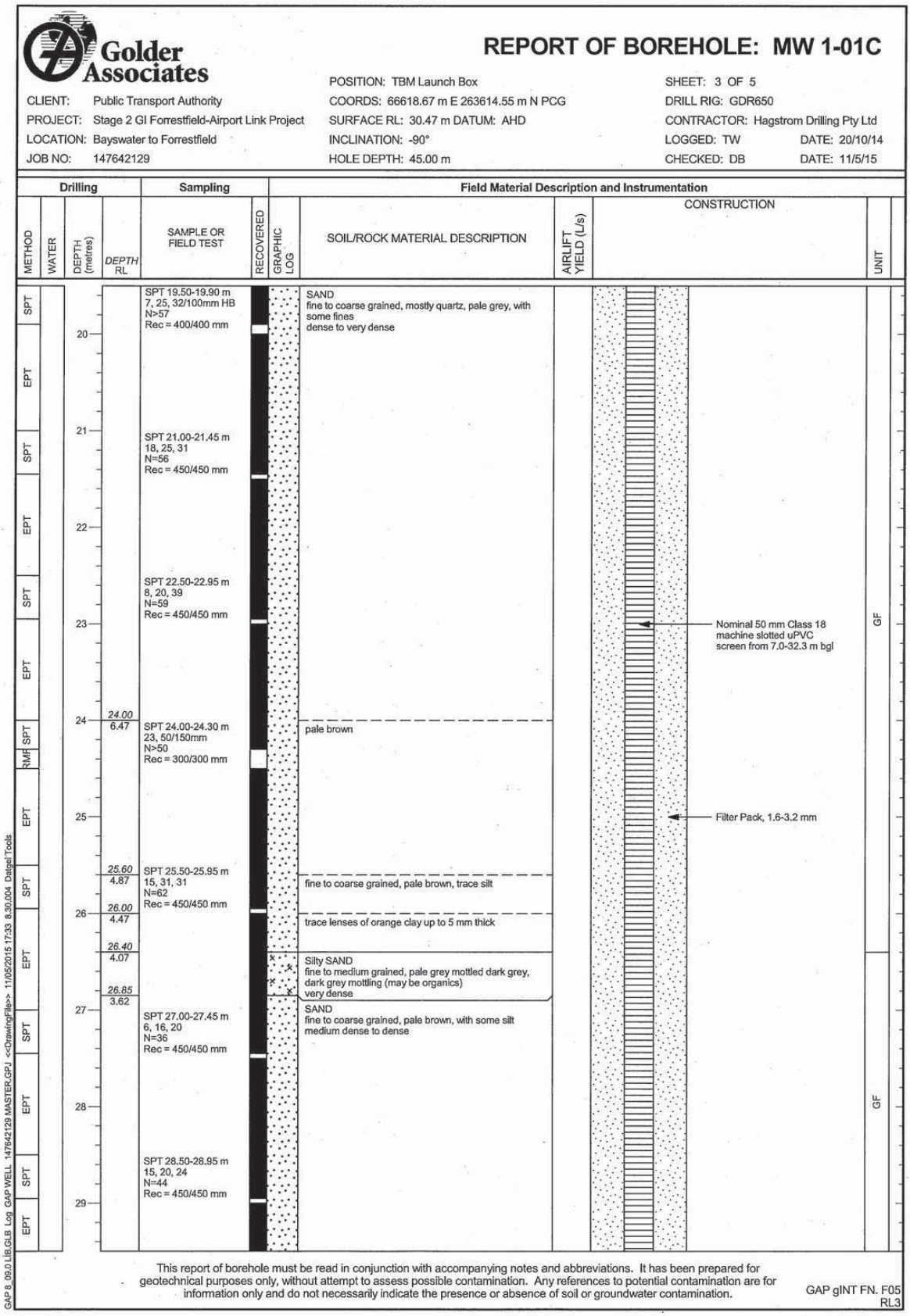
GAP gINT FN. F05 RL3

GAP 8_09.0 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:33 8.30.004 Datgel Tools



Golder Associates

REPORT OF BOREHOLE: MW 1-01C

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

POSITION: TBM Launch Box
COORDS: 66618.67 m E 263614.55 m N PCG
SURFACE RL: 30.47 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 45.00 m

SHEET: 3 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 20/10/14
CHECKED: DB DATE: 11/5/15

Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION / UNIT
SPT		20		SPT 19.50-19.90 m 7, 25, 32/100mm HB N>57 Rec = 400/400 mm			SAND fine to coarse grained, mostly quartz, pale grey, with some fines dense to very dense		
EPT									
SPT		21		SPT 21.00-21.45 m 18, 25, 31 N=56 Rec = 450/450 mm					
EPT		22							
SPT				SPT 22.50-22.95 m 8, 20, 39 N=59 Rec = 450/450 mm					
EPT		23							Nominal 50 mm Class 18 machine slotted uPVC screen from 7.0-32.3 m bgl
RMT SPT		24	24.00 6.47	SPT 24.00-24.30 m 23, 50/150mm N>50 Rec = 300/300 mm			pale brown		
EPT		25							Filter Pack, 1.6-3.2 mm
SPT			25.60 4.87	SPT 25.50-25.95 m 15, 31, 31 N=62 Rec = 450/450 mm			fine to coarse grained, pale brown, trace silt		
EPT		26	26.00 4.47				trace lenses of orange clay up to 5 mm thick		
SPT			26.40 4.07				Silty SAND fine to medium grained, pale grey mottled dark grey, dark grey mottling (may be organics) very dense		
EPT			26.85 3.62				SAND fine to coarse grained, pale brown, with some silt medium dense to dense		GF
SPT		27		SPT 27.00-27.45 m 6, 16, 20 N=36 Rec = 450/450 mm					
EPT		28							GF
SPT				SPT 28.50-28.95 m 15, 20, 24 N=44 Rec = 450/450 mm					
EPT		29							

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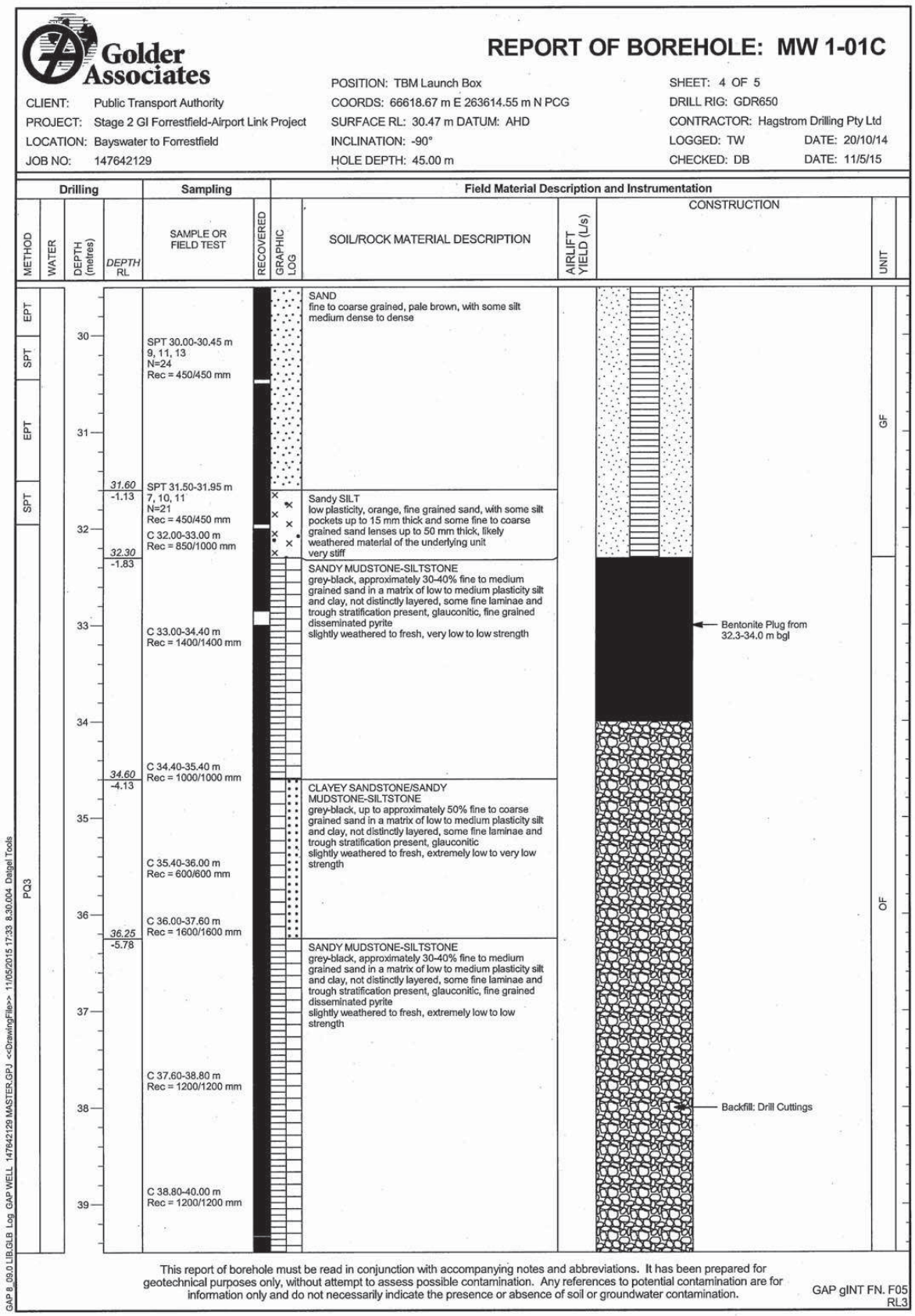
GAP gINT FN. F05 RL3


Golder Associates
REPORT OF BOREHOLE: MW 1-01C
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
POSITION: TBM Launch Box
COORDS: 66618.67 m E 263614.55 m N PCG
SURFACE RL: 30.47 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 45.00 m
SHEET: 4 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 20/10/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
EPT
SPT
EPT
SPT
PQ3
SAND
fine to coarse grained, pale brown, with some silt
medium dense to dense
SPT 30.00-30.45 m
9, 11, 13
N=24
Rec = 450/450 mm
31.60
-1.13
SPT 31.50-31.95 m
7, 10, 11
N=21
Rec = 450/450 mm
Sandy SILT
low plasticity, orange, fine grained sand, with some silt pockets up to 15 mm thick and some fine to coarse grained sand lenses up to 50 mm thick, likely weathered material of the underlying unit
very stiff
C 32.00-33.00 m
Rec = 850/1000 mm
32.30
-1.83
SANDY MUDSTONE-SILTSTONE
grey-black, approximately 30-40% fine to medium grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic, fine grained disseminated pyrite
slightly weathered to fresh, very low to low strength
C 33.00-34.40 m
Rec = 1400/1400 mm
Bentonite Plug from 32.3-34.0 m bgl
C 34.40-35.40 m
34.60
Rec = 1000/1000 mm
-4.13
CLAYEY SANDSTONE/SANDY MUDSTONE-SILTSTONE
grey-black, up to approximately 50% fine to coarse grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic
slightly weathered to fresh, extremely low to very low strength
C 35.40-36.00 m
Rec = 600/600 mm
C 36.00-37.60 m
36.25
Rec = 1600/1600 mm
-5.78
SANDY MUDSTONE-SILTSTONE
grey-black, approximately 30-40% fine to medium grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic, fine grained disseminated pyrite
slightly weathered to fresh, extremely low to low strength
C 37.60-38.80 m
Rec = 1200/1200 mm
Backfill: Drill Cuttings
C 38.80-40.00 m
Rec = 1200/1200 mm
GF
OF
30
31
32
33
34
35
36
37
38
39
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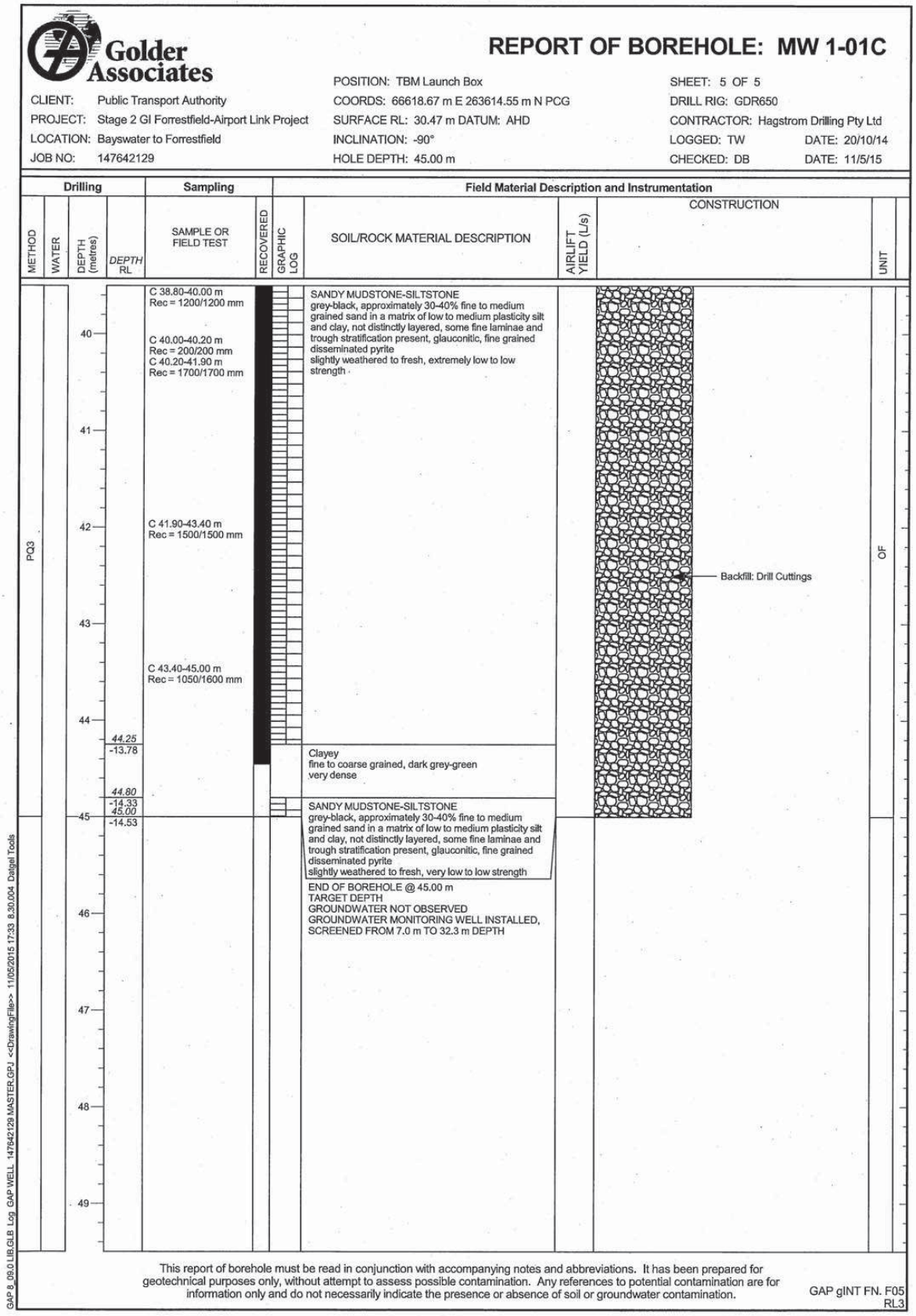
GAP gINT FN. F05 RL3
GAP 8_09.0 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:33 8.30.004 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 1-01C
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
POSITION: TBM Launch Box
COORDS: 66618.67 m E 263614.55 m N PCG
SURFACE RL: 30.47 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 45.00 m
SHEET: 5 OF 5
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 20/10/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
PQ3
C 38.80-40.00 m
Rec = 1200/1200 mm
C 40.00-40.20 m
Rec = 200/200 mm
C 40.20-41.90 m
Rec = 1700/1700 mm
C 41.90-43.40 m
Rec = 1500/1500 mm
C 43.40-45.00 m
Rec = 1050/1600 mm
SANDY MUDSTONE-SILTSTONE
grey-black, approximately 30-40% fine to medium grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic, fine grained disseminated pyrite
slightly weathered to fresh, extremely low to low strength
Backfill: Drill Cuttings
OF
44.25
-13.78
Clayey
fine to coarse grained, dark grey-green
very dense
44.80
-14.33
45.00
-14.53
SANDY MUDSTONE-SILTSTONE
grey-black, approximately 30-40% fine to medium grained sand in a matrix of low to medium plasticity silt and clay, not distinctly layered, some fine laminae and trough stratification present, glauconitic, fine grained disseminated pyrite
slightly weathered to fresh, very low to low strength
END OF BOREHOLE @ 45.00 m
TARGET DEPTH
GROUNDWATER NOT OBSERVED
GROUNDWATER MONITORING WELL INSTALLED, SCREENED FROM 7.0 m TO 32.3 m DEPTH
40
41
42
43
44
45
46
47
48
49
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.
GAP gINT FN. F05 RL3
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Golder Associates

REPORT OF BOREHOLE: MW 1-01D

SHEET: 1 OF 2

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

COORDS: 66623.68 m E 263577.81 m N PCG
SURFACE RL: 30.190 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 33.00 m

DRILL RIG: DR005
CONTRACTOR: J&S
LOGGED: NA DATE: 6/11/14
CHECKED: DB DATE: 11/5/15

Drilling				Sampling		Field Material Description and Instrumentation		
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)

WB

29/11/14 12:04, Water Level - mb gatic cover

0 — 30.19
SAND
fine to coarse grained, brown, sub-rounded to sub-angular

3.00 — 27.19
Gravelly SAND
fine to coarse grained, pale brown, sub-rounded to sub-angular

5.00 — 25.19
Clayey SAND
fine to medium grained, pale grey, sub-rounded to sub-angular,

9.00 — 21.19
Clayey Gravelly SAND
fine grained, pale grey, sub-rounded to sub-angular

12.00 — 18.19
Clayey SAND
fine to medium grained, pale grey, sub-rounded to sub-angular

18.00 — 12.19
No recovery, fines too small for sieve

CONSTRUCTION

- Flush-mounted lockable steel cover
- Cement Plug from 0.0-1.0 m bgl
- Backfill: Sand
- 50 mm Class 18 PVC blank casing 0.0-7.0 m bgl
- Bentonite Seal from 4.0-5.5 m bgl

Well Development
Date: 7/11/2014
Method: Airlift
Duration: 58 minutes
Removed Volume: 2,300 L
Appearance: Clear
Airlift Rate: N/A

- Nominal 50 mm Class 18 machine slotted uPVC screen from 7.0-32.0 m bgl
- Filter pack, 1.6-3.2 mm

GAP 8_09.0 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:33 8.30.004 Datgel Tools

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GAP gINT FN. F05 RL3

Golder Associates

REPORT OF BOREHOLE: MW 1-01D

SHEET: 2 OF 2

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

COORDS: 66623.68 m E 263577.81 m N PCG
SURFACE RL: 30.190 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 33.00 m

DRILL RIG: DR005
CONTRACTOR: J&S
LOGGED: NA DATE: 6/11/14
CHECKED: DB DATE: 11/5/15

Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION
WB		20	21.00 9.19				No recovery, fines too small for sieve		
		22					SAND fine to medium grained, yellow-brown, sub-rounded to sub-angular		Nominal 50 mm Class 18 machine slotted uPVC screen from 7.0-32.0 m bgl
		24	24.00 6.19				Clayey SAND fine to coarse grained, grey, sub-rounded to sub-angular		
			25.00 5.19				SAND fine to coarse grained, grey, sub-rounded to sub-angular		Filter pack, 1.6-3.2 mm
		26							
		28	28.00 2.19				Clayey SAND fine to medium grained, red-brown, with pockets of grey clayey fine grained sand		
		30						1.5	
		32	32.00 -1.81				Sandy CLAY dark grey and green, medium plasticity		End Cap
			33.00 -2.81				END OF BOREHOLE @ 33.00 m TARGET DEPTH GROUNDWATER NOT OBSERVED GROUNDWATER MONITORING WELL INSTALLED, SCREENED FROM 7.0 m TO 32.0 m DEPTH		
		34							
		36							
		38							

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F05 RL3

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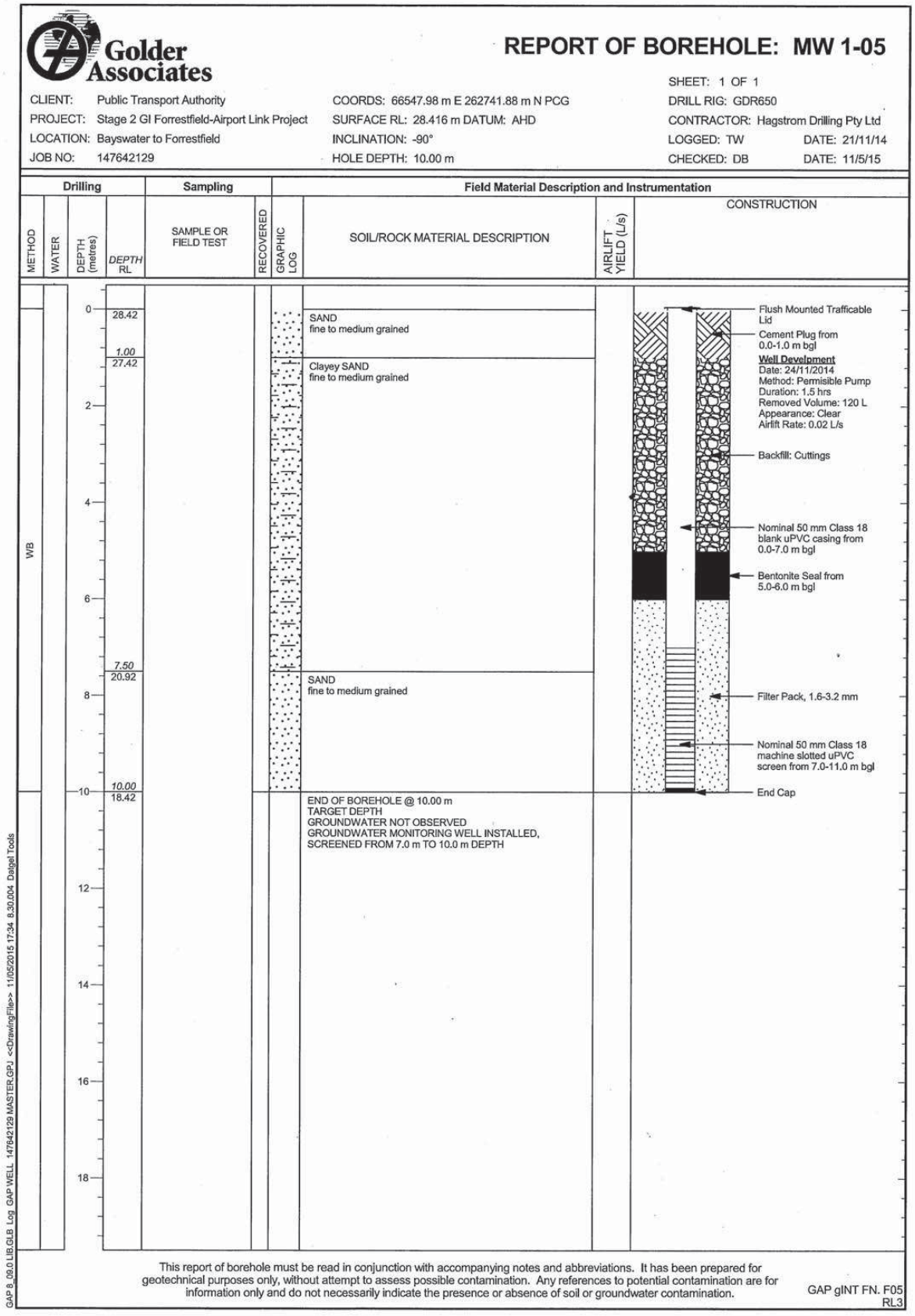
Golder Associates
REPORT OF BOREHOLE: MW 1-05
SHEET: 1 OF 1
CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129
COORDS: 66547.98 m E 262741.88 m N PCG
SURFACE RL: 28.416 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 10.00 m
DRILL RIG: GDR650
CONTRACTOR: Hagstrom Drilling Pty Ltd
LOGGED: TW DATE: 21/11/14
CHECKED: DB DATE: 11/5/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
WB
28.42
SAND
fine to medium grained
1.00
27.42
Clayey SAND
fine to medium grained
7.50
20.92
SAND
fine to medium grained
10.00
18.42
END OF BOREHOLE @ 10.00 m
TARGET DEPTH
GROUNDWATER NOT OBSERVED
GROUNDWATER MONITORING WELL INSTALLED,
SCREENED FROM 7.0 m TO 10.0 m DEPTH
Flush Mounted Trafficable Lid
Cement Plug from 0.0-1.0 m bgl
Well Development
Date: 24/11/2014
Method: Permisible Pump
Duration: 1.5 hrs
Removed Volume: 120 L
Appearance: Clear
Airlift Rate: 0.02 L/s
Backfill: Cuttings
Nominal 50 mm Class 18 blank uPVC casing from 0.0-7.0 m bgl
Bentonite Seal from 5.0-6.0 m bgl
Filter Pack, 1.6-3.2 mm
Nominal 50 mm Class 18 machine slotted uPVC screen from 7.0-11.0 m bgl
End Cap
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GAP gINT FN. F05 RL3
GAP 8_09.0 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:34 8.30.004 Datgel Tools

Golder Associates

REVISION A REPORT OF BOREHOLE: PW 1-01

SHEET: 1 OF 2

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

COORDS: 66618.950 m E 263607.530 m N PCG
SURFACE RL: 30.320 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 33.00 m

DRILL RIG: KL 100 Heli
CONTRACTOR: J&S
LOGGED: NA DATE: 7/11/14
CHECKED: SWG DATE: 11/5/15

Drilling				Sampling		Field Material Description and Instrumentation		
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION
WB		0	30.32				SAND fine to coarse grained, grey and red-brown, sub-rounded to sub-angular		Lockable Steel Riser, 0.4 m agl Cement Plug from 0.0-1.0 m bgl Backfill: Sand from 1.0-2.7 m bgl 203 mm Class 18 PVC blank casing from 0.0-4.2 m bgl Bentonite Seal from 2.7-3.7 m bgl
		2	2.00 28.32				Clayey SAND fine to medium grained, red-brown, sub-rounded to sub-angular		
		4	4.00 26.32				grey and pale brown		**Well Development** Date: 7/11/2014 Method: Submersible Pump Duration: 10 hrs Removed Volume: 6500 L Appearance: Clear Airlift Rate: 7 L/s
		6							
		8							
		10	10.00 20.32				pale grey, fine to coarse grained, trace clay		Filter Pack, size 1.6-3.2 mm from 3.7-31.2 m bgl 203 mm Class 18 PVC machine slotted screen from 4.2-31.2 m bgl
		12							
		14							
		16							
		18							

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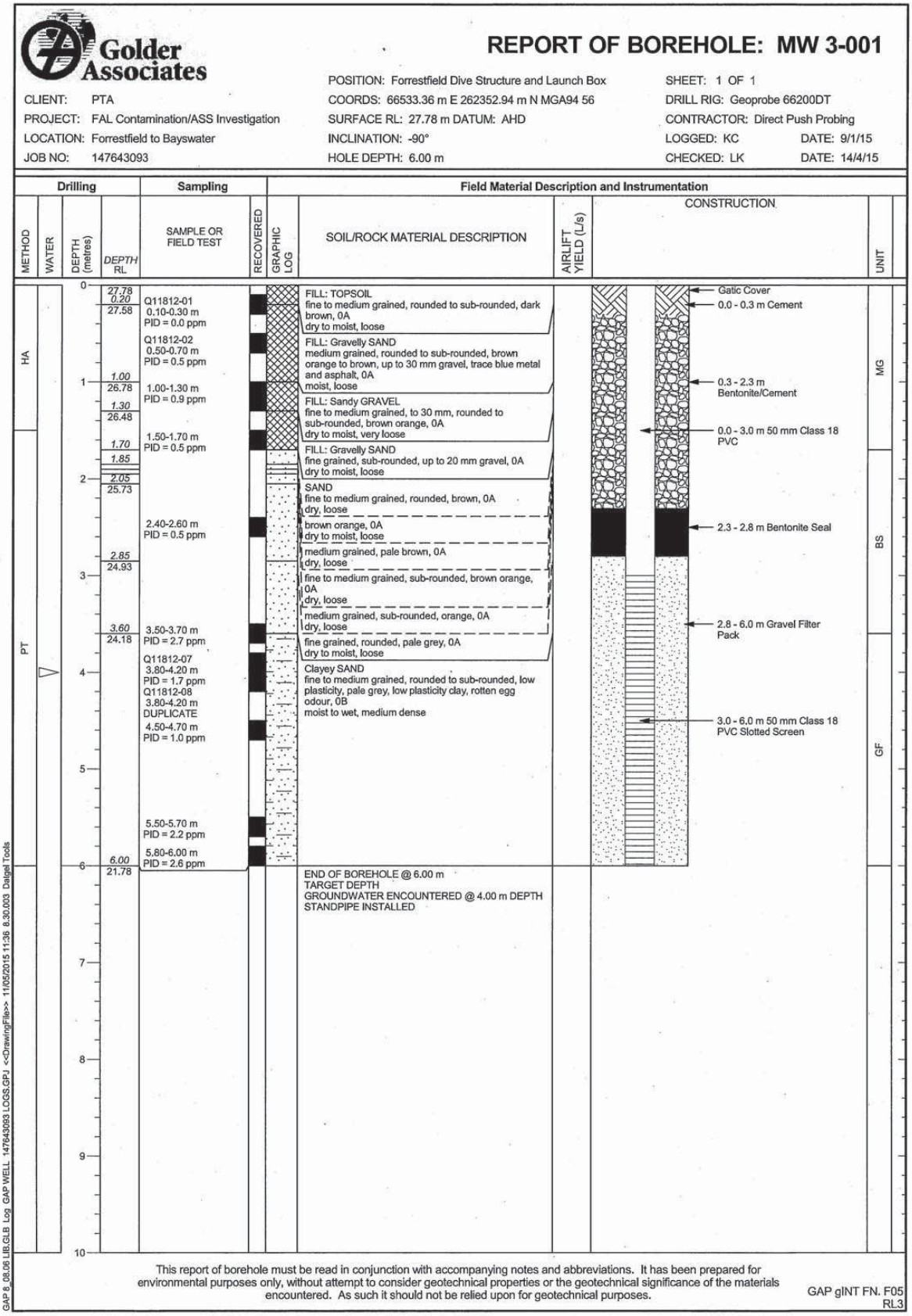
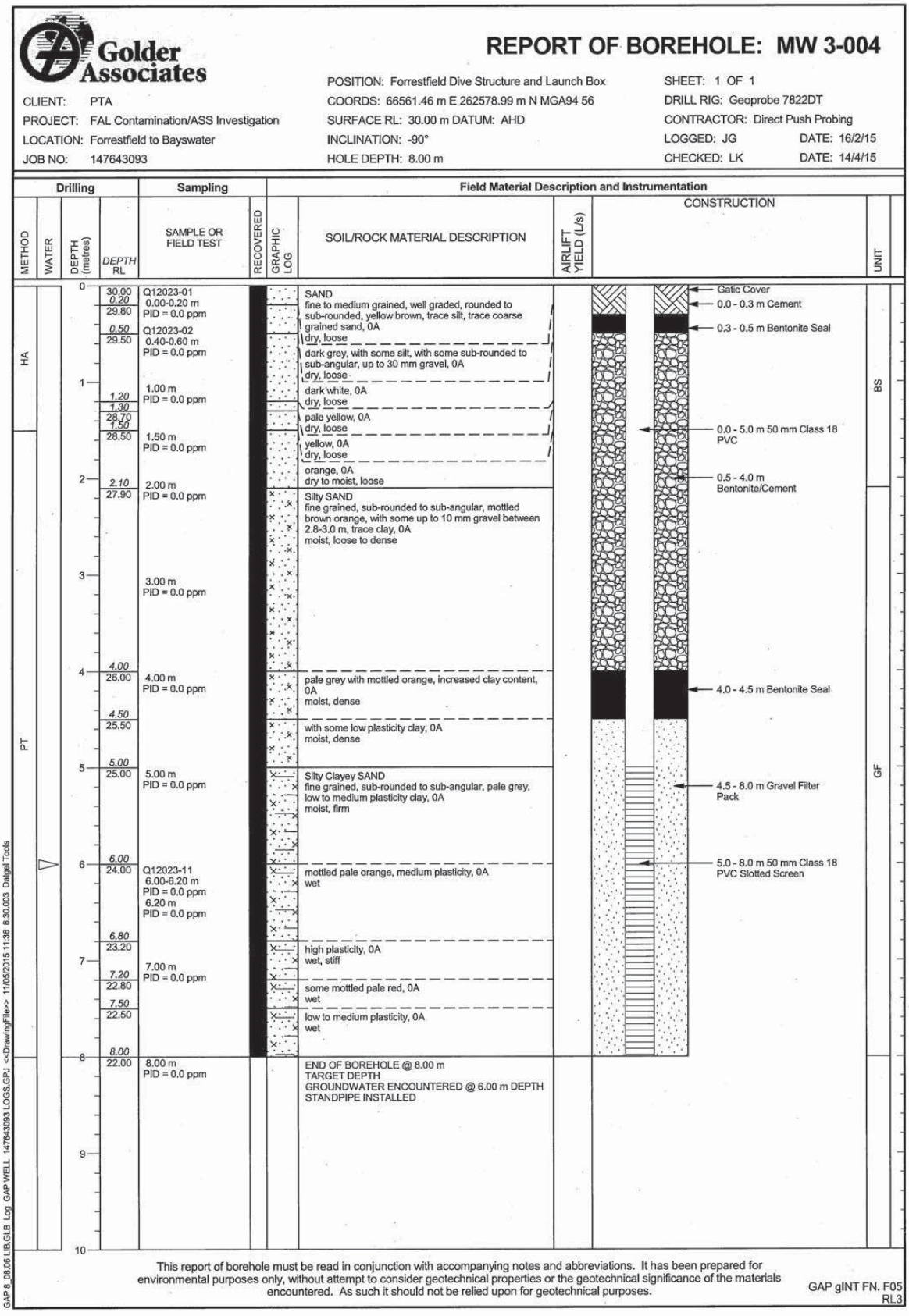
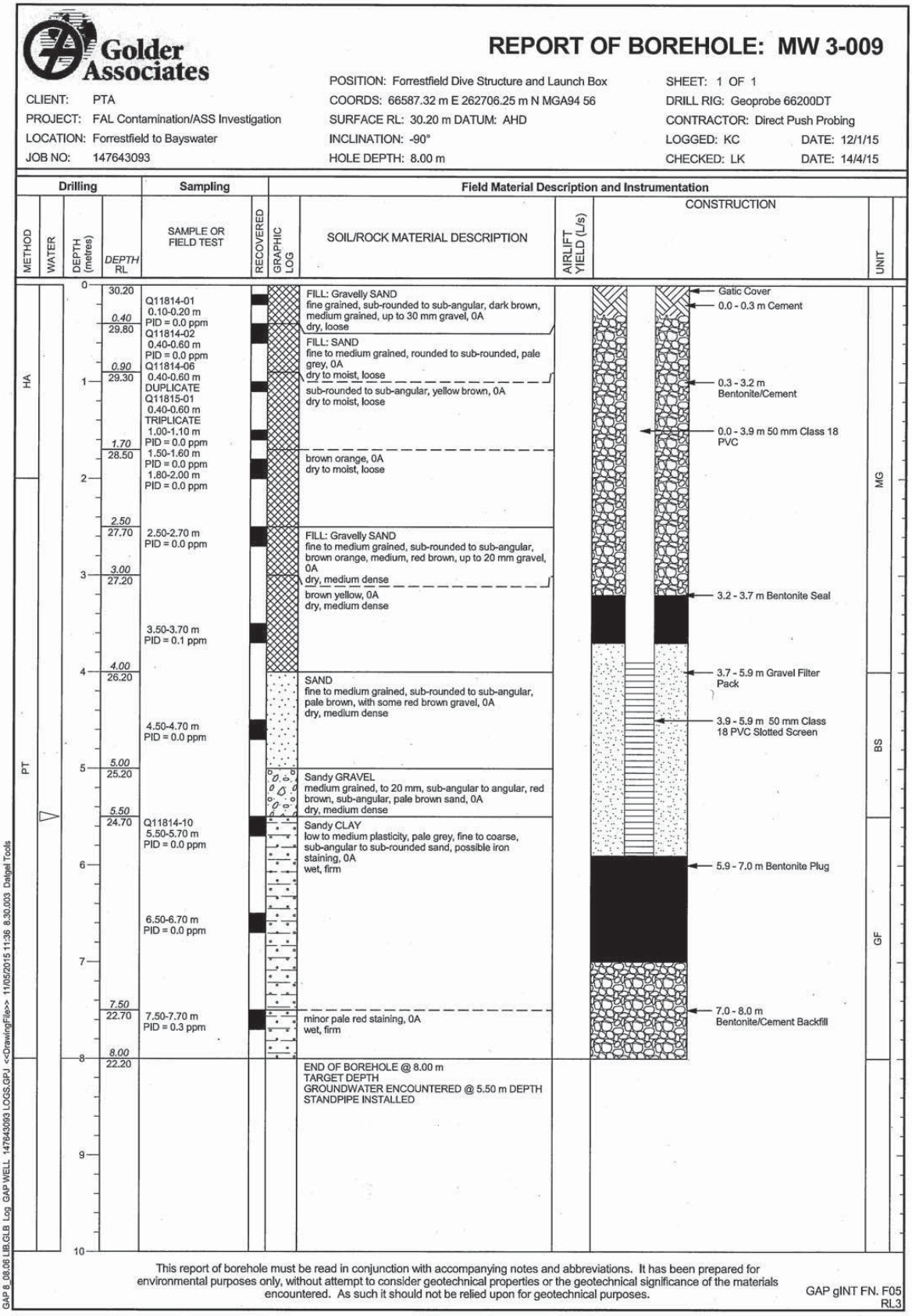
GAP gINT FN. F05 RL3

GAP 8_08.06 LIB.GLB Log GAP WELL 147642129 MASTER.GPJ <<DrawingFile>> 11/05/2015 17:56 8.30.004 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 3-001
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66533.36 m E 262352.94 m N MGA94 56
SURFACE RL: 27.78 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 6.00 m
SHEET: 1 OF 1
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: KC DATE: 9/1/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
MG
BS
GF
27.78
0.20
FILL: TOPSOIL
fine to medium grained, rounded to sub-rounded, dark brown, 0A
dry to moist, loose
Q11812-01
0.10-0.30 m
PID = 0.0 ppm
27.58
Q11812-02
0.50-0.70 m
PID = 0.5 ppm
1.00
FILL: Gravelly SAND
medium grained, rounded to sub-rounded, brown orange to brown, up to 30 mm gravel, trace blue metal and asphalt, 0A
moist, loose
26.78
1.00-1.30 m
PID = 0.9 ppm
1.30
FILL: Sandy GRAVEL
fine to medium grained, to 30 mm, rounded to sub-rounded, brown orange, 0A
dry to moist, very loose
26.48
1.50-1.70 m
PID = 0.5 ppm
1.70
FILL: Gravelly SAND
fine grained, sub-rounded, up to 20 mm gravel, 0A
dry to moist, loose
1.85
2.05
SAND
fine to medium grained, rounded, brown, 0A
dry, loose
25.73
brown orange, 0A
dry to moist, loose
2.40-2.60 m
PID = 0.5 ppm
medium grained, pale brown, 0A
dry, loose
2.85
fine to medium grained, sub-rounded, brown orange, 0A
dry, loose
24.93
medium grained, sub-rounded, orange, 0A
dry, loose
3.60
3.50-3.70 m
PID = 2.7 ppm
24.18
fine grained, rounded, pale grey, 0A
dry to moist, loose
Q11812-07
3.80-4.20 m
PID = 1.7 ppm
Q11812-08
3.80-4.20 m
DUPLICATE
4.50-4.70 m
PID = 1.0 ppm
Clayey SAND
fine to medium grained, rounded to sub-rounded, low plasticity, pale grey, low plasticity clay, rotten egg odour, 0B
moist to wet, medium dense
5.50-5.70 m
PID = 2.2 ppm
5.80-6.00 m
PID = 2.6 ppm
6.00
21.78
END OF BOREHOLE @ 6.00 m
TARGET DEPTH
GROUNDWATER ENCOUNTERED @ 4.00 m DEPTH
STANDPIPE INSTALLED
Gatic Cover
0.0 - 0.3 m Cement
0.3 - 2.3 m Bentonite/Cement
0.0 - 3.0 m 50 mm Class 18 PVC
2.3 - 2.8 m Bentonite Seal
2.8 - 6.0 m Gravel Filter Pack
3.0 - 6.0 m 50 mm Class 18 PVC Slotted Screen
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:36 8.30.003 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 3-004
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66561.46 m E 262578.99 m N MGA94 56
SURFACE RL: 30.00 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 8.00 m
SHEET: 1 OF 1
DRILL RIG: Geoprobe 7822DT
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 16/2/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
30.00 0.20 Q12023-01 0.00-0.20 m PID = 0.0 ppm
SAND fine to medium grained, well graded, rounded to sub-rounded, yellow brown, trace silt, trace coarse grained sand, 0A dry, loose
29.80 0.50 Q12023-02 0.40-0.60 m PID = 0.0 ppm
dark grey, with some silt, with some sub-rounded to sub-angular, up to 30 mm gravel, 0A dry, loose
29.50 1.00 m PID = 0.0 ppm
dark white, 0A dry, loose
1.20 1.30 28.70 1.50
pale yellow, 0A dry, loose
28.50 1.50 m PID = 0.0 ppm
yellow, 0A dry, loose
orange, 0A dry to moist, loose
2.10 2.00 m PID = 0.0 ppm
27.90
Silty SAND fine grained, sub-rounded to sub-angular, mottled brown orange, with some up to 10 mm gravel between 2.8-3.0 m, trace clay, 0A moist, loose to dense
3.00 m PID = 0.0 ppm
4.00 26.00 4.00 m PID = 0.0 ppm
pale grey with mottled orange, increased clay content, 0A moist, dense
4.50 25.50
with some low plasticity clay, 0A moist, dense
5.00 25.00 5.00 m PID = 0.0 ppm
Silty Clayey SAND fine grained, sub-rounded to sub-angular, pale grey, low to medium plasticity clay, 0A moist, firm
6.00 24.00 Q12023-11 6.00-6.20 m PID = 0.0 ppm 6.20 m PID = 0.0 ppm
mottled pale orange, medium plasticity, 0A wet
6.80 23.20
high plasticity, 0A wet, stiff
7.00 m PID = 0.0 ppm
7.20 22.80
some mottled pale red, 0A wet
7.50 22.50
low to medium plasticity, 0A wet
8.00 22.00 8.00 m PID = 0.0 ppm
END OF BOREHOLE @ 8.00 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 6.00 m DEPTH STANDPIPE INSTALLED
Gatic Cover
0.0 - 0.3 m Cement
0.3 - 0.5 m Bentonite Seal
0.0 - 5.0 m 50 mm Class 18 PVC
0.5 - 4.0 m Bentonite/Cement
4.0 - 4.5 m Bentonite Seal
4.5 - 8.0 m Gravel Filter Pack
5.0 - 8.0 m 50 mm Class 18 PVC Slotted Screen
BS
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:36 8.30.003 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 3-009
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66587.32 m E 262706.25 m N MGA94 56
SURFACE RL: 30.20 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 8.00 m
SHEET: 1 OF 1
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: KC DATE: 12/1/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
30.20
0.40
29.80
0.90
29.30
1.70
28.50
2.50
27.70
3.00
27.20
4.00
26.20
5.00
25.20
5.50
24.70
7.50
22.70
8.00
22.20
Q11814-01
0.10-0.20 m
PID = 0.0 ppm
Q11814-02
0.40-0.60 m
PID = 0.0 ppm
Q11814-06
0.40-0.60 m
DUPLICATE
Q11815-01
0.40-0.60 m
TRIPLICATE
1.00-1.10 m
PID = 0.0 ppm
1.50-1.60 m
PID = 0.0 ppm
1.80-2.00 m
PID = 0.0 ppm
2.50-2.70 m
PID = 0.0 ppm
3.50-3.70 m
PID = 0.1 ppm
4.50-4.70 m
PID = 0.0 ppm
Q11814-10
5.50-5.70 m
PID = 0.0 ppm
6.50-6.70 m
PID = 0.0 ppm
7.50-7.70 m
PID = 0.3 ppm
FILL: Gravelly SAND
fine grained, sub-rounded to sub-angular, dark brown, medium grained, up to 30 mm gravel, 0A
dry, loose
FILL: SAND
fine to medium grained, rounded to sub-rounded, pale grey, 0A
dry to moist, loose
sub-rounded to sub-angular, yellow brown, 0A
dry to moist, loose
brown orange, 0A
dry to moist, loose
FILL: Gravelly SAND
fine to medium grained, sub-rounded to sub-angular, brown orange, medium, red brown, up to 20 mm gravel, 0A
dry, medium dense
brown yellow, 0A
dry, medium dense
SAND
fine to medium grained, sub-rounded to sub-angular, pale brown, with some red brown gravel, 0A
dry, medium dense
Sandy GRAVEL
medium grained, to 20 mm, sub-angular to angular, red brown, sub-angular, pale brown sand, 0A
dry, medium dense
Sandy CLAY
low to medium plasticity, pale grey, fine to coarse, sub-angular to sub-rounded sand, possible iron staining, 0A
wet, firm
minor pale red staining, 0A
wet, firm
END OF BOREHOLE @ 8.00 m
TARGET DEPTH
GROUNDWATER ENCOUNTERED @ 5.50 m DEPTH
STANDPIPE INSTALLED
Gatic Cover
0.0 - 0.3 m Cement
0.3 - 3.2 m Bentonite/Cement
0.0 - 3.9 m 50 mm Class 18 PVC
3.2 - 3.7 m Bentonite Seal
3.7 - 5.9 m Gravel Filter Pack
3.9 - 5.9 m 50 mm Class 18 PVC Slotted Screen
5.9 - 7.0 m Bentonite Plug
7.0 - 8.0 m Bentonite/Cement Backfill
MG
BS
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
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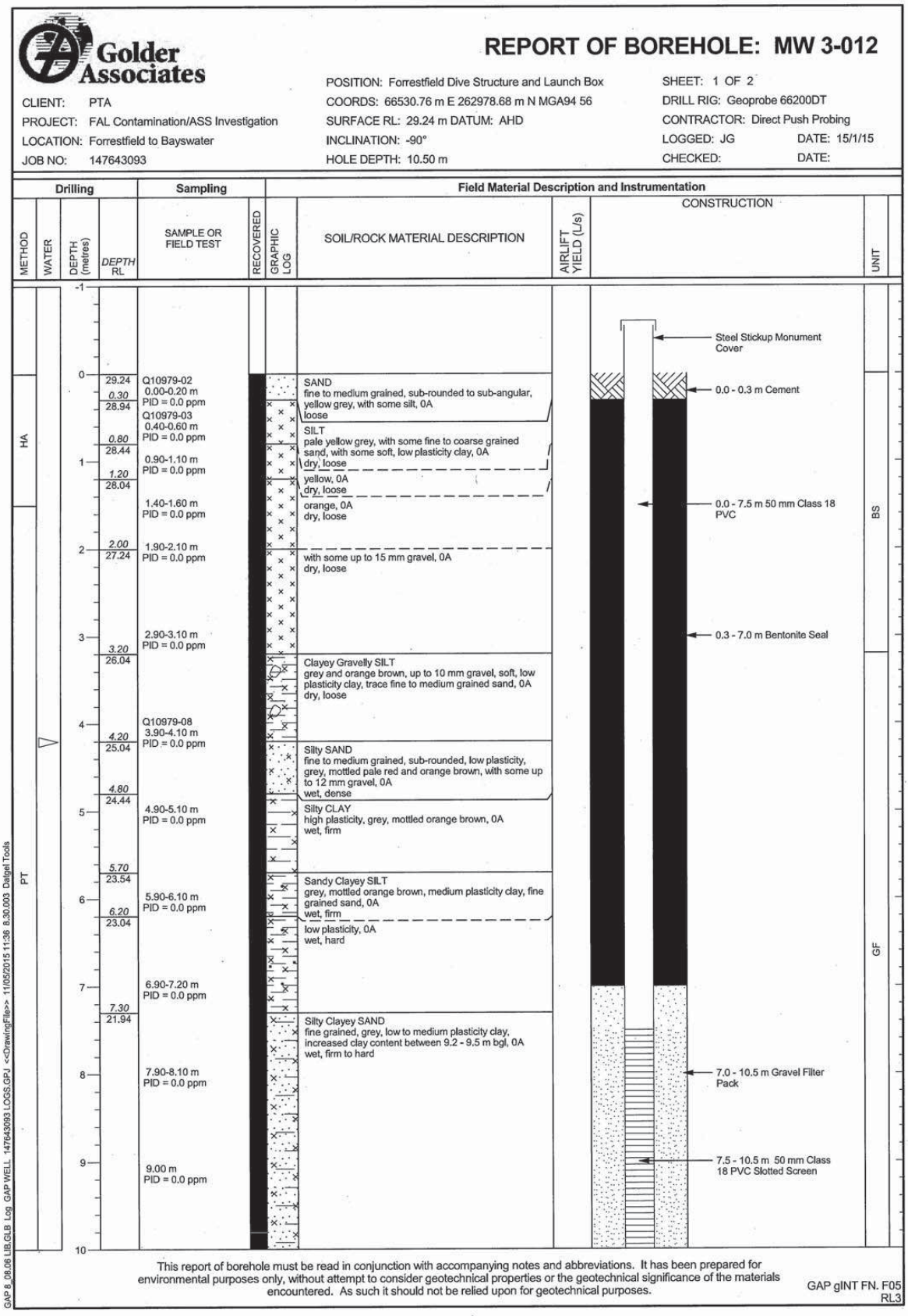

Golder Associates
REPORT OF BOREHOLE: MW 3-012
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66530.76 m E 262978.68 m N MGA94 56
SURFACE RL: 29.24 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 10.50 m
SHEET: 1 OF 2
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 15/1/15
CHECKED: DATE:
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
29.24
0.30
28.94
Q10979-02
0.00-0.20 m
PID = 0.0 ppm
SAND
fine to medium grained, sub-rounded to sub-angular, yellow grey, with some silt, 0A
loose
Q10979-03
0.40-0.60 m
PID = 0.0 ppm
0.80
28.44
SILT
pale yellow grey, with some fine to coarse grained sand, with some soft, low plasticity clay, 0A
dry, loose
0.90-1.10 m
PID = 0.0 ppm
1.20
28.04
yellow, 0A
dry, loose
1.40-1.60 m
PID = 0.0 ppm
orange, 0A
dry, loose
2.00
27.24
1.90-2.10 m
PID = 0.0 ppm
with some up to 15 mm gravel, 0A
dry, loose
2.90-3.10 m
PID = 0.0 ppm
3.20
26.04
Clayey Gravelly SILT
grey and orange brown, up to 10 mm gravel, soft, low plasticity clay, trace fine to medium grained sand, 0A
dry, loose
Q10979-08
3.90-4.10 m
PID = 0.0 ppm
4.20
25.04
Silty SAND
fine to medium grained, sub-rounded, low plasticity, grey, mottled pale red and orange brown, with some up to 12 mm gravel, 0A
wet, dense
4.80
24.44
4.90-5.10 m
PID = 0.0 ppm
Silty CLAY
high plasticity, grey, mottled orange brown, 0A
wet, firm
5.70
23.54
Sandy Clayey SILT
grey, mottled orange brown, medium plasticity clay, fine grained sand, 0A
wet, firm
5.90-6.10 m
PID = 0.0 ppm
6.20
23.04
low plasticity, 0A
wet, hard
6.90-7.20 m
PID = 0.0 ppm
7.30
21.94
Silty Clayey SAND
fine grained, grey, low to medium plasticity clay, increased clay content between 9.2 - 9.5 m bgl, 0A
wet, firm to hard
7.90-8.10 m
PID = 0.0 ppm
9.00 m
PID = 0.0 ppm
Steel Stickup Monument Cover
0.0 - 0.3 m Cement
0.0 - 7.5 m 50 mm Class 18 PVC
0.3 - 7.0 m Bentonite Seal
7.0 - 10.5 m Gravel Filter Pack
7.5 - 10.5 m 50 mm Class 18 PVC Slotted Screen
BS
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:36 8.30.003 Datgel Tools

Golder Associates

REPORT OF BOREHOLE: MW 3-012

CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093

POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66530.76 m E 262978.68 m N MGA94 56
SURFACE RL: 29.24 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 10.50 m

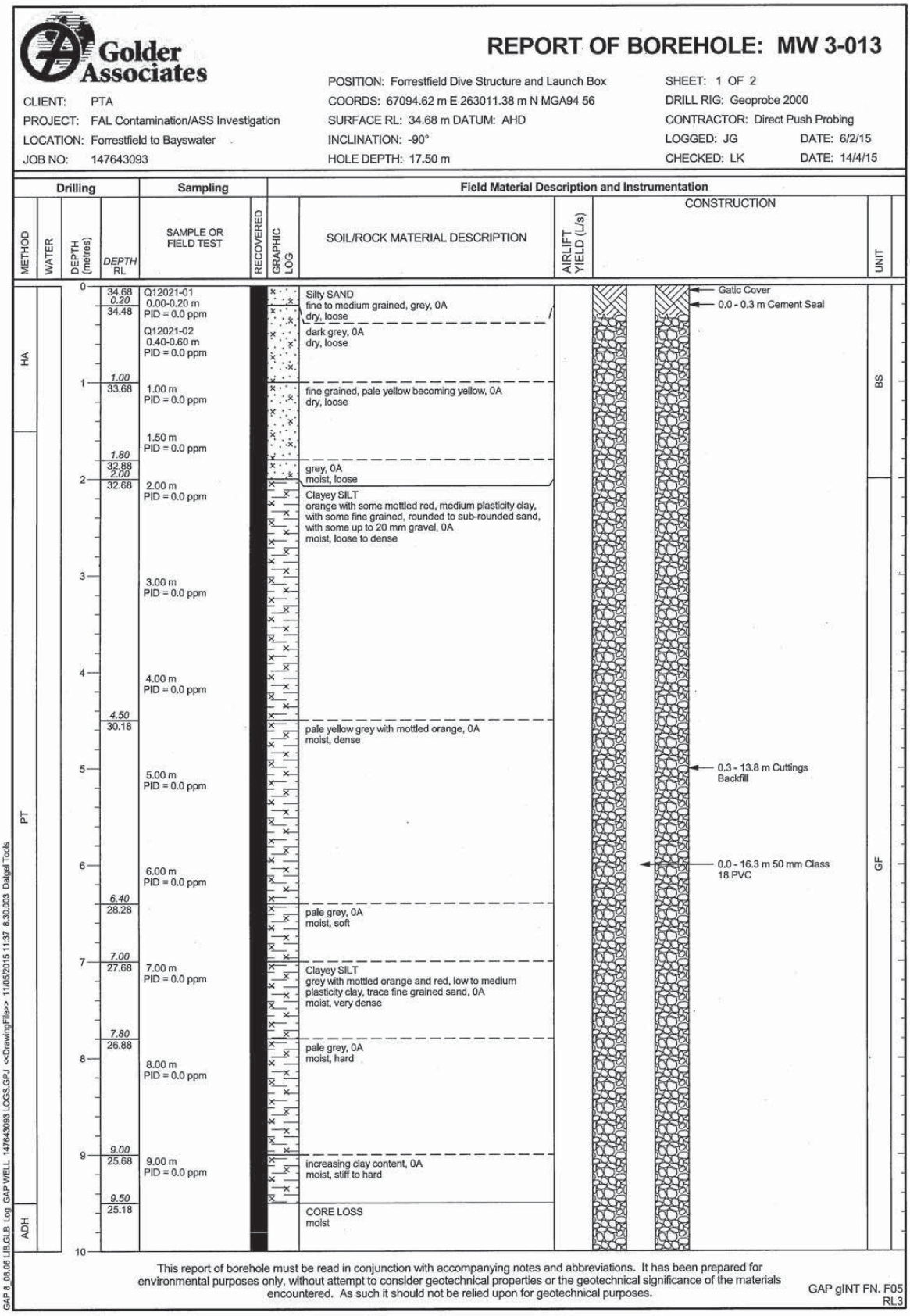
SHEET: 2 OF 2
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 15/1/15
CHECKED: DATE:

Drilling				Sampling		Field Material Description and Instrumentation				
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION	UNIT
PT		10		10.00 m PID = 0.5 ppm						GF
			10.50 18.74				END OF BOREHOLE @ 10.50 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 4.20 m DEPTH STANDPIPE INSTALLED			
		11								
		12								
		13								
		14								
		15								
		16								
		17								
		18								
		19								
		20								
		21								

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

GAP gINT FN. F05 RL3

GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:37 8.30.003 Datgel Tools



Golder Associates

REPORT OF BOREHOLE: MW 3-013

CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093

POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 67094.62 m E 263011.38 m N MGA94 56
SURFACE RL: 34.68 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 17.50 m

SHEET: 1 OF 2
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 6/2/15
CHECKED: LK DATE: 14/4/15

Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION / UNIT
HA		0	34.68	Q12021-01 0.00-0.20 m PID = 0.0 ppm			Silty SAND fine to medium grained, grey, 0A dry, loose		Gatic Cover; 0.0 - 0.3 m Cement Seal; BS
			0.20 34.48	Q12021-02 0.40-0.60 m PID = 0.0 ppm			dark grey, 0A dry, loose		
		1	1.00 33.68	1.00 m PID = 0.0 ppm			fine grained, pale yellow becoming yellow, 0A dry, loose		
				1.50 m PID = 0.0 ppm					
			1.80 32.88				grey, 0A moist, loose		
		2	2.00 32.68	2.00 m PID = 0.0 ppm			Clayey SILT orange with some mottled red, medium plasticity clay, with some fine grained, rounded to sub-rounded sand, with some up to 20 mm gravel, 0A moist, loose to dense		
		3		3.00 m PID = 0.0 ppm					
		4		4.00 m PID = 0.0 ppm					
PT			4.50 30.18				pale yellow grey with mottled orange, 0A moist, dense		0.3 - 13.8 m Cuttings Backfill; GF
		5		5.00 m PID = 0.0 ppm					
		6		6.00 m PID = 0.0 ppm					0.0 - 16.3 m 50 mm Class 18 PVC
			6.40 28.28				pale grey, 0A moist, soft		
		7	7.00 27.68	7.00 m PID = 0.0 ppm			Clayey SILT grey with mottled orange and red, low to medium plasticity clay, trace fine grained sand, 0A moist, very dense		
			7.80 26.88				pale grey, 0A moist, hard		
		8		8.00 m PID = 0.0 ppm					
		9	9.00 25.68	9.00 m PID = 0.0 ppm			increasing clay content, 0A moist, stiff to hard		
ADH			9.50 25.18				CORE LOSS moist		
		10							

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GAP gINT FN. F05 RL3

GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:37 8.30.003 Datgel Tools

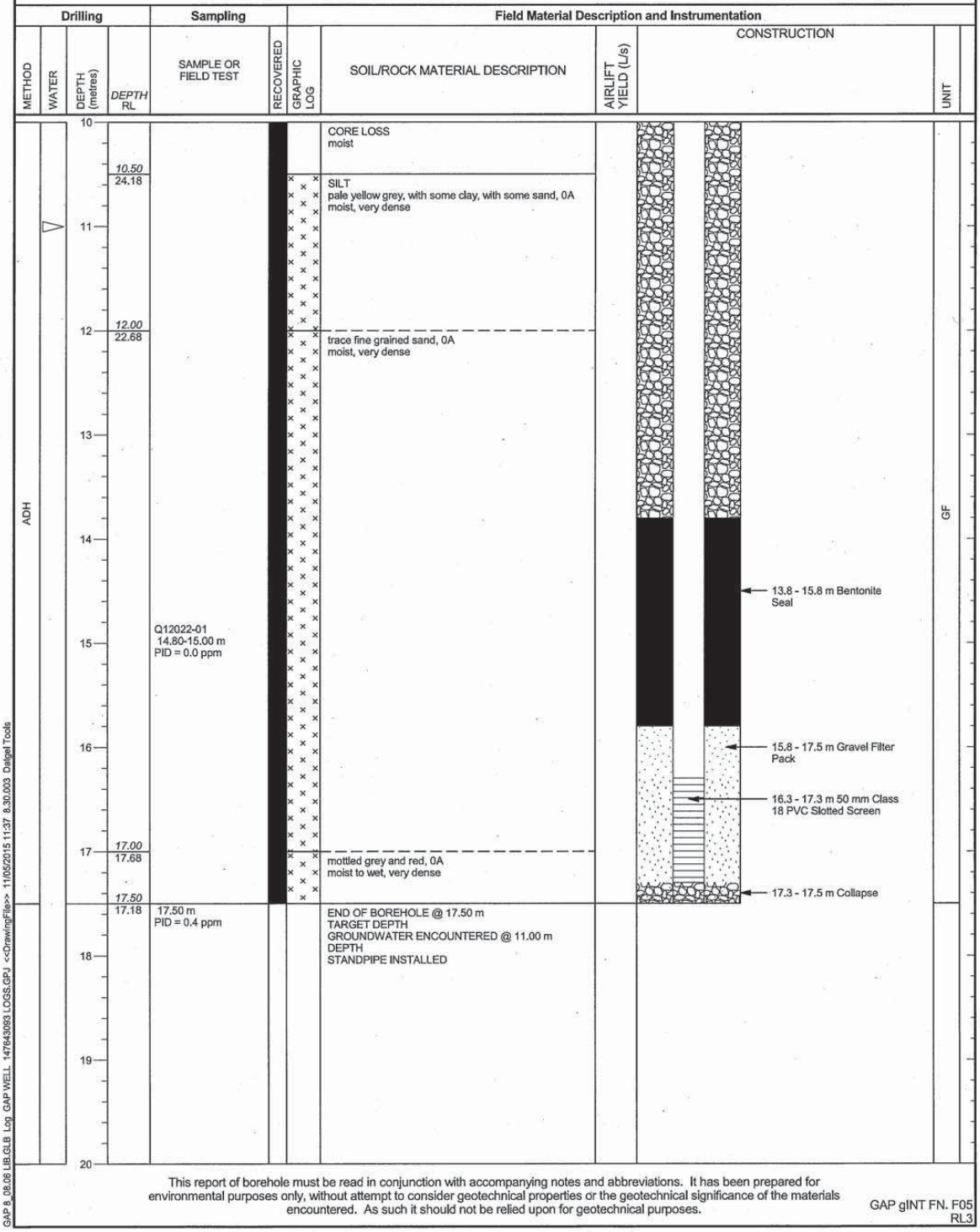
Golder Associates

REPORT OF BOREHOLE: MW 3-013

CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093

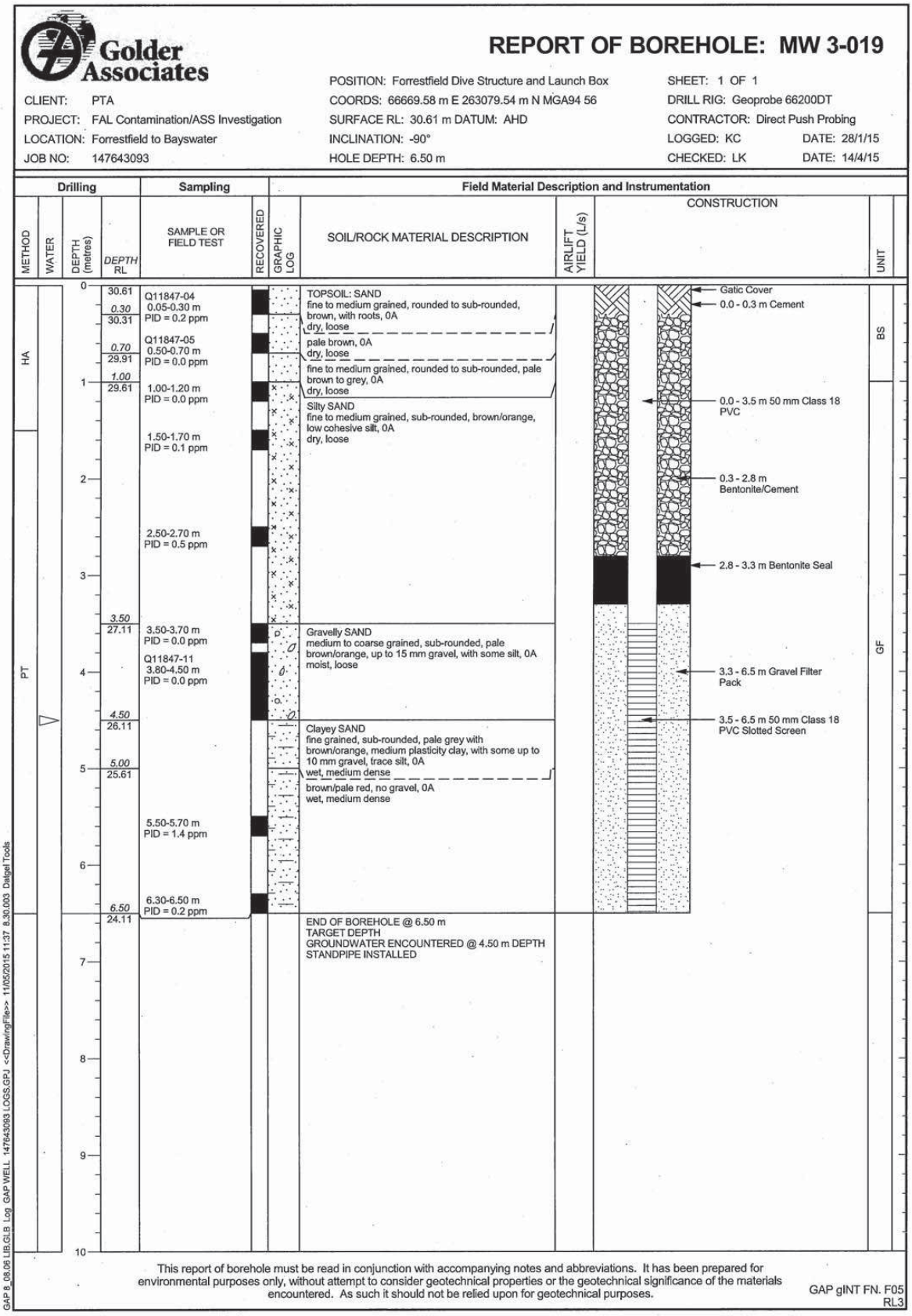
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 67094.62 m E 263011.38 m N MGA94 56
SURFACE RL: 34.68 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 17.50 m

SHEET: 2 OF 2
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 6/2/15
CHECKED: LK DATE: 14/4/15



This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

GAP gINT FN. F05 RL3


Golder Associates
REPORT OF BOREHOLE: MW 3-019
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66669.58 m E 263079.54 m N MGA94 56
SURFACE RL: 30.61 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 6.50 m
SHEET: 1 OF 1
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: KC DATE: 28/1/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
30.61
Q11847-04
0.05-0.30 m
PID = 0.2 ppm
0.30
30.31
Q11847-05
0.50-0.70 m
PID = 0.0 ppm
0.70
29.91
1.00
29.61
1.00-1.20 m
PID = 0.0 ppm
1.50-1.70 m
PID = 0.1 ppm
2.50-2.70 m
PID = 0.5 ppm
3.50
27.11
3.50-3.70 m
PID = 0.0 ppm
Q11847-11
3.80-4.50 m
PID = 0.0 ppm
4.50
26.11
5.00
25.61
5.50-5.70 m
PID = 1.4 ppm
6.30-6.50 m
PID = 0.2 ppm
6.50
24.11
TOPSOIL: SAND
fine to medium grained, rounded to sub-rounded, brown, with roots, 0A
dry, loose
pale brown, 0A
dry, loose
fine to medium grained, rounded to sub-rounded, pale brown to grey, 0A
dry, loose
Silty SAND
fine to medium grained, sub-rounded, brown/orange, low cohesive silt, 0A
dry, loose
Gravelly SAND
medium to coarse grained, sub-rounded, pale brown/orange, up to 15 mm gravel, with some silt, 0A
moist, loose
Clayey SAND
fine grained, sub-rounded, pale grey with brown/orange, medium plasticity clay, with some up to 10 mm gravel, trace silt, 0A
wet, medium dense
brown/pale red, no gravel, 0A
wet, medium dense
END OF BOREHOLE @ 6.50 m
TARGET DEPTH
GROUNDWATER ENCOUNTERED @ 4.50 m DEPTH
STANDPIPE INSTALLED
Gatic Cover
0.0 - 0.3 m Cement
0.0 - 3.5 m 50 mm Class 18 PVC
0.3 - 2.8 m Bentonite/Cement
2.8 - 3.3 m Bentonite Seal
3.3 - 6.5 m Gravel Filter Pack
3.5 - 6.5 m 50 mm Class 18 PVC Slotted Screen
BS
GF
0
1
2
3
4
5
6
7
8
9
10
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
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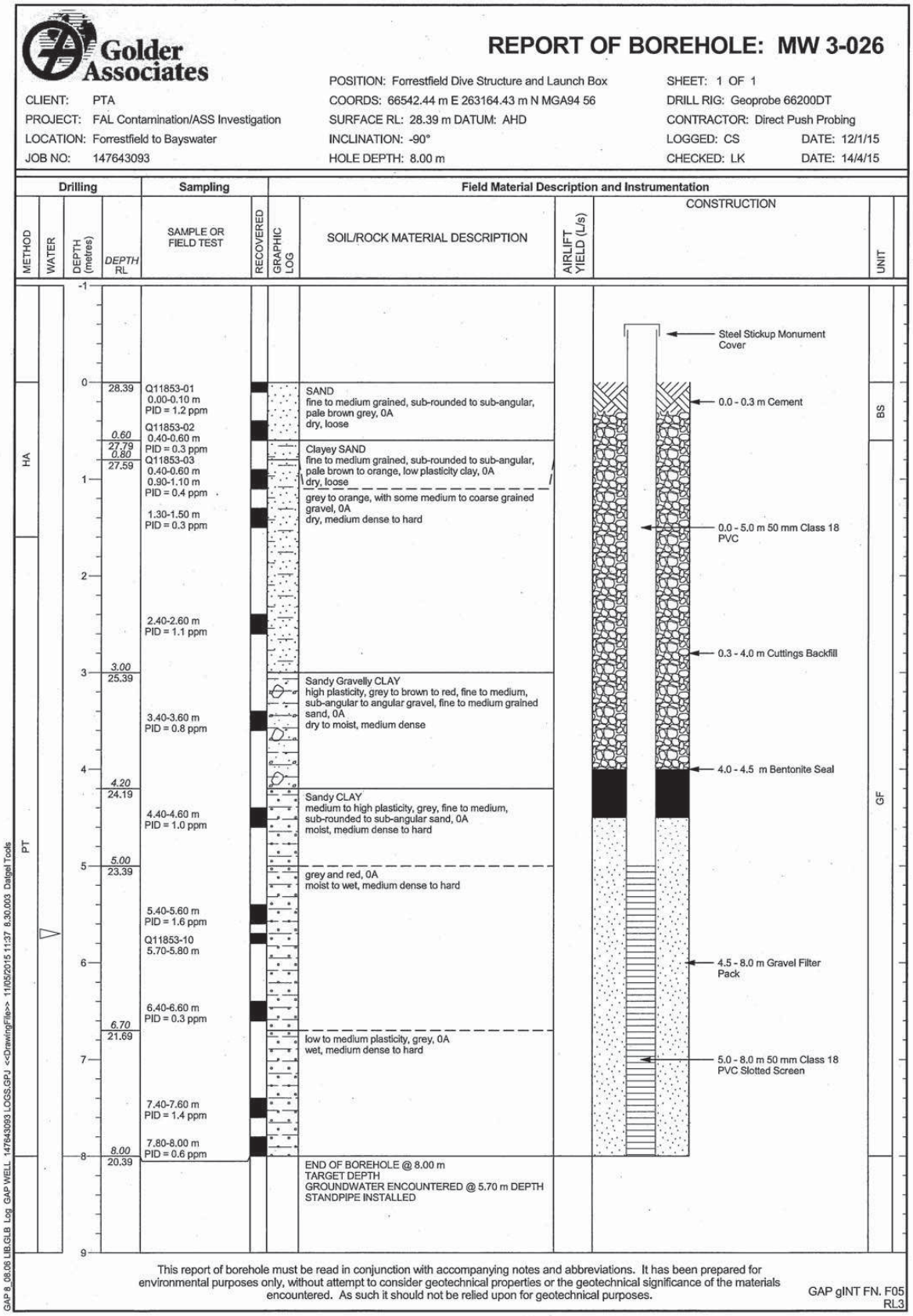
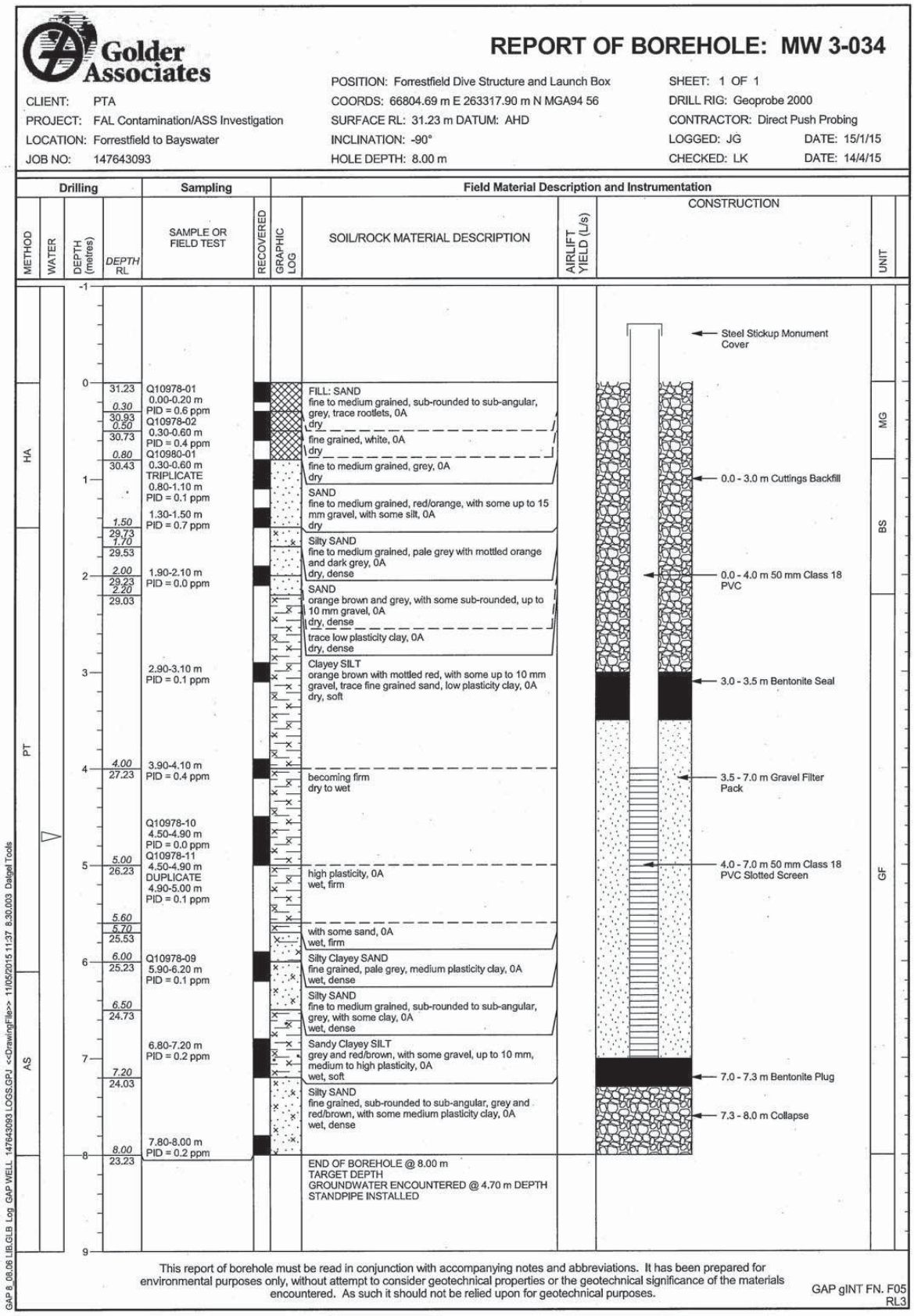

Golder Associates
REPORT OF BOREHOLE: MW 3-026
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66542.44 m E 263164.43 m N MGA94 56
SURFACE RL: 28.39 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 8.00 m
SHEET: 1 OF 1
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: CS DATE: 12/1/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
28.39
0.60
27.79
0.80
27.59
3.00
25.39
4.20
24.19
5.00
23.39
6.70
21.69
8.00
20.39
Q11853-01
0.00-0.10 m
PID = 1.2 ppm
Q11853-02
0.40-0.60 m
PID = 0.3 ppm
Q11853-03
0.40-0.60 m
0.90-1.10 m
PID = 0.4 ppm
1.30-1.50 m
PID = 0.3 ppm
2.40-2.60 m
PID = 1.1 ppm
3.40-3.60 m
PID = 0.8 ppm
4.40-4.60 m
PID = 1.0 ppm
5.40-5.60 m
PID = 1.6 ppm
Q11853-10
5.70-5.80 m
6.40-6.60 m
PID = 0.3 ppm
7.40-7.60 m
PID = 1.4 ppm
7.80-8.00 m
PID = 0.6 ppm
SAND
fine to medium grained, sub-rounded to sub-angular, pale brown grey, 0A
dry, loose
Clayey SAND
fine to medium grained, sub-rounded to sub-angular, pale brown to orange, low plasticity clay, 0A
dry, loose
grey to orange, with some medium to coarse grained gravel, 0A
dry, medium dense to hard
Sandy Gravelly CLAY
high plasticity, grey to brown to red, fine to medium, sub-angular to angular gravel, fine to medium grained sand, 0A
dry to moist, medium dense
Sandy CLAY
medium to high plasticity, grey, fine to medium, sub-rounded to sub-angular sand, 0A
moist, medium dense to hard
grey and red, 0A
moist to wet, medium dense to hard
low to medium plasticity, grey, 0A
wet, medium dense to hard
END OF BOREHOLE @ 8.00 m
TARGET DEPTH
GROUNDWATER ENCOUNTERED @ 5.70 m DEPTH
STANDPIPE INSTALLED
Steel Stickup Monument Cover
0.0 - 0.3 m Cement
0.0 - 5.0 m 50 mm Class 18 PVC
0.3 - 4.0 m Cuttings Backfill
4.0 - 4.5 m Bentonite Seal
4.5 - 8.0 m Gravel Filter Pack
5.0 - 8.0 m 50 mm Class 18 PVC Slotted Screen
BS
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:37 8.30.003 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 3-034
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66804.69 m E 263317.90 m N MGA94 56
SURFACE RL: 31.23 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 8.00 m
SHEET: 1 OF 1
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 15/1/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
AS
MG
BS
GF
31.23
0.00-0.20 m
PID = 0.6 ppm
Q10978-01
0.30
30.93
0.50
30.73
0.30-0.60 m
PID = 0.4 ppm
Q10978-02
0.80
30.43
0.30-0.60 m
TRIPLICATE
Q10980-01
0.80-1.10 m
PID = 0.1 ppm
1.30-1.50 m
PID = 0.7 ppm
1.50
29.73
1.70
29.53
2.00
1.90-2.10 m
PID = 0.0 ppm
29.23
2.20
29.03
2.90-3.10 m
PID = 0.1 ppm
4.00
3.90-4.10 m
PID = 0.4 ppm
27.23
Q10978-10
4.50-4.90 m
PID = 0.0 ppm
Q10978-11
5.00
4.50-4.90 m
DUPLICATE
26.23
4.90-5.00 m
PID = 0.1 ppm
5.60
5.70
25.53
6.00
Q10978-09
25.23
5.90-6.20 m
PID = 0.1 ppm
6.50
24.73
6.80-7.20 m
PID = 0.2 ppm
7.20
24.03
7.80-8.00 m
PID = 0.2 ppm
8.00
23.23
FILL: SAND
fine to medium grained, sub-rounded to sub-angular, grey, trace rootlets, 0A
dry
fine grained, white, 0A
dry
fine to medium grained, grey, 0A
dry
SAND
fine to medium grained, red/orange, with some up to 15 mm gravel, with some silt, 0A
dry
Silty SAND
fine to medium grained, pale grey with mottled orange and dark grey, 0A
dry, dense
SAND
orange brown and grey, with some sub-rounded, up to 10 mm gravel, 0A
dry, dense
trace low plasticity clay, 0A
dry, dense
Clayey SILT
orange brown with mottled red, with some up to 10 mm gravel, trace fine grained sand, low plasticity clay, 0A
dry, soft
becoming firm
dry to wet
high plasticity, 0A
wet, firm
with some sand, 0A
wet, firm
Silty Clayey SAND
fine grained, pale grey, medium plasticity clay, 0A
wet, dense
Silty SAND
fine to medium grained, sub-rounded to sub-angular, grey, with some clay, 0A
wet, dense
Sandy Clayey SILT
grey and red/brown, with some gravel, up to 10 mm, medium to high plasticity, 0A
wet, soft
Silty SAND
fine grained, sub-rounded to sub-angular, grey and red/brown, with some medium plasticity clay, 0A
wet, dense
END OF BOREHOLE @ 8.00 m
TARGET DEPTH
GROUNDWATER ENCOUNTERED @ 4.70 m DEPTH
STANDPIPE INSTALLED
Steel Stickup Monument Cover
0.0 - 3.0 m Cuttings Backfill
0.0 - 4.0 m 50 mm Class 18 PVC
3.0 - 3.5 m Bentonite Seal
3.5 - 7.0 m Gravel Filter Pack
4.0 - 7.0 m 50 mm Class 18 PVC Slotted Screen
7.0 - 7.3 m Bentonite Plug
7.3 - 8.0 m Collapse
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:37 8.30.003 Datgel Tools

REPORT OF BOREHOLE: MW 3-038

Golder Associates

CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093

POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66549.27 m E 263393.16 m N MGA94 56
SURFACE RL: 29.33 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 7.50 m

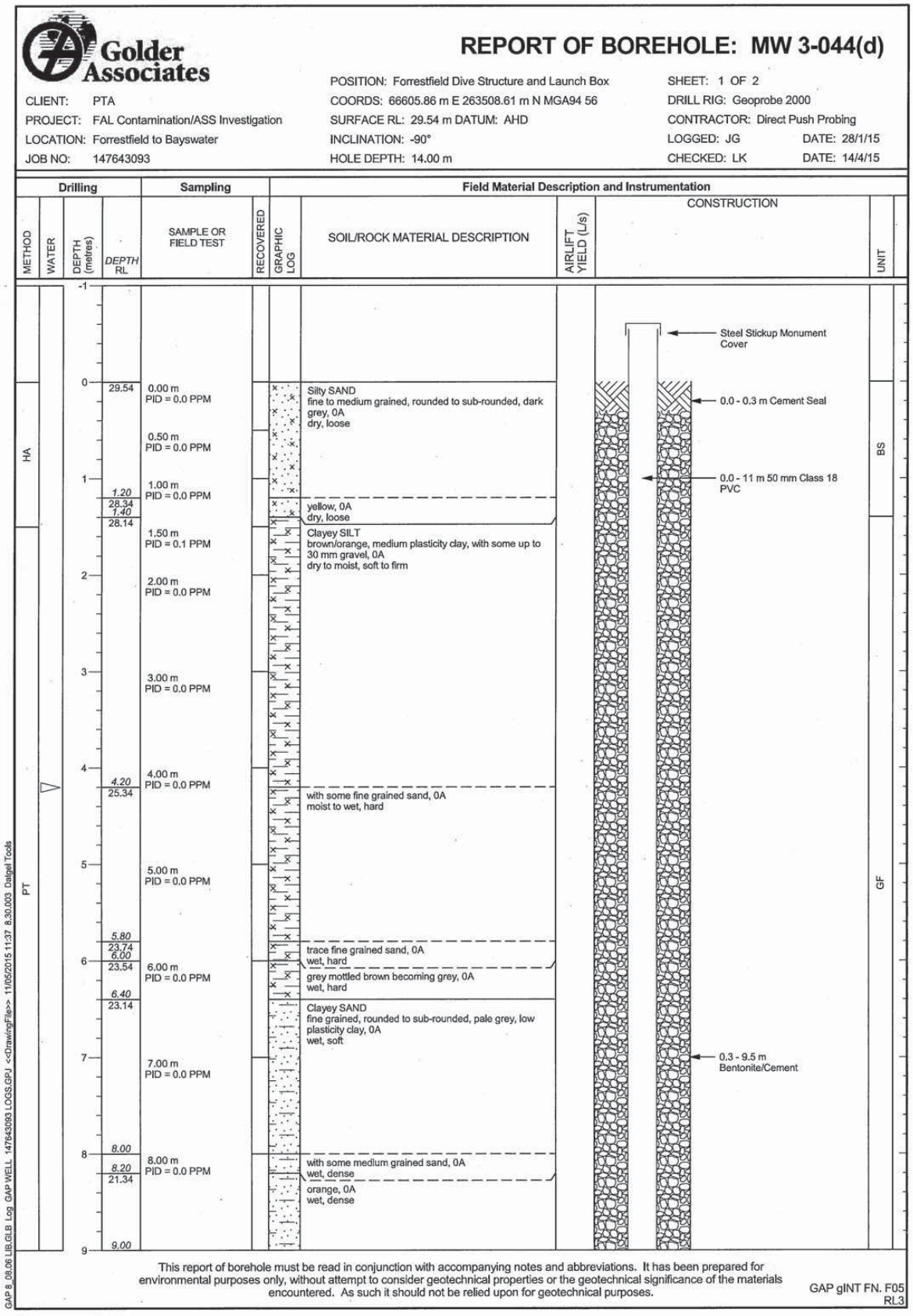
SHEET: 1 OF 1
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: KC DATE: 9/1/15
CHECKED: LK DATE: 14/4/15

Drilling				Sampling		Field Material Description and Instrumentation				
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION	UNIT
HA		0	29.23	Q11813-01 0.10-0.30 m			FILL: SAND fine to medium grained, sub-rounded, grey, organic odour, 0A dry, loose		Steel Stickup Monument Cover; 0.0 - 0.3 m Concrete	MG
			0.40 28.93	Q11813-02 0.50-0.70 m			pale grey, 0A dry, loose			
		1		1.00-1.30 m PID = 1.1 ppm			FILL: Gravelly SAND medium to coarse grained, sub-angular, brown orange, with some coarse grained gravel and cobbles up to 150 mm, 0A dry, loose			
			1.40 1.50 27.83	1.50-1.70 m PID = 0.6 ppm			fine to coarse grained, sub-rounded, dark brown orange, with some coarse grained quartz gravel up to 10 mm, 0A dry, loose		0.0 - 4.5 m 50 mm Class 18 PVC	
PT		2					Sandy CLAY medium plasticity, brown orange mottled with grey, with some medium, sub-angular gravel up to 10 mm, with some fine to medium grained, sub-angular sand, 0A dry, very dense			GF
				2.50-2.70 m PID = 0.4 ppm					0.3 - 3.8 m Cuttings Backfill	
		3		3.50-3.70 m PID = 0.8 ppm					3.8 - 4.3 m Bentonite Seal	
		4	4.50 24.83	4.50-4.70 m PID = 2.1 ppm			low plasticity, pale grey, mottled red to pale red, with some fine to medium grained, sub-rounded sand, trace silt, 0A dry to moist, hard			
		5		5.50-5.70 m PID = 1.4 ppm					4.3 - 7.5 m Gravel Filter Pack	
	▽	6		Q11813-11 6.00-6.30 m						
				6.50-6.70 m PID = 1.7 ppm					4.5 - 7.5 m 50mm Class 18 PVC Slotted Screen	
		7	7.50 21.83	7.30-7.50 m PID = 2.3 ppm						
		8					END OF BOREHOLE @ 7.50 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 6.00 m DEPTH STANDPIPE INSTALLED			
		9								

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

GAP gINT FN. F05 RL3

GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:37 8.30.003 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 3-044(d)
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66605.86 m E 263508.61 m N MGA94 56
SURFACE RL: 29.54 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.00 m
SHEET: 1 OF 2
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 28/1/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
0.00 m PID = 0.0 PPM
0.50 m PID = 0.0 PPM
1.00 m PID = 0.0 PPM
1.50 m PID = 0.1 PPM
2.00 m PID = 0.0 PPM
3.00 m PID = 0.0 PPM
4.00 m PID = 0.0 PPM
5.00 m PID = 0.0 PPM
6.00 m PID = 0.0 PPM
7.00 m PID = 0.0 PPM
8.00 m PID = 0.0 PPM
29.54
1.20
28.34
1.40
28.14
4.20
25.34
5.80
23.74
6.00
23.54
6.40
23.14
8.00
8.20
21.34
9.00
Silty SAND
fine to medium grained, rounded to sub-rounded, dark grey, 0A
dry, loose
yellow, 0A
dry, loose
Clayey SILT
brown/orange, medium plasticity clay, with some up to 30 mm gravel, 0A
dry to moist, soft to firm
with some fine grained sand, 0A
moist to wet, hard
trace fine grained sand, 0A
wet, hard
grey mottled brown becoming grey, 0A
wet, hard
Clayey SAND
fine grained, rounded to sub-rounded, pale grey, low plasticity clay, 0A
wet, soft
with some medium grained sand, 0A
wet, dense
orange, 0A
wet, dense
Steel Stickup Monument Cover
0.0 - 0.3 m Cement Seal
0.0 - 11 m 50 mm Class 18 PVC
0.3 - 9.5 m Bentonite/Cement
BS
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:37 8.30.003 Datgel Tools

Golder Associates

REPORT OF BOREHOLE: MW 3-044(d)

CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093

POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66605.86 m E 263508.61 m N MGA94 56
SURFACE RL: 29.54 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.00 m

SHEET: 2 OF 2
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 28/1/15
CHECKED: LK DATE: 14/4/15

Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION / UNIT
PT		9	20.54	9.00 m PID = 0.1 PPM			with some silt, 0A wet, dense		
			9.40						
			20.14				Clayey SILT pale grey, medium plasticity clay, 0A wet, soft		
		10	10.00						
			19.54	10.00 m PID = 0.0 PPM			Silty SAND fine grained, sub-rounded to sub-angular, pale grey, with some clay, 0A wet, dense		
		11		11.00 m PID = 0.0 PPM					
		12	12.00 17.54	12.00 m PID = 0.0 PPM			Silty Clayey SAND fine grained, sub-rounded to sub-angular, pale grey, low to medium plasticity clay, 0A wet, dense		
		13		13.00 m PID = 0.1 PPM					
		14	14.00 15.54	14.00 m PID = 0.0 PPM			END OF BOREHOLE @ 14.00 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 4.20 m DEPTH STANDPIPE INSTALLED		
		15							
		16							
		17							
		18							
		19							

CONSTRUCTION: 9.5 - 10.5 m Bentonite Seal; 10.5 - 14.0 m Gravel Filter Pack; 11.0 - 14.0 m 50 mm Class 18 PVC Slotted Screen

UNIT: GF

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

GAP gINT FN. F05 RL3

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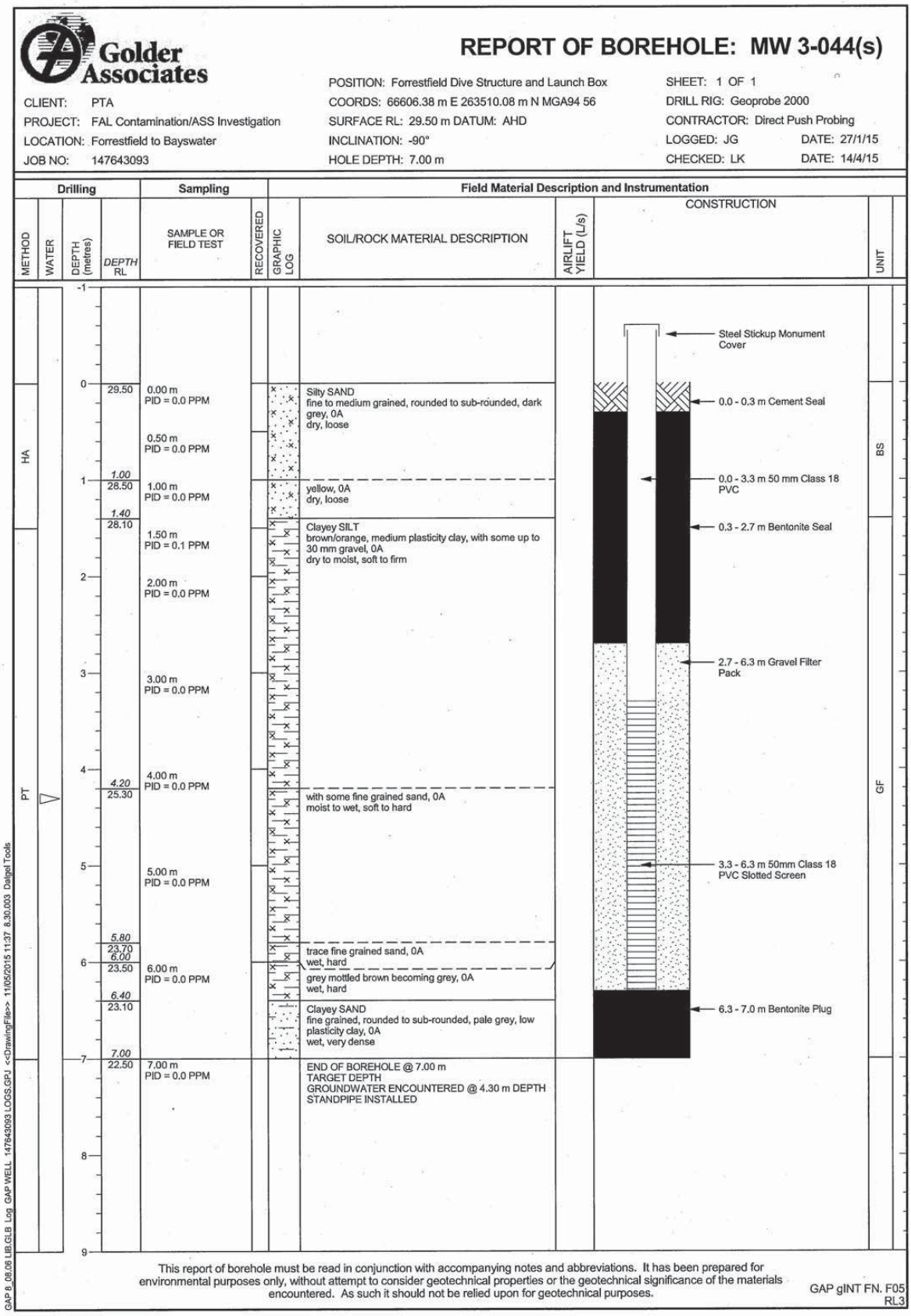
Golder Associates
REPORT OF BOREHOLE: MW 3-044(s)
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66606.38 m E 263510.08 m N MGA94 56
SURFACE RL: 29.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 7.00 m
SHEET: 1 OF 1
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 27/1/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
BS
GF
29.50
0.00 m PID = 0.0 PPM
Silty SAND
fine to medium grained, rounded to sub-rounded, dark grey, 0A
dry, loose
0.50 m PID = 0.0 PPM
1.00
28.50
1.00 m PID = 0.0 PPM
yellow, 0A
dry, loose
1.40
28.10
1.50 m PID = 0.1 PPM
Clayey SILT
brown/orange, medium plasticity clay, with some up to 30 mm gravel, 0A
dry to moist, soft to firm
2.00 m PID = 0.0 PPM
3.00 m PID = 0.0 PPM
4.20
25.30
4.00 m PID = 0.0 PPM
with some fine grained sand, 0A
moist to wet, soft to hard
5.00 m PID = 0.0 PPM
5.80
23.70
6.00
23.50
6.00 m PID = 0.0 PPM
trace fine grained sand, 0A
wet, hard
grey mottled brown becoming grey, 0A
wet, hard
6.40
23.10
Clayey SAND
fine grained, rounded to sub-rounded, pale grey, low plasticity clay, 0A
wet, very dense
7.00
22.50
7.00 m PID = 0.0 PPM
END OF BOREHOLE @ 7.00 m
TARGET DEPTH
GROUNDWATER ENCOUNTERED @ 4.30 m DEPTH
STANDPIPE INSTALLED
Steel Stickup Monument Cover
0.0 - 0.3 m Cement Seal
0.0 - 3.3 m 50 mm Class 18 PVC
0.3 - 2.7 m Bentonite Seal
2.7 - 6.3 m Gravel Filter Pack
3.3 - 6.3 m 50mm Class 18 PVC Slotted Screen
6.3 - 7.0 m Bentonite Plug
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
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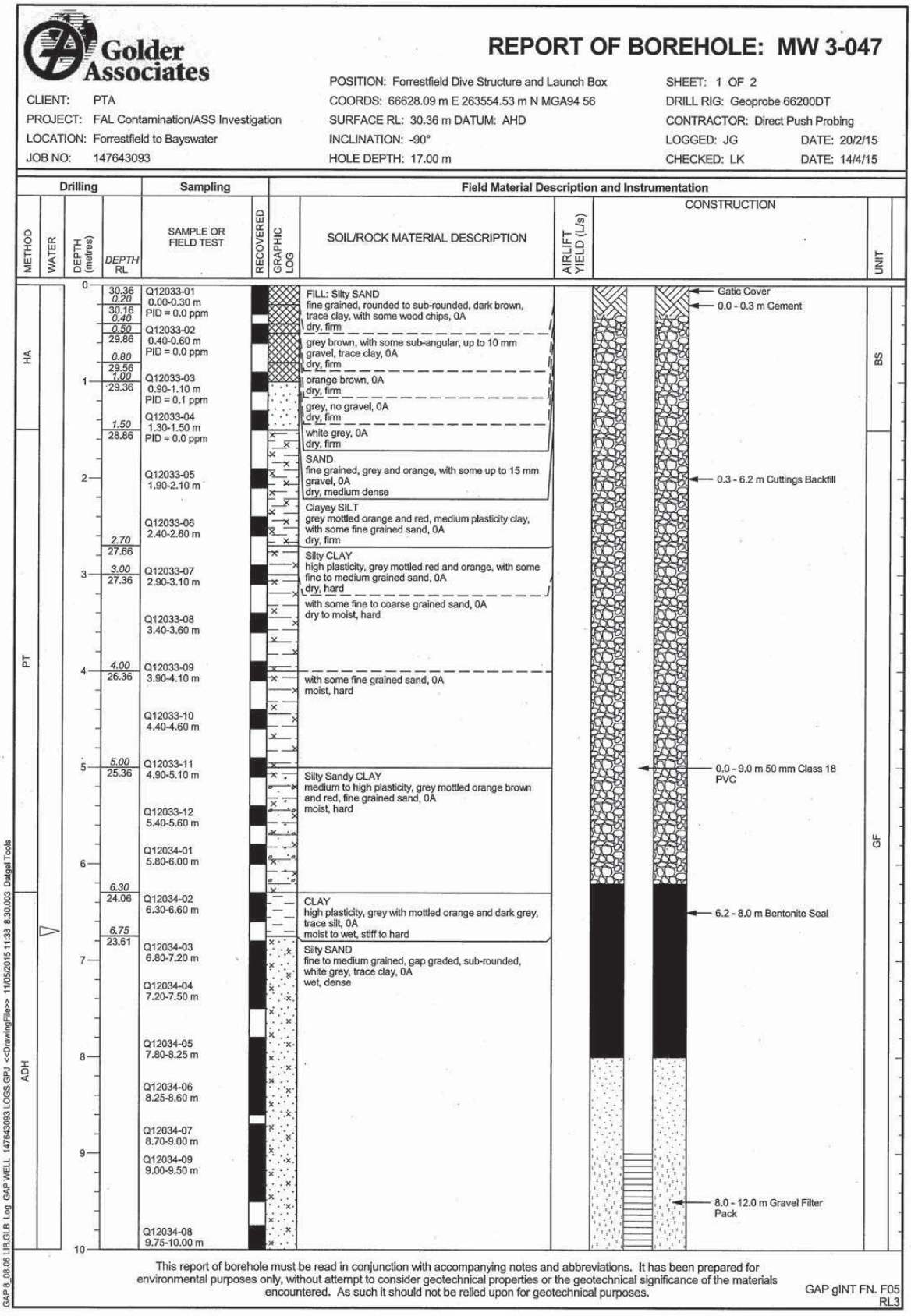
Golder Associates
REPORT OF BOREHOLE: MW 3-047
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66628.09 m E 263554.53 m N MGA94 56
SURFACE RL: 30.36 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 17.00 m
SHEET: 1 OF 2
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 20/2/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
ADH
BS
GF
30.36 Q12033-01 0.00-0.30 m PID = 0.0 ppm
0.20
30.16
0.40
0.50 Q12033-02 0.40-0.60 m PID = 0.0 ppm
29.86
0.80
29.56
1.00 Q12033-03 0.90-1.10 m PID = 0.1 ppm
29.36
Q12033-04 1.30-1.50 m PID = 0.0 ppm
1.50
28.86
Q12033-05 1.90-2.10 m
Q12033-06 2.40-2.60 m
2.70
27.66
3.00 Q12033-07 2.90-3.10 m
27.36
Q12033-08 3.40-3.60 m
4.00 Q12033-09 3.90-4.10 m
26.36
Q12033-10 4.40-4.60 m
5.00 Q12033-11 4.90-5.10 m
25.36
Q12033-12 5.40-5.60 m
Q12034-01 5.80-6.00 m
6.30
24.06 Q12034-02 6.30-6.60 m
6.75
23.61
Q12034-03 6.80-7.20 m
Q12034-04 7.20-7.50 m
Q12034-05 7.80-8.25 m
Q12034-06 8.25-8.60 m
Q12034-07 8.70-9.00 m
Q12034-09 9.00-9.50 m
Q12034-08 9.75-10.00 m
FILL: Silty SAND fine grained, rounded to sub-rounded, dark brown, trace clay, with some wood chips, 0A dry, firm
grey brown, with some sub-angular, up to 10 mm gravel, trace clay, 0A dry, firm
orange brown, 0A dry, firm
grey, no gravel, 0A dry, firm
white grey, 0A dry, firm
SAND fine grained, grey and orange, with some up to 15 mm gravel, 0A dry, medium dense
Clayey SILT grey mottled orange and red, medium plasticity clay, with some fine grained sand, 0A dry, firm
Silty CLAY high plasticity, grey mottled red and orange, with some fine to medium grained sand, 0A dry, hard
with some fine to coarse grained sand, 0A dry to moist, hard
with some fine grained sand, 0A moist, hard
Silty Sandy CLAY medium to high plasticity, grey mottled orange brown and red, fine grained sand, 0A moist, hard
CLAY high plasticity, grey with mottled orange and dark grey, trace silt, 0A moist to wet, stiff to hard
Silty SAND fine to medium grained, gap graded, sub-rounded, white grey, trace clay, 0A wet, dense
Gatic Cover
0.0 - 0.3 m Cement
0.3 - 6.2 m Cuttings Backfill
0.0 - 9.0 m 50 mm Class 18 PVC
6.2 - 8.0 m Bentonite Seal
8.0 - 12.0 m Gravel Filter Pack
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
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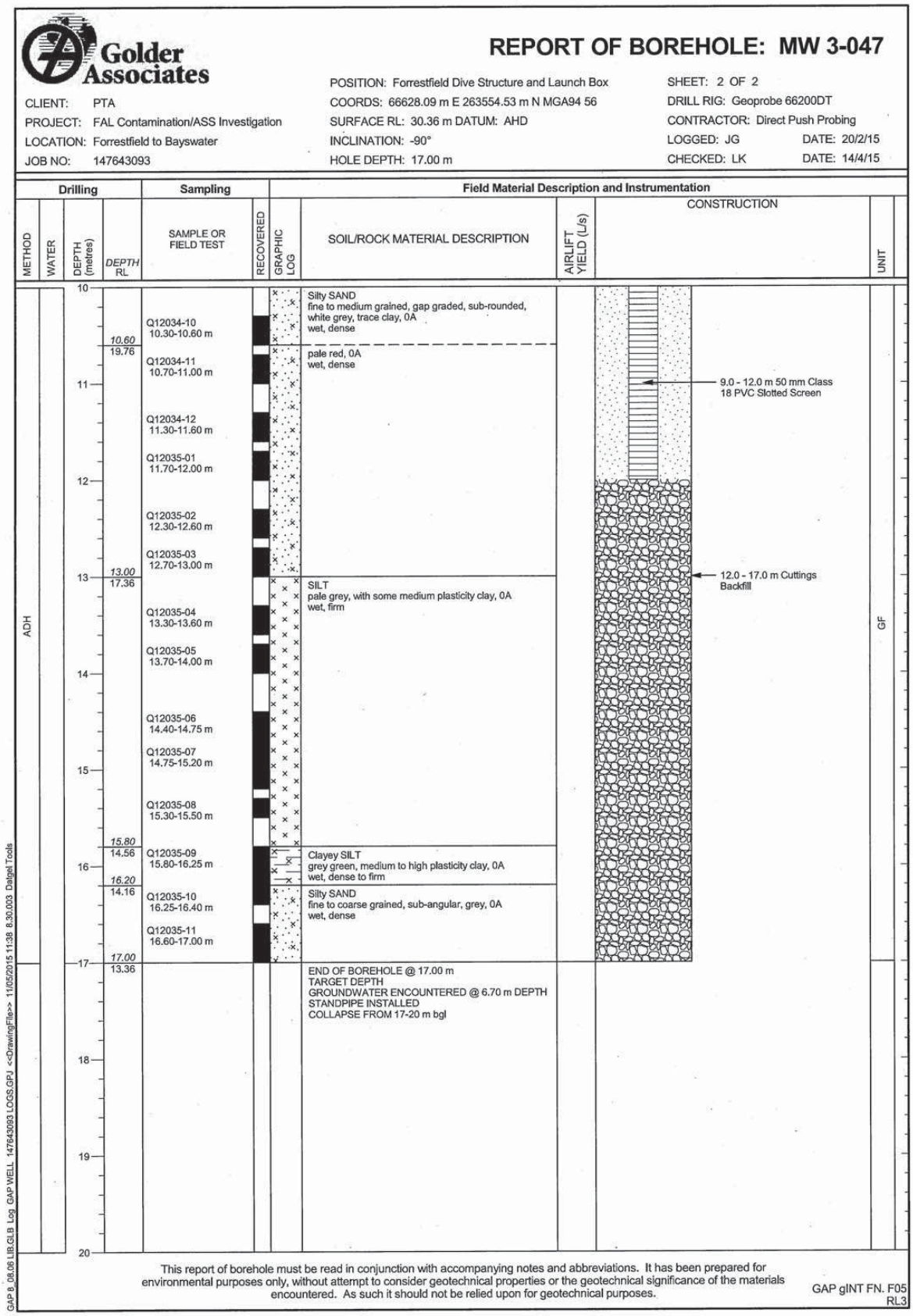

Golder Associates

REPORT OF BOREHOLE: MW 3-047

CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093

POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66628.09 m E 263554.53 m N MGA94 56
SURFACE RL: 30.36 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 17.00 m

SHEET: 2 OF 2
DRILL RIG: Geoprobe 66200DT
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 20/2/15
CHECKED: LK DATE: 14/4/15

Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION / UNIT
ADH		10		Q12034-10 10.30-10.60 m			Silty SAND fine to medium grained, gap graded, sub-rounded, white grey, trace clay, 0A wet, dense		
			10.60 19.76						
				Q12034-11 10.70-11.00 m			pale red, 0A wet, dense		9.0 - 12.0 m 50 mm Class 18 PVC Slotted Screen
		11		Q12034-12 11.30-11.60 m					
				Q12035-01 11.70-12.00 m					
		12		Q12035-02 12.30-12.60 m					
				Q12035-03 12.70-13.00 m					
		13	13.00 17.36				SILT pale grey, with some medium plasticity clay, 0A wet, firm		12.0 - 17.0 m Cuttings Backfill
				Q12035-04 13.30-13.60 m					
				Q12035-05 13.70-14.00 m					
		14		Q12035-06 14.40-14.75 m					
				Q12035-07 14.75-15.20 m					
		15		Q12035-08 15.30-15.50 m					
			15.80 14.56	Q12035-09 15.80-16.25 m			Clayey SILT grey green, medium to high plasticity clay, 0A wet, dense to firm		GF
		16	16.20 14.16	Q12035-10 16.25-16.40 m			Silty SAND fine to coarse grained, sub-angular, grey, 0A wet, dense		
				Q12035-11 16.60-17.00 m					
		17	17.00 13.36				END OF BOREHOLE @ 17.00 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 6.70 m DEPTH STANDPIPE INSTALLED COLLAPSE FROM 17-20 m bgl		
		18							
		19							
		20							

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

GAP gINT FN. F05 RL3

GAP 8_08.06.LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:38 8.30.003 Datgel Tools

Golder Associates

REPORT OF BOREHOLE: MW 3-051(d)

CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093

POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66559.82 m E 263663.84 m N MGA94 56
SURFACE RL: 29.41 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 17.50 m

SHEET: 1 OF 2
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: CS DATE: 9/1/15
CHECKED: LK DATE: 14/4/15

Drilling				Sampling		Field Material Description and Instrumentation				
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION	UNIT
HA		0	29.41	0.00 m PID = 0.4 ppm			Silty SAND fine to medium grained, well graded, sub-angular, brown grey, 0A dry, medium dense		Steel Stickup Monument Cover 0.0 - 0.3 m Cement	BS
			0.60 28.81	0.50 m PID = 0.3 ppm			SAND fine to medium grained, sub-angular, grey becoming pale yellow, with some silt, 0A dry, medium dense			
		1	1.20 28.21	1.00 m PID = 0.4 ppm			Silty SAND fine grained, sub-rounded to sub-angular, pale yellow becoming yellow, 0A dry, medium dense to dense		0.0 - 15.5 m 50 mm Class 18 PVC	
			1.50 27.91	1.50 m PID = 0.0 ppm			orange yellow, with some sub-rounded, up to 10 mm gravel, 0A dry, dense			
			1.80 27.61				Silty Clayey SAND fine grained, pale yellow and orange, low plasticity, hard clay, with some up to 20 mm gravel, 0A dry, dense			
		2	2.40 27.01				Clayey SILT pale yellow grey and orange, medium plasticity, soft clay, 0A moist to wet, very dense			
		3	3.20 26.21				Silty CLAY high plasticity, pale yellow grey mottled orange and red, with some up to 5 mm gravel-sized fragments of hard clay, 0A wet, stiff			
PT		4	4.50 24.91				trace medium to coarse sand, 0A wet, stiff to very stiff		0.3 - 14.0 m Cuttings Backfill	GF
		5								
		6	6.30 23.11				CLAY high plasticity, pale grey yellow, with some silt, trace sub-rounded, fine grained sand, 0A wet, hard			
			6.50 22.91				with some fine to medium grained sand, 0A wet, hard			
		7	7.50 21.91				SAND fine to medium grained, sub-rounded to sub-angular, pale grey, trace silt, 0A wet, loose			
		8	8.30 21.11				trace clay, 0A wet, loose			
			8.60 20.81				mottled red, 0A wet, loose			
		9	9.00							

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GAP gINT FN. F05 RL3

GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:38 8.30.003 Datgel Tools

Golder Associates

REPORT OF BOREHOLE: MW 3-051(d)

CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093

POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66559.82 m E 263663.84 m N MGA94 56
SURFACE RL: 29.41 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 17.50 m

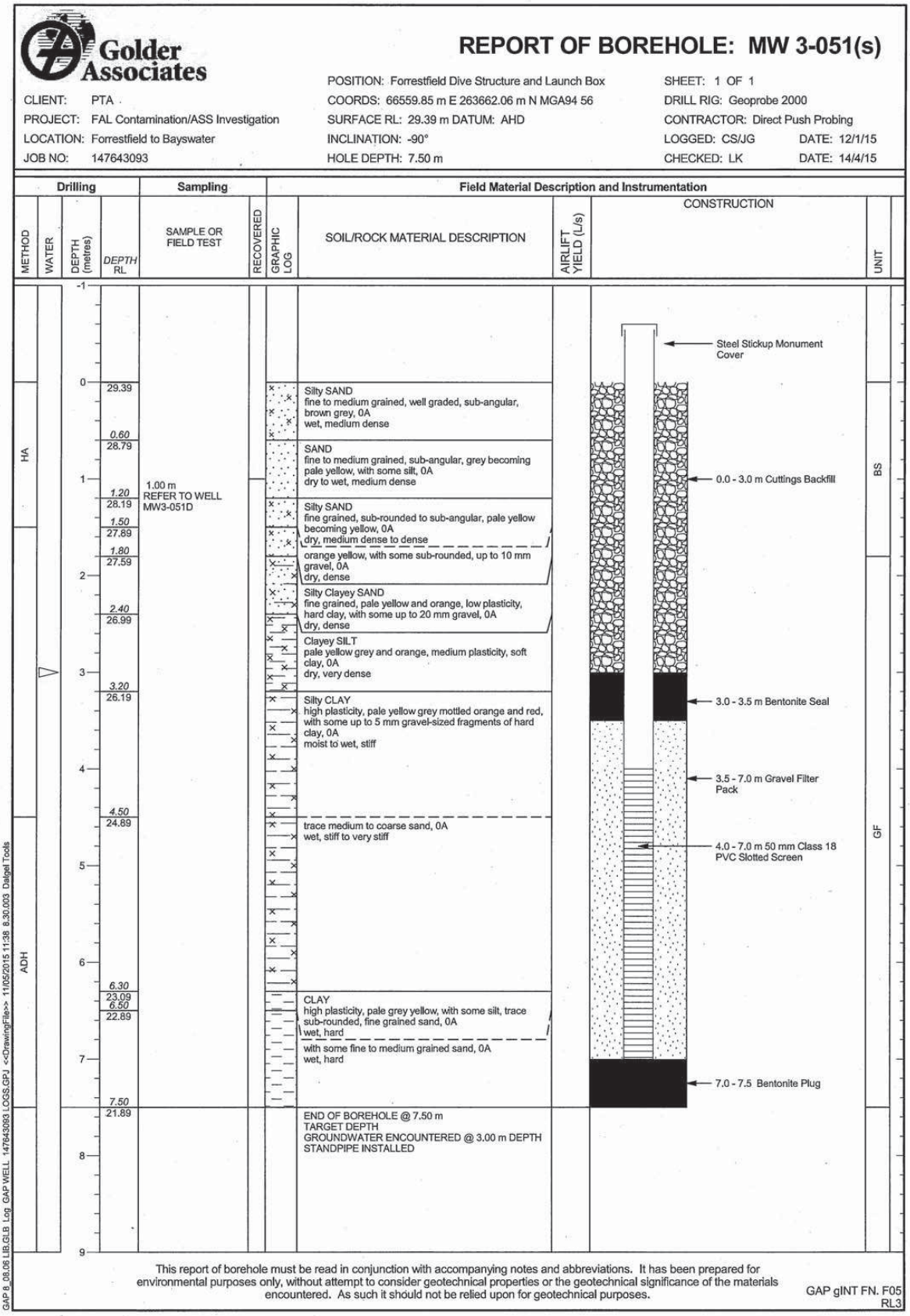
SHEET: 2 OF 2
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: CS DATE: 9/1/15
CHECKED: LK DATE: 14/4/15

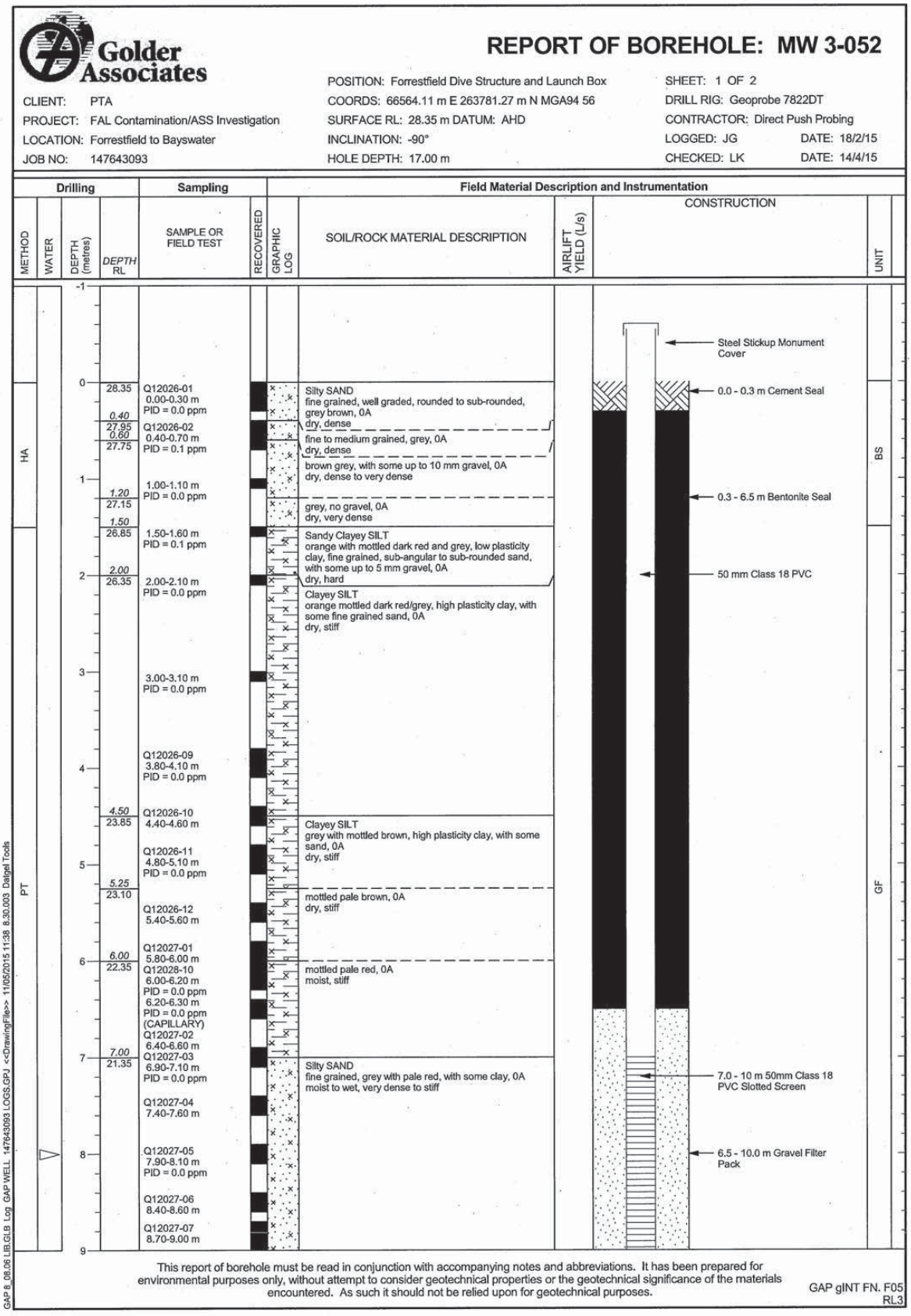
Drilling				Sampling		Field Material Description and Instrumentation			
METHOD	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION	AIRLIFT YIELD (L/s)	CONSTRUCTION / UNIT
PT		9	20.41				trace pale white to grey clay, 0A wet, loose		
		10							
		11	11.30						
			18.11				SILT pale grey, with some hard, low to medium plasticity clay, trace fine grained sand, 0A wet, loose		
		12							
			13.00						
		13	16.41				with some fine grained sand, 0A wet, loose		
		14							14.0 - 15.0 m Bentonite Seal
		15							
			15.40						
			14.01				SILT grey, with some fine grained, sub-rounded to sub-angular sand, 0A wet, loose		15.0 - 17.5 m Gravel Filter Pack
			15.70						
			13.71				SAND fine to medium grained, sub-rounded to angular, grey, with silt, 0A wet, loose		
		16	16.20						
			13.21				trace silt, 0A wet, loose		15.5 - 17.5 m 50 mm Class 18 PVC Slotted Screen
			16.60						
			12.81				CORE LOSS		
			17.00						
		17	12.41				SAND fine to medium grained, sub-rounded to angular, grey, trace silt, 0A wet, loose		
			17.50						
			11.91				END OF BOREHOLE @ 17.50 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 3.00 m DEPTH STANDPIPE INSTALLED		GF
		18							
		19							

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.

GAP gINT FN. F05 RL3

GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:38 8.30.003 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 3-051(s)
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66559.85 m E 263662.06 m N MGA94 56
SURFACE RL: 29.39 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 7.50 m
SHEET: 1 OF 1
DRILL RIG: Geoprobe 2000
CONTRACTOR: Direct Push Probing
LOGGED: CS/JG DATE: 12/1/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
ADH
29.39
0.60
28.79
1.20
28.19
1.50
27.89
1.80
27.59
2.40
26.99
3.20
26.19
4.50
24.89
6.30
23.09
6.50
22.89
7.50
21.89
1.00 m
REFER TO WELL
MW3-051D
Silty SAND
fine to medium grained, well graded, sub-angular,
brown grey, 0A
wet, medium dense
SAND
fine to medium grained, sub-angular, grey becoming
pale yellow, with some silt, 0A
dry to wet, medium dense
Silty SAND
fine grained, sub-rounded to sub-angular, pale yellow
becoming yellow, 0A
dry, medium dense to dense
orange yellow, with some sub-rounded, up to 10 mm
gravel, 0A
dry, dense
Silty Clayey SAND
fine grained, pale yellow and orange, low plasticity,
hard clay, with some up to 20 mm gravel, 0A
dry, dense
Clayey SILT
pale yellow grey and orange, medium plasticity, soft
clay, 0A
dry, very dense
Silty CLAY
high plasticity, pale yellow grey mottled orange and red,
with some up to 5 mm gravel-sized fragments of hard
clay, 0A
moist to wet, stiff
trace medium to coarse sand, 0A
wet, stiff to very stiff
CLAY
high plasticity, pale grey yellow, with some silt, trace
sub-rounded, fine grained sand, 0A
wet, hard
with some fine to medium grained sand, 0A
wet, hard
END OF BOREHOLE @ 7.50 m
TARGET DEPTH
GROUNDWATER ENCOUNTERED @ 3.00 m DEPTH
STANDPIPE INSTALLED
Steel Stickup Monument Cover
0.0 - 3.0 m Cuttings Backfill
3.0 - 3.5 m Bentonite Seal
3.5 - 7.0 m Gravel Filter Pack
4.0 - 7.0 m 50 mm Class 18 PVC Slotted Screen
7.0 - 7.5 Bentonite Plug
BS
GF
This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for environmental purposes only, without attempt to consider geotechnical properties or the geotechnical significance of the materials encountered. As such it should not be relied upon for geotechnical purposes.
GAP gINT FN. F05 RL3
GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:38 8.30.003 Datgel Tools


Golder Associates
REPORT OF BOREHOLE: MW 3-052
CLIENT: PTA
PROJECT: FAL Contamination/ASS Investigation
LOCATION: Forrestfield to Bayswater
JOB NO: 147643093
POSITION: Forrestfield Dive Structure and Launch Box
COORDS: 66564.11 m E 263781.27 m N MGA94 56
SURFACE RL: 28.35 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 17.00 m
SHEET: 1 OF 2
DRILL RIG: Geoprobe 7822DT
CONTRACTOR: Direct Push Probing
LOGGED: JG DATE: 18/2/15
CHECKED: LK DATE: 14/4/15
Drilling
Sampling
Field Material Description and Instrumentation
METHOD
WATER
DEPTH (metres)
DEPTH RL
SAMPLE OR FIELD TEST
RECOVERED
GRAPHIC LOG
SOIL/ROCK MATERIAL DESCRIPTION
AIRLIFT YIELD (L/s)
CONSTRUCTION
UNIT
HA
PT
BS
GF
28.35
0.00-0.30 m
PID = 0.0 ppm
Silty SAND
fine grained, well graded, rounded to sub-rounded, grey brown, 0A
dry, dense
0.40
27.95
Q12026-02
0.40-0.70 m
PID = 0.1 ppm
0.60
27.75
fine to medium grained, grey, 0A
dry, dense
brown grey, with some up to 10 mm gravel, 0A
dry, dense to very dense
1.00-1.10 m
PID = 0.0 ppm
1.20
27.15
grey, no gravel, 0A
dry, very dense
1.50
26.85
1.50-1.60 m
PID = 0.1 ppm
Sandy Clayey SILT
orange with mottled dark red and grey, low plasticity clay, fine grained, sub-angular to sub-rounded sand, with some up to 5 mm gravel, 0A
dry, hard
2.00
26.35
2.00-2.10 m
PID = 0.0 ppm
Clayey SILT
orange mottled dark red/grey, high plasticity clay, with some fine grained sand, 0A
dry, stiff
3.00-3.10 m
PID = 0.0 ppm
Q12026-09
3.80-4.10 m
PID = 0.0 ppm
4.50
23.85
Q12026-10
4.40-4.60 m
Clayey SILT
grey with mottled brown, high plasticity clay, with some sand, 0A
dry, stiff
Q12026-11
4.80-5.10 m
PID = 0.0 ppm
5.25
23.10
mottled pale brown, 0A
dry, stiff
Q12026-12
5.40-5.60 m
Q12027-01
5.80-6.00 m
6.00
22.35
Q12028-10
6.00-6.20 m
PID = 0.0 ppm
mottled pale red, 0A
moist, stiff
6.20-6.30 m
PID = 0.0 ppm
(CAPILLARY)
Q12027-02
6.40-6.60 m
7.00
21.35
Q12027-03
6.90-7.10 m
PID = 0.0 ppm
Silty SAND
fine grained, grey with pale red, with some clay, 0A
moist to wet, very dense to stiff
Q12027-04
7.40-7.60 m
Q12027-05
7.90-8.10 m
PID = 0.0 ppm
Q12027-06
8.40-8.60 m
Q12027-07
8.70-9.00 m
Steel Stickup Monument Cover
0.0 - 0.3 m Cement Seal
0.3 - 6.5 m Bentonite Seal
50 mm Class 18 PVC
7.0 - 10 m 50mm Class 18 PVC Slotted Screen
6.5 - 10.0 m Gravel Filter Pack
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GAP gINT FN. F05 RL3
GAP 8_08.06 LIB.GLB Log GAP WELL 147643093 LOGS.GPJ <<DrawingFile>> 11/05/2015 11:38 8.30.003 Datgel Tools

Appendix 2
Test pit locations and logs

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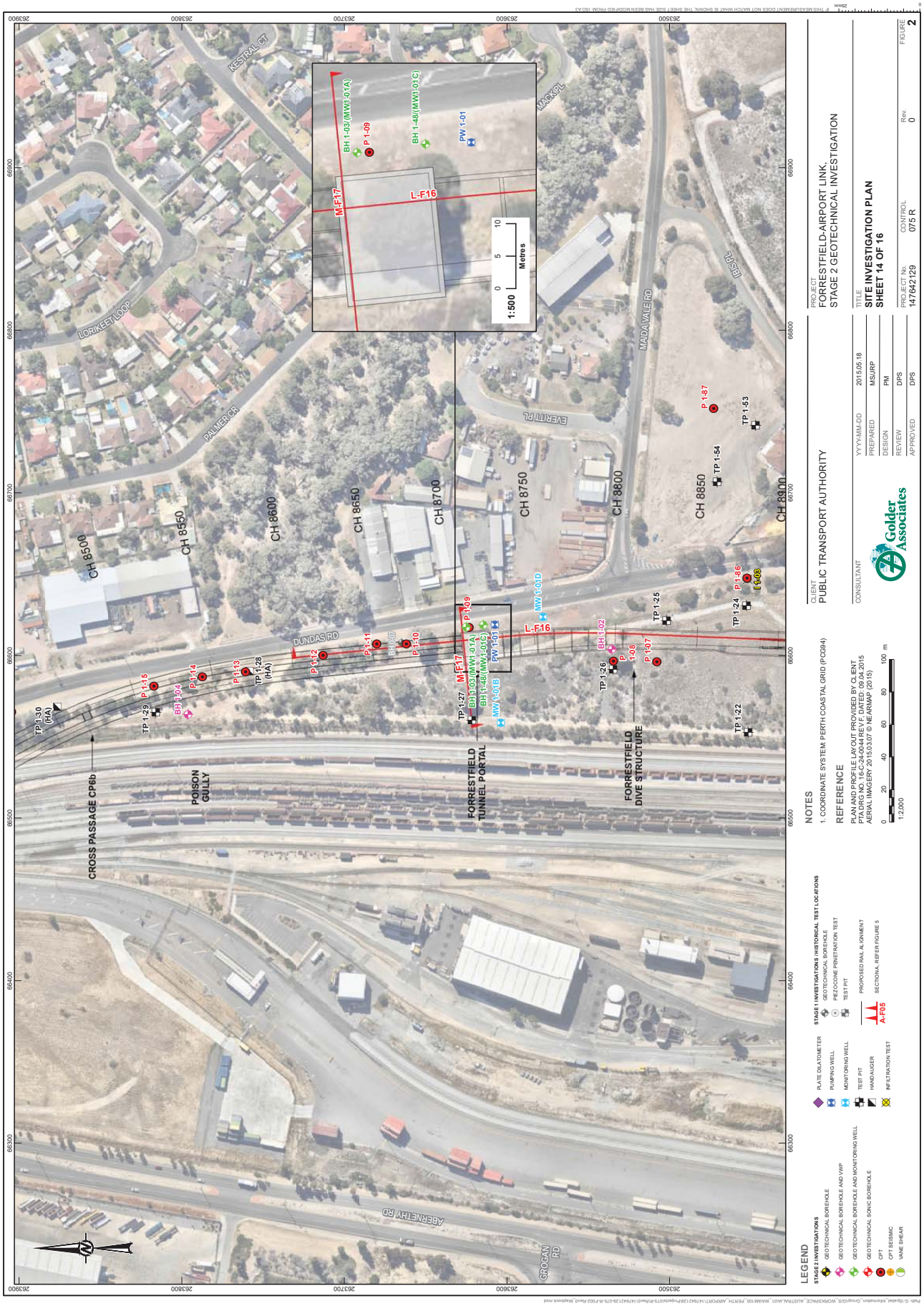
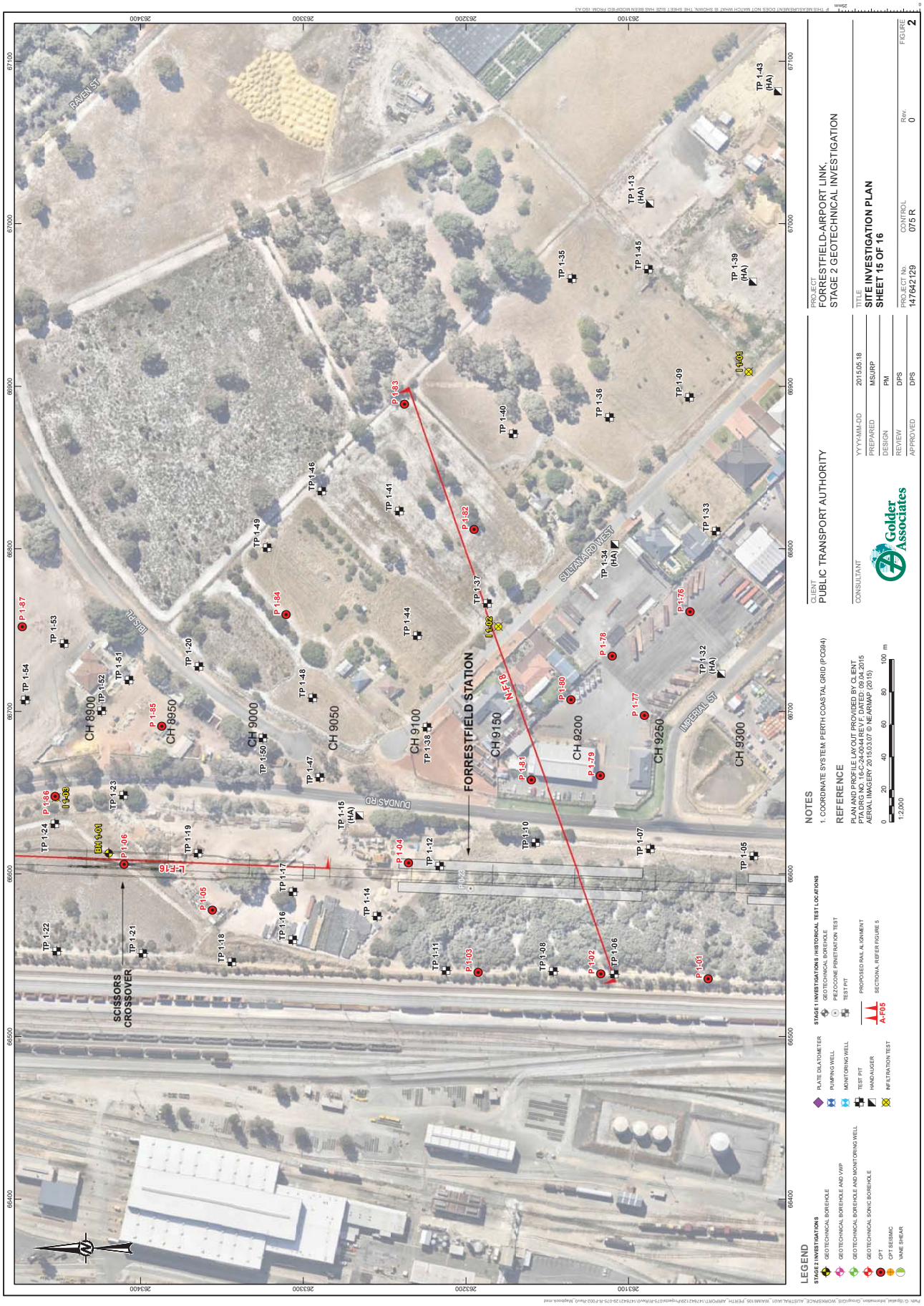

CROSS PASSAGE CP6b
POISON GULLY
FORRESTFIELD TUNNEL PORTAL
FORRESTFIELD DIVE STRUCTURE
DUNDAS RD
ABERNETHY RD
GROGAN RD
MAIDA VALE RD
KESTRAL CT
LORIKEET LOOP
PALMER CR
EVERITT PL
IBIS PL
CH 8500
CH 8550
CH 8600
CH 8650
CH 8700
CH 8750
CH 8800
CH 8850
CH 8900
L-F16
M-F17
1:500
Metres
LEGEND
NOTES
1. COORDINATE SYSTEM: PERTH COASTAL GRID (PCG94)
REFERENCE
PLAN AND PROFILE LAYOUT PROVIDED BY CLIENT
PTA DRG NO. 16-C-24-0044 REV F, DATED: 09.04.2015
AERIAL IMAGERY 2015.03.07 © NEARMAP (2015)
1:2,000
CLIENT
PUBLIC TRANSPORT AUTHORITY
CONSULTANT
Golder Associates
PROJECT
FORRESTFIELD-AIRPORT LINK,
STAGE 2 GEOTECHNICAL INVESTIGATION
TITLE
SITE INVESTIGATION PLAN
SHEET 14 OF 16
PROJECT No. 147642129
CONTROL 075 R
Rev. 0
FIGURE 2


FORRESTFIELD STATION
SCISSORS CROSSOVER
RAVEN ST
DUNDAS RD
SULTANA RD WEST
IMPERIAL ST
CH 8900
CH 8950
CH 9000
CH 9050
CH 9100
CH 9150
CH 9200
CH 9250
CH 9300
LEGEND
NOTES
1. COORDINATE SYSTEM: PERTH COASTAL GRID (PCG94)
REFERENCE
PLAN AND PROFILE LAYOUT PROVIDED BY CLIENT
PTA DRG NO. 16-C-24-0044 REV F, DATED: 09.04.2015
AERIAL IMAGERY: 2015.03.07 © NEARMAP (2015)
CLIENT
PUBLIC TRANSPORT AUTHORITY
CONSULTANT
Golder Associates
PROJECT
FORRESTFIELD-AIRPORT LINK
STAGE 2 GEOTECHNICAL INVESTIGATION
TITLE
SITE INVESTIGATION PLAN
SHEET 15 OF 16
PROJECT No. 147642129
CONTROL 075 R
Rev. 0
FIGURE 2

Golder Associates

REPORT OF TEST PIT: TP 1-20

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

POSITION: Forrestfield Carpark
COORDS: 66727.67 m E 263364.08 m N PCG (dGPS)
SURFACE RL: 30.64 m DATUM: AHD (dGPS)
PIT DEPTH: 2.50 m
BUCKET TYPE: 300 mm toothed

SHEET: 1 OF 1
MACHINE: 4-6t Excavator
CONTRACTOR: Universal Diggers
LOGGED: ALH DATE: 12/12/14
CHECKED: DB DATE: 25/4/15

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	PERTH PENETROMETER TEST (AS1289.6.3.3) Blows per 150 mm 0 5 10 15 20 25	UNIT
BH	L		0.0	30.64				SP	FILL: SAND fine to medium grained, sub-rounded, siliceous, grey-brown, approximately 10-15% non-plastic silt, trace rootlets, trace gravel and brick fragments to fine gravel size		L - MD		SEAT	MG
				0.30 30.34				SP	SAND fine to medium grained, sub-rounded, siliceous, grey, trace silt	D - M	MD			BS
			1.0	1.30 29.34				SP / SC	Interbedded SAND & Clayey SAND fine to medium grained, mottled orange-brown and grey, approximately 15% low plasticity clay, with interfingered pockets of sand up to approximately 40% of volume, with some fine to medium, irregular, weakly to well cemented lateritic gravel	M	MD - St	Material is friable and breaks up during excavation PP = 2-2.5 kg/cm²		
	L-M		2.0		TP 1-20-1 BDS 1.80-2.50 m									GF
			2.5	28.14					TEST PIT DISCONTINUED @ 2.50 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED					
			3.0											
			3.5											

Sketch & Other Observations



This report of test pit must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F03i RL3

GAP 8_09.0 LIB.GLB Log GAP NON-CORED WITH SKETCH 147642129 MASTER.GPJ <<DrawingFile>> 06/05/2015 15:11 8.30.003 Datgel Tools

REPORT OF HAND AUGERED BOREHOLE: TP 1-28 (HA)

Golder Associates

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

POSITION: Bored Tunnels
COORDS: 66590.37 m E 263758.29 m N PCG (dGPS)
SURFACE RL: 29.25 m DATUM: AHD (dGPS)
INCLINATION: -90°
HOLE DEPTH: 2.10 m

SHEET: 1 OF 1
LOGGED: AT DATE: 15/10/14
CHECKED: DB DATE: 25/4/15

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	PERTH PENETROMETER TEST (AS1289.6.3.3) Blows per 150 mm	UNIT
HA	H		0.0	0.10 29.15				SP	TOPSOIL: Gravelly SAND	D				
				0.30 28.95				SP	fine to coarse grained, dark grey, fine to medium grained, rounded to sub-angular gravel				Seat	
			0.5		TP 1-28(HA)-01 DS 0.50-0.70 m				SAND fine to coarse grained, sub-rounded, grey-brown, with some low plasticity clay		VD			BS
				0.90 28.35					dark grey					
	M-H		1.0		TP 1-28(HA)-02 DS 1.10-1.50 m			SC	Clayey SAND fine to medium grained, orange-brown and yellow-brown, low plasticity clay	D - M	D			
				1.50 27.75	TP 1-28(HA)-03 DS 1.50-2.00 m			CL-CI	Sandy CLAY low to medium plasticity, orange-brown and yellow-brown, fine to medium grained sand		H			GF
	H-R		2.0	2.00 27.25					with some fine to medium grained, sub-rounded to rounded gravel				(130 mm)	
				27.15					END OF HAND AUGER @ 2.10 m REFUSAL GROUNDWATER NOT OBSERVED BACKFILLED					
			2.5											
			3.0											
			3.5											

PERTH PENETROMETER TEST (AS1289.6.3.3) Blows per 150 mm: 0 5 10 15 20 25

Sketch & Other Observations



This report of hand augered borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F03h RL3

GAP 8_09.0 LIB.GLB Log GAP NON-CORED WITH SKETCH 147642129 MASTER.GPJ <<DrawingFile>> 06/05/2015 15:13 8.30.003 Datgel Tools

Golder Associates

REPORT OF TEST PIT: TP 1-29

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

POSITION: Bored Tunnels
COORDS: 66565.11 m E 263815.87 m N PCG (dGPS)
SURFACE RL: 29.22 m DATUM: AHD (dGPS)
PIT DEPTH: 2.60 m
BUCKET TYPE: 600 mm Bladed

SHEET: 1 OF 1
MACHINE: 4-6t Excavator
CONTRACTOR: Universal Diggers
LOGGED: AT DATE: 27/10/14
CHECKED: DB DATE: 25/4/15

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	PERTH PENETROMETER TEST (AS1289.6.3.3) Blows per 150 mm 0 5 10 15 20 25	UNIT
EX	H		0.0	0.10 29.12				CL-CI	FILL: Sandy CLAY low to medium plasticity, mottled orange-brown and red-brown, fine to coarse grained sand, with some fine to medium grained gravel	D	H	Inferred road base material.	Seat	
			0.5		TP 1-29-01 BDS 0.50 m			SP	SAND fine to coarse grained, grey, becoming yellow-brown, with some low plasticity fines		MD			BS
	L		1.0	1.30 27.92				GP	Sandy GRAVEL fine to medium grained, sub-rounded, yellow-brown and orange-brown, fine to coarse grained sand	D - M		Clay content increasing with depth		
			1.5	1.60 27.62				SC	Clayey SAND fine to coarse grained, yellow-brown and orange-brown, approximately 20% low plasticity clay, with some fine to medium grained, sub-rounded gravel		VD			GF
			2.0		TP 1-29-02 BDS 1.70 m								27	
			2.5	26.62					TEST PIT DISCONTINUED @ 2.60 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED					
			3.0											
			3.5											

Sketch & Other Observations



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Golder Associates

REPORT OF TEST PIT: TP 1-46

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

POSITION: Forrestfield Carpark
COORDS: 66835.63 m E 263288.46 m N PCG (dGPS)
SURFACE RL: 31.22 m DATUM: AHD (dGPS)
PIT DEPTH: 1.30 m
BUCKET TYPE: 300 mm toothed

SHEET: 1 OF 1
MACHINE: 4-6t Excavator
CONTRACTOR: Universal Diggers
LOGGED: ALH DATE: 2/12/14
CHECKED: DB DATE: 25/4/15

Excavation					Sampling		Field Material Description							
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 150 mm 0 5 10 15 20 25	UNIT
EX	L		0.0	0.10 31.12				SP	TOPSOIL: SAND fine to medium grained, sub-rounded, siliceous, grey, trace silt, trace organics and rootlets	D	L			
				0.30 0.40 30.82	BDS 0.40-0.80 m			SP	SAND fine to medium grained, sub-rounded, siliceous, grey, trace silt, with some roots and rootlets up to 50 mm in diameter		L - MD	50 mm diameter root at 0.2m depth.		BS
			0.5					GC	becoming yellow-white, isolated roots	D - M			HB/50 mm	
	H-R		1.0						Sandy Clayey GRAVEL fine to coarse grained, rounded to sub-rounded, well cemented, lateritic, orange-brown and grey, approximately 15-20% low plasticity clay, fine to coarse grained sand, very weakly to weakly iron cemented mass, with interfingered pockets of grey, very weakly cemented sand		D	Hard excavation, ripping with excavator teeth to penetrate.		GF
	R			29.92					TEST PIT DISCONTINUED @ 1.30 m REFUSAL GROUNDWATER NOT ENCOUNTERED BACKFILLED					
			1.5											
			2.0											
			2.5											
			3.0											
			3.5											

Sketch & Other Observations



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GAP gINT FN. F03i RL3

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Golder Associates

REPORT OF TEST PIT: TP 1-49

CLIENT: Public Transport Authority
PROJECT: Stage 2 GI Forrestfield-Airport Link Project
LOCATION: Bayswater to Forrestfield
JOB NO: 147642129

POSITION: Forrestfield Carpark
COORDS: 66800.91 m E 263322.18 m N PCG (dGPS)
SURFACE RL: 31.11 m DATUM: AHD (dGPS)
PIT DEPTH: 2.40 m
BUCKET TYPE: 300 mm toothed

SHEET: 1 OF 1
MACHINE: 4-6t Excavator
CONTRACTOR: Universal Diggers
LOGGED: ALH DATE: 2/12/14
CHECKED: DB DATE: 25/4/15

Excavation					Sampling		Field Material Description							
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 150 mm 0 5 10 15 20 25	UNIT
EX	L		0.0	31.11				SP	TOPSOIL: SAND fine to medium grained, sub-rounded, siliceous, grey, with some non-plastic silt, trace rootlets and organics	D	L		SEAT	
				0.20										
				30.91	TP 1-49-01 BDS 0.20-0.40 m			SP	SAND fine to medium grained, sub-rounded, siliceous, grey, trace silt	D - M	L - MD			BS
				0.40										
			0.5	30.71	TP 1-49-02 BDS 0.40-0.60 m				white					
				0.70										
	M			30.41				SC	Gravelly Clayey SAND fine to coarse grained, sub-rounded to sub-angular, orange-brown, variable fines content between 20-40% low to medium plasticity clay, fine to medium grained, weakly to well cemented, lateritic gravel			DCP reseated at 1.1 m depth.	SEAT	
			1.0		TP 1-49-03 BDS 1.00-1.50 m									
			1.5							M	MD - D			GF
				1.80										
	M-H			29.31					with some grey mottles, isolated sandy lenses					
			2.0											
			2.5	28.71					TEST PIT DISCONTINUED @ 2.40 m REFUSAL GROUNDWATER NOT ENCOUNTERED BACKFILLED					
			3.0											
			3.5											

Sketch & Other Observations



This report of test pit must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F03i RL3

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element.

Technical Appendix E – Community Infrastructure Strategy

ccs strategic

UPDATED FINAL REPORT

CITY OF KALAMUNDA
FORRESTFIELD NORTH
STRUCTURE PLAN
COMMUNITY INFRASTRUCTURE STRATEGY

For

city of kalamunda

July 2021



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EXECUTIVE SUMMARY

Following the preparation of an initial Community Infrastructure Strategy (CIS) for the Forrestfield North (FFN) area further work was undertaken dealing with population forecasts for the precinct and surrounding catchment areas.

The new population forecasts have revealed both lower build out numbers and a slower rate of development. This will result in lower and later demand for community facilities in the precinct.

From a community infrastructure planning perspective, once the population to be serviced is known, facility needs can be determined. The question is not if, but rather when facilities will be required. Development delays occasioned a slowing economy, failure to secure finance or labour and materials shortages are not unusual and affect the timing of provision. However, the principal determinant of when facilities should be provided is demand driven by population milestones.

When the population to be serviced changes significantly, the number and scale of facilities required needs to be reviewed. In this instance, with an appreciably lower service population now forecast together with other facility planning occurring in the City of Kalamunda, the size and scale of the facilities proposed for Forrestfield North needs to be reviewed.

The community infrastructure needs for Forrestfield North has been reviewed through the same process originally applied with a particular focus on changes to the demographic profile and rate of residential uptake, notwithstanding that a great deal of the demand for the facilities proposed in Forrestfield North will emanate from surrounding areas.

The infrastructure needs have then reviewed in consideration of the agreed vision for the area and a set of guiding principles for facility provision. These have not changed.

The recommended infrastructure development program has been tailored to the available land parcels resulting in three major precincts being identified for development noting that two of these three land parcels have changed. The first is the sporting precinct (SP) associated with the proposed education precinct (EP) offering a local primary school. This area remains unchanged and is large enough to provide for a district level sport and recreation precinct provided that the POS allocation within the primary school site is amalgamated with the POS allocation for active playing fields. Refer Figure 10.

The second is a future community hub site (CH). Elements originally identified as required in this location included a library and community meeting and function facilities. In the intervening period the City of Kalamunda has also considered aquatic facility provision and together with a fitness centre these elements are now also considered key components of a future community hub. As the diversity of the hub has grown and its location moved into the transit oriented development (TOD) precinct there has also been consideration of including additional facilities such as childcare, serviced offices, arts and cultural facilities and a council service desk. Refer Figure 14. The City has consequently identified early provision of the community hub as a significant attractor to stimulate development and service the broader foothills community.

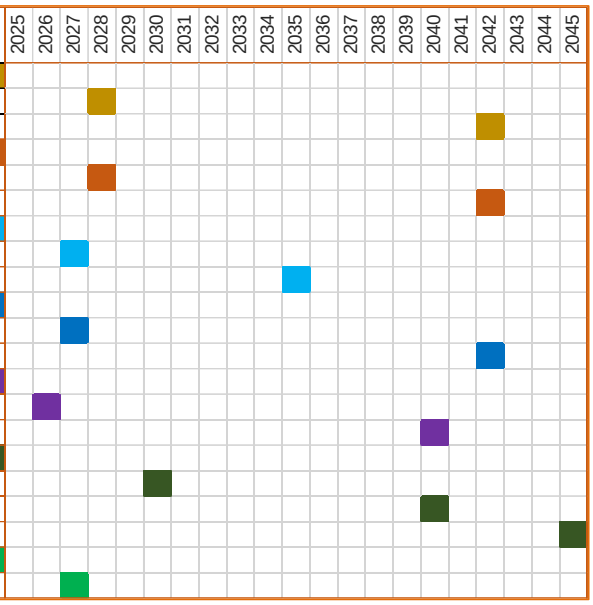
The third land parcel considered in the original CIS was a strategically situated Town Park offering civic and social amenity in a landscaped setting. The Town Park was to accommodate the proposed community hub. With the relocation of the community hub into the TOD precinct, the civic and social amenities are now to be removed from the Town Park and incorporated into the community hub.

The schedule of amenities identified through the revised needs analysis process and a forecast staged approach to development has been prepared based on the revised forecast land release and population growth projections.

It is noted however that the City proposes to pursue funding opportunities with a view to bringing the development of the community hub on much sooner than dictated solely by population milestones. If successful the implementation timeline may alter significantly.

Timing for development of the primary school will be determined by the Education Department and is not anticipated to occur before 2040.

Implementation summary	Year
Community Centre	
Stage 1 - 940m^2	2028
Stage 2 - 560m^2	2042
Branch library	
Stage 1 - 1200m^2	2028
Stage 2 - 1600m^2	2042
Aquatic centre	
Stage 1 - Indoor pools	2027
Stage 2 - Outdoor pool and slides	2035
Fitness centre	
Stage 1 - 700m^2	2027
Stage 2 - 500m^2	2042
Childcare centre	
Stage 1 - 60 places	2026
Stage 2 - 40 places	2040
Sports precinct	
Stage 1 - Playing field & changerooms	2030
Stage 2 - Clubhouse	2040
Stage 3 - School oval	2045
Town Park	
Stage 1 - Parkland	2027



The cost of implementation of this program is summarised in the table below.

	Element	Current Cost June 2021
	Community Hub	
1.1	Child Care Centre - Stage 1	$ 1,136,125
1.2	Child Care Centre - Stage 2	$ 693,875
2.1	Branch Library - Stage 1	$ 1,631,750
2.2	Branch Library - Stage 2	$ 8,240,887
3.1	Community Centre - Stage 1	$ 6,687,055
3.2	Community Centre - Stage 2	$ 2,729,750
4.1	Aquatic Centre - Indoor Pools - Stage 1	$ 13,914,118
4.2	Aquatic Centre - Outdoor Pool & Slides - Stage 2	$ 7,734,495
5.1	Fitness Centre - Stage 1	$ 4,058,788
5.2	Fitness Centre - Stage 2	$ 1,962,675
6.1	Carpark - Stage 1	$ 1,091,550
6.2	Carpark - Stage 2	$ 420,375
7.1	External Works - Stage 1	$ 1,153,549
7.2	External Works - Stage 2	$ 32,811
8.1	External Services - Stage 1	$ 676,875
8.2	External Services - Stage 2	$ 49,875
	Total	$ 52,214,551

	Sports Precinct	
9.1	Stage 1 - Playing fields and Changerooms	$ 3,977,556
9.2	Stage 2 - Clubhouse	$ 2,225,327
9.3	Stage 3 - School Oval	$ 1,409,904
	Total	$ 7,612,787
	Town Park	
10.1	Stage 1 - Parkland	$ 3,563,676
	Total	$ 3,563,676
11.0	**TOTAL CONSTRUCTION COST**	**$ 65,976,677**
13.0	**ESCALATION**	
	Current Total Construction Cost	$ 65,976,677
13.1	Total Escalation to 2045	**$ 28,640,387**
13.0	**ESTIMATED TOTAL COMMITMENT**	**$ 94,617,064**

The table below summarises shows the anticipated developer contribution for community infrastructure development. Further detail is provided in section 14.

Developer contributions % of development cost	FFN TOD precinct contribution at build-out	FFN Residential precinct contribution at build-out
Community Centre	3.0%	13.3%
Branch library	2.5%	11.1%
Aquatic centre	2.0%	9.0%
Fitness centre	2.7%	11.8%
Childcare centre	3.6%	15.9%
Sports precinct	5.2%	22.8%
Town Park	10.1%	44.8%

1. INTRODUCTION

This report outlines the community infrastructure requirements for Forrestfield North based on updated population projections released in 2021.

Alignment with the district structure plan and community facility guidelines has been retained. The capacity and provision of community infrastructure in surrounding areas has also been reviewed, noting that the City of Kalamunda has initiated a series of parallel studies addressing library and aquatic and recreation centre provision within the context of a broader Community Facilities Plan.

It is noted that since the original Community Infrastructure Strategy (CIS) was prepared, the principal community purposes site within the structure plan area has been relocated from within the residential precinct to the transit oriented development (TOD) precinct.

This update adopts the proposed community purpose site location opposite the train station as the location for the community hub (CH), removing these elements from the landscaped parklands (Town Park) component of the original CIS.

As before, the actual detail of each type of facility development may vary as the community establishes and the people who take up residence in the area have an opportunity to be involved in the design development process.

The requirements outlined in this report will provide the community with an adequate and flexible suite of community facilities. The approach taken here is to identify those services that are likely to be required and provide opportunities for those services to be efficiently delivered.

2. DEMOGRAPHIC ANALYSIS

2.1. Catchment Population

The original projections forecast a build-out population of 14,450 in Forrestfield North and over 75,000 in the broader catchment area by 2041.

	2016	2021	2026	2031	2036	2041
Forrestfield North	397	896	3,393	5,890	10,170	14,450
High Wycombe	13,039	13,595	13,884	14,069	14,311	14,500
Forrestfield	13,646	14,842	15,912	16,653	17,218	17,500
Maida Vale	4,948	5,437	5,965	8,079	10,658	14,100
Wattle Grove	6,185	7,476	8,099	9,717	11,947	15,018
Total	**38,215**	**42,247**	**47,253**	**54,408**	**64,304**	**75,568**

Table 1: Original Population Forecasts (AEC September 2017)

Revised population forecasts in Table 2 show slightly less than 55,000 residents in the catchment area by 2041 and a revised build-out figure of around 61,000 by 2050. This is a reduction in total catchment of 20%.

This assessment includes infill development in Forrestfield, High Wycombe and Maida Vale plus new land releases identified for The Hales, Cell 9 and Wattle Grove South, plus a distinction between the residential and TOD precincts in Forrestfield North.

Locality	2021	2031	2041	2050
	Forecast id	Based on Yields Analysis	Based on Yields Analysis	Based on Yields Analysis
Forrestfield North				
TOD precinct		151	1,359	1,359
Residential precinct		850	3,948	5,998
Total	896	1,001	5,307	7,357
High Wycombe				
Infill @	2.6 per dwelling	668	1,277	1,825
75% of infill		501	957	1,369
Total	11,935	12,436	12,892	13,304
Forrestfield				
Hales		650	650	650
Infill @	2.6 per dwelling	772	1,474	2,103
Total	13,931	15,353	16,055	16,684
Maida Vale				
MV South		2,124	4,954	7,077
Infill @	2.6 per dwelling	668	1,277	1,825
25% of infill		167	19	456
Total	4,650	6,941	9,923	12,183
Wattle Grove				
Cell 9		972	972	972
WG South		1,063	2,481	3,544
Total	6,236	8,271	9,689	10,752
Total Foothills	**37,648**	**44,002**	**53,867**	**60,281**
Total City of Kalamunda^	**60,558^**	**66,565^**	**71,407^**	**75,695***

Table 2: Revised Population Forecasts
(Urbis, DevelopmentWA, City of Kalamunda April 2021 and Forecast.id^)

Assumptions:

1. Build out has been extended from 2041 to 2050
2. Total City Population growth^ from 2041 to 2050 is estimated at 0.65% annually*
3. Development projections have been based on the medium yield build out scenario
4. Population density has been based on 2.6 person per household

For community infrastructure planning, the long-term build-out figure of 60,000 residents in the foothill's catchment (by 2050) has been applied in lieu of the previously forecast 75,000.

In terms of the immediate catchment within Forrestfield North, an estimated build out population of 7,357 has been applied through to 2050. This is less than half of the original estimate of 15,000 by 2041.

2.2. Catchment areas

Figure 1 shows 1km, 2km, 3km and 5km radius catchment circles from the new High Wycombe train station. The proposed residential precinct for Forrestfield North falls within a 1.75km radius before the geographical barrier of Roe Highway.

The approved local structure plan for the residential precinct includes a flyover of Roe Highway connecting to Ravenswood Road on the east (refer the red double headed arrow). This will open access to and from areas on the east of Roe Highway, which at this stage are predominantly large rural residential lots which have been identified as urban expansion under the Western Australian Planning Commission (WAPC) North-East Sub-Regional Structure Plan. To the west there are airport and freight rail facilities within which there are no readily accessible community facilities, nor residents to be serviced in Forrestfield North.

The 3km radius is just short of the Roe Highway/Tonkin Highway interchange to the south and to the north extends to Adelaide Street, just short of the Great Eastern Highway Bypass. The 5km radius cuts into Cell 9 in Wattle Grove.

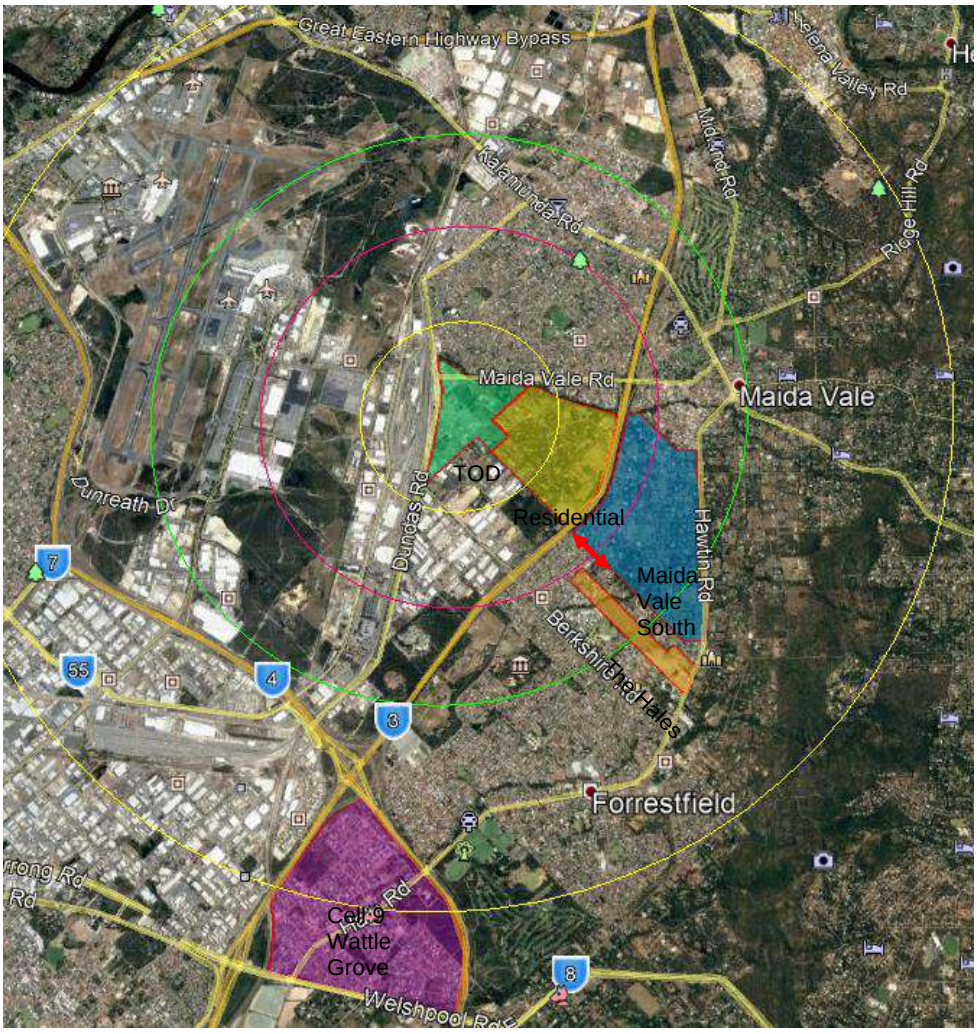


Figure 1: Catchment radii (1km, 2km, 3km and 5km) around the local structure plan area

From a community facility planning perspective, local level facilities will be required to fall within the boundaries of the rail line to the west, Roe Highway to the east, Tonkin Highway to the south and Kalamunda Road to the north.

Given the nature of the zoning in the surrounding areas, existing local facilities of interest will be restricted to provision within High Wycombe to the north.

The catchment for district level facilities, nominally within a 5km radium will extend beyond the immediate geographical barriers and beyond Maida Vale and Forrestfield with some consideration of access to facilities in Wattle Grove.

The catchment for regional level facilities will extend east and up the hill to Gooseberry Hill and Kalamunda, but more likely to south and west to Kenwick, Beckenham and Queens Park and north to Hazelmere, Guildford and Midland. The new Forrestfield Airport Link train line will also allow foothills residents easier access to facilities in Bayswater.

It is noted that there is very limited unconstrained land within the Forrestfield North area for community infrastructure purposes, and specifically sports space allocations, other than the old Brand Road landfill site. Should this area be set aside as a sports space it will require extensive rehabilitation. Dependent on site layout the area could offer local and potentially district level accommodation if the open space component of the proposed primary school land allocation is adjacent to and connected to the sports space.

The landfill site is the subject of detailed investigations to determine its suitability and rehabilitation requirements for this purpose.

Provision for regional standard community infrastructure will require a focus outside the Forrestfield North area.

2.3. Social characteristics

The population of the foothills area has a significantly different social profile to the hills area[1]. This is characterised by:

- Higher density development - 11.78 persons per hectare in High Wycombe compared to 6.59 in Kalamunda
- A greater level of disadvantage - SEIFA index in the 50th percentile for the foothills compared to in the 90th percentile for the hills
- A significantly younger population in the foothills than in the hills, particularly in the younger workforce aged 25-34
- JobSeeker support measured in April 2021 was much higher in the foothills than in the hills - High Wycombe 7.2% compared to just 4.9% in Kalamunda, Maida Vale and Gooseberry Hill

These differences are anticipated to perpetuate and potentially further diverge as the rate of population growth in the foothills continues to outstrip the hills.

[11] https://profile.id.com.au/kalamunda/annual-migration-by-location?WebID=130

3. LITERATURE REVIEW

3.1. Forrestfield North District Structure Plan

The District Structure Plan offers high-level strategic planning guidance on future land use, employment, broad density direction and the coordination and provision of major infrastructure. This includes:

- Location of high schools;
- District water management requirements;
- Movement networks;
- Coordination of infrastructure provisions;
- Location and distribution of regional open space;
- Land use buffers;
- Environmental assets; and
- Activity centres.

It is noted that there is a requirement to ensure the protection of the existing ecological assets in the area, including Poison Gully Creek (a designated nature space), whilst providing opportunities for sports space, recreation space[2] and other community facilities for the future local population.

District Structure Plan Summary Table:		Structure Plan Ref (section no.)
Item	Data	
Total area covered by structure plan	264.1 hectares	3.1
Area of each land use proposed: • Residential • Commercial • Industrial • Rural Residential	 • 100.6 hectares • 27.6 ha ('Activity Centre' & 'Mixed Use' areas) • 74.7 hectares • N/A	5.2 and 5.3
Total estimated lot yield	Estimated lot yield to be determined at local structure planning stage	N/A
Estimated number of dwellings	4,250 - 5,250	5.3, 6.1, 6.2 and 6.3
Estimated residential site density	33.2 - 40.1 dwellings per hectare, inclusive of 'Residential', 'Activity Centre' and 'Mixed Use' areas	5.2 and 5.3
Estimated population	9,350 - 11,550 (@2.2 persons per household)	5.3, 6.1, 6.2 and 6.3
Number of high schools	Nil	5.5.3

[2] DSR POS Classification framework which describes Nature Space ,Sports Space and Recreation Space, http://www.dsr.wa.gov.au/docs/default-source/file-support-and-advice/file-facilitiy-management/framework-for-open-space-online-version.pdf?sfvrsn=4

District Structure Plan Summary Table:		Structure Plan Ref (section no.)
Item	Data	
Number of primary schools	To be determined at local structure planning stage	5.5.3
Estimated commercial floor space	Retail - 23,000 - 32,500m^2 net lettable area Commercial - 229,000 - 394,500m^2 net lettable area	5.3, 6.1 and 6.2
Estimated area and percentage of public open space given over to: • Regional open space • District open space • Neighbourhood parks • Local Parks	• 16.3 hectares 6.1% • Determined at local structure planning stage • Determined at local structure planning stage • Determined at local structure planning stage	4.3, 4.4, 4.5, 4.6 and 4.9
Estimated percentage of natural area	24.2 hectares 9.2% Natural areas include those designated as 'Parks and Recreation – Local and Regional' incorporating Bush Forever and identified conservation areas. Additional natural areas may be identified for conservation purposes at local structure planning stage.	4.3, 4.4, 4.5, 4.6 and 4.9

Table 3: District Structure Plan Summary

3.2. City of Kalamunda Community Facilities Audit (2017)

The Community Facilities Audit for the Foothills and Plains section of the City was originally prepared in 2010 and updated in April 2017. This inventory has been used to help build the profile of community infrastructure needs for Forrestfield North in section 7.

The audit notes that that the library and community centre in Forrestfield have an estimated remaining life of 15 and 21 years respectively requiring their replacement in 2032 and 2038 respectively. In High Wycombe, the library and community and recreation centre are forecast to be removed in 2038 and 2062 respectively.

Of particular note is the extent of use of the sports spaces in the City as shown below:

Reserve Name	Summer use	Hours	Winter use	Hours
Scott Reserve	Cricket	88	Football	41
Fleming Reserve	Cricket (social only - concrete pitch no topping)	n/a	Football (informal and incidental)	n/a
Maida Vale Reserve	Cricket -Diamond sports	86	Soccer	67

Hartfield Park 1	Cricket	40	Hockey	29
Hartfield Park 2	Cricket	38	Rugby	15
Hartfield Park 3			Soccer	37
Morrison Oval	Cricket	38	Rugby Soccer	34
Reid Oval	Diamond sports	14	Football	32
Pioneer Park	decommissioned			

Table 4: Community Facilities Audit Summary

Many of the City's reserves are approaching or exceeding the recommended maximum load of 30-35 hours use per week. Even though new hockey/ tee ball sports fields have recently been developed at Hartfield Park, the City remains short of sports space.

3.3. City of Kalamunda Public Open Space Strategy (2018)

This strategic document prepared by officers of the City and peer reviewed by CCS Strategic in its preparation in 2017. The evaluation of existing POS provision in the City determined that there is an inadequate provision of sports space. The strategy notes that the Foothills provide a lot of sport and recreation based reserves, whereas the Hills mostly consist of nature and recreation based reserves. Only Forrestfield and Wattle Grove achieve the 10% POS provision however by 2036 the level of provision will be inadequate with an additional 16ha of sports space.

The quality and functionality of the smaller local parks is generally quite low. In comparison most Neighbourhood, District and Regional Open space parks are of a reasonable standard. The larger, multi-function reserves are more attractive to residents, have greater usage and are an easier maintenance asset than the dispersed low usage small local parks.

The focus of the strategy is to provide attractive multi-function POS and rationalise any small Local Open Sace areas. It is likely the Foothills will have to compensate for the Hills limited sports space through existing sports reserves and future sports reserves.

Calculations used in the strategy suggest that Forrestfield North will require 11.5 hectares of sports space by 2050 (15.7m^2 for each of the forecast 7,357[3] residents). Additionally, Forrestfield North may have to provide for High Wycombe's shortfall in sports space. However, given the environmental constraints of Forrestfield North it may be difficult to provide the sports space required.

The old landfill site on Brand Road has been identified as a potential location for a sports reserve. The costs of remediation will have to be investigated to identify if this option is viable. The site has the potential to provide a reserve of approximately 9ha, albeit in an odd shape with only around 7ha clustered in a readily useable shape.

[3] Based on revised population forecasts in Table 2

3.4. Scott Reserve Master Plan, ABV, May 2020

This master plan proposes the consolidation of Scott Reserve as a district level sports space serving cricket (1 turf and 2 synthetic wickets) and junior football (1 full size and 3 junior fields). It also proposes the demolition of the existing High Wycombe Community and Recreation Centre and replacement with a new community centre comprising a 300m^2 main hall, two multipurpose rooms of 75m^2 and a meeting room of 30m^2. An area of 50m^2 is to be allocated for ongoing lease by the Foothills Learning Centre.

Notably the fitness centre / gym is not proposed to be replaced. The estimated useful life of this building suggests that this replacement program would occur in the period 2038 to 2040. A further detailed feasibility study will need to be undertaken closer to this time, to determine need noting the timing of the community centre in the Forrestfield North.

3.5. Guidelines for Australian Public Libraries, APLA 2020

This updated guide identifies five core service offerings for public libraries.

- Physical and digital content and collections, including general, specialist, local studies, heritage and Cultural collections
- Information and reference services
- Reading, literacy, learning, wellbeing, cultural and creative programs
- Access to computers, the internet, printers, scanners and other mainstream technology, as well as support in developing digital literacy
- Places and spaces where people can relax, work, meet, learn, connect and create.

The following standards are cited.

Measure	Library service population	per capita measure	
		Median	Range
Annual expenditure	20,000 to 99,999	$48.00	$39.00-$62.00
Staff per 3,000 population	10,000 to 49,999	1.25	1.5
Qualified librarians	Per 10,000	1.0	1.2
Opening hours	20,000 to 49,999	48	56
Expenditure on materials	Per capita	$4.50	
Collection items	Per capita	1.6	1.4
Collection age	Less than 50,000	40%	45%
Internet devices	Per 2,500	1.0	1.2
Registered members	Catchment population	35%	35%-45%
Library visits	Per capita	4.0	4.5
Loans (physical + digital)	Per capita	6.0	7.0
Loans of physical items	20,000 to 49,999	2.0	3.0
Visits to library website	Per capita	2.1	
Hours of use of computers	Per capita	0.3	
Attendance at programs	Per capita	0.3	0.35

Table 5: Library Provision Guidelines

3.6. People Places - A Guide for Public Library Buildings in NSW 2020

This document prepared by the State Library Service of NSW is a default guide to library planning in Australia. If offers the following:

Minimum size	190m2	Only serves 2,750 people
Base area	30% of floor space	Area for collections and computers
Functional and service areas	70% of floor space	Reading and study areas, service desk and staff work areas, specialist areas, amenities
Collection to be housed	65%-75%	Remainder is on loan
Shelving	4 shelves high	1,500mm between rows

Table 6: Library Floor Space Requirements

4. COMMUNITY INFRASTRUCTURE TRENDS ANALYSIS

4.1. Overview

There are numerous trends in the provision of community infrastructure led primarily by:

- an economic imperative to do more with less;
- a changing community profile, particularly an ageing demographic;
- ageing infrastructure; and
- increased community expectations influenced by;
    - greater mobility;
    - access to information; and
    - access to technological advances.

A summary of the key trends is provided below.

1. Size and Scale

In recent times, many councils have moved away from providing small, stand-alone community buildings for local neighbourhood populations. This is due to the management and maintenance costs, limited use, lack of flexibility, security problems, and lack of capacity for staffing. Instead, there is a move towards the provision of fewer, yet larger facilities designed for a larger catchment area that can provide higher quality amenity and a wider range of services and activities. This is trend is reinforced by evidence that people frequently choose to bypass poorer quality local facilities within walking distance and travel further to facilities that offer better amenity and choice. Ready access to transport and strong mobility supports this trend.

Note that even primary schools, are growing in size with a general design population up from 430 to 540 students despite Year 7 students now accommodated in high schools.

2. Multi-Purpose and Multi-Function Facilities

Community facilities must respond to increasingly diverse and complex social needs. It is simply not viable to provide separate facilities for each of the myriad demands now evident in a community.

To make best use of limited resources and ensure higher rates of utilisation across the week and at weekends, community buildings need to provide for multiple uses and target groups and be adaptable as needs change over time.

Successful community facilities tend to be those that offer a diversity of well organised and well attended services, programs and activities. This diversity requires a variety of flexible spaces and amenities, capable of multiple functions and accessible to all. A key to this flexibility is not only in functional facility design but also in the availability of specialised equipment and fit-out, especially audio visual and staging / seating provision.

3. Staffing

Well used, active and vibrant community buildings tend to be those that have staff who can identify community needs and organise and deliver services, activities and programs across the week. The older style unstaffed or caretaker controlled halls for hire are frequently underutilised. Poor levels of use are often apparent in leased facilities under the exclusive care and control of a particular interest group.

Professional facility management and program staff can be important in ensuring there is a good mix of activities that will appeal to a variety of people, and that the facility is not monopolised by particular groups. On-site management is also often critical in providing services and programs for high need target groups, to enhance the social benefit of the facility.

Having fewer, larger facilities increases the requirement and viability of staffing these larger facilities, thereby increasing levels of activity and utilisation. Given the difficulties of securing government funding for staff, many councils are engaging specialist facility management contractors to service providers or community organisations with a broad community development focus to ensure they are continuously activated.

4. Location

Well used community facilities tend to be in places where people already have cause to congregate, such as shopping centres and schools, and to a lesser degree, those which are well served by public transport. This reduces the need for separate trips and enhances visibility, safety and convenient access. There is a move away from building stand-alone facilities in residential areas, which are often poorly utilised. Instead, leading practice favours the clustering of community buildings in activity centres, to enhance accessibility and connectivity with related uses.

5. Co-Location

The co-location of community services, involving shared or joint use of buildings amongst several service providers, is a commonly espoused objective of many new buildings. Co-location usually involves bringing community services together in a single location, sometimes as part of some form of multi-service centre. Co-location is a response to the fragmentation and lack of integration of related services and is intended to enhance both coordination among services and convenience for clients who can access multiple services from a single location.

Co-location has potential advantages in pooling resources to provide a better range of facilities (such as meeting rooms, training facilities) that may not be afforded if each were provided separately. An additional motivator is to make more efficient use of resources, by sharing common facilities rather than each organisation having its own separate space and generic furniture and equipment. Providing co-located services also enhances synergies between services and more integrated delivery of services to meet the needs of the community.

6. Community Hub Models

Numerous councils across Australia are moving towards a 'hub' model in the provision of community buildings. A 'smart Hub' model has been espoused by the City of Kalamunda for the Kalamunda Town Centre, Forrestfield Shopping Centre Precinct and for the Forrestfield North Activity Centre.

A hub is more than a multi-purpose community centre or a co-location of services. A hub brings together, either in the same building or a cluster of buildings, an extensive mix of uses that provide an activity centre an access point for meeting a diverse range of community needs.

These may include facilities such as a library, recreation centre, health care and social support services, childcare, meeting space for community groups, office accommodation for community organisations, space for community functions and events and possibly some form of enterprise, whether that be commercial or social in nature. Hubs are well integrated into other uses in the surrounding area, such as local shops, activity centres, open space, schools, civic places and transport nodes.

The essence of a community hub is the concentration of activity that occurs and how the mix of those activities is accessible to and serves the needs of a diverse range of community members.

7. Place-Making and Community Identity

Community buildings provide important gathering places for people and are catalysts for community activity and social interaction. They are recognised as having potential to contribute to the creation of vital public spaces that help engender a sense of place and distinctive community identity. The design of community buildings can enhance the physical quality and appearance of public places to reinforce a place's identity and make it a more attractive environment for people to gather and interact with each other.

Design is a large part of place making, but another significant component is planning. Planning can enhance the human experience of a place by ensuring that there is a mix of uses that will meet a variety of needs and will attract a diversity of people at different times of the day. This mix and variety add to safety (perceived and real) as well as vibrancy.

When located in or with retail and commercial centres community facilities can help to reinforce the role of those centres as public gathering, meeting and information sharing places. It is important that community buildings have a civic quality, sense of stability and level of amenity that marks them as an important place in the community, and that encourages people to interact in the public realm.

When social and cultural activities are encouraged and programmed into community spaces the 'place' comes alive.

8. Community Building

Community facilities are recognised as providing an important focus for community building activities, enhancing the connections and relationship among people in order to strengthen common values and promote collective goals. These goals may include community cohesion, safer neighbourhoods, support for isolated or disadvantaged people, healthier children and families, more local employment opportunities, greater cultural recognition, more equitable access to housing or more profitable local businesses.

Recognising the role that community facilities can play in providing a focal point where people with common interests can come together, and a base for community development activities, is important in planning community buildings.

9. Sustainability

The increasing focus on all aspects of sustainability means that not only are sustainable design, materials, energy and water aspects of the design of community buildings important, so too is sustainability in terms of funding, management and maintenance arrangements. Commonly, income from user charges, hire fees and rent from tenancy arrangements is insufficient to cover the costs of maintenance of community buildings.

Many councils have been exploring other income generating activities, such as operating commercial cafes or fitness centres, running monthly markets or incorporating convenience retail outlets. The growing wellness industry, specifically highlighted by allied health providers offers a blend of community and commercial service delivery. Some are income generating activities, some are run as social enterprises and some are operated by or to service disadvantaged groups. Capacity for commercial operations may need to be built into the design of the facility, to ensure compatibility with other activities and programs. These uses will also enable subsidisation of other activities.

4.2. Megatrends in Sport and Recreation

An Australian Sports Commission[4] study released by CSIRO in April 2013 identifies six megatrends likely to shape the Australian sports sector of the next 30 years. The megatrends are shown below in an interlinked and overlapping Venn diagram. This captures the connection between the different forces potentially shaping the future.



Figure 2: Megatrends affecting Sport

1. A Perfect Fit

Individualised sport and fitness activities are on the rise. We are increasingly playing sport to get fit, rather than getting fit to play sport.

2. From Extreme to Mainstream

There is a rise of lifestyle, adventure and alternative sports, which are particularly popular with younger generations. These sports typically involve complex, advanced skills and have some element of inherent danger and/or thrill-seeking.

3. More than Sport

The broader benefits of sport are being increasingly recognised by governments, business and communities. Sport can help achieve mental and physical health, crime prevention, social development and international cooperation objectives.

4 The Future of Australian Sport, Megatrends shaping the sports sector over coming decades, ASC and CSIRO, April 2013

4. Everybody's Game

Australia faces an ageing population. This will change the types of sports we play and how we play them. Australians are embracing sport into their old age. To retain strong participation rates, sports of the future will need to cater for senior citizens.

They will also need to cater for the changing cultural make-up of Australia. Australian society has become, and will continue to become, highly multicultural. Different cultures have different sporting preferences and recreation habits.

5. New Wealth, New Talent

Population and income growth throughout Asia will create tougher competition and new opportunities for Australia both on the sports field and in the sports business environment. Asian countries are investing heavily in sports capabilities and, especially in the case of China, have rapidly improved gold medal outcomes at the Olympics over recent decades.

As disposable incomes grow, the populations of Asian countries are becoming more interested in sport. This may create new markets for sports television, sports tourism, sports equipment, sport services and sports events.

6. Tracksuits to Business Suits

Sports with higher salaries may draw athletes away from those with lower salaries. Loosely organised community sports associations are likely to be replaced by organisations with corporate structures and more formal governance systems considering market pressures.

The cost of participating in sport is also rising and this is a participation barrier for many people. Several studies indicate that for those living at or below the poverty line, participation in sports and recreation activities were not high on their priority list.[5].

In a culturally diverse community, other barriers to participation include fear of racism or discrimination, access barriers such as language or lack of transport, affective barriers where participation is not culturally important or competition is too confronting, resource barriers including time and finance, physiological barriers due to ill-health and interpersonal barriers stemming from low confidence and lack of self-esteem.[6].

4.3. Popular physical activities

The following chart from the AusPlay 2020[7] shows the rate of participation in the top ten activities for adults on the left and children on the right.

Walking is the most popular physical recreation undertaken which makes footpaths, tracks and trails the most important type of recreation facility that can be provided. This is reinforced by running ranked at 3 for adults and 9 for children.

For adult's, fitness and gym activities ranked at number two represents the first activity where some form of specialised facility is required, similar to swimming which ranks 1 for children. The most popular team sport for both adults and children is football (soccer).

5 https://dspace.nwu.ac.za/handle/10394/14934

6 https://www.sprc.unsw.edu.au/media/SPRCFile/Report8_08_CALD_Women_in_sport.pdf

7 https://app.powerbi.com/view?r=eyJrIjoiMzlmNjZiOTYtYTVjNC00MzUwLTk2OWMtZTEwMDljZTBjYzI0IiwidCI6IjhkMmUwZjRjLTU1ZjItNGNiMS04ZWU3LWRhNWRkM2ZmMzYwMCJ9

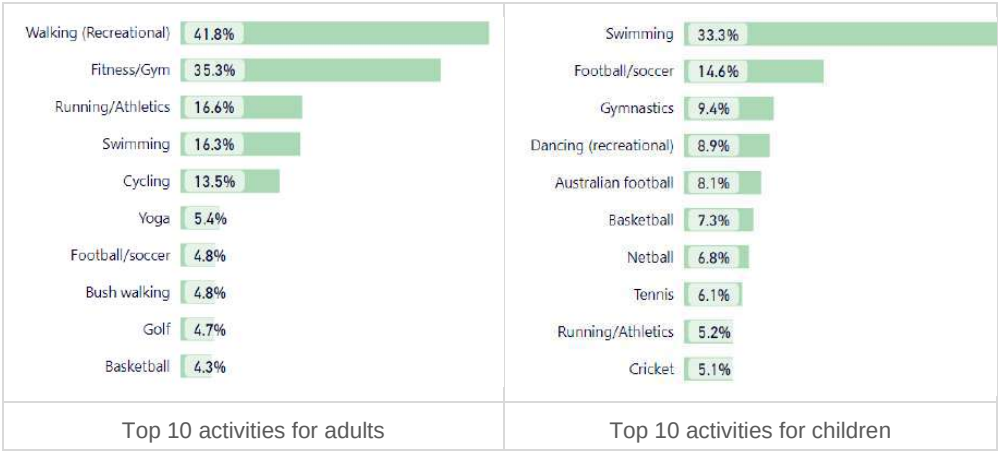


Figure 3: Total participation in top ten activities, 2020 - AusPlay

4.4. Trends in library services

Released in March 2021 the latest Annual Public Library Statistics[8] from 2019-20 show the considerable impact of Covid-19 on library services with a 24% decrease in physical attendances and a 23% increase in the use of on-line services, culminating with a 3% growth in library memberships in 2019-20.

The report follows a suite of data over the past 5 years which bear consideration in planning for new library and information services. Whilst library costs in total and costs per capita have risen year on year (on average 2.8% per annum), there was a decrease in costs over the previous year of around 4% due to a rationalisation of resources.

Physical collections are getting smaller and the per capita usage of the collections fell by 13% in 2019-20. Website visits per capita rose by nearly 20%. Loans per capita is decreasing (down nearly 14% over the past 5 years) and registered members is trending down (by nearly 7%) although customer visits per capita is stable and customers overall is on the rise (up 2.2%).

From a planning perspective library floor area will have a progressively smaller allocation to book stock and a correspondingly greater allocation to internet capability, local history collections and on-site programs and services where patrons interact on a personal level. The assumption in this study is that overall library floor space requirements will remain unaltered.

4.5. Summary and Analysis of Trends

There is a move towards the provision of larger, more diverse, multifunctional facilities that become a destination in their own right, offering a wide variety of experiences.

Targeted programs for special needs and interest groups and for a specific age and gender are increasingly delivered from multipurpose facilities through the use of flexible room layouts and portable / adjustable fittings and equipment. These programs cater to the social, cultural, physical, recreation and fitness needs of the community.

[8] https://www.nsla.org.au/news/2019-20-australian-public-libraries-statistics

The venues that stage these programs provide spaces for social interaction and networking and are usually supported by hospitality (food and beverage) and sometimes retail services. These are places of community building where identity and connection to place are fostered.

5. VISION AND GUIDING PRINCIPLES

5.1. DSP Vision

The District Structure Plan[9] states:

"The long-term vision for Forrestfield North is to create an attractive, vibrant and sustainable urban setting within a landscaped context, focussed on medium and high-density housing with local employment opportunities. The area will have direct access to Perth's regional road network and will be serviced by high quality public transport focussed on the new Forrestfield Train Station. Forrestfield North will include the following key elements:

- Medium and high-density urban neighbourhoods focussed on a new activity centre and commercially focussed Transit Oriented Development (TOD) based around the train station.
- Significant new parklands that ensure the protection of the existing ecological assets in the area, including Poison Gully Creek, whilst providing opportunities for passive and active recreation for an increased local population.
- New centres of employment within the activity centre and TOD precinct around the train station. "

With respect to community infrastructure considerations the District Structure Plan further states:

Reference	Commentary
p 31 4.1 Environmental	Careful consideration of potential future uses for the Brand Road landfill site, including non-sensitive recreational or commercial land uses and additional contamination investigations if required to support such uses at the local structure planning stage
p 41 5.2.1.1 Mixed Use	Local open spaces will also be provided that meet the active and passive recreational requirements of residents and users of the area and that protect the environmental values of the nearby TEC and Poison Gully Creek.
p 41 5.2.2. Activity centre vision	The main street environment is intended to be the main location for entertainment and other recreational activities within Forrestfield North with a strong focus on activated food and beverage uses.
pp 441-44 5.2.3, 5.2.4 Residential built form	Substantial well designed local open space will be provided that meets the active and passive recreational requirements of residents and users of the area, that enhances linkages within the proposed movement network and that protects the environmental values of the area, including the nearby TEC and Poison Gully Creek.
p 47 5.5	… an appropriate hierarchy of community facilities will be established as part of future detailed local structure plans to ensure that: • State level services continue to be located in the Perth CBD;

[9] Forrestfield North District Structure Plan (KALA/2015/2), Section 1.3, p8.

Community facilities	• Regional services continue to be located in Midland, Belmont or Cannington; • District level facilities that rely on higher densities should be encouraged to locate in the Shire (now City), including within the Kalamunda Townsite, Forrestfield North Activity Centre Precinct and Forrestfield Forum; and • Local community facilities relevant to the Forrestfield North population should be located within the immediate area, including within the Forrestfield Station TOD Precinct. Community and social infrastructure requirements include: • Provision of a range of facilities to cater for people of different abilities and cultural backgrounds; • Spaces and places for interaction to promote social inclusion and connection; • Services that provide support for individuals, families and groups; • Services that provide passive and active recreational opportunities for all community sectors; • Facilities that can provide a central and easily accessed location for service provision and/or community initiated activity; and • Visual markers of community identity including public art, environmental features, streetscape, landscaping and gardens.
p 47 5.5.1 Health services	These could be located within the Forrestfield North Activity Centre Precinct or the Forrestfield Station TOD Precinct. Local structure planning should provide for the establishment of health facilities where appropriate.
p 47 5.5.2 Aged care services	The preparation of detailed local structure plans for Forrestfield North are expected to specifically consider and provide: • Locations for aged care accommodation and allied facilities within close proximity and with excellent linkages to the proposed activity centre and TOD precinct; • Spaces for a range of activities for an active ageing population; • Space for allied health services provided through the public health system on an outreach basis; • Affordable office accommodation for not for profit organisations that provide support services to the elderly; and • Neighbourhood based respite day care centres, particularly for people with dementia who live at home.
pp 47-48 5.5.3 Schools	Current and future needs for secondary education for Forrestfield North residents should be adequately provided through schools in the surrounding suburbs, and specialist high schools throughout the metropolitan area. The need for an additional primary school in the area in the longer term will be determined in conjunction with the Department of Education as part of detailed local structure planning processes in due course if required in response to projected population growth. If required, the location of a primary school will be determined as part of this process and, should be located to take advantage of public transport opportunities and any proposed sporting and recreational facilities. Consultation with key stakeholders will be required as well as detailed site investigations to inform the ultimate location of any required primary school.
p 48	At a local neighbourhood level, availability of youth friendly spaces is an important consideration. It is important that the needs of young people are

5.5.4 Children	recognised in the planning of public space at a neighbourhood/local level as well as at district and regional levels.
p 48 5.6 Open Space	…. the landscaped character of Forrestfield North will be retained and enhanced through the retention and protection of areas of remnant vegetation and with the creation of new publicly accessible parklands. It is expected that detailed planning and development of the new parklands will balance the need for waterway edge stabilisation associated with Poison Gully, ecological protection, stormwater management and limited availability of groundwater for reticulation purposes, with public access and the provision of active and passive recreation uses. The minimum total area of local Public Open Space (POS) within the area is estimated at approximately 13 hectares, of which an estimated 2.6 hectares will require irrigation. Much of the POS is to be rehabilitated/ landscaped with native vegetation and will require limited, if any, irrigation. It is noted that a minimum of 10% local POS will need to be provided as a result of detailed local structure planning processes and that additional local POS beyond the 10% minimum may be required in order to ensure adequate protection of the significant environmental values of the area.
p 48 5.7 Environmental protection	Establishment of vegetation protection and enhancement areas as local parks and recreation reserves including retention and rehabilitation of ecological linkages where possible. Establishment of a Poison Gully Creek buffer zone as a local parks and recreation reserve along the northern boundary of the subject land as determined in the Poison Gully Creek Foreshore Assessment.
p 49 5. Urban water management	Integrate stormwater treatment into the landscape – use stormwater in the landscape by incorporating multi-use corridors that maximise the visual and recreational amenity of developments.
p 59 5.9 Bus routes	One or more of these services can be re-routed during school holidays to service a primary school (if required) and any recreational or sporting precinct within the area as identified through future local structure planning processes.

Table 7: Summary of Community Infrastructure Provision from the Forrestfield DSP

5.2. Guiding Principles

The following principles have been extracted from previous bodies of work variously undertaken by the City of Kalamunda and CCS Strategic relating to the provision of community infrastructure. They have been reviewed and expanded to guide community infrastructure provision for Forrestfield North.

When applied, these principles have been shown to enhance the performance potential of community facilities and spaces in terms of achieving higher levels of utilisation, being recognised as a source of social support in communities and contributing to the identity and sense of place of an area. They also reflect key trends in community infrastructure planning as evidenced by direct experience, extensive case study research and literature reviews. These guiding principles should be used to guide the planning and design of community infrastructure within the Forrestfield North area.

1. A co-ordinated and integrated network of facilities

Community facilities and sporting spaces should be planned and delivered to create an integrated hierarchical network of facilities and spaces. This approach requires consistency in application across the various levels of provision including whole of City, regional, district and local provision, and reduces the duplication of services, programs, spaces and amenities. This approach also allows distinct, unique or specialist services or amenities to be provided in appropriate locations.

2. Central to catchment and equitable access

Community facilities and sporting spaces should wherever possible be centrally located within the catchment area they intend to serve to enable equitable access. Facilities should be outward facing, welcoming and designed to be accessible to all. This principle is also reflected in the draft WAPC Operational Policy 2.4 for schools[10].

3. Location to promote visibility and accessibility

To best serve the needs of the community, and promote increased levels of utilisation, facilities should be highly visible and easily accessible. Buildings must comply with the legislative requirements of universal design and provide high levels of physical access, connectivity and wayfinding. Visibility of activity within the building also attracts increased interest.

4. Integrated/co-located

Co-locating and integrating a variety of community facilities to create a community hub is strongly encouraged. The grouping of compatible and complementary uses within the one location provides a focal point within the community, providing opportunities for people to meet, learn, play, socialise and express their culture.

The community hub model can extend beyond co-locating community facilities, to clustering community facilities with other activity generating uses such as transport nodes, shops, government service outlets, schools, childcare, open spaces and playgrounds.

5. Resilient and multiple use

Community facilities should be designed and built for maximum flexibility, with the capacity to be readily modified or expanded to adapt as needs change. Acknowledging that for some activities there is a minimum size or fit-out standard, buildings should be multi-purpose, and capable of delivering a range of programs and services.

6. Serving identified social needs

Community facilities should address the social needs of the particular community in which it is located in order to contribute to the community's health, wellbeing and quality of life. Programs, activities and services offered should respond to the needs and interests of the people that live and work within the particular catchment area to foster long term social benefits for the community. The planning and design of facilities should reflect the potential programs, activities and services envisaged through extensive stakeholder engagement.

7. Contribute to public domain and sense of place

Community facilities should contribute to urban vitality, local identity and sense of place, and become important focal points and gathering places for the community.

[10] https://www.dplh.wa.gov.au/getmedia/1f4cd2af-2c6a-4a13-9025-4fb1c9662be0/DCP-Draft-Operational_Policy_2-4_Planning_for_school_sites

A strong connection between the facility and the broader community can be fostered through the development of facilities on landmark sites, and with distinctive architecture and quality design.

Community facilities should be distinctive civic buildings and welcoming places and should present as a reflection of local culture. This helps ensure they develop a strong local profile and are well known in the community, thereby promoting high levels of usage. Incorporating public art into the building design is also important in creating distinctive and welcoming facilities.

8. Connected to public transport, pedestrian and cycling networks

Community facilities and sporting spaces should ideally be located within a 400-metre walking distance of a regular public transport stop. Linkages to pedestrian and cycling networks provides another avenue to promote the accessibility of facilities and is a further means to encourage sustainable transport choices and a healthy and active lifestyle.

9. Sufficient size and design to enable expansion and adaptation

Site selection and building design must allow for expansion or modification as the community and its needs change over time.

10. Financial viability and environmental sustainability

Community facilities should be financially viable (which may include an agreed operating loss in recognition of a broader community benefit) and provide value for money for their users, owners and operators.

While capital costs are often a major issue, ongoing operational costs are likely to exceed the capital investment and become a critical cost consideration for the longer term. Building design efficiencies that reduce ongoing operating and maintenance costs, and include revenue generating elements such as tenantable spaces, should be considered.

11. Value for Money

Local procurement processes must look to ensure value for money through competitive tendering processes against well detailed and unambiguous specifications.

12. Safety and security

Community facilities should be designed in accordance with Crime Prevention through Environmental Design (CPTED) principles. They should provide a high degree of personal safety for people entering and leaving the building, especially at night. Locating facilities in active areas and providing adequate lighting ensures higher levels of passive surveillance and increased security.

13. Master planned and staged strategy

Master planning provides an opportunity to locate facilities and spaces in areas where utilisation can be optimised and negative or consequential impacts on the community, environment and other uses can be minimised. Building location and orientation are also important considerations in reducing any potential future conflict with users and the building's surrounds.

Many of the master plans will respond to growing population demands over time and therefore will be expected to be progressively implemented. A staged implementation plan is inherent in the master planning process.

6. ANALYSIS OF STAKEHOLDER FEEDBACK

6.1. Initial feedback

A summary report on stakeholder consultation was prepared by TPG (now element) following the first round of engagement in June 2017.

An on-line survey revealed the respondents' desire was for Forrestfield North to be family oriented with a strong bushland presence and a relaxed village lifestyle. The design of the place whilst distinctly modern should feature the natural creeks and streams offering ready recreational access and bushland style living, noting that provision for active sport was also highly desirable.

A series of workshops were also held which revealed the following key infrastructure findings:

- Retained connection to the bush and the feeling of open space
- A focus on active recreation provision
- The need for a recreation centre, not just a place to kick a footy
- A focus on active transport requiring quality footpaths and cycle paths
- A well-lit and CCTV serviced public realm for safety
- Podium (stage) and shade canopy for outside events and performance space
- Various accommodations for community activities including:
    - Arts and Crafts
    - Library
    - Bicycling
    - Cinema
    - Swimming
    - Interactive play
    - Childcare, adult day care
    - Community garden
    - Markets/night markets
    - Active sports in a central location
    - Local courts (tennis / basketball)
    - Admiring public art
    - Social gatherings
    - Natural museum

6.2. Recent feedback

Dialogue with City of Kalamunda officers has been undertaken as part of this update and review of the CIS with respect to community centre, library and aquatic and fitness centre provision in the City.

6.2.1. Community Centre

Accommodation for arts and cultural pursuits within the foothills community has been given a heightened focus. The core elements of meeting spaces and function rooms remain with the introduction of new features including a community radio station, an arts workshop and an artist in residence studio. With the Forrestfield North community hub proposed as a major foothills hub, the City is likely to run programs, events and activities in and around the hub to activate the community. Office and essential storage space will be required and including a customer service space for foothills residents to readily access City of Kalamunda services has also been proposed.

The increase in scale of the Forrestfield North community hub has consequences for the proposed new community centre at Scott Reserve. This will need to be reassessed.

6.2.2. Library

City of Kalamunda staff confirmed that a new library in Forrestfield North would affect both foothills branch libraries, however no fixed or firm position has been taken. In forecasting demand this review has assumed:

- A new library in Forrestfield North would see the closure of the High Wycombe library. Note that this building has an estimated useful life through to 2062 and therefore its future, perhaps for another purpose, needs to be considered.
- The Forrestfield library will be considerably downsized and relocated to the Forrestfield Shopping centre as part of a digital hub and customer service centre for a broad range of City services. Existing patrons will either move to digital services or use the existing High Wycombe branch until an alternative is provided. The estimated useful life of this building is through to 2032 however the transition may occur sooner due to pressing needs for other facility development in Forrestfield.

6.2.3. Aquatic centre

There is no fixed or firm decision by Council on the future provision of aquatic facilities in the City, however it is noted that:

- Even with a downward revision of the future population in the foothills, the percentage of the Kalamunda population living in the foothills is already larger that the population living in the Hills and will continue to increase.
- The existing Kalamunda Water Park will ultimately fail and need to be replaced.
- The logical solution is to develop a new aquatic centre in proximity to the majority of the population.
- Combining a future aquatic centre with other community facilities as part of a multifaceted community hub is highly desirable.
- Aquatic centre viability is greatly enhanced by the inclusion of a fitness centre and this is considered an essential part of the hub development.
- There is the possibility of a privately operated aquatic centre being established on Hawtin Road in Forrestfield (3.8km away), similar to the existing Maida Vale indoor swimming centre on Gooseberry Hill Road (2.9km away).

6.2.4. Tenantable spaces

With the development of the High Wycombe Train station and relocation of the community hub into the TOD precinct, the profile of the community hub is significantly enhanced. There is the opportunity to provide ancillary and support services for the community within the hub. Suitable spaces for commercial tenants as part of the community hub could add to the activation of the TOD precinct. Consideration is proposed for a range of tenantable spaces to provide commercial services not usually provided by local government but essential to community wellbeing and livelihood. These include:

- Food and beverage outlet - café / coffee shop
- General Practitioner services
- Pharmacy
- Child care (not crèche)

- Infant health clinic
- Allied health providers
  - Physiotherapists
  - Chiropractors
  - Naturopaths
  - Remedial masseurs
  - Nutritionists
  - Occupational therapists
  - Psychologists
  - Social workers
- Government services under the Services Australia banner
  - Centrelink
  - Medicare
  - Child support

The commentary in section 6.2 has been taken into consideration in determining size, scale and cost for the CIS.

7. ASSESSMENT OF COMMUNITY NEED

The table below has been developed through a comprehensive assessment of existing community infrastructure provision, PLA WA Community Facility Guidelines and consultant expertise.

The approximate distance of travel (km) to a home point in the centre of Forrestfield North shown in column 4 has been measured for all existing facilities using the shortest or most likely route considering existing roads and column 5 offers the PLA WA facility provision ratio guideline.

Column 6 indicates whether provision of this facility is required in Forrestfield North (designated with a ✓, and where that provision is location dependent it is indicated with CH for the community hub location, TP for the town park or SP for the sporting precinct.

Column (7) refers to how each need is proposed to be met within Forrestfield North or referred to facilities in other locations.

This commentary takes into account the existing level of provision, the PLA WA guideline, industry trends, stakeholder consultation and population forecasts.

The various colours across the rows are solely for distinction between each classification of facility.

Community Infrastructure		Nearest current provision	km from FFN	PLA WA Guideline	Required in FFN	Notes/Comments
1	2	3	4	5	6	7
1. Children and families						
1.1	Child care (Early learning/long day care)			1:4000-8000	✓ CH	Local level in community hub
	1.1.1	Eastern Region Family Day Care	12.3			
	1.1.2	Good Start Early Learning Centre	8.9			
	1.1.3	Good Start Early Learning Centre	5.3			
1.2	Child care (Occasional care)			1:12000-15000	✓	District provision by private provider
1.3	Maternal and child health			1:30000-50000	✓ CH / SP	District level in community hub or sporting precinct
	1.3.1	Gooseberry Hill Child Health Centre	6.7			
1.4	Out of hours school care			1:4000-6000	✓ SP	Local level in sporting precinct
	1.4.1	Kalamunda Out of School Care	11.2			
1.5	Playgroup			1:4000-6000	✓ CH / SP	Local level in community hub or sporting precinct
	1.5.1	Little Tackas Playgroup	13.2			
	1.5.2	Scallywags	8.7			
	1.5.3	Woodlupine Family Centre Playgroup	5.7			
1.6	Primary School			1:5000	✓	At least one primary school required locally To be established adjacent to the sporting precinct
	1.6.1	Dawson Park	3.9			
	1.6.2	Edney	2.1			
	1.6.3	Falls Road	10.4			
	1.6.4	Gooseberry Hill	6.6			
	1.6.5	Heritage College	5.2			
	1.6.6	High Wycombe	2.9			
	1.6.7	Hillside Christian School	5.1			
	1.6.8	Lesmurdie	14.0			
	1.6.9	Mary's Mount	6.7			
	1.6.10	Matthew Gibney Catholic	3.7			
	1.6.11	St Brigid's	15.1			
	1.6.12	Wattle Grove	7.6			
	1.6.13	Woodlupine	5.4			
1.7	Toy library			1:6000-15000	✓ CH	Currently provided at Kalamunda RSL, additional facility desirable
	1.7.1	Kalamunda and Districts Toy Library	7.5			

Community Infrastructure		Nearest current provision	km from FFN	PLA WA Guideline	Required in FFN	Notes/Comments
1	2	3	4	5	6	7
2. Youth						
2.1	BMX track			1:25000-30000	×	
	2.1.1	Fleming Reserve	2.3			No additional provision required
	2.1.2	Ray Owen Reserve	13.6			
2.2	Drop-in /programs centre			1:20000-30000	✓ CH	As part of community hub
	2.2.1	High Wycombe Com & Rec Centre	2.1			
2.3	Guides and Brownies			No guideline	✓ CH	As part of community hub
2.4	Secondary School			No guideline	?	
	2.4.1	Carmel Adventist College	15.6			No additional requirement - maybe a private school
	2.4.2	Darling Range Sports College	3.8			
	2.4.3	Heritage College Perth	5.2			
	2.4.4	Hillside Christian School	5.1			
	2.4.5	Kalamunda Christian School	10.7			
	2.4.6	Kalamunda Senior High	7.9			
	2.4.7	Lesmurdie Senior High School	13.9			
	2.4.8	Mazenod College	12.9			
	2.4.9	St Brigid's	15.1			
2.5	Scouts and Cubs			No guideline	? CH	
	2.5.1	1st Forrestfield Scouts	7.1			Potential hirer of community hub
	2.5.2	1st Kalamunda Scouts	7.7			
	2.5.3	Boys Brigade	6.9			
	2.5.4	1st Walliston Scout Group	11.2			
2.6	Skatepark			1:5000-10000	×	No additional provision required - revert Fleming Reserve, Hartfield Park and Maida Vale Reserve
	2.6.1	Fleming Reserve	2.3			
	2.6.2	Maida Vale Reserve	3.4			
	2.6.3	Hartfield Park	6.5			
	2.6.4	Kalamunda	8.3			
3. Adults						
3.1	Arts and crafts centre			1:50000	✓ CH	
	3.1.1	Kalamunda Performing Arts Centre	7.7			As part of community hub
	3.1.2	Jack Healey SCC	7.4			
	3.1.3	Jorgensen Park Pavilion	8.2			
3.2	Animal welfare services			No guideline	×	
	3.2.1	Kanyana WRC	15.9			By private provider
		Horse Rescue and Rehab				
3.3	Learning Centre			1:6000-15000	✓ CH	As part of community hub
3.4	Service Groups			No guideline	×	
	3.4.1	CWA Kalamunda	7.6			No specific provision - use community hub or commercial facilities
	3.4.2	Darling Range RSL	7.6			
	3.4.3	CWA Foothills	6.3			
	3.4.4	Inner Wheel (Hartfield Country Club)	8.3			
	3.4.5	Lions Kalamunda	8.0			
	3.4.6	Lions Forrestfield / High Wycombe	4.2			
	3.4.7	Rotary Kalamunda	6.4			
	3.4.8	The Women's Powder Room	4.1			

Community Infrastructure		Nearest current provision	km from FFN	PLA WA Guideline	Required in FFN	Notes/Comments
1	2	3	4	5	6	7
4. Seniors						
4.1	Aged accommodation			No guideline	✓	As per structure plan
4.2	Seniors Centre/Autumn centre (well aged)			1:20000-30000	✓	Commercial provision within the seniors village or in community hub
	4.2.1	Woodlupine Family Centre	5.7			
	4.2.2	Jack Healey SCC	7.4			
4.3	Long day care / respite (frail aged)			1:3000-40000	×	District level provision
4.4	Men's Shed			No guideline	×	No provision proposed - revert to Foothills
	4.4.1	Foothills Men's Shed	5.2			
	4.4.2	Kalamunda Men's shed	10.5			
4.5	Bridge			No guideline	✓ CH	No stand alone facility - use community hub
	4.5.1	Kalamunda Districts Bridge Club	6.8			
5. All ages						
5.1	Amphitheatre			In district open space	✓ CH	As part of landscape within community hub
5.2	Aquatic centre			1:60000	✓ CH	Foothills aquatic centre - indoor + outdoor pools + fitness centre as part of community hub
	5.2.1	Kalamunda Aquatic Centre	8.3			
	5.2.2	Darling Range Sports College	3.8			
	5.2.3	Aqua Tots Maida Vale Swim School	3.3			
5.3	Community Centre			1:20000-30000 D	✓ CH	As part of community hub
5.4	Neighbourhood Centres and Community Halls			1:5000 N	✓	As part of community hub
	5.4.1	Anderson Road Community Hall (16+15+15)	5.2			
	5.4.2	Woodlupine Community Centre (369)	5.7			
	5.4.3	Forrestfield Hall (115)	5.1			
	5.4.4	Cyril Rd Community Hall (196)	3.3			
	5.4.5	Headingly Rd Cottage	6.7			
	5.4.6	Jorgensen Pk Pavilion	8.2			
	5.4.7	Falls Farm (40)	15.7			
	5.4.8	Lesmurdie Hall (211)	13.6			
	5.4.9	Walliston Hall (90)	11.5			
	5.4.10	Forrestfield Library Exhibition Room (50)	5.1			
	5.4.11	Town Square Community Hall	6.9			
5.5	Fire and emergency services			Set by DFES	×	
5.6	Fitness centre			1:50000	✓ CH	As part of the community hub
	5.6.1	Hartfield Park Recreation Centre	6.7			
5.7	Footpath/DUP network			At least one side of every street	✓	Dual use footpaths on both sides of main urban streets
5.8	Gallery			1:50000	✓ CH	As part of the community hub
5.9	Indoor sports centre			1:50000	×	No additional provision - revert Hartfield Park, High Wycombe CRC and Ray Owen
	5.9.1	High Wycombe Com & Reec Centre (300 - 3/4 court)	2.1			
	5.9.2	Ray Owen Sports Centre (300 - 6 courts)	13.6			
	5.9.3	Hartfield Park Recreation Centre (980 - 2 courts)	6.7			

Community Infrastructure		Nearest current provision	km from FFN	PLA WA Guideline	Required in FFN	Notes/Comments
1	2	3	4	5	6	7
5.10	Library			Refer Libraries NSW model	✓ CH	New library in community hub - replaces High Wycombe and downsized Forestfield
	5.10.1	Forrestfield Library (22,968)	5.1			
	5.10.2	High Wycombe (18,924)	3.1			
	5.10.3	Lesmurdie (12,207)	13.9			
	5.10.4	Kalamunda (???)				
5.11	Museum			1:250000	×	No provision
5.12	TBA					
5.13	Performing arts centre			1:50000	✓ CH	No separate provision - revert Kalamunda - capture activity in community hub
	5.13.1	Kalamunda Performing Arts Centre	7.7			
5.14	Places of Worship			No guideline	×	Privately provided
5.15	Playground			1:5000	✓ SP	Specific playground provision throughout the POS within FFN with priority focus on the community hub and the sporting precinct
	5.15.1	Ollie Worrell Reserve	3.8		✓ CH	
	5.15.2	Scott Reserve	2.1			
	5.15.3	Peter Hegney Reserve	2.5			
	5.15.4	MacKenzie Park	3.2			
	5.15.5	Hewson Park	4.1			
	5.15.6	Rangeview Park	3.1			
	5.15.7	Progress Park	3.6			
	5.15.8	Jacaranda Springs Park	5.5			
	5.15.9	Pine Tree Reserve	3.0			
	5.15.10	Gladys Newton Park	3.8			
	5.15.11	Emms Reserve	3.8			
	5.15.12	Viv Robinson Park	3.4			
	5.15.13	Peter Annus Park	3.1			
	5.15.14	Agraulia Court Park	1.8			
5.16	Public Toilets			Required in all areas where people	✓ SP ✓ CH	Specific public toilet provision throughout the POS with priority focus on the community hub and the sporting precinct
	5.16.1	Kalamunda Library Toilets	7.1			
	5.16.2	Stirk Park	6.4			
	5.16.3	Public Toilets behind Police Station	7.5			
	5.16.4	Falls Road – SKAMP	10.5			
	5.16.5	Lower Lesmurdie Falls (not found)	???			
	5.16.6	Jorgensen Park	8.2			
	5.16.7	Pickering Brook (Beside school)	18.1			
	5.16.8	Fleming Reserve	2.3			
	5.16.9	Alan Anderson Reserve	11.6			
	5.16.10	Maida Vale Reserve	4.4			
	5.16.11	Gooseberry Hill Reserve	6.7			
	5.16.12	Town Square Public Toilets	6.9			
	5.16.13	Lesmurdie Falls	13.9			
	5.16.14	High Wycombe Train Station	0.0			
5.17	Recreation Centre			1:50000	×	No additional provision - revert Hartfield Park, High Wycombe CRC and Ray Owen
	5.17.1	Hartfield Park	6.7			
	5.17.2	High Wycombe	2.1			

Community Infrastructure		Nearest current provision	km from FFN	PLA WA Guideline	Required in FFN	Notes/Comments
1	2	3	4	5	6	7
5.18	Nature space			<40% of POS	✓	As provided by bush forever reservations
5.19	Recreation Open Space			<40% of POS	✓	As provided within POS allocations
5.12	Sports Open Space			>40% of POS	✓	As provided in sporting precinct - Brand Road landfill site
6. Sports/Activity specific accommodation						
6.1	Archery			No guideline	×	No specific allocation
		Stirk Park	6.5			
6.2	Athletics			1:30000 D	✓ SP	Grassed track and field amenities in the sporting precinct
	6.2.1	Little Aths Forrestfield	6.8			
	6.2.2	Little Aths High Wycombe	2.8			
	6.2.3	Belmont Little Athletics Centre	8.5			
6.3	Badminton			Refer Rec Centres 5.17	×	No additional provision - revert Hartfield Park and High Wycombe
6.4	Baseball with cut-outs -Kalamunda Rangers			1:8000-10000	✓ SP	Within sporting precinct
	6.4.1	Maida Vale Reserve	4.4			
6.5	Basketball			1:3000-4000	×	No additional provision - revert Hartfield Park, High Wycombe CRC and Ray Owen - 4 extra courts proposed
	6.5.1	Kalamunda Districts (6 indoor +4)	13.6	Ray Owen		
	6.5.2	Hartfield Park (2 indoor)	6.7	Hartfield Park		
	6.5.3	High Wycombe (1 indoor)	2.1	High Wycombe		
6.6	BMX			1:25000 D	×	Revert hills area
6.7	Bowls			1:50000-75000 D	×	No additional provision - revert Forrestfield and Kalamunda
	6.7.1	Forrestfield and Districts (2)	7.0			
	6.7.2	Kalamunda (3)	6.4			
	6.7.3	Pickering Brook (2)	17.5			
6.8	Bridle paths			No guideline	?	Potential trail along Poison Gully Creek
	6.8.1	Maida Vale Reserve	4.2			
6.9	Climbing wall			Refer Rec Centre 5.17	×	No additional provision
6.10	Cricket			1:8000-10000	✓ SP	Within sporting precinct
	6.10.1	High Wycombe - Scott Reserve (2+1)	2.2	Scott Reserve		
	6.10.2	Kalamunda	7.9	Kostera Oval		
	6.10.3	Forrestfield - Morrison Oval	6.8	Hartfield Park		
	6.10.4	Lesmurdie-Mazenod	13.6	Ray Owen Reserve		
	6.10.5	Pickering Brook	17.5			
6.11	Croquet			1:175000	×	No provision - revert to bowls clubs
		No provision	2.2			

Community Infrastructure		Nearest current provision	km from FFN	PLA WA Guideline	Required in FFN	Notes/Comments
1	2	3	4	5	6	7
6.12	Dance			Refer Community Centre or Hall	✓ CH	As part of community hub
	6.12.1	Scott Reserve	2.2			
6.13	Equestrian			No guideline	×	No provision
	6.13.1	Walliston Riding and Pony Club	11.5			
6.14	Softball and Teeball - Diamond sports			1:8000-10000	✓ SP	Within sporting precinct
	6.14.1	Kalamunda Rangers	4.4	Maida Vale Reserve		
	6.14.2	Forrestfield Flyers	3.7	Hartfield Park		
6.15	Football (AFL)			1:5000	✓ SP	Within sporting precinct
	6.15.1	Forrestfield Juniors - Reid oval	6.8			
	6.15.2	High Wycombe Amateurs - Scott Reserve (2)	2.2			
	6.15.3	High Wycombe Juniors - Scott Reserve (1)	2.2			
	6.15.4	Kalamunda Districts	13.6			
	6.15.5	Pickering Brook	17.5			
6.16	Golf			1:30000	×	No provision - revert Hartfield or Hillview
	6.16.1	Hartfield Park Country Club (18)	8.3	Hartfield Park		
	6.16.2	Hill View (18)	3.7	Hartfield Park		
6.17	Gymnastics			Refer Rec Centres 5.17	✓ CH	Potential use of community hub for Kindy Gym
6.18	Hockey (synthetic)			1:75000	×	No synthetic - revert Guildford
	6.18.1	Kalamunda Districts (grass)	6.8	Hartfield Park		
	6.18.2	John Reid Oval (grass)				
	6.18.3	Guildford (synthetic)				
6.19	Martial arts			Refer Recreation Centre or Hall	✓ CH	As part of community hub
6.20	Netball			1:3000-4000	×	No provision - revert Maida Vale or Ray Owen
	6.20.1	Kalamunda Districts (6 indoor + 10 outdoor)	13.6	Ray Owen		
	6.20.2	Maida Vale (12)	3.4	Sports Centre		
6.21	Singing / Choral			Refer Community Centre or Hall	✓ CH	As part of community hub
6.22	Soccer			1:3000-4000	✓ SP	Within sporting precinct
	6.22.1	Forrestfield United (3)	6.8			
	6.22.2	Morrison Oval (2)	6.8			
	6.22.3	Kalamunda United (6)	4.4			
6.23	Squash			No guideline	×	No provision proposed - revert Hartfield Park
	6.23.1	Hartfield Park (4)	6.8			
6.24	Swimming			1:60000 N	✓ CH	Foothills aquatic centre - indoor + outdoor pools + fitness centre as part of community hub - pending detailed design
	6.24.1	Darling Range Sports College - Kalamunda Districts	3.8			
	6.24.2	Kalamunda Aquatic Centre	8.3			
	6.24.3	Aqua Tots Maida Vale Swim School	3.3			

Community Infrastructure		Nearest current provision	km from FFN	PLA WA Guideline	Required in FFN	Notes/Comments
1	2	3	4	5	6	7
6.25	Tai Chi			Refer Rec Centre or Community hall	✓ CH	As part of community hub
6.26	Tennis			8:15000	×	
	6.26.1	Forrestfield (6)	7.0			No provision - revert Rangeview and Maida Vale
	6.26.2	Rangeview (4)	3.1			
	6.26.3	Maida Vale (12)	4.4			
	6.26.4	Kalamunda (10)	8.2			
	6.26.5	Lesmurdie (8)	10.4			
6.27	Volleyball			Refer Rec Centre 5.17	×	No provision proposed - revert Hartfield Park or High Wycombe
	6.27.1	Hartfield Park Recreation Centre (2)				
	6.27.2	High Wycombe (2 indoor)	2.1			
6.28	Water polo			1:75000	✓ CH	Foothills aquatic centre - part of community hub - pending detailed design
	6.28.1	Kalamunda Aquatic Centre	8.3			
6.29	Yoga			Refer Rec Centre or Community hall	✓ CH	As part of community hub
	6.29.1	Kundaliini Yoga and Meditation	6.7			

Table 8: Proposed community facility provision for residents of FFN

8. LAND PARCEL AVAILABILITY

A preliminary assessment of potentially available land parcels for community infrastructure provision was presented to the consultant team at the beginning of the study. This was to show possibilities rather than to make firm recommendations. The scoping exercise was to see what would fit.

For example, Figure 4 indicates that up to 6 rectangular pitches (soccer, rugby) could be accommodated on the old landfill site at Brand Road. The site measures approximately 7ha and can also accommodate two full size AFL ovals 165 x 135m and at a squeeze up to three club level cricket fields (60m radius). In this sense the site could be classified as a district level provision. Utilisation of this area is predicated on the ability to adequately remediate the landfill to allow the establishment of grassed playing fields. The black outlined indicates the proposed parking and pavilion location which is understood to be on a relatively undisturbed portion of the site.

It is also noted that the adjacent primary school site will require a playing field. By using a portion of the school site for playing fields the scale of the development could truly be of district scale.

8.1. Sports Space Opportunities



Figure 4: Potential playing field layouts on Brand Road landfill site

8.2. Community Service Opportunities

Opportunities for community service provision were articulated in the District Structure Plan as being focused on the activity centre precinct, nominally as part of a community hub provided in conjunction with a future town park. This indicated community facilities being located in the western portion of the residential precinct as shown in the pink rectangle.



Figure 5: Initially identified Community Service facility location options

It is now proposed that the community hub (red polygon in the image below) be relocated to a site opposite the train station (blue polygon) in the TOD precinct .

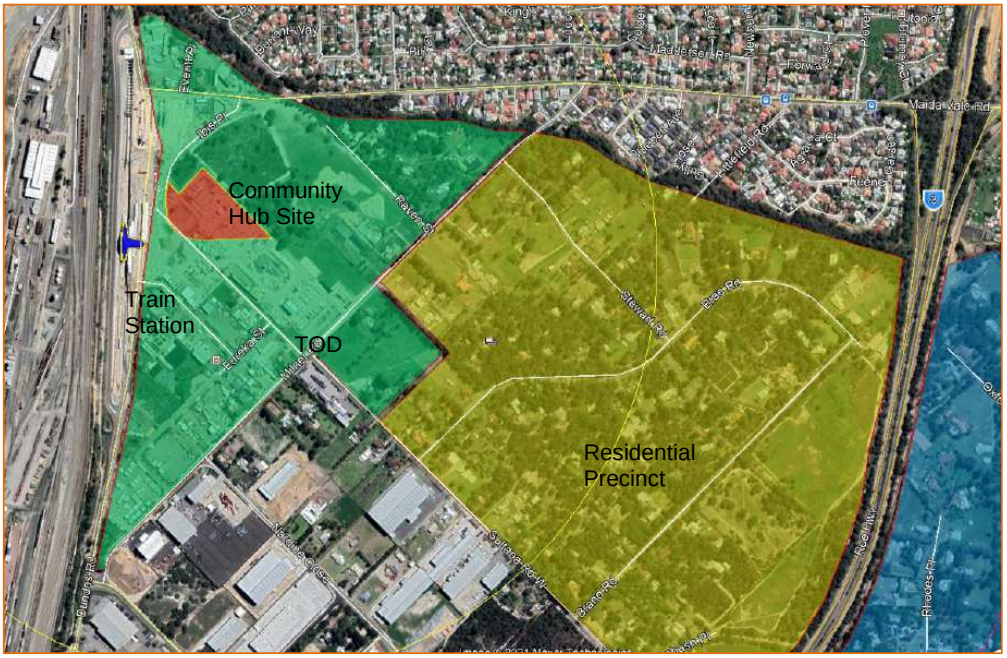


Figure 6: Revised community hub location (shown in red)

The town park will remain as an allocation of POS in the residential area.



Figure 7: Revised town park location (shown dotted in red)

9. SOLUTIONS ANALYSIS

9.1. Sports Space

The active open space analysis in the City of Kalamunda POS Strategy reveals a shortage of sports space in the foothills area. The old Brand Road landfill site provides an opportunity to assist in meeting the shortfall. Other investigations carried out revealed:

- Fleming Reserve in High Wycombe has been developed in a manner to exclude sports being allocated to this site for anything other than informal training.
- Pioneer Park in Forrestfield has been decommissioned pending further compaction and remediation works to prepare the area for stable and sustainable development. Note that the Master Plan prepared by AECOM in 2015 appears to respond to existing site settlement constraints. The remediation of this site is not expected to occur for a number of decades, if at all, with alternative uses being actively explored.
- Ollie Worrell Reserve in High Wycombe could be used as a sports space capable of accommodating two soccer fields or one AFL field (albeit with the wrong orientation). If the site is used as a competition venue, changeroom and potentially clubroom facilities would need to be considered. This reserve is approximately 3km from the centre of the Forrestfield North residential precinct.
- The decommissioned Brand Road landfill site would appear to be the best, if not the only option for sports space development within the Forrestfield North Local Structure plan area. Being an old landfill, this site will present similar challenges to that experienced at Pioneer Park, however landfilling on this site was not as deep and the site stopped receiving waste sooner than Pioneer Park. Less remediation may be

required for playing fields. This site is unlikely to be suitable for residential development and could provide for district level playing fields servicing the community if combined with provision on the adjacent primary school site.

- The proposed playing fields amenities complex will require changeroom facilities to service both playing fields (nominally two sets of changerooms) as well as clubhouse facilities for the resident cubs. It is anticipated that these clubrooms would be multipurpose and given the connection to the adjacent primary school could offer out of school hours care services and support both playgroup and toy library functions.
- It is argued that the out of school care service is ideally located next to the school as recommended in this report.

9.2. Library

The current library provision in the City of Kalamunda is detailed in Table 6.

Library	High Wycombe	Kalamunda	Forrestfield	Lesmurdie
Building condition rating	2	3	4	Ed. Dept.
Estimated years remaining	45 (2062)	21 (2038)	15 (2032)	?
Active membership	2,145	6,752	3,130	1,864
Total issues p.a.	46,376	155,689	68,482	39,549
Floor area (m^2)	425	830	626*	1205**
Per capita Book stock	1.44	5.41	1.67	1.38
Stock, Books, Audio, DVD	12,771	26,540	17,966	22,457***
Periodicals #	377	1,107	604	331
Public Computer terminals #	4	8	5	5
Toy library area	N/A	N/A	21.6	N/A
Local history collection area	N/A	33.8	N/A	N/A
Staff work area (m^2)	33	30	37	Unknown
Meeting/training rooms area	N/A	N/A	62	N/A
Storage area (m^2)	10	16	8	Unknown
Foyer lobby area (m^2)	N/A	66	21.5	Unknown
Public amenities area (m^2)	16.5 m^2	-	12	Unknown

Table 9: City of Kalamunda library data

* Not including the 50m2 exhibition room
** Shared use agreement with Lesmurdie High
*** Including school stock

The provision of a library service in Forrestfield North is predicated on the closure of the High Wycombe branch library. Noting that this building has a forecast useful life to 2062[11] it is anticipated that the building will be repurposed when the Forrestfield North library is established.

[11] City of Kalamunda Community Facilities Audit 2017

The Forrestfield library building has a forecast useful life to 2032[12]. The library site has been identified for possible repurposing to accommodate an expanded police station, which may mean earlier relocation to leased premises in the Shopping centre.

If the repurposing is to occur it is anticipated that the Forrestfield Library will be downsized and relocated into approximately 320m^2 of leased premises in the Forrestfield shopping centre. The relocated Forrestfield library would operate as a digital hub and Customer Services Centre for a variety of City services rather than a traditional branch library.

Planning for the Forrestfield North library is influenced by the following assumptions

- The Kalamunda library will continue to operate as the central library
- A new branch library in Forrestfield North branch should be sized to service a target catchment population drawn primarily from Forrestfield North, High Wycombe, Forrestfield, Wattle Grove and Maida Vale.
- The catchment population for a proposed Forrestfield North library is estimated over time as shown in table 6. It is anticipated that the Forrestfield library / digital hub will continue to service the 50% of the resident population in Forrestfield. 15% of the residents from Maida Vale and 20% from Wattle Grove will use Forrestfield or another service in lieu of Forrestfield North.
- With the advent of the High Wycombe train station, a library on the adjacent community hub site will usurp some of the central branch load assuming city workers / commuters will use the Forrestfield North branch. An estimated 10% of the Hills population is anticipated to use Forrestfield North library.

Ratio	Area	2021	2031	2041	Build out 2050
100%	Forrestfield North	896	1,001	5,307	7,357
100%	High Wycombe	11,935	12,436	12,892	13,304
50%	Forrestfield	6,966	7,677	8,028	8,342
85%	Maida Vale	3,488	5,206	7,442	9,137
80%	Wattle Grove	6,236	8,271	9,689	10,752
	Commuters	N/A	2,042	2,131	2,155
	Total	28,738	35,672	44,543	50,115

Table 10: FFN library forecast catchment population

- The established trend of a decreasing demand on book stock and an increase in on-line services is expected to continue.
- Accordingly, a book stock ratio of 1.4 per capita is proposed for the Forrestfield North library. This has a resultant effect slightly reducing the floor area required.

Applying this data in the People Places[13], the NSW Library Service planning calculator, both population and service driven calculations are possible. The calculator requires the space requirement to be based on the 10 year population forecast. Assuming the new Forrestfield North library is to be developed by 2031 (10 years from now) , the catchment population to be serviced will be 33,360 foothills residents with 2,042 commuter patrons.

[12] City of Kalamunda Community Facilities Audit 2017
[13] https://www.sl.nsw.gov.au/public-library-services/people-places/library-building-calculator

The population based calculator indicates a library floor area of 1,767m^2.

Using the service based calculator with a collection of 1.4 items per capita, the library will house 49,941 items and require a floor area of 1,848m^2.

Based on Western Australian standards these calculations seem high. A slightly more modest approach is proposed targeting 1,600m^2 of floor space.

9.3. Community Centre

A community meeting place is essential in every community. It provides the space for the development of belongingness as described in the third level of Maslow's hierarchy of need.

Additionally, community centres offer spaces for learning, sharing, social celebrations, for the expression of culture, creativity, kinship and local community.

It is noted that the existing High Wycombe Community and Recreation Centre has several functionality issues that results in an underperforming asset for the community. The Scott Reserve Master Plan proposes a new community centre be developed for the site, however given the scale of development and co-location opportunities at the Forrestfield North Community Hub site the development of the Scott Reserve Community Centre may not be required. This will be subject to further investigation.

Contemporary community centres are however much more than just meeting spaces.

Kalamunda is renowned for its artistic and creative community, however existing accommodations such as the Kalamunda Performing Arts Centre and the Zig Zag Gallery are located in the hills. There is an opportunity to provide accommodation for the creative and artistic in the foothills area by including suitable accommodation as part of the community infrastructure in Forrestfield North. The specific needs of individuals and community groups in the foothills will need to be identified during the detailed design stage.

There are six elements to consider that would provide suitable accommodation in Forrestfield North.

1. Function and meeting rooms

There is a requirement for a variety of spaces to accommodate the civic, social and operational needs of the local community. This requires a series of rooms of various sizes, to cater for social celebrations such as engagements, weddings and anniversaries, for business related gatherings such as seminars, conferences and meetings, for civic activities such as citizenship ceremonies and community awards and for general get-togethers for a multitude of purposes. These spaces all need to be serviced by suitable amenities (e.g., toilets, dressing/change/shower rooms, kitchen and bar areas and storage) and must be suitably equipped with furniture and equipment (especially audio visual and other tech items). The areas may be subdivisible by dividing walls to enhance flexibility.

2. Exhibition / gallery spaces

These can be a mixture of permanent and ephemeral spaces. A suggested option is for a small permanent display space in a common area (lobby) supported by access to larger spaces on an as needed basis in a meeting or function room for specific exhibitions and shows.

3. Workshop / activity spaces

Critical to the cultivation and progression of creative and artistic talent is a place to learn and practice those skills. This requires suitably designed and equipped areas. Examples include a suitable floors and mirrors for dance, appropriate acoustics for musical and choral works, wet areas, wheels and clay storage for pottery and sophisticated and technical equipment for multimedia, digital and film making.

4. Artist studio / work spaces

As with impulse buying and the science behind placing chocolates at the supermarket checkout, ready and consistent exposure to artistic and creative activity imbues participation. Having a resident artist within the community centre will demonstrate a commitment to the arts. Having an arts group as a resident tenant will similarly strengthen the Centre's connection to the arts as well as drawing patrons in an observer and / or participant capacity.

5. Performance space

Whilst it is not intended to usurp the role of the Kalamunda Performing Arts Centre at the top of the hill, there is a need for a performance space within the Hub. This can be done in two ways. Firstly, through the use of temporary / portable equipment such as stage, sound and lighting facilities in the halls of the community centre.

The second and perhaps most important is to provide opportunity to outdoor performance. An amphitheatre as part of the landscaping on site is one way that this could be achieved.

Critical to the activation of the community centre will be the need to manage the demands of tenants and hirers who require certainty of access on a regular daily, weekly or monthly basis, and those groups that seek to hire the facility for block bookings or seasons such as occurs with performances, shows and exhibitions.

6. Community radio station studio

A further consideration is accommodation for a local radio station. Community radio stations are by definition operated, owned, and influenced by the communities they serve. Often seen as a tool for social change, community radio allows true participatory communication which is essential for sustainable development. It is also an excellent way to communicate with a specific community or group (sometimes marginalized or vulnerable) or those whose main language is not the official national language. The social profile of the foothill's community suggests it may benefit significantly by such as service.

The design of this community centre will be influenced by the priority given to each of the 6 elements described above and the interplay with library spaces. It is anticipated that the Community Centre will have a floor space of at least 1,200m^2.

9.4. Aquatic Centre

A separate business case is being prepared addressing the future provision of aquatic facilities in the City. As the demographic analysis indicates the foothills area already accommodates a larger percentage of the City population than the hills area and this will accentuate over time.

The anticipated demise of Kalamunda Water Park calls for a replacement facility. It is logical to locate a new aquatic centre in the area of greatest population and more importantly greatest demand. Swimming participation rates are highest in adults aged 35-44 and children aged 5-8 years. This is representative of the age profile of foothills residents with the median age being in the 30-39 age bracket for adults and the 0-9 age group for children. Residents in the hills are collectively older with a median age of 50-54 for adults and 10-14 years for children.

Forrestfield North offers a suitably sized parcel of land for the establishment of a community hub, located opposite the new High Wycombe train station and capable of accommodating a district scale aquatic centre.

The design detail outlining size and scale of the proposed facility is provided in the Aquatic Centre Business Case and summarised as follows:

- Outdoor heated 8 lane 50m pool
- Indoor heated 8 lane 25m pool
- Indoor heated program pool
- Indoor heated leisure pool
- Spa sauna and steam room
- High spec change, toilet and shower facilities
- Refreshment outlet and lounge area
- Merchandise outlet
- Crèche

9.5. Fitness Centre

It is common practice to add fitness centre facilities to aquatic centre facilities to improve service offerings and operational viability. Now that an aquatic component is being contemplated, the intent is to include an integrated health and fitness centre. A minimum floor space of 1,200m^2 is suggested offering the following components.

- Cardio zone
- Spin room
- Free weights area
- Pin loaded machine area
- Personal / Circuit training area
- Group fitness room
- Warm-up / cool down area
- High intensity interval training (HIIT) suite
- Appraisal room
- Allied health consulting rooms
- High spec change, toilet and shower facilities
- Refreshment outlet and lounge area
- Merchandise outlet
- Crèche

9.6. Public Open Space

The extensive network of POS throughout the structure plan area is largely restricted through bush forever and conservation classifications. In addition to the Town Park there is a retention of green space around the old landfill site, along the northern side of Brand Road and along Poison Gully Creek.

The Town Park allocation (refer Figure 7) provides an informal open space area which could readily include a variety of support facilities including:

- Amphitheatre
- Community garden
- Outdoor stage
- Dog exercise area

There is a need to ensure the conservation areas are not alienated from the local residents. Ideally a network of formal and informal pathways, tracks and trails will permit and encourage these areas to be accessed, albeit in a controlled way.

Where bush forever sites require fencing to protect TECs, pedestrian access gates, formed pathways and interpretive signage should be provided. In less sensitive areas, formalised access ways should be developed to encourage pedestrian thoroughfare, both as a means of shortest access route through the suburban areas and as a means of connection to natural bush.

Focused vistas into these POS areas from the surrounding residential developments is to be encouraged. At a minimum, these views should be enhanced through active management of the natural and remnant bushland reflecting CPTED principles.

10. SPATIAL MAPPING AGAINST PROVISION HIERARCHY

The image below is a snapshot from Google Earth with all the local, district and regional facilities identified in section 7 plotted on the map. The clusters of facilities are quite evident as follows:

- High Wycombe - Maida Vale - shown in yellow oval
- Kalamunda - shown in the purple oval
- Lesmurdie - shown in the blue oval
- Forrestfield - shown in the green oval

Note that additional facilities can be found further afield as you travel north to Midland and Guildford, west to Belmont and east to Pickering Brook. The Forrestfield Airport train link will also provide connections to facilities in Bayswater.

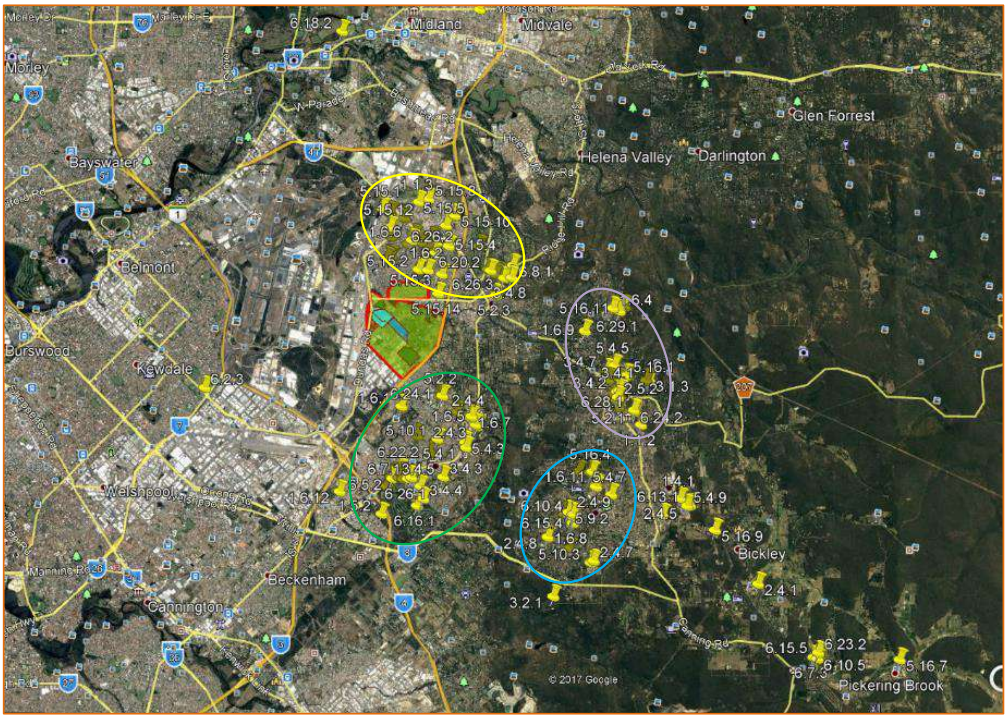


Figure 8: Spatial clustering of existing community infrastructure

Local service needs for Forrestfield North will for the most part need to be met from provision within Forrestfield North. A range of district level facilities requirements may be required in the Forrestfield North area while regional facilities will certainly need to be provided elsewhere.

11. CONCEPT PLANS

In terms of community infrastructure provision there are three key precincts and a series of general amenity provisions to be accommodated throughout the remaining areas. These are discussed below.

11.1. Education and Sporting Precinct

The area comprising the old Brand Road Landfill site is well situated and offers a large enough area to accommodate district level sporting facilities. The virgin land adjacent to the land fill site is suitable for the accommodation of a primary school. The initial concept is shown in Figure 9. It is noted that the land area allocated for the school is approximately 3.5ha and accordingly it is anticipated that the Education provider (public or private) will most likely seek a joint use/shared development arrangement to access portion of the playing fields.

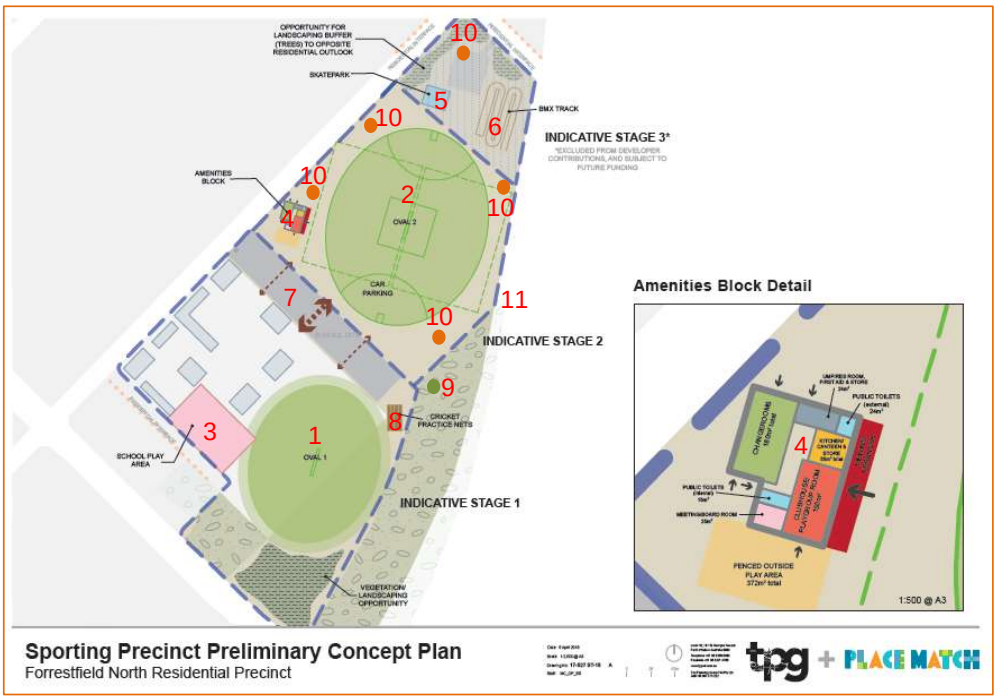


Figure 9: Original Education and Sporting Precinct Concept Plan

Legend

1. Oval playing field - cricket, junior AFL
2. Multipurpose playing field - all codes
3. School play area – off the main playing fields
4. Club, change, playgroup, out of school care
5. Skatepark
6. BMX track
7. Carpark
8. Cricket practice nets
9. Water supply bore and storage tanks
10. Site furniture - shade and seating
11. 2.4m wide red bitumen walk trail

The image above shows a stand-alone cricket field (1) and a multipurpose sporting field (2). The actual use of the playing fields will be determined by future demand given that development of these facilities is likely to be on the 5-10-year horizon.

A revised design is in shown in figure 10. This design allows for additional grassed field sports to be accommodated, including capacity for two full size senior AFL, four rectangular fields for rugby, soccer or hockey and summer season overlays for athletics, cricket and diamond sports. Naturally not all sports can be accommodated at this site and it is anticipated that both summer and winter codes will share the available grounds, which will be developed fit for purpose. The variation in colour between the playing surface and the surrounding area reflects a reference to hydrozoning to minimise water use.



Figure 10: Updated Education and Sporting Precinct Concept Plan

There will need to be district playing field standard amenities on this site. For Forrestfield North it is proposed that these should be developed as multipurpose facilities to accommodate early childhood and children's services such as playgroup, toy library, after school hours care and vacation care programs. Proximity to the school makes this an ideal location for such activities.

This multipurpose facility will also serve as a clubhouse for the sporting clubs based on site. The development will need to include gender neutral changeroom facilities (2 sets), an umpire's room, first aid room, universally accessible public toilets and a kiosk or canteen with a kitchen to service the children's activities and sporting participants and spectators. A covered viewing area (verandah) should front the playing field.

The parking areas are positioned to service the playing fields, the multipurpose amenities building and the school.

Note that the revised plan excludes the skate park and BMX track. These facilities are adequately provided at Fleming Reserve, Hartfield Park and Maida Vale Reserve and adjacent to the Kalamunda Water Park in Kalamunda.

11.2. Town Park

The original CIS proposed a Town Park as part of a community hub situated on the community purposes site located east of Milner Road in the residential precinct.



Figure 11: Original Town Park and Community Hub Location Plan

The original concept design for the town park and community hub site combined is shown in Figure 12 providing for a community centre, library, market square and associated parking and landscaping.

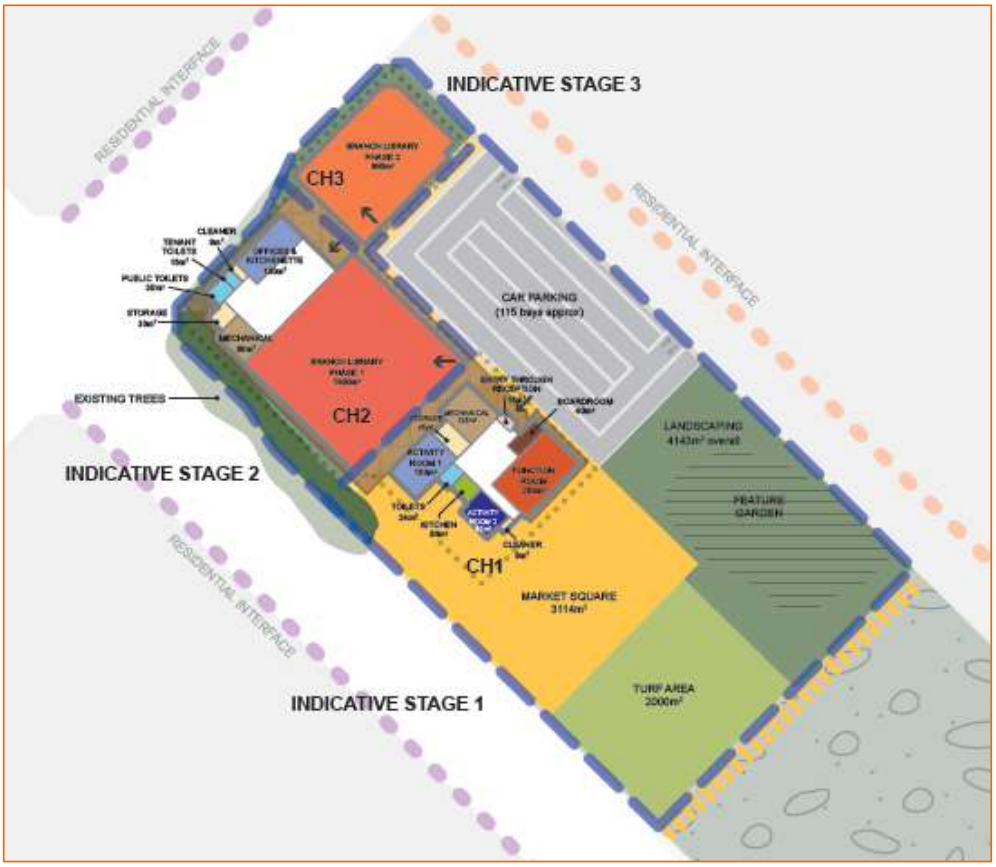


Figure 12: Previous Community Hub Preliminary Concept Plan

This town park shape has now been slightly reconfigured and the community hub site relocated into the TOD precinct opposite the new High Wycombe train station.

The park elements originally proposed for the town park remain largely unaltered and include areas of high quality green space and high end urban landscape combining the following elements:

- Shade (natural and man-made)
- Connecting pathways
- Seating
- Drinking fountain
- Water feature
- Public toilets (self-cleaning style)
- Community information and signage
- Car park with shade tree planting
- Public art – stand-alone and integrated
- Clear open turf areas with good sightlines
- Areas for civic and social celebrations
- Power and water connections for events
- Security lighting
- Feature lighting
- Play equipment
- Podium with shade canopy

A revised concept plan for the town park is shown in Figure 13



Figure 13: Revised Town Park Concept Plan

11.3. Community Hub

The community hub component, now positioned within the TOD precinct and opposite the train station is proposed to provide a social gathering, meeting and activity space for a multitude of community purposes.

The community hub concept as depicted in Figure 14 reflects a residential precinct setting. Relocation to the TOD precinct provides incentive for the co-location of a range of other community, institutional and recreational facilities. This has encouraged the introduction of a new aquatic centre and fitness centre together with childcare facilities (indoor and outdoor). The hub is also to include a range or arts and cultural accommodations such as a community radio station, workshop spaces (wet and dry), an artist in residence studio and exhibition / gallery spaces. The landscaped garden areas could also provide for an outdoor performance space.

The following components are proposed to be included to meet the variety of need identified.

- Branch library
- Main function room (300pax)
- Secondary function room (150pax)
- Board / meeting room (20pax)
- Kitchen (commercial grade)
- Manager / Reception
- Public toilets (as part of the building)
- Activity room 1 – dry (100pax)
- Activity room 2 – wet (40pax)
- Storage areas
- Circulation space and lobby
- Community Radio studio

- Artist workshop
- Exhibition / gallery space
- Aquatic centre 50 outdoor heated pool
- Aquatic centre 25m indoor heated pool
- Aquatic centre indoor program pool
- Aquatic centre leisure pool
- Crèche
- Workshop spaces (wet and dry)
- Artist in residence studio
- Tenantable space (office and workroom)
- Fitness centre
- Parking
- Childcare centre
- Childcare centre outdoor play area
- Landscaped gardens
- Community radio station

Figure 14 provides an indicative layout of these features on the community purposes site opposite the High Wycombe train station.

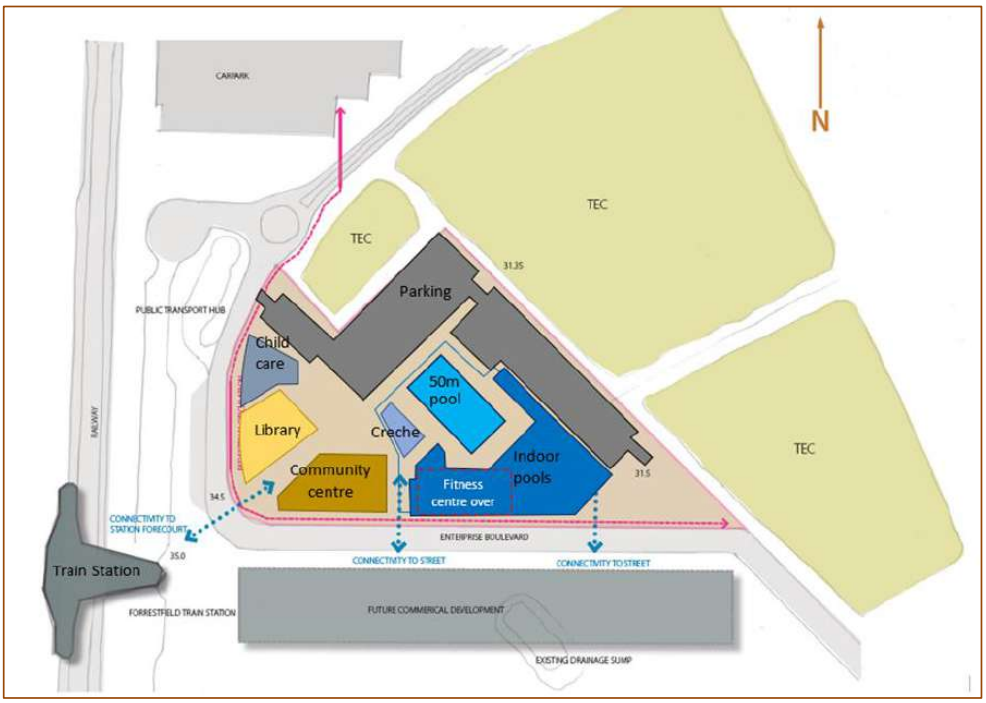


Figure 14: FFN Community Hub Concept Plan

12. IMPLEMENTATION TIMELINE

The revised population projections described in Table 2 indicate that Forrestfield North as a stand-alone suburb will not reach a targeted critical mass for facility provision until around 2040. It is not until then that the combined TOD and residential precinct catchment population is forecast to have exceeded 5,000 and warrant a full suite of facilities.

However, by 2040 the broader catchment population anticipated to use the community hub and sporting precinct will have grown from the current 37,678 to in excess of 53,000 and is already well beyond critical mass. Accordingly, it is the broader catchment population that must be considered rather than just the Forrestfield North community.

Demand for the establishment of the proposed facilities should be triggered by demand and this will be influenced by:

- The shortage of playing fields and player amenities in the foothills
- The forecast failure of Kalamunda Water Park
- The redevelopment or removal the High Wycombe Community and Recreation Centre and consequent loss of the fitness centre
- The proposed closure of the High Wycombe library
- The relocation and reduction in size of the Forrestfield library
- The opportunity to service foothills residents with council services located locally
- Reconsideration of a proposal to renew facilities on Scott Reserve in favour of the facilities in the Forrestfield North Community Hub
- The establishment of the High Wycombe train station

One of the questions to consider in the timing of facility and amenity provision is whether provision should lead or lag population arrival. Developers will typically provide a selection of lead amenities such as local recreation parks and playgrounds and footpaths as part of the marketing package to launch a new estate.

Forrestfield North presents an unusual situation given the broader catchment and the train station already in situ. The City of Kalamunda proposes to pursue funding opportunities with a view to bringing the development of the community hub on much sooner than dictated solely by Forrestfield North catchment population milestones. If successful the implementation timeline may alter significantly.

The triggers identified above and the broad catchment area suggests that many of the proposed facilities, regardless of when they are developed will actually be lag provided. The earliest possible provision is encouraged as it will be aimed to pick up on shortages in current provision and to replace existing provision.

The exception is perhaps the provision of facilities which are local in scale and aimed at serving only the new Forrestfield North residential population. These facilities are primarily proposed for the Town Park.

The following broad development timeline is proposed noting that many of the facilities are recommended for staged development. Should funding opportunities permit the aim would be to develop the components of the community hub in one stage.

The elements listed are reflected in the concept plans in section 11. A summary table is shown below with more detail in table 12.

Implementation summary	Year	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
Community Centre																						
Stage 1 - 940m^2	2028				■																	
Stage 2 - 560m^2	2042																		■			
Branch library																						
Stage 1 - 1200m^2	2028				■																	
Stage 2 - 1600m^2	2042																		■			
Aquatic centre																						
Stage 1 - Indoor pools	2027			■																		
Stage 2 - Outdoor pool and slides	2035											■										
Fitness centre																						
Stage 1 - 700m^2	2027			■																		
Stage 2 - 500m^2	2042																		■			
Childcare centre																						
Stage 1 - 60 places	2026		■																			
Stage 2 - 40 places	2040																■					
Sports precinct																						
Stage 1 - Playing field & changerooms	2030						■															
Stage 2 - Clubhouse	2040																■					
Stage 3 - School oval	2045																					■
Town Park																						
Stage 1 - Parkland	2027			■																		

Table 11: Implementation summary

The detailed breakdown of the elements that comprised each stage is described below.

Community Centre	Year	Building element
Stage 1 (ground floor development)	2028	Main function room 300m^2
		Manager / Reception 65m^2
		Board / meeting room 30m^2
		Circulation gallery and lobby 320m^2
		Kitchen (commercial grade) 50m^2
		Activity room 1 – dry 80m^2
		Public toilets (as part of the building) 50m^2
		Storage areas 45m^2
		Landscaped gardens 80m^2
		Parking 55 bays
Stage 2 (First floor development - built in 2028 to accommodate the main portion of the stage 1 library. Refit and refurbishment in 2042 as the upper level of the community centre)	2042	Secondary function room 150m^2
		Artist workshop 50m^2
		Activity room 2 – wet 50m^2
		Community Radio studio 40m^2
		Artist in residence studio / workshop 50m^2
		Tenantable space (office and workroom) 100m^2
		Public toilets (as part of the building) 30m^2
		Storage areas 30m^2
		Parking 22 bays
Branch library		

Stage 1 (Housed in upper level of community centre and portion of fitness centre)	2028	1,200m^2 Parking 45 bays
Stage 2 (provided as a new 1600m^2 building)	2042	1600m^2
Aquatic centre		
Stage 1	2027	8 lane x 25m indoor pool 500m^2 Indoor program pool 175m^2 Indoor leisure pool 250m^2 Changerooms 175m^2 Crèche 160m^2 Crèche outdoor play area 160m^2 Café kiosk 45m^2 Circulation 320m^2 Parking 100 bays
Stage 2	2035	50m 8 lane outdoor heated pool and ramp 1,040m^2 Water slides Water slides splash pool 30m^2 Water slides - plant room 40m^2 Additional changerooms 100m^2 Additional parking 50 bays Landscaped gardens 3,000m^2
Fitness centre		
Stage 1 (1200m^2 built in 2027 with 310m^2 allocated to library)	2027	890m^2 Parking 70 bays
Stage 2 (refit and refurbishment of area used by stage 1 library)	2042	310m^2 Additional parking 30 bays
Childcare centre		
Stage 1	2026	60 place centre 250m^2 Outdoor play area 350m2 Parking 10 bays
Stage 2	2040	40 place centre 150m^2 Outdoor play area 250m^2
Sports precinct		

Stage 1	2030	Multipurpose playing field - all codes 205m x 175m
		Secondary playing field 165m x 135m + buffer
		Changerooms x 4, first aid room, umpire's room, kiosk, public toilets, storerooms, viewing verandah 576m^2
		Cricket wickets x 2
		Cricket practice nets 3 bays
		2.4m wide red bitumen walk trail - 600m
		Water supply bore and storage tanks
		Parking 50 bays
		External services, power, water, sewer, drainage, fire
Stage 2	2040	Clubroom, playgroup, out of school care 200m^2
		Site furniture - shade and seating
		Additional parking 30 bays
Stage 3	2045	School playing field 185m x 155m
Town Park		
Stage 1	2027	2.4m wide red bitumen walk trail 500m
		Public art – stand-alone and integrated
		Open turf areas with good sightlines
		Areas for civic and social celebrations
		Power and water connections for events
		Security lighting
		Feature lighting
		Play equipment
		Podium with shade canopy

Table 12: FFN implementation plan by facility and component

13. ORDER OF PROBABLE COST

The following cost schedules have been prepared at an elemental level and costed by Neil Butler from NBQSS.

13.1. Education and Sporting Precinct

The cost of developing the primary school is anticipated to be a Department of Education cost and accordingly has not been included here. However, the cost of developing a full sized playing field on the school site, to ensure sporting precinct is a true district level facility has been included. It is anticipated that a joint development and shared use agreement will be established with the Department of Education.

Project delivery costs are included in the order of probable cost for ech community facility and have been calculated as follows:

Site works Project On-costs		
Site furniture	2%	Further analysis is required of these items as the project proceeds. An indicative loading of 43% has been allowed to cover the items listed to the left
Computers etc.	0%	
AV equipment	0%	
Kitchen Equipment	0%	
Legal fees	2%	
Professional Fees	8%	
Public Art	1%	
City of Kalamunda recoverable costs	5%	
Project preliminaries	10%	
Design contingency	10%	
Construction contingency	5%	
Total project on-cost allowance	43%	
Land costs excluded		

Table 13: Project cost allowance for site works such as playing fields

Building Project On-costs		
Loose furniture	6%	Further analysis is required of these items as the project proceeds. An indicative loading of 59% has been allowed to cover the items listed to the left
Computers etc.	1%	
AV equipment	1%	
Kitchen Equipment	2%	
Legal fees	2%	
Professional Fees	10%	
Public Art	2%	
City of Kalamunda recoverable costs	5%	
Project preliminaries	10%	
Design contingency	10%	
Construction contingency	10%	
Total project on-cost allowance	59%	
Land Costs excluded		

Table 14: Project cost allowance for building works

The appropriate project on-cost allowance has been added to each of the elemental cost in the schedules below.

	Element	Current Cost June 2021
	Community Hub	
1.1	Child Care Centre - Stage 1	$ 1,180,825
1.2	Child Care Centre - Stage 2	$ 721,175
2.1	Branch Library - Stage 1	$ 1,695,950
2.2	Branch Library - Stage 2	$ 8,565,118
3.1	Community Centre - Stage 1	$ 6,950,152
3.2	Community Centre - Stage 2	$ 2,837,150
4.1	Aquatic Centre - Indoor Pools - Stage 1	$ 14,313,880
4.2	Aquatic Centre - Outdoor Pool & Slides - Stage 2	$ 8,038,803
5.1	Fitness Centre - Stage 1	$ 4,218,478
5.2	Fitness Centre - Stage 2	$ 2,039,895
6.1	Carpark - Stage 1	$ 1,091,550
6.2	Carpark - Stage 2	$ 420,375
7.1	External Works - Stage 1	$ 1,153,549
7.2	External Works - Stage 2	$ 32,811
8.1	External Services - Stage 1	$ 676,875
8.2	External Services - Stage 2	$ 49,875
	Total	$ 53,986,460
	Sports Precinct	
9.1	Stage 1 - Playing fields and Changerooms	$ 5,716,109
9.2	Stage 2 - Second field and Clubhouse	$ 1,300,528
9.3	Stage 3 - School Oval	$ 1,409,904
	Total	$ 8,426,541
	Town Park	
10.1	Stage 1 - Parkland	$ 3,563,676
	Total	$ 3,563,676
11.0	**TOTAL CONSTRUCTION COST**	**$ 65,976,677**
13.0	**ESCALATION**	
	Current Total Construction Cost	$ 65,976,677
13.1	Total Escalation to 2045	**$ 28,640,387**
13.0	**ESTIMATED TOTAL COMMITMENT**	**$ 94,617,064**

Table 15: Summary of total community infrastructure costs escalated as per implementation

Itemised cost estimates by the proposed stages of development are provided below.

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
COSTINGS							
Please note that this information is for indicative budgeting purposes only and should not be used as the basis for making a financial commitment							
Prior to making a financial commitment a detailed budget should be prepared based on input from the architect and the relevant consultants							
FORRESTFIELD NORTH RESIDENTIAL PRECINCT							
SPORTS PRECINCT							
Refer to Concept Plans - Figure 10, Figure 12 and Figure 14							
It has been assumed that all infrastructure roads and street footpaths will be provided by others and do not form part of these costs							
	Stage 1						
1.1	Main Oval						
1.1.01	205m x 175m - includes buffer						
1.1.02	Site remediation (clearing + compaction)	m2	35,875	$ 4	$ 143,500	$ 60,988	$ 204,488
1.1.03	Site resurfacing and levelling (300mm topsoil)	m2	35,875	$ 18	$ 645,750	$ 274,444	$ 920,194
1.1.04	Reticulation	m2	35,875	$ 4	$ 143,500	$ 60,988	$ 204,488
1.1.05	Stolons	m2	35,875	$ 3	$ 107,625	$ 45,741	$ 153,366
1.1.06	Spectator fence	m	500	$ 125	$ 62,500	$ 26,563	$ 89,063
1.1.07	Goal posts (Soccer)	No	4	$ 2,550	$ 10,200	$ 4,335	$ 14,535
1.1.08	Cricket pitch - synthetic	No	1	$ 13,000	$ 13,000	$ 5,525	$ 18,525
1.1.09	Sports lighting	Item	1	$225,000	$ 225,000	$ 95,625	$ 320,625
1.2	Top oval						
1.2.01	165m x 135m + 10m buffer all round						
1.2.02	site remediation (clearing + compaction)	m2	28,675	$ 4	$ 107,531	$ 45,701	$ 153,232
1.2.03	site resurfacing and levelling (300mm topsoil)	m2	28,675	$ 18	$ 516,150	$ 219,364	$ 735,514
1.2.04	reticulation	m2	28,675	$ 4	$ 114,700	$ 48,748	$ 163,448
1.2.05	stolons	m2	28,675	$ 3	$ 86,025	$ 36,561	$ 122,586
1.2.06	Goal post set (AFL)	item	2	$ 3,750	$ 7,500	$ 3,188	$ 10,688
1.2.07	cricket pitch - synthetic	item	1	$ 13,000	$ 13,000	$ 5,525	$ 18,525
1.3	Practice nets						
1.3.01	Bank of 3 synthethic cricket nets	item	1	$ 57,000	$ 57,000	$ 24,225	$ 81,225

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
1.4.	Amenities Block						
1.4.01	Changerooms, clubhouse and playgroup						
1.4.02	Changerooms 1+2 (incl toilet and shower)	m2	145	$ 2,700	$ 391,500	$ 229,028	$ 620,528
1.4.03	Changerooms 3+4 (incl toilet and shower)	m2	145	$ 2,700	$ 391,500	$ 229,028	$ 620,528
1.4.04	Umpires room	m2	15	$ 2,000	$ 30,000	$ 17,550	$ 47,550
1.4.05	First aid room	m2	15	$ 2,200	$ 33,000	$ 19,305	$ 52,305
1.4.06	Storerooms	m2	80	$ 1,500	$ 120,000	$ 70,200	$ 190,200
1.4.07	Public toilets - External access	m2	26	$ 3,500	$ 91,000	$ 53,235	$ 144,235
1.4.08	Kiosk/canteen	m2	25	$ 3,000	$ 75,000	$ 43,875	$ 118,875
1.4.09	Clubhouse store 1 (furniture)	m2	15	$ 1,500	$ 22,500	$ 13,163	$ 35,663
1.4.10	Viewing verandah 3m wide	m2	80	$ 215	$ 17,200	$ 10,062	$ 27,262
1.4.11	Meeting / Board room	m2	30	$ 2,400	$ 72,000	$ 42,120	$ 114,120
1.5	Carpark						
1.5.01	50 bays plus crossover	m2	1500	$ 65	$ 97,500	$ 41,438	$ 138,938
1.5.02	Allowance for lighting	Item			$ 30,000	$ 12,750	$ 42,750
1.5.03	Pathways 80m x 2.4m wide	m2	192	$ 65	$ 12,480	$ 5,304	$ 17,784
1.6	Water supply						
1.6.01	Bore	Item	1	$ 80,000	$ 80,000	$ 34,000	$ 114,000
1.6.02	Storage tanks (35kl) including base and pumps	item	2	$ 30,000	$ 60,000	$ 25,500	$ 85,500
1.6.03	Electrical supply (200m run)	item	1	$ 25,000	$ 25,000	$ 10,625	$ 35,625
1.7	External Services						
1.7.01	It has been assumed that all infrastructure services (Sewer, water, gas, electricity) will be provided to the site boundary		Note				
1.7.02	Allowance for site stormwater services	Item	1	$ 10,000	$ 10,000	$ 4,250	$ 14,250
1.7.03	Allowance for site sewer services	Item	1	$ 15,000	$ 15,000	$ 6,375	$ 21,375
1.7.04	Allowance for site water services	Item	1	$ 10,000	$ 10,000	$ 4,250	$ 14,250
1.7.05	Allowance for site electricity services	Item	1	$ 15,000	$ 15,000	$ 6,375	$ 21,375
1.7.06	Allowance for site gas services	Item	1	$ 5,000	$ 5,000	$ 2,125	$ 7,125
1.7.07	Allowance for site fire services	Item	1	$ 15,000	$ 15,000	$ 6,375	$ 21,375
	TOTAL - STAGE 1				**$ 3,871,661**	**$ 1,844,448**	**$ 5,716,109**

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
	Stage 2						
2.1	Amenities block						
2.1.01	clubhouse/playgroup room	m2	200	$ 2,400	$ 480,000	$ 280,800	$ 760,800
2.1.02	clubhouse kitchen/canteen upgrade	m2	25	$ 1,000	$ 25,000	$ 14,625	$ 39,625
2.1.03	clubhouse store 1 (furniture)	m2	15	$ 1,500	$ 22,500	$ 13,163	$ 35,663
2.1.04	clubhouse store 2 (equipment)	m2	15	$ 1,500	$ 22,500	$ 13,163	$ 35,663
2.1.05	viewing verandah 5m wide	m2	75	$ 215	$ 16,125	$ 9,433	$ 25,558
2.1.06	meeting / board room	m2	25	$ 2,400	$ 60,000	$ 35,100	$ 95,100
2.1.07	public toilets - Internal access	m2	25	$ 3,500	$ 87,500	$ 51,188	$ 138,688
			380				
2.2	Outdoor play area						
2.2.01	Fenced outside play area						
2.2.02	Grassed area including soil preparation and grass	m2	300	$ 29	$ 8,700	$ 3,698	$ 12,398
2.2.03	Riding track	m2	60	$ 3	$ 180	$ 77	$ 257
2.2.04	Play equipment and shade sails	item	1	$ 75,000	$ 75,000	$ 31,875	$ 106,875
2.2.05	Sheltered verandah	m2	30	$ 550	$ 16,500	$ 7,013	$ 23,513
2.2.06	Outdoor store - Metal shed	m2	15	$ 500	$ 7,500	$ 3,188	$ 10,688
2.2.07	Palisade fencing and gates pedestrain gate	m	76	$ 145	$ 11,020	$ 4,684	$ 15,704
	TOTAL - STAGE 2				**$ 832,525**	**$ 468,003**	**$ 1,300,528**
	Stage 3						
3.1	School Oval						
3.1.01	165m x 135m + 10m buffer all round						
3.1.02	Site remediation (clearing + compaction)	m2	28,675	$ 4	$ 107,531	$ 45,701	$ 153,232
3.1.03	Site resurfacing and levelling (300mm topsoil)	m2	28,675	$ 18	$ 516,150	$ 219,364	$ 735,514
3.1.04	Seticulation	m2	28,675	$ 4	$ 114,700	$ 48,748	$ 163,448
3.1.05	Stolons	m2	28,675	$ 3	$ 86,025	$ 36,561	$ 122,586
3.2	Carpark						
3.2.01	60 bays plus crossover	m2	2,000	$ 65	$ 130,000	$ 55,250	$ 185,250
3.2.02	Allowance for lighting	Item	1	$ 35,000	$ 35,000	$ 14,875	$ 49,875
	TOTAL - STAGE 3				**$ 989,406**	**$ 420,498**	**$ 1,409,904**
	TOTAL - SPORTS PRECINCT- ALL STAGES						**$ 8,426,541**
	Goods and Services Tax	Item		10%			$ 842,654
	Total Sports Precinct all stages including GST						$ 9,269,195

Table 16: Order of probable costs for Sports Precinct

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
COSTINGS							
Please note that this information is for indicative budgeting purposes only and should not be used as the basis for making a financial commitment							
Prior to making a financial commitment a detailed budget should be prepared based on input from the architect and the relevant consultants							
FORRESTFIELD NORTH RESIDENTIAL PRECINCT							
TOWN PARK		Site Area - 2.5 Hectares					
Refer to Concept Plans - Figure 10, Figure 12 and Figure 14							
Note	It has been assumed that all infrastructure roads and street footpaths will be provided by others and do not form part of these costs						
1.1	**Stage 1 - Parkland**						
1.1.01	Shade (mature trees to be retained)	Note					
1.1.02	Shade shelters (3 off)	No	3	$ 15,000	$ 45,000	$ 19,125	$ 64,125
1.1.03	Red bitumen walk trail (500m x 2.4m)	m2	1200	$ 65	$ 78,000	$ 33,150	$ 111,150
1.1.04	Seating	No	4	$ 2,500	$ 10,000	$ 4,250	$ 14,250
1.1.05	Drinking fountain including dog fountain	No	1	$ 8,000	$ 8,000	$ 3,400	$ 11,400
1.1.06	Public toilets (self-cleaning style)	No	1	$ 160,000	$ 160,000	$ 68,000	$ 228,000
1.1.07	Community information signage - aluminium - (7 No.) - 1 at each path entrance	Item			$ 35,000	$ 14,875	$ 49,875
1.1.08	Community information signage - Digital (2 No)	Item			$ 30,000	$ 12,750	$ 42,750
1.1.09	Clear open turf areas with good sightlines including soil preparation and reticulation	m2	14000	$ 28	$ 392,000	$ 166,600	$ 558,600
1.1.10	Rain gardens	m2	6000	$ 45	$ 270,000	$ 114,750	$ 384,750
1.1.11	Drought resistant groundcover planting	m2	5000	$ 25	$ 125,000	$ 53,125	$ 178,125
1.1.12	Raised podium with shade canopy	No	1	$ 60,000	$ 60,000	$ 25,500	$ 85,500
1.1.13	Power and water connections for events	Item			$ 70,000	$ 29,750	$ 99,750
1.1.14	Security lighting - solar powered	No	40	$ 10,000	$ 400,000	$ 170,000	$ 570,000
1.1.15	Feature lighting	Item			$ 100,000	$ 42,500	$ 142,500
1.1.16	Play equipment and shade sails	Item			$ 200,000	$ 85,000	$ 285,000
1.1.17	Public art – stand-alone and integrated - 1%	Item			$ 35,000	$ 14,875	$ 49,875
1.1.18	Perimeter log barrier to park boundary	m	800	$ 30	$ 24,000	$ 10,200	$ 34,200
1.1.19	BBQ's	Item	2	$ 8,000	$ 16,000	$ 6,800	$ 22,800
1.1.20	Site furniture - bins, etc	Item			$ 4,500	$ 1,913	$ 6,413
1.1.21	Clear site of vegetation, small trees etc	m2	14000	$ 2	$ 28,000	$ 11,900	$ 39,900
1.1.22	Allowance for demolition and removal of existing buildings	Item	1	$ 50,000	$ 50,000	$ 21,250	$ 71,250
1.1.23	Carparking	m2	945	$ 85	$ 80,325	$ 34,138	$ 114,463
	Total Stage 1 - Parkland				$ 2,220,825	$ 943,851	$ 3,164,676

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
1.2	**External Services**						
Note	It has been assumed that all infrastructure services (Sewer, water, gas, electricity) will be provided to the						
1.2.01	Allowance - stormwater services	Item			$ 120,000	$ 51,000	$ 171,000
1.2.02	Allowance - sewer services	Item			$ 10,000	$ 4,250	$ 14,250
1.2.03	Allowance - water services	Item			$ 50,000	$ 21,250	$ 71,250
1.2.04	Allowance - electricity services	Item			$ 100,000	$ 42,500	$ 142,500
1.2.05	Allowance - gas services	Item			$ -	$ -	$ -
1.2.06	Allowance - fire services	Item			$ -	$ -	$ -
						$ -	$ -
	Total Stage 1 - External Services				$ 280,000	$ 119,000	$ 399,000
	TOTAL - STAGE 1				**$ 2,500,825**	**$ 1,062,851**	**$ 3,563,676**
	TOTAL - TOWN PARK - ALL STAGES				**$ 2,500,825**	**$ 1,062,851**	**$ 3,563,676**
	Goods and Services Tax	Item		10%			$ 356,368
	Total Town Park All stages including GST						$ 3,920,043

Table 17: Order of probable costs for the Town Park

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
COSTINGS							
Please note that this information is for indicative budgeting purposes only and should not be used as the basis for making a financial commitment							
Prior to making a financial commitment a detailed budget should be prepared based on input from the architect and the relevant consultants							
FORRESTFIELD NORTH COMMUNITY HUB							
COMMUNITY HUB - STAGE 1							
Refer to Concept Plans - Figure 10, Figure 12 and Figure 14							
It has been assumed that all infrastructure roads and street footpaths will be provided by others and do not form part of these costs							
1.1	**Child Care Centre**						
1.1.01	Child Care Building	m2	250	$ 2,700	$ 675,000	$ 394,875	$ 1,069,875
1.1.02	Child Care Outdoor	m2	350	$ 200	$ 70,000	$ 40,950	$ 110,950
	Total Child Care Centre				$ 745,000	$ 435,825	$ 1,180,825
2.1	**Library**						
2.1.01	Additional cost to fit out top floor of Community Centre as temporary Library	m2	890	$ 800	$ 712,000	$ 416,520	$ 1,128,520
2.1.02	Additional cost to fit out top floor of Fitness Centre as temporary Library	m2	310	$ 800	$ 248,000	$ 145,080	$ 393,080
2.1.03	Lift	Item			$ 90,000	$ 52,650	$ 142,650
2.1.04	Stairs	Item			$ 20,000	$ 11,700	$ 31,700
				Total Library	$ 1,070,000	$ 625,950	$ 1,695,950
3.0	**Community Centre**						
3.1.01	Community Centre - Ground Floor	m2	900	$ 2,100	$ 1,890,000	$ 1,105,650	$ 2,995,650
3.1.02	Community Centre including bridge with Library - First Floor	m2	890	$ 2,100	$ 1,869,000	$ 1,093,365	$ 2,962,365
3.1.03	Lift - Service Lift	Item			$ 90,000	$ 52,650	$ 142,650
3.1.04	Stairs	Item			$ 20,000	$ 11,700	$ 31,700
3.1.05	Allowance for airconditioned glass bridge to link temporary library in Community Centre and Fitness centre	Item			$ 154,304	$ 90,268	$ 244,572
3.1.06	Allowance for temporary foyer to the Western end of Community (180m^2)	Item			$ 361,650	$ 211,565	$ 573,215
	Total Community Centre	m2	1790	$ 2,450	$ 4,384,954	$ 2,565,198	$ 6,950,152

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
4.1	**Indoor Heated Aquatic Facility**						
	Swimming Pools						
Note	Pool costs include filtration and pool equipment, backwash tanks and balance tanks						
4.1.1	Indoor 25m x 8 lane pool	m2	1085	$ 2,100	$ 2,278,500	$ 1,332,923	$ 3,611,423
4.1.2	Learn to Swim pool	m2	120	$ 2,100	$ 252,000	$ 147,420	$ 399,420
4.1.3	Hydro Pool	m2	70	$ 2,400	$ 168,000	$ 98,280	$ 266,280
4.1.4	Leisure Water	m2	250	$ 2,100	$ 525,000	$ 307,125	$ 832,125
		m2	1525		$ 3,223,500	$ -	$ 3,223,500
4.1.5	Heating to pools	Item			$ 220,000	$ 128,700	$ 348,700
4.1.6	Pool blankets	Item			$ 40,000	$ 23,400	$ 63,400
4.1.7	Pool hoist to hydrotherapy	Item			$ 20,000	$ 11,700	$ 31,700
4.1.8	Allowance for lane ropes etc	Item			$ 50,000	$ 29,250	$ 79,250
4.1.9	Allowance for water features	Item			$ 200,000	$ 117,000	$ 317,000
					$ 530,000	$ -	$ 530,000
	Aquatic Facility including foyer with Community Centre - Ground Floor						
4.1.10	Pool Hall	m2	1670	$ 2,100	$ 3,507,000	$ 2,051,595	$ 5,558,595
4.1.11	Electoral Office	m2	100	$ 2,400	$ 240,000	$ 140,400	$ 380,400
4.1.12	Changerooms	m2	160	$ 2,700	$ 432,000	$ 252,720	$ 684,720
4.1.13	Reception/Lobby	m2	20	$ 2,500	$ 50,000	$ 29,250	$ 79,250
4.1.14	Administration	m2	150	$ 2,400	$ 360,000	$ 210,600	$ 570,600
4.1.15	Kiosk	m2	60	$ 3,500	$ 210,000	$ 122,850	$ 332,850
4.1.16	Plantroom	m2	170	$ 1,500	$ 255,000	$ 149,175	$ 404,175
4.1.17	Storage areas	m2	120	$ 1,500	$ 180,000	$ 105,300	$ 285,300
4.1.18	Spa/Steam/Sauna	m2	80	$ 5,000	$ 400,000	$ 234,000	$ 634,000
4.1.19	Creche indoor	m2	120	$ 2,700	$ 324,000	$ 189,540	$ 513,540
4.1.20	Circulation	m2	249	$ 2,100	$ 522,900	$ 305,897	$ 828,797
		m2	2899	$ 2,236	$ 6,480,900	$ 3,791,327	$ 10,272,227
4.1.21	Creche outdoor	m2	160	$ 480	$ 76,800	$ 44,928	$ 121,728
4.1.22	Service yard	m2	50	$ 2,100	$ 105,000	$ 61,425	$ 166,425
					$ 181,800	$ 106,353	$ 288,153
Total Indoor Heated Aquatic Facility		m2	2899	$ 3,593	$ 10,416,200	$ 3,897,680	$ 14,313,880
4.2	**Outdoor Swimming Pool and Slides**						
	Total Outdoor Swimming Pool & Water Slide Facility				$ -	Refer Stage 2	

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
5.1	**Fitness Centre**						
Note	Excludes gymnasium equipment						
5.1.1	Reception	m2	30	$ 2,500	$ 75,000	$ 43,875	$ 118,875
5.1.2	Lobby	m2	10	$ 2,500	$ 25,000	$ 14,625	$ 39,625
5.1.3	Administration	m2	45	$ 2,400	$ 108,000	$ 63,180	$ 171,180
5.1.4	Change/locker room	m2	80	$ 2,700	$ 216,000	$ 126,360	$ 342,360
5.1.5	Cardio Zone	m2	100	$ 2,100	$ 210,000	$ 122,850	$ 332,850
5.1.6	Pin-loaded Zone	m2	100	$ 2,100	$ 210,000	$ 122,850	$ 332,850
5.1.7	Free weights Zone	m2	100	$ 2,100	$ 210,000	$ 122,850	$ 332,850
5.1.8	GF Studio 1	m2	110	$ 2,100	$ 231,000	$ 135,135	$ 366,135
5.1.9	GF Studio 2	m2		$ 2,100	$ -	$ -	$ -
5.1.10	PT room	m2	45	$ 2,100	$ 94,500	$ 55,283	$ 149,783
5.1.11	Appraisal Room	m2	15	$ 2,100	$ 31,500	$ 18,428	$ 49,928
5.1.12	Spin Room	m2	80	$ 2,100	$ 168,000	$ 98,280	$ 266,280
5.1.13	Plantroom	m2	50	$ 1,500	$ 75,000	$ 43,875	$ 118,875
5.1.14	Storage	m2	25	$ 1,500	$ 37,500	$ 21,938	$ 59,438
5.1.15	Allied Health	m2		$ 2,400	$ -	$ -	$ -
5.1.16	Circulation	m2	100	$ 2,000	$ 200,000	$ 117,000	$ 317,000
5.1.17	Are allocated to stage 1 library	m2	310	$ 2,000	$ 620,000	$ 362,700	$ 982,700
		m2	1200	$ 1,576	$ 1,891,500	$ 1,469,228	$ 3,980,728
	Lifts and Stairs						
5.1.17	Lift serving two levels	No	1	$90,000	$ 90,000	$ 52,650	$ 142,650
5.1.18	Staircases	m ris	12	$ 5,000	$ 60,000	$ 35,100	$ 95,100
					$ 150,000	$ 87,750	$ 237,750
	Total Fitness Centre	m2	1200	$ 1,701	$ 2,041,500	$ 1,556,978	$ 4,218,478
6.1	**Car Park**						
6.1.01	Child Care Drop Off and parking bays	m2	600	$ 85	$ 51,000	$ 21,675	$ 72,675
6.1.02	On grade open carpark	Bays	300	$ 2,100	$ 630,000	$ 267,750	$ 897,750
6.1.03	Lighting to carpark	Item			$ 85,000	$ 36,125	$ 121,125
			Total Car Park		$ 766,000	$ 325,550	$ 1,091,550
7.1	**External Works**						
7.1.01	Landscaping including reticulation	m2	4000	$ 56	$ 224,000	$ 95,200	$ 319,200
7.1.02	External paving to building	m2	1900	$ 140	$ 266,000	$ 113,050	$ 379,050
7.1.03	Fencing to pool external areas	m2	130	$ 145	$ 18,850	$ 8,011	$ 26,861
7.1.04	Allowance for playground equipment and shadesails	Item			$ 75,000	$ 31,875	$ 106,875
7.1.05	BBQ	No	3	$ 8,000	$ 75,000	$ 31,875	$ 106,875
7.1.06	External signage	Item			$ 50,000	$ 21,250	$ 71,250
7.1.07	Landscaping including reticulation to area of Future Library comprising portion of paving	m2	721	$ 98	$ 70,658	$ 30,030	$ 100,688
7.1.08	Allowance for site furniture to area of Future Library	Item			$ 30,000	$ 12,750	$ 42,750
			Total External Works		$ 809,508	$ 344,041	$ 1,153,549

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
8.1	**External Services**						
Note	It has been assumed that all infrastructure services have been provided to the boundary of the site						
8.1.01	External Stormwater - Allowance	Item			$ 100,000	$ 42,500	$ 142,500
8.1.02	External Sewer drainage- Allowance	Item			$ 150,000	$ 63,750	$ 213,750
8.1.03	External Water - Allowance	Item			$ 50,000	$ 21,250	$ 71,250
8.1.04	External Gas service	Item			$ 25,000	$ 10,625	$ 35,625
8.1.05	External Fire service	Item			$ 100,000	$ 42,500	$ 142,500
8.1.06	External light and power - Allowance for lighting to pool area	Item			$ 50,000	$ 21,250	$ 71,250
	Total External Services				$ 475,000	$ 201,875	$ 676,875
9.00	**TOTAL STAGE 1 CONSTRUCTION COST**						**$ 31,281,258**
	Goods and Services Tax	Item		10%			$ 3,128,126
	Total Stage 1 cost including GST						**$ 34,409,384**

Table 18: Order of probable costs for Stage 1 FFN Community Hub Infrastructure

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
COMMUNITY HUB - STAGE 2							
Refer to Concept Plans - Figure 10, Figure 12 and Figure 14							
It has been assumed that all infrastructure roads and street footpaths will be provided by others and do not form part of these costs							
1.2	**Child Care Centre**						
1.2.01	Child Care Building	m2	150	$ 2,700	$ 405,000	$ 236,925	$ 641,925
1.2.02	Child Care Outdoor	m2	250	$ 200	$ 50,000	$ 29,250	$ 79,250
	Total Child Care Centre				$ 455,000	$ 266,175	$ 721,175
2.2	**Library**						
2.01	Library - Ground Floor	m2	1200	$ 2,900	$ 3,480,000	$ 2,035,800	$ 5,515,800
2.02	Library - First Floor	m2	400	$ 2,900	$ 1,160,000	$ 678,600	$ 1,838,600
2.03	Lift	Item			$ 90,000	$ 52,650	$ 142,650
2.04	Stairs	Item			$ 20,000	$ 11,700	$ 31,700
2.05	Alllowance for demolition of temporary foyer, lift and stairs	Item			$ 27,000	$ 15,795	$ 42,795
2.06	New foyer (250m2)				$ 626,860	$ 366,713	$ 993,573
			Total Library		$ 5,403,860	$ 3,161,258	$ 8,565,118

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
3.2	**Community Centre**						
3.2.01	Refurbish lower floor to align with new developments	m2	900	$ 1,000	$ 900,000	$ 526,500	$ 1,426,500
3.2.02	Refurbish top floor after relocation of Library	m2	890	$ 1,000	$ 890,000	$ 520,650	$ 1,410,650
	Total Community Centre	m2	890	$ 2,011	$ 1,790,000	$ 1,047,150	$ 2,837,150
4.2	**Outdoor Swimming Pool and Slides**						
	Swimming Pool						
4.2.1	50m x 20m (8 lane) reinforced concrete swimming pool with ramp pool access complete including filtration and pool equipment. Includes dive pool extension, backwash tank, balance tank	Item			$ 2,415,000	$ 1,412,775	$ 3,827,775
4.2.2	Allowance to heat pool	Item			$ 220,000	$ 128,700	$ 348,700
4.2.3	New pool plant room	m2	125	$ 1,500	$ 187,500	$ 109,688	$ 297,188
4.2.4	External equipment store	m2	55	$ 1,500	$ 82,500	$ 48,263	$ 130,763
4.2.5	Internal equipment store	m2	35	$ 1,800	$ 63,000	$ 36,855	$ 99,855
4.2.6	Allowance for lane ropes etc	Item			$ 50,000	$ 29,250	$ 79,250
4.2.7	Pool blankets - 50m pool	Item			$ 80,000	$ 46,800	$ 126,800
4.2.8	Concourse paving	m2	800	$ 140	$ 112,000	$ 65,520	$ 177,520
4.2.9	Concourse drainage	Item			$ 10,800	$ 6,318	$ 17,118
4.2.10	Tiered seating and shade cover	m2	550	$ 1,100	$ 605,000	$ 353,925	$ 958,925
4.2.11	Life guard centre	m2	48	$ 750	$ 36,000	$ 21,060	$ 57,060
4.2.12	Service yard	m2	75	$ 1,000	$ 75,000	$ 43,875	$ 118,875
	Sub-Total Swimming Pool				$ 3,936,800	$ 2,303,028	$ 6,239,828
	Water Slide Facility						
4.2.13	Allowance for water slides including stairs and launching pad facility	Item			$ 1,000,000	$ 585,000	$ 1,585,000
4.2.14	Filtration system	Item			$ 135,000	$ 78,975	$ 213,975
	Sub-Total Water Slide Facility				$ 1,135,000	$ 663,975	$ 1,798,975
	Total Outdoor Swimming Pool & Water Slide Facility				$ 5,071,800	$ 2,967,003	$ 8,038,803

Item	Description	Unit	Qnty	Rate	Amount	Project Costs	Item Cost
5.2	**Fitness Centre**						
	Lifts and Stairs						
5.2.01	Lift serving two levels - Refurbishment	No	1	$25,000	$ 25,000	$ 14,625	$ 39,625
5.2.02	Staircases	m ris	12	$ -	$ -	$ -	$ -
					$ 25,000	$ 14,625	$ 39,625
	Refurbishment						
5.2.03	Refurbish top floor after relocation of Library	m2	310	$ 1,200	$ 372,000	$ 217,620	$ 589,620
5.2.04	Refurbish balance of Fitness Centre after relocation of Library	m2	890	$ 1,000	$ 890,000	$ 520,650	$ 1,410,650
					$ 1,262,000	$ 738,270	$ 2,000,270
	Total Fitness Centre	m2	1200	$ 1,073	$ 1,287,000	$ 752,895	$ 2,039,895
6.2	**Car Park**						
6.2.01	On grade open carpark	Bays	100	$ 2,100	$ 210,000	$ 89,250	$ 299,250
6.2.02	Lighting to carpark	Item			$ 85,000	$ 36,125	$ 121,125
						$ -	
			Total Car Park		$ 295,000	$ 125,375	$ 420,375
7.2	**External Works**						
7.2.01	Clear landscaping including reticulation to area of Future Library	m2	721	$ 25	$ 18,025	$ 7,660.63	$ 25,685.63
7.2.02	Remove site furniture to area of Future Library	Item			$ 5,000	$ 2,125.00	$ 7,125.00
			Total External Works		$ 23,025	$ 9,786	$ 32,811
8.2	**External Services**						
Note	It has been assumed that all infrastructure services have been provided to the boundary of the site						
8.2.01	External Stormwater - Allowance	Item			$ 10,000	$ 4,250	$ 14,250
8.2.02	External Sewer drainage- Allowance	Item			$ 5,000	$ 2,125	$ 7,125
8.2.03	External Water - Allowance	Item			$ 5,000	$ 2,125	$ 7,125
8.2.04	External Gas service	Item			$ 5,000	$ 2,125	$ 7,125
8.2.05	External Fire service	Item			$ 10,000	$ 4,250	$ 14,250
			Total External Services		$ 35,000	$ 14,875	$ 49,875
	TOTAL STAGE 2 CONSTRUCTION COST				**$ 14,360,685**	**$ 8,344,517**	**$ 22,705,202**
	Goods and Services Tax	Item		10%			$ 2,270,520
	Total Stage 2 cost including GST						**$ 24,975,722**

Table 19: Order of probable costs for Stage 2 FFN Community Hub Infrastructure

These costs have then been escalated through to the date of construction as detailed in Table 8 in accordance with construction cost index history and projections provided by the Australian Institute of Quantity Surveyors. The effect of cost escalation is shown in table 20 using the multiplier in row 3 of the table.

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	Element	Current Cost June 2021	Year	Stage 1 2025	Stage 1 2026	Stage1 2027	Stage 1 2028	Stage 1 2030
				1.134	1.169	1.204	1.241	1.318
	Community Hub							
1.1	Child Care Centre - Stage 1	$ 1,180,825	2026	-	1,380,190	-	-	-
1.2	Child Care Centre - Stage 2	$ 721,175	2040	-	-	-	-	-
2.1	Branch Library - Stage 1	$ 1,695,950	2028	-	-	-	2,105,050	-
2.2	Branch Library - Stage 2	$ 8,565,118	2042	-	-	-	-	-
3.1	Community Centre - Stage 1	$ 6,950,152	2028	-	-	-	8,626,680	-
3.2	Community Centre - Stage 2	$ 2,837,150	2042	-	-	-	-	-
4.1	Aquatic Centre - Stage 1	$ 14,313,880	2027	-	-	17,240,852	-	-
4.2	Aquatic Centre - Stage 2	$ 8,038,803	2035	-	-	-	-	-
5.1	Fitness Centre - Stage 1	$ 4,218,478	2027	-	-	5,081,092	-	-
5.2	Fitness Centre - Stage 2	$ 2,039,895	2042	-	-	-	-	-
6.1	Carpark - Stage 1	$ 1,091,550	2026	-	1,275,842	-	-	-
6.2	Carpark - Stage 2	$ 420,375	2035	-	-	-	-	-
7.1	External Works - Stage 1	$ 1,153,549	2025	1,308,403	-	-	-	-
7.2	External Works - Stage 2	$ 32,811	2034	-	-	-	-	-
8.1	External Services - Stage 1	$ 676,875	2025	767,739	-	-	-	-
8.2	External Services - Stage 2	$ 49,875	2034	-	-	-	-	-
		$ 53,986,460		2,076,142	2,656,032	22,321,944	10,731,730	-
	Sports Precinct							
9.1	Stage 1 - Playing Fields and Changeroom	$ 5,716,109	2030	-	-	-	-	7,534,351
9.2	Stage 2 - Clubhouse	$ 1,300,528	2040	-	-	-	-	-
9.3	Stage 3 - School Oval	$ 1,409,904	2045	-	-	-	-	-
		$ 8,426,541		-	-	-	-	7,534,351
	Town Park							
10.1	Stage 1 - Parkland	$ 3,563,676	2027	-	-	4,292,394	-	-
		$ 3,563,676		-	-	4,292,394	-	-
11.0	**TOTAL CONSTRUCTION COST**	**$ 65,976,677**		**2,076,142**	**2,656,032**	**26,614,338**	**10,731,730**	**7,534,351**
13.0	**ESCALATION**							
	Current Total Construction Cost	$ 65,976,677						
13.1	Total Escalation to 2045	**$ 28,640,387**						
13.0	**ESTIMATED TOTAL COMMITMENT**	**$ 94,617,064**		**$ 2,076,142**	**$ 2,656,032**	**$ 26,614,338**	**$ 10,731,730**	**$ 7,534,351**

	Element	Current Cost June 2021	Year	Stage2 2034	Stage2 2035	Stage2 2040	Stage2 2042	Stage 3 2045	Total
				1.486	1.532	1.780	1.890	2.069	
	Community Hub								
1.1	Child Care Centre - Stage 1	$ 1,180,825	2026	-	-	-	-	-	$ 1,380,190
1.2	Child Care Centre - Stage 2	$ 721,175	2040	-	-	1,283,707	-	-	$ 1,283,707
2.1	Branch Library - Stage 1	$ 1,695,950	2028	-	-	-	-	-	$ 2,105,050
2.2	Branch Library - Stage 2	$ 8,565,118	2042	-	-	-	16,190,291	-	$ 16,190,291
3.1	Community Centre - Stage 1	$ 6,950,152	2028	-	-	-	-	-	$ 8,626,680
3.2	Community Centre - Stage 2	$ 2,837,150	2042	-	-	-	5,362,948	-	$ 5,362,948
4.1	Aquatic Centre - Stage 1	$ 14,313,880	2027	-	-	-	-	-	$ 17,240,852
4.2	Aquatic Centre - Stage 2	$ 8,038,803	2035	-	12,313,364	-	-	-	$ 12,313,364
5.1	Fitness Centre - Stage 1	$ 4,218,478	2027	-	-	-	-	-	$ 5,081,092
5.2	Fitness Centre - Stage 2	$ 2,039,895	2042	-	-	-	3,855,930	-	$ 3,855,930
6.1	Carpark - Stage 1	$ 1,091,550	2026	-	-	-	-	-	$ 1,275,842
6.2	Carpark - Stage 2	$ 420,375	2035	-	643,906	-	-	-	$ 643,906
7.1	External Works - Stage 1	$ 1,153,549	2025	-	-	-	-	-	$ 1,308,403
7.2	External Works - Stage 2	$ 32,811	2034	48,770	-	-	-	-	$ 48,770
8.1	External Services - Stage 1	$ 676,875	2025	-	-	-	-	-	$ 767,739
8.2	External Services - Stage 2	$ 49,875	2034	74,134	-	-	-	-	$ 74,134
		$ 53,986,460		122,904	12,957,270	1,283,707	25,409,169	-	$ 77,558,899
	Sports Precinct								
9.1	Stage 1 - Playing Fields and Changerooms	$ 5,716,109	2030	-	-	-	-	-	$ 7,534,351
9.2	Stage 2 - Clubhouse	$ 1,300,528	2040	-	-	2,314,968	-	-	$ 2,314,968
9.3	Stage 3 - School Oval	$ 1,409,904	2045	-	-	-	-	2,916,452	$ 2,916,452
		$ 8,426,541		-	-	2,314,968	-	2,916,452	$ 12,765,772
	Town Park								
10.1	Stage 1 - Parkland	$ 3,563,676	2027	-	-	-	-	-	$ 4,292,394
		$ 3,563,676		-	-	-	-	-	$ 4,292,394
11.0	**TOTAL CONSTRUCTION COST**	**$ 65,976,677**		**122,904**	**12,957,270**	**3,598,676**	**25,409,169**	**2,916,452**	**$ 94,617,064**
13.0	**ESCALATION**								
	Current Total Construction Cost	$ 65,976,677							
13.1	Total Escalation to 2045	**$ 28,640,387**							
13.0	**ESTIMATED TOTAL COMMITMENT**	**$ 94,617,064**		**122,904**	**12,957,270**	**3,598,676**	**25,409,169**	**2,916,452**	**$ 94,617,064**

Table 20: Escalation of community infrastructure costs to build-out

14. DEVELOPER CONTRIBUTIONS

The following table details the estimated percentage of the population serviced by each of the major elements of community infrastructure:

- on a suburb by suburb basis for the foothills' catchment
- for the balance of the City for the hills' catchment

By way of explanation, the community centre will service Forrestfield North residents, be they in the residential or TOD precinct, and a large percentage of the high Wycombe and Maida Vale communities but a slightly lesser share of the Forrestfield. These percentages are influenced by the availability of alternative facilities (refer table 8) and also the scale and diversity of amenity proposed for the community centre in the hub.

The library will be a major branch outlet servicing the foothills. The closure of the High Wycombe branch will direct all of the High Wycombe residents to the community hub and the downsizing of the Forrestfield library will send the majority of current users to the community hub whilst maintaining a service of convenience for some Forrestfield, Maida Vale and Wattle Grove residents. The commuters from the hills will make use of the library due to its convenience near the train station.

The aquatic centre and fitness centre will service 100% of foothills residents and an estimated 40% of hills residents. The scale of the pool being a major attractor and a way point for commuters using the train.

The child care centre will have a broad attraction largely influenced by the commuters dropping their children off before catching the train to work.

The sports precinct is proposed to be a district scale facility although the majority of the users are anticipated to come from the foothills.

The town park will service 100% of the Forrestfield North residents, but a much smaller percentage of residents from other suburbs, primarily because they have local parks in their own area.

Table 21 identifies the developer contributions for the Forrestfield North TOD precinct and the Forrestfield North residential precinct based on the population served by the various facilities at catchment build-out projected to 2050.

Developer contributions	Community Centre	Branch library	Aquatic centre	Fitness centre	Childcare centre	Sports precinct	Town Park
% of resident population in each suburb served at build-out in 2050							
Forrestfield North - TOD Precinct	100%	100%	100%	100%	100%	100%	100%
Forrestfield North - Residential Precinct	100%	100%	100%	100%	100%	100%	100%
High Wycombe	75%	100%	100%	100%	50%	30%	5%
Forrestfield	50%	70%	100%	65%	50%	30%	40%
Maida Vale	70%	90%	100%	75%	50%	30%	2%
Wattle Grove	80%	80%	100%	75%	50%	30%	50%
Commuters / Hills residents	15%	15%	40%	15%	25%	20%	5%
Forecast resident population by suburb at Build-out (2050)							
Forrestfield North - TOD Precinct	1,359	1,359	1,359	1,359	1,359	1,359	1,359
Forrestfield North - Residential Precinct	5,998	5,998	5,998	5,998	5,998	5,998	5,998
High Wycombe	13,304	13,304	13,304	13,304	13,304	13,304	13,304
Forrestfield	16,684	16,684	16,684	16,684	16,684	16,684	16,684
Maida Vale	12,183	12,183	12,183	12,183	12,183	12,183	12,183
Wattle Grove	10,752	10,752	10,752	10,752	10,752	10,752	10,752
Hills population (balance of the city)	15,414	15,414	15,414	15,414	15,414	15,414	15,414
Catchment population catered for at build out (2050) - Demonstrated Need - Nexus							
Forrestfield North - TOD Precinct	1,359	1,359	1,359	1,359	1,359	1,359	1,359
Forrestfield North - Residential Precinct	5,998	5,998	5,998	5,998	5,998	5,998	5,998
High Wycombe	9,978	13,304	13,304	13,304	6,652	3,991	665
Forrestfield	8,342	11,679	16,684	10,845	8,342	5,005	6,674
Maida Vale	8,528	10,965	12,183	9,137	6,092	3,655	244
Wattle Grove	8,602	8,602	10,752	8,064	5,376	3,226	5,376
Commuters / Hills residents	2,312	2,312	6,166	2,312	3,854	3,083	771
FFN TOD precinct contribution at build-out	**3.0%**	**2.5%**	**2.0%**	**2.7%**	**3.6%**	**5.2%**	**6.4%**
FFN Residential precinct contribution at build-out	**13.3%**	**11.1%**	**9.0%**	**11.8%**	**15.9%**	**22.8%**	**28.4%**

Table 21: FFN developer contributions for community infrastructure

element.

Technical Appendix F – TIA

TRANSPORT IMPACT ASSESSMENT

Forrestfield North

Residential Precinct

Septmeber 2021

Final

city of kalamunda

kctt

Transport Impact Assessment
KC00604.000 Forrestfield North - Residential Precinct

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Prepared by: **KCTT (Trading as KC Traffic and Transport Pty Ltd)**
ABN 35 148 970 727 |
Postal address: **PERTH:** Unit 7, No 10 Whipple Street Balcatta WA 6021 | **BELGRADE**: 23 Hilandarska, Beograd 11000
Phone: 08 9441 2700 |
Website: www.kctt.com.au |

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Appendix 1 - The layout of the proposed development
Appendix 2 - Transport Planning and Traffic Plans
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Appendix 4 - Traffic Modelling Report

1 Executive Summary

GENERAL

- The Local Structure Plan Area for Residential Precinct is located within the City of Kalamunda, approximately 12km from the Perth CBD. Roe Highway bounds it to the east, part of the existing Maida Vale Residential area to the north, Milner Road to the west and Sultana Road West to the south.
- According to the LPS, the subject lots are historically zoned rural living with approximately fifty rural single houses within the proposed area. The LSP area for the Residential Precinct is surrounded by complimentary residential uses to the north and industrial and commercial uses to the south and west.
- This iteration of the Transport Impact Assessment addresses the reduced projected yields in both – Residential Precinct and the TOD Precinct. The previous reporting assessed a maximum build-out option, while this report will assess what is deemed to be a realistic development projection.
- High Wycombe Train Station is under construction currently. Once completed, this station will be the terminus of the extended Bayswater line providing direct connectivity to the airport and CBD.
- Proposed Land Uses within the subject LSP area are residential (total of 2,417dwellings), primary school (estimated for 540 students) and recreational areas inclusive of District and Local Open Space. Please refer to Section 2.3. Land Uses for details.
- Following authorities were consulted (outside of TAG group meetings):-
    - Main Roads WA – for new road alignments, ROM modelling, planned road and intersection upgrades in the immediate network;
    - PTA – for known proposed public transportation expansion routes;
    - Department of Transport – for sustainable initiatives inclusive of but not limited to Safe Active Streets, autonomous vehicles etc.
    - Metronet – for planned development in and around the High Wycombe Train Station.
- In all projections, three horizon years were considered:
    - 2031 – it is assumed that 15% of Forrestfield North Residential Precinct will be constructed
    - 2041 – it is assumed that 65% of Forrestfield North Residential Precinct will be constructed
    - 2050 – it is assumed that 100% of Forrestfield North Residential Precinct will be constructed.

ROAD NETWORK

- Within the LSP area, there are 6 existing roads where some of the roads are still unconstructed. Most notable changes to the existing road network include:
    - Addition of TOD Connector;
    - Extension of Raven Street
    - Realignment of part of Brae Road;
    - Milner Road upgrade; and
    - Maida Vale Road upgrade.

Note: Overpass connecting Forrestfield North and Maida Vale South over Roe Highway is planned after 2050; therefore it was not included in traffic distribution for for the purposes of this report.

Some of the existing intersections will require and upgrade, while new intesections will be created. Key intersections in the LSP area are:

- Maida Vale Road / Milner Road intersection will be reconfigured from sign controlled to a roundabout;
- Milner Road / Raven Street and Milner Road / Stewart Road will also be configured to a roundabout;
- Milner Road / TOD Connector will be ultimately configured as a sign controlled intersection.

Please refer to Section 2.20 Proposed Internal Road Network for proposed cross-sections of existing and proposed roads.

PUBLIC TRANSPORT

- Since the surrounding area is about to go through significant changes, it is expected that public transport services will be adjusted to suit (frequency and distribution). It is expected that buses will operate along Berkshire Road, Dundas Road, Maida Vale Road (feeder routes to High Wycombe Train Station) and along the future overpass connecting the TOD Connector and Ravenswood Road, when constructed. After completion of the overpass, new routes will likely be introduced connecting Maida Vale South and other suburbs east of the Roe Highway with the High Wycombe Train Station primarily. However it should be noted that the overpass will be constructed some time after 2050; therefore it is beyond the scope of this LSP.

- A driverless shuttle servicing the residential area and providing a direct connection to the railway station should be considered. The potential route would include Stewart Road, Brand Road and TOD connector. Once the overpass is constructed, the service can be expanded further into Maida Vale South (after 2050).

CYCLING NETWORK

- Every major road within the LSP area will have either a shared or a separate cycling path, while all minor roads will have pedestrian paths.

- Separate Cycle Lanes are proposed for:
    - TOD Connector
    - Stewart Road
    - Milner Road (north of Sultana Road West)
    - Maida Vale Road
- Bicycle parking should be provided in the proposed school, district open space, and commercial areas to further encourage cycling. Safe bicycle storage should be ample at the High Wycombe Train Station. This will allow residents to use sustainable modes of transport and create a fully integrated transportation system. There is potential to consider a smart bike network within the City of Kalamunda that would complement the new Cycling Plan for the City of Kalamunda.

PARKING

- On-street parking will be provided through each of the main linkages in the overall Forrestfield North project area and the LSP area specifically. The following streets, as a minimum, will have some form of on-street parking:
    - Brae Road

  - Brand Road
  - Milner Road (north of Sultana Road West)
  - TOD Connector
  - Stewart Road
  - Some lower-order roads
- Well-designed on-street parking will contribute to overall street amenity and will help reduce average operating speeds on the road.
- In general, when providing on-street parking, no more than 4 (four) consecutive bays should be provided. Parking lanes will have to be broken with mature vegetation maintained appropriately to ensure appropriate sight distances are maintained.
- Parking/charging points for electric vehicles should be provided at a minimum rate of 1 in 20 standard parking bays (5% as prescribed in Green Star - Design and As Built), preferably 1 in 10. This requirement should be applied to all public parking areas and parking in multi-dwelling complexes.
- The use of electric vehicles is on the rise, and given the reduction in the pollution they provide, the use should be further encouraged. While in individual dwellings, private owners/developers can choose to implement charging points for electric vehicles, in multiple dwelling complexes and non-residential buildings, it is important to provide charging points so that the residents can use electric vehicles. The mandatory rate should be reviewed and revised every 5 years given the technology leaps.

- It is expected that delivery and service vehicles (such as waste removal vehicles) servicing the residential area will not require designated parking spaces, given that they can operate safely within the road reserve.

TRANSPORT IMPACT

- Currently at the LSP area, there are approximately 50 single residences. This equates to a 450 VPD generated from the Residential Precinct.

- Given that a primary school and a district open space will be constructed within the Residential Precinct, there will be some degree of reciprocity of traffic generation and attraction between the uses. The total traffic generated by the Residential Precinct is expected to be approximately 17,914 vehicular trips per day (VPD), with 16,978 VPD being discharged on the external network. The Residential Precinct is likely to generate 2,212 vehicular trips in the AM peak hour and 2,250 vehicular trips in the PM peak hour, with approximately 80% of traffic discharged onto the external road network. While the reporting focuses on the Residential Precinct, the modelling includes residential and all other precincts traffic, inclusive of the future TOD and Activity Precincts. Refer to Appendix 4 for more details on traffic modelling. All proposed roads are sized to cater for the additional traffic volumes successfully.

- Appendix 3 details the performance of the key intersections. Since forecasting was completed for horizon years 2031 and 2050, modelling should be taken with caution, particularly for 2050. ROM model supplied by MRWA shows quite strong growth of passing traffic in this period; however, in reality, the traffic growth will depend on several factors such as:

  - Economic outlook and population growth - ROM model supplied relies on the optimistic outlook and accounts for several approved projects and structure plans. The long term economic trends are difficult to predict in the aftermath of the COVID-19 pandemic.
  - Government policies, development of public transport and other sustainable transportation options - If the development of the state is treated as “business as usual”, unsustainable dependence on the personal vehicle will continue. Suppose all government levels effectively

promote and enable sustainable transportation methods (cycling, public transport, etc.); we can expect a notable mode shift in Western Australia, resulting in a slowdown of traffic growth rates.
- Technology advancement. Given the rapid development of technology, realistic possibility of work from home, active use of online shopping and novel transportation modes, it can be anticipated that by 2050 the way people use space might change drastically. This will naturally affect passing traffic volumes.

- All of the key roads are of the same or lower Liveable Neighbourhoods hierarchy when compared to the previous revisions of this report. (please refer to sections 2.20, 2.22 and 2.22)
- Based on the development yield discussed in this report, the overpass connecting Forrestfield North and Maida Vale South will not be required by 2050.
- In summary, traffic growth on all corridors should be carefully monitored, and requirements for upgrades of the existing network should be regularly reassessed to avoid over-commitment to land-take required to facilitate adequate infrastructure.

2 Transport Impact Assessment

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2.1 Location

Structure Plan	Forrestfield North Residential Precinct – Local Structure Plan.
Street Number	n/a
Road Name/s	n/a
Suburb	City of Kalamunda

Description of Site

The Local Structure Plan Area for Residential Precinct is located within the City of Kalamunda, approximately 12km from the Perth CBD. Roe Highway bounds it to the east, part of the existing Maida Vale Residential area to the north, Milner Road to the west and Sultana Road West to the south.

Subject lots are currently zoned for rural living, with approximately fifty rural single houses within the subject area.

2.2 Technical Literature Used

Local Government Authority	City of Kalamunda
Type of Development	Primarily Residential; with additional land uses: Primary School; Recreational areas inclusive of District and Local Open Space
Are the R-Codes referenced?	YES
If YES, nominate which:	State Planning Policy 7.3 Residential Design Codes Volume 1 - 2019 R-Codes (incorporating amendments gazetted on 2/8/2013, 23/10/15 and 2/3/2018 and 24/5/2019)
Name other Relevant Documents referenced?	Guide to Traffic Management – Part 3: Traffic Studies and Analysis, Austroads, 2008 Guide to Traffic Management – Part 11: Parking, Austroads, 2008 Guide to Traffic Management – Part 12: Traffic Impacts of Developments, Austroads, 2008
Is the NSW RTA Guide to Traffic Generating Developments Version 2.2 October 2002 (referenced to determine trip generation/attraction rates for various land uses) referenced?	YES

Which WAPC Transport Impact Assessment Guideline should be referenced?	Transport Assessment Guidelines for Developments Volume 2 - Structure Plans and Volume 5 - Technical Appendix
Are there applicable LGA schemes for this type of development?	YES
Number of Scheme	No 3
Name of Scheme	City of Kalamunda Local Planning Scheme
Are Austroads documents referenced?	YES
Is the Perth Transport Plan for 3.5 million and beyond referenced?	YES
List of other documents:	Restricted Access Vehicles: Prime Mover, Trailer Combinations – Operating Conditions, Main Roads WA, 2012 Forrestfield Station Access Strategy and Concept Design of Dundas Road, Worley Parsons, 2014 Disability Access and Inclusion Plan 2017-2022, City of Kalamunda

2.3 Land Uses

Are there any existing Land Uses within the Structure Plan Area?	YES
If YES, nominate:	Approximately fifty (50) single residences and associated outbuildings on separate lots
According to the Metropolitan Region Scheme and LPS / TPS, what zone is the Structure Plan Area?	The proposed land is currently zoned Rural – Special Rural (between Roe Highway, Sultana Road West, Milner Road, Raven Street and Poison Gully Creek). Under the Metropolitan Region Scheme (MRS), all the subject properties are zoned Urban.

Proposed Land Uses

How many types of land uses are proposed?	Four (4)
Nominate land use type and yield	Residential; Primary School; Recreational areas inclusive of District and Local Open Space;

Development Type	Single and Grouped Dwellings	Multiple Dwellings	Total Number of Dwellings
Residential	2,267	150	2,417

	Total Area	Estimated No. of Students
Primary School	App 4 ha	540 (Ultimate Scenario)

	Total Area
District Open Space	App 7 ha

Are the proposed land uses complementary with the surrounding land-uses?	The LSP area for Residential Precinct is surrounded by complementary residential uses to the north and industrial and commercial uses to the south and west.

Forrestfield North LSP area consists of a Residential Precinct, TOD Precinct and an Activity Centre Precinct. While this report will focus on a more detailed analysis of the residential precinct, traffic modelling has considered the entire Forrestfield North District Area.

2.4 Local Road Network Information

How many existing roads are there within the Structure Plan Area?	6 (six) roads Parts of some of the roads are still unconstructed

Name of Roads within the Structure Plan Area / Road Classification and Description:

Road 1

Road Name	**Milner Road**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	7.5m
Classification	Local Distributor
Speed Limit	70 km/h
Bus Route	NO
On-street parking	NO
RAV Network	RAV 2; South of Nardine Close only

Road 2

Road Name	**Sultana Road West**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	6m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
RAV Network	NO

Road 3

Road Name	**Brand Road**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	8m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
RAV Network	NO

Road 4

Road Name	**Brae Road**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	6m
Classification	Access Road

Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
RAV Network	NO

Road 5

Road Name	**Stewart Road**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	6.5m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
RAV Network	NO

Road 6

Road Name	**Smokebush Place**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	7m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
Note*	Road partly unconstructed
RAV Network	NO

Name of Other Roads within 2km radius of site, or roads likely to take increased traffic due to the development:

Road 1

Road Name	**Berkshire Road**
Number of Lanes	one lane per direction
Road Reservation Width	approximately 20m
Road Pavement Width	9m (4.5m per lane)
Classification	Distributor B
Speed Limit	70 km/h
Bus Route	286 - Perth - Maida Vale via Belmont Forum 287 - Perth – Forrestfield via Belmont Forum 288 - Perth - Maida Vale via Belmont Forum & Forrestfield 294 - Midland Station - Westfield Carousel via Forrestfield & High Wycombe These bus routes operate east of Roe Highway
On-street parking	NO
RAV Network	RAV 7

Road 2

Road Name	**Dundas Road**
Number of Lanes	one lane per direction
Road Reservation Width	approximately 20m
Road Pavement Width	7m (3.5m per lane)
Classification	Distributor B
Speed Limit	70 km/h
Bus Route	NO
On-street parking	NO
RAV Network	RAV 6 north of Berkshire, RAV 7 south of Berkshiure

Road 3

Road Name	**Maida Vale Road**
Number of Lanes	one lane per direction
Road Reservation Width	approximately 20m
Road Pavement Width	9m (4.5m per lane)
Classification	Distributor B
Speed Limit	60 km/h
Bus Route	YES
If YES Nominate Bus Routes	294 - Midland Station - Westfield Carousel via Forrestfield & High Wycombe 296 - Perth – Kalamunda via Gooseberry Hill Road 298 - Perth - Maida Vale via Belmont Forum & Abernethy Road
On-street parking	NO
RAV Network	NO

Road 5

Road Name	**Roe Highway**
Number of Lanes	two lanes per direction, with central median
Road Reservation Width	approximately 100 m
Road Pavement Width	7m pavement each direction (3.5m lanes) with 12.5m median
Classification	Primary Distributor
Speed Limit	100 km/h - SLK [28.81 - 34.50]
Bus Route	NO
On-street parking	NO
RAV Network	RAV 7

Road 7

Road Name	**Imperial Street**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	6m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
RAV Network	NO

Road 8

Road Name	**Nardine Close**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	10m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
RAV Network	RAV 7

Road 9

Road Name	**Ibis Place**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	6.5m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
Note*	Road still under construction
RAV Network	NO

Road 10

Road Name	**Raven Street**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 20m
Road Pavement Width	6m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
RAV Network	NO

Road 11

Road Name	**Ashby Close**
Number of Lanes	two-way one lane
Road Reservation Width	approximately 18m
Road Pavement Width	6.5m
Classification	Access Road
Speed Limit	50 km/h
Bus Route	NO
On-street parking	NO
RAV Network	RAV 7

2.5 Traffic Volumes

Road Name	Location of Traffic Count	Vehicles Per Day (VPD)	Vehicles per Peak Hour (VPH)				Heavy Vehicle %	Year	
			AM Peak VPH	AM Peak Time	PM Peak VPH	PM Peak Time	*If HV count is Not Available, are HV likely to be in higher volumes than generally expected?*	Date of Traffic Count	*If older than 3 years multiply with a growth rate (3% growth rate per annuum)*
Berkshire Road	West of Roe Highway (SLK 0.75)	6,531	552	06:45	564	15:15	26.8%	2019/ 2020	5,035
	East of Roe Highway (SLK 1.58)	5,829	460	07:45	468	14:45	11.2%	Dec 2015	6,757
	40m East of Milner Road *	5,054	383	07:00	463	16:00	15.9%	Aug 2016	5,688
	West of Roe Highway Ramp (Northbound) **	7,919	511	08:00	748	16:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-
	East of Roe Highway Ramp (Northbound) **	7,101	522	08:00	640	16:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-
	Ramp on to Roe Highway (Northbound) North of Berkshire Road **	2,487	250	08:00	183	16:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-
	West of Roe Highway Ramp (Southbound) **	11,569	849	08:00	1,076	16:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-
	East of Roe Highway Ramp (Southbound) **	11,292	928	08:00	1,047	16:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-
	Ramp on to Roe Highway (Southbound) South of Berkshire Road **	2,551	142	08:00	260	16:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-
Roe Highway	South of Kalamunda Road (SLK 33.94)	44,657	3,624	07:00	3,823	16:15	12.7%	2018/ 2019	-
	North of Berkshire Road	53,578	4,285	07:15	4,848	16:00	17.1%	2019/ 2020	-
	Ramp off to Maida Vale Road (Northbound) South of Maida Vale Road (SLK 0.26)	4,946	293	11:30	480	16:00	11.7%	Dec 2015	5,733
	Ramp off to Berkshire Road (Northbound) South of	6,180	457	08:00	527	16:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-

	Berkshire Road**								
	Ramp off to Berkshire Road (Southbound) North of Berkshire Road**	2,940	248	08:00	241	16:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-
Newburn Road	South of Kalamunda Road (SLK 0.08)	5,882	462	08:15	555	16:00	4.8%	2018/ 2019	-
Hawtin Road	South of Maud Road (SLK 1.98)	7,025	592	08:00	668	15:15	8.3%	2019/ 2020	-
	South of Kalamunda Road**	8,944	828	08:00	868	17:00	N/A – HV not likely to be in higher volumes than generally expected	Feb 2020	-
Maida Vale Road	30m West of Myerson Crescent*	5,968	582	08:00	625	17:00	6.1%	Sep 2016	6,717
	166 m West of Butcher Road*	1,994	137	07:00	220	16:00	9.1%	Jun 2019	-
	67m East of Milner Road*	3,711	278	07:00	359	16:00	8.0%	Mar 2018	-
	20m West of Littlefield Street*	6,162	675	08:00	778	16:00	7.3%	Nov 2018	-
	170m East of Dundas Road*	2,430	187	07:00	254	17:00	7.0%	Mar 2018	-
	78m West of Milner Road*	3,062	211	08:00	299	16:00	7.3%	Apr 2018	-
	65m East of Plover Road*	8,851	659	08:00	971	16:00	7.6%	Sep 2019	-
	100m West of Jaeger Court*	3,870	276	08:00	411	16:00	8.3%	Nov 2020	-
	West of Hawtin Road (SLK 0.10)	7,106	596	08:00	683	17:00	9.2%	Dec 2015	8,237
	Ramp on to Roe Highway (Southbound) South of Maida Vale Road (SLK 0.23)	5,720	511	07:15	436	16:15	17.0%	Dec 2015	6,631
Abernethy Road	South of Dundas Road (SLK 4.96)	21,232	1,663	07:15	1,720	15:45	23.6%	Dec 2015	24,613
	South of Kalamunda Rd (SLK 6.54)	17,958	1,335	07:30	1,472	15:45	21.7%	2018/ 2019	-
Apricot Street	57 M South West of Fruit Tree Crescent*	1,538	109	08:00	142	17:00	5.6%	Apr 2016	1,731
Dundas Road	South of Maida Vale Road (SLK 2.04)	4,770	372	07:30	424	16:00	19.4%	2016/ 2017	5,368
	40m South of Sultana Road West*	2,708	194	06:00	264	16:00	22.3%	Jul 2016	3,047
	25m North of Onyx Court*	6,091	421	08:00	603	16:00	13.7%	Jun 2016	6,855
	41m South of Carolyn Way*	4,564	434	07:00	387	16:00	20.3%	Oct 2016	5,136

	205m North of Maida Vale Road*	5,687	373	08:00	506	16:00	12.3%	Mar 2018	-
	165m North of Berkshire Road*	4,267	311	07:00	347	15:00	19.4%	Mar 2018	-
	25m South of Kapok Court	5,953	422	07:00	615	16:00	11.5%	Nov 2020	
Dawson Avenue	60m South West of Berkshire Road *	3,100	267	08:00	293	17:00	5.4%	Jul 2016	3,489
Sultana Road West	60m North of Milner Road *	260	20	11:00	28	15:00	18.9%	Oct 2016	292
Harrison Road	35m East of Dundas Road *	971	80	11:00	101	14:00	24.1%	Aug 2016	1,092
Milner Road	32m South West of Sultana Road West *	2,397	228	07:00	236	16:00	14.1%	Mar 2018	-
	120m South of Raven Street *	1,537	163	07:00	151	16:00	9.2%	Mar 2018	-
	45m North East of Stewart Road *	1807	182	07:00	173	16:00	9.4%	Mar 2018	-
	150m South of Eureka Street *	3,864	360	07:00	346	16:00	19.3%	Sep 2019	3,003
Brae Road	295m North of Sultana Road *	149	13	07:00	14	14:00	17.1%	Oct 2016	167

Note - These traffic counts have been received from the City of Kalamunda*
*Note**- These traffic volumes have been derived from SCATS data obtained through Main Roads. Although SCATS should not be used as a sole source of data it is a good tool to verify fluctuations in flow.*

2.6 Vehicular Crash Information

Is Crash Data Available on Main Roads WA website?	YES
Analysis period	01/01/2016 – 31/12/2020
Locations at which no crashes were reported in the above period	Midblock - Stewart Road, Raven Street, Brae Road, Sultana Road W, Milner Road, Ibis Place, Brand Road Intersections - Milner Road: All intersections except with Maida Vale Road and Eureka Street (listed below).

Road Name	Road Hierarchy	Speed Limit	Crash Statistics			
			No of KSI Crashes (Fatal + Hospital)	No of Medical Attention Crashes	No of PDO Major Crashes	No of PDO Minor Crashes
Berkshire Road & Roe Highway (Northbound) off to Berkshire Road & Berkshire Road on to Roe Highway (Northbound)*	Distributor B / Primary Distributor / Primary Distributor	70kph / 70kph / 70kph	0	0	10	3
Berkshire Road & Roe Highway (Southbound) off to Berkshire Road & Berkshire Road on to Roe Highway (Southbound)*	Distributor B / Primary Distributor / Primary Distributor	70kph / 70kph / 70kph	0	0	1	2
Berkshire Road & Dundas Road	Distributor B / Distributor B	70kph/ 70kph	1	0	0	1
No of MVKT Travelled at Location		approximately 7,000*365*5years*0.3km=3.83 MVKT				

KSI Crash Rate		1 per 3.83= 0.26 KSI crashes / MVKT				
Comparison with Crash Density and Crash Rate Statistics		0.26 KSI crashes / MVKT is higher than the network average of 0.07 KSI crashes / MVKT.				
Other Crash Rate		2 per 3.83= 0.52 other crashes / MVKT				
Comparison with Crash Density and Crash Rate Statistics		0.52 crashes / MVKT crash rate is lower than the network average of 1.83 crashes / MVKT.				
Maida Vale Road & Maida Vale Road on to Roe Highway (Southbound)	Distributor B / Primary Distributor	60kph / 60kph	1	1	5	1
No of MVKT Travelled at Location		approximately 10,000*365*5years*0.3km=5.47 MVKT				
KSI Crash Rate		1 per 5.47 = 0.18 KSI crashes / MVKT				
Other Crash Rate		7 per 5.47= 1.28 other crashes / MVKT				
Comparison with Crash Density and Crash Rate Statistics		0.18 KSI crashes / MVKT is higher than the network average of 0.07 KSI crashes / MVKT. 1.28 crashes / MVKT crash rate is lower than network average 1.83 crashes / MVKT.				
Maida Vale Road & Roe Highway (Northbound) Off to Maida Vale Road	Distributor B / Primary Distributor	60kph / 60kph	1	8	13	13
No of MVKT Travelled at Location		approximately 9,000*365*5years*0.3km=4.93 MVKT				
KSI Crash Rate		1 per 4.93= 0.2 KSI crashes / MVKT				
		0.2 KSI crashes / MVKT is higher than the network average of 0.07 KSI crashes / MVKT.				
Other Crash Rate		35 per 4.93= 7.09 other crashes / MVKT				
Comparison with Crash Density and Crash Rate Statistics		7.09 crashes / MVKT crash rate is significantly higher than the network average 1.83 crashes / MVKT.				
Maida Vale Road & Milner Road	Distributor B / Local Distributor	60kph / 70kph	0	0	1	0
Milner Road & Eureka Street	Local Distributor / Access Road	70kph / 50kph	1	0	0	0
Maida Vale Road [SLK 0.88 - 2.93] From the eastern ramp to Roe Highway to Dundas Road	Distributor B	60kph	1	1	4	1
No of MVKT Travelled at Location		approximately 5,000*365*5years*2.05km=18.71 MVKT				
KSI Crash Rate		1 per 18.71= 0.2 KSI crashes / MVKT				
		0.05 KSI crashes / MVKT is lower than the network average of 0.07 KSI crashes / MVKT.				
Other Crash Rate		7 per 18.71= 7.09 other crashes / MVKT				
Comparison with Crash Density and Crash Rate Statistics		0.37 crashes / MVKT crash rate is significantly lower than the network average 1.83 crashes / MVKT.				
Maida Vale Road & Plover Road	Distributor B / Access Road	60kph / 50kph	0	0	3	1
Maida Vale Road & Newburn Rd	Distributor B / Local Distributor	60kph / 50kph	0	0	2	1
Maida Vale Road & Jaeger Court	Distributor B / Access Road	60kph / 50kph	0	0	1	0
Maida Vale Road & Bluebell Avenue	Distributor B / Access Road	60kph / 50kph	0	0	1	0

*Note * - Even though the MRWA crash reports provide results for the past 5 years, Berkshire Road and Roe Highway ramps were constructed in early 2016, and therefore the results cannot be considered complete.*

The following tables shows the Crash Density and Crash Rates on Metropolitan Local and Regional Roads as obtained from Main Roads WA on the 13th May 2020 by email request:

Crash Density and Crash Rate on Metropolitan Local Roads Network only

	All Crashes		Serious Injury Crashes (Fatal+Hospital)	
	Average Annual Crash Density (All Crashes/KM)	Average Annual Crash Rate (All Crashes/MVKT)	Average Annual Crash Density (Ser. Inj. Crashes/KM)	Average Annual Crash Rate (Ser. Inj. Crashes/MVKT)
Metro Local Road - Midblock	2.67	0.86	0.11	0.04
Metro Local Road - All	5.70	1.83	0.22	0.07

Note: Based on 5-years data for the period 2015 to 2019.

Crash Density and Crash Rate on Metropolitan State Roads Network only

	All Crashes		Serious Injury Crashes (Fatal+Hospital)	
	Average Annual Crash Density (All Crashes/KM)	Average Annual Crash Rate (All Crashes/MVKT)	Average Annual Crash Density (Ser. Inj. Crashes/KM)	Average Annual Crash Rate (Ser. Inj. Crashes/MVKT)
Metro State Road - Midblock	22.39	0.42	0.87	0.02
Metro State Road - All	52.67	0.98	1.68	0.03

Note: Based on 5-years data for the period 2015 to 2019.

With increased urbanisation of the area, many intersections will be reconstructed, and therefore, road safety will be significantly improved.

2.7 Public Transport Accessibility

How many bus routes are within 400 metres of the subject site? 3 bus routes

How many rail routes are within 800 metres of the subject site? Currently no rail routes – Future Forrestfield Airport Link Route

Bus / Rail Route	Description	Peak Frequency	Off-Peak Frequency
294	Midland Stn – Westfield Carousel via Forrestfield & High Wycombe	20 minutes	120 minutes
296	Perth - Kalamunda via Gooseberry Hill Road	60 minutes	120 minutes
287	Perth - Forrestfield via Belmont Forum	30 minutes	no service
298	Perth - Maida Vale via Belmont Forum & Abernethy Road	90 minutes	no service

Walk Score Rating for Accessibility to Public Transport.

10 – 30 Some Transit. A few nearby public transportation options.

Is the development in a Greenfields area? Partially

Additional information on planned improvements:

High Wycombe Train and Forrestfield Airport Link

Forrestfield-Airport Link METRONET

" Completing the Forrestfield-Airport Link - an 8.5km three-station railway spur connected to the Midland Line near Bayswater Station – is part of the first stage of METRONET.

As well as creating a 20-minute train trip between the city and the eastern suburbs, once complete, the rail link will make access to Perth Airport quicker, easier and more affordable for Perth residents and visitors alike.

The project is an important step in improving public transport options for our eastern suburbs. By 2022 the Forrestfield-Airport Link is expected to generate 20,000 passenger trips every day – increasing to 29,000 daily by 2031. With three new stations at Redcliffe, Airport Central and Forrestfield, the new train line will

- *Provide a viable alternative to car travel between the eastern suburbs and Perth.*
- *Enable Perth Airport to continue growing as a nationally important centre of employment, commerce and international trade.*
- *Encourage domestic and international tourism with improved access between Perth Airport and the city. Boost employment, residential and economic growth by encouraging transit oriented development around the new suburban train stations at Redcliffe and Forrestfield.*

Each new station presents different opportunities for their local communities.

High Wycombe Train Station

The catchment area for Forrestfield Station includes the suburbs of High Wycombe, Forrestfield, Maida Vale, Gooseberry Hill and Kalamunda. To make connecting with train services from these suburbs easier, the station precinct is being designed as an intermodal transport hub. This means there will be facilities for passengers arriving at the station by bus, car, bicycle or foot.

To meet demand for parking, a multi-level car park accommodating 1200 cars will be built on land bordered by Maida Vale Road and Ibis Place. While the original plan was for an at-grade car park, the new design will improve access as passengers will now be able to park within 300m of the station's entrance. This new design frees up approximately eight hectares of land for future development. The solution not only meets passenger needs, but also supports METRONET's vision to create connected communities within walking distance of the station and the City of Kalamunda's Forrestfield North District Structure Plan.

Construction of the car park is scheduled to being as soon as tunnelling is finished and will be ready for when first trains run on the Forrestfield Line."

Public Transport Authority website accessed on 30.07.2021.:
http://www.pta.wa.gov.au/forrestfieldairportlink/rail-map :

" High Wycombe Station

The above-ground High Wycombe Station, positioned alongside Dundas Road, will be a terminus station serving a large catchment area in Perth's eastern suburbs and foothills.

- *20-minute journey to CBD*
- *2-zone fare to Perth Station*
- *8-bay bus interchange*
- *1200 parking bays*

Once operational Airport Line trains will be integrated into the existing network, travelling between Claremont Station and Perth Station on the Fremantle Line, along the Midland Line east of the Perth CBD to Bayswater and then spur off towards High Wycombe utilising the new underground track."

Forrestfield Airport Link Project Transport Assessment – Forrestfield Station:

" The station will comprise an at grade passenger rail station, an adjacent bus station with 8 active and 4 layover bays, and a small kiosk to serve intermodal passengers. Car parking with up to 2,500 bays will be located at the development to provide park and ride opportunities.

Active transport will be well catered for with the provision of an integrated network of paths that will bring passengers directly to the Station. There will be secure bike parking with space for 180 bikes and U-rails in the Station forecourt.

The development of the Station will include upgrades to Sultana Road West, Ibis Place and Imperial Street, along with a reconfiguration of the Maida Vale Road / Ibis Place intersection to allow ease of access for buses into the bus station. Relocation of Dundas Road is required for the construction of the Station and this will assist the Shire

in its aim of eliminating heavy vehicles from residential areas and restricting it to the light industrial areas to the south of the Station."
It should be noted that the early documents indicate a parking provision of 2,500 bays, however the total number has been reduced to 1,800 bays. Initially 1,200 bays will be developed as a multi-story parking facility opposite the train station with the remainder to be built out at a later stage. This is in line with the general vision for the station as an alternative transport option which promotes the reduction of car usage and dependence.

2.8 Pedestrian Infrastructure

Describe existing local pedestrian infrastructure within a 400m radius of the site:

Existing pedestrian access through the Forrestfield North LSP area for Residential Precinct is very limited due to the low intensity of current land-uses. The extent of development for the area envisaged under the LSP will have a significantly higher activity intensity; therefore, the requirement for good quality pedestrian linkages emerges. One of the key objectives of the Forrestfield North LSP area for the Residential Precinct is to identify key linkages within the proposed LSP area. A plan depicting all of the linkages described below is shown in Appendix 2.

Classification	Road Name
" Principal Shared Path (PSP)"	The path along Roe Highway (south of Berkshire Road)
" Other Shared Path (Shared by Pedestrians & Cyclists)"	Maida Vale Road (east of Littlefield Road), Milner Road, Berkshire Road, Palmer Crescent (west of Mack Place), Mack Place, Madderson Road, Golden Crescent (east of Jade Court), Jade Court, Edney Road, Feeney Gardens, Roe Highway (400m north of Berkshire Road)

Does the site have existing pedestrian facilities YES, on Milner Road and Berkshire Road

Does the site propose to improve pedestrian facilities? YES

If YES, describe the measures proposed.

Pedestrian Paths

It is essential to develop a solid and permeable network of pedestrian paths in order to encourage pedestrian movement. The network of the proposed pedestrian paths is shown in Appendix 2.

Please refer to Section 2.20. for the proposed Internal Road Network for cross-sections of existing and proposed roads. Every major road within the LSP area will have either a shared path or a separate pedestrian path.

All pedestrian and shared paths should be designed to be accessible by all community members, in accordance with the City of Kalamunda's Disability Access and Inclusion Plan 2017-2022 or any other subsequent document of this nature. The exact location of pram ramps and other elements is to be determined later in the project; however, the pram ramps should be positioned to allow continuous movement and shortest crossing distances.

What is the Walk Score Rating?

0-20 Car-Dependent. Almost all errands require a car.

2.9 Cycling Infrastructure

Are there any PBN Routes within an 800m radius of the subject site? YES

If YES, describe:

Existing cyclist access through the Forrestfield North LSP area for Residential Precinct is very limited due to the low intensity of current land-uses. The extent of development for the area envisaged under the LSP will have a significantly higher activity intensity; therefore, the requirement for good quality cyclist linkages emerges. One of the key objectives of the Forrestfield North LSParea is to identify key linkages within the proposed LSP area. A plan depicting all of the linkages described below is shown in Appendix 2.

Classification	Road Name
" Bicycle Lanes or Sealed Shoulder Either Side"	Abernethy Road, Roe Highway (north of Berkshire Road), Newburn Road
" Principal Shared Path (PSP)"	The path along Roe Highway (south of Berkshire Road)
" Good Road Riding Environment"	Maida Vale Road (west of Priory Road), Priory Road, Newburn Road, Milner Road, Berkshire road (west of Ashby Close), Gilba Road, Bruce Road, Apricot Street, Sultana Road East (east of Bruce Road), Myerson Crescent, Jacks Street
" Other Shared Path (Shared by Pedestrians & Cyclists)"	Maida Vale Road (east of Littlefield Road), Milner Road, Berkshire Road, Palmer Crescent (west of Mack Place), Mack Place, Madderson Road, Golden Crescent (east of Jade Court), Jade Court, Edney Road, Feeney Gardens, Roe Highway (400m north of Berkshire Road)

Are there any PBN Routes within a 400m radius of the subject site? YES

If YES, describe:

Classification	Road Name
" Bicycle Lanes or Sealed Shoulder Either Side"	Abernethy Road, Roe Highway (north of Berkshire Road), Newburn Road
" Principal Shared Path (PSP)"	Path along Roe Highway (south of Berkshire Road)
" Good Road Riding Environment"	Maida Vale Road (west of Priory Road), Priory Road, Newburn Road, Milner Road, Berkshire Road (west of Ashby Close)
" Other Shared Path (Shared by Pedestrians & Cyclists)"	Maida Vale Road (east of Littlefield Road), Milner Road, Berkshire Road, Palmer Crescent (west of Mack Place), Mack Place, Madderson Road, Golden Crescent (east of Jade Court), Jade Court, Edney Road, Feeney Gardens, Roe Highway (400m north of Berkshire Road)

Does the site have existing cyclist facilities? NO

Does the site propose to improve cyclist facilities? YES

If YES, describe the measures proposed.

Please refer to Section 2.20. for the proposed Internal Road Network for cross-sections of existing and proposed roads. Every major road within the structure plan area will have either a shared path or a dedicated cycle lane.

Additionally, the City of Kalamunda has adopted a Bicycle Plan, dated December 2017, prepared by Cardno. The ultimate cycling network from this document is shown in Appendix 2, and the routes going through the LSP area are outlined below:
Note: This was prepared prior to the current structure planning so did not consider further routes within the plan area.

Classification	Road Name
" Principal Route"	Roe Highway, the path along the highway
" Strategic Route"	Milner Road, Maida Vale Road, Future TOD Connector
" Local Route"	Dundas Road, Berkshire Road

Note: Department of Transport is moving to a different classification of Cyclist Infrastructure as follows:

Primary route (" Red Route")

Function: Primary routes are high demand corridors that connect to major destinations. They provide high quality, safe, convenient (and, where possible uninterrupted) routes that form the spine of the cycle network. These routes are conducive to medium or long-distance commuting/utility, recreational, training and tourism trips.

Form: Primary routes are high-quality cycle only or shared paths located adjacent to major roads, rail corridors, rivers and ocean foreshores. Where the environment allows, these are in the form of a Principal Shared Path (PSP). A PSP is a fully lit and separated facility. In locations where vehicles have been grade-separated, the cycle route will also be grade-separated. PSPs are to be designed in accordance with the WA Transport Portfolio's PSP Policy.

Secondary Route (" Blue Route")

Function: Secondary routes have lower demand than primary routes but provide similar levels of quality, safety and convenience. These routes connect primary routes and major activity centres such as shopping precincts, industrial areas or major health, education, sporting and civic facilities.

Form: Secondary routes can take on several forms and are designed to suit the environment in which they are located. These forms include:

- High quality shared paths;
- Bi-directional protected bike lanes;
- Protected on-road bike lanes; and
- Safe Active Streets (Bicycle Boulevards).

Road Cycling Route (" Yellow Route")

Function: Road cycling routes are designated routes for training, sports or recreational cyclists to undertake long distance rides in on-road environments.

Form: Road cycling routes are predominantly located on lower order, rural or semi-rural roads on the outskirts of cities and towns. Sections may follow busier roads, particularly as road cycling routes typically begin and end in built up areas and often follow scenic roads popular with other road users. These routes support cyclists undertaking challenging longer distance rides by raising awareness and encouraging safe behaviour by all road users. This is achieved through advisory signage, warning technology and other road safety initiatives.

Tourist Routes (" Brown Routes")

Function: Tourist trails provide long-distance, off-road (predominantly unsealed) riding experiences through natural settings, away from motorised traffic. They often support recreational and tourism trips between regions.

Form: Trails are typically located within underutilised transport and service corridors in rural areas. Due to their relatively gentle gradients, former railways make excellent candidates for trails. Purpose built trails may be constructed to connect existing corridors. Trails should be constructed from well drained, compacted gravel with supporting infrastructure such as way-finding signage. They may be sealed when they run through towns, busy road crossings or in special circumstances.

2.10 Vehicular Parking

Local Government	City of Kalamunda
Local Government Document Utilised	Local Planning Scheme No. 3 State Planning Policy 3.1 - R-Codes WAPC Apartment Design Policy (Draft) Guide to Traffic Management Part 11: Parking

Description of Parking Requirements in accordance with utilised Documents:

Residential:

- 1-bedroom dwellings – Location B – 1 bay per dwelling
- 2+ bedroom dwellings – Location B – 1.25 bay per dwelling
- Visitor Parking – 1 bay per 4 dwellings, up to 12 dwellings. 1 bay per 8 dwellings for the 13th dwelling and above.

Primary School:

- 1 bay for every staff member, plus 14 drop off bays for every 100 students. (Local Planning Scheme No. 3)

Recreational areas inclusive of Local Open Space:

- 20 spaces per court; 50 spaces per football field (Guide to Traffic Management Part 11: Parking -Table C2 3: Car parking provision rates, Brisbane City Council, Queensland)

Land Use Type	Rate above	Yield	Vehicle Parking Requirements
Residential	As per R Codes; Note: WAPC Apartment Design Policy (currently a DRAFT version) might be applicable for apartments once the finalised version is published.	150 apartment dwellings 2,267 house dwellings	Varies; refer to ***Note** below
Primary School	1 bay for every staff member	Assume 54 staff	54
	14 drop off bays for every 100 students	Assume 540 students	76
Recreational areas inclusive of District Open Space (Sporting Precinct)	20 spaces per court 50 spaces per football field	Assume 2 courts and one football field*	90

***Note * - Strategy City of Kalamunda Forrestfield North Structure Plan Community Infrastructure Strategy** outlines concept plans for the Education and Sporting Precincts and the Community Centre and Town Park Precinct, and the yields have been sourced from this document.*

Justification

***Note:**The predominant use is residential; therefore, it is expected that most residences will provide parking on the premises, in accordance with the Residential Design Codes or the finalised version of the WAPC Apartment Design Policy. KCTT believes that every house will have its own garage, providing parking for the owner (in the garage) and visitors (at the driveway). Residential buildings will have to provide parking garages with the number of parking bays in accordance with the R-codes or finalised version of the SPP 7.3, depending on the location.

In accordance with the City of Kalamunda Local Planning Scheme No 3, the approximate number of parking bays required for the Primary School is 130. This should be reassessed once more detail is known and individual development applications are submitted.

Some provisional rates are provided for the District Open Space (Sporting Precinct); however, this development should be assessed on its own merits once the final composition and staging of the sporting fields and associated facilities are known. On-street parking should be considered, particularly in the area surrounding District Open Space (Sporting Precinct) and other recreational areas.

Strategy City of Kalamunda Forrestfield North Structure Plan Community Infrastructure Strategy outlines that Sporting Precinct will have approximately 120 bays delivered over two stages of 60 bays each. The Primary School would also use these in a shared use arrangement for pick up/drop off.

Improvement in surrounding:

On-Street Parking
On-street parking will be provided through each of the main linkages in the Forrestfield North LSP area and particularly in the area surrounding District Open Space (Sporting Precinct). It is considered that the following streets as a minimum will have some form of on-street parking: -

- Brae Road
- Brand Road
- Milner Road (north of Sultana Road West)
- TOD Connector
- Stewart Road
- Some lower-order roads

On-street parking will contribute to overall street amenity and will help reduce average operating speeds on the road.
In order to create an appealing urban design response, where on-street parking has a sole function (it is not AM/PM bus priority lane), three or fewer consecutive parking bays will be allowed. If more than 3 consecutive on-street bays are planned, a vegetation strip will be used to break down the continuous line of pavement.

Have Vehicle Swept Paths been checked for Parking? NO

Not applicable for this stage of development.

2.11 Bicycle Parking

Local Government	City of Kalamunda
Reference Document Utilised	City of Kalamunda's Local Planning Scheme No 3 Austroads – Guide to Traffic Management Part 11: Parking Securabike – Bicycle Parking Handbook

Description of Parking Requirements:

The City of Kalamunda does not provide requirements for the provision of bicycle parking.

Bicycle parking provisions for schools are to be in accordance with the Austroads Guide to Traffic Management - Parking (Part 11), page 141:

School *- 1 per 5 pupils over year 4*

Justification

It is assumed that residents of houses will store their bicycles and equipment within their respective dwellings. Therefore, KCTT believe that there is no need for additional bicycle parking provision in residential precincts, however parking should be provided at the primary school and District Open Space (Sporting Precinct).

It is most likely that the utilisation of bicycles within the subject site area will be more viable and attractive to residents. Cycling is further promoted through a network of cycle lanes and shared paths connecting all residential areas to the main attractors.

2.12 ACROD Parking

Class of Building	**Class 1a** - a detached house or one of a group of two or more dwellings separated by a fire resisting wall, including a row house, terrace house, town house or villa unit. **Class 2** – a building containing 2 or more dwelling units (eg: flats, apartments) **Class 9b** - An assembly building, including a trade workshop, laboratory or the like, in a primary or secondary school, but excluding any other parts of the building that are of another class.
Does this building class require specific provision of ACROD Parking?	YES – non-residential uses will require provision of ACROD Parking.
Reference Document Utilised	Building Code of Australia

Description of Parking Requirements:

Class 1a *– no provision for ACROD parking;*

Class 2 *– no provision for ACROD parking unless there are accessible units within the building;*
Class 9b *- School - 1 ACROD bay for every 100 carparking spaces or part thereof;*
Other assembly building - up to 1,000 carparking spaces - 1 ACROD bay for every 50 carparking spaces or part thereof and 1 ACROD bay for each additional 100 carparking spaces or part thereof in excess of 1,000 carparking spaces."

Justification

These requirements will be reviewed as part of the respective Development Applications for each of the sites.

2.13 Parking / Charging Stations for Electrical Vehicles

Class of Building	**Class 1a** - a detached house or one of a group of two or more dwellings separated by a fire resisting wall, including a row house, terrace house, town house or villa unit. **Class 2** – a building containing 2 or more dwelling units (eg: flats, apartments) **Class 9b** - An assembly building, including a trade workshop, laboratory or the like, in a primary or secondary school, but excluding any other parts of the building that are of another class.
Does this building class require specific provision of parking / charging station for electrical vehicles?	All residential buildings with more than 10 dwellings and non-residential buildings should consider provision of parking / charging points for electrical vehicles.

Description of Parking Requirements:

Parking / charging points for electrical vehicles should be provided at a minimum rate of 1 in 20 standard parking bays (5% as prescribed in Green Star - Design and As Built), preferably 1 in 10 standard parking bays.

Justification

The use of electrical vehicles is on the rise and given the reduction in pollution they provide the use should be further encouraged. While in individual dwellings, private owners / developers can choose to implement charging points for electrical vehicles, in multiple dwelling complexes and non-residential buildings it is important to provide charging points so that the residents have an option for using electrical vehicles.

The mandatory rate should be reviewed and revised every 5 years given the technology leaps.

2.14 Delivery and Service Vehicles

Guideline Document used as reference: NSW RTA Guide to Traffic Generating Developments

Requirements

Residential flat buildings *(50% of spaces adequate for trucks): < 200 flats or home units = 1 space per 50 flats or home units;*

Commercial premises *(50% of spaces adequate for trucks): 1 space per 4,000m^2 GFA (if GFA < 20,000m^2);*
Other Uses *(50% of spaces adequate for trucks): 1 space per 2,000m^2 GFA."*

Justification

It is expected that delivery and service vehicles (such as waste removal vehicles) servicing the residential area will not require designated parking spaces given that they can operate safely within the road reserve.

Service and delivery vehicles for the primary school and District Open Space (Sporting Precinct) will require appropriate parking allocated on site. The crossovers should be designed to accommodate movement of service vehicles as a minimum.

2.15 Calculation of Development Generated / Attracted Trips

What are the likely hours of operation?	For residential land uses, the hours of operation are not applicable.
What are the likely peak hours of operation?	AM 08:00 to 09:00 PM 16:30 to 17:30
Do the development generated peaks coincide with existing road network peaks?	YES
If YES, Which:	Partially both [AM Peak and PM Peak]
Guideline Document Used	**WAPC Transport Assessment Guidelines for Developments**
Rates from above document:	***Residential** – 0.8 vehicle trips per dwelling for the AM and PM peak hours. A 25% IN / 75% OUT split has been adopted for the AM peak and a 67% IN / 33% OUT split for the PM peak hour;* ***Schools** - 1 vehicle trips per dwelling for the AM and PM peak hours. A 50% IN / 50% OUT split has been adopted for both peaks.*
Guideline Document Used	**NSW RTA Guide to Traffic Generating Developments**
Rates from above document:	***Residential** - The NSW RTA Guide to Traffic Generating Developments suggests developments of this type in Sydney tend to generate between 4 and 5 vehicular trips per dwelling for medium to high density developments. In Perth, the Department of Planning and Infrastructure conducted a series of studies in the late 1990's / early 2000's which showed that higher density dwellings tended to average closer to 5.5 vehicle trips per day. These studies assumed that anywhere between 50% and 70% of commuters were travelling to the work by car as a driver.* The following rates were agreed upon with the City of Kalamunda: 8 vehicular trips per day for R30 and R40; 6.5 vehicular trips per day per residence for R60 houses, 5.5 vehicular trips per day per residents for R80 houses and apartments, and 5 vehicular trips per day for R100 Apartments.
Guideline Document Used	**Transportation Engineers (ITE) Common Trip Generation Rates (9th edition)**
Rates from above document:	***Sporting / Soccer Complex*** *Fields: 71.33 vehicular trips per day per field*
Base data for trip calculation (AM peak trips)	Residential: 10% of VPD (25% IN / 75% OUT); School: 1 per student District Open Space (Sporting Precinct): 1.4 trips per playing field (50% IN / 50% OUT)
Base data for trip calculation (PM peak trips)	Residential: 10% of VPD (67% IN / 33% OUT) School: 1 per student District Open Space (Sporting Precinct): 20.67 trips per playing field (70% IN / 30% OUT)

Transport Impact Assessment
KC00604.000 Forrestfield North - Residential Precinct

Land Use Type	Rate above	Yield	Daily Traffic Generation VPD	Peak Hour Traffic Generation	
				AM VPH	PM VPH
Residential (R30 and R40 Houses)	8.0 VPD per unit Peak - 10% of VPD	938	7,504	750	750
Residential (R60 Houses and Apartments)	6.5 VPD per unit Peak - 10% of VPD	1,056 units	6,864	686	686
Residential (R80 Houses and Apartments)	5.5 VPD per unit Peak - 10% of VPD	423 units (150 apartments)	2,327	233	233
	Total Residential:	***2,417 units***	***16,691***	***1,669***	***1,669***
Primary School	2 VPD per student	540 students	216	108	108
	Peak – 1 VPH per student *(based the local use - 80% reciprocity applied**)*		1,080	540	540
District Open Space (Sporting Precinct)	71.33 VPD per court AM Peak – 1.4 VPH per court PM Peak – 20.67 VPH per court	2 courts (as per Sporting Precinct Preliminary Concept Plan)	71	2	21
	(based on the proximity of the primary school and the local use - 50% reciprocity applied)		143	3	41
	Total traffic with reciprocity applied:		**16,978**	**1,779**	**1,798**
	Total traffic without reciprocity:		**17,914**	**2,212**	**2,250**

Note * - Strategy City of Kalamunda Forrestfield North Structure Plan Community Infrastructure Strategy *outlines concept plans for the Education and Sporting Precincts and the Community Centre and Town Park Precinct and the yields have been sourced from this document.*

Note ** - *It is anticipated that only 20% of school trips will be generated from outside of the LSP area.*

The estimated yield of 2,417 dwellings is expected within the LSP area. The LSP report indicates an estimated population of 5,998 in the FFN Residential Precinct based on the information received from the City of Kalamunda. According to the City of Kalamunda's household summary on profile.id.com.au 9% of the City's residents are of primary school age.
80% of the assumed 540 children is 432, which is approximately 7.2% of the expected number of future FFN residents, less than the City of Kalamunda average. This more than accounts for the likely reduction in school-age children within higher-density housing forms. Even if the ratio is changed in favour of trips outside of the LSP area, this will not significantly impact traffic distribution and the surrounding road network. The school is expected to generate only up to 1,080 VPD which is less than 6.5% of the total Residential Precinct traffic generation.
Based on the above, KCTT believe that the distribution of 80% local / 20% outside LSP area) should be applied.
It should also be noted that while the cumulative peak volumes represent the most conservative scenario, in reality, peak times of various uses may coincide only partially.

Does the site have existing trip generation/attraction?	YES
No of Daily Trips	50 units * 9 VPD = 450 VPD
No of AM Peak Hour Trips	50 units * 0.8 VPH = 40 VPH
No of PM Peak Hour Trips	50 units * 0.8 VPH = 40 VPH
What is the total impact of the new proposed development?	High impact
Total additional daily traffic to the surrounding road network	16,978 – 450 = **16,528 VPD**
Total additional AM peak traffic to the surrounding road network	1,779 – 40 = **1,739 VPH**
Total additional PM peak traffic to the surrounding road network	1,798 – 40 = **1,758 VPH**

2.16 Trip Purposes

Determine the likely percentage share for different trip purposes based on the land usage.

Land Use Type	Employment	Shopping	Education	Social / Recreational
Residential	40%	17.5%	25%	17.5%
Industrial	100%	n.a.	n.a.	n.a.
Mixed Use	60%	20%	5%	15%

2.17 Expected Origin / Destination

Name the closest existing major residential generators and non-residential attractors of traffic and the distance from the boundaries of the Structure Plan Area.

Residential	Employment (profile.id)	• Potential place of work of future residents of Forrestfield North LSP area: a. West (City of Perth) – 32.5% b. Local (Perth Airport area) – 10% c. Local (Forrestfield North LSP area) – 20% d. South (City of Gosnells / City of Canning) - 10% e. East (City of Kalamunda) - 10% f. West (City of Belmont) – 7.5% g. North (City of Swan) – 5% h. WA Undefined / Other Areas – 5% • Excluding work from home, likely sources of employment within the Forrestfield North area include industrial land-uses in the south-east in the vicinity of Berkshire Road and around the future proposed High Wycombe Train Station; TOD Precinct and Activity Centre Precinct. • To the immediate west of the site is a significant employment catchment around the Perth Airport. • The High Wycombe Train Station provides excellent opportunities for commuting to the Perth CBD.
	Shopping	• Strong opportunities for local shopping within the Forrestfield North area. • Local shopping – High Wycombe Shopping Centre / Forrestfield Shopping Centre • Regional Shopping – Belmont Forum / Carousel Cannington
	Education	• Edney Primary School (corner Edney Road / Newburn Road, High Wycombe), Dawson Park Primary School, High Wycombe Primary School, Woodlupine Primary School; Maida Vale Primary School, Forrestfield Primary School (all within 3km from the LSP area). • Primary School to be allocated within the LSP area. • Kalamunda Senior High School, Darling Range Sports College Forrestfield, Mazenod College Lesmurdie, St Brigid's College Lesmurdie, Belmont City College (High School)
	Social/ Recreational	• 17.5% of all trips are deemed to be local for social / recreational purposes. These types of trip purposes are expected to include sporting / local social trips etc.

		• In an area such as Forrestfield North LSP Area, this could be as high as 25%, however for the purposes of this Transport Impact Assessment we will utilise 17.5% as it places a more conservative and realistic volume of traffic onto the key intersections for analysis.
Commercial and Mixed Use	Employment	• The TOD and Activity Centre Precincts are likely to attract employment trips from the Forrestfield North area, plus generally from the: - o City of Kalamunda to the east (35%) o City of Belmont to the west (25%) o City of Swan / Shire of Mundaring to the north (15%) o City of Gosnells / City of Canning to the south (15%) o Other areas (10%)
	Shopping/ Social	At this point the full range of uses that will be located within the Activity Centre Precinct is not determined. Therefore, the centre is treated as commercial premises for the purposes of this report.
Industrial	Employment	The TOD and Activity Centre Precincts are likely to attract employment trips from the Forrestfield North LSP area, plus generally from the: - • City of Kalamunda to the east (35%) • City of Belmont to the west (25%) • City of Swan / Shire of Mundaring to the north (15%) • City of Gosnells / City of Canning to the south (15%) • Other areas (10%)

2.18 Traffic Flow Distribution onto External Road Networks

How many routes are available for access / egress to the site?	Eight main routes (as modelled in Paramics – please refer to Appendix 4 for detailed traffic distribution) 17,914 VPD / 2,250 VPH
Route 1	
Provide details for Route No 1	**To / from the south via Roe Highway**
Percentage of Vehicular Movements via Route No 1	20%
Route 2	
Provide details for Route No 2	**To / from the south via Hawtin Road**
Percentage of Vehicular Movements via Route No 2	5%
Route 3	
Provide details for Route No 3	**To / from the east via Kalamunda Road**
Percentage of Vehicular Movements via Route No 3	7.5%
Route 4	
Provide details for Route No 4	**To / from the north via Roe Highway**
Percentage of Vehicular Movements via Route No 4	15%
Route 5	
Provide details for Route No 5	**To / from the west via Kalamunda Road**
Percentage of Vehicular Movements via Route No 5	10%
Route 6	
Provide details for Route No 6	**To / from the south via Abernethy Road**

Percentage of Vehicular Movements via Route No 6	8%
Route 7	
Provide details for Route No 7	**To / from the south via Dundas Road**
Percentage of Vehicular Movements via Route No 7	6%
Route 8	
Provide details for Route No 8	**To / from the east via Gooseberry Hill Road**
Percentage of Vehicular Movements via Route No 8	2%
Internal Trips	25% (Inclusive of trips to TOD precinct) + 1.5% to the Forrestfield North Industrial area

*Note: Please refer to Appendix 4 - Traffic modelling report for detailed traffic distribution

2.19 Road Safety

Are sight distances adequate at proposed intersections?	N/A

Justification

All distances between intersections should be spaced according to Liveable Neighbourhoods. To be reviewed in more detailed stages of planning.

Are there any proposed interventions to streets surrounding schools, neighbourhood centres, child and aged person day care facilities, etc?	YES

If YES, nominate which:

Some traffic calming devices are desirable especially in the vicinity the proposed primary school. Chicanes, speed humps, wombat crossings and/or other methods should be considered when designing streets around schools to lower operating speeds and improve safety. Variable speed limit should be considered on all roadways within 200m from the school entry in accordance with the relevant MRWA guidelines.

Furthermore, narrow lanes are advised (3.3m as a maximum width) to increase side friction and reduce operative speed. Long blocks of on-street parking are to be avoided – vegetation strips are recommended to be implemented after each block of maximum 3 on-street parking bays.

2.20 Proposed Road Network

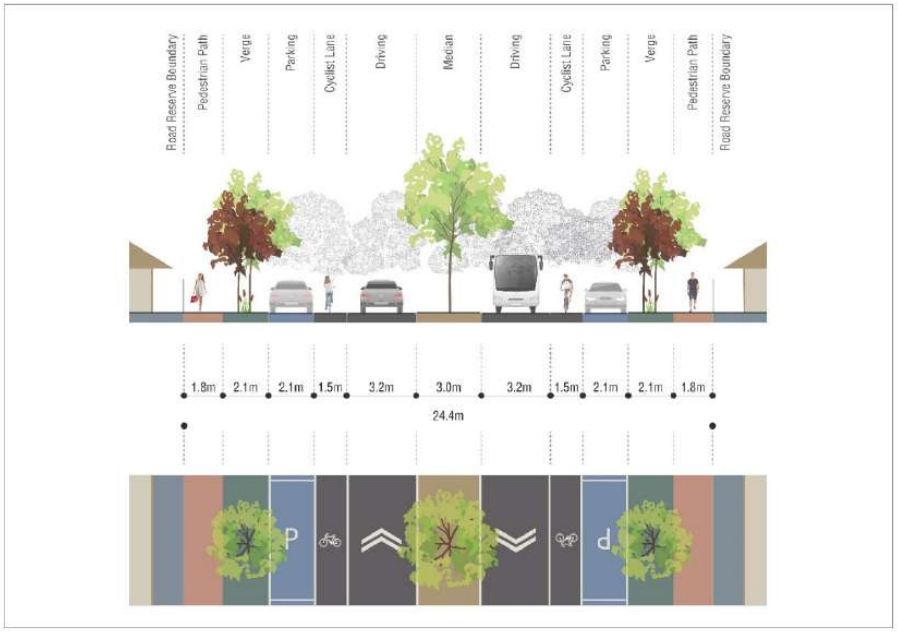
Guideline Document used as reference	Cross-sections for main transit routes were developed in discussion with the City of Kalamunda, however comparable Liveable Neighbourhood classification is provided.
How many proposed roads are there within the Structure Plan Area?	Several road types as listed below Please note that the Residential Precinct is a portion of the wider Forrestfield North Area and following list of roads shows only the roads within the subject area. *Note: The internal road network within the LSP area shown in Appendix 1 and 2 is only an indicative road network. **Note: Cross-sections shown below are indicative in nature and are intended to show main principles and treatments for various traffic modes. In developing the lower order streets and public open spaces Public Realm Guidelines should be referred to.

Name of Roads within the Structure Plan Area / Road Classification and Description:

Road 01

Name	TOD Connector
Projected Traffic Volumes	1,428 (2031) 6,432 (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	24.4m
Proposed Road Pavement Width	3.2m per traffic lane
Proposed Median Width	3.0m
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on both sides of the road reservation 1.5m cycling lane on both sides of the road reservation
Equivalent LN Classification	Neighbourhood Connector A
Proposed Speed Limit	50kph
Proposed Bus Route Extension / Introduction	YES
If YES Nominate Bus Routes	It is expected that new Bus Routes will be introduced to / from the High Wycombe Train along with an Autonomous Bus Circular Route
Proposed On-street parking	YES (2.1 parallel parking on both sides)

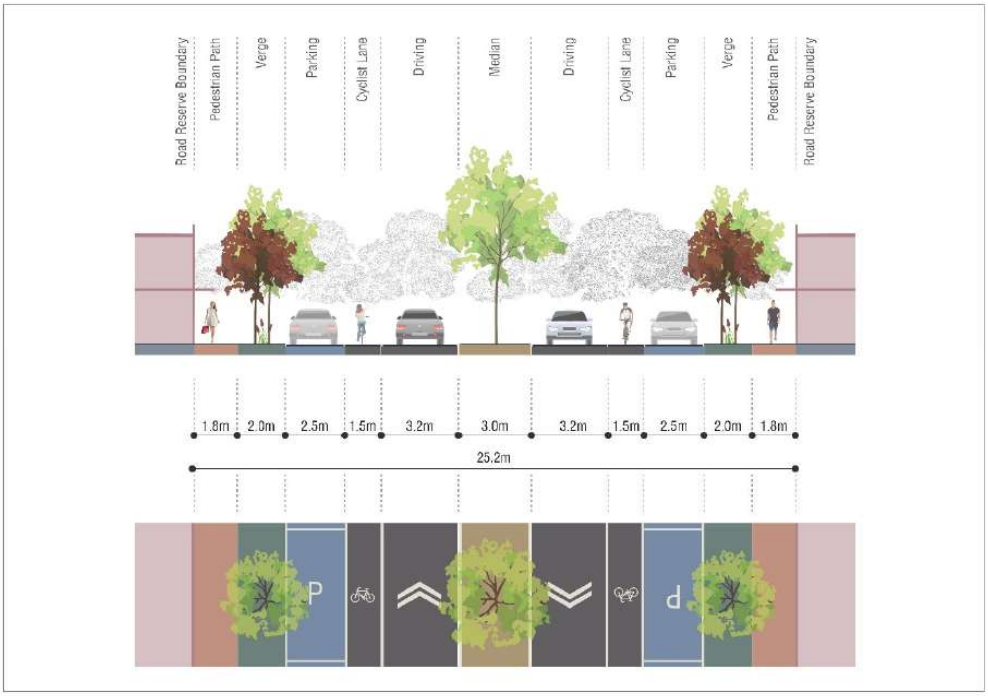
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 2a

Name	Milner Road (Between Sultana Road West and Stewart Road)
Projected Traffic Volumes	4,045 (2031) 8,110 (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	25.2
Proposed Road Pavement Width	3.2m per traffic lane
Proposed Median Width	3.0m
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on both sides of the road reservation 1.5m cycling lane on both sides of the road reservation
Equivalent LN Classification	Integrator B
Proposed Speed Limit	60kph
Proposed Bus Route Extension / Introduction	YES
If YES Nominate Bus Routes	Autonomous Bus Circular Route
Proposed On-street parking	YES (2.5m parallel parking on both sides)

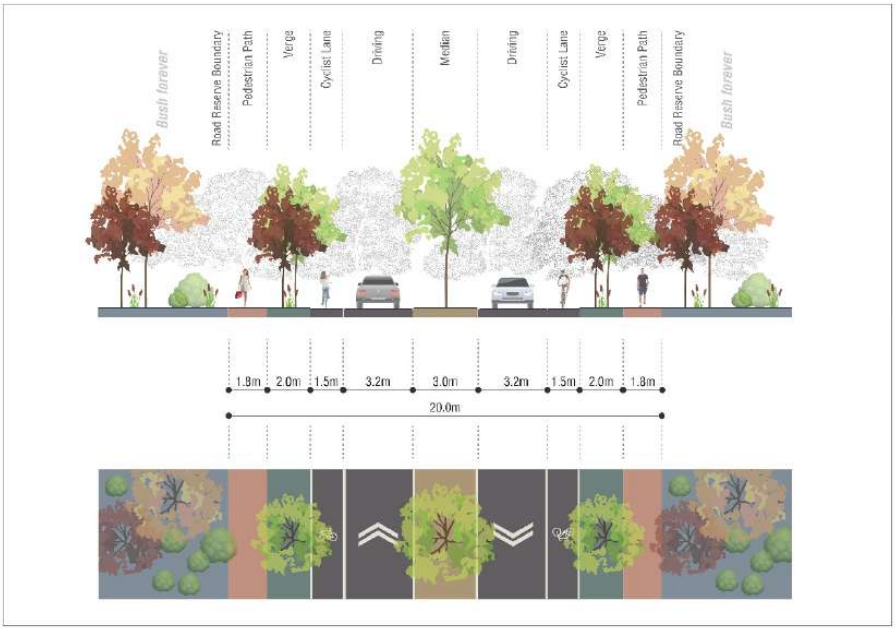
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 2b

Name	Milner Road (North of Stewart Road)
Projected Traffic Volumes	3,914 (2031)
	9,288 (2050)
Proposed Number of Lanes	one lane per direction
Proposed Road Reservation Width	20.0m
Proposed Road Pavement Width	3.2m per traffic lane
Proposed Median Width	3.0 m
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on both sides of the road reservation
	1.5m cycling lane on both sides of the road reservation
Equivalent LN Classification	Integrator B
Proposed Speed Limit	60kph
Proposed Bus Route Extension / Introduction	NO
Proposed On-street parking	NO

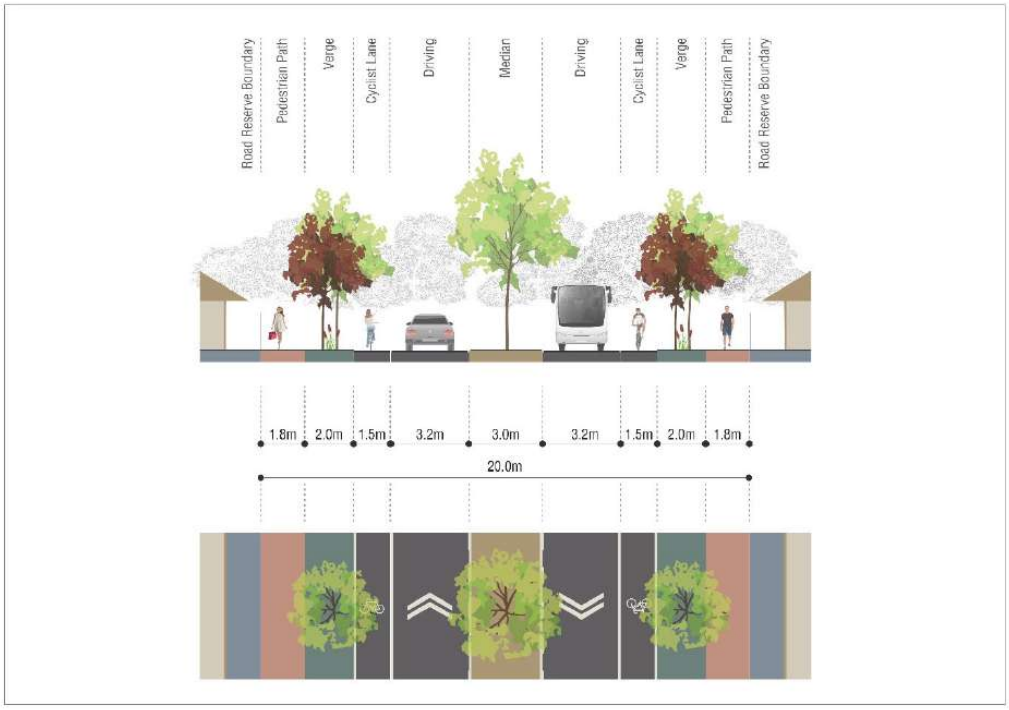
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 03

Name	Maida Vale Road
Projected Traffic Volumes	6,522 (2031) 13,072VPD (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	20.0m
Proposed Road Pavement Width	3.2m per traffic lane
Proposed Median Width	3.0 m
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on both sides of the road reservation 1.5m cycling lane on both sides of the road reservation
Equivalent LN Classification	Integrator B
Proposed Speed Limit	60kph
Proposed Bus Route Extension / Introduction	YES
If YES Nominate Bus Routes	It is expected that new Bus Routes will be introduced to / from the future High Wycombe Train.
Proposed On-street parking	NO

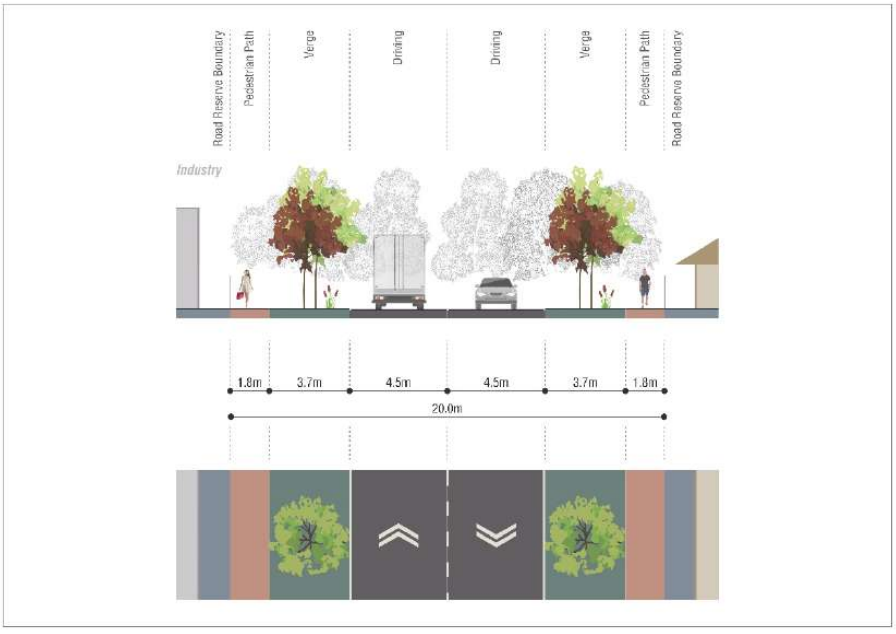
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 04a

Name	Sultana Road West (east of Milner Road)
Projected Traffic Volumes	786 (2031) 1,872 (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	20.0m
Proposed Road Pavement Width	4.5m per traffic lane
Proposed Median Width	no median
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on both sides of the road reservation
Equivalent LN Classification	Access Street
Proposed Speed Limit	50kph
Proposed Bus Route Extension / Introduction	NO
If YES Nominate Bus Routes	-
Proposed On-street parking	NO

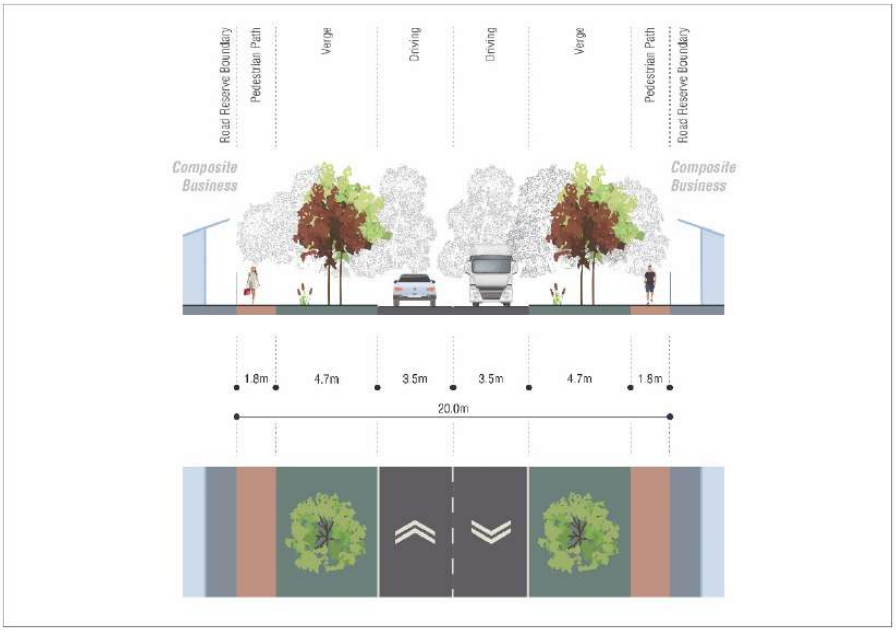
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 04b

Name	Sultana Road West (East of Brae Road)
Projected Traffic Volumes	452 (2031) 1,664 VPD (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	20.0m
Proposed Road Pavement Width	3.5m per traffic lane
Proposed Median Width	no median
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on both sides of the road reservation
Equivalent LN Classification	Access Street
Proposed Speed Limit	50kph
Proposed Bus Route Extension / Introduction	NO
If YES Nominate Bus Routes	-
Proposed On-street parking	NO

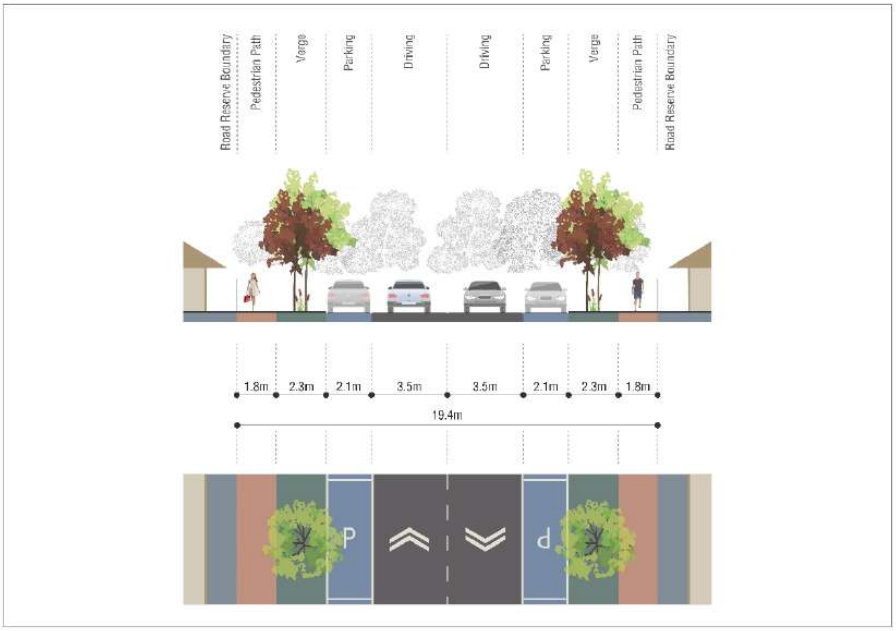
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 05

Name	Brae Road (East of TOD Connector)
Projected Traffic Volumes	439 (2031) 2,599 (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	19.4m
Proposed Road Pavement Width	3.5 per traffic lane
Proposed Median Width	no median
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on both sides of the road reservation
Equivalent LN Classification	Neighbourhood Connector B
Proposed Speed Limit	50kph
Proposed Bus Route Extension / Introduction	YES
If YES Nominate Bus Routes	Autonomous Bus Circular Route
Proposed On-street parking	YES (2.1m wide parking lane on both sides)

Provide graphics of the proposed internal road cross section within the Structure Plan Area



Transport Impact Assessment
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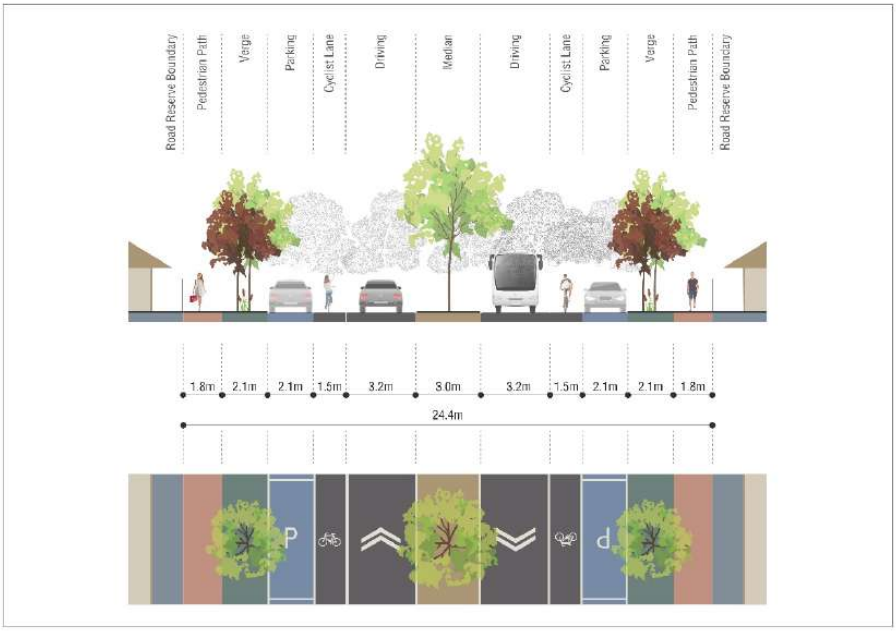
Road 06

Name	Stewart Road
Projected Traffic Volumes	791 (2031)
	4,739 (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	24.4m
Proposed Road Pavement Width	3.2m per traffic lane
Proposed Median Width	3.0m
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on both sides of the road reservation
	1.5m cycling lane on both sides of the road reservation
Equivalent LN Classification	Neighbourhood Connector A
Proposed Speed Limit	50kph
Proposed Bus Route Extension / Introduction	YES
If YES Nominate Bus Routes	Autonomous Bus Circular Route
Proposed On-street parking	YES (2.1m parallel parking on both sides)

Provide graphics of the proposed internal road cross section within the Structure Plan Area



Transport Impact Assessment
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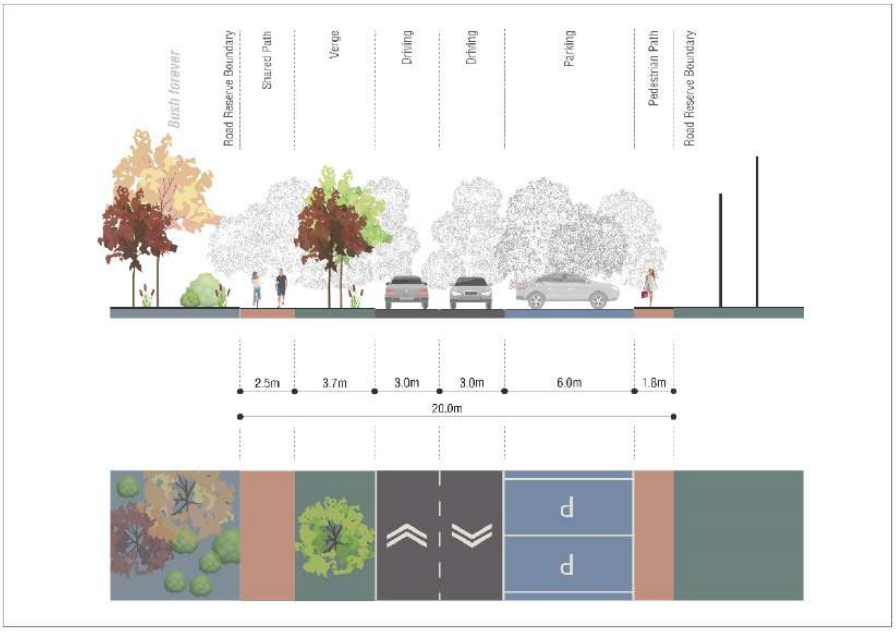
Road 07a

Name	Brand Road at District Open Space (Sporting Precinct)
Projected Traffic Volumes	247 (2031) 2,011 (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	20.0m
Proposed Road Pavement Width	3.0 per traffic lane
Proposed Median Width	no median
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on the eastern side of the road reservation 2.5m shared path on the western side of the road reservation
Equivalent LN Classification	Access Street B
Proposed Speed Limit	40kph
Proposed Bus Route Extension / Introduction	NO
If YES Nominate Bus Routes	-
Proposed On-street parking	YES (6.0m angular parking on the eastern side of the road reservation)

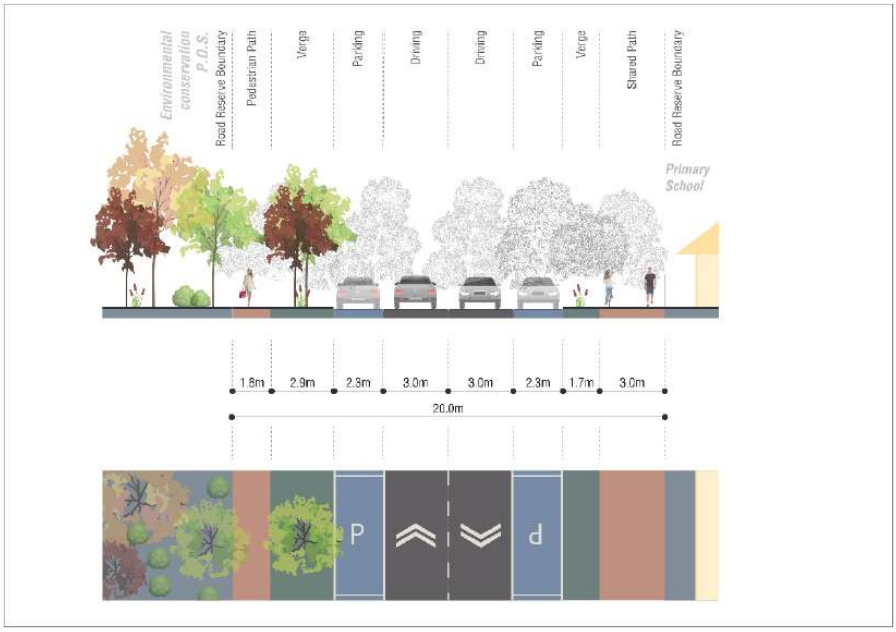
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 07b

Name	Brand Road - South of District Open Space (Sporting Precinct)
Projected Traffic Volumes	247 (2031) 2,011 (2050)
Proposed Number of Lanes	One lane per direction
Proposed Road Reservation Width	20.0m
Proposed Road Pavement Width	3.0m per traffic lane
Proposed Median Width	no median
Proposed Pedestrian / Cyclist / Shared Path Width	1.8 pedestrian path on the western side of the road reservation 3.0m shared path on the eastern side of the road reservation
Equivalent LN Classification	Access Street B
Proposed Speed Limit	40kph
Proposed Bus Route Extension / Introduction	NO
If YES Nominate Bus Routes	-
Proposed On-street parking	YES (2.3m parking lanes on both sides)

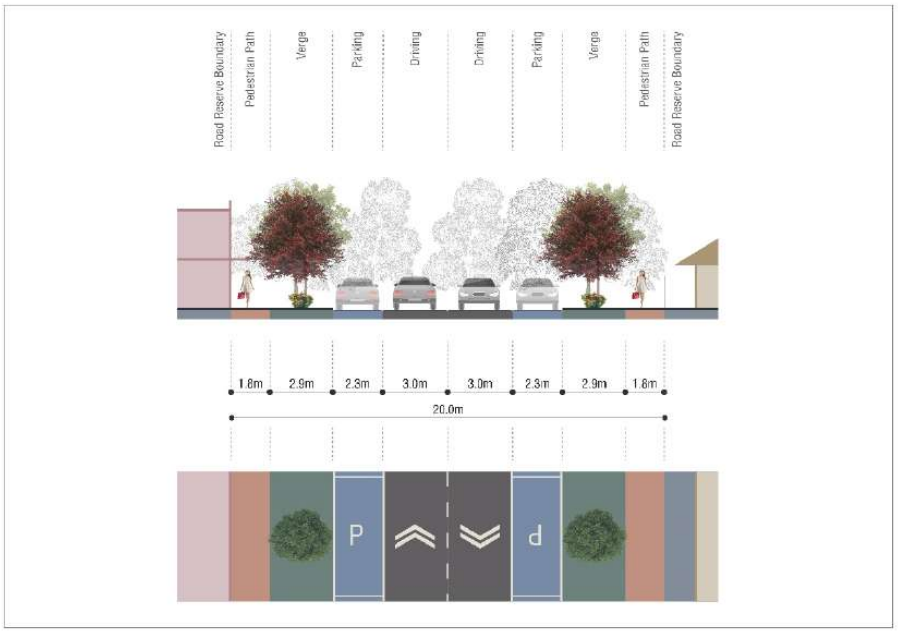
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 08a

Name	Urban Residential Street – type 1
Projected Traffic Volumes	Up to 3,000 VPD (2050)
Proposed Number of Lanes	one lane per direction
Proposed Road Reservation Width	20.0m
Proposed Road Pavement Width	3.0m per traffic lane
Proposed Median Width	N/A
Proposed Pedestrian / Cyclist / Shared Path Width	1.8m Pedestrian Paths on both sides
Equivalent LN Classification	Access Street B
Proposed Speed Limit	40kph
Proposed Bus Route Extension / Introduction	NO
If YES Nominate Bus Routes	-
Proposed On-street parking	YES (2.3 parallel parking on both sides)

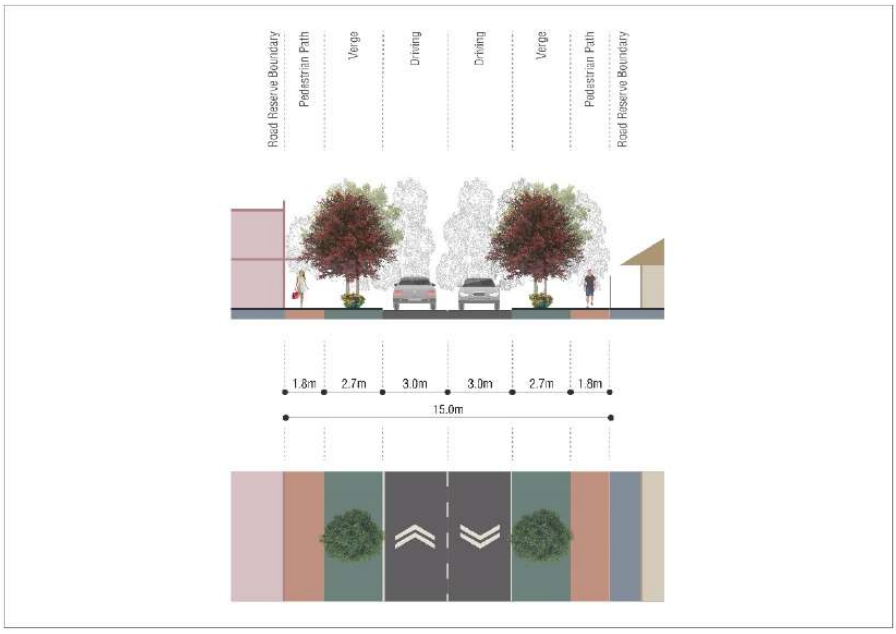
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 08b

Name	Urban Residential Street – type 2
Projected Traffic Volumes	Up to 1,000 VPD (2050)
Proposed Number of Lanes	one lane per direction
Proposed Road Reservation Width	15.0m
Proposed Road Pavement Width	3.0m per traffic lane
Proposed Median Width	N/A
Proposed Pedestrian / Cyclist / Shared Path Width	1.8m Pedestrian Paths on both sides
Equivalent LN Classification	Access Street D
Proposed Speed Limit	40kph
Proposed Bus Route Extension / Introduction	NO
If YES Nominate Bus Routes	-
Proposed On-street parking	NO

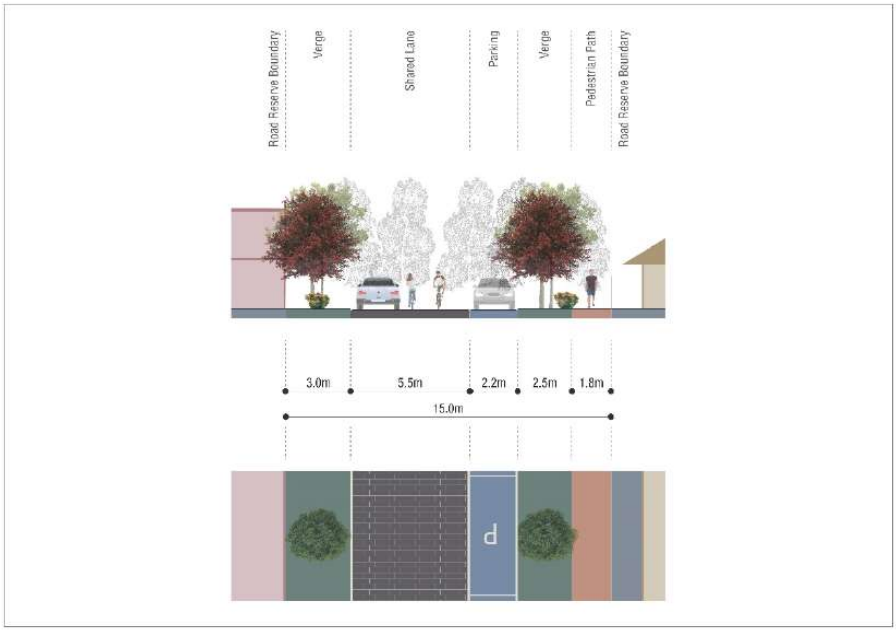
Provide graphics of the proposed internal road cross section within the Structure Plan Area



Road 09

Name	Safe Active Street
Projected Traffic Volumes	Up to 1,000 VPD (2050)
Proposed Number of Lanes	shared lane – no linemarking
Proposed Road Reservation Width	15.0m
Proposed Road Pavement Width	2.25m per traffic lane – lanes are shared space where cyclist have advantage over passenger vehicles
Proposed Median Width	N/A
Proposed Pedestrian / Cyclist / Shared Path Width Equivalent LN Classification	1.8m Pedestrian Path on one side Access Street D
Proposed Speed Limit	30kph
Proposed Bus Route Extension / Introduction	NO
If YES Nominate Bus Routes	-
Proposed On-street parking	YES (2.3 parallel parking on one side)

Provide graphics of the proposed internal road cross section within the Structure Plan Area



2.21 Proposed Intersection Controls

Name the intersection control of the key proposed intersections:

Intersection 1	
Name	Dundas Road / Berkshire Road / Milner Road
Proposed Intersection Control	Roundabout
Intersection 2	
Name	Milner Road / TOD Connector
Proposed Intersection Control	Signalised
Intersection 3	
Name	Milner Road / Maida Vale Road
Proposed Intersection Control	Roundabout
Intersection 4	
Name	Milner Road / Stewart Road
Proposed Intersection Control	Roundabout
Intersection 5	
Name	Milner Road / Raven Street
Proposed Intersection Control	Roundabout
Intersection 6	
Name	Brand Road / TOD Connector
Proposed Intersection Control	Sign Controlled – Give-way
Intersection 7	
Name	Brae Road / TOD Connector
Proposed Intersection Control	Sign Controlled – Give-way
Intersection 8	
Name	Brand Road / Brae Road
Proposed Intersection Control	Sign Controlled – Give-way
Intersection 9	
Name	Stewart Road / Brae Road
Proposed Intersection Control	Roundabout
Intersection 10	
Name	Sultana Road West / Brae Road
Proposed Intersection Control	Sign Controlled – Give-way
Intersection 11	
Name	Milner Road / Sultana Road West
Proposed Intersection Control	T-intersection LILORI

All other intersections will be configured as yield or sign controlled intersections.

2.22 Proposed Internal Transport Networks

Are there any changes/additions to the existing road network?	YES Please refer to Appendices 1 and 2 for the road layout and network configuration. Dundas Road was realigned to facilitate the construction of High Wycombe Train. The realignment was not proposed by this Structure Plan. Most notable changes: • Addition of TOD Connector • Realignment of part of Brae Road to accommodate TOD Connector. • Sultana Road West will be terminated north of the current intersection with Brand Road. • The character of Milner Road east and west of the intersection with Sultana Road West will be different – the western section will be designed to cater for the movement of RAV vehicles, while the eastern portion will be designed as an urban boulevard.
Were there any discussions/agreements with MRWA regarding intersections with or direct access onto roads under their jurisdiction?	N/A
Are there any pedestrian/cycle networks and crossing facilities proposed for the roads within the Structure Plan Area?	YES Shared Paths are proposed for: • Milner Road (Sultana Road West -Berkshire Road) • Brand Road • Berkshire Road Separate Pedestrian Paths are proposed for: • Maida Vale Road • Berkshire Road • Brae Road • Brand Road • Milner Road • TOD Connector • Stewart Road • Newburn Road • Urban Residential Streets Separate Cycle Lanes are proposed for: • TOD Connector • Stewart Road • Milner Road (north of Sultana Road West) • Maida Vale Road The connection of Littlefield Boulevard over Poison Gully Creek, which would allow for pedestrian and cycling traffic, is considered.
Were there any discussions/agreements with the local authority over local road networks and pedestrian and cycle facilities?	The City of Kalamunda's bicycle plan was considered in this proposal. Department of Transport has also commenced the initiative of Safe Active Streets (SAS) that was considered in this project. While no direct corridors were designated as SAS, a number of local access streets can be considered for this initiative.

Were there any discussions / agreements with PTA / Transperth on new bus services or extensions / alterations to existing bus services to serve the Structure Plan Area? *If YES, nominate*:	YES In order for new lines to be introduced, the overpass on Roe Highway needs to be constructed; however, this is likely to occur beyond 2050. After completing the overpass, new lines will be introduced to connect Maida Vale South and other suburbs east of the Roe Highway with the High Wycombe Train.

2.23 Changes to External Transport Networks

Are there any proposed changes to the road network?	YES • In Perth and Peel Transport Plan @3.5million, it is stated that by 2050 Roe Highway will be upgraded to 8-lane freeway standard. • Realignment of Dundas Road • Realignment of Brae Road
Are there any proposed changes to the intersection controls?	• Grade separation of Kalamunda Road / Roe Highway intersection - Completed in 2021 • Roundabout at the realigned intersection of Dundas Road / Berkshire Road / Milner Road • 2021 - Roundabouts construction is started at the intersections of the on and off ramps to Roe Highway and Maida Vale Road.
Are there any proposed changes to the pedestrian/cycle networks and crossing facilities?	The major changes external to the LSP area will be within Maida Vale South LSP after its completion. Other major changes are mostly internal to the structure plan area or at its boundary. Maida Vale Road will also feature improved cycling and pedestrian facilities.
Are there any proposed changes to the public transport services?	Since the entire surrounding area is about to go through significant changes, it is expected that many changes will occur in public transport services provision. Until the future road network is in detailed stages of planning, no precise information is available. It is expected that buses will operate along Berkshire Road, Dundas Road and Maida Vale Road.
Proposed innovative transport initiatives	A driverless shuttle should be considered. This shuttle can provide a direct connection between the proposed railway station and the residential precinct, with a potential for expansion of service once the overpass is constructed, which is not expected until after 2050. Alternatively, a pool of smaller vehicles can be considered as it can be stored and operated locally (either as a part of the community service or as a part of the railway station complex) Given the prominence of the railway station and the intention to design a nearby Transit-Oriented Development, appropriate bicycle parking facilities should be considered within the proposed station parking areas. This would enable residents to

cycle to the station and take advantage of a fully integrated sustainable transportation system.

2.24 Integration with Surrounding Area

Are there any existing major residential generators of traffic within a minimum of 800 metres from the boundaries of the Structure Plan Area?	YES
If YES, nominate:	High Wycombe to the north; Future Maida Vale South to the east
Are there any existing major non-residential attractors of traffic within a minimum of 800 metres from the boundaries of the Structure Plan Area?	YES
If YES, nominate:	• Existing Industrial Zone south of Berkshire Road • Although not within an 800m radius, Perth Airport is located approximately 2km to the west of the LSP area • Future High Wycombe Train Station • Edney Primary School
What are the main desire lines between the structure plan land uses and these external attractors/generators?	Via Dundas Road, Abernethy Road, Maida Vale Road, future TOD Connector and beyond 2050 via overpass above Roe Highway.
Will the existing transport networks, plus any proposed changes, adequately match these desire lines, particularly for pedestrians, cyclists and public transport users?	YES Once all planned upgrades are completed (new roads and upgrades of existing roads) the whole area will be well connected to the existing and future surrounding major attractors/generators.
Identify any deficiencies or areas for improvement in the surrounding transport networks and/or areas where improvements could be made.	N/A The area is well planned; when all the infrastructure is completed, it is expected that the network will function without any major issues.

2.25 Analysis of Transport Networks

Determine the year(s) for assessment and the time period(s) for the traffic flow analysis.	2031 (with approximately 15% of Forrestfield North Project Area constructed and operational) 2041 (with approximately 65% of Forrestfield North Project Area constructed and operational) 2050+ (as the full build-out)
Determine structure plan generated traffic.	17,914 VPD Besides Residential Precinct, structure plan generated traffic includes all traffic from the Forrestfield North TOD and Activity Centre Precincts. Refer to Appendix 4 for more details on traffic modelling.

Structure Plan Impact on Internal and Surrounding External Road Network

Road (Link)	Section	Total Daily Traffic (2031)	External Daily Traffic (2031)	Residential Precinct (2031)	Total Daily Traffic (2050)	External Daily Traffic (2050)	Residential Precinct (2050)
Roe Highway	South of Berkshire Road	120,028	119,171	561	158,183	153,824	3,296
			99.29%	0.47%		97.24%	2.08%
	Between Berkshire Rd and Maida Vale Rd	113,361	113,310	44	140,469	140,182	233
			99.96%	0.04%		99.80%	0.17%
	North of Maida Vale Road	101,905	101,898	0	125,922	125,868	0
			99.99%	0.00%		99.96%	0.00%
	North of Kalamunda Road	108,552	108,026	483	139,007	136256	2,543
			99.52%	0.44%		98.02%	1.83%
Berkshire Road	West of Roe Hwy	16,404	14,422	681	25,843	18,302	4,017
			87.92%	4.15%		70.82%	15.54%
	East of Roe Hwy	17,883	16,721	164	31,805	28,444	954
			93.50%	0.92%		89.43%	3.00%
	South of Milner Rd	15,659	13,606	741	24,915	17301	4,078
			86.89%	4.73%		69.44%	16.37%
Dundas Road	South of Berkshire Road	11,057	10,443	325	15,169	13,236	1,173
			94.45%	2.94%		87.26%	7.73%
	South-west from Old Dundas Road alignment	10,413	9,600	0	13,680	12,306	0
			92.19%	0.00%		89.96%	0.00%
	North of Old Dundas Road alignment	12,471	10530	599	19,964	13407	3,045
			84.44%	4.80%		67.16%	15.25%
Maida Vale Road	East of Ibis Place	3,308	930	682	7,620	1,101	3,600
			28.11%	20.62%		14.45%	47.24%
	East of Raven Street	2,856	1,154	0	4,422	1,231	32
			40.41%	0.00%		27.84%	0.72%
	East of Milner Rd	6,522	4114	789	13,072	4178	4,892
			63.08%	12.10%		31.96%	37.42%
Milner Road	South of Maida Vale Rd	3,914	2,864.00	789	9,288	2,747	4,892
			73.17%	20.16%		29.58%	52.67%
	South of TOD Connector	4,045	3,001	882	8,110	2,820	4,393
			74.19%	21.80%		34.77%	54.17%
	North of Berkshire Rd	6,947	5217	1,066	12,928	5073	5,437
			75.10%	15.34%		39.24%	42.06%
Enterprise Boulevard	West of Maida Vale Rd	1,817	0	51	3,631	0	302
			0.00%	2.81%		0.00%	8.32%

	North of TOD Connector	663	0	21	1,924	0	103
			0.00%	3.17%		0.00%	5.35%
Raven Street	South of Maida Vale Rd	1,410	456	682	5,602	396	3,632
			32.34%	48.37%		7.07%	64.83%
	South of Milner Rd	1,015	0	1,015	5,984	0	5,984
			0.00%	100.00%		0.00%	100.00%
Stewart Road	East of Milner Rd	791	0	791	4,739	0	4,739
			0.00%	100.00%		0.00%	100.00%
TOD Connector	East of Milner Rd	1,428	319	804	6,432	323	4,464
			22.34%	56.30%		5.02%	69.40%
	South of Ibis Pl	695	0	129	2,322	0	555
			0.00%	18.56%		0.00%	23.90%
	South of Brae Rd	733	0	733	4,520	0	3,765
			0.00%	100.00%		0.00%	83.30%
Sultana Road West	West of Milner Rd	498	0	20	1,586	0	338
			0.00%	4.02%		0.00%	21.31%
	East of Milner Rd	786	564	184	1,872	554	1,081
			71.76%	23.41%		29.59%	57.75%
	West of Brae Street	452	217	209	1,664	180	1,332
			48.01%	46.24%		10.82%	80.05%
Newburn Road	North of Maida Vale Road	4,131	3534	483	6,568	3593	2,567
			85.55%	11.69%		54.70%	39.08%
Brae Road	East of TOD Connector	439	0	439	2,599	0	2,698
			0.00%	100.00%		0.00%	103.81%
Brand Road	North of TOD Connector	247	0	247	2,011	0	2,386
			0.00%	100.00%		0.00%	118.65%

Identify all schools within the structure plan area and those within 800 metres of the structure plan area.

Identify the most likely walk and cycle routes to each school from the catchment areas.

There are three schools within 800m of the structure plans: the proposed primary schools in the Residential Precinct LSP area and Maida Vale South LSP area and Edney Primary School.

The main walk and cycle routes will include the pedestrian and cycle lanes on TOD Connector and all other paths leading to Brand Road, where the future primary school will be located within the LSP area.

element.

Technical Appendix G – ISR

INFRASTRUCTURE SERVICING REPORT

Forrestfield North – Residential Precinct

Forrestfield North, Western Australia

October 2021

Rev F

HISTORY AND STATUS OF THE DOCUMENT

Revision	Date issued	Approved by	Issued To	Revision type
Rev A	20.10.2017	C Kleyweg	Peter Varelis	Issued for Review
Rev B	15.04.2018	C Kleyweg	Peter Varelis	Final
Rev C	17.04.2020	C Kleyweg	Murray Casselton (Element)	Final
Rev D	11.05.2020	C Kleyweg	Murray Casselton (Element)	Final
Rev E	15.09.2021	C Kleyweg	Murray Casselton (Element)	Final (updated to reflect the amendment of the LSP)
Rev F	06.10.2021	C Kleyweg	Malcom Somers (Element)	Comments from City of Kalamunda added

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Project Manager	Colin Kleyweg
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Name of the Document	Forrestfield North – Residential Precinct Infrastructure Servicing Report
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Prepared By: KCTT (Trading as KC Traffic and Transport Pty Ltd)
ABN 35 148 970 727 |
Postal address: PO Box 1456, Scarborough, WA 6922
Phone: 08 9441 2700 |
Website: www.kctt.com.au |

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Appendix 1 - KCTT Concept Design Drawings

1. KCTT Infrastructure Servicing Report

1.1 Executive Summary

The Forrestfield North Residential Precinct Local Structure Plan (LSP) has been carefully developed to promote equity between as many landowners as possible for the simple development of landholdings in accordance with the intent of the LSP. This Infrastructure Servicing Report focuses on a wide range of infrastructure development strategies inclusive of: -

- major road network upgrade requirements including upgrades to: -
    - Dundas Road realignment, between Berkshire Road and Maida Vale Road.
    - Berkshire Road (upgrade to 4-lanes).
    - Milner Road (upgrade to 2 lane divided carriageway, south of Sultana Road West).
    - Milner Road (upgrade to 2 lane divided carriageway between Sultana Road West and Maida Vale Road with parking and widened pedestrian environments plus cycling facilities).
    - Sultana Road West (improved industrial access road east of Milner Road).
    - Maida Vale Road (upgrade to 2-lane divided carriageway east of Milner Road).
    - Maida Vale Road (upgrade to 2 lane divided carriageway west of Milner Road).
    - Provision of new TOD Connector Boulevard linking the Forrestfield North Railway Station, through the Forrestfield North TOD and AC Precinct, the Forrestfield North Residential Precinct LSP Area to the Maida Vale South LSP Area.
- key intersection upgrades at the following locations: -
    - Ibis Place / Maida Vale Road.
    - Berkshire Road / Dundas Road / Milner Road (dual lane roundabout).
    - Milner Road / Sultana Road West.
    - Milner Road / Maida Vale Road.
    - Milner Road / TOD Connector Boulevard (new intersection).
- conceptual bridge and interchange upgrades at the Roe Highway / Maida Vale Road interchange. These existing t-intersections have been upgraded to roundabout intersections in accordance with current MRWA requirements.
- infrastructure for alternative transportation modes, inclusive of public transport, consideration of future transport modes in design, pedestrian, and cyclist requirements.
- provision of on-street car-parking on all major internal roads suitable for high-density development for interim transportation modal choice requirements in Perth, but allowing for future modal shifts.
- incorporation of streetscaping, place-making and urban design requirements in the public realm as part of the overall infrastructure planning and civil concept designs.
- upgrade requirements to existing wastewater infrastructure to cater for the full development of Forrestfield North Residential, Forrestfield North TOD and AC Precinct and the Maida Vale South Structure Plan areas, with an up-front infrastructure provision to be determined as part of future phases of the planning process in liaison with State Government to allow for development across both the Forrestfield North Residential LSP and Forrestfield North TOD and AC Activity Centre Plan (ACP) Areas considering the number of different landholders within the LSP and ACP areas.
- upgrade requirements for the reticulation of potable water.

- development of stormwater drainage strategies and the incorporation of Water Sensitive Urban Design strategies that will make Forrestfield North a strong proponent of WSUD, including: -
    - provision of infiltration drainage cells and storage cells in all major road networks.
    - at-source treatment at drainage pits.
    - infiltration / underground storage / WSUD measures at drainage collection points minimising the wastage of open space at ground levels in all POS / environmental conservation areas.
- future potential upgrade requirements for the reticulation of power assets into the Forrestfield North TOD and AC Precinct, to be determined iteratively as development proceeds and to be managed by developers on all roads abutting land to be developed as a standard WAPC condition of subdivision.
- future potential upgrade and relocation requirements for the connection of telecommunications and broadband internet, to be determined iteratively as development, to be managed by developers on all roads abutting land to be developed as a standard WAPC condition of subdivision; and
- future upgrade and relocation requirements for the provision of gas services, to be managed by ATCO Gas in coordination with developers where an open trench is provided by the developer for the reticulation of gas infrastructure.

Road Network

The road network has been designed to accommodate an interface between industrial land uses to the south and residential and activity centre uses north of Sultana Road West, with design to suit turning movements for RAV 4 and RAV 7 vehicles with key upgrades in Berkshire Road, Dundas Road, Milner Road (south of Sultana Road West) and in Sultana Road West. The Residential Precinct is expected to be a generator of local traffic in the short to medium term, therefore robust designs need to be accommodated for the expected traffic generation which will be applied to key road networks inclusive of Maida Vale Road, Milner Road north of Sultana Road West and the TOD Connector Boulevard and understanding the impacts of the trip generation on external road networks. This is examined in detail in KCTT's Transport Impact Assessments for the TOD and AC Precincts and the Residential Precinct.

Designing an interface between local residential, commercial, retail and traffic attracted to / generated by the proposed land-uses within the Residential and adjacent TOD and AC Precincts, and the regional traffic that will be attracted to the parking for the Forrestfield North Railway Station is a balancing act in the development of a strong Residential outcome on the periphery of the TOD and AC Precincts.

Therefore, within the Residential Precinct, boulevard-style pedestrian amenity, promotion of on-road cycling and strong, direct links to the TOD and AC Precinct are distinct themes in this LSP. The design for the roads within the Residential Precinct focuses on the mix of transportation usages and should not be designed with the car dominating all other forms of transportation. We recommend through the implementation phases of this project that consideration is continually given to designing road cross-sections in conjunction with the Integrated Transport Branch of the Department of Transport. These focuses include constraining vehicular speeds under 40kph and promoting mixed usage within these road reservations that allow for vehicular movement while providing safer environments for pedestrians, cyclists, and vulnerable road users. We believe that for Forrestfield North to become a vibrant centre, it is important that the streetscape environment is welcoming to more than just through vehicle movements and this is the ethos of the LSP.

Intersection Upgrades

There are a series of main intersections that require upgrade to accommodate the expected vehicular trip generations and attractions within the LSP and ACP Areas, including the Berkshire Road / Dundas Road / Milner Road intersection which is designed to be a reconfigured 4-lane, 4-way roundabout with capability for RAV 7 vehicles. The intersection of Milner Road and Sultana Road West is of high importance to the overall form and function of the residential and TOD and AC precincts because it forms the boundary between the industrial land-uses to the south and the urban land-uses to the north. This intersection is designed to accommodate left and right turn manoeuvres for RAV 4 vehicles. Additional upgrades include the intersection of Maida Vale Road and Milner Road, which will need to be upgraded to a roundabout featuring 2-lane approaches (one circulating lane) and the on-off ramps for Roe Highway / Maida Vale Road which will be reconfigured as roundabouts in accordance with current Main Roads WA policies.

Within the Residential Precinct, the intersection of Milner Road and Stewart Road, TOD Connector Boulevard and Brae Road, Brae Road and Stewart Road and the TOD Connector Boulevard and Brand Road are the intersections of high importance. These are discussed in greater detail in the KCTT Transport Impact Assessments for the LSP and ACP Precincts.

Bridge Structures

KCTT have developed a concept design for the required widening of the Maida Vale Road flyover. Due to increased traffic on Maida Vale Road, the bridge is maintained at 2-lanes. The connectivity between Maida Vale South and the Forrestfield North Railway Station is of future importance as a longer-term investment, however the earlier proposed TOD Connector bridge has been removed from this LSP due to uncertainties in development timeframes.

Alternative Transportation Infrastructure

The Forrestfield North Residential Precinct has a series of major pedestrian and cycling path networks providing full inter-connectivity within the Residential Precinct, and with High Wycombe and the TOD and Activity Centre Precincts to the west and Maida Vale South in the longer term. All roads have minimum 1.8 metre width pedestrian paths, with on-road cycling in Milner Road (north of Sultana Road West) and the TOD Connector Boulevard and shared paths on roads with higher order function.

The function of Maida Vale Road and Ibis Place is very important in the short to medium term as a main route of connectivity for local bus networks to access the Forrestfield North Railway Station. In the future, the TOD Connector Boulevard may provide direct connectivity between Forrestfield North and Maida Vale South, should the Maida Vale South LSP progress.

Wastewater Infrastructure

KCTT have held detailed discussions with the Water Corporation with relation to the upgrade and extension of wastewater infrastructure to service Forrestfield North and Maida Vale South as an interim measure, while the Water Corporation completes detailed planning for the Gooseberry Hill Planning Area. The interim plan involves the extension of wastewater infrastructure along Dundas Road for the TOD and AC Precincts and along Milner Road with 3 branch systems along Sultana Road West (picking up the proposed AC Precinct and the Industrial Composite land-uses in Sultana Road West, and into Raven Street and Stewart Road to service the majority of the Residential Precinct. Not all properties will be able to service directly off these extensions, however the premise is that the potential early delivery of wastewater infrastructure for the area will accelerate development potential across a greater number of landholdings than presently exists due to the disparate nature of land ownership in the Precinct Areas.

Given the significant changes in yields since the previous iteration of the Residential Precinct LSP, KCTT will coordinate this ISR with the Water Corporation to update planning for both wastewater and water.

Water Infrastructure

As for the wastewater above, KCTT have held detailed discussions with the Water Corporation in relation to the future requirements for water. The exact requirements for water infrastructure will be confirmed by the Water Corporation as the LSP process nears completion, however there are no impediments to short-term development in the Residential Precinct, with existing services capable of servicing initial developments.

Power

KCTT have held initial informal discussions with respected electrical consultants UPD in relation to current Western Power policies when considering large-scale / long-timeframe developments of this nature. The development of power infrastructure to suit developments of this type is an iterative process, as additional power capacity cannot be "stored". We understand that Western Power is currently not utilising new 1-hectare transformer / substation sites but is preferring to increase the capacity of existing major substations. Some lead-in work may be required after the first 5 to 10 years of development, but this will be contingent on the rate of development in Forrestfield North and the rate of expansion of other land-use assets connected to local substations and feeders. The main infrastructure requirement will be the undergrounding of existing HV and LV assets in roads to be widened and in road reserves to be closed. Power requirements for the area will need to allow for the relocation of many existing assets due to road widening / road reservation closure and may need to allow for either the relocation of HV assets, or the selected undergrounding of such assets. The requirements for undergrounding of existing overhead power assets are developer-funded requirements which form part of each developer's WAPC Conditions of Subdivision, where the existing roads directly fronts the proposed development landholdings.

Undergrounding of power should only be considered a DCP item where infrastructure identified in the DCP necessitates undergrounding, and the requirement is not otherwise required through the subdivision process.

Telecommunications / Gas

Telecommunications and Gas infrastructure are available in the Structure Plan areas for immediate development and as per the discussions above in relation to power and water, telecommunications and gas infrastructure are upgraded as development commences and concept planning for headworks infrastructure is finalised as development rates per annum are known with greater certainty.

Summary

In summary, all infrastructure items have been considered in detail in the Infrastructure Servicing Reporting conducted for this project, with appropriate items costed as for consideration as part of the future DCP for the Forrestfield North Project area.

2. Location

Table 1 - Location Information

Structure Plan	Local Structure Plan Precinct	Suburb	Locality (Shire, City etc.)
Forrestfield North District Structure Plan	Residential Precinct	High Wycombe	City of Kalamunda

Brief Description of Site

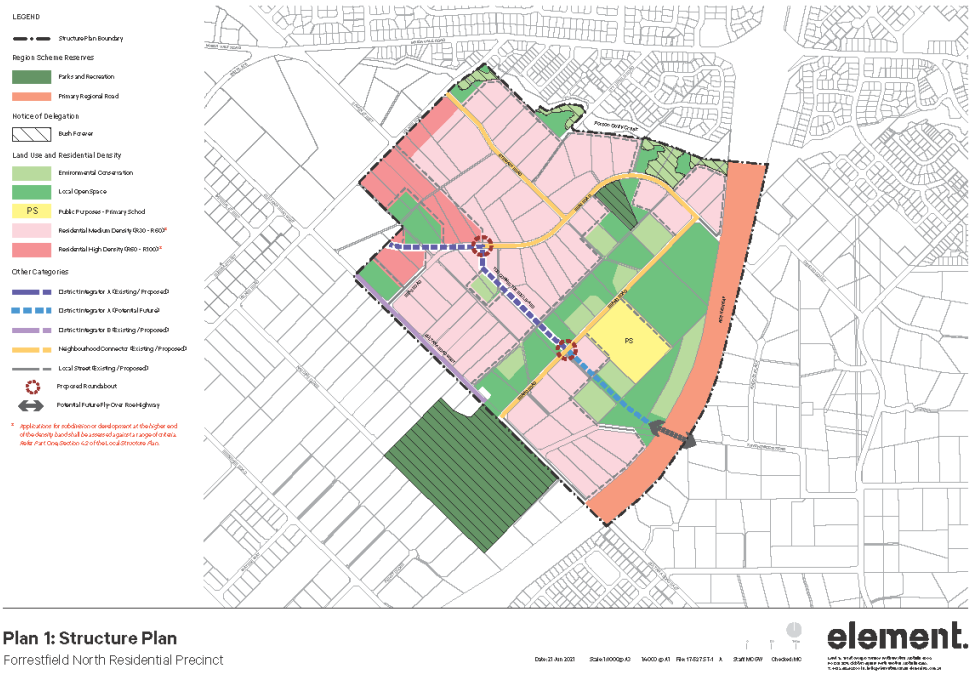
The Forrestfield North Residential Precinct Local Structure Plan (LSP) has developed iteratively with the LSP being largely influenced by the provision of the High Wycombe Railway Station. The Forrestfield North Residential Precinct area is bounded by Roe Highway to the east, Sultana Road to the south, Milner Road to the west and the Poison Gully Creek to the north-eastern corner of the intersection of Milner Road and Sultana Road West which has been planned as the future Activity Centre. The planning and engineering requirements for the Activity Centre will be discussed in detail in a separate ISR for the Forrestfield North Activity Centre and TOD Precinct ACP.

Historically, the land-uses in the Forrestfield North Residential Precinct have been low density rural residential, with retention of natural vegetation (ranging from sparse to heavily populated). The land uses surrounding the proposed LSP area include recreational and residential uses to the north (High Wycombe); to the east across Roe Highway (Forrestfield and Maida Vale); and industrial land-uses to the south (Forrestfield / Hazelmere) and industrial / bulky goods to the west (Perth Airport).

2.1 Proposed Development

The proposed development entails a Residential precinct of 108 hectares as part of the Forrestfield North District Structure Plan (DSP). The residential precinct is proposing medium to high-density urban residential land-uses which shall likely range from R40 through R80 residential development (Figure 2). This project is an excellent opportunity for larger-scaled deployment of housing typologies that target the “missing middle” which describes the lack of smaller lot/dwelling product between $80m^2$ and $250m^2$ in Perth. One of the key objectives of this ISR is to examine conceptual design for roads that minimises wholesale changing of existing ground levels. The existing vegetation and topography to the area are the key assets to be maintained.

Figure 1 - Local Structure Plan (Draft) by Element



(Element, 2021)

The Forrestfield North DSP nominated the following development yields, with the area of interest (residential precinct yield) highlighted in bold, with the current draft yields shown for the LSP in the right column: -

Table 2 – Forrestfield North Residential LSP Indicative Yields

Development Type	No of R30 Dwellings	No of R40 Dwellings	No of R60 Dwellings	No of R80 Dwellings	Total Number of Dwellings
Residential	360	578	1,056	424	2,418

	Total Area
Primary School	39,827 m^2 ≈ App 4 ha
	Total Area
Open Space Provision	316,802 m^2 ≈ App 31.7 ha

As shown in Table 2 above, the number of dwellings has been revised significantly since the DSP phase of Forrestfield North. This highlights the commitment of the various agencies to Forrestfield North (FFN) being a location that embraces TOD principles and provides a diverse range of housing typologies.

2.2 Existing Buildings

Table 3 - Data on Existing Buildings and Structures in the Forrestfield North Residential Precinct LSP

Does the feature existing buildings? If YES nominate.	YES, existing residential dwellings, mainly populated in the middle of precinct. Two businesses are in the south-east and north-east portions.
Number of buildings?	Approx. 70
Approximate age of buildings?	10-35 years, some potentially older
Is asbestos likely to be an issue? YES / NO	YES Desktop studies show that some existing buildings are at least 10-20 years old and thus asbestos could have been used in the construction of eaves fencing and other areas where asbestos was commonly used. Further investigation required to confirm.
Are septic tanks present? YES / NO	YES Wastewater plans for the precinct sourced from EsiNet show that there are minimal existing wastewater services in the FFN. Thus, the presence of septic tanks within the precinct should be considered on each private landholding.
Likely issues associated with remediation?	Key issues are likely to be asbestos in some buildings and structures to be demolished, and de-commissioning of septic tank / leach drain setups. These issues are local in nature and will be the responsibility of future land developers, therefore any structures in the future Public Open Space / Environmental Conservation areas will be addressed as part of future DCP preparation and acquisition processes.

2.3 Earthworks

Describe the general levels across the site	Ground surface contours fall from 45.0 AHD in the east to 32.0AHD in the west. The design ethos will be to retain existing topography throughout the provisions of smaller lots.
Describe AAMGL levels across the site	Strategen's LWMS shows MGL levels a minimum of 5 metres below the surface throughout the Residential Precinct LSP. The LSP is therefore not impacted by high groundwater.
Is Groundwater an issue on this site? If YES, is fill likely to be required? If YES, what is the quantum of fill?	NO Groundwater is expected to be no nearer than 5 metres within the surface topography across the site based on information provided in Strategen's LWMS.
Can cut to fill techniques be utilised? If YES, provide quantity m^3	YES, Cut to fill techniques are possible due to the large clearance between groundwater and the surface topography. However, this will be subject to further

	geotechnical investigation relatively to the quality of the in-situ material. The utilisation of cut to fill techniques will depend on and be dictated by the depth of Bassendean Sand and Yoganup Sands and will need to be reviewed at the detailed design phase for each subdivision.
What is the likely depth of topsoil (mm)?	To be indicated by Geotechnical report, expected to range between 100mm to 200mm.
Is the topsoil suitable for re-use?	POTENTIALLY. Further Geotechnical investigation required to investigate depth of Bassendean Sand and Yoganup Sands, to be confirmed. It is likely that topsoil can be re-used in verges and in POS areas.
Describe the natural vegetation on the site? Dense / Moderate / Sparse / Cleared	MODERATE-DENSE. Mature vegetation. Presence of trees with concentrated areas located in the central portion of the precinct. Western and eastern outskirts of the precinct are sparse. Explained in further detail in Environmental Reports.
Are there significant trees that need to be kept?	YES, Significant areas of existing vegetation have been maintained as part of the LSP.
What is the likely soil profile?	Perth Groundwater Atlas indicated that the site area is comprised of Bassendean Sand and Yoganup Sands: quartz sand (dunes). Further geotechnical investigation required to determine and confirm the in-situ soil.
Risk of acid sulphate soils? High / Moderate / Low	Perth Groundwater Atlas and Land Gate SLIP Portal investigations indicate that there is MODERATE-LOW risk of acid sulphates for the precinct. Further investigation required on the presence of Acid Sulphate Soils prior to conduction of works.
Is there peat or other unsuitable materials? If YES nominate the following;	UNLIKELY. Geotechnical report required for confirmation at each future development site.

For localised cut to fill (up to +/- 1.0 metre), it is highly likely that the existing soils will be suitable for re-use. This is a key component of sustainability and a key objective of the Forrestfield North Residential Precinct LSP. In 2016, KCTT completed research on the impact that overfilling land development sites has both economically and environmentally. Apart from the issues associated with difficulties in tree retention on filled developments, we found the following key metrics: -

Table 4 - KCTT Key Metrics for Earthworks Warrants (Table A)

Lot Size	Fill Depth	Fill Required Per Lot	Distance to Nearest Quarry	CO_2 Emissions Per Lot	Volatile Organic Compound
$80m^2$	1.0m	$230m^3$	40km	952kg	34,007kg
$100m^2$	1.0m	$250m^3$	40km	1035kg	36,964kg

$120m^2$	1.0m	$270m^3$	40km	1110kg	39,921kg
$160m^2$	1.0m	$310m^3$	40km	1283kg	45,835kg
$200m^2$	1.0m	$350m^3$	40km	1450kg	51,750kg

Table 5 below shows further pollution measures from the import of raw materials for filling residential development sites. This is very important when considering warrants for importation of fill.

Table 5 - KCTT Key Metrics for Earthworks Warrants (Table B)

Lot Size	Total Hydrocarbons (THC Per Lot)	Carbon Monoxide Cost Per Lot	Nitrogen Oxides (not per lot)	Particulate Matter Under 2.5 Micron Per Lot
$80m^2$	34,711kg	267,246kg	49,012kg	952kg
$100m^2$	37,730kg	290,485kg	53,214kg	1035kg
$120m^2$	40,748kg	313,724kg	57,536kg	1110kg
$160m^2$	46,785kg	360,201kg	66,060kg	1283kg
$200m^2$	52,822kg	406,679kg	74583kg	1450kg

Importation of fill is therefore a significant contribution to pollution due to its labour-intensiveness in the field of transportation. Therefore the proposed road and infrastructure designs in KCTT's 15% concept design plans seek to tie-in to existing levels as closely as possible to minimise requirements for importation of fill and / or carting of excess materials.

2.4 Roadworks

Do existing roads require upgrade?	YES With the new proposed residential development, all existing roads will need to be upgraded to compliment the new medium-high residential density development. Existing conditions of the roads are not adequate to accommodate the volume of traffic that will be generated by the new development. Current road widths are very narrow. This LSP proposes significant upgrading of key internal road networks.

In this section of the ISR, KCTT review in detail the existing road reservations and pavement composition, the proposed cross sections across the Residential and TOD and AC Precincts and provide analysis of the future road requirements for the Forrestfield North Residential and TOD and AC Precincts.

2.4.1 Existing Road Reservations and Pavements

The table below provides details on the existing roads that form a key part of the future road spine within the Forrestfield North Residential Precinct LSP area.

Table 6 - Data on the Existing Road Network

Road Name	Length (m)	Road Width (m)	Road Reserve Width (m)	Description
Sultana Road West	515	6.5	20	Two-way single road with an approximate width of 6.5m and road reserve width of 20m, according to desktop studies. With no road marking or kerbing therefore, the road will require upgrading. 2-way, 2-lane road.
Milner Road	1,630	7.5	20	Rural type road with no road markings or significant kerbing. 2-way, 2-lane road.
Dundas Road	1,150	8	20	Existing semi-mountable kerbing throughout. Major realignment works are required due to the Forrestfield North Railway Station works. 2-way, 2-lane road.
Imperial Street	310	6.5	20	Industrial type road with flush kerbing allowing drainage to flow overland onto verges. 2-way, 2-lane road.
Ibis Place	320	6.5	20	Existing coarse asphalt, rural residential road. Requires major upgrades, kerbing etc. 2-way, 2-lane road.
Raven Street	360	6.5	20	Existing coarse asphalt, rural residential road. Requires major road upgrades, kerbing etc. 2-way, 2-lane road.
Eureka Street	550	10.0	20	Industrial standard road. Fit for purposes. 2-way, 2-lane road.
Berkshire Road	1,085	9.0	20	Industrial Connector Road with 2 x 4.5m wide lanes and painted centreline.

2.4.2 LSP Road Cross Sections

The proposed road network will be discussed in detail in the Transport Impact Assessment (TIA), however from a civil infrastructure perspective the following roads have been identified as part of the road networks that are suitable for consideration as part of a future DCP, with each cross section showing the road name identifier.

Figure 2 – RD01 Berkshire Road Cross Section

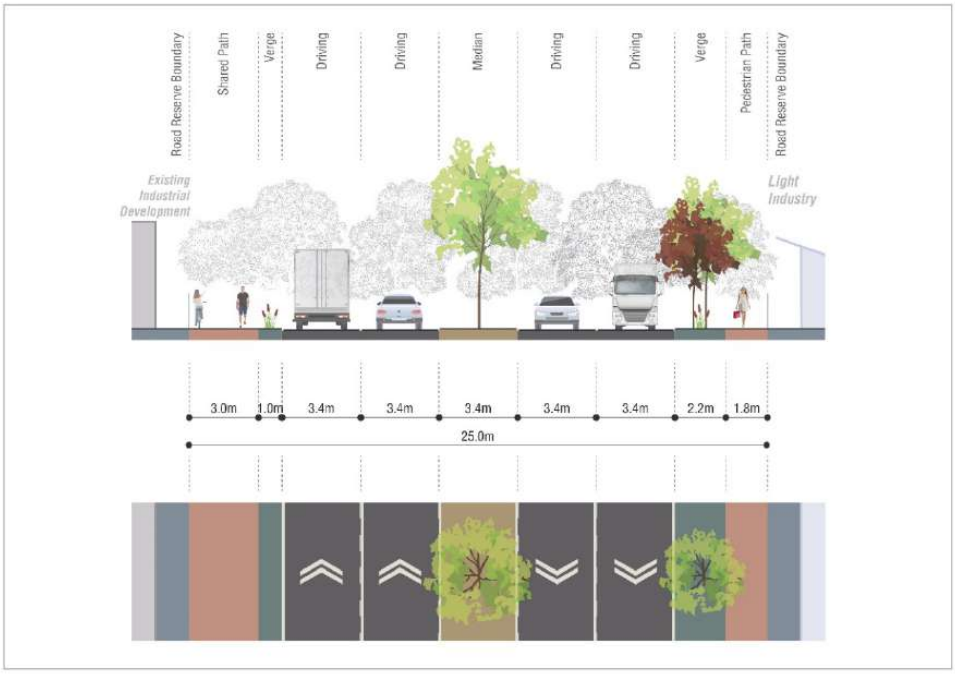


Figure 3 – RD02 Milner Road Cross Section (Sultana Road West to Stewart Road)

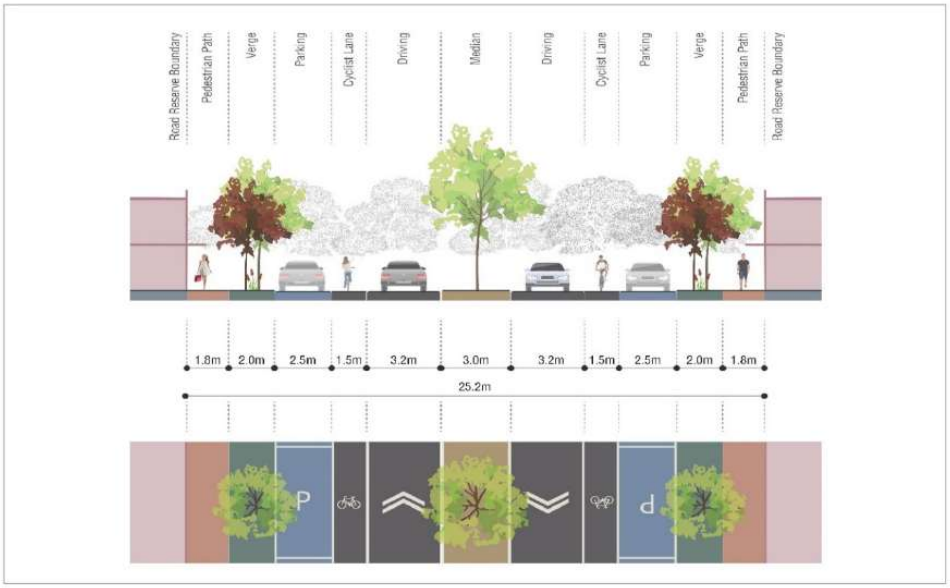


Figure 4 – RD03 Maida Vale Road (East of Milner Road), RD04 Maida Vale Road (Milner Road to Raven Street) and RD05 Maida Vale Road (West of Ibis Place)

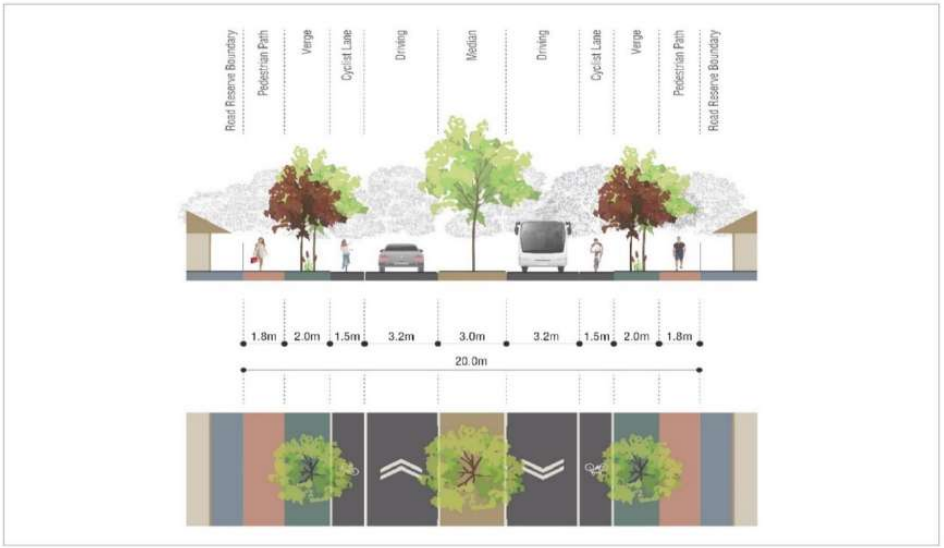


Figure 5 – RD06 Dundas Road (South of Berkshire Road), RD07 Dundas Road (Berkshire Road to Dundas Road Old) and RD08 Dundas Road (North of Deviation) Cross Section

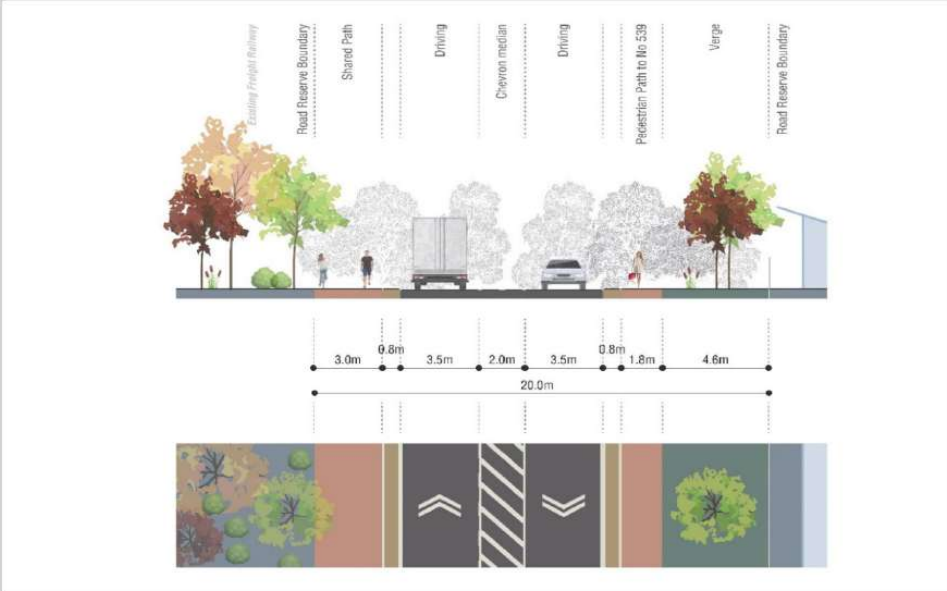


Figure 6 – RD09 Milner Road (Berkshire Road to Sultana Road West) and RD10 Milner Road (Stewart Road to Maida Vale Road) Cross Section

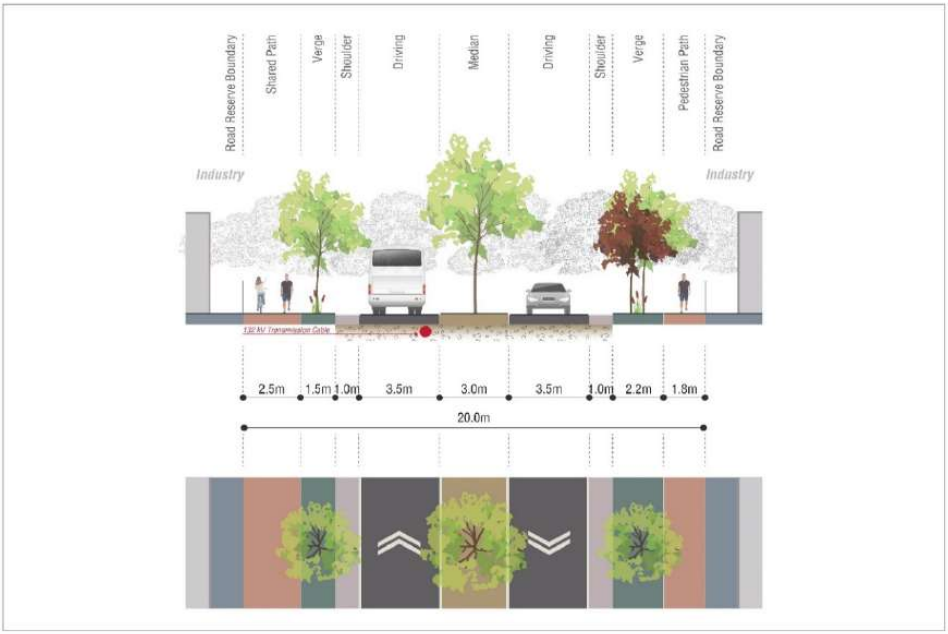


Figure 7 – RD11 Ibis Place / Enterprise Boulevard Cross Section

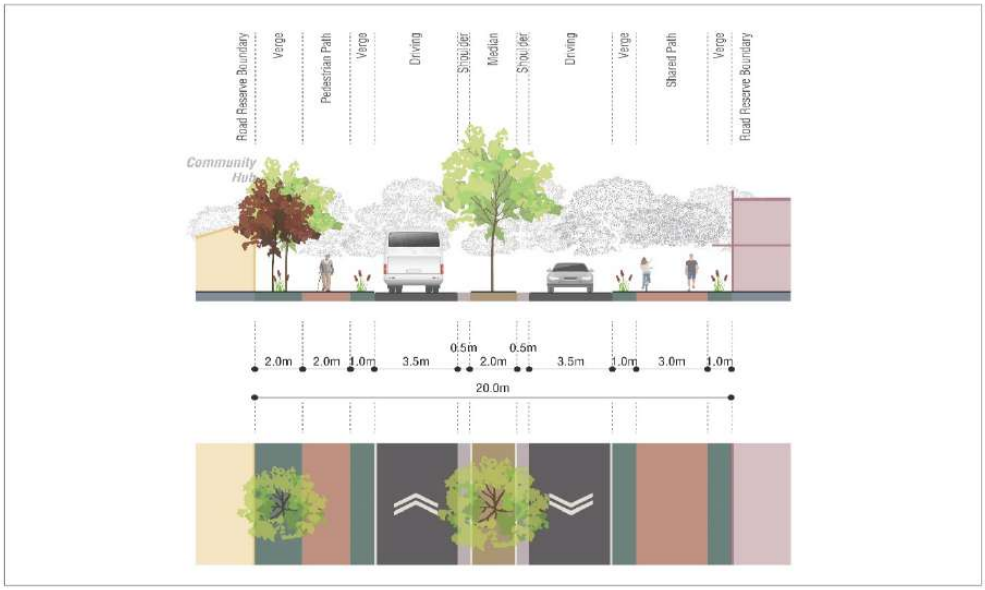


Figure 8 – RD12 Raven Street (Milner Road to Maida Vale Road) and RD13 Raven Street (Milner Road to Brae Road) Cross Section

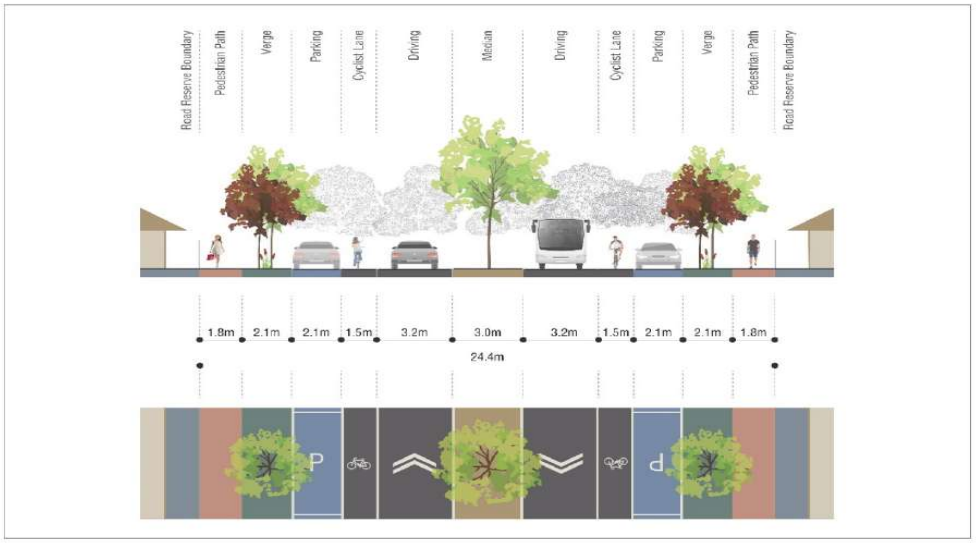


Figure 9 – RD14 TOD Connector Boulevard (Milner Road to Enterprise / Ibis), RD15 TOD Connector Boulevard (Milner Road to Brae Road) and RD16 TOD Connector Boulevard (East of Brae Road) Cross Section

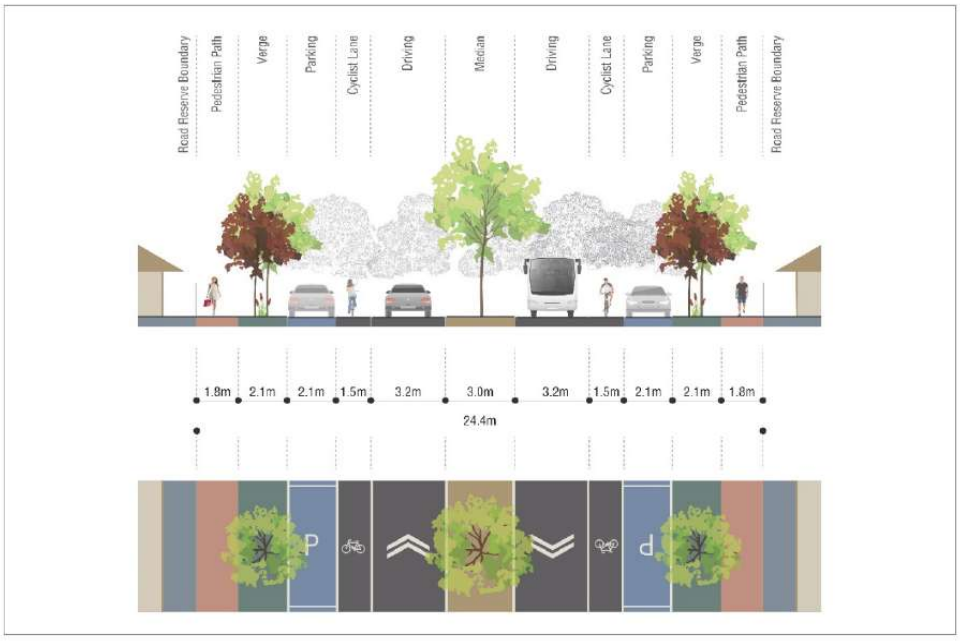


Figure 10 – RD17 Stewart Road (East of Milner Street) Cross Section

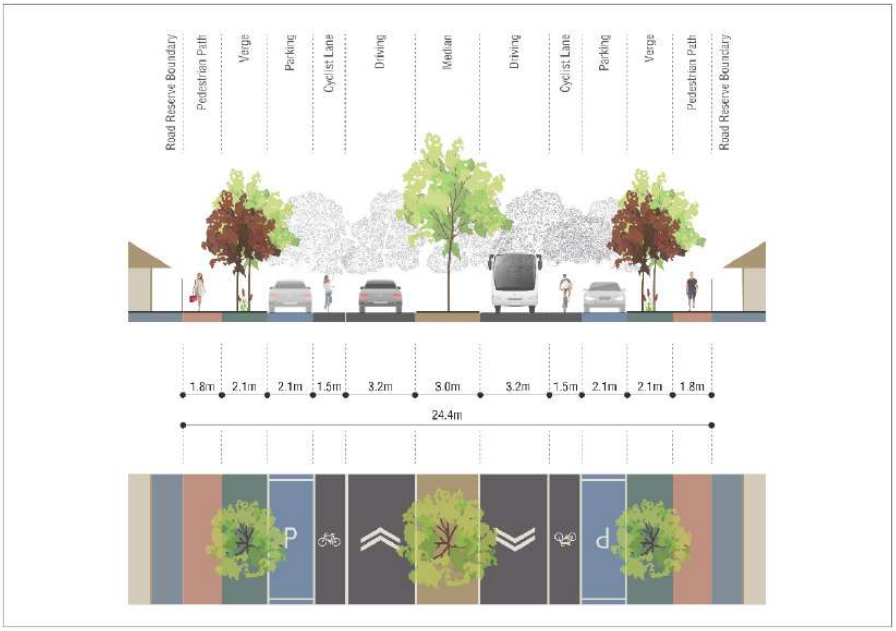
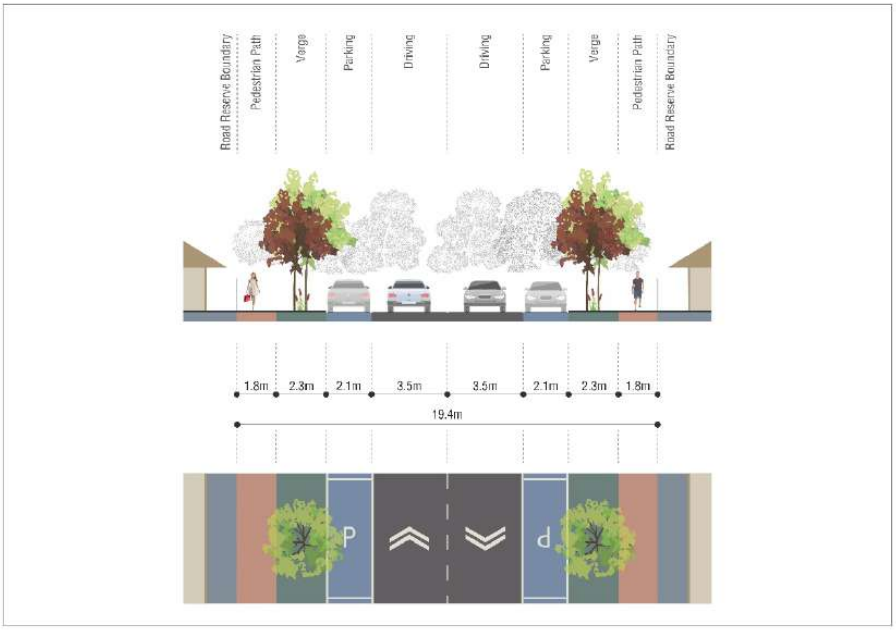


Figure 11 – RD18 Brae Road (East of TOD Connector Boulevard) and RD18A Brae Road (South of TOD Connector Boulevard) Cross Section



Note: RD18A is the same cross section in a 20.0 metre width road reserve.

Figure 12 – RD19 Brand Road (At District Open Space) Cross Section

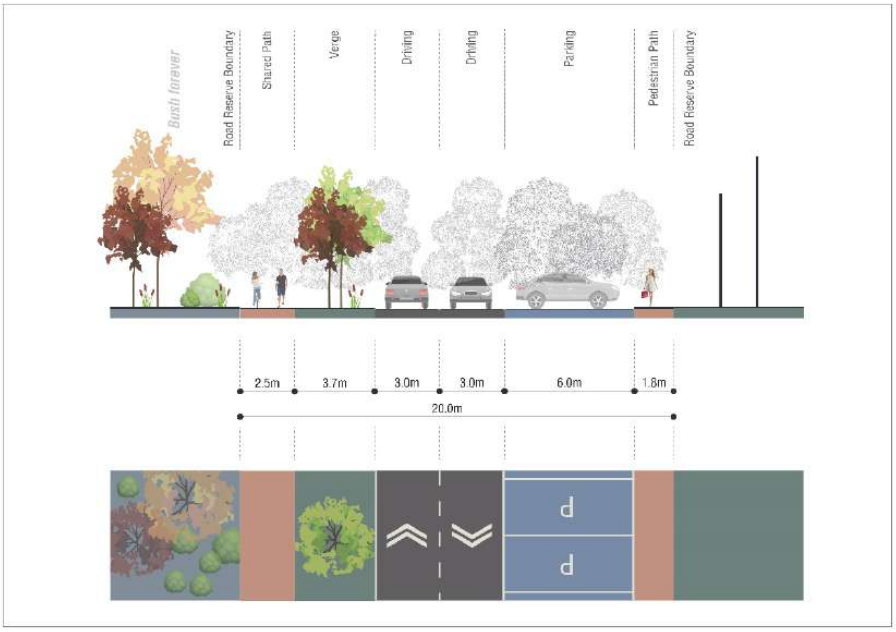


Figure 13 – RD19 Brand Road (South of District Open Space) Cross Section

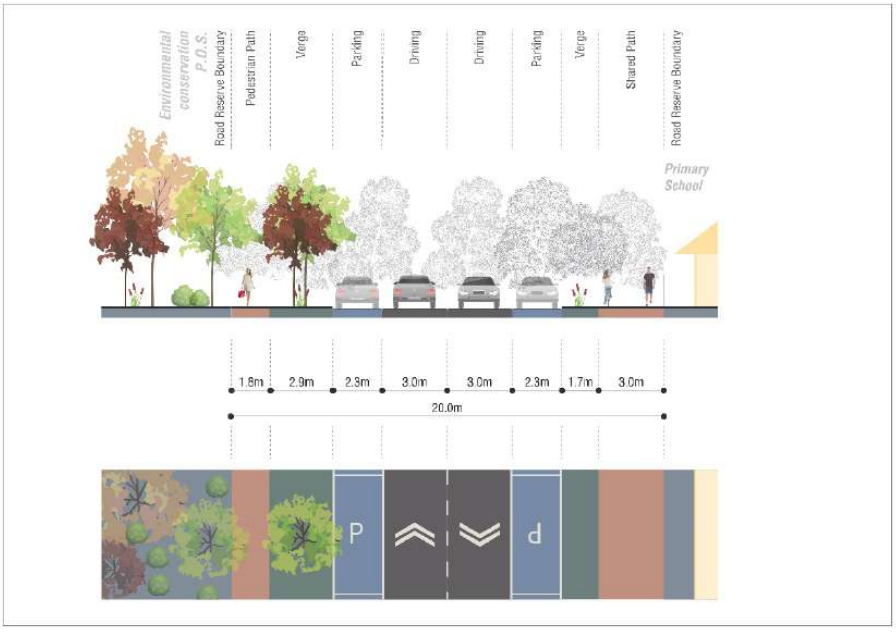
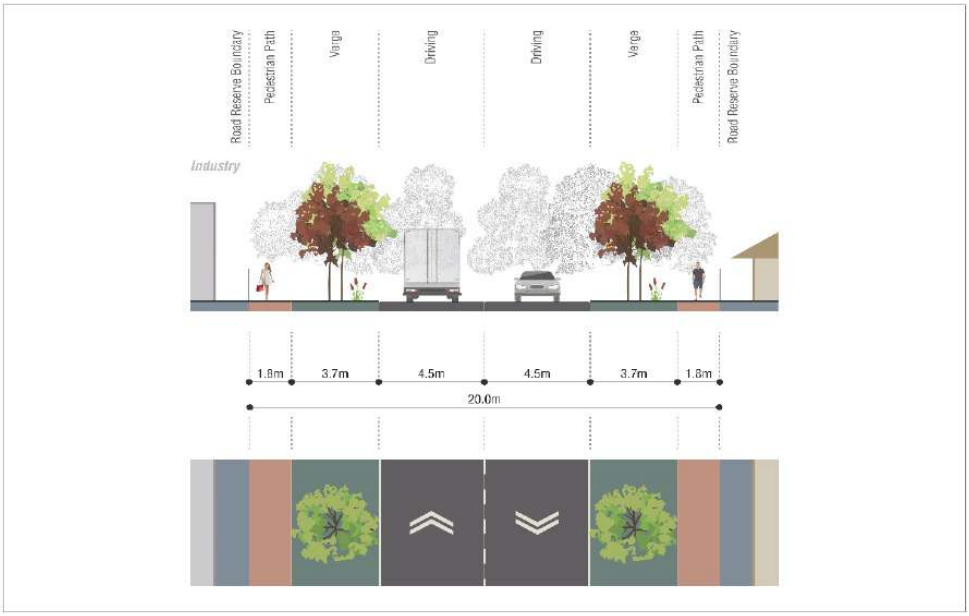


Figure 14 – Sultana Road West (East of Milner Road) Cross Section



Note: This cross section is existing.

2.4.3 Land Resumption Requirements for LSP Roads

The proposed road network will be discussed in detail in the Transport Impact Assessment (TIA), however from a civil infrastructure perspective the following roads have been identified as part of the key road networks that are suitable for consideration as part of a future DCP. The following table shows the existing road reservation, the new road reservation, the length of the road, (not including intersections) and any applicable areas of land acquisition.

Table 7 - Proposed Road Network

Road ID	Road Name	Existing Road Reserve (m)	New Road Reserve (m)	Length (m)	Land Acquisition
RD01	Berkshire Road (Between Roe Hwy and Milner Road)	20.0	25.0	976.9	(976.9 x 5) = 4,884.6m^2
RD02	Milner Road (Sultana Road West to Stewart Road)	20.0	25.2	547	(547 x 5.2) = 2,844.4m^2
RD03	Maida Vale Road (East of Milner Road)	20.0	20.0	690	No widening required.
RD04	Maida Vale Road (Milner to Raven)	20.0	20.0	643	No widening required.
RD05	Maida Vale Road (West of Ibis Place)	20.0	20.0	257	No widening required.
RD06	Dundas Road (south of Berkshire Road)	20.0	20.0	150	No widening required.

RD07	Dundas Road (Berkshire Road to Dundas Road Old)	0	20.0	363	No widening required. Created as condition of the Railway Station Development.
RD08	Dundas Road (North of Deviation)	0	20.0	116	No widening required. As above for RD07.
RD09	Milner Road (Berkshire to Sultana)	20.0	20.0	641	No widening required.
RD10	Milner Road (Stewart Road to Maida Vale Road)	20.0	20.0	230	No widening required.
RD11	Ibis Place (new road to be designated as Enterprise Boulevard)	0.0	20.0	280	No widening required. As above for RD07.
RD12	Raven Street (Milner Road to Maida Vale Road)	20.0	24.5	418	418 x 4.5 = 1,881m^2
RD13	Raven Street (Milner Road to Brae Road only)	0.0	24.5	427	427 x 24.5 = 10,461.5m^2
RD14	TOD Connector Boulevard (Milner Road to Enterprise / Ibis)	0.0	24.5	488	488 x 24.5 = 11,956m^2
RD15	TOD Connector Boulevard (Milner Road to Brae Road)	0.0	24.5	495	495 x 24.5 = 12,127.5m^2
RD16	TOD Connector Boulevard (East of Brae Road)	0.0	24.5	677	677 x 24.5 = 16,586.5m^2
RD17	Stewart Road (East of Milner Road)	20.0	24.5	552	552 x 4.5 = 2,484m^2
RD18	Brae Road (East of TOD Connector Boulevard)	19.4	19.4	875	No widening required.
RD18A	Brae Road (South of TOD Connector)	20.0	20.0	218	No widening required.
RD19	Brand Road	20.0	20.0	873	No widening required.

2.4.4 Land Resumption Requirements for Intersections

The proposed road network will be discussed in detail in the Transport Impact Assessment (TIA), however from a civil infrastructure perspective the following intersections have been identified as part of the key road intersections for consideration as part of a future DCP. The following table shows the proposed intersection, the proposed intervention or intersection type, the length of the road, and any applicable areas of land acquisition, measured from AutoCAD.

Table 8 - Key Intersections

Intersection ID	Intersection	Proposed Intervention	Land Acquisition
INT01	Milner Road / Maida Vale Road	2031:	n.a.

		Give Way Sign-controlled Intersection, T-Intersection	
		2041: Roundabout, T-Intersection	420m^2
INT02A	Maida Vale Road / Roe Hwy Off Ramp	2031: Roundabout, 3-way	n.a. (within reservation)
INT02B	Maida Vale Road / Roe Hwy On Ramp	2031: Roundabout, 3-way	n.a. (within reservation)
INT03	Maida Vale Road / Newburn Road	2031 Provision of left and right turn deceleration lanes on Newburn Road	n.a.
		2041: Roundabout; T-Intersection	420m^2
INT04	Maida Vale Road / Dundas Road	2031: Roundabout, 3-way	375m^2
INT05	TOD Connector / Milner Road	2031-2050: Signalised Intersection, 4-way	n.a.
INT06	Dundas Road Old / Dundas Road New	2031: Signalised Intersection, 3-way	n.a.
INT07	Milner Road / Sultana Road West	2031: LILORI Configuration	n.a.
INT08	Milner Road / Nardine Close	2031: LILORI Configuration	n.a.
INT09	Brae Road / Stewart Road	2031: Give Way Sign-controlled Intersection, T-Intersection.	n.a.
		2041: Median addition to Stewart Road as a part of road upgrade.	n.a.
INT10	TOD Connector / Brae Road / Raven Street	2031: Give Way Sign-Controlled Intersection, 4-way.	n.a.
		2041: Medians added to Raven Street and TOD Connector Approaches as a part of road upgrades	n.a.
INT11	Brae Road / Brand Road	2031: Give Way Sign-Controlled Intersection, T-Intersection.	n.a.
INT12	Maida Vale Road / Ibis Place	Constructed.	n.a.
INT13	Maida Vale Road / Raven Street	2031: Give Way Sign-Controlled Intersection, 3-way.	
		2041: Medians added to all approaches as a part of road upgrades.	
		2050:	420m^2

		Roundabout, 3-way.	
INT14	TOD Connector / Raven Street / Brae Road	2031: Roundabout, 4-way.	550m^2
INT15	Berkshire Road / Milner Road / Dundas Road	2031: 2-lane Roundabout, 4-way.	900m^2
INT16	TOD Connector / Brand Road	2031-2050: Give Way Sign-Controlled Intersection, T-Intersection (Potential future requirement for a 4-way intersection).	420m^2
INT17	Milner Road / Raven Street	2031-2050: Roundabout, 4-way.	500m^2
	Milner Road / Sultana Road West	2031: Channelized T-Intersection with Priority for Heavy Vehicles; LILORI (No Right-Out movement).	n.a.
		2041: Median to be added to Milner Road as a part of road upgrade.	n.a.
INT18	Milner Road / Stewart Road	2031: Give Way Sign-Controlled Intersection, 4-way.	n.a.
		2041: Medians added to 3 out of 4 approaches as a part of road upgrades.	n.a.
		2050: Roundabout, 4-way.	500m^2

2.4.5 Maida Vale Road / Roe Hwy Bridge Reconstruction

Significant works are proposed for the Roe Highway and Maida Vale Road interchanges under the Forrestfield North Residential LSP and the TOD and AC Precinct ACP. This section of Maida Vale Road is RD03A and comprises of a 95-metre section of road between the two proposed roundabout intersections with the Roe Highway On and Off Ramps. The proposed length of bridge span is approximately 50 metres between these two intersections and will involve a complete reconstruction of the bridge to suit the proposed road cross section.

2.4.6 Road Pavement Designs

In this section, KCTT have calculated ultimate pavement thicknesses based on the ultimate traffic volumes, with a CBR of 8% and assuming a 40-year pavement design life in accordance with Main Roads WA requirements.

Road ID	Road Name	Traffic Volumes (VPD)	Min Base Course Thickness (mm)	Total Flexible Pavement Thickness (mm)	Standard Pavement
RD01	Berkshire Road (Between Roe Hwy and Milner Road)	25,843	185	410	230mm sub-base 200mm base course

RD02	Milner Road (Sultana Road West to Stewart Road)	5,984	165	370	200mm sub-base 170mm base course
RD03	Maida Vale Road (East of Milner Road)	13,072	175	395	220mm sub-base 175mm base course
RD04	Maida Vale Road (Milner to Raven)	4,422	160	360	200mm sub-base 160mm base course
RD05	Maida Vale Road (West of Ibis Place)	7,620	170	375	200mm sub-base 175mm base course
RD06	Dundas Road (south of Berkshire Road)	15,169	180	395	200mm sub-base 200mm base course
RD07	Dundas Road (Berkshire Road to Dundas Road Old)	13,680	175	395	200mm sub-base 200mm base course
RD08	Dundas Road (North of Deviation)	13,680	175	395	200mm sub-base 200mm base course
RD09	Milner Road (Berkshire to Sultana)	12,928	175	395	200mm sub-base 200mm base course
RD10	Milner Road (Stewart Road to Maida Vale Road)	9,288	170	380	200mm sub-base 180mm base course
RD11	Ibis Place	3,631	160	350	200mm sub-base 160mm base course
RD12	Raven Street (Milner Road to Maida Vale Road)	5,602	165	365	200mm sub-base 165mm base course
RD13	Raven Street (Milner Road to Brae Road)	5,984	165	370	200mm sub-base 170mm base course
RD14	TOD Connector Boulevard (Milner Road to Enterprise / Ibis)	2,322	150	335	200mm sub-base 150mm base course
RD15	TOD Connector Boulevard (Milner Road to Brae Road)	6,432	165	370	200mm sub-base 170mm base course
RD16	TOD Connector Boulevard (East of Brae Road)	4,520	160	360	200mm sub-base 160mm base course
RD17	Stewart Road (East of Milner Road)	4,739	160	360	200mm sub-base 160mm base course
RD18	Brae Road (East of TOD Connector Boulevard)	2,599	155	340	180mm sub-base 160mm base course
RD18A	Brae Road (South of TOD Connector)	2,500	150	340	180mm sub-base 160mm base course
RD19	Brand Road	2,011	150	330	180mm sub-base 150mm base course

2.5 Stormwater Drainage

The Residential Precinct has a simple overland flow. The northern-most portion of the site drains toward Poison Gully Creek, however this represents less than 10% of the total catchment. In the northern third of the precinct, the overland flow is directed to the west – draining from Roe Highway towards Ibis Place. Meanwhile, the remaining southern two thirds of the precinct generally exhibit south-westerly directed flows. In the south-eastern portion of the precinct, the flow drains predominately west, parallel to Sultana Road West.

The key areas for detention of major stormwater drainage events in the residential precinct are in Brand Road near Sultana Road West and in the future Town Centre Park, north of the proposed Activity Centre.

Previously this ISR referred to the Strategen LWMS for catchment measurements. Since the completion of the Strategen LWMS there have been amendments to the LSP plan, including road layouts, areas and densities of Residential Precinct development layout and yields. This table provides a quick comparative analysis of the former Strategen LWMS catchments and the new catchment layout to suit the updated Forrestfield North Residential LSP layout.

Table 9 - Post-Development Catchments

Catchment Number	Strategen LWMS (m^2)	Catchment Number	KCTT ISR Review (m^2)
AS3	455,929	1	467,718
PG6	52,269	2	49,450
AS1	209,600	3	134,110
AS2	294,218	4	164,115
PG5	66,916	5	83,200
PG4	94,958	6	86,900
Total	**1,173,890**		**985,493**

The catchment review above shows a 20% change in total area of the Forrestfield North Residential LSP catchment areas from the previous iteration in 2017 to the present layout due to amendments in the LSP boundaries for the Residential Precinct and the TOD ACSP.

The key principles of the drainage design in Forrestfield North are to develop systems that promote Water Sensitive Urban Design (WSUD) principles and promotes the capture and re-utilisation of stormwater drainage runoff, whist allowing pre-development flows for the 1 in 1-year event to flow out of the LSP and ACP areas. The following tables show the assumptions for offsite flow under the pre-development scenario for the Forrestfield North Residential LSP: -

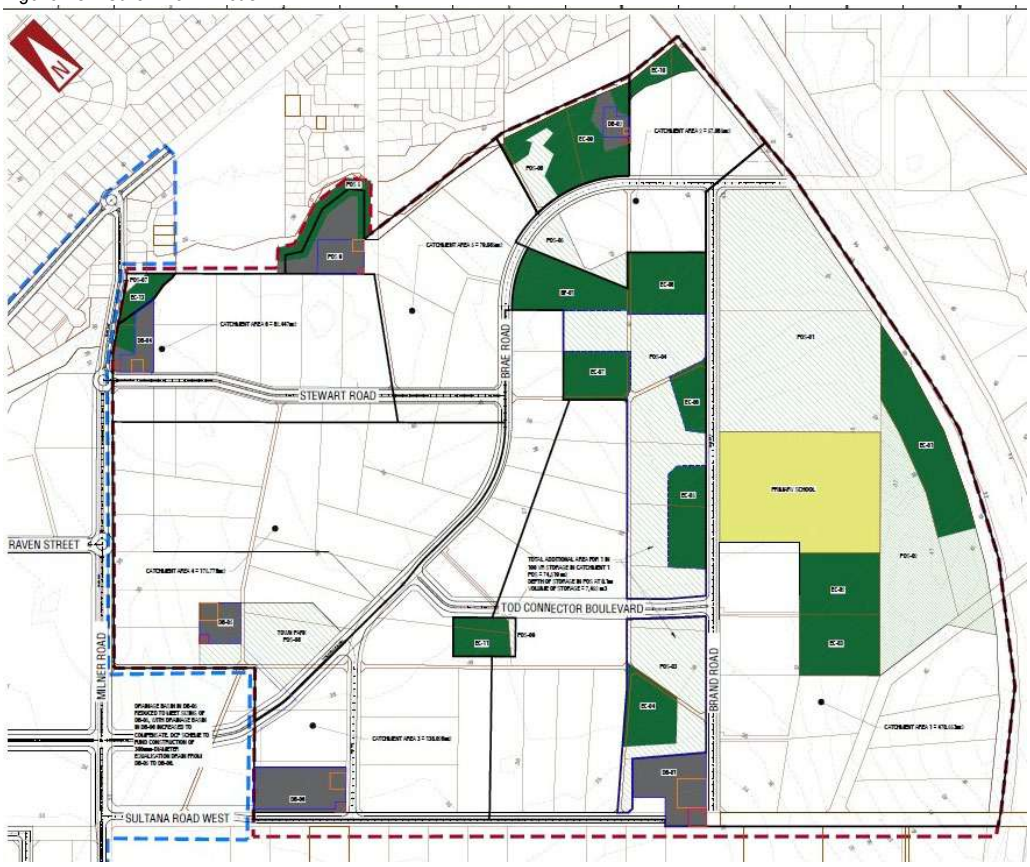
Table 10 - Pre-Development Catchment Area

Catchment Number	Area (m^2)	Description of Existing Flow Path	1 in 1 Year Flow Rate (l/sec)	1 in 1 Year Estimated Yearly Flow (ML)
1	467,718	Overland flow to existing bush forever in Industrial LSP and Into Sultana Road West	238	300.2

2	49,450	Overland flow to Poison Gully Creek	33.8	42.6
3	134,110	Overland flow into catchment 1 (TOD / Activity)	88.2	111.3
4	164,115	Overland flow directed into Sultana Road West and TOD / Activity ACP.	69.1	87.1
5	83,200	Overland flow to Poison Gully Creek	36.8	46.4
6	86,900	Overland flow to Poison Gully Creek	40.2	50.7
Total	**985,493**		**506.1**	**638.3**

The new catchment areas are shown on the following plan, which is included as an appendix to this report.

Figure 15 - Catchment Areas



The pre-development 1 in 1-year flows have been calculated for an approximate flow rate (in litres per second), and for an estimated outflow from site in ML / Annum. The flow rates for the 1 in 1-year event (in L / Sec), have been calculated using the following assumptions: -

- That the 1 in 1-year event is infiltrated in full in all existing lots and open space areas.
- That the 1 in 1-year event has a coefficient of runoff in all road reservations of 0.3.

In KCTT's post-development calculations we have run the coefficient of runoff for 1 in 1-year and 1 in 5-year flows at C = 0.8 outside of future lot areas. The increased provision for coefficient of runoff provides the City of Kalamunda with certainty at this high-level drainage review that the drainage calculations on a per cell and per development basis will be robust within the Forrestfield North Residential LSP area.

The purpose of understanding the pre-development flow paths and quantum's is to determine storage requirements for post-development flow catchments and the various storm events. In the residential precinct, there are several key locations for the detention and storage of stormwater runoff, in accordance with the findings in Strategen's LWMS, which have been reviewed by KCTT in the updated Residential LSP plans: -

- TOD Connector Boulevard
- Milner Road
- Stewart Road
- Brae Road
- Brand Road
- Sultana Road West

The following table shows the detailed drainage storage calculations for the revised Residential Precinct: -

Table 11 - Catchment Drainage Calculations

Storm Event	Catchment 1	Catchment 2	Catchment 3	Catchment 4	Catchment 5	Catchment 6
20% AEP Area	2,426m^2	256m^2	927m^2	1,093m^2	544m^2	603m^2
20% AEP Depth	0.6m	0.6m	0.6m	0.6m	0.6m	0.6m
20% AEP Volume	1,452m^3	157m^3	556m^3	661m^3	327m^3	363m^3
1% AEP Area	17,980m^2	1,457m^2	5,274m^2	6,006m^2	2,861m^2	3,133m^2
1% AEP Depth	0.9m	0.9m	0.9m	0.9m	0.9m	0.9m
1% AEP Volume	16,182m^3	1,312m^3	4,746m^3	5,405m^3	2,575m^3	2,819m^3

Stormwater Hydraulic Design

The sizing for the City of Kalamunda stormwater drainage network is based on calculating the 1 in 1-year, 1 in 5-year, and 1 in 100-year flows generated within road reservations only and the 1 in 100-year flow from POS and Environmental Conservation areas. The reason for this is that future development sites should be tasked with the management and re-use of all stormwater that lands within their respective landholdings. The capture of all storm events on-site promotes the concept of stormwater as a resource in Forrestfield North. Developers will have the choice of: -

- Using stormwater for flushing toilets/ irrigation etc.
- Planting roof top gardens
- Providing drainage detention on-site and allowing post-storm release into the City of Kalamunda Network.

KCTT have completed calculations for an envisaged potential major drainage network for consideration as part of a future DCP. Given the potential for amendment to the drainage network, specific details are not provided in this report, however the following basic principles are used in our drainage design: -

- Minimum drainage pipe size is 300mm-diameter
- Stormwater drainage pits are offset at a targeted 35 metres along the longitudinal sections, (based on 0.5% longitudinal grades on roads) of all major roads with a targeted depth of 1.5 metres to obvert of pipe to ensure the drainage system sits below, and doesn't clash with power, gas, telco and / or water services.

Where road longitudinal grades are greater than 0.5% drainage pit spacing can be increased, however at 15% design we believe it is prudent to allow for 35 metre spacings between drainage pits.

Considerations for Drainage Re-Use at an LSP Level

The key drainage re-use schemes considered in this report, which have been reviewed and considered by Strategen's LWMS document include: -

- At-Surface Treatment / Bio-Retention Drainage Swales
- Treatment At-Source (i.e. catch basin inserts)
- ECOAID Cells
- Stormwater harvesting / roof-top gardens

A Managed Aquifer Recharge system was reviewed in the LWMS, but the recommendation in the LWMS was that this should not be pursued as an economical consideration, therefore KCTT have not considered this further.

The following figures show general KCTT schematics for the proposed potential WSUD systems: -

Figure 16 - WSUD Schematic No 1 (Stormwater Re-Harvesting)

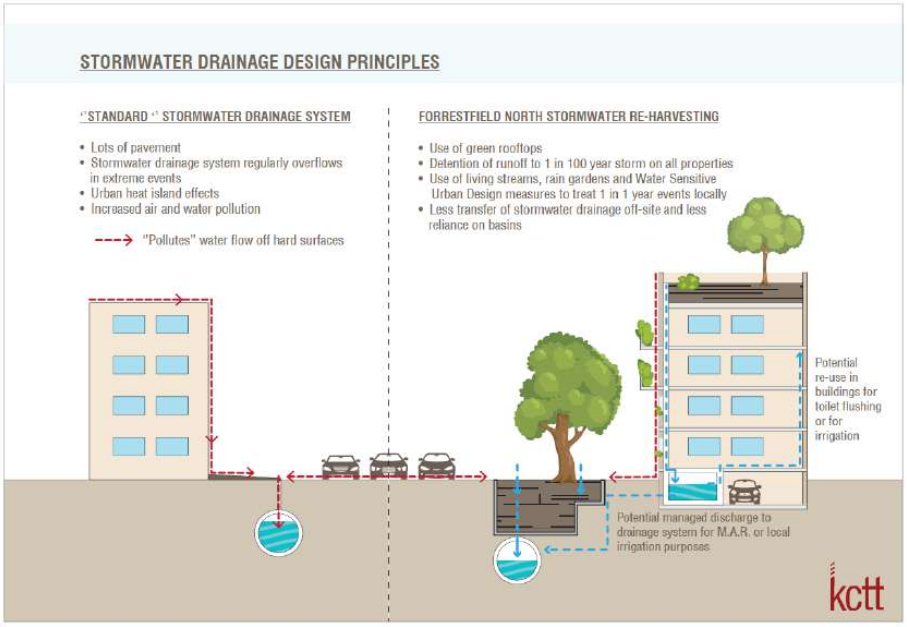


Figure 17 - WSUD Schematic No 2 Stormwater Drainage Re-use

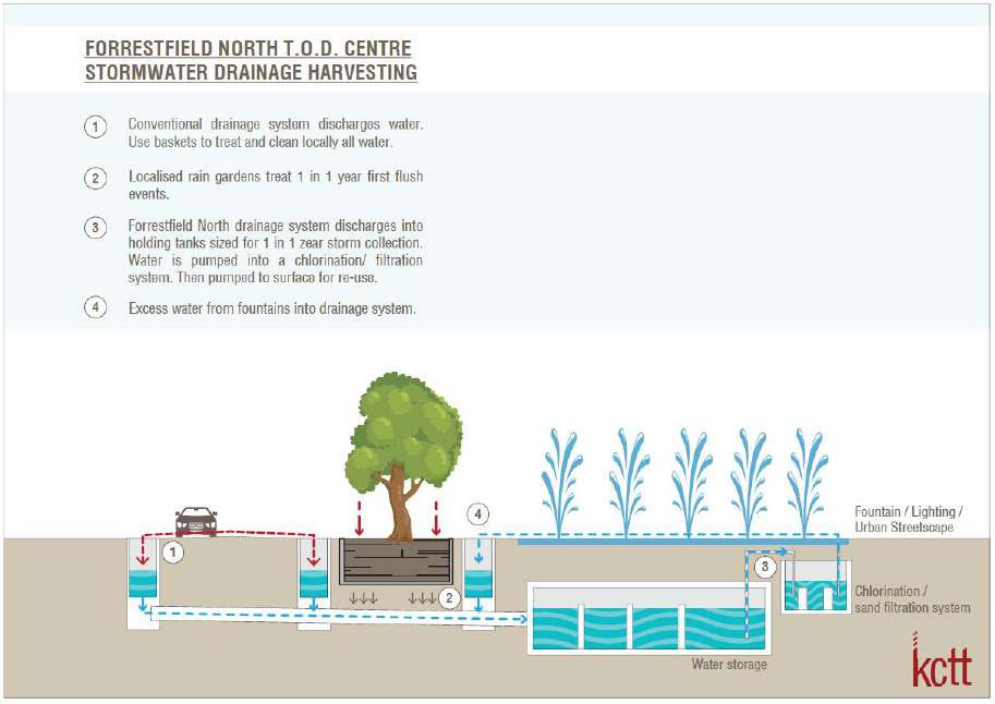


Figure 18 - WSUD Schematic No 3 (Aerial Imagery of Rooftop Gardens)



Source: CS Globe

Bio-Retention Swales

Bio-retention swales are a key component of the drainage design strategy for Forrestfield North. All medians are proposed to treat surface water, with all roads adjacent to POS and Environmental Conservation sites featuring bio-retention swales to treat and clean water prior to its entry to downstream environments.

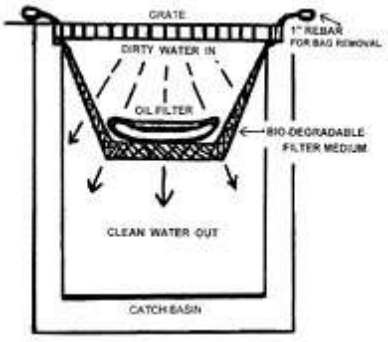
Catch Basin Inserts

Urban Stormwater Technologies has provided a quote for its scientifically proven storm water filtration devices - Catch Basin Inserts (CBI). These have been priced separately to the above, as they are a proposed addition to the pits which have been mentioned in the cost estimate. CBI's main function is the capture of and reduction of stormwater pollutants, which remove the gross pollutants (GP) at the source. To ensure this process ensures the pit floor is protected, the CBI's will be installed at each drainage pit. This means: -

- The base of the Side Entry Pit which is designed to infiltrate water will now be protected from the sand rolling onto the new road surface picking up the hydrocarbons and then entering the drain. We are seeing stagnant water in new Side Entry Pits in new subdivisions where home building has not yet started
- Protection of the Council infrastructure during the entire subdivisional works period
- Protection of the Council infrastructure during the entire construction phase this includes up to site inspection by the relevant Council
- By educating the installers of the drains and being present when they are installing them, we can ensure the drains are constructed where possible to allow the maximum size CBI to be installed

The below figure is an example of CBI's functionality: -

Figure 19 - Catch Basin Inserts



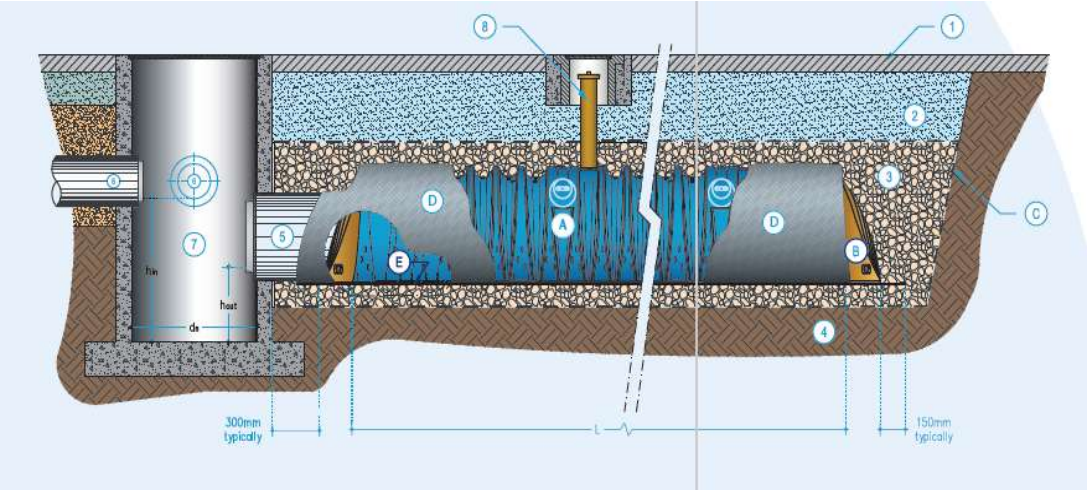
Source: http://emeraldseedandsupply.com/photos/eccat14_m.jpg

ECOAID System

The ECOAID is an underground modular stormwater management system used to detain, infiltrate or harvest stormwater run-off, and provides stormwater treatment by utilizing an internal gross pollutant and sediment trap. KCTT believe this is a great innovation which can be utilized throughout the entire Forrestfield North area. KCTT have sourced full pricing of the ECOAID system for the LSP and ACP.

The below is a figure sourced from the online ECOAID brochure, which outlines all the technical data and benefits of the system as an alternative to standard piping and pits used for stormwater drainage.

Figure 20 - ECOAid System



Source: https://www.geofabrics.co/sites/default/files/brochures/ecoAID_Brochure.pdf

2.6 Water

KCTT have commenced planning and have submitted this planning to the Water Corporation for consideration. The development of water infrastructure is generally simpler than wastewater planning because the water network does not need to be designed to consider depth of service as it's a pressurized system. This means that development can be catered for generally anywhere within the precinct with relation to the water infrastructure network.

At this stage, the Water Corporation are completing their planning for the ultimate development scenario. The provision of water infrastructure should not be considered as part of a future DCP. The following table shows the existing water infrastructure in the residential precinct: -

Table 12 - Existing Water Assets within the Forrestfield North Residential LSP Area

Road Name	Pipe Diameter	Location
Sultana Road West	205CI	Along south-east boundary of the precinct
Raven Street	100P-12	Along north-west boundary of precinct
Milner Road	150CI	Along northern boundary of precinct
Raven Street	100P-12	Within precinct- north-western portion
Stewart Road	100CI	Within precinct – northern portion
Brae Road	100CI	Within precinct – central portion
Brand Road	150CI	Within precinct – southern portion

Smokebush Place	100P-12	Within precinct – southern portion

2.7 Wastewater

KCTT have actively liaised with the Water Corporation through the various phases of the Forrestfield North LSP submissions for the Residential Precinct. The information is provided in detail in the below tables: -

Is the project in an existing Water Corporation Planning Area?	Yes. The LSP and ACP Areas are within the Gooseberry Hill Concept Plan.
Are amendments to Water Corporation Planning required?	Yes. Continued liaison with the Water Corporation is required with regards to future planning of infrastructure in the area. During the Forrestfield North Residential Precinct LSP submissions, KCTT provided full modelling of the estimated sewer flows based on the envisaged maximum dwelling yields likely under the planned R-codes for each area. This included review of future planning for: - • Maida Vale South LSP area on the eastern side of the Roe Highway, which is a total land area of over 1,200 hectares. • Forrestfield North Residential LSP Area. • Forrestfield North TOD and AC Precincts ACP. This information is shown below the current wastewater network below.

Current Wastewater Network

Location	Pipe Diameter	Lowest I.L.	Location
Sultana Road	225PVC-U	28.25	Intersection of Dundas / Sultana
Milner Road	225PVC-U	26.24	Near Intersection of Milner / Dundas / Berkshire
Dundas Road	600PVC	21.17	Near Intersection of Milner / Dundas / Berkshire
Imperial Street	225PVC-U	27.78	Intersection of Dundas / Imperial
Eureka Street	225PVC-U	26.95	Intersection of Milner / Eureka

The table below shows the breakdown of commercial, industrial, and residential zonings for the Forrestfield North Residential Precinct, with the TOD and AC Precinct and Maida Vale South combined to enable review by the Water Corporation within this document for the final sizing of sewer into the Forrestfield North Residential Precinct. The yields for the TOD and AC Precinct can be referred to in the TOD and AC Precinct ACP documents.

The yields for the Maida Vale South area are from 2017 and have not been updated further as the area is undergoing long-term planning and is not expected to be finalised in time for these LSP documents to be finalised.

Table 13 - Wastewater Flows (Residential Precinct, TOD and AC Precinct and Maida Vale South Catchments)

Catchment - Location	Total Area (ha)	Population Density / Persons Net Ha	Flow (Dry Ground)	Total Design Flow (L/s)
Residential Precinct				
Residential R30	12.0	105	180	2.8
Residential R40	14.45	120	180	3.8
Residential R60	17.6	180	180	6.9
Residential R80	5.3	200	180	2.3
Primary School	4.0	n/a	14976	0.5
Total (Residential Precinct)	**53.35**			**16.3**
TOD and AC Precinct				
Catchment 1A - Industrial	10.1	n/a	14976	1.3
Catchment 1B - Residential	8.5	180	195	3.3
Catchment 1B - Commercial	20.6	n.a.	21600	3.9
Catchment 1C – TEC	3.2	n.a.	n.a.	n.a.
Catchment 1D – Station Precinct	2.5	n.a.	9450	0.3
Catchment 1E – Commercial	2.7	n.a.	21600	0.5
Catchment 2 - Residential	14.2	200	195	6.2
Total (TOD and AC Precinct)	**73.9**			**15.5**
Maida Vale South				
Catchment 1	75	20	180	11.5
Catchment 2	83.3	30	180	19.1
Total (Maida Vale South)	**158.3**			**30.6**
Total (All Catchments)	**285.55**			**62.4**

The total ultimate wastewater flow to be accommodated into the existing Water Corporation system at the intersection of Dundas Road, Milner Road and Berkshire Road is therefore 62.4 l/sec.

Are any assets to be constructed considered trunk infrastructure (i.e. 300mm-diameter and greater?)	YES, major upgrades to the planned wastewater infrastructure are required. The Water Corporation has completed the updates to this planning. This report will be provided to the Water Corporation to enable further modification to the wastewater planning, as prior calculations were completed on higher densities within the Forrestfield North Residential and TOD and AC Precincts.
Are wastewater pumping stations required?	No.
Can the development be serviced adequately without the need for import fill? If NO, describe the fill requirements;	Yes. The planned fill around the Forrestfield North Railway Station requires consideration in the detailed design phases by each developer and the consulting engineer in coordination with the Water Corporation.
Is groundwater likely to be an issue?	Groundwater will be an issue for management throughout the TOD and AC Precincts as the main sewer for the whole of the Forrestfield North TOD, AC and Residential Precincts, plus the Maida Vale South LSP areas is fed from the intersection of Milner Road, Dundas Road and Berkshire Road and is approximately 6.5 metres depth. This depth will encounter groundwater throughout the TOD and AC Precincts. Where the works are pre-funded under instruction from the Water Corporation, the design team will need to provide full details on management of groundwater and potentially acid sulphate soils to the satisfaction of the Water Corporation, the City of Kalamunda and other agencies as is appropriate. This is a standard requirement of major infrastructure provision with the Water Corporation.

As part of our conceptual design process, we believe that a 375mm diameter pipe is required in Milner Road between Dundas Road and Sultana Road West. The following table shows likely infrastructure requirements for the development of this infrastructure: -

Table 14 - Requirements for the Extension of Wastewater Assets into the Forrestfield North Residential LSP Area

Road	Pipe Diameter (mm)	Location	Length (m)	Depth (m)
Milner Road	375	South of Sultana Road West	760.5	3-4
Milner Road	150	North of Sultana Road West to TOD Connector Boulevard.	618.2	3-4
Stewart Road	150	Length of Stewart Road between Milner and Brae Road	569.6	3-4
Sultana Road West	300	Length of Sultana Road West, between Milner and Brand Road	889.3	3-4
Brand Road	225	Between TOD Connector and Bush Forever	316	3-4
TOD Connector Boulevard (Future)	225	Between Roe Hwy and Brand Road (Long Term Extension by Maida Vale South)	431.3	3-4

Dundas Road	225	North of Milner Road Intersection. (This has been extended to the intersection of Imperial Street as at the date of this ISR.)	772	3-4

A 225mm-diameter sewer will be required in Dundas Road to service the TOD precinct. Each of the items listed in the table above, (except for the TOD Connector Boulevard extension between Brand Road and Roe Highway) are for consideration as part of a future DCP so that development can commence generally within the Residential Precinct, given the spread of land ownership in the precinct. The concept designs prepared by KCTT require approval by the Water Corporation.

2.8 Gas

Table 15 - Existing Gas Services Within the Forrestfield North Residential LSP Area

Are suitable gas services located adjacent to the site?	YES	
Pipe Diameter	Location	Approximate Depth
100 PVC (1.5 MP 70kPa)	Milner Road	750mm below ground level
155 PVC (1.5 MP 70kPa)	Sultana Road West	750mm below ground level
50 PVC (1.5 MP 70kPa)	Smokebush Place	750mm below ground level
100 PVC (1.5 MP 70kPa)	Brand Road	750mm below ground level

2.9 Power

Existing power services are generally considered to be adequate for interim development to occur in the Forrestfield North Residential Precinct. All existing services noted below will need to be undergrounded as part of all development works, with key infrastructure in Sultana Road West, Brand Road, Brae Road, Raven Street and Milner Road to be undergrounded for consideration as part of a future DCP. For landholdings that front development sites within the Forrestfield North Residential LSP, it will be a WAPC Condition of Subdivision that the developer undergrounds existing overhead power.

Therefore undergrounding of existing overhead power should only be considered a DCP item where infrastructure identified in the DCP necessitates undergrounding, and the requirement is not otherwise required through the subdivision process.

KCTT have consulted electrical consulting firm UPD to discuss likely requirements for power for a development of this size and stature. The process will require consultation with Western Power as development applications commence. Because of the likely long lead time to full development, a planning process for expansion of power assets is not required at this early stage of the planning process. Western Power have recently preferred upgrading existing transformer / substation sites, as opposed to managing additional 1-hectare sites. It is highly likely that this approach will be used in Forrestfield North, due to the proximity of major infrastructure in the Perth Airport landholdings. Consideration may be given to upgrading trunk infrastructure between Forrestfield North and the nearest zone substations / feeders.

Table 16 - Existing Power Assets within the Forrestfield North Residential Area LSP

Existing Services Location	Underground/Overhead	Location	Type
Sultana Road West	Overhead	Opposite side to southern boundary of the precinct	HV, LV
Smokebush Place	Overhead	Development side of road reserve	LV
Brand Road	Overhead	Within the precinct, along Brand Road	HV, LV
Brae Road	Overhead	Within the precinct	HV, LV
Stewart Road	Overhead	Opposite to development side of road reserve (northern boundary)	HV, LV
Raven Street	Overhead	Within the precinct	LV
Milner Road	Overhead	Development side of road reserve	HV, LV

2.10 Telecommunications

The provision of telecommunications into the Forrestfield North Residential LSP area is deemed to be similar in nature to the upgrade provisions required for power as described in Section 2.11 above. The existing telecommunications system in Milner Road and that presently feeds Sultana Road West, Stewart Road, Brae Road and Brand Road is not suitable for the proposed full development of the Forrestfield North Residential LSP, however the network will be upgraded both internally and externally through trunk infrastructure improvements iteratively as development cells are completed within the LSP area.

The area will also be provided with NBN communications which will assist in the overall upgrade of the trunk infrastructure into Milner Road for both the Residential and TOD and AC Precincts.

Under WAPC Conditions of Subdivision, the developer will be required to provide open trenching and pay for cabling, pits, and road ducts to reticulate their proposed subdivisions. Therefore, adjustment of telecommunications services for all roads that front developable areas should generally not form an item funded under the future DCP.

Table 17 - Existing Major Telecommunication Assets in the Forrestfield North Residential LSP Area

	YES	If YES/NO nominate type (NBN / Velocity Fibre Optic / Standard Telstra Copper / Other) and location?	If NO, distance from site (m)?
Are existing underground services available and suitable for connection immediately adjacent to the site?	YES	Telstra (Milner Road)	N/A

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Level 18, 191 St Georges Tce, Perth WA 6000
T. (08) 9289 8300 – **E.** hello@elementwa.com.au
elementwa.com.au