Shire of Serpentine Jarrahdale

March 2023

Serpentine Townsite Local Structure Plan

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Endorsement Page

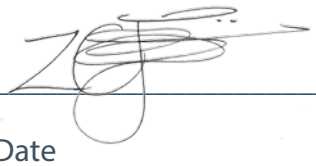
This structure plan is prepared under the provisions of the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2.

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

18 May 2023

Signed for and on behalf of the Western Australian Planning Commission:

an officer of the Commission duly authorised by the Commission pursuant to section 24 of the *Planning and Development Act 2005* for that purpose, in the presence of:



Witness

24 May 2023 Date

24 May 2033 Date of Expiry

Executive Summary

Item	Data	Structure Plan Re (section no.)
Total area covered by the structure plan	119 ha	1.2.2
Area of each land use proposed: Residential Commercial	 69.89ha 1.89ha	3.1
Total estimated lot yield	368 lots approximately	3.1.1
Estimated number of dwellings	368 dwellings approximately	3.1.1
Estimated residential site density	5.27 dwellings per site hectare	N/A
Estimated population	1,067 persons @ 2.9 persons per dwelling	3.1.1
Number of primary schools	1	3.1.3
Estimated commercial floorspace	5,000m^2 of Net Lettable Area (NLA)	3.1.2
Estimated area and percentage of public open space given over to: Local Parks	104,076m^2 (9.55%)	3.1.4

PART ONE: IMPLEMENTATION

Part 1: Implementation

1.0 Structure Plan Area

This part applies to the Serpentine Townsite Local Structure Plan (LSP) shown on Figure 1 and is located within the Shire of Serpentine Jarrahdale (the Shire).

2.0 Structure Plan Content

This Structure Plan comprises the:

- Statutory Section (Part 1);
- Explanatory Section (Part 2); and
- Appendices – Detailed Technical Reports.

3.0 Interpretation and Use Class Permissibility

The words and expressions used in this LSP shall have the same respective meanings as given to them in the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (the Scheme).

4.0 Relationship with the Scheme

4.1 The Serpentine Townsite Local Structure Plan constitutes a Local Structure Plan pursuant to Section 5.18 of the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 and the *Planning and Development (Local Planning Schemes) Regulations 2015*, Schedule 2 - Deemed provisions for local planning schemes.

4.2 The Structure Plan Map (Plan A) outlines future land use, zones and reserves applicable within the structure plan area. Pursuant to the *Planning and Development (Local Planning Schemes) Regulations 2015* Schedule 2 - Deemed provisions for local planning schemes, a decision maker of an application for development approval or subdivision approval is to have due regard to the provisions of this Local Structure Plan, including the Structure Plan Map, Implementation Section, Explanatory Section and Technical Appendices.

5.0 Operation Date

This Local Structure Plan comes into effect on the date that it is approved by the Western Australian Planning Commission.

6.0 Land Use and Subdivision Provisions

6.1 All subdivision proposals shall provide an indicative plan demonstrating how the maximum density(s) can be achieved, having regard to the surrounding/adjoining lots.

6.1.1 Local Development Plans (LDPs)

LDPs may be required for but not limited to the following lots contained within the LSP:

- Richardson Street (Lot 84; Lot 1; Lot 82; part of Lot 14; part of Lot 12; part of Lot 10)
- Reason – Adjacent to Bush Forever, proximity to railway line and abuts public open space / drainage.

- Karnup Road (part of Lot 17; part of Lot 18)

- Reason – Irregular lot shape.

- Rudall Street (part of Lot 102)
- Reason – Abuts public open space / drainage.

- Arnold Road (Lot 98; part of Lot 106)
- Reason – Abuts public open space / drainage.

Building protection/hazard reduction:

- Noise attenuation measures (including quiet house design)

6.2 The implementation of the LSP will be facilitated through development and subdivision approvals which may be required to include wider contextual analysis. Where necessary, planning consideration should include elements of development outside of the LSP area.

6.3 Development proposals that comply with the provisions of this LSP or an approved LDP are exempt from obtaining Planning Approval under Clause 5.1.2. of the Scheme. Separate Planning Approval obtained through the lodgement of a Development Application shall only be required if variations to the proposed LDP are proposed.

6.4 The implementation of the LSP will be facilitated through development and subdivision approvals which shall generally conform to the LSP. Applications shall generally comply with the Character Statement and Development Principles listed in the following sub-section:

6.4.1 Character Statement

The development and subdivision of land within the LSP area will be undertaken over an extended timeframe during which the Townsite will evolve as a significant community, commercial and civic locality in the Shire. Whilst cognisant of the land's urban zoning which will facilitate the development of the area as a modern contemporary neighbourhood, it is equally important that the site's character and rural history is captured and reflected in the LSP.

6.4.2 Visual Amenity and View Corridors

The visual amenity and view corridors within the subject area have been considered in the context of the current landscape within the LSP area. The main view corridors are facing the Darling Scarp, Serpentine River and the Serpentine Sports Reserve which could all contribute to public amenity. In general, the study area has a gentle undulating topography with vegetation present along most of the boundaries.

Development proposals within the Local Structure Plan area shall consider and seek to preserve view corridors and visual amenity.

6.4.3 Design Principles

The LSP is intended as a guide for future urban development with the objective of generally identifying appropriate locations for housing types and densities whilst permitting flexibility to ensure the delivery of a diverse range of dwelling styles.

The Local Structure Plan is to facilitate a well-connected, highly legible movement network, which encourages permeability and the development of a walkable neighbourhood. Lots should be configured to maximise street frontage, opportunities for passive surveillance and to reinforce the movement network identified by the Local Structure Plan. The neighbourhood centre is intended to function as a 'main street' form of development which generates activity towards the street. The Local Structure Plan requires that development proposals demonstrate this objective.

6.4.4 Biodiversity Principles

The primary objective of the Shire's Local Biodiversity Strategy is to maintain and enhance natural vegetation, living streams and biodiversity throughout the Shire where possible. It specifies the aim of incorporating biodiversity conservation values as a guide to development assessment.

6.4.5 Solar Design and Resource Efficiency Principles

Lot layout through subdivision and the construction of dwellings and ancillary development needs to be orientated to maximise opportunities for solar passive design and energy efficient design.

The layout of subdivision also needs to respect existing landforms / drainage and where practicable, provide opportunities to retain the natural topography. The minimisation of cut and fill should be explored at all stages of subdivision and development.

6.4.6 Subdivision and development should promote the existing grid road layout and provide a highly connected and walkable local movement network.

Subdivisions proposing cul-de-sac access are not supported.

7.0 Investigations and Management Plans

7.1 The following investigations and management plans may be required at the subdivision stage, where appropriate:

- Urban Water Management Plan/s (aligning with the Local Water Management Strategy);
- Site and Soil Evaluation
- Environmental Management Plan/s;
- Public Open Space Management Plan/s;
- Bushfire Management Plan/s;
- Acoustic Report (addressing noise impacts from the railway line);
- Wetland Assessment/s and/or Wetland Management Plan/s;
- Site specific (buffer) study/ technical information if required in accordance with the Environmental Protection Authority's 'Guidance for the Assessment of Environmental Factors – Separation Distances between Industrial and Sensitive Land Uses'.
- Environmental management plans prior to subdivision and development must address

the following where relevant:

- Contaminated soils
- Acid sulphate soils
- Hydrology
- Vegetation
- Flora
- Fauna

All studies, investigations and management plans are to be prepared in accordance with relevant legislation and State and local policies and guidelines. The Shire and/or the WAPC, as appropriate, may also require further studies.

8.0 Public Open Space and Infrastructure Coordination

Individual landowners will be responsible for the delivery of POS and road infrastructure at the time of subdivision.

Landowners will be required to cede land free of cost as required, while also making payment for the full cost of construction, for roads located within their landholdings as depicted on the Local Structure Plan.

Public open space shall be ceded free of cost as required by the Local Structure Plan at the time of subdivision/development.

The provision of public open space/cash-in-lieu for the whole of a portion of land may be required to be met entirely from the first stage of subdivision, or form any preceding stage, if considered desirable by the local government or the Western Australian Planning Commission.

9.0 Local Structure Plan

A copy of the LSP Map appears as Figure 1 below.

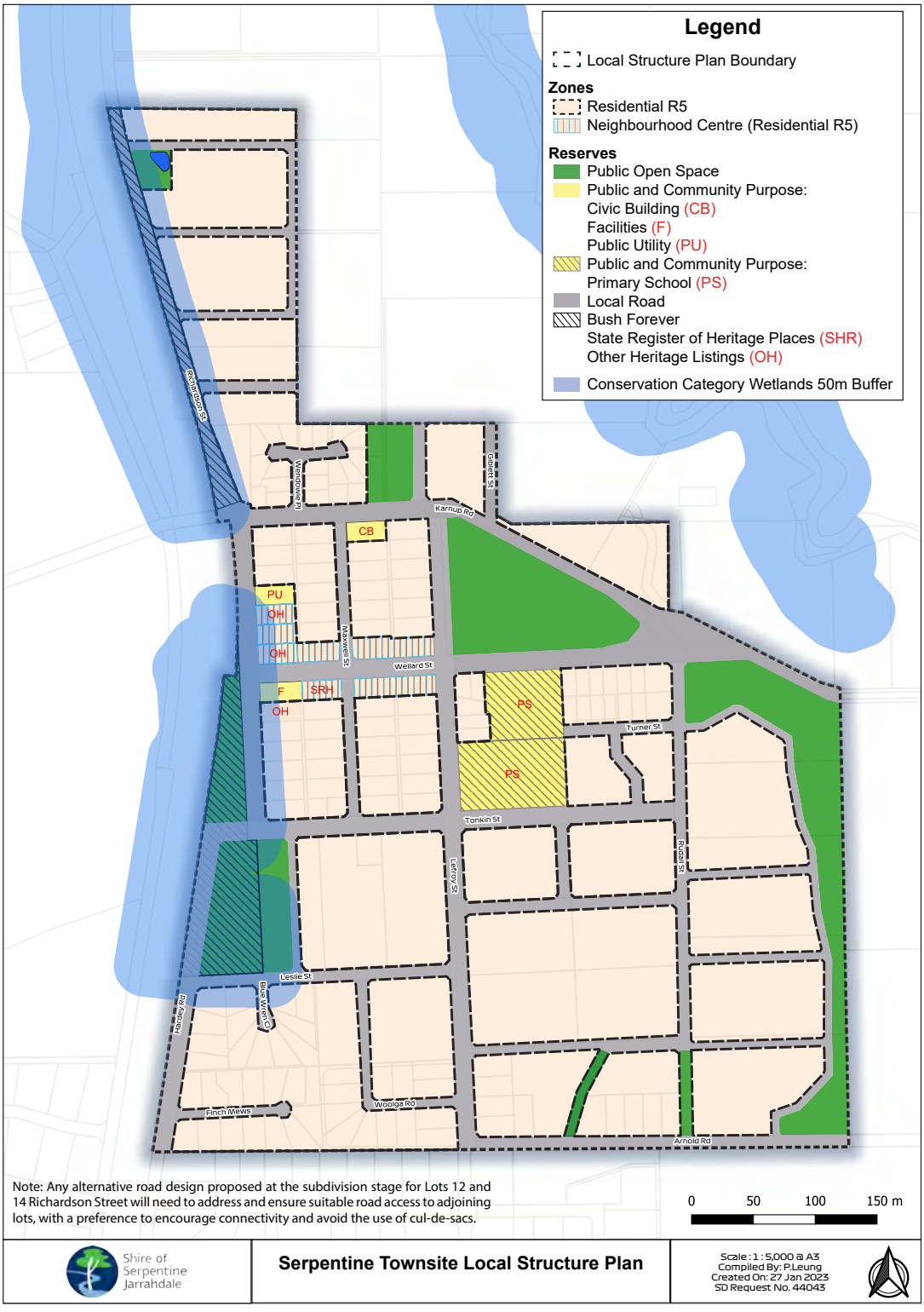


Figure 1: Local Structure Plan Map.

PART TWO: EXPLANATORY SECTION

1.0 Planning Background

1.1 Introduction and Purpose

The report has been prepared in support of a LSP in accordance with the Structure Plan related provisions of the Scheme and the Western Australian Planning Commission (WAPC) Structure Plan Guidelines.

The LSP aims to create an urban settlement which respects the historic environment of the Serpentine Townsite. The following main design principles have been established:

- To respect the heritage of Serpentine;
- To recognise the existing street layout pattern while providing guidance for future urban development;
- To provide for the growth of existing commercial, retail, civic and residential uses that have exposure to the existing and future movement network; and
- To capitalise upon views to the Darling Scarp and the Serpentine Sports Reserve.

This report provides a descriptive analysis of the LSP, including site description, the existing statutory planning framework, opportunities and constraints and the proposed implementation.

1.2 Land Description

1.2.1 Location

The subject land is located within the south-eastern corridor of the Perth metropolitan region, approximately 50 kilometres south-east of the Perth city centre in the Shire of Serpentine Jarrahdale (see Figure 2: Location Plan).

The subject area is bound by the railway line to the west, Arnold Street to the south, Lots 102-106 Rudall Street to the east and Lot 10 Richardson Street, Lot 15 Giblett Street and part of Lots 17 and 18 Karnup Road to the north.

Properties to the immediate north and east are zoned Rural under the Metropolitan Region Scheme (MRS) and are currently utilised for a variety of agricultural and conservation purposes.

South Western Highway, located to the east of the study area, carries a range of vehicles including buses and trucks between Perth and the south-west. A railway line is located directly west of the LSP area running parallel to Richardson Street and Hardey Road. An acoustic report should be prepared at subdivision stage for the northern part of the Serpentine Townsite to address the impact of noise from the railway line.

1.2.2 Area and Land Use

The Local Structure Plan area covers approximately 119 hectares of land and has the capacity to accommodate approximately 200 additional residential lots at a residential density of R5. Except for a small area of commercial land along Wellard Street and several existing public open spaces, the remainder of the Townsite is utilised for rural and residential purposes.

Figure 2: Location Plan.

The Serpentine retail area comprises of a small number of local convenience retail and service outlets, focussed along Wellard Street and parts of Richardson Street.

Other areas of activity include the Clem Kentish Reserve containing the Clem Kentish Hall, an adjacent Tractor and Machinery Museum, tennis courts, an oval with a cricket pitch and some bushland as well as the Serpentine Primary School along Lefroy Street.

1.3 Planning Framework

1.3.1 Zoning

Metropolitan Region Scheme (MRS)

All landholdings within the study area are zoned 'Urban' under the MRS (see Figure 3: MRS Zoning Plan).

Town Planning Scheme No.2

The subject site is comprised of land zoned 'Urban Development' and reserved for 'Parks and Recreation', 'Public Purpose' and 'Public and Community Purpose' under the Scheme (see Figure 4: Town Planning Scheme No. 2 Zoning Plan).

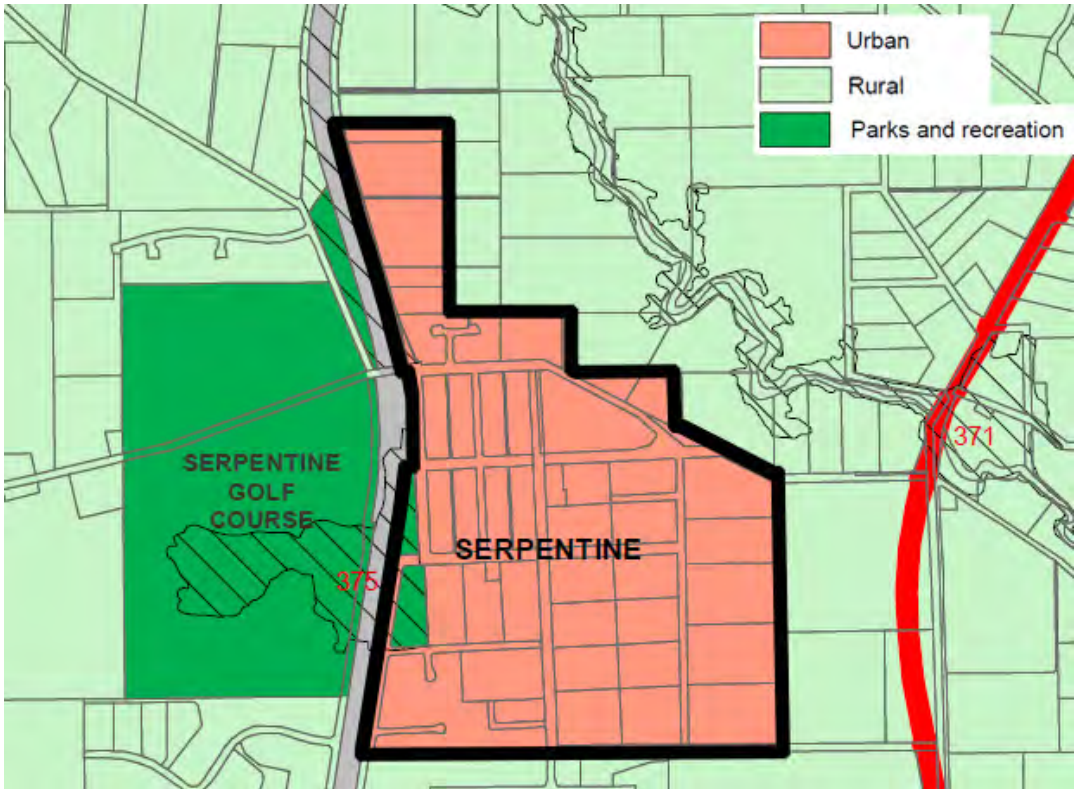


Figure 3: MRS Zoning Plan.

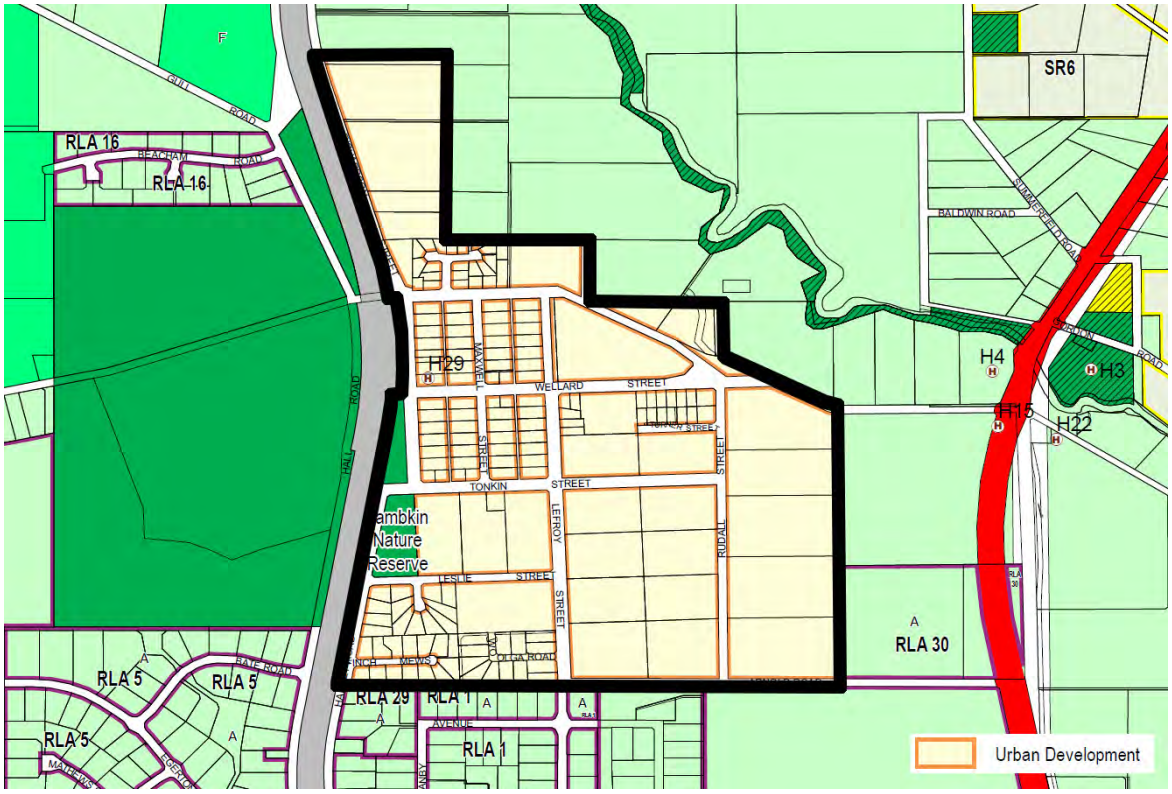


Figure 4: Town Planning Scheme No. 2 Zoning Plan.

The 'Urban Development' zone requires that a LSP be prepared to establish the pattern of development and zoning designations. The LSP aims to establish comprehensive structure planning mechanisms to limit continued ad hoc subdivision.

1.3.2 Strategic Context

Directions 2031 and Beyond

Directions 2031 and Beyond (Directions 2031) is a strategic plan that establishes a vision for the metropolitan Perth and Peel region. Six sub-regions are identified. The Shire of Serpentine Jarrahdale is within the South East sub-region, which is guided by the draft Outer Metropolitan Sub-regional Strategy.

Directions 2031 focuses on a 'Compact Growth' strategy for accommodating and servicing future population growth. This assumes a yield of 15 dwellings per hectare and seeks to balance the need for increased densities within existing urban areas with outward urban expansion. Improving and supporting transport networks is a key objective of this growth scenario.

The LSP achieves a yield of 5 dwellings per hectare. This is considered appropriate for Serpentine, given that the town remains distant from established and planned growth areas and retains an individual character defined by its history and rural setting.

The objectives of Directions 2031 are reflected in the LSP and are addressed in Section 2 - Site Conditions and Constraints of this report.

Perth and Peel @3.5 Million - South Metropolitan Peel Sub Regional Planning Framework

The Framework provides high-level strategic guidance for the future development of the Metropolitan South-West, Metropolitan South-East and Peel sectors to accommodate part of the long-term growth of the Perth and Peel regions to approximately 3.5 million people by 2050. The framework provides strategic guidance to government agencies and local governments on land use, land supply, land development, environmental protection, infrastructure investment and the delivery of physical and community/social infrastructure for each sub-region. The Serpentine Townsite has been identified within the urban land use category under the the Framework.

Shire of Serpentine Jarrahdale Local Planning Strategy

The Shire's Local Planning Strategy, approved in 2022, provides a coordinated strategic planning framework, capturing the long-term vision of the Shire and guiding its future growth and development. The Serpentine Townsite Local Structure Plan area is identified as an urban area accommodating a rural townsite under the Strategy.

A key objective of the Strategy is to increase the housing provision within the Serpentine Townsite to provide more opportunities for housing in a rural setting and to accommodate greater

populations to sustain the neighbourhood centre. Preserving the existing character of the Serpentine Townsite is also a key objective. The Strategy recognises the need for further planning to guide development and growth within the Serpentine Townsite.

1.3.3 State Policies and Guidelines

The LSP area and proposals are directly affected by the following State Planning Policies (SPPs). A summary of each policy and a short statement of relevance is provided.

State Planning Policy 2.1 - Peel Harvey Coastal Plain Catchment (SPP 2.1)

In general SPP 2.1 specifies land use and development controls for the Peel-Harvey Catchment to ensure the protection of wetlands and water resources. The policy contains provisions to ensure that proposals for urban and intensive agricultural development are assessed and undertaken in a manner that minimises its impact on local catchment areas.

SPP 2.1 seeks to minimise the export of nutrients (primarily phosphorous) from land use and development within the catchment to the drainage network. It deals in particular with phosphorous discharge arising from the subdivision and development of land and requires that this should not exceed pre-development levels. The pre-development monitoring establishes baseline water quality levels, against which future monitoring of drainage (post development) can be compared. Further to this, Public Open Space Management Plans will need to be prepared and implemented during the following subdivision process, in order to minimise nutrient export.

State Planning Policy 2.8 - Bushland Policy for the Perth Metropolitan Region (SPP 2.8)

Through the provision of a policy and implementation framework SPP 2.8 aims to ensure that bushland protection and management issues are addressed and considered in land use planning in the Perth Metropolitan Region. It seeks to establish a regional level conservation system with the intention of protecting and managing significant bushland areas to preserve biodiversity and environmental values.

SPP 2.8 functions as a supplementary policy to State Planning Policy 2: Environment and Natural Resources Policy (SPP 2), specifically addressing in detail the protection and management of Bush Forever areas and local bushland. The LSP area contains or abuts Bush Forever sites.

State Planning Policy 2.9 - Water Resources (SPP 2.9)

SPP 2.9 provides clarification and guidance in relation to planning for water resources to ensure the existing and long term quality and quantity of available water resources.

Policy measures include:

- Protecting significant environmental, recreational and cultural values of water resources;

- Preventing or ameliorating potential impacts arising from adverse water quality, removal of riparian vegetation, prevent erosion and pollution; and
- Promoting environmental rehabilitation, improved nutrient levels and restoring flows of watercourses.

The policy deals with surface and groundwater resources, wetlands, rivers, estuaries and Total Water Cycle Management.

The LSP adheres to the principles of Water Sensitive Urban Design and seeks to maximise onsite infiltration and to minimise the export of nutrients from the site. The LWMS calculations and designs for the LSP area demonstrably ensure that stormwater during rainfall events up to 100 year storm event will be detained onsite for the prescribed period.

State Planning Policy 3.5 - Historic Heritage Conservation (SPP 3.5)

SPP 3.5 sets out the principles of sound and responsible planning for the conservation and protection of Western Australia's historic heritage.

State Planning Policy 3.6 - Development Contributions for Infrastructure (SPP 3.6)

SPP 3.6 sets out development contribution provisions for standard infrastructure items as well as for community infrastructure items not included in the standard provisions through development contribution plans.

State Planning Policy 3.7 – Bushfire Prone Areas and Guidelines for Planning in Bushfire Prone Areas

SPP 3.7 and the associated Guidelines provides direction with regard to the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure.

State Planning Policy 5.4 - Road and Rail Noise (SPP 5.4)

SPP 5.4 is intended to ensure the minimisation of transport noise on nearby "noise sensitive premises" without imposing "unreasonable restrictions" on nearby development or increasing costs associated with the provision of infrastructure.

The policy defines:

- Criteria to be used in the assessment of proposals involving noise sensitive development in the vicinity of major transport corridors;
- Measures that can be adopted to reduce road and rail traffic noise; and
- The circumstances when such measures are required.

The provisions of SPP 5.4 are applicable to the northern part of the LSP area which is likely to be impacted by noise from the railway line and will require an acoustic assessment to be undertaken at subdivision stage.

State Planning Policy 7.3 - Residential Design Codes (R-Codes) - Volume 1

Under the provisions of the R-Codes, all residential development is controlled so as to ensure adequate standards of access, amenity and housing choice.

The LSP proposes a base density of R5 and supports generally regular lot shapes to ensure that land is readily developable. Future development must comply with the R-Codes and the Scheme.

Liveable Neighbourhoods

Liveable Neighbourhoods (LN) has been adopted by the WAPC to guide structure planning and subdivision throughout Western Australia. Objectives of particular relevance to this LSP include the following:

- To ensure a site-responsive approach to urban development that supports and enhances the context in which it is located, strengthens local character and identity, integrates with its context and promotes a sense of community;
- To provide a safe, convenient and legible movement network, and to provide attractive streetscapes;
- To ensure that urban development lots have a suitable level of amenity, services and access;
- To provide a network of well-distributed parks and recreation areas that offer a variety of safe, appropriate and attractive public open spaces;
- To integrate appropriate water management measures in an efficient urban structure and range of parkland types.

This LSP has been prepared in accordance with these and other relevant principles identified in LN. Further reference is to be made to LN at the subdivision stage, which entails more detailed design work relating to, for example, lot layout, servicing and access, public open space and urban water management.

Government Sewerage Policy 2019

The GSP requires consideration of sewage disposal at the earliest stage of planning, which will ensure that future development does not create new sewage-related health or environmental problems, or result in costly remediation measures.

1.3.4 Local Planning Policies

Local Planning Policy No. 2.4 - Water Sensitive Design (LPP 2.4)

LPP 2.4 seeks to ensure that best practice in water sensitive design is incorporated in structure planning, subdivision design and development. The implementation of this objective depends upon networks of Multiple Use Corridors, which serve an environmental function incorporating water quantity and quality management, nature conservation, ecological preservation, recreation, and education.

The LSP report demonstrates how future subdivision and development applications within Serpentine will comply with LPP 2.4. A Local Water Management Strategy (LWMS) for the LSP has been prepared by GHD and is included as Appendix 1.

Local Planning Policy No. 2.7 - Biodiversity Planning (LPP 2.7)

LPP 2.7 seeks to recognise the importance of biodiversity conservation as a consideration in the planning process. When a structure plan or changes to a structure plan is proposed, consideration must be given to the impact on local biodiversity targets which are outlined by LPP 2.7.

Local Planning Policy No. 4.3 - Landscape Protection (LPP 4.3)

LPP 4.3 aims to maintain the integrity and preserve the amenity of landscape considered to be of high value, identifying a Landscape Protection Area. The policy outlines specific provisions for the development of land wholly or partially contained within the Landscape Protection Area. The LSP area contains or abuts land within the Landscape protection Area.

Local Planning Policy No. 4.16 - Tree Retention and Planting (LPP 4.16)

LPP 4.16 seeks to protect and retain significant trees contributing to biodiversity and amenity and provide guidance as to when the Shire will support tree removal and require replacement planting and additional planting in degraded areas. The policy also provides guidance regarding the Shire's expectations for landscaping.

Local Planning Policy No. 4.17 - Multiple Use Trails (LPP 4.17)

LPP 4.17 seeks to "implement the Shire's vision to provide a trails network that expands on the existing trails and interlinks suburbs and communities", encouraging the incorporation of recreational trails within Multiple Use Corridors.

Recreational trails within the LSP area will be designed and constructed in accordance with the specifications of LPP 4.17 and in consultation with the Shire.

2.0 Site Conditions and Constraints

2.1 Geomorphic Wetlands

An Environmental Assessment of the LSP area prepared by PGV Environmental (Appendix 3) identifies seven wetlands occurring at the site. This includes three Multiple Use Wetlands, two Resource Enhancement Wetlands and two Conservation Category Wetlands (CCWs).

2.1.1 Multiple Use Wetlands

The Department of Environment and Conservation (DEC) considers Multiple Use Wetlands to be degraded wetlands mainly used for agricultural purposes. These wetlands serve hydrological functions such as groundwater recharge and flood mitigation but do not have specific management objectives. Much of the southern and eastern sections of the subject area is categorised as Multiple Use Wetlands. These wetlands have largely been developed or are Completely Degraded and could be used as detention basins or recharge areas.

2.1.2 Resource Enhancement Wetlands

DEC defines Resource Enhancement Wetlands as wetlands which may have been modified, but still support substantial ecological attributes and functions. Part of the north-eastern area of the LSP is classified as Resource Enhancement Wetlands. A smaller Resource Enhancement Wetland also occurs on the western side of the site. These wetlands have also largely been developed or are Completely Degraded and could be used as detention basins or recharge areas.

2.1.3 Conservation Category Wetlands (CCWs)

DEC classifies CCWs as the highest priority wetlands which support a high level of ecological attributes and functions. No development which may lead to further loss or degradation is permitted within a CCW or its buffer (typically 50 metres).

A Conservation Category Sumpland occurs in the area within and surrounding Lambkin Reserve to the west of the LSP area. Immediately adjacent is a Conservation Category Dampland. The LSP area is also adjacent to Conservation Category Palusplain and in proximity to Conservation Category Palusplain to the north.

The CCWs on the site are within existing Conservation Reserves and are within the existing developed areas. Increasing native vegetated buffers to these wetlands is not feasible. Therefore management of the wetlands will need to be active to ensure weeds and other deleterious impacts are managed appropriately. The Western Australian Planning Commission Guidelines for Determination of Wetland Buffer Requirements will guide the management of development to reduce potential impacts on wetland hydrologic regimes and attributes.

2.2 Landform

The site is generally flat to very gently undulating with elevations ranging from approximately 36m AHD to 30m AHD. The LSP area is situated against the backdrop of the Darling Scarp, which is the most significant topographical feature in the local area.

The preservation of views to the Scarp will be a primary consideration in the assessment of development applications within the LSP area.

2.3 Soils

2.3.1 Geology

The LSP area corresponds to an area of Pinjarra Phase (P7). The Pinjarra Plain System consists of a broad low relief plain west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. The Pinjarra Plain System is described as seasonally inundated swamps and depressions with very poor drained mottled yellow and sandy duplex soils.

The majority of the LSP area consists of fine to medium-grained sandy soils, with areas of gravelly sandy clay to the east and clayey peaty sands to the west. As some of the soil types occurring at the site are prone to waterlogging and ponding, surface water management will be required. It is recommended that to minimise the potential of soil erosion, ground disturbing activities should be kept to a minimum and the installation of temporary drop-out basins to capture and aid in the settling of clay fines should be considered.

The site does not contain any unique and topographical or geological formations and therefore these factors are not an impediment to development.

Figure 5: Typical views to the Darling Scarp.

2.3.2 Contaminated Soils

There are no registered contaminated sites within the LSP area. Historical land use maps show the site has been primarily residential with some intensified farming land uses present. It is likely that long term fertiliser use has contributed to elevated nutrient levels in surface and groundwater. Due to the past rural land uses of the area, it is suggested that a preliminary site investigation may be required at subdivision stage to identify any potential contamination at the site.

2.3.3 Acid Sulphate Soils (ASS)

The majority of the soils in the LSP area have moderate to low risk of ASS disturbance within 3 metres of the surface. A small area to the west of the site associated with Lambkin Reserve (along Tonkin Street) is classified as having a high to moderate risk of ASS. Activities in this area will need to be conducted in accordance with an approved Acid Sulphate Soil Management Plan at subdivision stage.

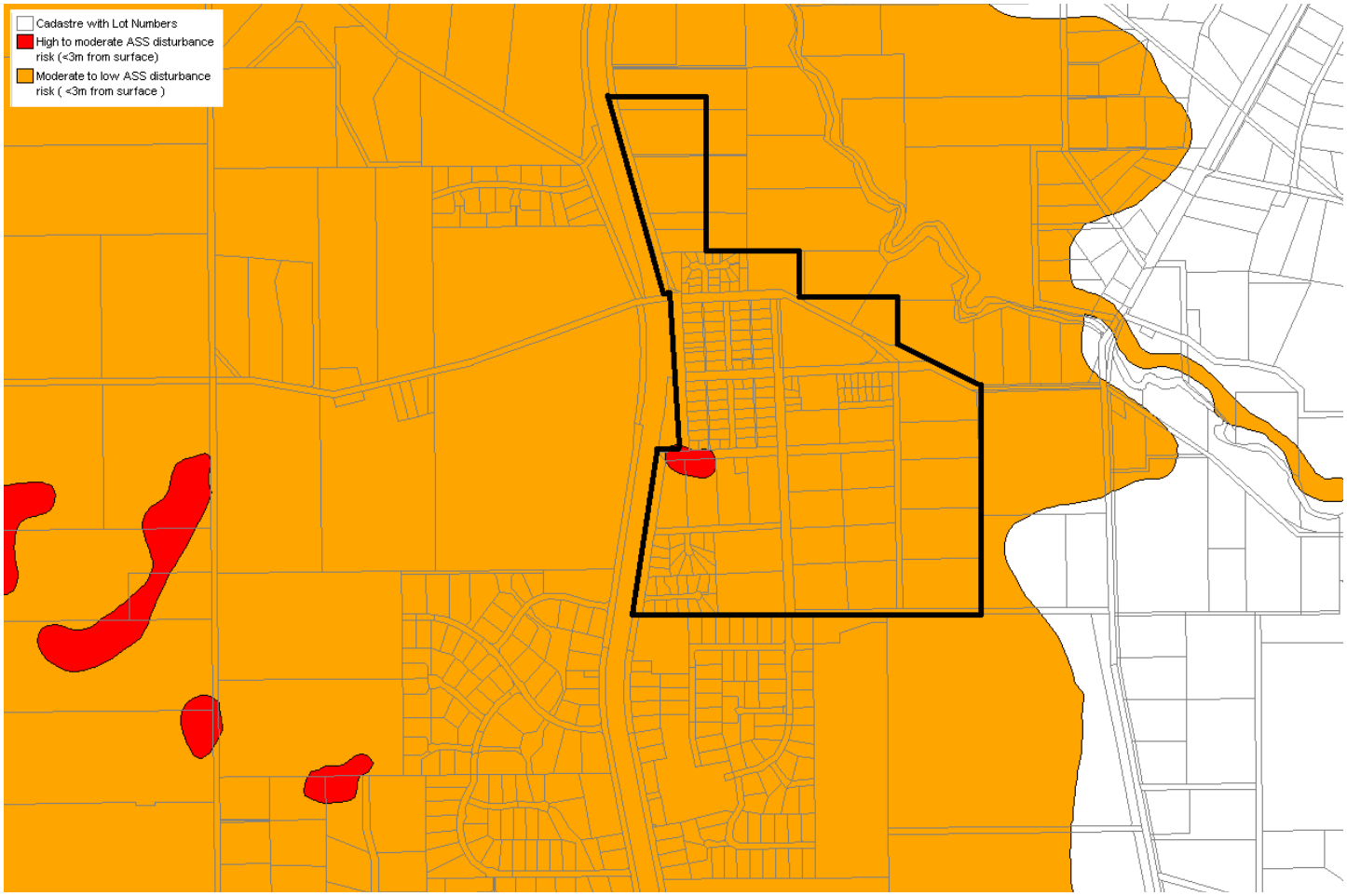


Figure 6: Acid Sulphate Soils.

2.4 Hydrology

The LWMS prepared by GHD and Addendum prepared by Urbaqua is a key supporting document for the LSP. The purpose of the LWMS is to provide objectives, criteria and requirements for the protection and management of the water cycle as part of land use planning and development at all levels of the planning system in the Serpentine study area.

A number of high level studies within the LSP area have provided a regional environmental context for the LWMS. These have been reviewed in order to provide suitable background information for the LSP area and provide indication of the issues requiring further investigation. A number of site-specific investigations into various aspects of the subject site have also been conducted to inform the LSP preparation process.

The LWMS has identified stormwater management, groundwater management and water conservation design criteria based on overarching documents and the requirements of the Shire, DoW and similar developments in the district.

2.4.1 Surface Water

The LSP area is situated approximately 400 metres south of the Serpentine River, which is the primary waterway in the local area. Surface water in the LSP area drains to the Serpentine River which flows in a generally south westerly direction and ultimately discharges in to the Peel Harvey Estuary.

The LSP area is known to experience regular water logging in the lower-lying areas with inundation due to poor internal drainage of soils and persistent winter rainfall which elevates the shallow water table to the surface of poorly drained flat land.

There are some shallow drains (approximately 0.2 - 0.5m deep) which help to drain the site. Located in the eastern part of the site is Water Corporation Hardey's Creek Main Drain which drains a small area in the south-east of the development area near Arnold Rd. It intersects the eastern site boundary near Wellard St and conveys runoff north to the Serpentine River. Hardey's Creek Main Drain has a second branch to the west which drains water from the south west into the other branch of the Main Drain and then into the Serpentine River.

There is a potential to improve the ecological value of the degraded channels at the site through rehabilitation. This could involve the introduction of native vegetation and sedges to stabilise the banks and ensuring existing exotic vegetation is retained until native endemic species are established to provide bank stabilisation.

2.4.2 Groundwater

The LSP area is outside the Department of Water's groundwater contour area. The maximum Groundwater Level is defined as being the surface level. Provision is required to ensure that groundwater and geotechnical monitoring is undertaken prior to any development

commencing in the area. The LSP area is not within a Department of Water public drinking water supply area.

2.5 Natural Areas, Biodiversity and Resource Efficiency

2.5.1 Vegetation

The environmental assessment undertaken by PGV Environmental identified potential impacts of the implementation of the LSP on biodiversity and natural areas within the Serpentine Townsite. The vegetation on the site has been largely historically cleared for the Townsite and rural purposes and is currently used as pasture for fodder conservation or grazing.

The LSP site falls within the Guildford Vegetation Complex. The structure of this complex is described as consisting of a mixture of Marri (Corymbia calophylla) and Jarrah (Eucalyptus marginata) open forest (in places tall open forest), with a small number of locations fringed by Eucalyptus rudis-Melaleuca rhaphiophylla woodlands along streams. Occasional areas of Eucalyptus lane-poolei are also found within the Guildford complex. The Guildford Complex is considered to be poorly reserved with 5% of the original extent of the vegetation remaining. Remnant vegetation occurs in the following locations within the LSP area:

- Lambkin Reserve north of Leslie Street;
- Part of Bush Forever Site 375 to the north of Tonkin Street;
- Road reserve in Turner Street;
- In the east of the site to the south of Karnup Road (Shire Reserve R 9157); and
- Railway Reserve to the west of the LSP area.

The remnant vegetation is representative of the poorly reserved Guildford Complex and contains threatened ecological communities and several conservation significant plant species. The remnant vegetation areas are considered to be in Very Good to Excellent Condition and are of regional significance.

Bushland vegetation on the LSP site is considered to be in Excellent to Very Good condition. The majority of vegetation within the LSP area is Completely Degraded and in some small areas it is Degraded to Completely Degraded. Bush Forever Site 375 which includes Lambkin Reserve is located within the LSP area. Bush Forever Site 365 is adjacent to the western boundary of the LSP area and Bush Forever Site 371 is in close proximity to the northern boundary of the LSP area.

The Threatened Ecological Community (TEC) vegetation within the Turner Road reserve should be protected. It is recommended that any trees be retained where possible in landscaped areas, parking areas and in road/entry areas. There should be minimal disturbance to vegetation resulting from construction activities undertaken in development areas adjacent to bushland areas and it should be in accordance with the Australian Standards for Protection of Trees on Development Sites.

All trees should be located on a site plan that shows canopy and trunk diameters and the

natural ground level at the base of each trunk.

2.5.2 Flora

Declared Rare Flora and priority species are present within small pockets of bushland in the LSP area. It is highly unlikely that such species will be present on the remainder of the LSP area. It is recommended that all areas of remnant vegetation which are subject to development are surveyed for significant flora and vegetation.

2.5.3 Fauna

The LSP area contains five habitat types:

- Completely cleared pasture;
- Parkland cleared Marri;
- Parkland cleared creeklines with exotic Eucalyptus Species;
- Native Woodland over Low Heath; and
- Low Heath and Weeds (Railway Reserve).

Completely cleared pasture dominates the LSP area in parts which are not developed. These areas are considered to be Highly Degraded Fauna Habitat. Parkland Cleared Corymbia Calophylla (marri) occurs in scattered areas within the LSP area, with a larger stand located to the south east. The parkland cleared stands are considered to be Disturbed Fauna Habitat. Lambkin Reserve is considered to be a Very Good Fauna Habitat. The low heath and weeds present in the Railway Reserve is considered to be Good Fauna Habitat for bandicoots, reptiles and a suite of insects. The remaining pockets of native woodland over low heath are more fragmented and considered to be Good Fauna Habitat.

Forest Red-tailed Black Cockatoo, Baudin's Cockatoo and Carnaby's Cockatoo are likely to be present on the site at some times of the year. The Cattle Egret may also be an irregular visitor to the area and the Southern Brown Bandicoot may be present in the bushland areas of the LSP.

Forest Red-tailed Black Cockatoo and possibly Baudin's Cockatoo and Carnaby's Black Cockatoo could be impacted by the development of the site if mature trees are cleared. These three black cockatoo species are listed under Section 18 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Black Cockatoos require a habitat which enables foraging, roosting and breeding. The bushland areas contain the best quality habitat for the Black Cockatoos and should therefore be retained. To mitigate any potential impacts it is recommended that Marri and Flooded Gum trees and other significant trees are retained wherever possible. There is potential to improve the Black Cockatoo habitat by planting appropriate species in drainage corridors, open space and road reserves. Assessment should be undertaken at subdivision stage to determine the implications of proposed development under the EPBC Act.

2.5.4 Resource Efficiency Principles

The housing design in the LSP area shall draw upon the natural setting, rural history and urban context of Serpentine to provide a unique residential character for the development.

The Townsite design provides opportunities for passive surveillance, community engagement and a mix of lot sizes which promotes diversity, walkability and supports transport use.

2.6 Heritage

The historic nature of Serpentine is reflected by the number of properties with heritage significance. The listed properties within the LSP area include the Serpentine General Store (6 Wellard Street) on the State Register of Heritage Places and the Old Serpentine Inn (corner of Richardson and Wellard Streets), the Serpentine Butcher Shop (19 Richardson Street) and Saint Kevin's Church (Richardson Street) which are identified on other heritage listings.

Much of the Local Structure Plan area falls within Registered Aboriginal Heritage Site 3582 Serpentine River under the *Aboriginal Heritage Act 1972*. A Section 18 application may need to be submitted by the landowner(s) to the Department of Planning, Lands and Heritage (DPLH) either at the time of subdivision, or prior to ground disturbing works. Landowners should refer to the 'Aboriginal Heritage Due Diligence Guidelines' and contact DPLH in this regard.

The significant presence of heritage listed properties and the general sense of heritage present within the Local Structure Plan area offers an opportunity to define and protect the rural amenity of the area. Elements which define the rural character and historic nature of the area can be used to develop development criteria which respond to these aspects.

Figure 7: Serpentine General Store.

3.0 Land Use and Subdivision Requirements

The urban design principles applied in the preparation of this LSP have emerged from the character of the site and the requirements of LN, as discussed above. These include:

- An overall layout that is site-sensitive and which integrates with its surrounds, recognising the Darling Scarp as the backdrop;
- An interconnected modified grid layout, affording the site strong legibility and a link to its natural amenities;
- Providing a variety of lot sizes that can accommodate a variety of housing product;
- Providing a high-quality, walkable urban environment;
- Providing a water sensitive design that is responsive to the existing site conditions;
- Providing high-quality POS for both passive and active recreation purposes.
- Ensuring lots are configured to maximise street frontage, opportunities for passive surveillance and to reinforce the movement network identified by the Local Structure Plan.
- Creating a neighbourhood centre, which is to be developed to function as a 'main street'.

3.1 Main Land Uses

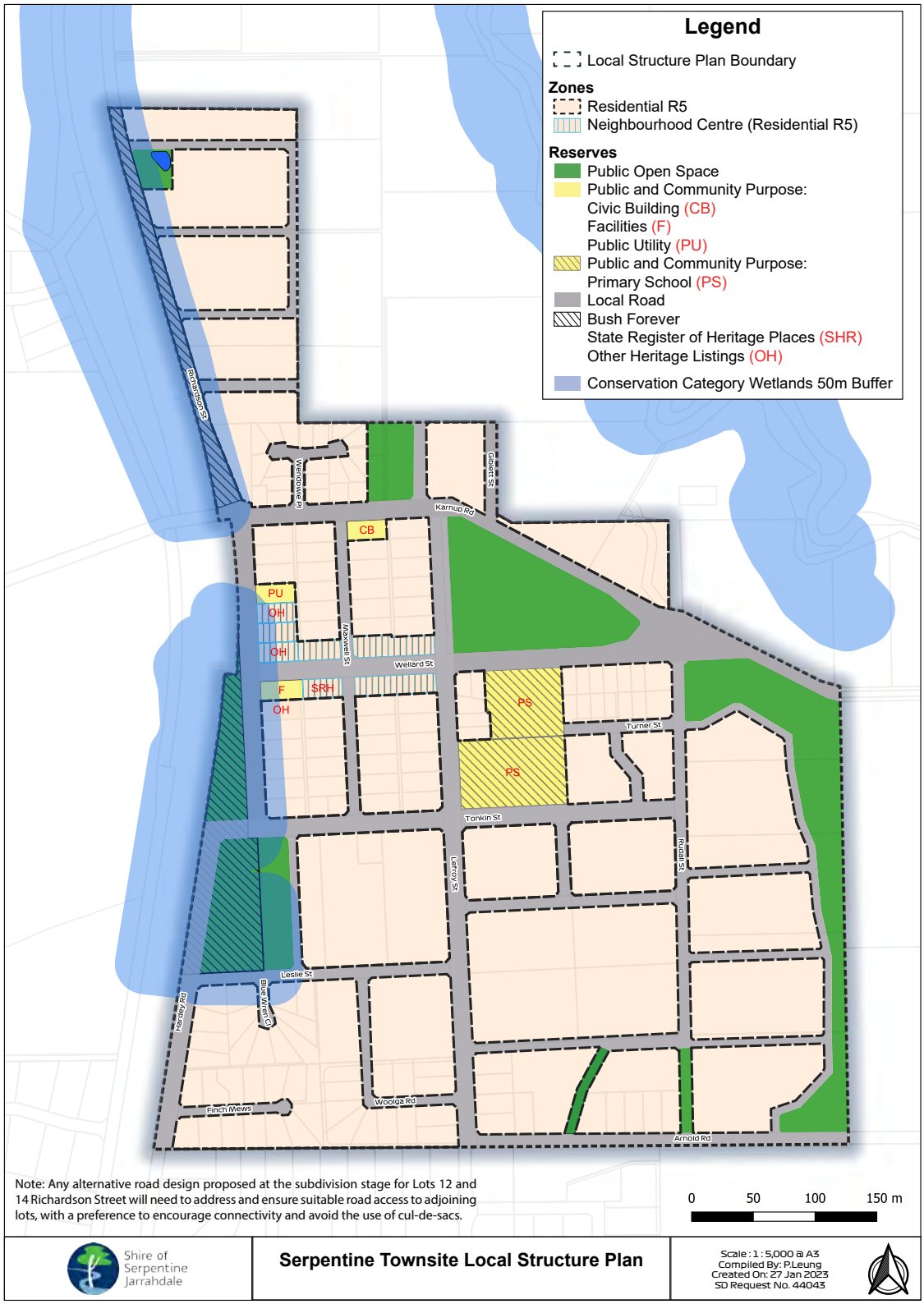


Figure 8: Land Use Plan

The main land uses proposed in the Local Structure Plan are:

- Residential R5
- Neighbourhood Centre
- Public Open Space
- Public and Community Purpose
- Education

A summary of the proposed land use areas is provided below:

Land Use Summary (LSP Area)	
Land Use	**Area (ha)**
Residential R5	69.89
Neighbourhood Centre	1.89
Public Open Space	15.62
Bush Forever	5.31
Public and Community Purpose	0.84
Primary School	3.29
Local Roads	27.18

Table 1: Proposed land use areas.

3.1.1 Residential

The Local Structure Plan identifies opportunities for residential subdivision at the R5 (2,000m^2) density. Table 2 provides residential lot yield approximations, which identify the existing number of lots in the Local Structure Plan area, and the potential lot yield if the existing lots are developed to the maximum density. Some existing lots do not have any further subdivision potential having already been subdivided at the density identified by the Local Structure Plan.

A range of lot types provide for diversity in built and housing type and maintain the rural character of the Townsite.

Existing Number of Residential Lots	162
Potential Lot Yield	368
Estimated Population	1,067 persons @2.9 persons per dwelling

Table 2: Residential Lot Yield Approximations

3.1.2 Activity Centres and Employment

Serpentine is not identified as an Activity Centre under SPP 4.2 however it is identified as a neighbourhood centre in the Shire's Activity Centre Strategy. As a designated neighbourhood centre, retail development will be able to occur to service growing demand. Its role as a retailing centre is limited to the sale of lower-order convenience goods to local residents.

Typically, local and neighbourhood retailing absorbs about 25-30% of annual retail expenditure with total annual expenditure equating to demand per household supporting about 2.2m^2 per capita.

Serpentine accommodates approximately 2000m^2 in commercial and retail floor space at present servicing the localities of Serpentine, Hopeland and Keysbrook.

Serpentine is expected to experience moderate growth within a fairly limited urban area. It would be reasonable to expect this area to accommodate a neighbourhood centre catering for up to 4,400 residents.

3.1.3 Education Facilities

The Serpentine Primary School is identified by the Department of Education as a medium sized Primary School catering for the needs of the Serpentine community and the surrounding area.

3.1.4 Public Open Space

Public Open Space will accommodate quality areas suitable for active and passive recreation purposes and are located within a short walk of most residents.

Public Open Spaces proposed in the LSP comprise:

- POS within Conservation Category Wetland (CCW) buffers which gain partial credit and are considered "restricted POS" under LN; and
- POS outside the CCW buffers, which may be:
    - » Excluded from POS calculations (if within 1:1 year drainage basins)
    - » Considered restricted POS (if within 1:5 year drainage basins but not within 1:1 year drainage basins), or
    - » Considered unrestricted POS (if not within 1:5 year drainage basins)

Variations to public open space provision during the detailed subdivision design will have regard to the passive recreation spaces, active recreation spaces, drainage, vegetation retention and other functions of public open spaces. Tables below outlines the Public Open Space Schedule.

Land Parcels	Area m²
Total LSP Site Area	1,191,676
Remove CCWs	
Lambkin Reserve CCW	11,291
Richardson St POS	19,830
Total Net Site Area	1,160,555
Deductions	
Primary School Site	32,937
Church Lot 51 Tonkin Street	2,187
Commercial Lots Richardson Street	6,089
Wellard Street Shops	12,868
Other Commercial, Public	6,089
Hardey Creek Drain	9,137
Lefroy Street Drain	1,605
Total Deductions	71,069
Gross Subdivisible Area (GSA)	1,089,486
Total POS Required (10% of GSA)	108,949
Unrestricted POS	
Hardey Creek POS	20,620
Karnup Road	43,044
Lefroy Street POS	6,487
North Park	3,070
Spencer Park	9,065
Total Unrestricted POS	82,286
Credited Unrestricted POS	82,286
Restricted POS	
Hardey Creek Basin	17,850
Hardey Creek Drain	2,458
Lefroy Street Drain	2,139
North Park Basin	684
Spencer Park Basin	456
Richardson Street POS	8,455
Total Restricted POS	32,043
Credited Restricted POS (20% Maximum)	21,790
Total POS Required (10% of GSA)	108,949
Total Credited POS (9.55% of GSA)	104,076

Table 3: Public Open Space Schedule.

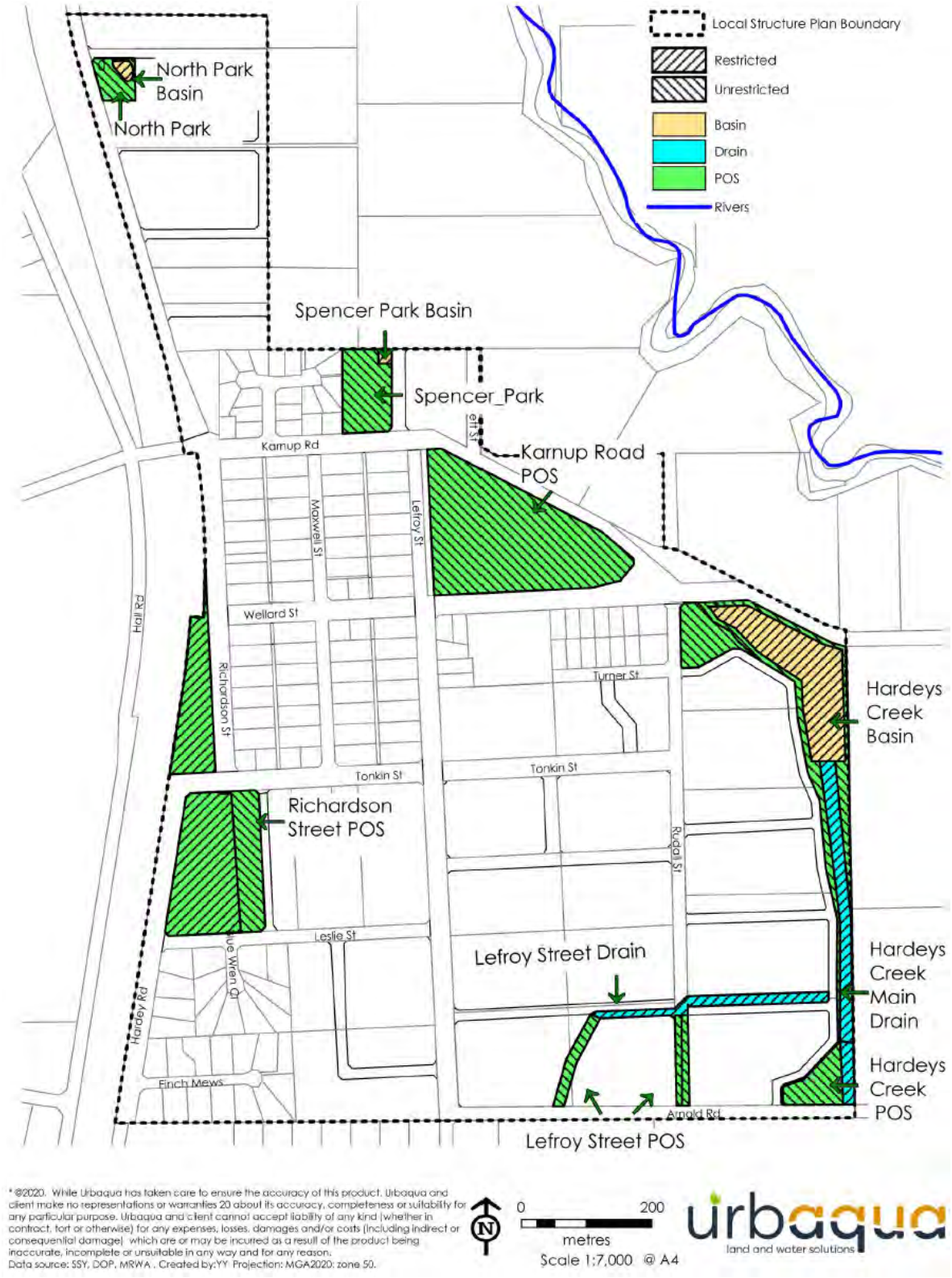


Figure 9: Public Open Space Areas.

3.1.5 Drainage

A comprehensive drainage strategy is included in the Local Water Management Strategy and Addendum (Appendix 1).

The existence of poorly draining soils and a high groundwater table results in the site becoming seasonally waterlogged. Therefore, infrastructure and buildings must be constructed with adequate separation from groundwater to safeguard against flooding:

- Finished floor levels shall be at least 1.2 metre above the maximum groundwater level (MGL);
- Where the predicted MGL is at or within 1.2 metre of the finished surface, adequate separation from groundwater must be provided by the importation of clean fill; and
- Imported fill is to incorporate a band of material that will reduce phosphorous export via leaching, while meeting the soil permeability and compaction criteria required by the Shire.

The proposed LSP incorporates water sensitive design principles for urban stormwater management, consistent with the WAPC's Better Urban Water Management, 2008.

An urban water management plan, in accordance with Better Urban Water Management (WAPC 2008), will be required to be submitted as a part of all subdivision applications within the Local Structure Plan area. Preparation of the urban water management plan is to be guided by the findings of the 'Serpentine Local Structure Plan Wastewater Management Strategy' in addition to the local water management strategy at Appendix 1. Please contact the Shire in this regard.

3.2 Movement Networks

The Transport Impact Assessment undertaken by Cardno indicated that the Local Structure Plan is not anticipated to have a material impact on the traffic operations and safety on the surrounding road network. All intersections are expected to operate at acceptable levels of service and capacity for all scenarios analysed and the proposed development is not anticipated to have a material impact on the traffic operations of the key intersections in the Local Structure Plan area.

It is expected that the Karnup Road / Wellard Street intersection will consist of a roundabout, with a final design to be confirmed at such time as improvement of this intersection is deemed necessary.

3.2.1 Road, Walking and Cycling Network

The main east-west neighbourhood connector (Karnup Road) links Serpentine to its hinterland and to the regional road network. The LSP structure is based on the existing street pattern in the Townsite. The Townsite pattern is based on a traditional grid formation and is direct, interconnected and highly legible with north-south, east-west building orientation. This pattern allows pedestrians and cyclists as well as vehicle users, access to key destinations within the urban area. This pattern has however been disrupted in some areas of the urban development zone by

the approval of cul-de-sac subdivisions.

Further expansion and development of the remaining portions of the Local Structure Plan area will benefit from duplicating the existing road layout. The grid road layout promotes a high degree of permeability, visibility and accessibility. Improvements and proposed modifications to the existing road hierarchy are based on Liveable Neighbourhoods classifications and are shown on the LSP. Proposed roads, parking bays and footpaths will be sited and designed in accordance with the specifications of Liveable Neighbourhoods and the Shire's requirements. The improvements to existing and proposed new road layouts are indicative only and are subject to planning at the time of subdivision and further development of the Townsite. The movement network will be supported by conceptual design and drainage information.

The Long Term Cycling Network Plan was endorsed by the Shire of Serpentine Jarrahdale on 20 April 2020 and identifies aspirational cycle routes within the Local Structure Plan area, including on Karnup Road, Wellard and Lefroy Streets. This will provide good cycle linkages to the neighbourhood centre, school and community facilities as well as the proposed residential lots to the north of the neighbourhood centre and should be incorporated into the structure plan. An extension of the proposed cycle network to incorporate the new proposed road network to the south of the structure plan should be included to ensure a complete and connected cycle network for the town. Bicycle access in the LSP area is to be in accordance with the Shire's Local Area Bicycle and Shared Path Plan.

Appropriate pedestrian infrastructure should be provided to enable all residents within the structure plan to easily and safely access the neighbourhood centre and primary school. Specific safe crossing facilities to complement this would need to be assessed at a later stage of the development process. The Shire's Local Planning Policy No. 4.17 - Multiple Use Trails (LPP 4.17) requires that at subdivision and rezoning stages multiple use trails are identified. It is recommended that the proposed network of footpaths within the LSP connects to existing trails linking to the Byford area and also to the walking/cycling infrastructure proposed within the Byford Town Centre. The Healthy by Design document prepared by the Heart Foundation recommends designing walking and cycling routes to and around local landmarks and points of interest.

A noise assessment will need to be undertaken especially towards the northern extent of the Townsite to address the impact the railway line will have on this development. The noise assessment will be undertaken in accordance with SPP 5.4 and prior to further subdivision within the Townsite.

The Transport Impact Assessment prepared by Cardno (Appendix 2) confirms the above objectives in terms of traffic volumes.

3.2.2 Public Transport

The TransWA Australind service stops at Serpentine four times daily (twice Perth-bound; twice Bunbury-bound). There are no localised public transport services current in the area.

3.3 Infrastructure Coordination, Servicing and Staging

3.3.1 Power

The existing Serpentine LSP area has underground power installed which can be extended as development occurs.

3.3.2 Scheme Water

Scheme water is available to the majority of the Local Structure Plan area. Where the subdivision of land not connected to scheme water is proposed the landowner(s) shall be required to service all proposed lots with scheme water as a condition of subdivision.

3.3.3 Wastewater Management

The Local Structure Plan area is not currently connected to the Water Corporation sewer network. Wastewater generated in the Local Structure Plan area is currently managed by alternative wastewater management systems such as on-site aerobic treatment units. A Wastewater Management Strategy was prepared by GHD to assess the options for the management of wastewater in the Local Structure Plan area. Based on the findings of the Wastewater Management Strategy the following requirements for subdivision and development apply:

Residential R5

Subdivision and development can be approved at a density of R5 (minimum 2,000m^2 lots) in unsewered areas under the Government Sewerage Policy 2019. Alternative wastewater management systems are considered appropriate at this density provided that the following requirements are achieved:

- A Site and Soil Evaluation is submitted to the Shire as part of the subdivision application.
- The wastewater management plan should be informed by the urban water management plan and include the following:
    - » A site feature plan depicting land and environmental features and areas subject to greater than 1 in 10 year ARI flooding and inundation;
    - » A land capability assessment, relevant to the proposed land use/development, with relevant geotechnical information and indicative lot layout and development plan/s;
    - » An investigation of local soils phosphorus retention potential;
    - » Demonstrate compliance with the Australian/New Zealand Standard – On-site domestic wastewater management (AS/NZS 1547:2012);
    - » Demonstrate compliance with the Government Sewerage Policy 2019 (as amended); and
    - » Demonstrate compliance with the Better Urban Water Management Guidelines (WAPC 2008).

3.3.4 Gas

Gas services are not available within the Local Structure Plan area.

4.0 Implementation

4.1 Adoption of the LSP

All development shall be determined in accordance with the LSP once it is approved by the Shire in terms of Clause 5.18 of the Scheme.

4.2 Modifications to the LSP

There may be circumstances under which the LSP may warrant modification, either through a Shire initiative or upon a request from a landowner or the community. Any proposed modification to the LSP must be undertaken in accordance with the relevant provisions of the Shire's Scheme and the WAPC's Structure Plan Guidelines.

The Shire may consider modifications to the LSP on condition that the modifications do not:

- Compromise the overall function or integrity of the LSP;
- Prejudice adjoining landowners in terms of amenity, interface or integration; and
- The modification must be able to demonstrate an improvement to the overall design and function of the LSP area.

5.0 Conclusion

The LSP seeks to provide a planning framework to guide urban development in Serpentine. The proposed land uses and subdivision layout are consistent with the planning context provided under the MRS and the Scheme. The LSP design has been guided by the principles of WAPC and Shire policies which provide strategic direction for the future development of the metropolitan area.

The information provided demonstrates that the subject site is capable of being further developed for urban purposes. Suitable provision of Public Open Space sites has been made. These facilities are connected to the surrounding areas through an integrated road layout. Servicing requirements including roads and utilities have been adequately addressed.

The LSP retains a strong link to the history of the area, the character of the existing Townsite and the natural topography of the land while also adapting these elements to an urban context and complying with district, regional and strategic objectives.

Appendices

- Appendix 1 – Local Water Management Strategy
- Appendix 2 – Transport Impact Assessment
- Appendix 3 – Environmental Assessment
- Appendix 4 – Wastewater Management Strategy
- Appendix 5 – Bushfire Management Plan
- Appendix 6 – Wetland Assessment

Shire of
Serpentine
Jarrahdale

Appendix 1 –
Local Water Management Strategy

Department of Planning

Serpentine Outline Plan

Local Water Management Strategy

February 2013

This report: has been prepared by GHD for Department of Planning and *may only be used and relied on by Department of Planning and mutually agreed parties for the purpose agreed between GHD and the Department of Planning as set out in section 2 of this report.*

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The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer sections 4, 5, 6 and 7 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

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Executive summary

This Local Water Management Strategy (LWMS) has been prepared by GHD Pty Ltd (GHD) for the Department of Planning in accordance with Better Urban Water Management (Western Australian Planning Commission, 2008). The purpose of the LWMS is to provide objectives, criteria and requirements for the protection and management of the water cycle as part of land use planning and development at all levels of the planning system for the Serpentine Outline Plan area.

The proposed Serpentine Outline Plan Area is located in the suburb of Serpentine within the Shire of Serpentine-Jarrahdale, approximately 50 km south of Perth CBD. The site covers approximately 90 hectares in area.

Water Use Strategy

To make the development area a leading example of water efficiency, the following measures will be implemented:

- Water efficient appliances: The development will have full compliance with the Building Code of Australia (BCA) and WA's "5-Star Plus Stage 1" supplement;
- In-house water use: The development will not be connected to scheme water and all in-house water will be sourced from rainwater. The self-sufficient nature of rainwater supply strongly encourages water conservation initiatives within households;
- Wastewater: The development will not be connected to a reticulated sewerage system. Domestic wastewater will be treated through on-site Aerobic Treatment Unit (ATU) effluent disposal systems, where the effluent can be recycled via irrigation of vegetated disposal areas; and
- Landscape irrigation: Public Open Space (POS) areas will be irrigated using local groundwater. Domestic gardens can be irrigated with effluent from the ATU systems. Any additional irrigation requirements can be sourced from rainwater or the installation of garden bores (subject to quality and quantity of groundwater within the area).

Stormwater Quantity Management Strategy

The proposed stormwater management strategy employs the following principles for the following events:

1 year ARI event

- Roofs will be connected to soakwells or rainwater tanks.
- Road runoff will be infiltrated as close to source as practical using water sensitive urban design (WSUD) measures such as infiltration devices such as bioretention basins/swales, soakwells and Atlantis cells.

5 year ARI event

- Will be collected and conveyed by swales. The swales will discharge directly to the Hardey's Creek Main Drain or will discharge to dry, shallow detention basins.
- Where swales and drains discharge to waterways and basins, the banks of the waterway or basin will be stabilised to prevent scouring.

100 year ARI event

- Events greater than the 5-year ARI event will be conveyed away from the development along roads and POS, discharging to Hardey's Creek Main Drain or Serpentine River. Basins have been sized to compensate major events up to the 100-year ARI event to the pre-development flow.

Groundwater Management Strategy

The existence of poorly draining soils and a high groundwater table results in the site becoming seasonally waterlogged. Therefore, infrastructure and buildings must be constructed with adequate separation from the groundwater to safeguard against flooding:

- Finished floor levels shall be at least 1.2 m above the maximum groundwater level (MGL). Where the predicted MGL is at or within 1.2 m of the finished surface, adequate separation from groundwater will be provided by the importation of clean fill; and
- Imported fill is to incorporate a band of material that will reduce phosphorous export via leaching, while meeting the soil permeability and compaction criteria required by the Shire of Serpentine-Jarrahdale.

Water Quality Management Strategy

Surface water from the development mostly discharges to the Hardey's Creek Main Drain and the Serpentine Drain which ultimately discharge into the Peel-Harvey Estuary system via the Serpentine River. Discharge from the development will meet the target water quality objectives identified in the Peel-Harvey Water Quality Improvement Plan (EPA, 2007).

It is proposed to adopt Water Sensitive Urban Design (WSUD) and Best Management Practices (BMPs) promoting retention, infiltration and treatment of events up to the 1-year ARI events, in accordance with the *Stormwater Management Manual for Western Australia* (DoW, 2004-2007). Structural measure will include a bioretention system which represents 2% of the total impervious area.

The key WSUD elements for the bioretention system incorporated into the design of subdivisions within the study area are:

- Biofiltration pockets: Wherever practical, these small biofiltration and infiltration systems will be incorporated into non-frontage verges (where they will not obstruct driveway crossovers) and road nibs.
- Vegetated median swales: Wherever practical, biofiltration and infiltration systems in the form of vegetated swales will be incorporated into median strips.

Implementation

The next stage for water management is to obtain subdivisional approvals supported by an Urban Water Management Plan (UWMP). The UWMP is to be consistent with the design criteria and strategies outlined in this LWMS and include site-specific detail design of the drainage system in consideration of other aspects of the overall design concept.

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Appendices

1. Introduction

GHD Pty Ltd (GHD) was commissioned by the Department of Planning to prepare a Local Water Management Strategy (LWMS) for the Serpentine Outline Plan area (the Site). The proposed development is located in the suburb of Serpentine within the Shire of Serpentine-Jarrahdale, approximately 50 kilometres (km) south of Perth CBD (Figure 2). The site covers approximately 90 hectares (ha) in area.

The purpose of this LWMS is to:

- Provide objectives, criteria and requirements for the protection and management of the water cycle as part of land use planning and development at all levels of the planning system for the Serpentine Outline Plan area;
- Identify key water environments and management issues across the Serpentine Outline Plan area;
- Provide guidance for the protection of significant water resource assets and the management of water resources, including waterway and catchment health; water (re)use and efficiency; and flooding and stormwater management, as part of future land use planning and development in the Outline Plan area, at all levels of the planning system; and
- Incorporate applicable principles from Better Urban Water Management (Western Australian Planning Commission, 2008).

This LWMS has been prepared in consultation with the Western Australian Planning Commission (WAPC) Departments of Environment and Conservation and Water (DEC and DOW, respectively), Water Corporation and the Shire of Serpentine-Jarrahdale. This LWMS has been prepared in accordance with the principals outlined in Better Urban Water Management framework (WAPC, 2008), which provides a model for developers to address water related management issues at the various stages of planning and presents interim water related design objectives for water conservation, groundwater and stormwater.

1.1 Total water cycle management - principles and objectives

Total water cycle management, also referred to as integrated water cycle management, 'recognises that water supply, stormwater and sewage services are interrelated components of catchment systems and therefore must be dealt with using a holistic water management approach that reflects the principles of ecological sustainability' (DoW 2004-07, *Stormwater management manual for Western Australia*).

The *State Planning Policy 2.9: Water Resources* (WAPC, 2004) outlines the key principles of integrated water cycle management as:

- Consideration of all water resources, including wastewater in water planning;
- Integration of water and land use planning;
- The sustainable and equitable use of all water sources, having consideration of the needs of all water users, including the community, industry and the environment;
- Integration of human water use and natural water processes; and
- A whole of catchment integration of natural resource use and management.

The principles and objectives for managing urban water as stated in *the Stormwater Manual for Western Australia* (DoW, 2004) are as follows:

- Water Quality: to maintain or improve the surface and groundwater quality within the Development Areas relative to predevelopment conditions.
- Water Quantity: to maintain the total water cycle balance within the Outline Plan area relative to the pre-development conditions.
- Water Conservation: to maximise the reuse of stormwater.
- Ecosystem Health: to retain natural drainage systems and protect ecosystem health.
- Economic Viability: to implement stormwater management systems that are economically viable in the long term.
- Public Health: to minimise the public risk, including risk from 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.

1.2 Planning background

The Serpentine Outline Plan is being prepared by the Western Australian Planning Commission (WAPC) to provide guidelines for the subdivision of urban zoned land in the Serpentine town site area, to ensure that the impact of environment and heritage are considered in the planning process. The Serpentine Outline Plan will provide a statutory plan and design criteria that aim to provide logical planning outcomes, while deterring subdivision applications that do not meet the requirements. The LWMS will investigate how water resources can be effectively managed by addressing all aspects of the water cycle, to ensure that key water issues are incorporated in the planning process at the local stage.

The planning framework for land and water planning is illustrated in Figure 1. The LWMS demonstrates how water resources can be considered in the land use planning system and to ensure consistency with *State Planning Policy 2.9: Water Resources* (WAPC, 2004).

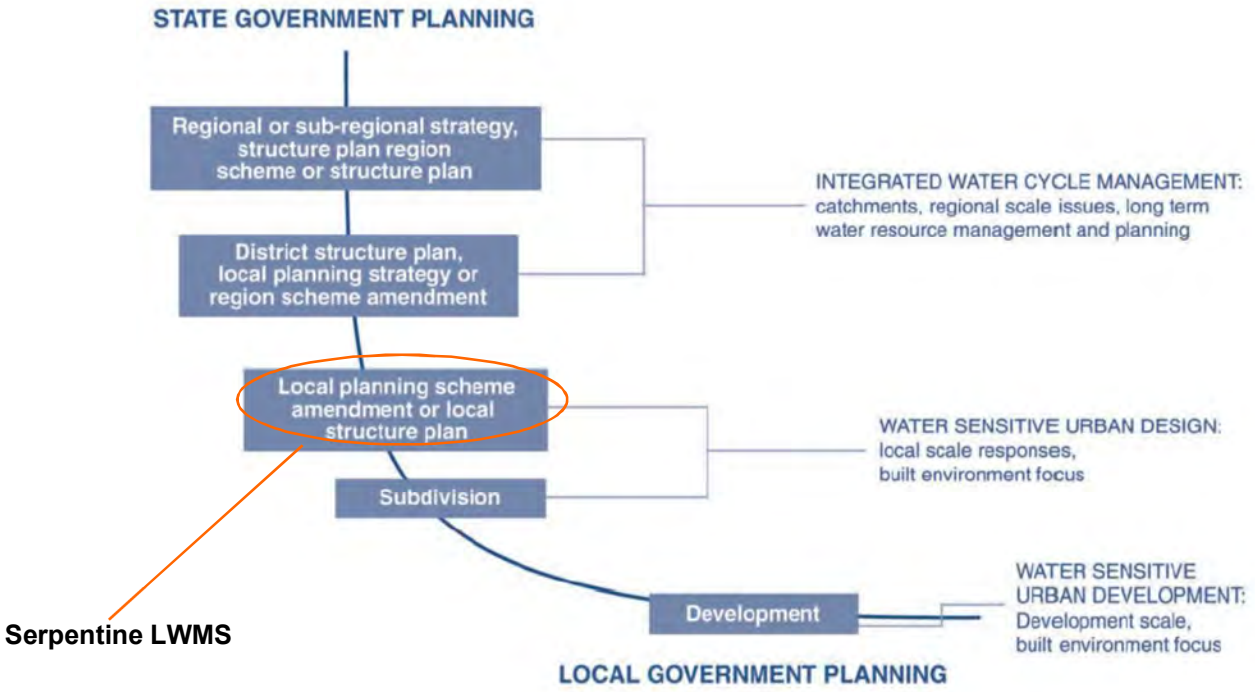

Figure 1 Planning framework for integrating the drainage planning with land planning

SOURCE: *Better Urban Water Management* (WAPC, 2008)

1.3 Previous studies

Information presented in a number of studies has been drawn upon in the developemnt of this LWMS and they are briefly summarised below:

- Murray Drainage and Water Management Plan (DoW, 2011) – presents a drainage and water management plan for a 375 km^2 study area extending from Nambeelup catchment in the north, the lower Serpentine River and Peel-Harvey estuary in the west, the Fauntleroy Drain catchment in south, and the darling ranges and foothills to the east. The DWMP area is predominantly within the Shire of Murray; however, 10% of the study area is located with the Shire of Serpentine-Jarrahdale, where the northern boundary is approximately 10 km south of this LWMS study area. The DWMP provides design principles for surface water and groundwater management, including drainage and flood control and water conservation and re-use measures.
- Serpentine River Floodplain Management Study (SKM, 2010) – presents a floodplain management strategy for the Serpentine, Baldivis, Karnup and Keralup areas, which conducted detailed hydrologic and hydraulic flood modelling of the catchment. The floodplain model incorporates this LWMS study area; and indicates that the study area is not subject to inundation for a 1:100 year ARI flood event.
- State Planning Policy (SPP) 2.1 Peel Harvey Catchment (WAPC, 2003) – sets down land use and development controls for the Peel Harvey catchment for the protection of wetlands and water resources. The policy contains provisions designed to ensure that proposals for urban and intensive agricultural development are carefully assessed and undertaken in a manner that minimises impact to the receiving water ways.

LEGEND

- Study Area
- Rivers
- Cadastre
- Roads

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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GHD

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Government of Western Australia
Department of Planning

SLIP ENABLER

Department of Planning
Serpentine Outline Plan LWMS

Locality Plan

Job Number	61-28174
Revision	0
Date	19 Feb 2013

Figure 2

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

G:\61\28174\GIS\Maps\MXD\6128174_G001_Fig2_RevB.mxd

Data source: Landgate: Roads - 20120510; DoP: Serpentine Aerial - 20120517, Cadastre - 20120517; DoW: Rivers - 20120510; GHD: Study Area - 20120510. Created by: bflorczak

2. Proposed development

2.1 Key elements in the Serpentine Outline Plan

The Serpentine Outline Plan is being prepared by the WAPC to provide guidelines for the subdivision of urban zoned land in the Serpentine townsite area, to ensure that the impact of environment and heritage are considered in the planning process.

The existing rural residential zoning (R5 – R10) will remain with no increase in the residential density within the study area; however, it is likely that the lot boundaries, drainage infrastructure and POS will be relocated according to future subdivision proposals. It is possible that a number of the larger, rural-style lots, may be subdivided in the future. Gross subdivisible area for the development is approximately 78.3 ha.

2.1.1 Land uses

The Town Planning Scheme Map for Serpentine contained in the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2 (Department of Planning, 2011) summarises the current landuse of the development area (Appendix A). The area predominantly consists of residential lots and contains a combination of R10 and R5 residential zoned lots. The development area also contains a number of commercial lots and public and community lots, and public open space and recreation areas.

The proposed outline plan is shown in Appendix B.

2.1.2 Public open space

There is an allowance of 10% of Public Open Space (POS) within the development area in accordance with Liveable Neighbourhoods (2007). The POS will be collocated to align with the water management strategy and most efficiently incorporated into drainage design and flood management and is shown in Figure 3.

The existing drainage basin and finch Mews and Blue Wren Close may be relocated at a future date in accordance with the Shire of Serpentine Jarrahdale requests.

Unrestricted POS within the development is comprised of approximately 15 ha in the north-east corner of the development (Memorial Gardens) and the created Lot 15 Giblett St POS. The existing park adjacent to the school will remain and new POS co located with drainage features will be created along Leslie Street, Lefroy Street and Rudall Street as shown in Figure 3.

Table 1 Unrestricted Public Open Space

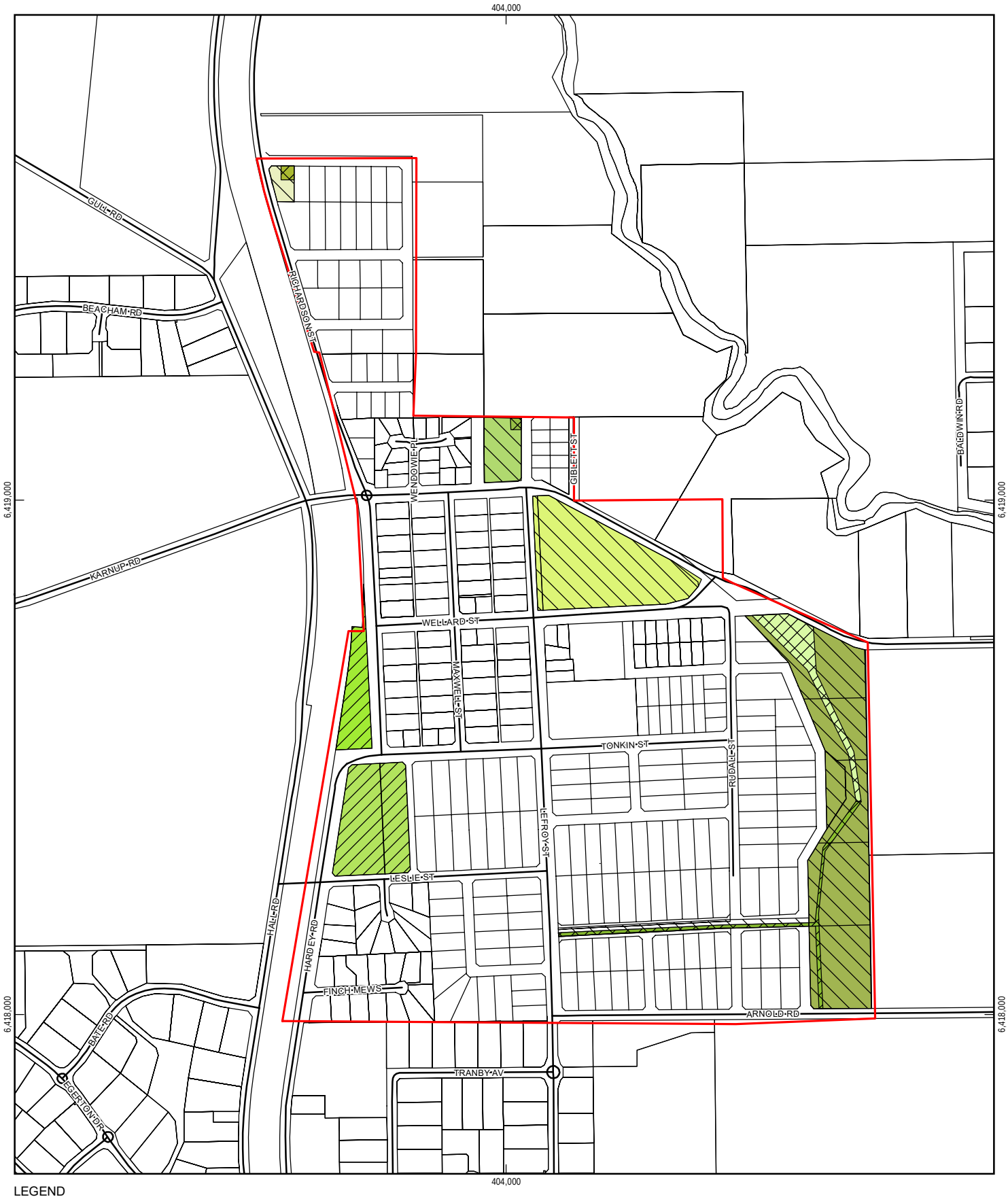
Unrestricted POS components	Area (m2)
Hardey's Creek POS 1	3699
Hardey's Creek POS 2	80788
Karnup Road POS	45529
Lefroy Street POS	8029
North Park	2902
Spencer Park	8982
Total Unrestricted POS	**149930**
80% Credit	**119943**

Restricted POS where usability is limited is to the drainage features (basins and living stream) where 5 year flows or storage is provided.

Table 2 Restricted Public Open Space

Restricted POS sites	Area (m2)
Hardey's Creek Basin	10140
Hardey's Creek Main Drain	3065
Lefroy Street Drain	3436
North Park Basin	673
Richardson Street POS	10500
Total Restricted POS	**27815**
20% Credit	**5563**

Detailed POS schedule and areas is provided in Appendix C.



LEGEND

- Study Area
- Cadastre
- Restricted
- Unrestricted
- Lefroy_Street_Drain
- Hardeys_Creek_POS
- Hardy_Creek_Basin
- Hardy_Creek_Drain
- Karnup_Road
- North_Park
- North_Park_Basin
- Richardson_Road_North
- Richardson_Road_South
- Spencer_Park
- Spencer_Park_Basin

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Serpentine Outline Plan LWMS

Public Open Space

Job Number 61-28174
Revision 0
Date 19 Feb 2013

Figure 3

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Data source: DoP: Serpentine Aerial - 20120517, New Cadastre - 20120517, Bush Forever Sites - 20120510; DEC: Geomorphic Wetlands - 20120510, Environmentally Sensitive Areas - 20120510; DIA: Aboriginal Heritage Sites - 20120510; GHD: Study Area - 20120510. Created by: bflorczak

3. Design criteria

The design criteria adopted for this LWMS have been based on the design objectives outlined in *Better Urban Water Management* (WAPC, 2008),the Urban Water Management design objectives outlined in the Shire of Serpentine-Jarrahdale Urban Water Management Draft Planning Policy No 62 (Shire Serpentine-Jarrahdale, 2011) and State Planning Policy 2.1 for the Peel Harvey Catchment (WAPC, 2003).

3.1 Water Conservation

The overall intention of the LWMS is to achieve the sustainable management of all aspects of the water cycle within the development with the use of potable water to be as efficient as possible. Specifically the objectives for integrated urban water management for the development are:

- Mandatory use of rainwater harvesting on the lot-scale as the primary potable water. The *State Water Strategy* (Government of Western Australia, 2003) sets a target of 20% reuse by 2012. The development aims to reduce the use of scheme water by providing an alternative fit for purpose water supply for drinking water use.

3.2 Water Quantity Management

The post development annual discharge volumes and peak flows are to be maintained relative to pre-development conditions, unless otherwise established through determination of ecological water requirements for sensitive environments. To achieve the above principle the following criteria will be applied:

- Ecological protection - For the critical one year average recurrence interval (ARI) event, the post development discharge volume and peak flow rates shall be maintained relative to pre-development conditions in all parts of the catchment. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles as agreed by DEC and DoW.
- Flood Management - Manage the catchment runoff for up to the 1 in 100 year ARI event in the development area to pre-development peak flows, unless otherwise indicated in an approved strategy or as negotiated with the relevant drainage service provider.
- Protect infrastructure and assets from inundation and flooding - Urban development usually results in the removal of significant areas of vegetation and replacement of permeable areas with buildings, roads and paved areas. This results in increased volumes and flows of surface runoff, which has the potential to cause flooding and inundation. Floor levels of all habitable buildings shall be a minimum of 1.2 m above groundwater level.

3.3 Water Quality Management

Maintain surface and groundwater quality at pre-development levels (winter concentrations) and if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub catchment in which the development is located. To achieve the above principle the following criteria will be applied:

- If the pollutant outputs of development (measured or modeled concentrations) exceed catchment ambient conditions, the proponent shall achieve water quality improvements in

the development area or, alternatively, arrange equivalent water quality improvement offsets inside the catchment. If these conditions have not been determined, the development should meet relevant water quality guidelines stipulated in the *National Water Quality Management Strategy* (ANZECC & ARMCANZ, 2000).

- Ensure that all runoff contained in the drainage infrastructure network receives treatment prior to discharge to a receiving environment consistent with the *Stormwater Management Manual* (DoW, 2004-2007) using structural controls representing 2% of connected impervious catchment
- Where implemented all outflows from sub soils will receive treatment prior to discharge to the stormwater system.
- Protect groundwater as a resource.

3.4 Commitment to best management practice

In order to meet the design criteria of reductions in total phosphorus, total nitrogen, total suspended solids and gross pollutants as compared to developments in which water treatment is not undertaken, it is necessary to use a combination of best management practice strategies. In addition, best management practice strategies reduce risks of flooding on housing and infrastructure while maximising the potential for stormwater to be treated as a resource.

The hierarchy of best management practice principles is as follows:

- Implement controls at or near the source to prevent pollutants entering the system and/or treat stormwater.
- Install in-transit measures to treat stormwater and mitigate pollutants that have entered the conveyance system.

Implement end-of-pipe controls to treat stormwater, addressing any remaining pollutants prior to discharging to receiving environments.

3.5 Objectives and strategy

A summary of the objectives for this LWMS is shown in Table 3.

Table 3 Water Management Objectives and Strategy

	Objective	Strategy
Water Conservation	Maximise the reuse of stormwater. Limit potable water use outside of homes and buildings. Reduce the average per capita potable water consumption.	Minimise potable water use outside of homes and buildings by providing alternative supplies and reducing demand by mandating the use of rainwater harvesting as the primary potable water source
Water Quantity	Maintain the total water cycle balance for ecological protection Minimise potential surface water pollution by use of non-structural and structural controls, in accordance to WSUD and BMP's.	Stormwater runoff shall be retained for up to the 1 hr 1-year ARI event off line from major flow paths. Attenuation of peak 5 and 100-year ARI developed flows to pre-development flows. Provide for the 100-year overflow path. Floor levels of all habitable buildings pad levels 0.5 m above the 100-year event flood level. Floor levels

	Protect property and infrastructure within and downstream of the development, to the required level of protection.	of all habitable buildings shall be a minimum of 1.2 m above groundwater level.
Water Quality Management	Maintain or improve the surface and groundwater quality within the study area relative to pre-development conditions. Maintain groundwater levels within the natural regime.	Using structural controls such as swales representing 2% of the connected impervious catchment in combination with non-structural controls such as public education campaigns, use of low phosphorus fertilisers in POS areas, to minimise potential pollution of stormwater and groundwater. Preliminary water quality targets will be established for the study area and reviewed and refined based upon future monitoring. Existing drainage inverts shall be maintained where possible.

4. Existing environment

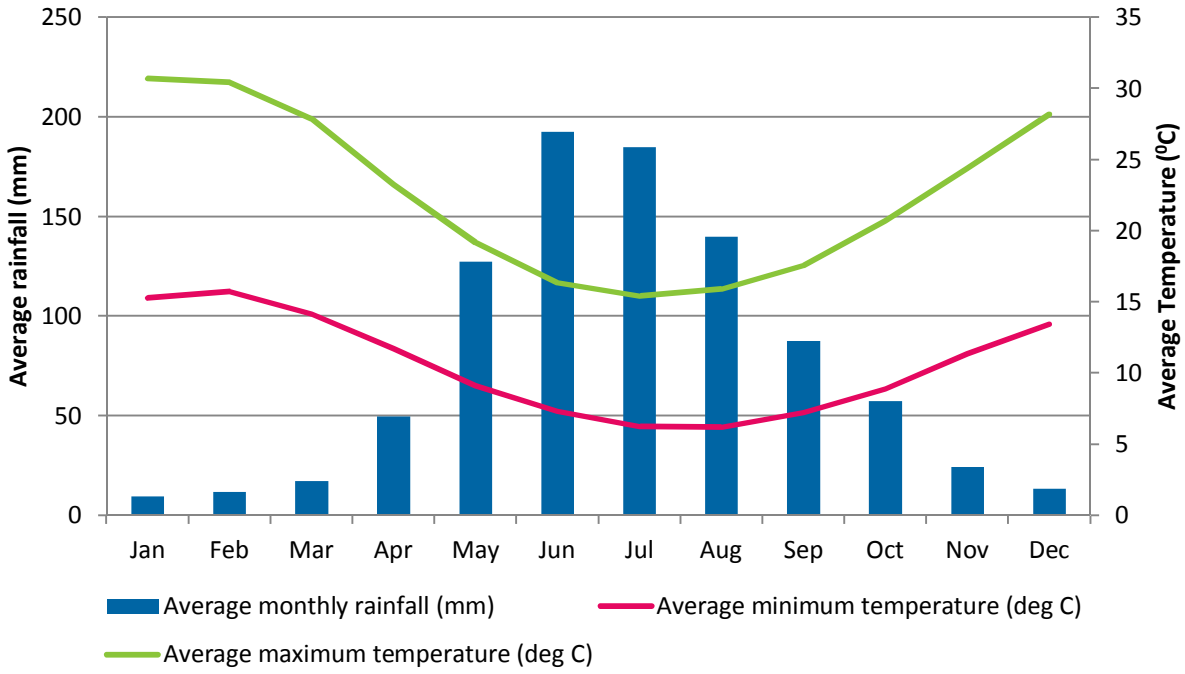
4.1 Location

The Serpentine Outline Plan development area is located in the suburb of Serpentine within the Shire of Serpentine-Jarrahdale approximately 50 km south of Perth as shown in Figure 2. The site is approximately 90 ha in area.

4.2 Climate

The climate in Serpentine is typically characterised by hot, dry summers, and cool wet winters. The nearest meteorological station which records rainfalls is the Serpentine gauge (station number 009039) which is approximately 2 km away from the development. The average annual rainfall at Serpentine from 1907 to 2011 is approximately 928 mm/annum. The nearest temperature station is at Karnet (station number 009111) which is approximately 10 km from the development. Figure 4 presents the monthly average rainfall at Serpentine and minimum and maximum temperature at Karnet, which indicates that on average 70% of the annual rainfall occurs over the months from May to August.

Figure 4 Monthly average temperature and rainfall



4.3 Topography

The site topography is characterised by a relatively flat palusplain (seasonally waterlogged land) varying between approximately 30 mAHD in the north-west corner to 35 mAHD in the middle of the site (Figure 5). As the site is not free-draining, it is important that drainage infrastructure is designed to convey runoff from the site in a controlled manner.

4.4 Land use

The current landuse within the development area is predominantly residential zoned R5 to R10, with a number of commercial and community lots and areas for POS and parks and recreation.

It is proposed that the landuse will remain largely residential a mixture of R5 and R10; however, the lot boundaries, POS and drainage network may be relocated, depending on future development plans.

4.5 Soils

4.5.1 Geology

The site corresponds to an area of Pinjarra Phase (P7). The Pinjarra Phase is described as seasonally inundated swamps and depressions with very poor drained acidic mottled yellow and sandy duplex soils.

The majority of the site consists of fine to medium-grained sandy soils, with areas of gravelly sandy clay to the east of the site and a pocket of clayey peaty sands in the west (Figure 7). The Geology Survey of Western Australia (1986) maps the site as Yilgran Craton (AYI(h)), described as granulite and migmatite, high grade metamorphic rock.

A geotechnical assessment will be required to be completed prior to final detailed design of earthworks and drainage. The geotechnical report will inform future Urban Water Management Plans (UWMPs).

4.5.2 Contaminated soils

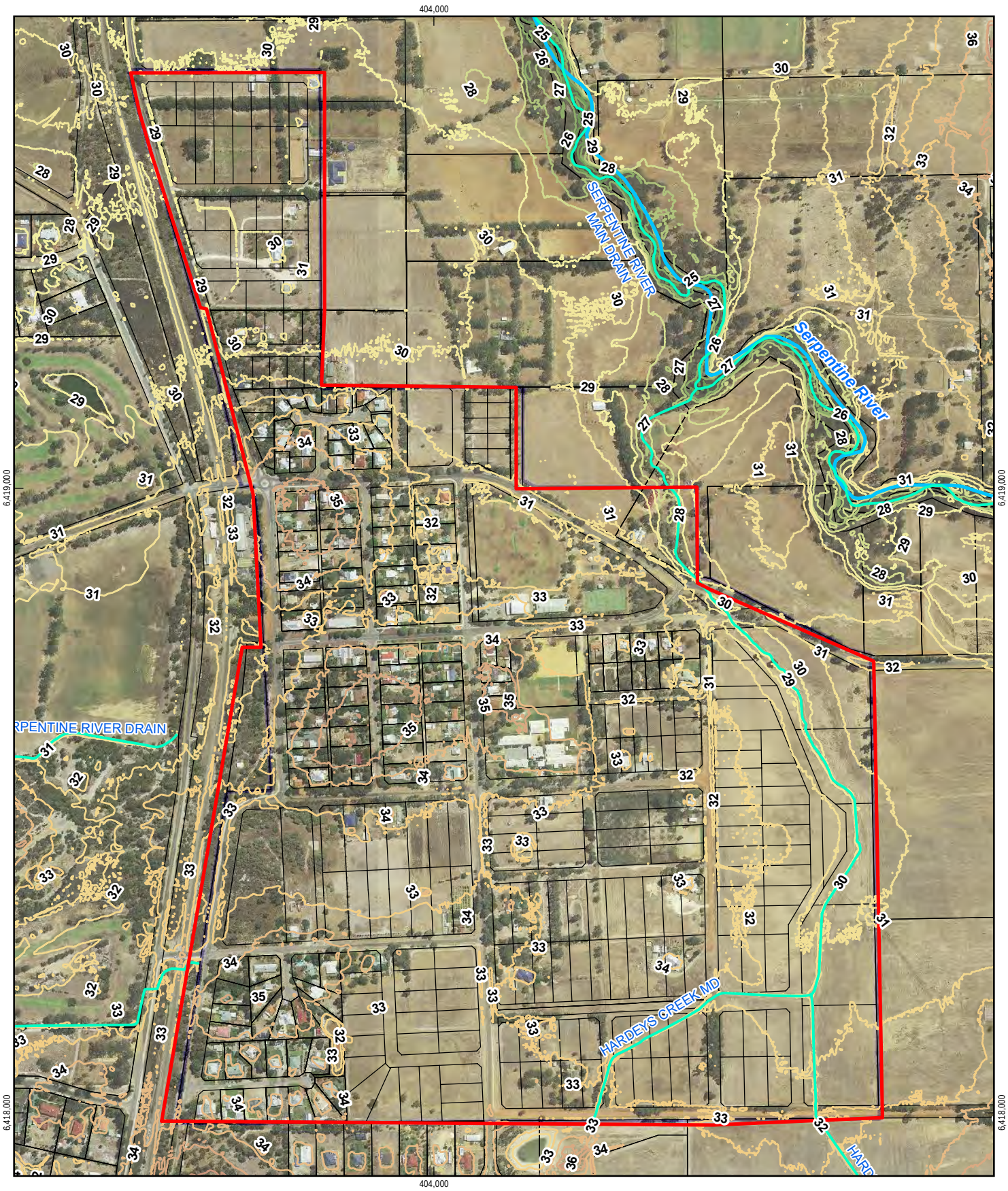
A search of the publically available DEC *Contaminated Sites Database* undertaken in May 2012 indicates that there are no registered contaminated sites within the development area. Historical landuse maps show the site has been primarily residential with some intensified farming land uses having previously been undertaken. It is likely long term fertilizer application has contributed to elevated nutrient levels in surface and groundwater.

4.5.3 Acid sulfate soils

Acid Sulfate Soils (ASS) are naturally occurring soils containing iron sulphides. These soils are typically benign within the anaerobic environment of their formation. However, when they become oxidised through various disturbances such as development, acidic soil, surface water and groundwater can result. Resultant sulphuric acid solubilises contaminants including heavy metals, potentially releasing lead, aluminium, iron, and arsenic into groundwater.

The main environmental indicator of ASS is shallow groundwater and/or waterlogging of laterites and sands, which may have generated sulphuric conditions, which lead to acid sulfate soils.

ASS risk mapping (Figure 6) indicates that the majority of the soils within the LWMS area have moderate to low risk of ASS. A small area to the west of the site (along Tonkin St) is classified as having a high to moderate risk of ASS occurring at depths less than 3 m from the surface. Works in this area will need to be conducted in accordance with an approved acid sulfate soil management plan.



LEGEND

Study Area	Cadastre	**LIDAR Contour 1m**	28	32	36	40	
Open Drains	cadastre_cliped_ammend_Sep2012-	25	29	33	37	41	
Rivers	CadastreOption2DashedLine-	26	30	34	38		
	cadastre_Option2-	27	31	35	39		

1: 551,311,233 (at A4)

2,050,000 0 2,200,000 2,300,000 2,400,000 2,500,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Topography and Drainage

Job Number	61-28174
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Date	19 Feb 2013

Figure 5

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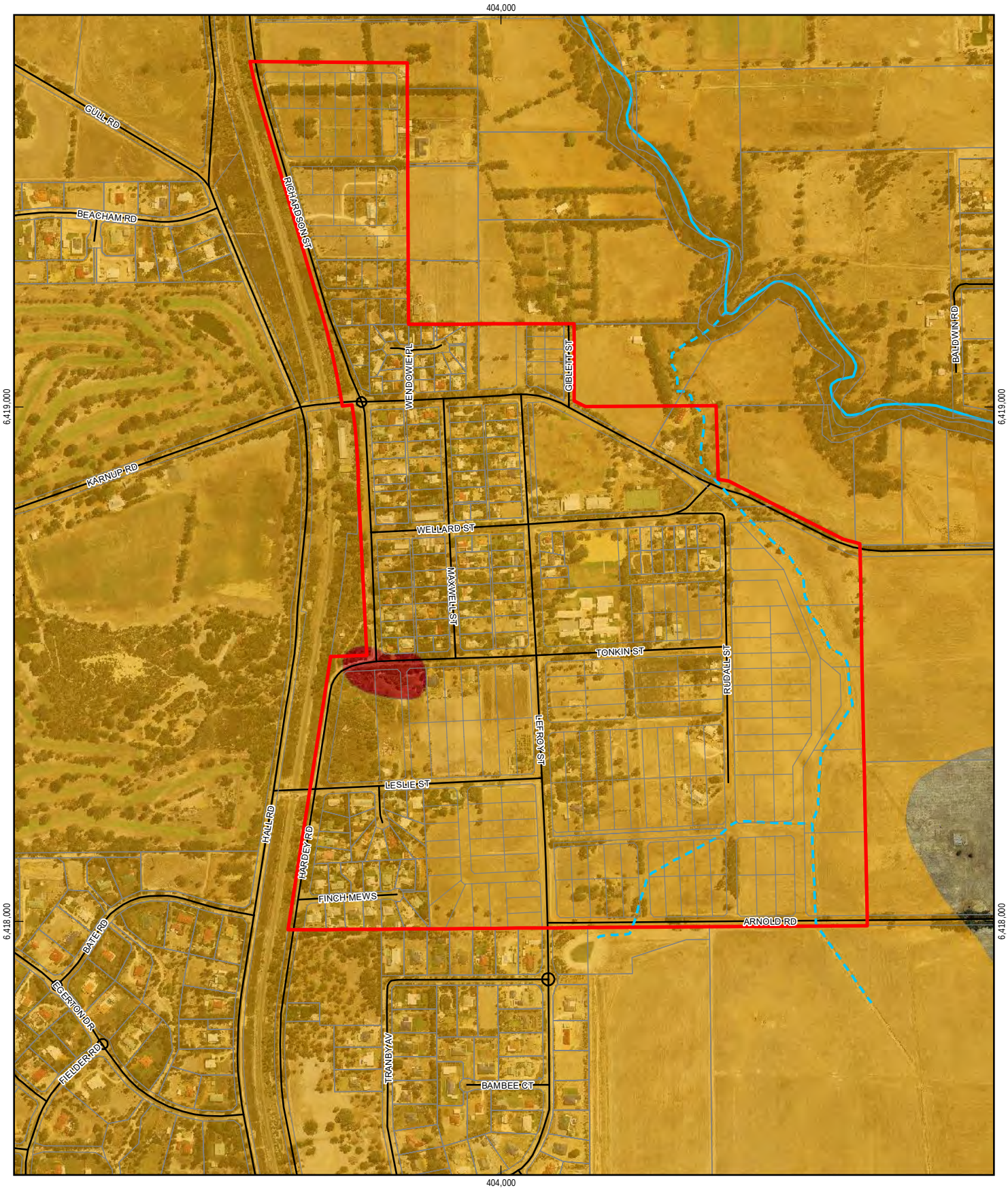
Data source: Water Corporation: Open Drains - 20120510; DoW: Rivers - 20120510, 100 year ARI Floodway and Flood Fringe Areas - 20120521; DoP: Serpentine Aerial - 20120517, Cadastre - 20120517, Contour 1m - 20120517; GHD: Study Area - 20120510. Created by: bflorczak



LEGEND

- Study Area
- Cadastre
- Roads

Acid Sulfate Soils

- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Serpentine Outline Plan LWMS

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Revision 0
Date 19 Feb 2013

Acid Sulfate Soils

Figure 6

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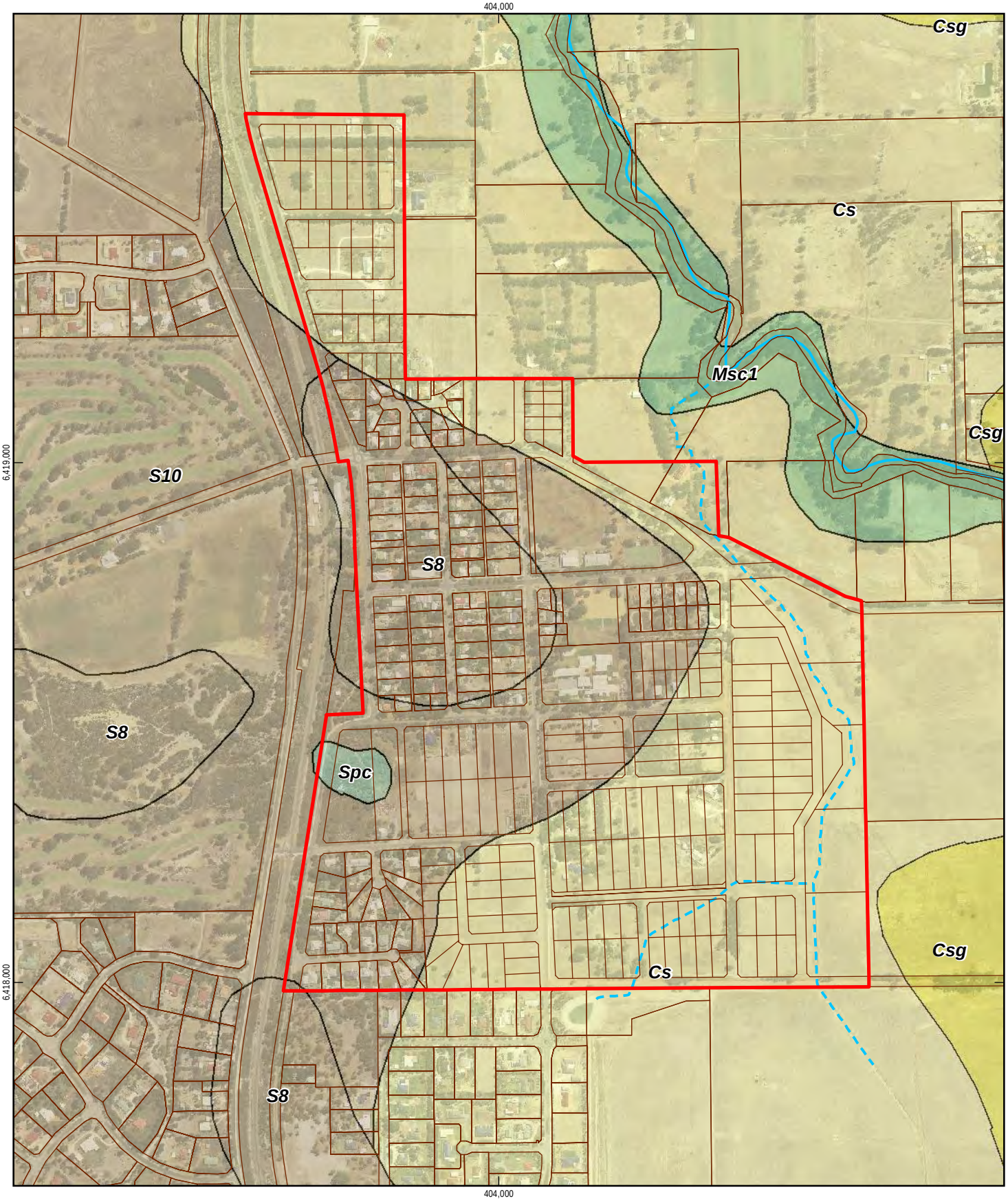
Data source: Landgate: Roads - 20120510; DoP: Serpentine Aerial - 20120517; DEC: Acid Sulfate Soils - 20120510; GHD: Study Area - 20120510. Created by: bflorczak



LEGEND

Study Area

LEVEL_NAME

Mainstream

Cadastre

Geology

Spc	*CLAYEY PEATY SAND - grey to black, quartz sand with variable organic content; minor clays, of lacustrine origin*	S8	*SAND - white to pale grey at surface, yellow at depth; fine to medium-grained, moderately sorted sub-angular to sub-rounded minor heavy minerals, of eolian origin*
Msc1	*CLAYEY SANDY SILT - pale brown, sand angular to rounded, low cohesion, of alluvial origin*	S10	*SAND - as S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin*
Csg	*GRAVELLY SANDY CLAY - variable with lenses of silt and gravel, quartz sand sub-angular with eolian rounded component, heavy minerals common, gravel rounded, of colluvial origin*	Cs	*SANDY CLAY - white, grey to brown, fine to coarse, sub-angular to rounded, clay of moderate plasticity; gravel and silt layers near scarp, of alluvial origin*

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Department of Planning
Serpentine Outline Plan LWMS

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Geology

Figure 7

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Data source: DoP: Serpentine Aerial - 20120517, Cadastre - 20120517; DOIR:Geology 50k - 20120518; GHD: Study Area - 20120510. Created by: bflorczak

4.6 Reserves, conservation areas and environmentally sensitive areas

4.6.1 Bush forever

A small area to the west of the site is classified by the Department of Planning as a Bush Forever site (BFS), as indicated in Figure 8. The site BFS No 375 is co-located with a conservation category wetland bound by Hall Road and Richardson Street.

4.6.2 Aboriginal Heritage

The northern portion of the LWMS study area is classified as a ceremonial and mythological Aboriginal Heritage Site, as indicated in Figure 8. The classification is related to the Serpentine River (Site No. S02407) which extends along the Serpentine River and floodplain. The classification is not likely to impact development of the site.

4.6.3 Environmentally sensitive area

The majority of the LWMS area is classified by the DEC as an environmentally sensitive area, as indicated in Figure 8. These areas correspond to declared geomorphic wetlands and are discussed in Section 4.7.2.

4.6.4 Significant flora and fauna

No Declared Rare Flora or Fauna as classified by the DEC has been recorded in the study area.

4.7 Waterways, wetlands and drainage

4.7.1 Surface water

The Serpentine area is known to experience regular water logging in the low-lying area, with inundation due to a combination of persistent winter rainfall elevating the shallow water table, which rises to the surface and inundates areas of flat terrain, and poor drainage.

The Serpentine River is located approximately 400 m north of the northern site boundary (Figure 5). The Serpentine River flows south-westerly in a natural channel through Serpentine until it ultimately discharges into the Peel-Harvey Estuary system.

The Water Corporation open drains are shown in Figure 5. The Water Corporation Hardey's Creek Main Drain which conveys runoff north to the Serpentine River, intersects the eastern site boundary near Wellard St and drains a small area in the south-east of the development area near Arnold Rd. The Water Corporation Serpentine River Drain intersects the western boundary near Leslie St, and conveys runoff west, and discharges into the Serpentine River.

The site is included in the Serpentine Floodplain Management Study (SKM, 2011). The flood modelling indicated that the study area is not subject to inundation from overtopping of drains during the 100 year ARI flood events. However, Hardey's Main Drain upstream of Karnup Road (just north of the LWMS study area) was identified as being subject to between 1 – 2.5 m of inundation (classified as high to extreme flooding risk) during a 100 flood event, which could result in backwater effects upstream in the drain. Serpentine River flood map is provided in Appendix G.

4.7.2 Geomorphic wetlands

The DEC's *Swan coastal geomorphic wetland mapping* (date) (Figure 8) indicates the LWMS area contains Multiple Use, Resource Enhancement and Conservation Category wetlands within the study area. The following text provides further detail regarding these varyingly classified wetlands.

Multiple Use wetland areas

Much of the southern and eastern parts of the site are classified as Multiple Use wetland. The Multiple Use wetland areas are totally or mostly cleared, and are used for agricultural purposes. These wetlands still serve hydrological functions, such as groundwater recharge and flood mitigation, but they do not have any specific management objectives.

Resource Enhanced wetland areas

Smaller areas in the north and west of the site are classified as Resource Enhancement wetlands. The Resource Enhancement wetlands areas are wetlands which may have been partially modified, but still support substantial ecological attributes and functions.

Conservation Category wetlands

Conservation category wetlands occur in both the west and east of the site. Conservation category wetlands are the highest priority wetlands and support a high level of ecological attributes and functions. No development which may lead to further loss or degradation is permitted within Conservation category wetlands.

The Conservation category wetland, located at 51 Tonkin Street No. 14974 (refer to Figure 8), appears to have been cleared in the past and is unlikely to continue to support any values for which conservation classification was awarded. To support development of this area a request to reclassify the wetland to a less stringent management category, and an update to the *Geomorphic Wetlands Swan Coastal Plain* dataset was submitted to the DEC. This request contained:

- Visual justification
- Desktop study of wetland values
- Wetland vegetation condition assessment

DEC has advised the request to reclassify the Conservation category wetland, located at 51 Tonkin Street No. 14974, to a less stringent management category of multiple use has been approved. Department of Planning has provided the communications and approvals in Appendix F.

The proposed land use of the currently designated Conservation Category wetland No. 14974 will remain as the current R10 and R5 residential zoning. Upon subdivision, the stormwater drainage infrastructure and management measures will be implemented in line with the Stormwater Management Strategy discussed in Section 6 of this document.

The Conservation Category wetland located within the eastern sector of the Outline Plan (Lambkin Reserve) bound by Tonkin Street to the North, Leslie Street to the South and Hardey Road to the West will remain untouched, with the proposed land use identified as Restricted Public Open Space.

In order to protect this wetland a 50 m buffer is provided to the wetland from all future development in line with DEC requirements for wetland protection. An assessment of the wetlands hydrology indicates no external catchments will grade to the Conservation Category wetland, development is therefore unlikely to increase runoff to this wetland. As discussed in

Section 6 of this document, the development will ensure additional stormwater is directed along existing drainage path way away from the wetland.

4.8 Groundwater

4.8.1 Levels and flows

The LWMS development area is situated outside of the DoW's groundwater contour area. DoW's historic maximum groundwater contours, show the minimum groundwater level is 30 mAHD, approximately 0 m below the natural surface based on the existing topography. Based on site evidence, groundwater is generally perched at surface level in low lying areas during the winter months and flows in a westerly direction towards Serpentine River.

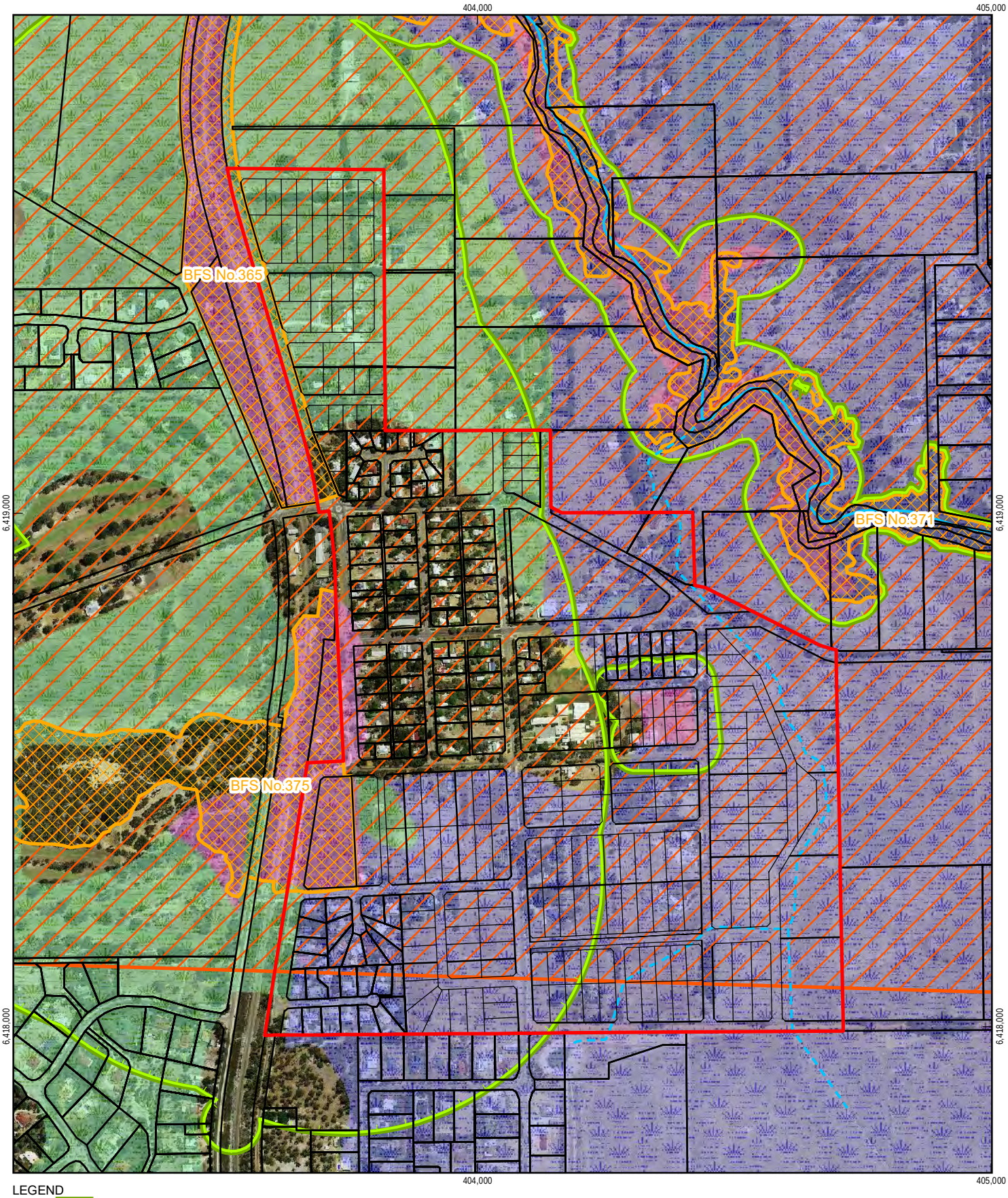
4.8.2 Groundwater quality

There is very limited groundwater quality data available for the study area. Based on previous land uses shallow groundwater quality is believed to have small concentrations of ortho-phosphorous in the groundwater. Total nitrogen (TN) concentrations are believed to be moderate, with moderate concentrations of nitrate and nitrite.

The site is classified by the DoW's as 'unsuitable for additional garden bores' due to the characteristics of the regional aquifer potentially resulting in poor groundwater quality and/or quantity (DoW, 2012). The geology of the site consists of clayey formations which could result in an unreliable water supply, and there is moderately high groundwater salinity level of between 1500 – 2000 mg/L, which could result in poor water quality (DoW, 2012). Garden bores can be installed and used to access groundwater for irrigation purposes; however, it is acknowledged that there are risks associated with the aquifer which could result in poor groundwater quality and/or quantity.

4.8.3 Future commitments

Due to the absence of further empirical data that could be used to characterise groundwater conditions in relation to depth and quality, a conservative design based on the Maximum Groundwater Level (MGL) defined as being ground level has been assumed in this LWMS. The requirement will be made to developers that both groundwater monitoring and a geotechnical assessment will be required, the data evaluated, and groundwater management measures identified prior to initiating development. The groundwater monitoring and geotechnical reports will be provided to DoW and the Shire of Serpentine Jarrahdale, as well as an updated groundwater management strategy, prior to development.



LEGEND

- Environmentally Sensitive Areas
- Bush Forever Sites
- Aboriginal Heritage Sites
- Cadastre

EVALUATION

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Government of Western Australia, Department of Planning

SLIP ENABLER

Department of Planning
Serpentine Outline Plan LWMS

Environmental and Heritage Constraints

Job Number 61-28174
Revision 0
Date 19 Feb 2013

Figure 8

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Data source: DoP: Serpentine Aerial - 20120517, New Cadastre - 20120517, Bush Forever Sites - 20120510; DEC: Geomorphic Wetlands - 20120510, Environmentally Sensitive Areas - 20120510; DIA: Aboriginal Heritage Sites - 20120510; GHD: Study Area - 20120510. Created by: bflorczak

5. Sustainable water use strategy

5.1 Water Efficient Fixtures and Fittings

It is proposed that the development permits only highly rated water efficient appliances and fittings. *The Water Use in Houses Code* Stage 1 requires that all tap fittings other than bath outlets and gardens taps must be minimum 4 stars Water Efficiency Labelling and Standards (WELS) rated, all showerhead must be a minimum 3 stars WELS rated and all sanitary flushing systems must be a minimum 4 stars WELS rated dual flush (Department of Housing and Works, 2007). This will be a requirement of the plumbing and design guidelines and be controlled though the inspection of houses when being connected to the non-drinking water supply. Further inspections will occur during change of ownership of properties by placing a condition on the title.

The water-using products covered by the WELS Scheme, are set out in Table 6. This table recommends WELS rating for these products.

Table 4 Specifications for Fixtures and Fittings

Product	Minimum WELS rating	Recommended WELS rating
Clothes washing machines	4	4.5
Dishwashers	4	4.5
Toilet (lavatory) equipment	4	4
Showers	3	4
Tap equipment	4	4
Urinal equipment	3	3

5.2 Efficient landscaping and irrigation measures

It is understood that POS areas within the LWMS study area are currently irrigated with groundwater abstracted from the local aquifer. Discussions with the Shire indicate that the intention is to continue to irrigate POS areas with groundwater in the short to medium term.

It is recommended that POS areas be designed to minimise irrigation requirements, with predominantly local native landscaping and keeping turf areas to a minimum. Innovative irrigation design methods and technologies will be used and the latest available documentation on irrigation in Western Australia will be followed, including:

- Urban Irrigation Best Management Practices (Irrigation Association of Australia, 2006);
- Waterwise Garden Irrigators Program – Design Principles, Specifications and Guidelines (Irrigation Association of Australia, 2007); and
- Waterwise Garden Irrigators Program – System Specifications, (Irrigation Australia, 2007).
- The following strategies will be applied to this development:

- Ensuring irrigation is installed according to Irrigation WA standards;
- Using rain sensors and soil moisture meters to turn irrigation off when not required;
- Using subsurface irrigation to reduce water lost to evaporation and wind displacement;
- Xeriscaping through use of plants with very little or no irrigation demand.

5.3 Fit-for-purpose water sources

5.3.1 In-house water demand

The subject land is not currently connected to the scheme water supply. The primary water supply to the residential development will be provided from rainwater harvesting from roof and shed runoff through the installation of rainwater tanks plumbed into houses.

The Shire of Serpentine Jarrahdale require a minimum rainwater tank storage of 109 kL (99 kL for domestic consumption and 10 kL storage for fire-fighting purposes) (personal communication, Shire Serpentine Jarrahdale, 2012). It is the responsibility of the landowner to maintain the upkeep of their rainwater tanks and any shortfall in water supply can be met by carting water.

5.3.2 External non-potable water demand

Household irrigation water demands can be met through re-use of effluent from the ATU systems. Additional irrigation requirements can be sourced from rainwater or the installation of garden bores. It is acknowledged that there are risks associated with the aquifer which could result in poor groundwater quality and/or quantity (Department of Water, 2011). The prospective purchases will be made aware of the risks of installing a garden bore on the subject lot at the point of sales, where of the associated risks will be included as part of the special provisions within the annexures of the sales contract.

Public open space irrigation can be met through existing groundwater allocation license holders transferring part or all of their licensed entitlement to new water users within the same subarea in accordance with Operations policy 5.13 – Water Entitlement Transactions for Western Australia (Department of Water, 2010). Applications for transfer will be assessed by Department of Water and relevant policies shall be complied with. Should additional non potable water be necessary groundwater allocation license are available within the Serpentine Area and an application for their use will be provided in future stages if required.

5.4 Rainwater harvesting water balance

5.4.1 Assumptions

The rainwater harvesting water balance was conducted to provide an indication of a suitable tank size for a variety of household occupancy rates (from 1 resident to 6 residents) and a variety of total harvestable roof areas (450 m^2, 500 m^2 and 700 m^2). The average lot sizes were estimated from the lot density in the updated cadastre plan provided by the WAPC. The maximum roof area was estimated from the minimum required open space per lot based on the zoning R codes from the Residential Zoning Codes.

Data from the Perth Residential Water Use Study 2008/2009 (Water Corporation, 2010) was used to provide an estimation of total in-house water demands, including both potable and non-potable water demands. The Perth Residential Water Use Study estimated an average annual usage of 56 kL/person/year, which incorporates savings from using water efficient appliances

and fittings. The annual demand was averaged over the year to generate a daily water demand (153 L/person/day), and multiplied by hourly demand factors to account for typical fluctuations in water demand over the course of the day. The water balance does not include demand for ex-house water usage such as irrigation.

Six minute rainfall data from the Jandakot rainfall gauging station (station number 009172) sourced from the Bureau of Meteorology was used to generate an hourly rainfall time series used in the rainwater harvesting water balance. The water balance was conducted for a typical high rainfall year, average rainfall year and low rainfall year (Table 5) to estimate a range of suitable rainwater tank volumes required to safeguard against prolonged dry periods.

It was assumed that rainfall in excess of 1 mm was required to generate roof runoff. The hourly water balance was conducted for the calendar year for the typical low, average and high rainfall years, beginning on the 1 January and ending 31 December. To establish an initial water volume in the tank, the water balance was run for an additional 7 month initialisation period using the average hourly rainfall data from 1 June to 31 December. Evaporation losses from the rainwater tank were not included in the water balance.

A minimum tank volume of 109 kL (where 99 kL is available for in-house water usage) was used in the calculations, based on requirements from the Shire of Serpentine Jarrahdale. A maximum tank size of 180 kL (where 170 kL is available for in-house water usage) was used in the calculations.

The results of the water balance are summarised in Table 6 to Table 8. The results indicate that for all lots with less than four residents, a 109 kL tank is sufficient to provide in-house water. Lots with a total roof area of 450 m^2 and between four to five residents require a larger tank of between 125 to 170 kL, and where there are six or more residents, the rainwater tank may require top-up. Lots with a total roof area of 500 m^2, and between four to five residents require a larger tank of between 125 to 155 kL, and where there are six or more residents, the rainwater tank may require top-up. Lots with a total roof area of 700 m^2, and between four to six residents require a tank of between 150 to 180 kL, and results indicate that these lots will not require top-up during dry rainfall years.

Table 5 Annual rainfall from Jandakot rainfall gauge (009172) for high, average and low rainfall years

Scenarios	Annual rainfall (mm)
High rainfall year (2000)	967
Average rainfall year (2002)	750
Low rainfall year (2004)	597

Table 6 Rainwater tank calculations for total roof area of 450 m^2

Number of residents	Annual demand (kL)	Low rainfall year			Average rainfall year			High rainfall year		
		Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)
1	56	217	109	0	281	109	0	383	109	0
2	112	217	109	0	281	109	0	383	109	0
3	168	217	109	0	281	109	0	383	109	0
4	224	217	125	0	281	109	0	383	109	0

Number of residents	Annual demand (kL)	Low rainfall year			Average rainfall year			High rainfall year		
		Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)
5	280	217	170	0	281	145	0	383	109	0
6	336	217	180	57	281	180	31	383	130	0

Table 7 Rainwater tank calculations for total roof area of 500 m^2

Number of residents	Annual demand (kL)	Low rainfall year			Average rainfall year			High rainfall year		
		Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)
1	56	241	109	0	312	109	0	425	109	0
2	112	241	109	0	312	109	0	425	109	0
3	168	241	109	0	312	109	0	425	109	0
4	224	241	125	0	312	109	0	425	109	0
5	280	241	155	0	312	140	0	425	109	0
6	336	241	180	25	312	180	5	425	115	0

Table 8 Rainwater tank calculations for total roof area of 700 m^2

Number of residents	Annual demand (kL)	Low rainfall year			Average rainfall year			High rainfall year		
		Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)	Total runoff (kL)	Tank size (kL)	Top-up (kL)
1	56	337	109	0	437	109	0	596	109	0
2	112	337	109	0	437	109	0	596	109	0
3	168	337	109	0	437	109	0	596	109	0
4	224	337	120	0	437	109	0	596	109	0
5	280	337	150	0	437	135	0	596	109	0
6	336	337	180	0	437	160	0	596	109	0

5.5 Wastewater

For the proposed R5 lots equal to or greater than 2000 m^2 there is no requirement by the Department of Health or the local authority for a connection to a sewerage system (Appendix E). No new R10 lots (lots equal to or greater than 1000 m^2) are proposed. Currently no sewer system is proposed for the Serpentine area.

Therefore individual lots within the rural residential development will be serviced by on-site Aerobic Treatment Unit (ATU) effluent disposal systems with the condition that use of an ATU meets the requirements outlined in Sections 5.1 and 5.7 of WAPC's Statement of Planning Policy No 2.1 *The Peel-Harvey Coastal Plain Catchment* (1992), and Section 5.2.2 of the WAPC Government Sewerage Policy: *Perth Metropolitan Region* (1995).

The selection of an appropriate ATU for the individual lots is the responsibility of the landowner, and the unit must comply with the Department of Health Code of Practice for the Design, Manufacture, Installation and Operation of ATUs (Department of Health, 2001).

The selection of an appropriate ATU for the individual lots is the responsibility of the landowner, and the unit must comply with the Department of Health Code of Practice for the Design, Manufacture, Installation and Operation of ATUs (Department of Health, 2001) and all additional requirements imposed by the Shire of Serpentine-Jarrahdale.

It is the responsibility of individual landowners to ensure that the wastewater treatment system adopted maintains adequate clearance to groundwater of 1.2 m and complies with Shire of Serpentine-Jarrahdale requirements (refer to Section 7 for indication fill requirements for groundwater separation). The building and effluent disposal envelope will be setback from drains located adjacent to the property boundary and from roadside table drains/swales to ensure sufficient horizontal separation. Shire of Serpentine-Jarrahdale requires effluent disposal areas to be defined early in the subdivision process for approval.

Effluent from ATU's is able to be disposed of via irrigation areas. Disposal to surface irrigation is not considered for a suitable option for this rural residential development due to high groundwater levels and other risks associated with surface disposal (public health risks, risk of runoff, risk of surface ponding, and disinfection).

Effluent will be disposed of via sub-surface irrigation (eg closely spaced and pressurised subsurface dripper pipework installed at a depth of 100 mm below the ground level) of a vegetated or landscaped disposal area. The sub-surface irrigation disposal area will be required to comply with setback requirements for buildings and other infrastructure.

The following measures are required to manage the risk nutrient runoff into the drains:

- Subsurface irrigation (closely spaced and pressurised subsurface dripper pipework installed at a depth of 100 mm below the ground level) is required to dispose of the effluent over a vegetated or landscaped disposal area;
- Construction of an irrigation disposal area with a minimum area of 150 m^2 which includes a layer of imported fill incorporating material that reduces phosphorus export (e.g. Spearwood Sands or a suitable clay mix);
- The irrigation pad requires a minimum 1.2 m of fill to provide sufficient vertical separation from the groundwater; and
- The irrigation disposal area is required to be located with a minimum separation distance of 30 m from the drainage network to increase the travel time and natural attenuation of nutrients prior to reaching the drains.

The following building pad criteria for each lot are required to ensure adequate clearance from groundwater levels:

- Aerobic Treatment Units: require a minimum 0.45 m separation to groundwater from the base of the tank;
- Alternative Treatment Units: require a minimum 0.6 m from the base of the unit to maximum groundwater levels.

It is the responsibility of the individual landowner and/or developer to receive approval from appropriate regulatory agencies to install an appropriate ATU system and ensure that quarterly servicing of the system is conducted by a contactor approved by the Department of Health.

6. Stormwater management strategy

6.1 Floodplain management

Recommendations for floodplain management are presented in the Serpentine River Floodplain management strategy (SKM, 2010). This study developed two-dimensional modelling of the Serpentine River catchment and resulted in the identification of floodway and flood fringe areas. The proposed Floodplain management plan (SKM, 2010) includes structural and non-structural measures for flood mitigation focused on managing potential flooding impacts on the site and to the immediate neighbouring land and drainage infrastructure.

6.1.1 Flood mitigation measures

Flood mitigation measures are focused on correct planning for appropriate land use in the structure plan areas and setting aside the land required for floodplain inundation depths. Existing and developed scenarios were presented within the Floodplain management strategy (SKM, 2010). The 'developed' case includes raised ground levels within subdivisions but no other modifications, such as waterway realignments or new or modified road crossings.

Planning measures recommended by the Flood plain management strategy (SKM, 2010) are:

- New dwellings in proposed and existing residential areas must have their floor levels elevated 500 mm above the 100 year annual recurrence interval flood level.
- New industrial or commercial premises should have their floor levels elevated 500 mm above the 100 year annual recurrence interval flood level.
- Major arterial roads with immunity to the 100-year annual recurrence interval flood level that access new residential areas and can provide egress to emergency services must be identified. Other residential streets should be designed to be serviceable up to the five-year annual recurrence interval flood event.

6.2 Pre development

The Serpentine area is known to experience regular water logging in the low-lying areas to the west of the study area. This inundation is due to a combination of persistent winter rainfall elevating the shallow water table, which rises to the surface and inundates vast areas of the flat terrain, and poor drainage.

Hardey's Creek Main Drain runs south to north draining the adjacent agricultural and residential lots via 2 x 1200 mm culverts under Arnold Road. The drain also receives stormwater from the existing urban developed south of Tranby Avenue through an existing Water Corporation storage basin and overflow via a 1200 mm diameter culvert under Arnold Road. The combined flow runs through an unlined trapezoidal channel to Karnup Road where a series of 2 x 1200 mm culverts and 2 x 1500 mm culverts outlets to the Serpentine River.

The proposed subdivision was divided into 15 catchments, with delineation primarily based on the grades of the natural surface and existing drains with key flow rates identified in Table 9. Stormwater modelling confirmed the extensive flooding and water logging the south eastern portion of the proposed development.

Table 9 Predevelopment flow rates

Location	5 Year Predevelopment Flow (m^3/s)	100 Year Predevelopment Flow (m^3/s)
Arnold Road Basin	6.00	11.68
Hardey's Creek Main Drain at Karnup Rd	8.17	17.90

6.3 Stormwater quantity

6.3.1 Proposed Stormwater Management Strategy

The drainage layout proposed in this LWMS refines the existing drainage in line with:

- The aspirations of the Serpentine Jarrahdale Shire for open drainage only;
- The proposed urban design concept for an integrated and rural feeling development; and
- Flood protection.

This resulted in the following key components:

- Modification of the western section of Hardey's Creek Main Drain from Arnold Road to Rudall Street to enable conveyance of major flood flows through the study area in a linear public open space type corridor with the following benefits:
  - No major drainage line along Arnold Road
  - Useable public open space within the study area serving a flood protection function during major events

  The Shire of Serpentine-Jarrahdale has indicated their support for the proposed modification to Hardey's Creek Main Drain (Appendix F).
- Relocation of the existing retention basin from the rear of Finch Mews and Blue Wren Court as requested by Shire of Serpentine-Jarrahdale. The storage of this basin has been included in the future basins following development.
- Construction of three new retention basins (Figure 10) in order to service much of the remaining proposed development and ensure pre-development peak flows into Hardey's Creek Main Drain are maintained.

Based on the above reasoning the proposed stormwater management strategy employs the following measures for the following events:

1 year ARI event

- Roofs will be connected to soakwells or rainwater tanks.
- Road runoff will be infiltrated as close to source as practical using water sensitive urban design (WSUD) measures such as infiltration devices such as bioretention basins/swales, soakwells and Atlantis cells.

5 year ARI event

- Will be collected and conveyed swales. The swales will discharge directly to the Hardey's Creek Main Drain or will discharge to dry, shallow detention basins.
- Where swales and drains discharge to waterways and basins, the banks of the waterway or basin will be stabilised to prevent scouring.

100 year ARI event

- Events greater than the 5-year ARI event will be conveyed away from the development along roads and POS, discharging to Hardey's Creek Main Drain or Serpentine River. Basins have been sized to compensate major events up to the 100-year ARI event to the pre-development flow.
- Lots will be set a minimum of 0.5 m above 100 year ARI flood level

6.3.2 Stormwater rates and volumes

Urbanisation results in an increased impervious area. Increased rates and volumes of stormwater runoff must be managed to protect infrastructure and assets from flooding and inundation, while water quantity and quality must be managed to protect wetlands and waterways from risk of increased inundation and contaminant loads. Surface water management must ensure that urban development does not increase the peak flows discharging to receiving environments.

The 5 and 100 year storage volumes and flow rates required for each of the basins are presented in Table 10. The indicative locations and surface areas of basins are shown in Figure 10. The detention storages should be located outside of the floodway, unless in the case of 2Basin which is online storage and landscaped into the surrounding public open space. Basins should be designed with a maximum water depth in a 100 year ARI event of 1.5 m with side slopes between 1:6 and 1:8. Indicative basin levels are provided in Table 11.

It is important to note the requirement to retain/detain the 1 year 1 hour ARI event and provide bio retention areas equivalent to 2% of the connected impervious area. Indicative storage volumes are provided below in Table 11.

Table 10 Basin Peak Flow Rates and Volumes

Location	5 year Flow (m^3/s)	100 Year Flow (m^3/s)	1 year Bio retention Volume (m^3)	5 Year Volume (m^3)	100 Year Volume (m^3)	Estimated 5 Year Area (m^2)	Estimated 100 Year Area (m^2)
1Basin	0.45	0.87	150	950	2200	950	2500
2Basin	8.00	17.20	900	7700	39800	8750	23600
3Basin	0.40	0.85	50	250	550	250	630

Table 11 Basin Levels and Bio retention Requirements

Location	Basin invert (m AHD)	Depth to Groundwater (m)	Top of Basin (m AHD)	5 Year Level (m AHD)	100 Year Level (m AHD)
1Basin	29.00	0.3	30.00	29.30	29.68
2Basin	28.50	0.0	30.10	29.55	30.01
3Basin	30.39	0.3	31.39	30.69	30.97

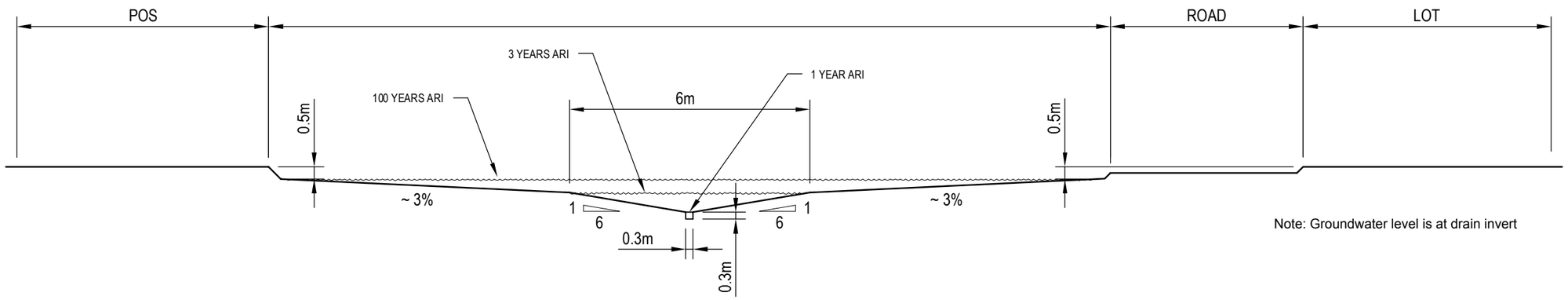
As described in Section 2.1.2 and shown in Figure 10 it is proposed to co-locate POS areas with drainage. Approximately 17.8 ha of the site is identified as POS with 15 ha being unrestricted POS. A total of 1.732 ha of the POS identified will be restricted POS to be used for drainage. Basins are designed to drain within 3 days of a major storm event to limited POS inundation time.

Downstream discharge flow rates from the development area follow and (incorporating upstream flows) do not exceed pre-development peak flow rates at Hardey's Creek Main Drain as shown in Table 12.

Table 12 Pre and Post Development Flow Rates

Location	5 Year Predevelopment Flow (m^3/s)	5 Year Post development Flow (m^3/s)	100 Year Predevelopment Flow (m^3/s)	100 Year Post Development Flow (m^3/s)
Hardey's Creek Main Drain at Karnup Rd	8.17	7.80	17.90	17.40

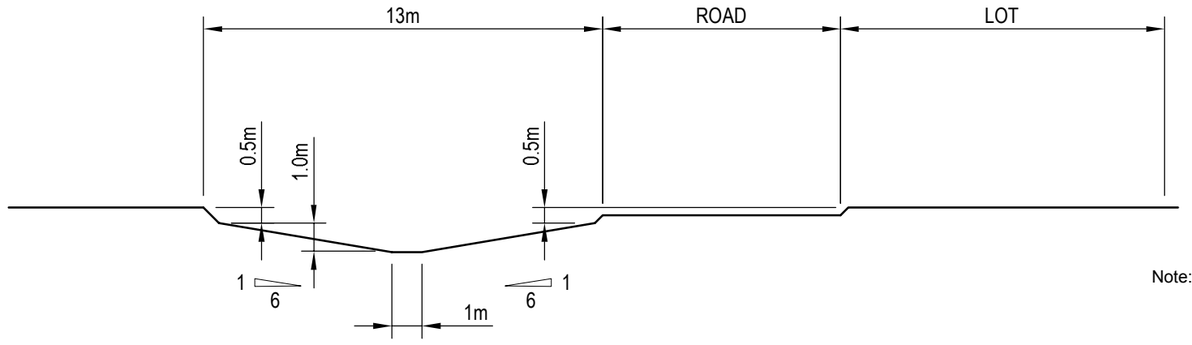
Hardey's Creek Main Drain is proposed to be a 1 m deep with 13 m top width and 1:6 sides (5 year ARI event flow depth would approximately equal 350 mm) living stream incorporated into the POS.



Note: Groundwater level is at drain invert

HARDY'S CREEK MAIN DRAIN (MULTIPLE USE CORRIDOR)

NTS



Note: Groundwater level is at swale invert

MINOR SWALE THROUGH ROAD RESERVE

NTS

0 2m 4m 6m

SCALE 1:200 AT ORINIGAL SIZE

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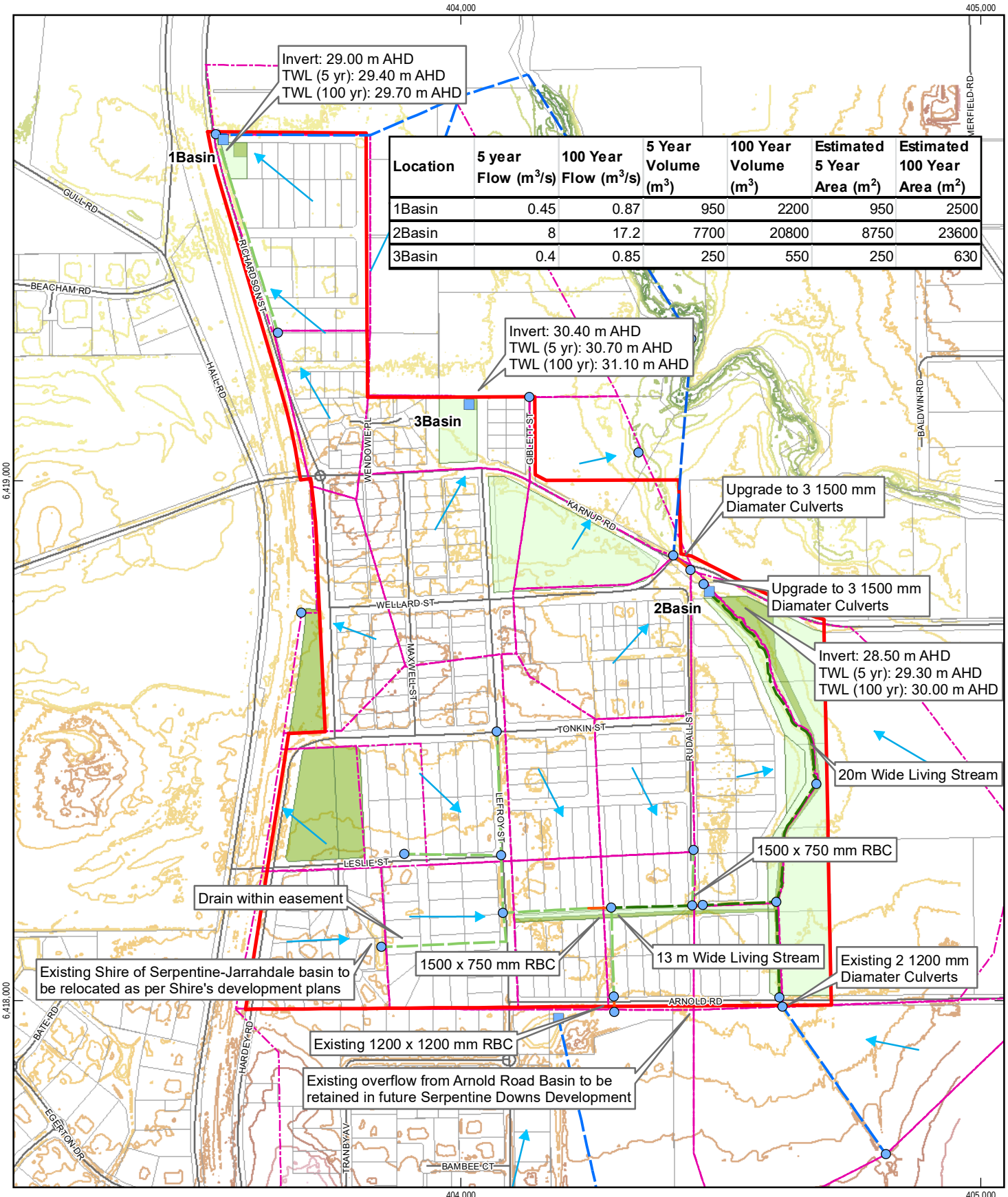
DEPARTMENT OF PLANNING
SERPENTINE OUTLINE PLAN LWMS
SWALE CROSS SECTION

job no. 6128174
rev no. A

scale 1:200 for A3 date DEC 2012

Figure 9

GHD HOUSE 239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.



Location	5 year Flow (m^3/s)	100 Year Flow (m^3/s)	5 Year Volume (m^3)	100 Year Volume (m^3)	Estimated 5 Year Area (m^2)	Estimated 100 Year Area (m^2)
1Basin	0.45	0.87	950	2200	950	2500
2Basin	8	17.2	7700	20800	8750	23600
3Basin	0.4	0.85	250	550	250	630

LEGEND

- Node
- Storage
- Culverts
- Drain
- Living Stream
- River
- Bioretention swale
- Catchment Flow Direction
- Study Area
- Catchments
- Cadastre
- Roads

POS

- Restricted (bioinfiltration pocket)
- Unrestricted

1: 10,000 (at A4)

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

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Department of Planning
Serpentine Outline Plan LWMS

Job Number 61-28174
Revision 0
Date 19 Feb 2013

Stormwater Management Strategy Figure 10

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G:\61\28174\GIS\Maps\MXD\6128174_G006_Fig8_RevD.mxd

Data source: DoP: Serpentine Aerial - 20120517, New Cadastre - 20120517, Bush Forever Sites - 20120510; DEC: Geomorphic Wetlands - 20120510, Environmentally Sensitive Areas - 20120510; DIA: Aboriginal Heritage Sites - 20120510; GHD: Study Area - 20120510. Created by: bflorczak

6.4 Fill requirements

100 year ARI flood event modelling results are presented in longitudinal sections in Appendix E. Fill requirements adjacent to modelled waterways are estimated not to exceed 1.5 m.

No on site groundwater monitoring or investigations have been undertaken so it is not possible to accurately determine the amount of fill required as a result of groundwater levels at this stage. Fill requirements away from the waterways must be determined in conjunction with appropriate earthworks designs to achieve satisfactory surface and subsurface drainage grades and block levels appropriate to the nature and size of developed lots and may vary substantially from this estimate. Refer Section 7.2 for groundwater level management.

6.5 Stormwater quality

To address stormwater and flood management, the principles of the minor/major system of drainage will be employed. The minor drainage system accommodates the low frequency ARI event, typically less than 5 year ARI events. The major drainage system is a system of swales, kerbs and roads to attenuate and infiltrate peak surface water flows.

It is proposed to adopt Water Sensitive Urban Design (WSUD) and Best Management Practices (BMPs) promoting retention, infiltration and treatment of events up to the 1-year ARI events, in accordance with the *Stormwater Management Manual for Western Australia* (DoW, 2004-2007).

Where development is associated with an ecosystem that is dependent on a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of DEC.

Where development is associated with any new or existing waterway or open drain that intersects the shallow water table, and that may discharge pollutants from the shallow groundwater to receiving environments, the following interim nutrient reduction targets will be adopted until such time as appropriate site-specific targets are developed.

- As compared with a development that does not actively manage water quality, the following should be achieved:
    - at least 60 per cent reduction of total phosphorous
    - at least 45 per cent reduction of total nitrogen

The phosphorous reduction target was adopted from *Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System – Phosphorus Management* (EPA 2008). It is anticipated that the site-specific nutrient reduction targets will be developed after one year of monitoring which will allow for a preliminary understanding of baseline conditions. The site-specific nutrient reduction targets will inform future UWMPs and will be adopted prior to any development activities.

Engineering drawings submitted to Council for approval must be supported by clear and auditable documentation, providing details of proposed staging and implementation of the surface and groundwater quantity and quality management strategy.

It is strongly recommended that developers meet with the Shire to discuss proposed surface and groundwater management strategies and to gain further guidance on site-specific requirements of the local authority at commencement of any urban water management plan.

6.5.1 Structural measures

The choice of structural treatment measures varies across the study area to suit streetscape and POS landscapes.

The proposed drainage plans uses multiple soak wells, Atlantis cells and basins to infiltrate the 1 year 1 hour ARI. The process of infiltration effectively filters the stormwater and is effective in the removal of particulate nutrients. To increase the potential of the infiltration device treatment media, such as Laterite is to be employed.

A bioretention system, which represents 2% of the total impervious area, will result in performance at the maximum possible reductions. The key WSUD elements to be incorporated into the design of subdivisions within the study area are:

- Biofiltration pockets: Wherever practical, these small biofiltration and infiltration systems will be incorporated into non-frontage verges (where they will not obstruct driveway crossovers) and road nibs.
- Vegetated median swales: Wherever practical, biofiltration and infiltration systems in the form of vegetated swales will be incorporated into median strips.

6.5.2 Non structural measures

Non-structural measures to control and reduce discharge of contaminants to the groundwater are based on source control of stormwater. Non-structural source control can include:

- Actions that aim to change behaviour such as public awareness campaigns and community education;
- Strata management operations and maintenance activities such as street sweeping, waste management, landscape maintenance and fertiliser use;
- Land use and management measures, such as sediment and erosion control during construction and permeable pavements;
- Develop landscaping guidelines for the proposed development area that recommend the use of appropriate native species in landscaping and provide advice on the responsible use of fertilisers and herbicides;
- Provide an effective waste-management plan for the area to ensure that litter and other waste does not collect in the drainage systems, including street sweeping; and
- Require all development construction projects, including road and infrastructure construction, to implement sediment and erosion control measures.
- Non-structural measures have been shown to be cost-effective long-term methods of improving water quality and reducing contamination.

6.6 Best Management Practices

Table 13 outlines the best management practices for maintaining a high level of surface water quality.

Table 13 Best management practices for surface water quality

Best management practices	Definition of recommended action
Residential	Use low water soluble fertiliser applied to sandy textured soils, applied

fertiliser	sparingly to gardens and turf.
	Minimise lawn areas or plant an alternative lawn.
	Fertilise only when symptoms of nutrient deficiency occur eg. Yellowing.
	Use a complete lawn fertiliser containing nitrogen, phosphorus and potassium, if fertiliser is required.
	Apply fertiliser at the maximum individual application rate, that is 25 g/m2 for couch and 12 g/m2 for kikuyu and buffalo grass.
	If fertiliser is required apply in spring or early autumn (Sept, Oct, Nov, Mar and Apr).
	Do not fertilise during summer or winter months.
	Do not over-water.
Soil remediation	Ensure all new urban developments in areas with sandy soils undergo soil remediation at the estate scale.
	At the lot scale blend or apply a layer of higher PRI soil 0-50 cm beneath the finished ground level to provide increased phosphorus retention.
	Use soil amendment materials such as yellow Spearwood sands, Karrakatta soils or brown loams.
	Remediate soil in accordance with Peel-Harvey coastal catchment water-sensitive urban design technical guidelines.
	Take care to maintain soil permeability.
Water and nutrient sensitive principles	Decision-making authorities should take a lead planning role in incorporating best management practices including water-sensitive urban design principles, criteria and outcomes in its strategic land use planning, policies structure plans and subdivision conditions.
Water-sensitive urban design	Compliancey with environmental quality criteria should be incorporated in local planning policy
	Ensure design complies with stormwater management policies
	Apply water-sensitive urban design treatment trains
	Prepare water management strategies
	Undertake soil amendment.
	Ensure total phosphorus and total nitrogen import and export criteria are met.
	Meet the minimum percentage area of deep-rooted perennial vegetation
	Impose building and landscaping covenants
	Ensure sound construction and building site management.

Drainage reform	Modify drainage management practices to reduce in-channel sediment movement as opportunities arise.
	Manage drainage as part of the total water cycle with the dual objectives of optimising stormwater runoff and reducing nutrient flows into the rivers and streams.

To ensure that WSUD features perform well, look attractive, require low maintenance, and to extend their design life, it is important to choose appropriate plant species for the construction of the WSUD feature. The choice of plant species for use is a function of:

- Size of WSUD feature;
- Location of WSUD feature in relation to roads and public open space;
- Prevailing soils and climate;
- Ability of the plant to absorb nutrients;
- Ability of the plant to meet hydraulic requirements;
- Ability of the plant to undergo periodic inundation, if required;
- Water/ irrigation demand of plant and ability to withstand drought;
- Prevailing salinity;
- Local representation of plant species;
- Root structure and behaviour;
- Plant size; and
- Visual appeal of plant.

Based on the above criteria Table 14 and Table 15, list the recommended species for use in the proposed WSUD features. Shire of Serpentine-Jarrahdale has provided a plant selection list based on accepted plant species for use in the Serpentine area. Refer to Appendix H for further details.

Table 14 Recommended plant species for infiltration/detention basins

Botanical Name		Common Name	Approved
Melaleuca	preissiana	Stout paperbark	Yes
Melaleuca	rhaphiophylla	Freshwater paperbark	Yes
Melaleuca	cuticularis	Saltwater paperbark	
Melaleuca	lateritia	Robin redbreast bush	
Banksia	littoralis	Swamp banksia	
Banksia	seminuda	River banksia	
Carex	appressa	Tall sedge	Yes
Carex	fascicularis	Tassel sedge	Yes

Carex	inversa	Knob sedge	
Dianella	caerulea	King Alfred	
Dianela	revoluta	Little Rev	
Lomandra	histrix	Tropic Belle	
Lomandra	longifolia	Lomandra	
Juncus	caespiticius	Grassy rush	
Juncus	holoschoenus	Jointleaf rush	
Juncus	kraussii	Sea rush	Yes
Juncus	pallidus	Pale rush	Yes
Juncus	pauciflorus	Loose flower rush	Yes
Juncus	subsecundus	Finger rush	Yes
Goodenia	pulchella	subsp. Coastal Plain	
Eucalyptus	occidentalis	Flat-topped-yate	Yes
Eucalyptus	rudis	Flooded gum	
Casuarina	cunninghamiana	Casuarina	
Ficinia	nodosa	Knotted club rush	Yes
Lepidosperma	gladiatum	Coastal sword-sedge	Yes

Table 15 Recommended plant species for bioretention swales/biofiltration pockets

Botanical Name		Common Name	Approved
Carex	appressa	Tall sedge	
Carex	appressa	Tassel sedge	
Carex	inversa	Knob sedge	
Juncus	caespiticius	Grassy rush	Yes
Juncus	holoschoenus	Jointleaf rush	Yes
Juncus	kraussii	Sea rush	Yes
Juncus	pallidus	Pale rush	Yes
Juncus	pauciflorus	Loose flower rush	
Juncus	subsecundus	Finger rush	
Ficinia	nodosa	Knotted club rush	Yes

Dianella	caerulea	King Alfred	Yes
Dianela	revoluta	Little Rev	
Lomandra	histrix	Tropic Belle	
Lomandra	longifolia	Lomandra	
Lepidosperma	gladiatum	Coastal sword-sedge	

6.7 Disease Vector Management

The drainage network has been designed to ensure that detained immobilised stormwater is fully infiltrated or conveyed within a 96 hour time period between the months of November and May, in compliance with the Shire of Serpentine-Jarrahdale's design criteria for Urban Water Management (Shire Serpentine-Jarrahdale, 2011).

Additionally, regular inspections and maintenance of the bioretention swales is recommended to control weed growth and minimise silt build-up to prevent clogging and reduce ponding after each storm event.

7. Groundwater management strategy

7.1 Glossary of terms

Controlled groundwater level

Controlled groundwater level (CGL) is a groundwater level endorsed by DoW and is the depth at which subsoil drains are installed. In the absence of groundwater monitoring, the GCL should be placed at the maximum groundwater level (MGL) which has been defined as being at the surface level. Sub-surface drainage may not be installed below the controlled groundwater level.

Maximum groundwater level

Maximum groundwater level is a groundwater level endorsed by the DoW. The actual level selected will vary according to availability of data and/or modelling results, but is commonly the maximum recorded groundwater level for a high rainfall condition. In the absence of data this level is assumed at groundwater level.

Developments will be required to make the development surface level 1.2 m above the maximum groundwater level, if subsurface drainage is not installed and meet all requirements for ATU separation.

Phreatic line

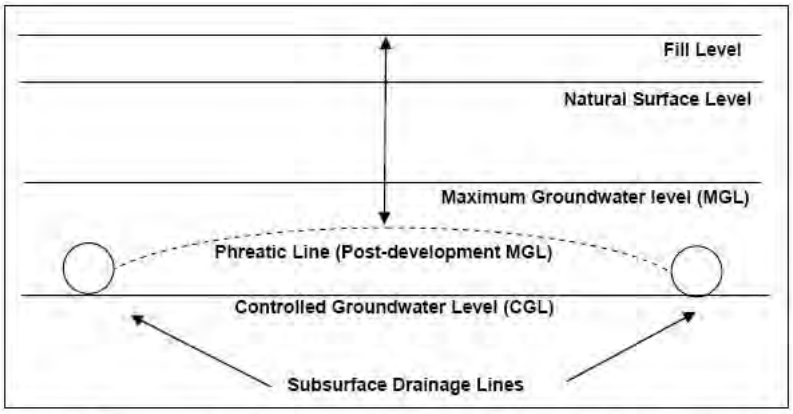
The phreatic line is the modified (post development) maximum groundwater level following the installation of subsurface drainage and is in fact an arc in between subsurface drainage lines, as indicated in Figure 11

When subsurface drainage is installed the phreatic line becomes the level from which building floor level clearance to groundwater is measured termed Design Groundwater Level (DGL).

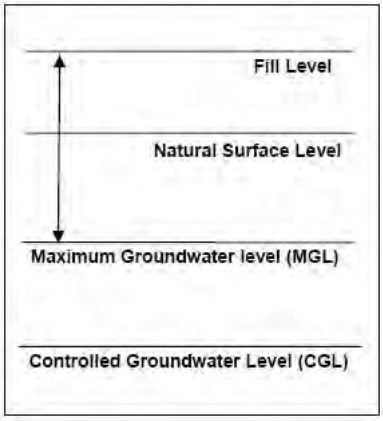
7.2 Groundwater Levels

The building finished floor levels and effluent disposal areas (reticulation pad) within each individual lot must maintain at least 1.2 m clearance from the MGL through the importation of clean fill, in compliance with the Shire's building requirements. This meets the requirements of groundwater clearance of more than 0.45 m and 0.6 m for the ATU systems. Imported fill is to incorporate a band of material that will reduce phosphorus export via leaching (e.g. Spearwood Sands), while meeting soil permeability and compaction criteria required by the Shire of Serpentine-Jarrahdale.

Examples of different ways in which the groundwater clearance and subsurface drainage criteria may be met under different conditions are presented below in Figure 11. Case 1: The natural surface is less than 1.2 m above maximum groundwater level. Subsurface drainage is installed at controlled groundwater level to control the maximum groundwater level. However, because the natural surface is less than 1.2 m above the resultant phreatic line, some additional fill has also been provided to meet the minimum clearance requirement.



Case 2: The natural surface is less than 1.2 m above maximum groundwater level. Fill is provided to meet the minimum clearance requirement.



Case 3: The natural surface is greater than 1.2 m above maximum groundwater level. No fill or subsurface drainage is required to meet the minimum clearance requirement.

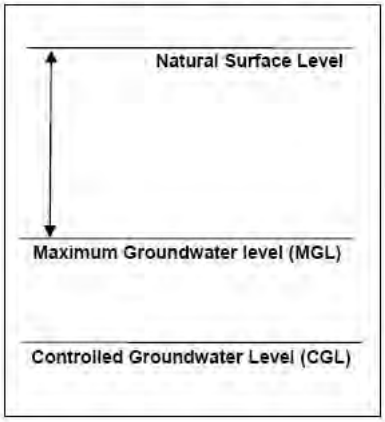


Figure 11 Meeting the groundwater clearance and subsurface drainage criteria.

To protect housing from flooding and damage from groundwater, the predicted maximum groundwater level must be determined, through modelling and/or measurement. As this information is not currently available, local studies shall be undertaken and endorsed by the DoW. Where the predicted maximum groundwater level is at or within 1.2 m of the surface the importation of clean fill and/or the provision of sub surface drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub surface drainage will need to be placed at a DoW approved controlled groundwater level.

Further investigations will be required in the next stage of planning to determine local scale predicted maximum groundwater level for individual developments to determine whether subsurface drainage is required for protection of urban infrastructure.

Where a perched water table exists or the predicted maximum groundwater level is at or within 1.2 m of the natural ground level, the importation of clean fill and the provision of subsurface drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub surface drainage will need to be placed at or above the approved controlled groundwater level. The design of proposed subsurface drainage systems should determine the resulting phreatic line (or the line marking the upper surface of the zone of saturation in the soil) termed the Design Groundwater Level in between drainage lines and finished lot levels should be a minimum of 0.8 m above.

Any clean fill imported onto the site is to incorporate a band of material that will reduce phosphorus export via soil leaching, whilst also meeting soil permeability and soil compaction criteria specified by the local government authority. The bio-retention system and drainage inverts are set at or above controlled groundwater level although existing inverts below the level may remain. Sub surface drainage is to be installed at or above controlled groundwater level and must be designed with free-draining outlets.

Figure 12 illustrates those areas that will require subsoil drainage/fill to meet the required separation. Subsoil drains will be required to discharge to Hardey's Creek Main Drain above base flow water depth in order to ensure that subsoil outlets are free draining.

7.3 Groundwater Quality

The environmental values of groundwater within, and surrounding, the study area must be upheld.

To ensure that the existing groundwater quality is maintained, the quality of the stormwater infiltration to groundwater will be maximised through:

- Adopting a treatment train approach to runoff, through the use of WSUD and BMPs such as permeable pavements, buffer strips, bioretention swales, rain gardens, biofiltration pockets, median swales, gross pollutant traps, and infiltration basins;
- Xeriscaping to avoid the use of fertilisers;
- Recommending a maintenance plan for the upkeep of the treatment train; and
- Recommending a monitoring program is implemented during construction and post development to ensure that the management measures for stormwater quality are meeting the design objectives.

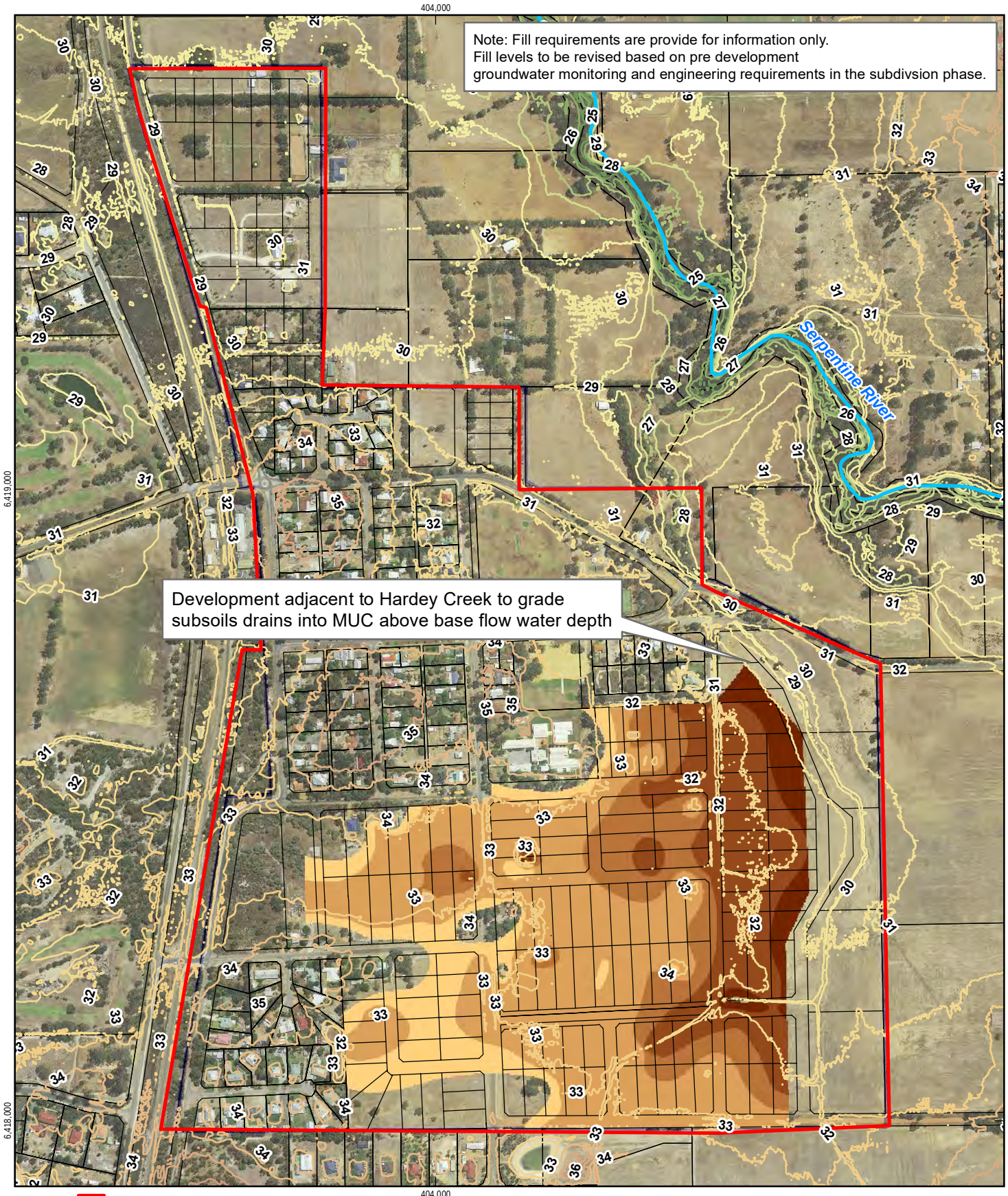
Where development is associated with an ecosystem that is dependent on a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of DEC.

Where development is associated with any new or existing waterway or open drain that intersects the shallow water table, and that may discharge pollutants from the shallow groundwater to receiving environments, the following interim targets will be adopted until such time as appropriate site-specific targets are developed.

- As compared with a development that does not actively manage water quality, the following should be achieved:
  - at least 60 per cent reduction of total phosphorous
  - at least 45 per cent reduction of total nitrogen

Engineering drawings submitted to council for approval must be supported by clear and auditable documentation, providing details of proposed staging and implementation of the surface and groundwater quantity and quality management strategy.

It is strongly recommended that developers meet with the Shire to discuss proposed surface and groundwater management strategies and to gain further guidance on site-specific requirements of the Shire at commencement of any urban water management plan.



LEGEND

Study Area
Cadastre

Approxminate Fill Height (based on MGL at surface)

Greater than 1.5 m
1.0 - 1.5 m
0.5 - 1.0 m
0.2 - 0.5 m
Less than 0.2 m

LIDAR Contour 1m

25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

1: 8,224 (at A4)

0 30 60 120 180 240 300
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

GHD
CLIENTS | PEOPLE | PERFORMANCE

Government of Western Australia, Department of Planning

SLIP ENABLER

Department of Planning
Serpentine Outline Plan LWMS

Indicative Fill Requirements

Job Number	61-28174
Revision	0
Date	19 Feb 2013

Figure 12

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

G:\61\28174\GIS\Maps\MXD\6128174_G008_Fig12_Rev0.mxd

Data source: Water Corporation: Open Drains - 20120510; DoW: Rivers - 20120510, 100 year ARI Floodway and Flood Fringe Areas - 20120521; DoP: Serpentine Aerial - 20120517, Cadastre - 20120517, Contour 1m - 20120517; GHD: Study Area - 20120510. Created by: bflorczak

8. Monitoring

8.1 Predevelopment monitoring

The limited number of existing groundwater bores within the study area has led to an absence of pre-existing groundwater quantity/quality data. Therefore a pre-development monitoring program should be implemented to establish a baseline data set to inform the UWMP. Pre-development groundwater monitoring will commence at minimum eighteen (18) months before site works begin and continue through construction. Table 16 presents the recommended pre-development monitoring program for surface and groundwater quality and quantity for a minimum of 18 months or as indicated by the Department of Water.

Table 16 Recommended pre-development monitoring program

	Site	Frequency	Parameter
Surface Water	As indicated by the Regional Water Quality Monitoring Program by Shire of Serpentine Jarrahdale.	Monthly grab samples	◗ **Physical Properties** (pH, EC and temperature, DO, turbidity). ◗ **Nutrients** (TN, FRP, TKN, ammonia, TP, TOC, DOC) ◗ **TSS**
		Tri-annually	◗ TRH, PAH, BTEX, hardness as $CaCO_3$ and total metals (Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se, Zn)
Groundwater	Network of monitoring bores providing a suitable spatial representation of the study area.	Monthly, to be reviewed after the first year of monitoring.	◗ **In-situ** pH, EC and temperature. ◗ **Unfiltered sample**: pH, EC, TN, FRP, TKN, ammonia, TP ◗ **Filtered sample**: nitrate/nitrite and PO_4 ◗ Water level (max and min levels)

As there are multiple land owners within the study area, it is also recommended that the monitoring program should be a collaborative effort between all land owners. The advantages of such an approach include:

- Consistency in data collection, analysing and interpretation;
- Resource sharing; and
- Allows for the establishment of a communication network between land owners.

8.2 Recommended post-development monitoring program

In addition to the monitoring outlined in Table 16, the following is the recommended post-development monitoring program.

To assess the impacts of the development on water quality within the development area, surface water samples will be collected monthly during the winter (June, July and August if the drain is flowing) at locations to be specified in the UWMP. Groundwater levels will be measured and recorded monthly, with samples collected quarterly for laboratory analysis in the months of January, April, July and October from a network of monitoring bores providing a suitable spatial

representation of the study area. Samples will be analysed for the following water quality parameters:

- Water flows and level;
- In-situ pH, Electrical Conductivity (EC) and Temperature;
- Total Suspended Solids (TSS);
- Total Nitrogen (TN) and Total Kjeldahl Nitrogen (TKN);
- Ammonia (NH_4);
- Nitrate and Nitrite (NO_x);
- Total phosphorus (TP); and
- Orthophosphate (PO_4^{3-}).

The following additional parameters are recommended in locations where drainage intercepts shallow groundwater systems:

- Total titratable acidity and total alkalinity;
- Major anions (chloride, bromide and sulphate);
- Major cations (calcium, magnesium, sodium and potassium); and
- Iron and aluminum.

A summary of an example of a surface water and groundwater monitoring program is presented in Table 17 below. Three years of post-development monitoring shall be carried out.

Table 17 Monitoring programme summary

	Sites	Frequency	Parameters
Surface water	Developments inflow and outflow locations Detention storages inflow and outflow Water bodies	Site specific	Water levels
		Monthly during the winter (June, July and August if the drain is flowing)	In-situ pH, EC and temperature. Unfiltered sample: pH, EC, TN, FRP, TKN, ammonia, TP Filtered sample: nitrate/nitrite and PO4,
Groundwater	Network of monitoring bores providing a suitable spatial representation of the study area.	Monthly	Water level
		Quarterly (typically Jan, Apr, July, Oct)	In-situ pH, EC and temperature. Unfiltered sample: pH, EC, TN, FRP, TKN, ammonia, TP Filtered sample: nitrate/nitrite and PO4

8.3 Reporting

The Developer will prepare an annual water quality report for each year of monitoring, which will be presented to the Shire and DoW. This report will summarise the results from the years sampling, groundwater levels in areas where subsoil drainage has not been installed, and include a qualitative review of the performance of the drainage and water management system.

Reporting and Monitoring shall be in accordance with ANZECC and the DoW QA/QC systems to allow inclusion into DoW's WIN database.

8.4 Contingency Action Plan

A site specific contingency action plan with associated trigger values must be developed. As a minimum the contingency action plan must include communication with the land owners, DoW and the Shire of Serpentine-Jarrahdale as a priority action when trigger values are breached.

When developing trigger values for water quality, ANZECC recommends that a minimum of 24 months data be available. As there has been no pre-development monitoring undertaken at the time of preparing the LWMS, trigger values cannot be calculated as per the ANZECC guidelines (80^{th} percentile for moderate level of protection and 95^{th} percentile for high level of protection). As such, interim guidelines for trigger values have been developed based on the ANZECC guidelines presented in Table 18.

It is anticipated that the site-specific targets will be developed after two years of pre-development monitoring. The site-specific targets will be reported in future UWMPs and will be adopted prior to any development activities.

Table 18 Trigger Values

Analyte	Units	ANZECC Guideline
Nutrients		Freshwater
Chlorophyll a	ug/L	3-5
Filterable reactive phosphate	ug/L	5
Total Nitrogen*	ug/L	350
Total Phosphorus	ug/L	10
Oxides of nitrogen	ug/L	10
Ammonium	ug/L	10
Total Kjeldahl nitrogen		-
Other		
Electrical conductivity (EC) [a]	uS/cm	300-1500
Turbidity b	NTU	10-100
Dissolved oxygen	% saturation	90 (lower limit)
pH	-	6.5-8.0
Total suspended solids		-

a: Lower EC values are typically associated with rainfall events. During summer, higher values are common due to water being lost to evaporation.
b: Deep water bodies typically are low in turbidity. Shallow water bodies generally have a higher turbidity due to wind induced mixing of sediments.

Should the trigger levels be exceeded in two consecutive monitoring events it is proposed that a meeting be held between the developers, land owners, DoW, DEC, the Shire and the Peel Harvey Catchment Council and other relevant parties to discuss likely causes (based on the constituent profile) and appropriate ways forward, as presented in Table 19.

Table 19 Contingency Action Matrix

Suspected Cause	Possible Solutions	Responsible Party for Implementing Contingency Action Plan
Over use of fertiliser	Community engagement on appropriate use of fertiliser	Developer /Shire
Animal waste from stables	Community engagement on appropriate disposal of animal waste	Shire
Sedimentation from construction erosion	Control of erosion by contractors	Developer/Land Owner
Green waste	Community engagement on the appropriate collection and disposal of green waste; Implement street sweeping	Shire
Spills	Referral to EPA	Developer/Land owner
Failure of WSUD devices	Repair and/or maintenance of WSUD devices	Developer /Shire
Other	As appropriate	As appropriate

9. Implementation plan

9.1 Developer commitments

The next stage for water management is to be subdivision approvals supported by an UWMP. The UWMP is to be prepared to be consistent with the designs and strategies proposed in this LWMS. The UWMP should address:

- Detail to the design proposed in the LWMS and compliance with the objectives;
- Detailed stormwater management design;
- Geotechnical considerations such as infiltration rates, as informed by a geotechnical assessment; and
- Specific structural and non-structural methods to be implemented.

The developer is committed to the roles detailed in the report and outlined in Table 20.

9.2 Roles and responsibilities

Table 20 outlines the roles and responsibilities for the actions recommended in this LWMS for the development area.

Table 20 Roles and responsibilities

Role	Responsibility	Requirement
UWMP	Developer	An approved Urban Water Management Plan at subdivision application.
Design and Construction of Drainage System	Developer	Hand over to Shire of Serpentine – Jarrahdale at Practical Completion.
Geotechnical investigation	Developer	To be completed prior to final detailed design of earthworks and drainage and presented in support of development application.
Non-Structural Controls: Land use and Management	Developer	Sediment and erosion control during construction.
Water Quality Monitoring and Reporting	Developer	Monitoring Program (Section 8). Annual report prepared by the Developer to be submitted to the Shire of Serpentine – Jarrahdale and DoW following 12 months of monitoring.
Water Use Efficiency	Developer	Developer to provide landowners with rainwater tank and garden bore information packs at settlement.
Water Use Efficiency	Landowner	Landowner to comply with Building Code of Australia requirements checked during building approval stage.

Installation and maintenance of on-site effluent disposal system (ATUs)	Landowners	Approved Installation will be conducted during building construction. Once installed, the ATU systems require quarterly servicing by a Department of Health approved contractor.

9.3 Funding

Drainage infrastructure specific to the subdivision will be financed by the developer. Drainage infrastructure at the lot scale will be funded by individual landowners.

9.4 Next steps

The next stage for water management is to obtain subdivisional approvals supported by a UWMP. The UWMP is to be consistent with the design criteria and strategies outlined in this LWMS and include site-specific detail design of the drainage system in consideration of other aspects of the overall design concept.

The following issue will be addressed prior to the development of the UWMP and will be used to inform the UWMP:

- Detailed design and refinement of proposed infrastructure including drainage and development requirements for stormwater and shallow groundwater management;
- Modifications proposed to the Hardey's Creek Main Drain will need to be approved in writing by the Water Corporation
- Additional groundwater studies if sufficient groundwater resource is available for irrigation of the proposed POS or if further groundwater allocation is required.

The following issues will need to be addressed within the UWMP:

- Demonstration that the UWMP will meet the objectives and criteria stated in the LWMS;
- Demonstration of compliance with regulatory requirements, including required licences and approvals, *Building Code of Australia* and *Plumbing Code of Australia*;
- Detailed designs for the major/minor stormwater management system, including Best Management Practices (BMPs) to achieve the water quality and quantity objectives given in the LWMS;
- Identifying floor level heights;
- Undertake pre-development monitoring as outlined in Section 8.1;
- Establish a groundwater monitoring program to establish local controlled groundwater level;
- Operational and maintenance responsibilities and liabilities.
- The EMP should address any potential impacts associated with construction activities including acid sulfate soils, erosion and sediment control and management of any required dewatering.

10. References

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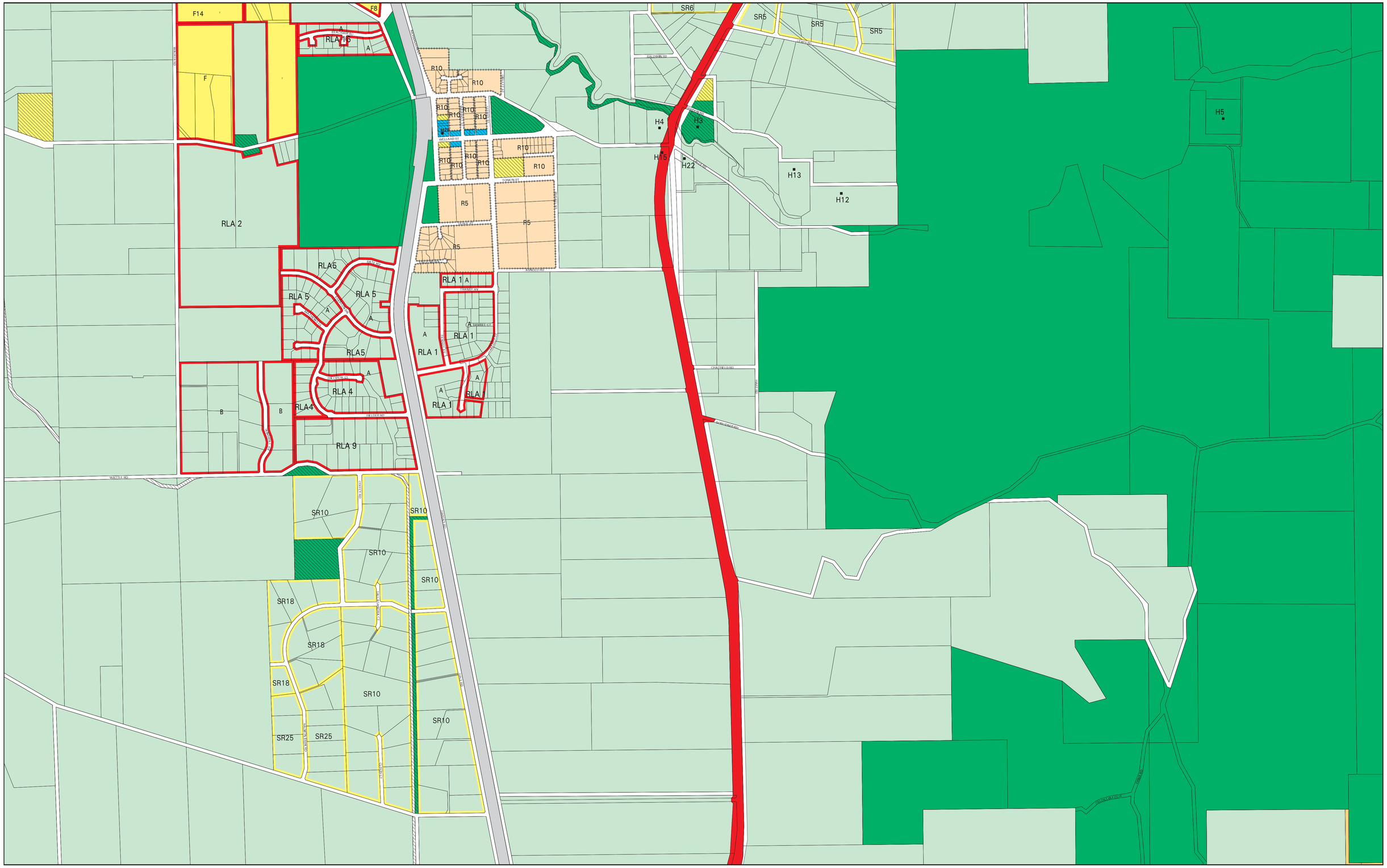
Appendices

Appendix A – Town Planning Scheme



Produced by Mapping and GeoSpatial Data Branch, Department of Planning.

Whilst all care has been taken to accurately portray the current Scheme provisions, no responsibility shall be taken for any omissions or errors in this documentation.

Consultation with the respective Local Government should be made to view a legal version of the Scheme. Please advise the Department of Planning of any omissions or errors in the document.

Base Information Supplied by the Western Australian Land Information Authority, GL248-2007-2

SHIRE OF SERPENTINE-JARRAHDALE

TOWN PLANNING SCHEME NO 2

(DISTRICT SCHEME)

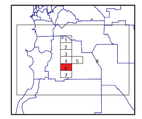
N

GDA
GEODETIC DATUM OF AUSTRALIA

SCALE 1:20000

0 500 m

MAP OVERVIEW



Authorised: Victor Chew
Plot date: 16 Feb 2012
G.Gazette: 04-August-1989

TOWN PLANNING SCHEME MAP No. 6 of 8

Appendix B - Development Plan

Serpentine Townsite outline plan - option 2

Appendix C – POS Schedule

Serpentine Townsite Local Structure Plan

Land Parcels	Area (m²)
Total Townsite Area (m²)	1191345.47
Lambkin Reserve CCW	17037.9
Richardson POS	11278.74
Total Net Site Area	1163028.83
Other Deductions	
Primary School site	19260.2
Church Lot 51 Tonkin Street	19396.2
Commercial Lots Richardson St	4073
Wellard St Shops	8328.5
Other Commercial, Public,Com.	8095
Total Deductions	59152.9
Gross Subdivisable Area	1103875.93
Total POS Required (10% GSA)	110388
POS (Unrestricted)	
Hardeys Creek POS	3699
Hardeys Creek POS	80788.41
Karnup Road	45528.81
Lefroy Street POS	8028.88
North Park	2902.27
Spencer Park	8981.91
Total Unrestricted POS	149929.28
80% Credit	119943.42
POS (Restricted)	
Hardeys Creek Basin	10140.09
Hardeys Creek Drain	3065.19
Lefroy Street Drain	3436.42
North Park Basin	673.17
Richardson Street POS	10500
Total Restricted POS	27814.87
Max 20% credit	5562.97
Unrestricted POS Component	119943.42
Restricted POS Component	5562.97
Total POS Required	110388
Total POS Contribution	125506.39
POS Oversupply	15121.39

N

0 50 100

Metres

Produced by:
Mapping & GeoSpatial Data Branch
Department of Planning, WA
On behalf of:
Western Australian Planning Commission

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Peel\SerpentineTownsiteLSP_v1.0_20121204\
SerpentineTownsiteLSP.mxd

Base information supplied by:
Western Australian Land Information Authority
LI 430-2009-4

Legend

- residential R5
- residential R10
- local centre
- educational/institutional
- community facility
  - PS - *primary school*
  - CH - *church*
- community facility - other
- public open space
- drainage
- local road
- Bush Forever
- structure plan boundary
- R code extent
- existing cadastre

KARNUP
WENDOWIE PL
GIBLETT STREET
RICHARDSON ROAD
MAXWELL STREET
LEFROY ROAD
WELLARD STREET
CH
TURNER STREET
PS
RUDALL STREET
TONKIN STREET
HARDEY ROAD
LESLIE STREET
BLUE WREN CL
FINCH MEWS
ARNOLD ROAD

DRAFT COPY ONLY
Department of Planning working plan, data not yet validated.
Internal use only - not for distribution.

Serpentine Townsite Local Structure Plan

Figure X

Appendix D – 5-Star Plus

Department of Housing and Works
Government of Western Australia

5 Star Plus

Energy Use in Houses Code
Water Use in Houses Code

Playing our part in building better communities for Western Australia

Introduction

In May 2006, Western Australia adopted the minimum 5 Star energy efficiency provisions of the Building Code of Australia for all new homes. Now the Government has gone further and introduced 5 Star Plus – that builds on the energy efficiencies from 5 Star with the added benefits of water reduction measures for all homes right across the State.

5 Star Plus is based around two new Codes:

The Energy Use in Houses Code - confirms the existing 5 Star provisions for house design and construction and adds requirements for energy efficient water heating.

The Water Use in Houses Code - aims to reduce the consumption of water in residential homes by requiring water efficient fittings, minimising the wastage of water and facilitating the appropriate use of alternative sources of water such as grey water and rain water.

5 Star Plus will be applicable to new homes approved for construction after 1 September 2007, however, existing home owners can also use these Codes to improve energy and water efficiency in their homes. During 2008, the Government will investigate measures to apply the 5 Star Plus provisions to existing homes.

The Energy Use in Houses Code and Water Use in Houses Code are written to supplement the Building Code of Australia (BCA) and adopt BCA definitions and format for consistency. The Codes are published together for the convenience of builders, plumbers and certifiers who may need a convenient reference on site.

The Codes are available online at **www.5starplus.wa.gov.au**

Energy Use in Houses Code

Application

This Code applies to all new buildings classified as Class 1 and 10 buildings by the Building Code of Australia.

Interpretation

"The Building Code of Australia" means the latest edition of the Building Code of Australia published from time to time by, or on behalf of, the Australian Building Codes Board, but not including explanatory information published with that Code.

Objective

The objective of this Code is to reduce greenhouse gas emissions.

Functional Statement

In order to reduce greenhouse gas emissions, a building, including its services, is to be capable of efficiently using appropriate sources of energy.

Compliance With This Code

A building will comply with this Code if its construction satisfies all the Performance Requirements. Compliance with the Performance Requirements can be shown by:

(a) Complying with the Deemed-to-Satisfy provisions as listed in the Acceptable Construction Practice; or

(b) Formulating an alternative solution that is shown to be equivalent to the Deemed-to-Satisfy provisions; or

(c) Formulating an alternative solution that is verified using an acceptable verification method; or

(d) Formulating an alternative solution that is based on expert judgement or supported by suitable evidence in accordance with clause 1.2.2 of the Building Code of Australia; or

(e) Any combination of the above.

Energy Use in Houses Code

Performance Requirements

PR1 – Building

A building must comply with the Building Code of Australia Performance Requirement P2.6.1.

PR2 – Services

A building's domestic services including any associated distribution system and components must have features that comply with the Building Code of Australia, Performance Requirement P2.6.2.

PR3 – Hot Water Systems

A building's hot water systems including any associated components must have features that produce low levels of greenhouse gases when heating water.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS1 satisfy the Performance Requirement PR1 for a building.

(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS2 satisfy the Performance Requirement PR2 for a building.

(c) Compliance with all of the Deemed-to-Satisfy provisions of DTS3 satisfy the Performance Requirement PR3 for a building.

Deemed to Satisfy Provisions

DTS 1 – Thermal Comfort

The building must comply with the provisions of Part 3.12 of the Building Code of Australia for Building Fabric, External Glazing, Building Sealing and Air Movement.

DTS 2 – Services

The building must comply with the provisions of Part 3.12 of the Building Code of Australia for Services.

DTS 3 – Hot Water Systems

A hot water system must be either:

(i) a solar hot water system, complying with AS 2712-2002, that has been tested in accordance with AS 4234-1994, and achieves a minimum energy saving of 60% for a hot water demand level of 38MJ per day for climate zone 3; or

(ii) a gas hot water system, complying with AS 4552-2005 that achieves a minimum energy rating of "5 stars"; or

(iii) a heat pump hot water system, complying with AS 2712-2002 that has been tested in accordance with AS 4234-1994, and achieves a minimum energy saving of 60% for a hot water demand level of 38MJ per day for climate zone 3.

Explanatory Notes:

1. **BCA Performance Requirement P2.6.1**

   A building must have, to the degree necessary, a level of thermal performance to facilitate the efficient use of energy for artificial heating and cooling appropriate to –

   (a) the function and use of the building; and
   (b) the internal environment; and
   (c) the geographic location of the building; and
   (d) the effects of nearby permanent features such as topography, structures and buildings; and
   (e) solar radiation being—
      (i) utilised for heating; and
      (ii) controlled to minimise energy for cooling; and
   (f) the sealing of the building envelope against air leakage; and
   (g) the utilisation of air movement to assist cooling.

2. **BCA Performance Requirement P2.6.2 – Services**

   A building's domestic services including any associated distribution system and components must have features that, to the degree necessary, facilitate the efficient use of energy appropriate to –

   (a) the domestic services and its usage; and
   (b) the geographic location of the building; and
   (c) the location of the domestic services; and
   (d) the energy source.

3. **AS 2712-2002** details the design and construction of solar and heat pump water heaters.

4. **AS 4234-1994** sets out the method of testing and calculation of energy consumption for domestic solar water heaters and heat pumps.

5. **AS 4552-2005** details the design of gas forced water heaters for hot water supply and/or central heating.

Water Use in Houses Code

Application

This Code applies to all new buildings classified as Class 1 and 10 buildings by the Building Code of Australia.

Interpretation

"The Building Code of Australia" means the latest edition of the Building Code of Australia published from time to time by, or on behalf of, the Australian Building Codes Board, but not including explanatory information published with that Code.

"Alternative Internal Water Supply" refers to a water supply such as collection of rainwater on site, external third pipe non-potable water source, on-site bores or the like, other than potable water supplied by a licensed water service provider, and approved for use inside a dwelling.

"Alternative External Water Supply" refers to a water supply such as collection of rainwater on site, external third pipe non-potable water source, re-cycled grey water, on-site bores or the like, other than potable water supplied by a licensed water service provider, and approved for use outside a dwelling.

"Potable Water" refers to water intended for human consumption supplied by a licensed water service provider.

Objective

The objective of this Code is to reduce water demand by efficiently using water, and minimising the wasting of water, and facilitating the appropriate use of alternative sources of water.

Functional Statement

To reduce potable water demand a building must:

(a) enable the efficient use of potable water; and
(b) prevent excessive loss of potable water; and
(c) have the capacity to connect to alternative sources of water supply; and
(d) use alternative sources in situations of high water demand or restricted availability of potable water.

Compliance With This Code

A building will comply with this Code if its construction satisfies all the Performance Requirements. Compliance with the Performance Requirements can be shown by:

(a) complying with the Deemed-to-Satisfy provisions as listed in the Acceptable Construction Practice; or
(b) formulating an alternative solution that is shown to be equivalent to the Deemed-to-Satisfy provisions; or
(c) formulating an alternative solution that is verified using an acceptable verification method; or
(d) formulating an alternative solution that is based on expert judgement or supported by suitable evidence in accordance with clause 1.2.2 of the Building Code of Australia; or
(e) any combination of the above.

Explanatory Notes:

Stage 1 of the Code will be prescribed in the Building Regulations to apply from 1 September 2007.

Stage 2 of the Code will be prescribed in the Building Regulations to apply from date to be determined.

Implementation of Stage 2 of the Code is dependent on further consultation and research to determine areas of application and on amendments to plumbing regulations and processes as well as ensuring compliance with health regulations and policies.

Water Use in Houses Code

Stage 1 - To apply from 1 September 2007

Performance Requirements

PR1 – Water Use Efficiency

A building must have features that, to the degree necessary, facilitate the efficient use of potable water appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building.

PR2 – Water Loss Prevention

A building, including any water holding structures, must have features that, to the degree necessary, prevent the excessive loss of potable water appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the effects of permanent features such as topography, structures and buildings.

PR3 – Hot Water Use Efficiency

A building must have features that, to the degree necessary, facilitate the efficient use of hot water appropriate to:

(a) the geographic location of the building; and
(b) the available hot water supply for the building; and
(c) the function and use of the building.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS1 satisfies the Performance Requirement PR1 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS2 satisfies the Performance Requirement PR2 for a building.
(c) Compliance with all of the Deemed-to-Satisfy provisions of DTS3 satisfies the Performance Requirement PR3 for a building.

Deemed to Satisfy Provisions

DTS 1 – Water Use Efficiency

(a) all tap fittings other than bath outlets and garden taps must be minimum 4 stars WELS rated.
(b) all showerheads must be minimum 3 stars WELS rated.
(c) all sanitary flushing systems must be a minimum 4 stars WELS rated dual flush.

DTS 2 – Swimming Pool Covers and Blankets

An outdoor private swimming pool or spa associated with a Class 1 building must be supplied with a cover, blanket or the like that:

(a) is designed to reduce water evaporation; and
(b) is listed on the Smart Approved Watermark Scheme.

DTS 3 – Hot Water Use Efficiency

All internal hot water outlets (taps, showers, washing machine water supplies) must be connected to a hot water system or a recirculating hot water system with pipes installed and insulated in accordance with AS/NZS 3500:2003. Plumbing and Drainage, Part 4 Heated Water Services. The pipe from the hot water system or recirculating hot water system to the furthest hot water outlet must not exceed 20 metres in length or 2 litres of internal volume.

Explanatory Notes:

The Smart Approved Watermark Scheme is implemented through the National Water Commission as a simple identification label about water efficient products. Further information can be obtained from www.nwc.gov.au

Stage 2 - To apply from (date to be determined)

Performance Requirements

PR4 – Alternative Water Supply Use Capacity

A building, including any associated plumbing, must have features that, to the degree necessary, facilitate the future use of alternative water supplies appropriate to:

(a) the geographic location of the building; and
(b) the function and use of the building; and
(c) the soil type and ground condition; and
(d) the available alternative sources of water; and
(e) the size and type of external landscaping.

PR5 – Grey Water Use Capacity

A building including any associated plumbing, located on a lot of a size and in a location suitable for recycling of grey water, must have features that, to the degree necessary, facilitate the future use of grey water recycling appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for landscaping; and
(c) the function and use of the building; and
(d) the soil type and ground condition; and
(e) the available alternative sources of water; and
(f) the size and type of external landscaping.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS4 satisfies the Performance Requirement PR4 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS5 satisfies the Performance Requirement PR5 for a building.

Deemed to Satisfy Provisions

DTS 4 – Alternative Water Supply Use Capacity

All sanitary flushing systems and washing machines must be able to be connected at a later date, to an appropriate alternative water supply without the need to break, or cut into the fabric of the building to run new pipes.

DTS 5 – Grey Water Use Capacity

All shower, bath, laundry trough and washing machine drains must be able to be connected at a later date to an appropriate grey water diversion system without the need to break, or cut into the fabric of the building to run new pipes.

Explanatory Notes:

1. Health regulations apply to the use of alternative water supplies and will, amongst other things, limit the alternative water sources suitable for various uses.
2. The DTS 4 provisions do not require rainwater tanks. They require buildings to be able to be connected to such alternative water supplies relatively easily at a later date (i.e. the buildings are to be alternative supply 'ready'). Subject to health regulations and policies, alternative water supplies could also include bore water, third pipes, and the like.
3. All plumbing work associated with these requirements must be carried out by licensed plumbers and in accordance with all relevant plumbing regulations.

Water Use in Houses Code

Performance Requirements

PR6 – Alternative Internal Water Supply

A building with more than two showers or two WC facilities must use alternative internal water supplies for internal uses appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the available alternative sources of water.

PR7 – Alternative External Water Supply

A building located on a lot of a size and in a location likely to use significant potable water for landscaping use must use alternative internal or external water supplies appropriate to:

(a) the geographic location of the building; and
(b) the available potable water supply for the building; and
(c) the function and use of the building; and
(d) the soil type and ground condition; and
(e) the available alternative sources of water; and
(f) the size and type of external landscaping.

Deemed to Satisfy Provisions

DTS 6 – Alternative Internal Water Supply

All sanitary flushing systems and clothes washing facilities must be connected to an alternative internal cold water supply.

DTS 7 – Alternative External Water Supply

(a) All external garden taps and irrigation systems must be connected to an alternative external water supply; or
(b) all shower, bath, laundry trough and washing machine drains must be connected to an approved grey water diversion and recycling system.

Acceptable Construction Practice

(a) Compliance with all of the Deemed-to-Satisfy provisions of DTS6 satisfies the Performance Requirement PR6 for a building.
(b) Compliance with all of the Deemed-to-Satisfy provisions of DTS6 or DTS7 satisfies the Performance Requirement PR7 for a building.

Explanatory Notes:

1. Houses required to be "grey water ready" under PR5 are those on large enough lots to allow drains carrying appropriate water to be run outside the house before connection to other waste pipes, and where there is likely to be enough landscaped area to adequately dilute the grey water.
2. Lots where houses are required to comply with PR7 will be identified through regulations. Further research is needed with relevant stakeholders to resolve which lots will be subject to this requirement.
3. Health regulations apply to the use of alternative water supplies and will, amongst other things, limit the alternative water sources suitable for internal or external use in different localities. For example most private bore water, whilst it may be suitable for garden use, may be inappropriate for use internally.
4. Alternative water supplies can include but is not limited to, rainwater tanks, bore water, third pipes, and the like.
5. Subject to health regulations an acceptable alternative internal water supply is an appropriately sized rainwater tank harvesting the rainwater runoff from the roof.
6. Subject to health regulations an acceptable alternative external water supply is a domestic bore.
7. All plumbing work associated with alternative water supplies must be carried out by licensed plumbers and in accordance with all relevant plumbing regulations.
8. The Water Use in Houses Code is implemented in two stages to allow amendment of plumbing regulations and training of licensed plumbers to ensure alternative water supplies are appropriate and safe, and that there is no risk of cross contamination with potable water supplies.

Further information

These Codes are intended to supplement the Building Code of Australia and will be called up by the Building Regulations 1989

For further information about 5 Star Plus please visit our website at www.5starplus.wa.gov.au

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Appendix E – ATU agreement

Sarah Glasson

From: Myles Busbridge
Sent: Friday, 8 February 2013 9:59 AM
To: Sarah Glasson
Subject: FW: Serpentine Townsite and the use of ATUs

CompleteRepository: 619999999
Description: Misc Email Database
JobNo: 99999
OperatingCentre: 61
RepoEmail: 619999999@ghd.com
RepoType: Overhead
SubJob: 99

As for disccuson

From: Bothma, Jorine [mailto:Jorine.Bothma@planning.wa.gov.au]
Sent: Friday, 8 February 2013 8:12 AM
To: Myles Busbridge
Subject: FW: Serpentine Townsite and the use of ATUs

Myles

Please receive a copy of the email from Department of Health below.

Kind Regards

JORINE BOTHMA
Senior Strategic Planner– Metropolitan South East Perth and Peel Planning
Department of Planning L 5, 140 William Street PERTH WA 6000
P: 08 6551 9539 | F: 08 6551 9001
E: Jorine.Bothma@planning.wa.gov.au

From: Tan, Allen [mailto:Allen.Tan@health.wa.gov.au]
Sent: Tuesday, 20 November 2012 4:35 PM
To: Bothma, Jorine
Cc: Theobald, Richard
Subject: RE: Serpentine Townsite and the use of ATUs

Jorine,

We did not talk about anything relating to Sewerage and Drainage Act.

What is applicable is the Government Sewerage Policy- Perth Metropolitan Region. Under this Policy, new R10 zoning is not permitted in the Serpentine townsite – the maximum density allowed without sewer connection is R5 (2000m2 lots). Therefore, rezoning for new subdivisions will need to take this Policy into consideration. However, existing R10 lots can use ATU systems for developments. Use of ATUs are also acceptable for existing and future R5 zoned land.

I hope this clarifies the matter.

Allen Tan
Scientific Officer
Water Unit

T: (08) 93884938 F: (08) 93884910
E: allen.tan@health.wa.gov.au

Department of Health, Western Australia
Environmental Health Directorate
Public Health and Clinical Services Division
Grace Vaughan House | 227 Stubbs Terrace | SHENTON PARK WA 6008
PO Box 8172 | Perth Business Centre | WA 6849
www.public.health.wa.gov.au

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From: Bothma, Jorine [mailto:Jorine.Bothma@planning.wa.gov.au]
Sent: Tuesday, 20 November 2012 4:01 PM
To: Tan, Allen
Subject: RE: Serpentine Townsite and the use of ATUs

Allen

Thank you for the response.

The effective drainage plan and an appropriate groundwater management strategy are being developed as part of the LWMS.

There is one aspect I need to clarify with you and which we have briefly spoken about over the phone and that is with reference to the Sewerage and Drainage Act. Can we state that DoH has no objection to the 1000 – 2000 sqm being served by ATU's within Serpentine being the respective R10 and R5 zonings?

Kind Regards

JORINE BOTHMA
Senior Strategic Planner– Metropolitan South East Perth and Peel Planning
Department of Planning L 5, 140 William Street PERTH WA 6000
P: 08 6551 9539 | F: 08 6551 9001
E: Jorine.Bothma@planning.wa.gov.au

From: Tan, Allen [mailto:Allen.Tan@health.wa.gov.au]
Sent: Wednesday, 14 November 2012 5:31 PM
To: Bothma, Jorine
Cc: Theobald, Richard
Subject: FW: Serpentine Townsite and the use of ATUs

Hello Jorine,

While the Department of Health has no objection to the use of ATUs in the Serpentine townsite, it is to be noted that ATUs are still on-site wastewater treatment and disposal systems. As such, lots must have suitable site conditions for effluent disposal on a long term basis and large enough to accommodate the ATU system.

Serpentine townsite is known to have a high winter water table either as perched water over clay soils or as high groundwater levels. Because of such site conditions and poor drainage in place, on-site wastewater systems have been known to fail. It is imperative that an effective drainage plan for the township and the new areas be developed as a prerequisite for the Serpentine Outline Development Plan and implemented before new developments occur.

Regards,

Allen Tan
Scientific Officer
Water Unit
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E: allen.tan@health.wa.gov.au

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Appendix F – Support for modifications to Hardey's Creek Main Drain

Appendix G – Hydraulic and Hydrologic Modelling Outputs

Modelling Discussion

GHD built an InfoWorks CS hydrologic and one-dimensional hydraulic model of the existing and proposed development, and simulated the model for a range of design storms. InfoWorks CS is a computer program for simulating catchment hydrology and one-dimensional flows in conduits and open channels. Data is input via GIS files, tables and a graphical user interface, and results are produced graphically and in GIS and tabular format.

The hydrology was simulated using the SWMM model, based on the parameters listed in Table 21, Table 22 and Table 23. These parameters are consistent with regional storm water modeling for the Serpentine area.

Existing drainage pipe sizes and number was supplied by the Shire of Serpentine-Jarrahdale. Existing drains were modeled through supplied LIDAR elevation information accurate to 200 mm.

Modelling assumptions

- Infiltration modeled at a constant rate of 4 mm/hour
- Existing culverts as per Shire of Serpentine Jarrahdale information
- All existing table drains 1:2, 0.5 m deep, 1 m wide, Manning's n 0.030
- Groundwater inflow is 50 L/s/km drain (0.131 m^3/s at Hardey's Creek1)
- River level 29.858 m (100 year ARI flood level reaches 30 m AHD contours which corresponds to a flood depth of 600 mm, therefore assume 400 mm flood depth for 5 year ARI flood depth which corresponds to 29.858 m AHD)

Modelling parameters

Table 21 InfoWorks model runoff surface properties

Runoff surface	Surface roughness (Mannings n)	Initial loss (mm)	Infiltration loss (mm/hour)	Fixed runoff coefficient
Road	0.015	0.001	N/A	0.9
Rural	0.050	0.010	4	N/A
Building	0.015	0.016	4	N/A
Upper Catchment	0.035	0.008	N/A	0.6

Table 22 IFD data

Input	Value
2 yr ARI intensity	
- 1 hr	23.31
- 12 hr	4.9

Input	Value
- 72 hr	1.51
50 yr ARI intensity	
- 1hr	37.44
- 12 hr	7.9
- 72 hr	2.46
Geographical factors	
- F2	4.86
- F50	17.29
Location skewness	0.67
Zone	8

Table 23 InfoWorks model catchment properties for pre development scenario

Subcatchment ID	Total area (ha)	Vector slope (m/m)	Catchment dimension (m)	Road (%)	Rural (%)	Building (%)
1	4.332	0.004	117.4	9.973	83.363	6.664
2	6.566	0.001	144.6	21.716	62.787	15.497
3	14.576	0.001	215.4	25.159	59.919	14.922
4	8.154	0.004	161.1	17.28	72.396	10.324
5	14.49	0.002	214.8	23.146	71.734	5.12
6	10.834	0.001	185.7	16.053	80.463	3.484
7	7.014	0.003	149.4	18.043	59.504	21.95
8	17.532	0.001	236.2	9.943	89.868	0.189
A	32.665	0.012	322.5	0	99.911	0
B	8.977	0.001	169	5.855	94.145	0
C	50.63	0.001	401.4	0.024	99.765	0
D	87.527	0.002	527.8	7.675	87.651	4.618
E	18.119	0.001	240.2	0	100	0
F	48.488	0.009	392.9	0	100	0
G	11.926	0.009	594.2	0	99.976	0

Validation

No flow data was available to validate model parameters so some values (surface roughness and initial losses) were obtained from a validated model for Mundijong Whitby (8 km north) due to the similarities between the two sites.

Comparison of calculated peak flows from the Serpentine LWMS to previous modeling results was undertaken for upland catchments. Peak Infoworks 100 year ARI flow rates for the 660 ha

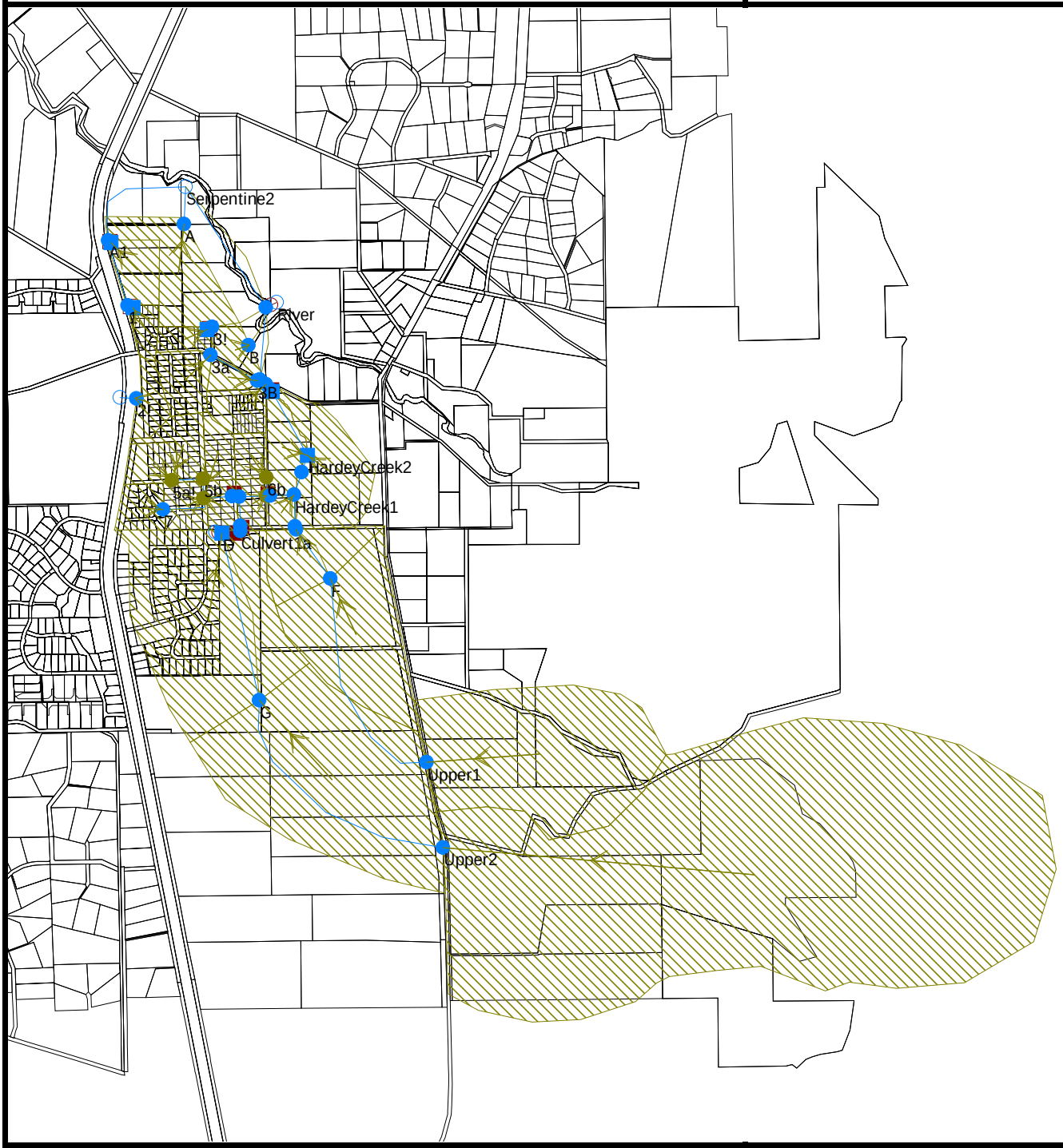
catchment of the Arnold Rd basin were modeled at 11.68 m^3/s. This is in close agreement to the Serpentine Downs Estate Drainage Strategy (cardno, 2009) modelled flow rate of 12 m^3/s.

An independent check on these models was undertaken based on modelling of upland catchments within the 2008 Byford Townsite DWMP. Calculated peak flows on a unit area basis for the 660 ha Arnold Rd basin catchment gives a 100 year peak flow of 11.9 m^3/s thus the developed Serpentine Outline Plan LWMS Infoworks model is consistent with past calibrated regional models.

Network - Serpentine Outline Plan LWMS Simulation - 6H100Y

Map Centre Coords
x: 406147, y: 6417725
Date Printed: 18/12/2012
Scale 1:35000

1000m



Data Flags
- #A - Asset Data
- #D - System Default
- #G - Data from GeoPlan
- #I - Model Import
- #V - CSV Import
- SC - ball

Serpentine_post#12 (mb) open channel_100#1
- Key
- Nodes [system types]
  - [combined,foul,storm]
  - [other,overland]
- Links [system types]
  - 2D Boundary
  - CC TV
  - Conduit [combined,foul,storm]
  - Conduit [other,overland]
  - Culvert Inlet [all]
  - Culvert Outlet [all]
  - Flap valve [all]
- Flume [all]
- General Line
- Node [all]
- Orifice [all]
- Porous Wall
- Prune [all]
- Pump (all types) [all]
- Results Line (2D)
- River [all]
- River [combined,foul,other,overland]
- River [storm]
- Screen [all]
- Siphon [all]
- Sluice gate [all]
- User Control [all]
- Weir [all]
- Subcatchments [system types]
  - 2D IC Polygon
  - 2D Simulation Polygon
  - Flood Compartment
- Mesh Polygon
- Polygon Zone
- Porous Polygon
- Results Polygon (2D)
- Roughness Polygon
- Subcatchment [all]
- Symbols
  - 2D Point Source
  - Break Node
  - Compound Weir/Orifice
  - Flood Point
  - Hyperlink
  - Outflow Node
  - Pond node
  - Results Point (2D)
  - Storage Node
  - Var. crest level weir
  - Var. sluice gate
  - Var. width weir
  - Vortex

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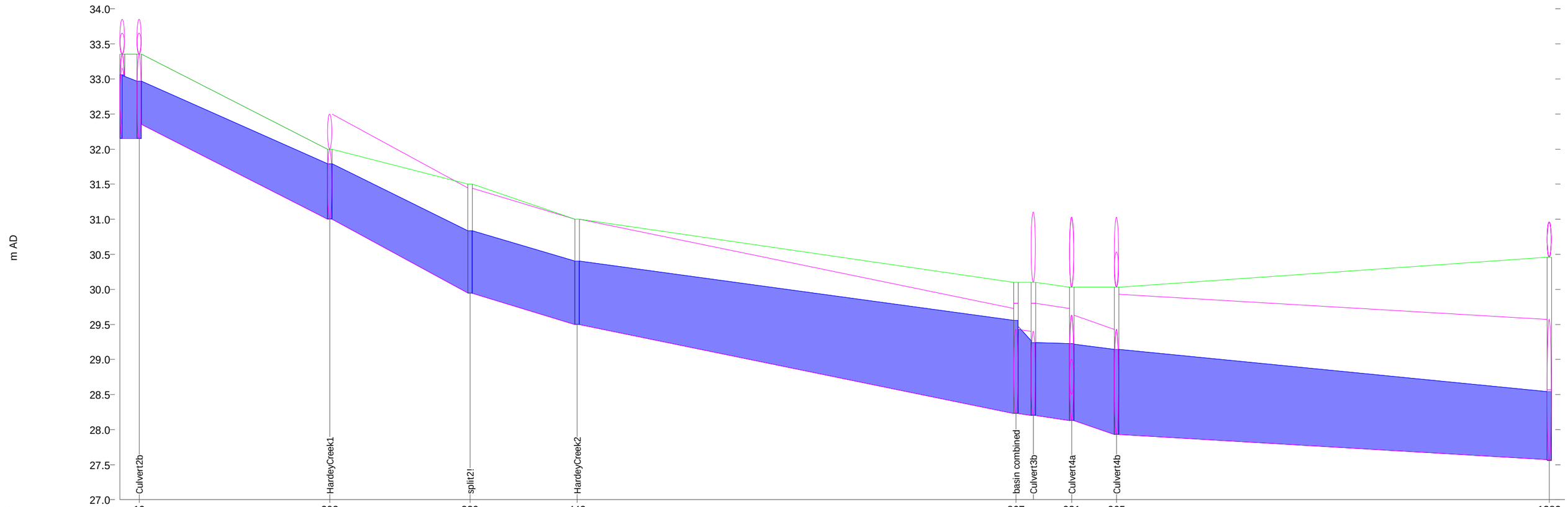
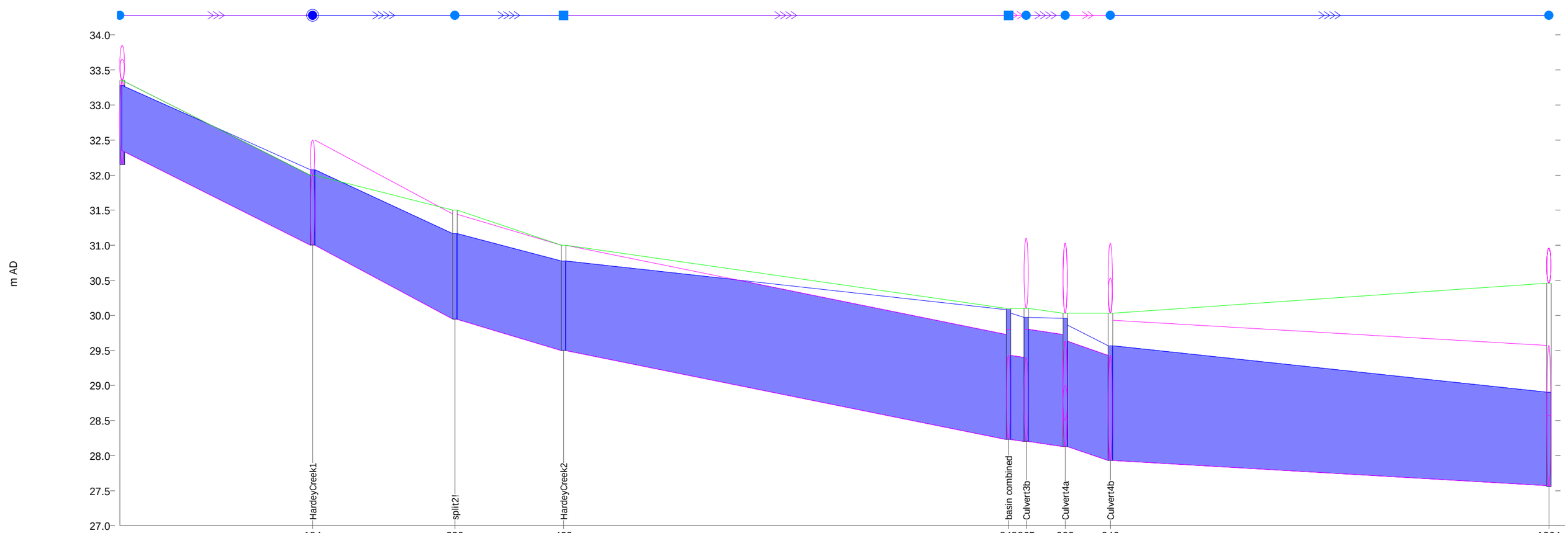


Link	-	Culvert2b.1	HardeyCreek1.1	split2!.1	HardeyCreek2.1	-	-	-	Culvert4b.1	
US Node ID	-	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	-	-	Culvert4a	Culvert4b	
ds node	-	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1	
length (m)	-	184.2	135.7	103.5	424.6	-	37.2	43.3	418.5	
Shape ID	-	OT1:6	OT1:6	OT1:6	OT1:6	-	OT1:2	CIRC	OT1:6	
width (mm)	-	1000	1000	1000	2000	-	10000	1500	1000	
height (mm)	-	1000	1500	1500	1500	-	1600	1500	2000	
Sediment Depth (r	0	0	0	0	0	0	0	0	0	
us inv (m AD)	-	32.352	31.000	29.944	29.500	-	28.200	28.130	27.930	
ds inv (m AD)	-	31.000	29.948	29.500	28.230	-	28.130	27.930	27.570	
DS Depth (m)	-	0.791	0.888	0.905	1.328	-	1.096	1.216	0.973	
DS Flow (m3/s)	-	3.98565	7.54702	7.54690	7.74877	-	7.66144	2.61610	7.84529	
DS Velocity (m/s)	-	0.881	1.342	1.304	1.744	-	0.575	1.706	1.180	
US Flow (m3/s)	-	3.98508	7.54711	7.54702	7.79343	-	7.66005	2.61616	7.84830	

Node	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
Node ID	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
x (m)	404612.8	404606.7	404650.7	404684.3	404478.3	-	-	404408.9	404443.4
y (m)	6418005.9	6418190.0	6418318.4	6418416.3	6418787.6	-	-	6418855.7	6419272.8
ground (m AD)	33.352	32.000	31.500	31.000	30.100	-	30.030	30.030	30.458
level (m AD)	32.968	31.791	30.836	30.405	29.558	-	29.226	29.146	28.543

Long Section (Hardy's Creek MD Arnold Rd to Karnup Rd)

5 year ARI



m		184		320		423			848	865	902	946		1364
Link	Culvert2b.1		HardeyCreek1.1		split2!.1		HardeyCreek2.1		-	-	-		Culvert4b.1	
US Node ID	Culvert2b		HardeyCreek1		split2!		HardeyCreek2		-	-	Culvert4a		Culvert4b	
ds node	HardeyCreek1		split2!		HardeyCreek2		basin combined		-	-	Culvert4b		Serpentine1	
length (m)	184.2		135.7		103.5		424.6		-	37.2	43.3		418.5	
Shape ID	OT1:6		OT1:6		OT1:6		OT1:6		-	OT1:2	CIRC		OT1:6	
width (mm)	1000		1000		1000		2000		-	10000	1500		1000	
height (mm)	1000		1500		1500		1500		-	1600	1500		2000	
Sediment Depth (r	0		0		0		0		0	0	0		0	
us inv (m AD)	32.352		31.000		29.944		29.500		-	28.200	28.130		27.930	
ds inv (m AD)	31.000		29.948		29.500		28.230		-	28.130	27.930		27.570	
DS Depth (m)	1.076		1.217		1.277		1.853		-	1.826	1.639		1.335	
DS Flow (m3/s)	10.95723		16.10159		16.09916		16.86476		-	-	5.78762		17.35406	
DS Velocity (m/s)	1.368		1.595		1.455		1.884		-	0.677	3.166		1.444	
US Flow (m3/s)	10.95586		16.10315		16.10159		17.11255		-	-	5.78763		17.36283	

Node	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
Node ID	Culvert2b	HardeyCreek1	split2!	HardeyCreek2	basin combined	-	-	Culvert4b	Serpentine1
x (m)	404612.8	404606.7	404650.7	404684.3	404478.3	-	-	404408.9	404443.4
y (m)	6418005.9	6418190.0	6418318.4	6418416.3	6418787.6	-	-	6418855.7	6419272.8
ground (m AD)	33.352	32.000	31.500	31.000	30.100	-	30.030	30.030	30.458
level (m AD)	33.282	32.076	31.165	30.777	30.083	-	29.956	29.569	28.905

Long Section (Hardy's Creek MD Arnold Rd to Karnup Rd)
100 year ARI

Appendix H – DEC Wetland Reclassification Response

Government of **Western Australia**
Department of **Environment and Conservation**

Your ref:
Our ref:
Enquiries: Anthea Jones
Phone: 08 9219 8710
Email: anthea.jones@dec.wa.gov.au

Ms Jorine Bothma
Senior Strategic Planner- Metropolitan South East
Department of Planning
L 5, 140 William Street
PERTH WA 6000

Dear Ms Bothma

RE: REQUEST TO REVIEW THE *GEOMORPHIC WETLANDS SWAN COASTAL PLAIN* DATASET FOR UFI 15002

I refer to your email correspondence of 4 December 2012 requesting modifications to the management category of Conservation management category dampland UFI 15002 within the *Geomorphic Wetlands Swan Coastal Plain* dataset (the dataset).

The area of particular focus with respect to this review was the portion of Conservation category dampland directly east of the UCL on Richardson Road, which extends over a road reserve and private property. A bitumen road (Richardson Road) extends through the centre of the road reserve and dwellings are located on the private properties within the mapped Conservation management category dampland.

As this wetland is an extensive dampland, differing management categories may be assigned to areas of dampland with differing values. In this case, the portion of the dampland that extends over Richardson Road and residential dwellings contains few remaining natural values, and its values are therefore commensurate with Multiple Use management category.

It should be noted that the Conservation management category boundary extends beyond the UCL to include the roadside vegetation on the western side of Richardson Road. This is because the aerial photography appears to show some native vegetation within the road reserve and because the boundary of a threatened ecological community extends into the road reserve.

Figure 1 shows the current management category of UFI 15002 within the dataset. Figure 2 shows the proposed modifications to the management category within the dataset.

Please be aware that this review relates only to wetland mapping, and not any associated land use proposal.

Please contact Anthea Jones on 9219 8710 if you require further information on this matter.

Yours sincerely,

Dr Michael Coote
Principal Coordinator, Wetlands Section
for the Director General

5 December 2012

Figures:

Figure 1: Current *Geomorphic Wetlands Swan Coastal Plain* dataset mapping.

Figure 2: Proposed modifications to *Geomorphic Wetlands Swan Coastal Plain* dataset.

References:

Hill AL, Semeniuk CA, Semeniuk V & Del Marco A (1996) *Wetlands of the Swan Coastal Plain Volume 2B: Wetland Mapping, Classification and Evaluation*. Wetland Atlas, Water and Rivers Commission and Department of Environmental Protection, Perth.

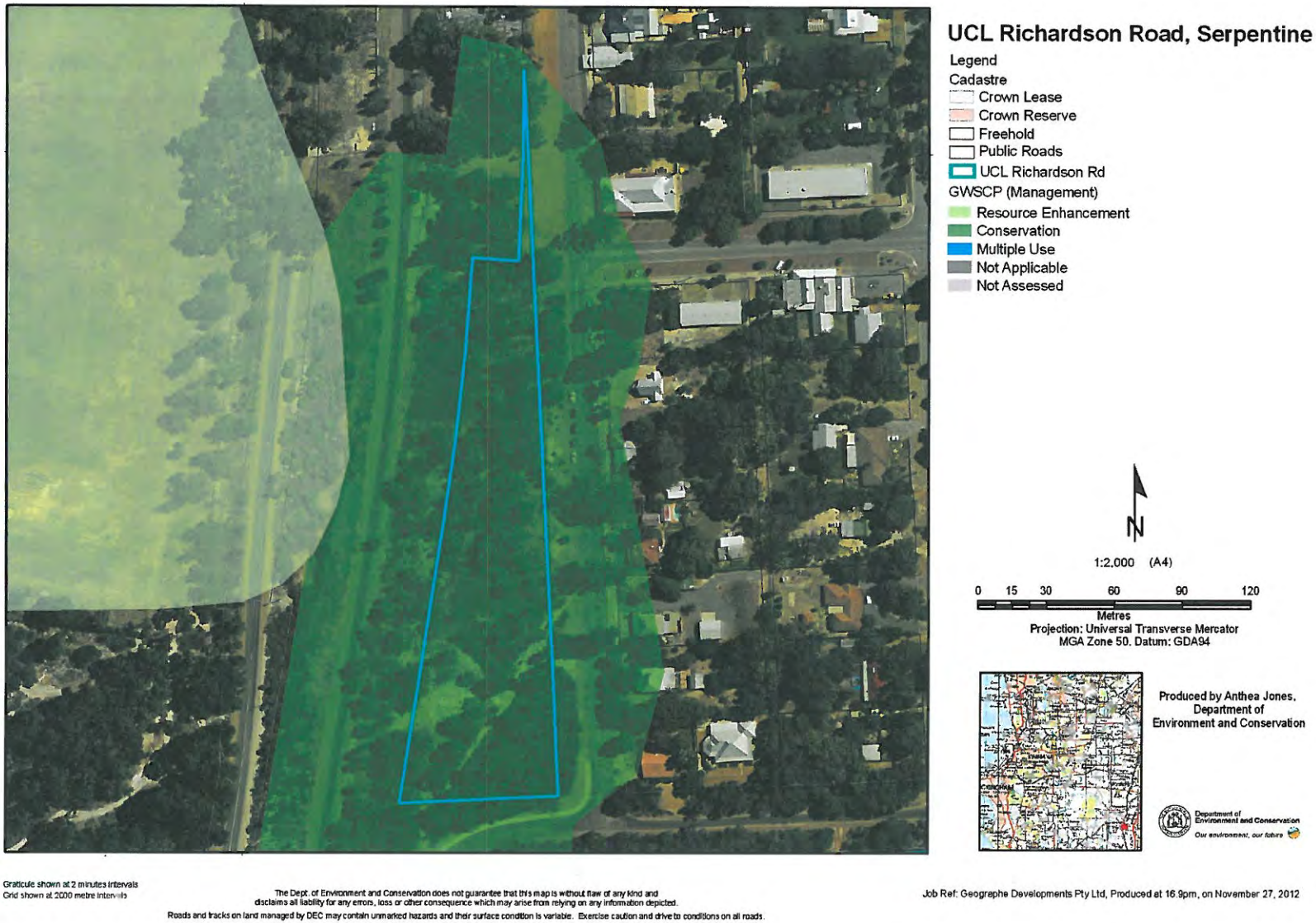


Figure 1: Current *Geomorphic Wetlands Swan Coastal Plain* dataset mapping (UCL highlighted in blue).

Species and Communities Branch, Nature Conservation Division
Address: 17 Dick Perry Ave, Kensington
Ph: (08) 9334 0333
Postal: Locked Bag 104 Bentley Delivery Centre, BENTLEY WA 6983

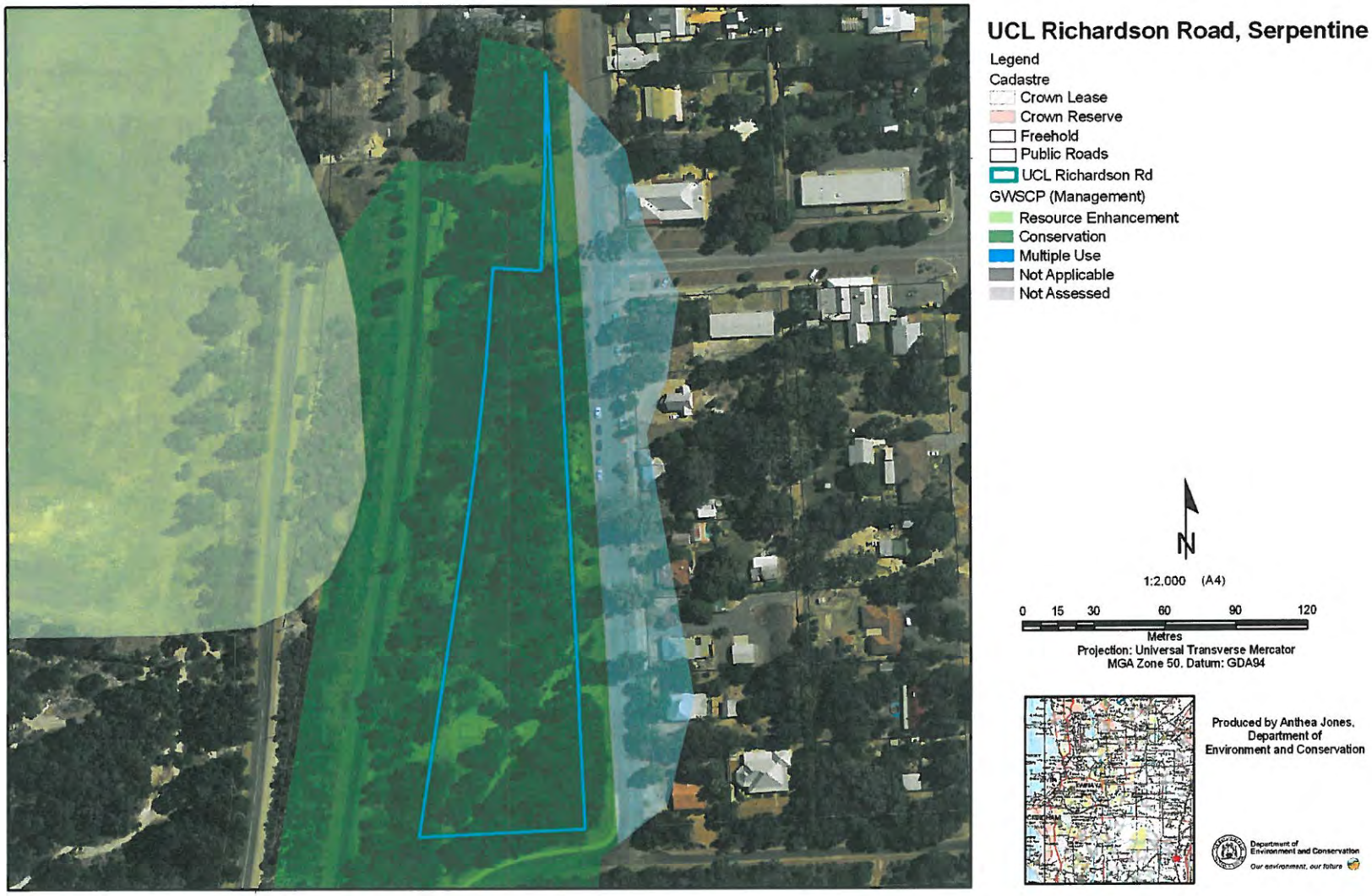


Figure 2: Proposed modifications to *Geomorphic Wetlands Swan Coastal Plain* dataset (UCL highlighted in blue).

Myles Busbridge

From: Bothma, Jorine <Jorine.Bothma@planning.wa.gov.au>
Sent: Tuesday, 9 October 2012 2:13 PM
To: Myles Busbridge
Subject: FW: Advice on reclassification of CCW in Serpentine Townsite

Myles

I have received comments from DEC on the eastern CCW lot in Tonkin Street below. I am awaiting feedback on whether the newly created road width adjacent to the western CCW site (as per our revised layout plan) will be sufficient to accommodate a buffer area for these sites and will report back as soon as possible.

Kind Regards

JORINE BOTHMA
Senior Strategic Planner– Metropolitan South East
Perth and Peel Planning
Department of Planning
L 5, 140 William Street
PERTH WA 6000
P: 08 6551 9539 | F: 08 6551 9001
E: Jorine.Bothma@planning.wa.gov.au

From: Maguire, Jacqui [mailto:Jacqui.Maguire@dec.wa.gov.au]
Sent: Tuesday, 9 October 2012 8:29 AM
To: Bothma, Jorine
Cc: Jones, Anthea
Subject: RE: Advice on reclassification of CCW in Serpentine Townsite

Hi Jorine,

Thanks for sending through the photos. As you would be aware I forwarded these on to an officer at DEC's Wetlands Section who reviewed them in the context of the management classification of the mapped conservation category wetland (CCW). It was determined that on the basis of the photographs and the most recent aerial photography, Wetlands Section would re-evaluate UFI 14974 as Multiple Use (MU) management category.

The Wetlands Section will include this wetland reclassification in the modifications queue and will address the changes to the dataset accordingly. This could take one or two months.

However for the purposes of planning and finalisation of the LWMS, DEC would be satisfied for the current CCW (UFI 14974) to be considered as a MU wetland.

It would be recommended however that prior to finalising any structure plans for the site that an adequate study on the wetlands in the area be undertaken to confirm mapping and if necessary modify any wetlands boundaries and classification for the subject site in accordance with DEC's standard process. If you are involved in any other similar planning processes it would be good to see this wetland review work done prior to any water and drainage planning to avoid similar situations (and ensure that the LWMS can be implemented without wetland impacts).

Thanks and if you have any queries then feel free to ring.

Jacqui

Jacqui Maguire
Department of Environment & Conservation
Swan Coastal District
Ph: 9303 7743 Fax: 9405 0777
Mobile: 0439 977 455
Email: jacqui.maguire@dec.wa.gov.au

From: Bothma, Jorine [mailto:Jorine.Bothma@planning.wa.gov.au]
Sent: Monday, 8 October 2012 2:40 PM
To: Maguire, Jacqui
Subject: RE: Advice on reclassification of CCW in Serpentine Townsite

Jacqui

Hope you had a great weekend and good luck for the first full week ahead after the Public Holiday.

I am attaching the photos I have taken of the site this morning. I hope I have captured the correct species and that it was done at the right angles. Could you please forward them on to your Wetlands branch? I have captured the entire scope of the CCW 14974 site. However, if I need to take some more pictures I will do so gladly please do not hesitate to ask.

Thanks so much for your kind assistance.

Kind Regards

JORINE BOTHMA
Senior Strategic Planner– Metropolitan South East
Perth and Peel Planning
Department of Planning
L 5, 140 William Street
PERTH WA 6000
P: 08 6551 9539 | F: 08 6551 9001
E: Jorine.Bothma@planning.wa.gov.au

From: Maguire, Jacqui [mailto:Jacqui.Maguire@dec.wa.gov.au]
Sent: Monday, 24 September 2012 10:04 AM
To: Bothma, Jorine
Subject: RE: Advice on reclassification of CCW in Serpentine Townsite

HI Jorine,

I have sent your email onto our Wetlands Branch at DEC and they have agreed that the site does appears degraded from the aerial photo and probably warrants a reclassification (downgrade of management category). While they accept that on this occasion that the full process may not be required, it would be very useful for them to have some current on-ground photos of the site. They will not have the opportunity to get out there and take these so I wondered if you could arrange for the consultants to do it? They just need to note the current vegetation (if any) on site and level of inundation (if any).

If you can get these photos, you can send them to me and I can provide them to our Wetlands Branch for review.

Cheers

Jacqui

Jacqui Maguire
Department of Environment & Conservation
Swan Coastal District
Ph: 9303 7743 Fax: 9405 0777
Mobile: 0439 977 455
Email: jacqui.maguire@dec.wa.gov.au

From: Bothma, Jorine [mailto:Jorine.Bothma@planning.wa.gov.au]
Sent: Friday, 21 September 2012 11:20 AM
To: Maguire, Jacqui
Subject: Advice on reclassification of CCW in Serpentine Townsite

Jacqui

I am so sorry I missed your visit the other day; it would have lovely to meet up with you. Hope all is well with the weekend a few hours away.

I need to pick your brain on something please. I have decided to send you my question in an email as I do not want to bombard you unnecessarily and it allows you to respond at your own leisure. If we could have a way forward to the consultants within the next two weeks it would be just fine.

OK, HERE IT IS...
The Department of Planning has appointed GHD to undertake a Local Water Management Strategy for the Serpentine Townsite area. This is done in good faith to assist the Shire with a Local Structure Plan for the Townsite area.

There is a conservation category wetland located at 51 Tonkin Street (no 14974). (See attachment to this email). The consultant reported that this wetland appears to have been cleared in the past and is unlikely to support any values for which water conservation was awarded. However, in order to re-classify this wetland under a less stringent management category, a request to update the Geomorphic Wetlands Swan Coastal Plain dataset must be submitted to DEC. This would involve amongst other things a desktop study and wetland vegetation condition assessment. The draft LWMS was also referred to Department of Water (DoW). DoW inquired whether the wetland was going to be reclassified before or after approval of the LWMS. Is it possible to defer this re-classification to after the LWMS? The Department does not have sufficient funds left on this project budget to undertake the re-classification prior to finalising the LWMS and I was wondering whether there was any way around it. I could also maybe add that the proposed land use of this wetland will remain R10 and R5.

I may also be worth to mention that the Lambkin Reserve (Conservation Category wetland) and Richardson Street POS (Bush Forever site) is also located within the Townsite area even though they are not part of the developable area. We are currently amending our proposed layout plan to have road interfaces right around Lambkin Reserve similar to the Richardson Street POS.

Kind Regards and thanks a million

JORINE BOTHMA
Senior Strategic Planner– Metropolitan South East
Perth and Peel Planning
Department of Planning
L 5, 140 William Street
PERTH WA 6000
P: 08 6551 9539 | F: 08 6551 9001
E: Jorine.Bothma@planning.wa.gov.au

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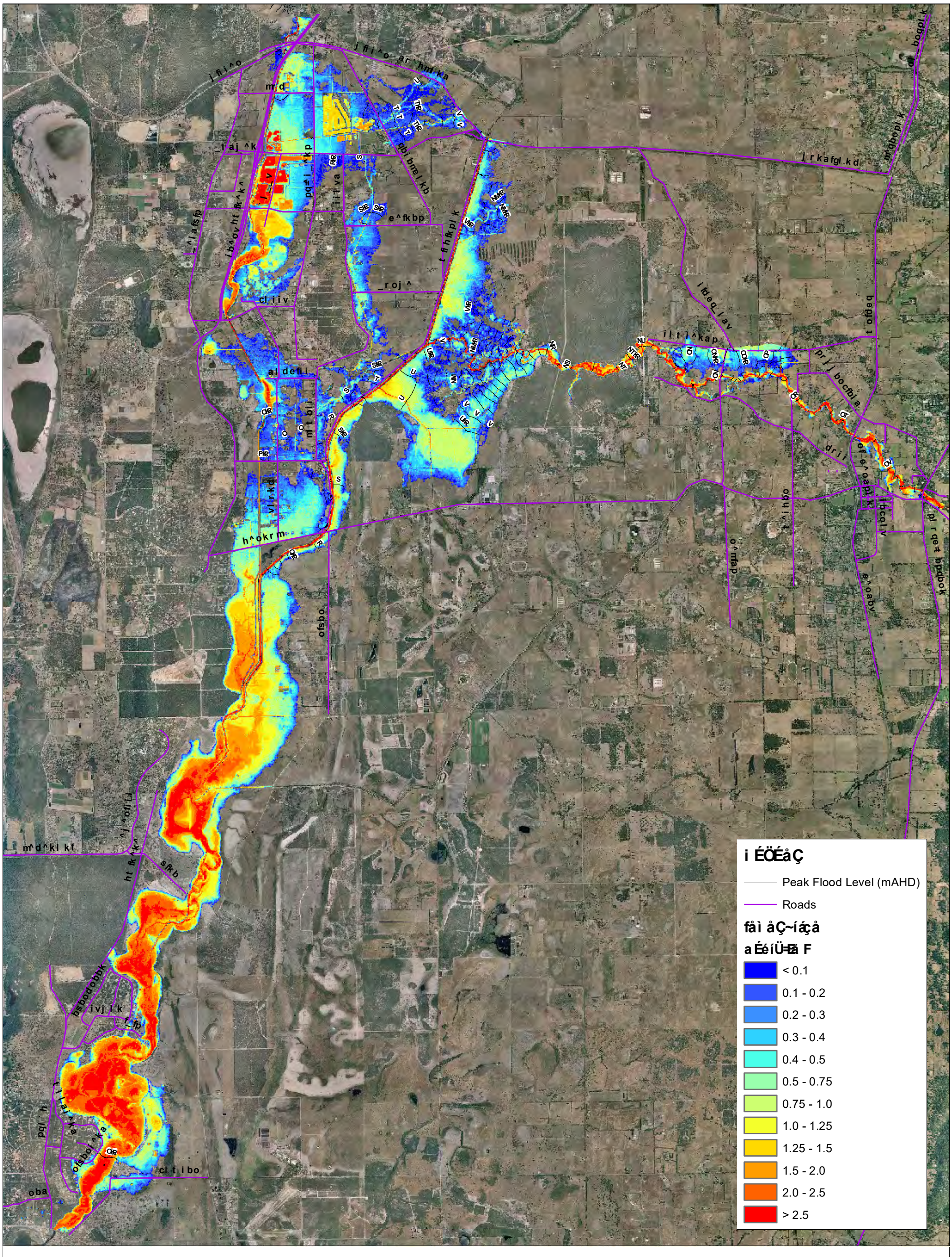
Appendix I – SKM Serpentine Flood Study 100 year ARI Flood map


i ÉÖÉåÇ
Peak Flood Level (mAHD)
Roads
fåì åÇ~íáçå
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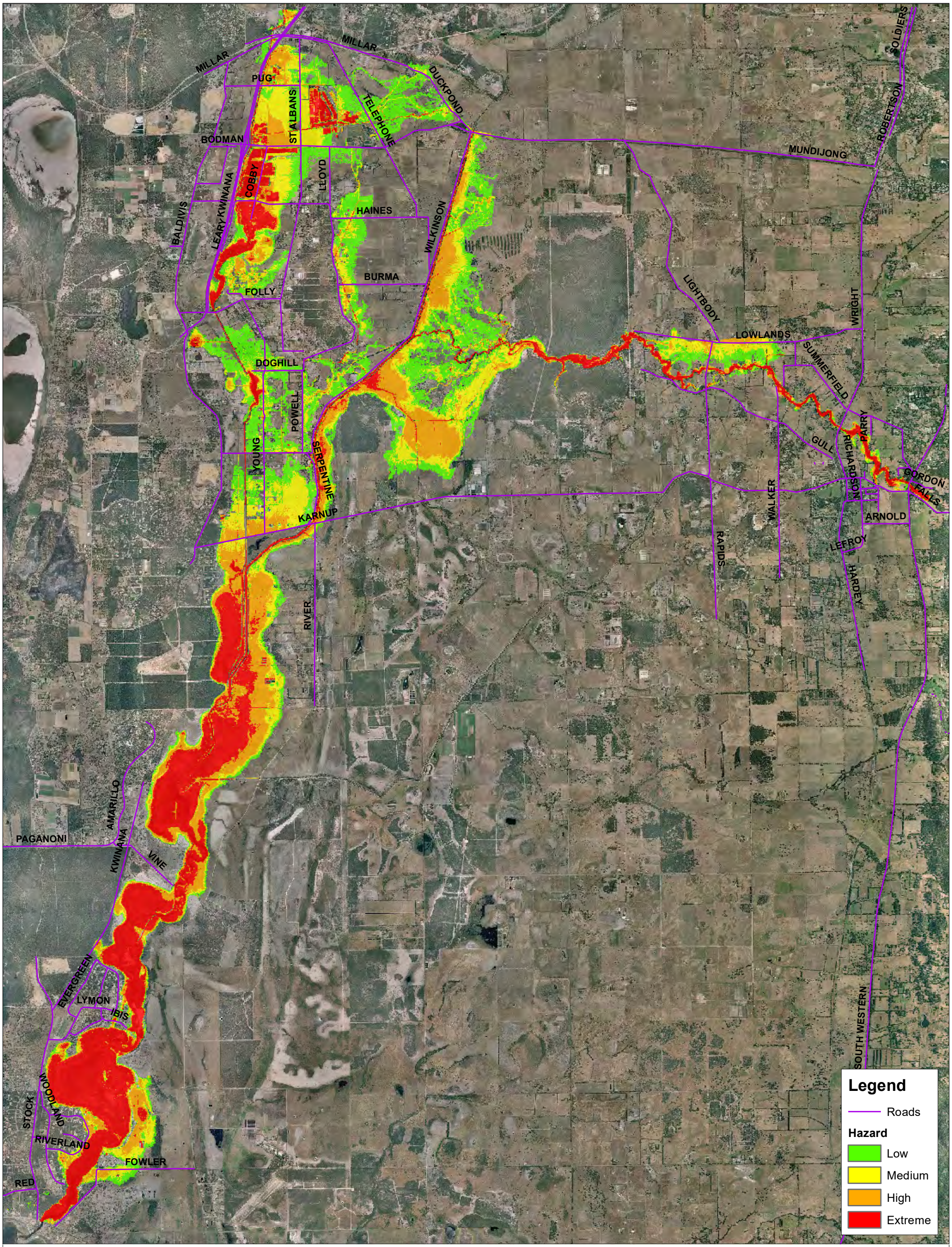
< 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.75
0.75 - 1.0
1.0 - 1.25
1.25 - 1.5
1.5 - 2.0
2.0 - 2.5
> 2.5
0 0.5 1 2 3 4 5
Kilometres
Author: Sarah Gosling
Date: 05/02/10
Job No: QE09396.100
SINCLAIR KNIGHT MERZ
SKM
I:\QENV\Projects\QE09396\Spatial\Arc_MXD\Serpentine\Figures\Serpentine_Existing_100y_Inundation.mxd



SERPENTINE RIVER FLOOD STUDY

Figure A-2 100 Year ARI Event Flood Hazard - As Existing

0 0.5 1 2 3 4

Kilometres

Author: Sarah Gosling
Date: 05/02/10
Job No: QE09396.100

SINCLAIR KNIGHT MERZ
SKM

I:\QENV\Projects\QE09391\Spatial\Arc_MXD\Serpentine\Figures\Serpentine_Existing_100y_Hazard.mxd

Appendix J – Plant Selection List

	6128174 "Serpentine Outline Plan LWMS"- PLANT SELECTION LIST						
	Infiltration Basins						
	BOTANICAL NAME		**COMMON NAME**	**HEIGHT**	**WIDTH**	**LOCATION**	
	Melaleuca	preissiana	Stout paperbark	6-10m	3-5m	Tolerates waterlogged soils. Periodic inundation Salt Water Tolerant	Uplands
	Melaleuca	rhaphiophylla	Freshwater paperbark	6m	3m	Wet depressions or clay flats	Levee/ Channel
	Melaleuca	cuticularis	Saltwater paperbark	5m	6m	tolerant to both waterlogging and in the salt air and water - Drought tolerant	
	Melaleuca	lateritia	Robin redbreast bush	2.5m		Fringing watercourses and in wet seasonally depressions	
	Banksia	littoralis	Swamp banksia	12m		Swampy areas, does not tollerate inundation, prefers areas subject to only short winter water logging. -Deep sands and well drained soils, drought resistant	
	Banksia	seminuda	River banksia	20m		Richer heavier soils along riverbanks and seasonally wet depressions	
	Carex	appressa	Tall sedge	2m	0.5m	Brackish water, occur seasonally inundated or shallow permanent water	Levee
	Carex	fascicularis	Tassel sedge	1.5m	1m	Fresh to brackish water. Seasonally waterlogged or partially inundated watercourses and lake margins	Levee
	Carex	inversa	Knob sedge	0.1-0.15m	0.2m	seasonally wet or water logged soils and in fresh to semi saline conditions.	
	Dianella	caerulea	King Alfred	0.3-0.5m			
	Dianela	revoluta	Little Rev	0.3-1.5m		Variety of soils, laterite, granite, limestone	
	Lomandra	histrix	Tropic Belle				
	Lomandra	longifolia					
	Juncus	caespiticius	Grassy rush	.09-.6m		Peaty Saline sand, winter depressions	
	Juncus	holoschoenus	Jointleaf rush	.3-1m		Sand, swamps, creeks.	
	Juncus	kraussii	Sea rush	0.8-1.5m		Saline to brackish habitats fringing watercourses and lakes, also on sea shores	Channel- Levee
	Juncus	pallidus	Pale rush	2m		Common in seasonally damp areas. Max water depth 0.05m	(Levee)
	Juncus	pauciflorus	Loose flower rush	1m		Permanently damp or seasonally wet soil fringing fresh watercourses	Levee
	Juncus	subsecundus	Finger rush	1m		Moist seasonally wet soils	Levee
	Goodenia	pulchella	subsp. Coastal Plain	0.5m		Seasonally wet sites, undulating dunes	
	Eucalyptus	occidentalis	Flat-topped-yate	20m	5m	Wet depressions or clay flats	Uplands
	Eucalyptus	rudis	Flooded gum	25m	4m	prolonged periods of flooding usually found in waterlogged areas,	
	Casuarina	cunninghamiana		5-9m	5m	Loam over granite, Eucalyptus woodlands along creek edge	
							Levee
	Ficinia	nodosa	Knotted club rush	1m		Sands coastal dunes, winter wet depressions and fringing rivers and lke margins - Highly tolerant to salt spray and waterlogging-	
							levee/ uplands
	Lepidosperma	gladiatum	Coastal sword-sedge	1.5m		Perennial, found in seasonally moist or wet sands as well as dry dunes, full sun- part shade - Tolerates direct salt winds and alkaline soils.	
	Bioretention Swales and Pockets						
	Carex	appressa	Tall sedge	2m	0.5m	Brackish water, occur seasonally inundated or shallow permanent water	
	Carex	appressa	Tassel sedge	1.5m	1m	Fresh to brackish water. Seasonally waterlogged or partially inundated watercourses and lake margins	
	Carex	inversa	Knob sedge	0.1-0.15m	0.2m	seasonally wet or water logged soils and in fresh to semi saline conditions.	
	Juncus	caespiticius	Grassy rush	.09-.6m		Peaty Saline sand, winter depressions	Channel- Levee
	Juncus	holoschoenus	Jointleaf rush	.3-1m		Sand, swamps, creeks.	(Levee)
	Juncus	kraussii	Sea rush	0.8-1.5m		Saline to brackish habitats fringing watercourses and lakes, also on sea shores	Levee
	Juncus	pallidus	Pale rush	2m		Common in seasonally damp areas. Max water depth 0.05m	Levee
	Juncus	pauciflorus	Loose flower rush	1m		Permanently damp or seasonally wet soil fringing fresh watercourses	
	Juncus	subsecundus	Finger rush	1m		Moist seasonally wet soils	

							Levee
	Ficinia	nodosa	Knotted club rush	1m		Sands coastal dunes, winter wet depressions and fringing rivers and lke margins - Highly tolerant to salt spray and waterlogging-	
	Dianella	caerulea	King Alfred	0.3-0.5m			levee/ uplands
	Dianela	revoluta	Little Rev	0.3-1.5m		Variety of soils, laterite, granite, limestone	
	Lomandra	histrix	Tropic Belle				
	Lomandra	longifolia					
	Lepidosperma	gladiatum	Coastal sword-sedge	1.5m		Perennial, found in seasonally moist or wet sands as well as dry dunes, full sun- part shade - Tolerates direct salt winds and alkaline soils.	
		Found In SMEC_Enviro Report-Species Extracted					
	Ornimental Landscape Plant						

Appendix K – Checklist for integrated water cycle management assessment of local structure plan

Checklist for integrated water cycle management assessment of local structure plan or local planning scheme amendment

1. Tick the status column for items for which information is provided.
2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column.
3. Provide brief comments on any relevant issues.
4. Provide brief description of any proposed best management practices, eg. multi-use corridors, community based-social marketing, water re-use proposals.

Local water management strategy item	Deliverable	☑	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements & requirements for BMPs and critical control points	☑	
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		☑	Section 1
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	☑ ☑	Section 2 Appendix A, B and C
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	☑	Section 2 Figure 2
Design criteria			
Agreed design objectives and source of objective		☑	Section 3
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 4
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	☑	Figure 5
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Figure 6
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	☑	Figure 8
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	☑	Figure 5 Appendix E and G
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	☑	Available information provided in Section 3
Water use sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		☑	Section 5
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		☑	Section 5
Wastewater management		☑	Section 5
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100yr event Plan Long section of critical points	☑ ☑	Section 6 Figure 10 Appendix E
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event Plan	☑	Section 6 Appendix E

Local water management strategy item	Deliverable	☑	Comments
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan Typical cross sections	☑ ☑	Section 6 Typical cross section provided in Figure 9
Groundwater management strategy			
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	☑	Section 7 Figure 11 and 12
Actions to address acid sulfate soils or contamination		☑	
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		☑	Section 8
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 9
Implementation			
Developer commitments		☑	Section 10
Roles, responsibilities, funding for implementation		☑	Section 10
Review		☑	Section 10

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	A Drummond	M Busbridge	On File	N Gamage	On File	Not Released
1	M Busbridge	N Gamage	On File	N Gamage	On File	06/06/12
2	M Busbridge	N Gamage	On File	N Gamage	On File	18/12/12
3	M Busbridge	N Gamage	On File	N Gamage	On File	21/01/2013
4	S Glasson	N Gamage	On File	N Gamage	On File	13/02/2013

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Serpentine Townsite

Local Water Management Strategy Addendum

Prepared for Shire of Serpentine Jarrahdale

By Urbaqua

March 2023

urbaqua
land and water solutions

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1 ADDENDUM INTRODUCTION

The Serpentine Townsite Local Water Management Strategy (LWMS) (GHD, 2013) was prepared to support the Local Structure plan and provide water management strategies based on available site investigations, regional information, site layout, and guiding documents at the time. This addendum updates the water management strategies to reflect revisions to the site concept, additional investigations that have since been completed, and further guiding documents that are now relevant.

Since completion of the LWMS, additional site investigations have been undertaken in support of subdivision within the Study Area, and planning upstream. These include the *109 Lefroy Street, Serpentine Urban Water Management Plan* (McDowall Affleck, 2017) and the *Lots 102 to 106 Rudall Street Serpentine Townsite Flood Modelling Report* (Coterra, 2017). The latter, through detailed flood modelling, indicated that the Public Open Space (POS) on the eastern boundary could be reduced without impacting on flood risks and management.

These investigations, along with other planning considerations, have led to the preparation of the revised Local Structure Plan, shown in Figure 1. The plan has the following modifications:

- Reduced density, with the removal of R10 and implementation of R5 across the site;
- Modified POS on the eastern side; and
- Minor road modification.

The revised water management strategies also consider the latest guidance from the *Decision Process for Stormwater Management in Western Australia* (DWER, 2017) and the *Government Sewerage Policy* (DPLH, 2019). Revisions to strategies based on these documents are outlined in the relevant sections.

This addendum provides additional or revised information based on the information outlined above. The document is structured to mimic the previous LWMS structure, with text provided only for the sections that require updating. The addendum should be read in conjunction with the LWMS (GHD, 2013) for complete context.

1.1 Total water cycle management – principles and objectives

No revisions - as per LWMS.

1.2 Planning background

No revisions - as per LWMS.

1.3 Previous studies

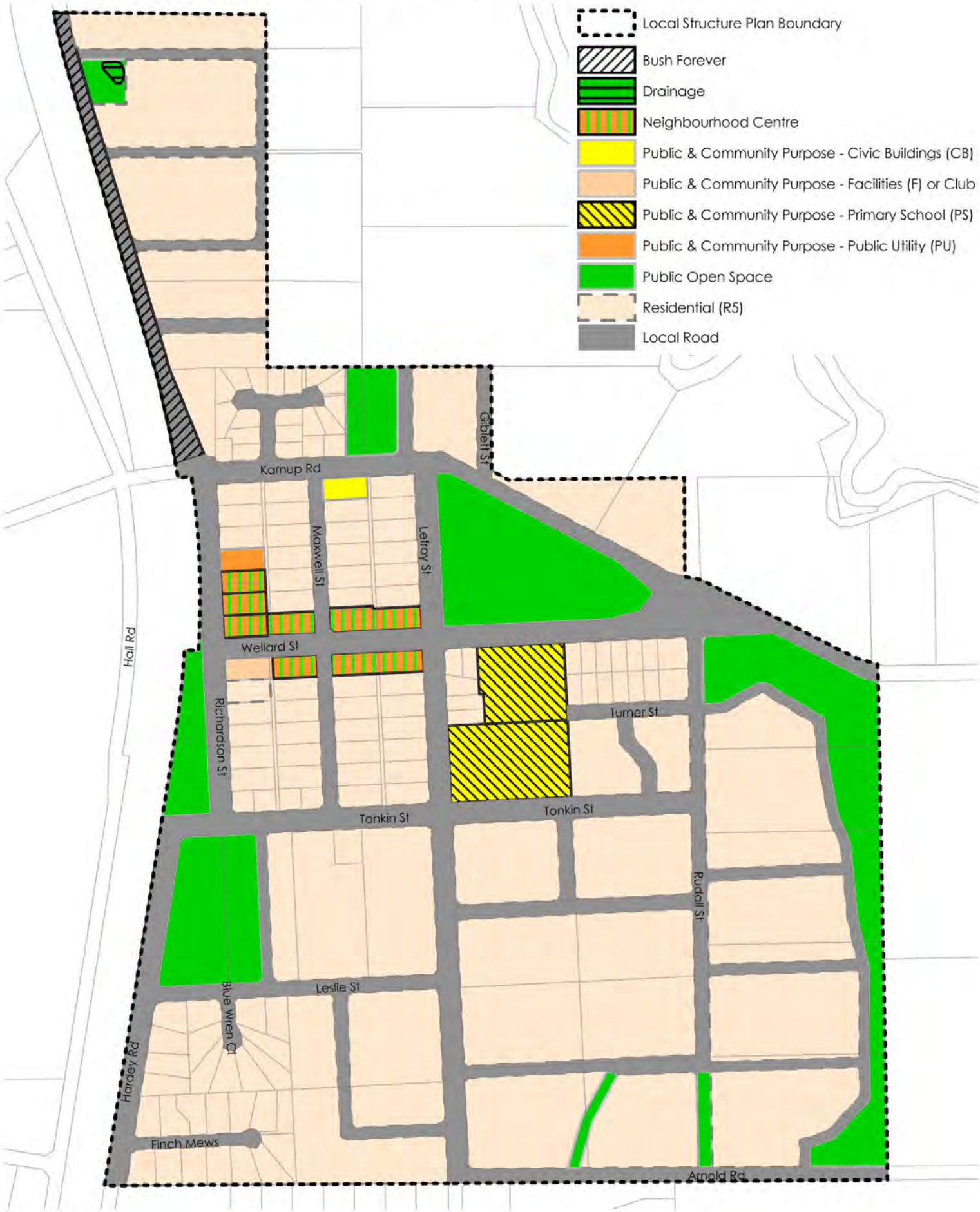
Additional information to the LWMS content.

Two relevant studies have been completed within the Study Area since the LWMS was prepared. The *109 Lefroy Street, Serpentine Urban Water Management Plan* (McDowall Affleck, 2017) was prepared in support of 13 green title lots in the south west corner of the Study Area. Onsite geotechnical investigations did not identify groundwater within 2.5 m beneath the surface, though shallow, perched groundwater would be anticipated during wetter months. In

this subdivision, the 1 year ARI event (1 hour) is retained onsite in soakwells (installed within imported fill material). The 5 year ARI event discharges either to an existing basin to the west or to Lefroy Street depending on the internal catchments. The 100 year ARI discharges to the Lefroy Street swale to Hardy Creek Main Drain.

The *Lots 102 to 106 Rudall Street Serpentine Townsite Flood Modelling Report* (Coterra, 2017) was prepared to outline an alternative configuration of the Hardy Creek Main Drain and increase developable land within this site. Detailed 2D flood modelling was undertaken to determine the 1, 5 and 100 year ARI floodplains based on LIDAR data and hydrological modelling. The modelling results indicated that the drain could be realigned as a living stream on the eastern boundary of the site. The recommended layout has been incorporated into the revised structure plan (Figure 1).

Shire of Serpentine Jarrahdale - Serpentine Townsite Local Water Management Strategy
Figure 1 - Serpentine Townsite Local Structure Plan



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metres
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2 PROPOSED DEVELOPMENT

2.1 Key elements in the Serpentine Outline Plan

Revised information to the LWMS content.

The proposed development (Figure 1) will no longer include R10 zoning, only R5 zoning.

2.2 Land uses

Revised information to the LWMS content.

The revised outline plan is provided in Figure 1 and Appendix A.

2.3 Public open space

Owing to changes in the living stream configuration (Section 6.3), the POS schedule across the site has been modified. Revised areas (with reference to previous calculations) are provided in Table 1 and Table 2. A detailed POS schedule is provided in Appendix 2. The revised numbers are based on measurement of the proposed structure plan (Unrestricted POS Areas), updated modelling information from Coterra (2017) and/or the LWMS (GHD, 2013).

With regards to the POS calculations, deductions for land that accommodates stormwater runoff from less than the 1 year ARI event (Hardey Creek drain and Lefroy St drain) have been included in the POS schedule. Land that manages stormwater runoff from between the 1 year ARI event and the 5 year ARI event is restricted POS, while land that manages stormwater above the 5 year ARI event is unrestricted POS, consistent with Liveable Neighbourhoods (2009).

Table 1: Unrestricted POS

Unrestricted POS components	LWMS Area (2013)	Revised Area (2023)
Hardey's Creek POS 1	3,699 m^2	-
Hardey's Creek POS 2	80,788 m^2	20,620 m^2
Karnup Road POS	45,529 m^2	43,044 m^2
Lefroy Street POS	8,029 m^2	6,487 m^2
North Park	2,902 m^2	3,070 m^2
Spencer Park	8,982 m^2	9,065 m^2
Total Unrestricted POS	149,930 m^2	82,286 m^2
Unrestricted POS Credit	149,929 m^2	82,286 m^2

Table 2: Restricted POS

Unrestricted POS components	LWMS Area (2013)	Revised Area (2023)
Hardey's Creek Basin	10,140 m^2	17,850 m^2
Hardey's Creek Main Drain	3,065 m^2	2,458 m^2
Lefroy Street Drain	3,436 m^2	2,139 m^2
North Park Basin	673 m^2	684 m^2
Spencer Park Basin	-	456 m^2
Richardson Street POS	10,500 m^2	8,455 m^2
Total Restricted POS	27,815 m^2	32,043 m^2
20% Credit	22,078 m^2	21,790 m^2

3 DESIGN CRITERIA

3.1 Water conservation

No revisions - as per LWMS.

3.2 Water quantity management

No revisions - as per LWMS.

3.3 Water quality management

Revised information to the LWMS content.

Water quality management remains a key component of the water management strategy. The *Decision Process for Stormwater Management in Western Australia* (DWER, 2017) states that the first 15 mm of rainfall should be managed prior to discharge to a receiving environment (rather than 2% of the connected impervious area).

3.4 Commitment to best management practice

Additional information to the LWMS content.

Proposed new areas of development, as well as existing areas that have the opportunity to be retrofitted, should include current best practice water quality improvement measures and infiltration higher in the catchment utilising roadside rain gardens, median swales and tree pits

3.5 Objectives and strategy

Revised information to the LWMS content.

Table 3: Water management objectives and strategies

	Objective	Strategy (2013)	Revised Strategy (2023)
Water Conservation	Maximise the reuse of stormwater. Limit potable water use outside of homes and buildings. Reduce the average per capita potable water consumption.	Minimise potable water use outside of homes and buildings by providing alternative supplies and reducing demand by mandating the use of rainwater harvesting as the primary potable water source	No revisions.
Water Quantity	Maintain the total water cycle balance for ecological	Stormwater runoff shall be retained for up to the 1 hr 1-year ARI event off	The 15 mm rainfall event will be managed onsite. No revisions to

	Objective	Strategy (2013)	Revised Strategy (2023)
	protection Minimise potential surface water pollution by use of non-structural and structural controls, in accordance to WSUD and BMP's. Protect property and infrastructure within and downstream of the development, to the required level of protection.	line from major flow paths. Attenuation of peak 5 and 100-year ARI developed flows to pre-development flows. Provide for the 100-year overflow path. Floor levels of all habitable buildings pad levels 0.5 m above the 100-year event flood level. Floor levels of all habitable buildings shall be a minimum of 1.2 m above groundwater level.	management of 5 year and 100 year ARI flows. No revisions to the separation to flood levels. Minimum groundwater level separation for treated wastewater disposal is 1.5 m.
Water Quality	Maintain or improve the surface and groundwater quality within the study area relative to predevelopment conditions. Maintain groundwater levels within the natural regime.	Using structural controls such as swales representing 2% of the connected impervious catchment in combination with non-structural controls such as public education campaigns, use of low phosphorus fertilisers in POS areas, to minimise potential pollution of stormwater and groundwater. Preliminary water quality targets will be established for the study area and reviewed and refined based upon future monitoring. Existing drainage inverts shall be maintained where possible.	Bio-filters should be sized to manage the 15 mm event rather than 2% of the connected impervious catchment. No revisions to the establishment of water quality targets or drainage inverts.

4 EXISTING ENVIRONMENT

4.1 Location

No revisions - as per LWMS.

4.2 Climate

Additional information to the LWMS content.

Inclusive of available 2020 rainfall data, the annual rainfall average is 921 mm (down from 928 mm reported in the LWMS). Since 2000, the annual rainfall is approximately 753 mm, down approximately 18% from the long term average.

4.3 Topography

No revisions - as per LWMS.

4.4 Land use

Additional information to the LWMS content.

Additional subdivision has occurred along Lefroy Street (R5) and the eastern end of Wellard Street (R10) since completion of the LWMS. The former is discussed in the *109 Lefroy Street, Serpentine Urban Water Management Plan* (McDowall Affleck, 2017).

4.5 Soils

No revisions - as per LWMS.

4.6 Reserves, conservation areas and environmentally sensitive areas

4.6.1 Bush forever

No revisions - as per LWMS.

4.6.2 Aboriginal heritage

No revisions - as per LWMS.

4.6.3 Environmentally sensitive areas

Additional information to the LWMS content.

The LWMS outlines that the majority of the site is mapped as an environmentally sensitive area. Revisions to the mapping have resulted in an extension of the environmentally sensitive areas to the east of the Study Area, including Hardy Creek Main Drain.

4.6.4 Significant flora and fauna

No revisions - as per LWMS.

4.7 Waterways, wetlands and drainage

4.7.1 Surface water

No revisions - as per LWMS.

4.7.2 Geomorphic wetlands

The wetland at Tonkin Street (No. 14974) was previous classified as a Conservation Category Wetland (CCW) and has been reclassified as Multiple Use wetland.

4.8 Groundwater

No revisions - as per LWMS.

5 SUSTAINABLE WATER USE STRATEGY

5.1 Water Efficient Fixtures and Fittings

No revisions - as per LWMS.

5.2 Efficient landscaping and irrigation measures

No revisions - as per LWMS.

5.3 Fit-for-purpose water sources

Revised information to the LWMS content.

Irrigation from ATUs will be required to be disposed of only in dedicated areas (discussed in Section 5.5), and may not be sufficient for irrigation across the lot. Rainwater tanks and garden bores will be required for additional irrigation requirements.

5.4 Rainwater harvesting water balance

No revisions - as per LWMS.

5.5 Wastewater

Additional information to the LWMS content.

The proposed wastewater management strategy is now guided by the *Government Sewerage Policy* (Government of WA, 2019) that outlines specific requirements for sewage sensitive areas. The Study Area is entirely located within a sewage sensitive area related to the estuary catchments on the Swan and Scott Coastal Plain. Future development within sewage sensitive areas will be limited to a minimum of 1 ha lots, though the areas within the Study Area are possible as they are already zoned for urban use (permitting up to R10) (Government of WA, 2019).

No sewer system is proposed for this area, and lots will dispose of wastewater with secondary treatment units (Aerobic Treatment Units (ATUs)) with nutrient removal. These systems will require design to ensure that they maintain 1.5 m clearance to groundwater and there is sufficient disposal area based on soil types. Based on typical requirements for a single house, at least 180 m^2 is required for disposal via irrigation (Government of WA, 2019).

Effluent disposal areas shall address setback requirements to water resources (groundwater and surface water), and the disposal areas and location indicated on a plan. The disposal area is required to be at least 100 m away from any drainage components (discussed further in Section 6.5) and 30 m from private bores used for household drinking water purposes.

Adherence to these design criteria will be the responsibility of developer and demonstrated through the preparation of Urban Water Management Plans (see Section 9.1), or a site and soil evaluation in accordance with *AS/NZS 1547 On-site domestic wastewater management*. Both

will demonstrate the site and soil conditions, along with the capacity to accommodate the disposal application.

Land owners will be responsible for the operation and maintenance of the ATUs and the Shire will be responsible for audits, inspection and enforcement of compliance with Department of Health endorsed maintenance schedules and operating standards (Government of WA, 2019).

6 STORMWATER MANAGEMENT STRATEGY

6.1 Floodplain Management

Additional information to the LWMS content.

Recommendations for floodplain management were previously guided by the Serpentine River Floodplain management strategy (SKM, 2010), a regional 2D model of the catchment from the South West Highway to Mandurah. Subsequent flood modelling of the Hardy Creek Main Drain (Coterra, 2017) provides further guidance on the flood levels through the site, and subsequent revisions to the site layout. Details of this flood modelling are discussed in Sections 6.2 and 6.3 below.

Planning measures recommended in the Serpentine River Floodplain management strategy (SKM, 2010) are still applicable.

6.2 Pre development

Revised information to the LWMS content.

The *Lots 102 to 106 Rudall Street Serpentine Townsite Flood Modelling Report* (Coterra, 2017) outlines revised flood modelling undertaken for the Hardy Creek Main Drain. The modelling was updated to consider conditions specific to the local catchment (preference for dispersed flows on the flat and low-lying land) and culvert sizes and spill levels based on survey information rather than assumptions in the previous model. The revised model also included 1D elements within the 2D domain to improve accuracy. The Coterra modelling identified higher pre-development flows than the previous LWMS, as presented in Table 4.

Table 4: Flow Comparison LWMS (GHD, 2013) and Revised Flood Modelling (Coterra, 2017)

Peak Flows	LWMS	Revised Flood Modelling
Arnold Road Basin		
5 year ARI	6.00 m^3/s	5.85 m^3/s
100 year ARI	11.68 m^3/s	11.77 m^3/s
Karnup Road		
5 year ARI	8.17 m^3/s	10.93 m^3/s
100 year ARI	17.90 m^3/s	20.51 m^3/s

The pre-development flooding extent is shown in Appendix 3.

6.3 Stormwater Quantity

Revised information to the LWMS content.

The management of stormwater runoff through the site, particularly for flood storage, is influenced by the revised modelling undertaken by Coterra (2017). The LWMS outlines a multiple use corridor with a living stream on the eastern side of the POS. The alternative design

presented by Coterra has the living alignment on the eastern edge of the POS, increasing the developable area. The revised living stream alignment maintains the cross-sections presented in the LWMS and culverts at Wellard Road will be upgraded to 2 x 1500 mm diameter as per the LWMS. Inverts for the online basin (2Basin) were adjusted to reflect additional topographic information.

6.3.1 Proposed stormwater management strategy

No revisions - as per LWMS.

The proposed stormwater management strategy across the remainder of the site is consistent with the LWMS, namely,

- Relocation of the existing retention basin from the rear of Finch Mews and Blue Wren Court. The storage is accounted for in the future basins following development; and,
- Construction of three new retention basins (including the online basin) in order maintain pre-development flows.

The measures for the 1 year, 5 year and 100 year ARI events remain unchanged. The proposed stormwater layout is provided in Figure 2.

6.3.2 Stormwater volumes and rates

Revised information to the LWMS content.

The proposed infrastructure sizes are based on the information provided in the LWMS that is unchanged (1Basin and 3Basin) and revised modelling undertaken by Coterra (2017) for the living stream. No additional modelling has been undertaken for this addendum.

The 1 year 1 hour ARI treatment areas presented in the LWMS are based on a superseded assumption of bio-retention areas being sized equivalent to 2% of the connected impervious area. The revised guidance from DWER is that the 15 mm rainfall event should be managed, and bio-retention areas should be sized based on runoff from this event (Section 3.3).

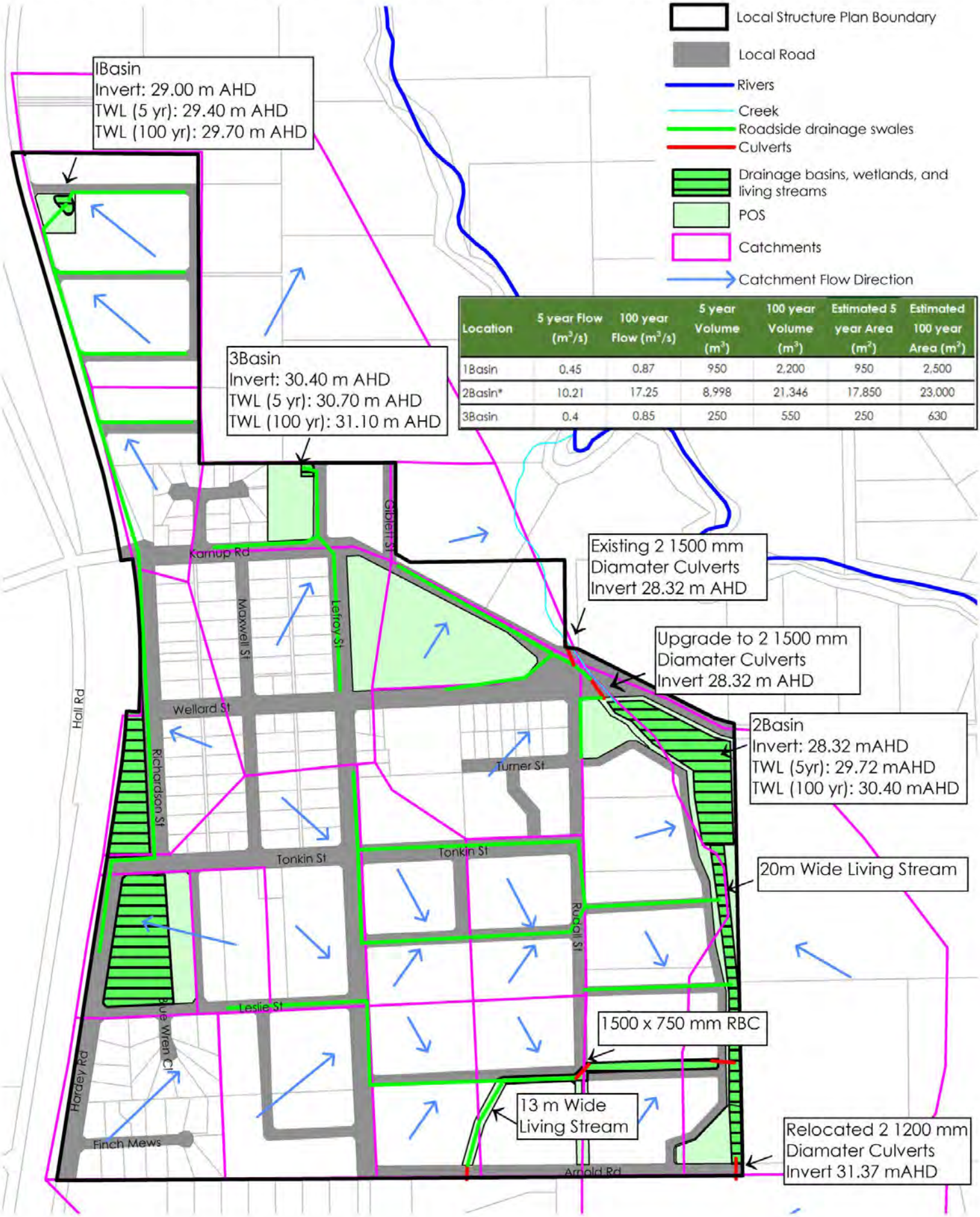
On lots, this runoff will be managed using soakwells or rainwater tanks within the lots.

For road reserves, this runoff will be managed in vegetated roadside drainage swales or in bio-retention areas co-located with drainage basins in POS areas. It is noted that in future, drainage basins may be replaced by underground storages (if preferred).

The estimated volume for the 1 year ARI event is based on the impervious portion (80%) of the road reserve areas within the catchments, multiplied by the 15 mm rainfall event (minus an initial loss of 2 mm to account for absorption in the road material). This volume doesn't account for infiltration that may occur in these systems during the rainfall event, and further refinement in detailed design may reduce the respective requirements.

The indicative storage volumes and peak flows are provided in Table 5 and Figure 2.

Shire of Serpentine Jarrahdale - Serpentine Townsite Local Water Management Strategy
Figure 2 - Revisions to the Stormwater Management Strategy



Location	5 year Flow (m^3/s)	100 year Flow (m^3/s)	5 year Volume (m^3)	100 year Volume (m^3)	Estimated 5 year Area (m^2)	Estimated 100 year Area (m^2)
1Basin	0.45	0.87	950	2,200	950	2,500
2Basin*	10.21	17.25	8,998	21,346	17,850	23,000
3Basin	0.4	0.85	250	550	250	630

Data source: SSY, DOP, MRWA . Created by:YY Projection: MGA2020: zone 50.

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Table 5: Basin Peak Flow Rates and Volumes

Location	5 year Flow (m^3/s)	100 year Flow (m^3/s)	1 year Bio-retention volume (m^3)	5 year Volume (m^3)	100 year Volume (m^3)	Estimated 5 year Area (m^2)	Estimated 100 year Area (m^2)
1Basin	0.45	0.87	210^	950	2,200	950	2,500
2Basin*	10.21	17.25	1,620^	8,998	21,346	17,850	23,000
3Basin	0.40	0.85	450^	250	550	250	630

* Coterra (2017)
^ Calculated for this addendum

Table 6: Basin Levels and Bio-retention requirements

Location	Basin Invert (mAHD)	Depth to Groundwater (m)	Top of Basin (mAHD)	5 year level (mAHD)	100 year level (mAHD)
1Basin	29.00	0.3	30.00	29.30	29.68
2Basin*	29.15	0.0	30.40	30.16	30.40
3Basin	30.39	0.3	31.39	30.69	30.97

* Coterra (2017)

6.4 Fill requirements

Revised information to the LWMS content.

The revised 100 year ARI modelling indicates that the flood depth within the online basin is up to 2.08 m, which is approximately 0.57 m higher than the basin in the LWMS. The minimum fill depth to achieve flood protection in adjacent lots may therefore be greater than the 1.5 m proposed in the LWMS. Design of the adjacent lots will be required to confirm 500 mm of separation to the 100 year flood level.

Fill require to achieve groundwater separation is dependent on further onsite monitoring and will be the responsibility of developer and demonstrated through the preparation of Urban Water Management Plans (see Section 9.1),

6.5 Stormwater Quality

6.5.1 Structural measures

Revised information to the LWMS content.

As discussed in Section 6.3.2, bio-retention areas should be sized to managed the 15 mm event based on the *Decision Process for Stormwater Management in Western Australia* (DWER, 2017). The proposed strategies in the LWMS remain applicable.

6.5.2 Non-structural measures

No revisions - as per LWMS.

6.6 Best Management Practises

No revisions - as per LWMS.

6.7 Disease Vector Management

No revisions - as per LWMS.

7 GROUNDWATER MANAGEMENT STRATEGY

7.1 Glossary of terms

No revisions - as per LWMS.

7.2 Groundwater levels

No revisions - as per LWMS.

The proposed groundwater management strategy across is consistent with the LWMS.

Additional information as a supplement to the LWMS content.

The minimum clearance for the wastewater disposal area is 1.5 m, based on guidance in the *Government Sewerage Policy* (DPLH, 2019). This disposal area may site above the surrounding lot to achieve this separation.

The lot clearance above the Maximum Groundwater Level may also be defined by the IPWEA specification; *Separation distances for groundwater controlled urban development* (2016). This approach defines separation based on soakwell disposal above the phreatic surface. This specification can minimise unnecessary fill material and associated costs for development.

Where subsoil drainage is proposed to control groundwater levels, outlets are to be provided into biofiltration areas for treatment prior to any discharge off site.

7.3 Groundwater quality

No revisions - as per LWMS

8 MONITORING

8.1 Pre-development monitoring

No revisions - as per LWMS.

8.2 Recommended post-development monitoring program

No revisions - as per LWMS.

8.3 Reporting

No revisions - as per LWMS.

8.4 Contingency Action Plan

No revisions - as per LWMS.

9 IMPLEMENTATION PLAN

9.1 Developer commitments

Additional information to the LWMS content.

The UWMPs will also need to demonstrate the following

- ability for the development to accommodate wastewater disposal, including consideration of site and soil conditions.
- fill requirements to achieve groundwater separation including further onsite monitoring where necessary.
- detailed design of any proposed subsoil drainage system including provision of biofiltration at outlets.

9.2 Roles and responsibilities

No revisions - as per LWMS.

9.3 Funding

No revisions - as per LWMS.

9.4 Next steps

No revisions - as per LWMS.

10 REFERENCES

Additional information to the LWMS content.

Coterra, 2017, *Lots 102 to 106 Rudall Street Serpentine Townsite Flood Modelling Report*.

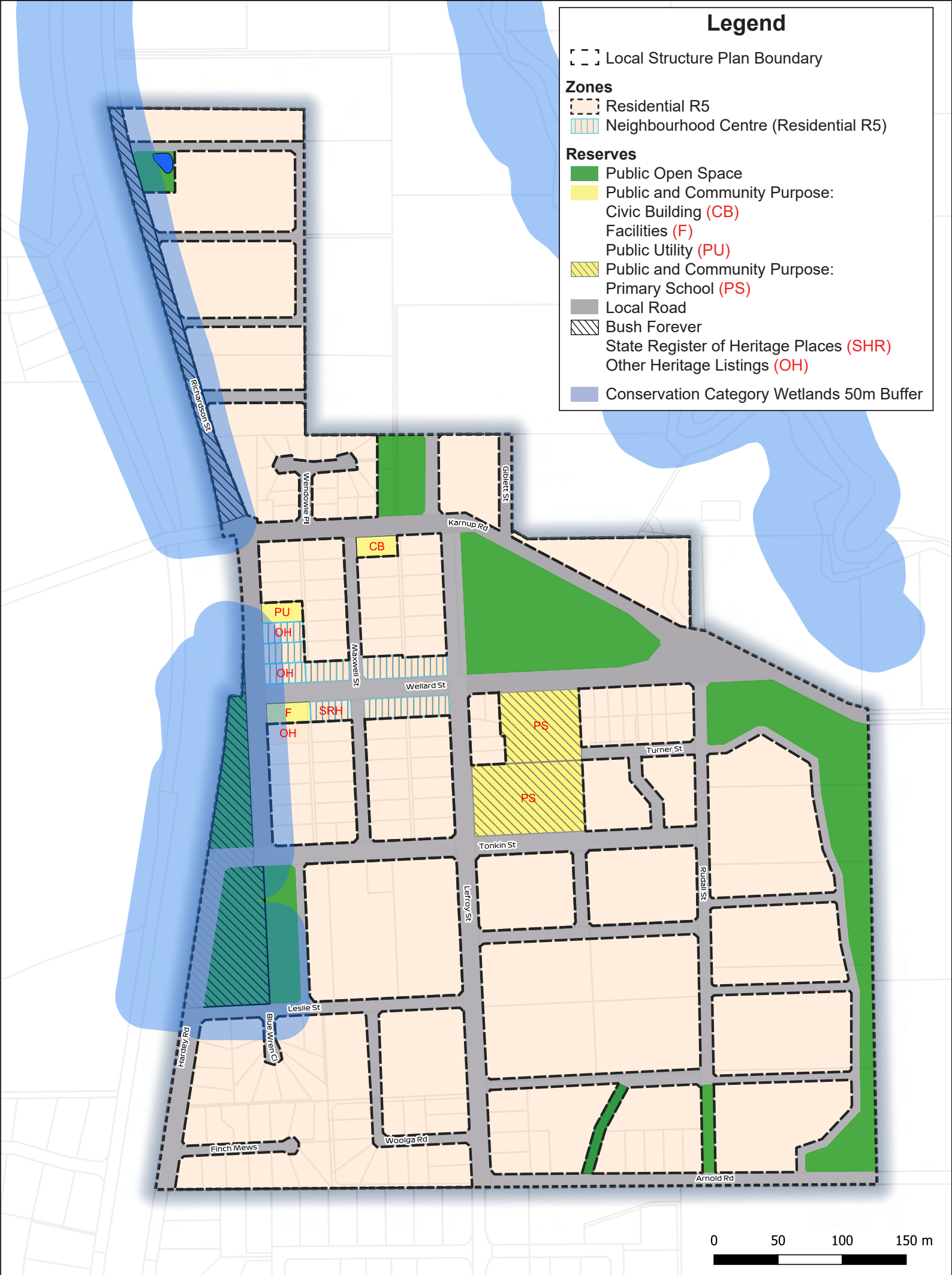
Department of Water and Environmental Regulation, 2017, *Decision Process for Stormwater Management in Western Australia*, Perth.

Government of WA, 2019, *Government Sewerage Policy*, Perth.

Institute of Public Works Engineering Australasia, 2016, *Separation Distances for Groundwater Controlled Urban Development* (Draft).

McDowall Affleck, 2017, *109 Lefroy Street, Serpentine Urban Water Management Plan*.

APPENDIX 1: DRAFT LOCAL STRUCTURE PLAN



Shire of Serpentine Jarrahdale

Serpentine Townsite Local Structure Plan

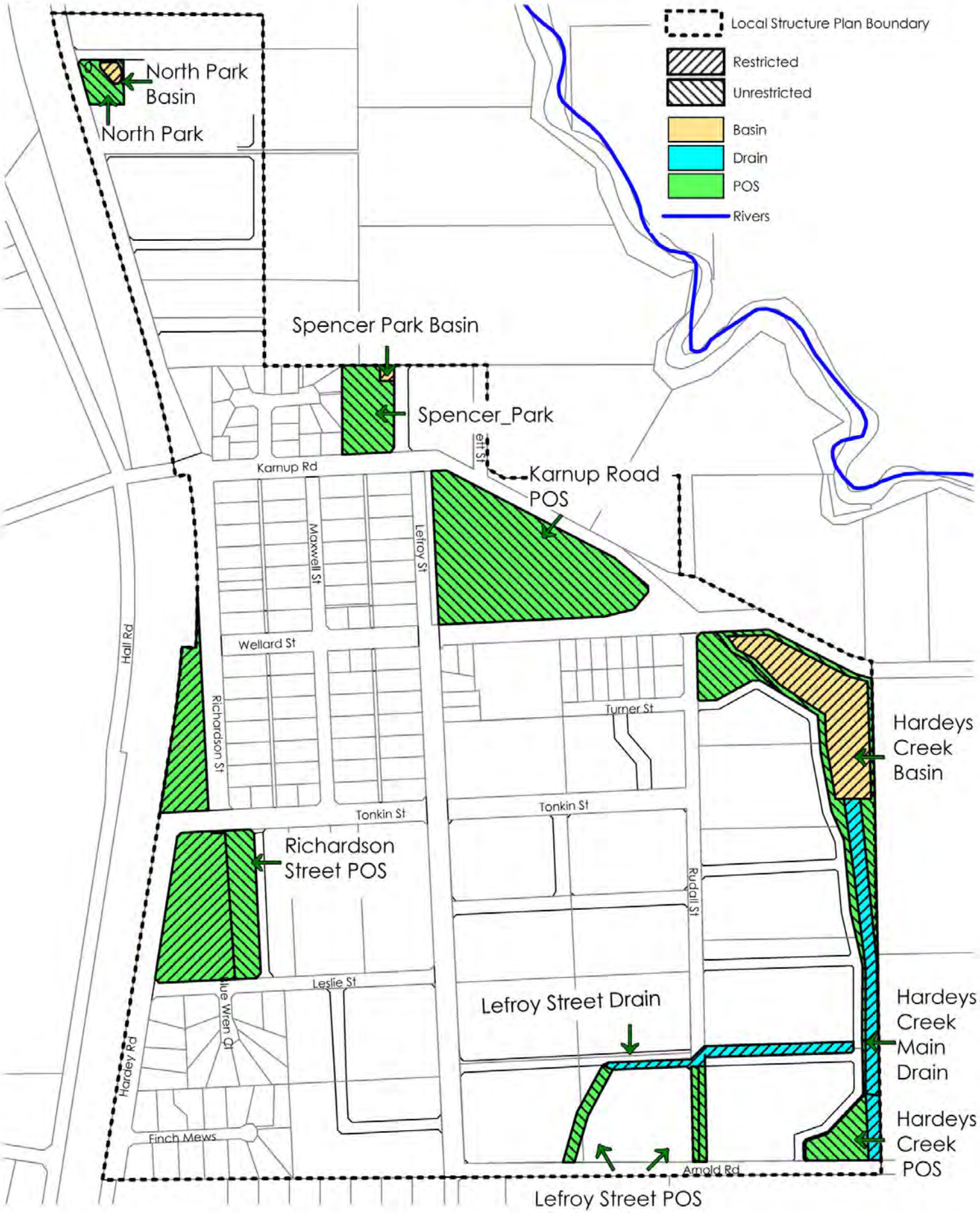
Scale : 1 : 5,000 @ A3
Compiled By: P.Leung
Created On: 27 Jan 2023
SD Request No. 44043

APPENDIX 2: POS SCHEDULE

Table 7: POS Schedule Summary

Land Parcels	LWMS Areas (m^2) (2013)	Addendum Areas (m^2) (2020)	Comment
Total Townsite Area	1,191,345	1,191,676	
Lambkin Reserve CCW	17,038	11,291	Lambkin and Richardson reserves incorrectly identified previously
Richardson POS	11,279	19,830	
Total Net Site Area	1,163,029	1,160,555	
Other Deductions			
Primary School Site	19,260	32,937	
Church Lot 51 Tonkin Street	19,396	2,187	
Commercial Lots Richardson Street	4,073	6,089	
Wellard Street Shops	8,329	12,868	
Other Commercial, Public	8,095	6,246	
Hardeys Creek Drain	-	9,137	Area based on Coterra (2017) with reduced length due to diversion
Lefroy Street Drain	-	1,605	Assumes roadside swale, 1m base, 1:6 side slopes and 150 mm depth (1yr)
Total Deductions	59,153	71,069	
Gross Subdivisable Area	1,103,876	1,089,486	
Total POS Required (10% GSA)	110,388	108,949	
POS (Unrestricted)			
Hardey Creek POS	3,699	-	
Hardey Creek POS	80,788	20,620	Reduced owing to realignment of Living Stream to the east
Karnup Road	45,529	43,044	
Lefroy Street POS	8,029	6,487	POS/MUC areas east-west and north-south (Rundall Street)
North Park	2,902	3,070	Referred to as 1Basin in LWMS
Spencer Park	8,982	9,065	Referred to as 3Basin in LWMS
Total Unrestricted POS	149,929	82,286	
POS (restricted)			
Hardeys Creek Basin	10,140	17,850	Referred to as 2Basin in the LWMS, area based on Coterra (2017)
Hardeys Creek Drain	3,065	2,458	Area based on Coterra (2017) with reduced length due to diversion. Portion carrying flow in the 1EY event has been moved to deductions
Lefroy Street Drain	3,436	2,139	Assumes roadside swale, 1m base, 1:6 side slopes and 350 mm depth (5yr), Portion carrying flow in the 1EY event has been moved to deductions
North Park Basin	673	684	
Spencer Park Basin	-	456	Not included in LWMS for unknown reasons
Richardson Street POS	10,500	8,455	
Total Restricted POS	27,815	32,043	
Maximum 20% Credit	22,078	21,790	
Totals			
Unrestricted POS Credit	149,929	82,286	
Restricted POS Credit	22,078	21,790	
Total POS Required	110,388	108,949	
Total POS Credited	172,007	104,076	
POS Oversupply	61,619	(4,873)	Shortfall due to reduced Hardey Creek POS and Lefroy Street MUC

Shire of Serpentine Jarrahdale - Serpentine Townsite Local Water Management Strategy
Figure 3 - POS Schedule



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APPENDIX 3: REVISED FLOOD MODELLING (COTERRA, 2017)

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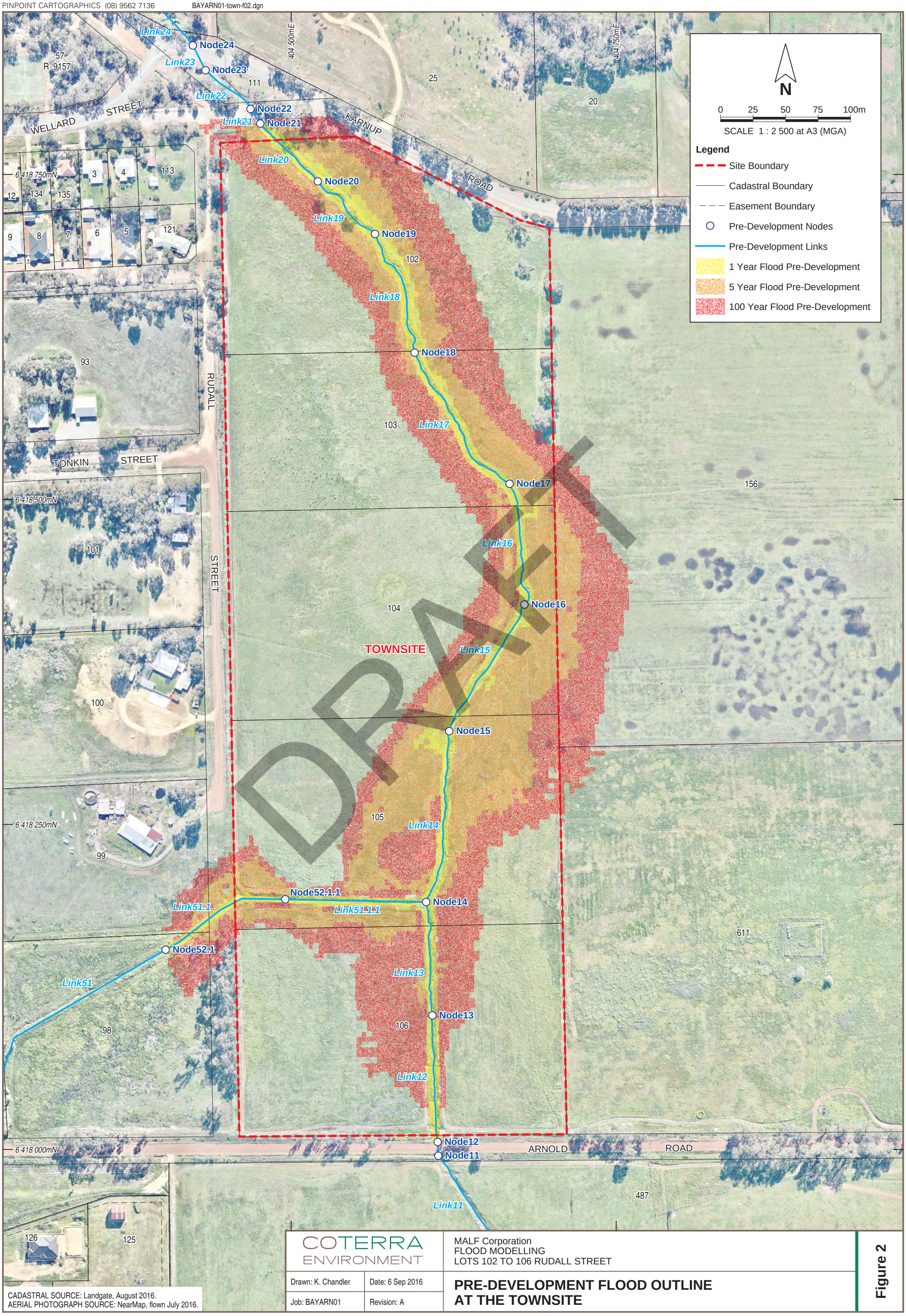


CADASTRAL SOURCE: Landgate, August 2016.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown July 2016.

COTERRA ENVIRONMENT

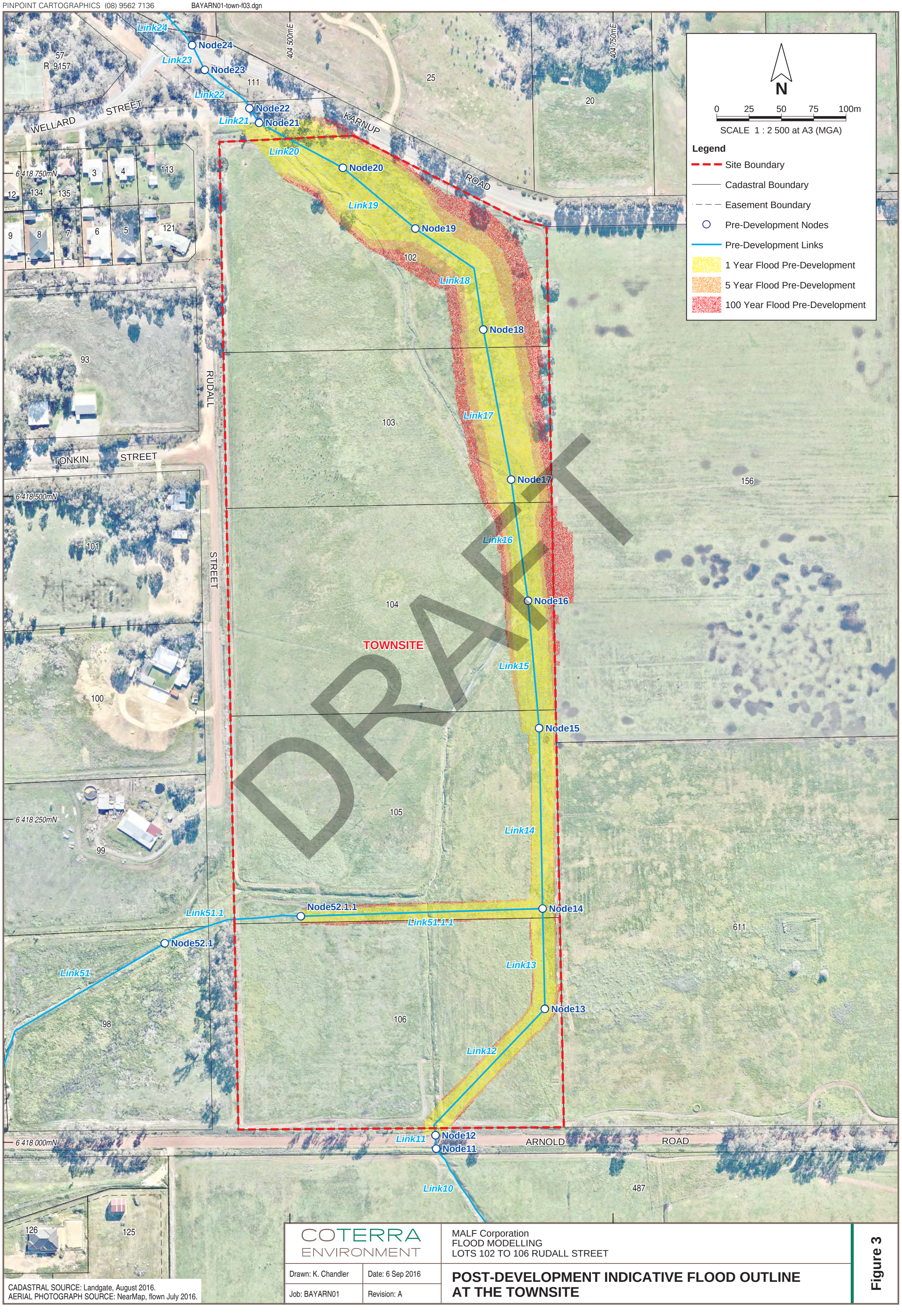
MALF Corporation
FLOOD MODELLING
LOTS 102 TO 106 RUDALL STREET

Drawn: K. Chandler | Date: 6 Sep 2016
Job: BAYARN01 | Revision: A

PRE-DEVELOPMENT FLOOD OUTLINE AT THE TOWNSITE

Figure 2

PINPOINT CARTOGRAPHICS (08) 9562 7136 BAYARN01-town-f03.dgn



CADASTRAL SOURCE: Landgate, August 2016.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown July 2016.

COTERRA ENVIRONMENT

MALF Corporation
FLOOD MODELLING
LOTS 102 TO 106 RUDALL STREET

Drawn: K. Chandler | Date: 6 Sep 2016
Job: BAYARN01 | Revision: A

POST-DEVELOPMENT INDICATIVE FLOOD OUTLINE AT THE TOWNSITE

Figure 3

Client: Shire of Serpentine Jarrahdale

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				Copies	Date
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Appendix 2 – Transport Impact Assessment

Transport Impact Assessment

Serpentine Townsite Local Structure Plan

CW1200480/304900895

Prepared for

Shire of Serpentine-Jarrahdale

8 December 2022

Cardno

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1 Introduction

1.1 Background

Cardno now Stantec was commissioned by the Shire of Serpentine-Jarrahdale to prepare a Transport Impact Assessment (TIA) for the Serpentine Townsite located within the Shire of Serpentine-Jarrahdale. The structure plan proposes residential dwellings, neighbourhood centre, public and community purpose lots.

The purpose of this transport assessment is to address access requirements to the development area by all modes of transport and to identify the likely traffic generation and associated impacts on the surrounding road network, and safety of the proposed development. Discussion regarding pedestrian, cycle and public transport considerations are also provided.

This report has been prepared in accordance with the *Western Australian Planning Commission (WAPC) Transport Impact Assessment Guidelines for Developments: Volume 2: Planning Schemes, Structure Plans and Activity Centre Zones* (2016).

2 Existing Situation

2.1 Site Location

The Shire of Serpentine-Jarrahdale is located in the south-east of Western Australia. The Shire is located approximately 45 kilometres south of Perth CBD.

The structure plan consists primarily of schools, public and community purpose facilities, open spaces, and residential lots, some of which are already built but a few remain still vacant.

The main access to the subject site is via Karnup Road, which connects the Structure plan to the west (Kwinana Freeway) and to the east (South Western Highway). Richardson Street, Hall Road, and Hardey Road borders the structure plan, and all these roads provide a north-south connection parallel to South Western Highway.

The location of the proposed site is shown in **Figure 2-1** and **Figure 2-2.**

Figure 2-1 Local Structure Plan Location

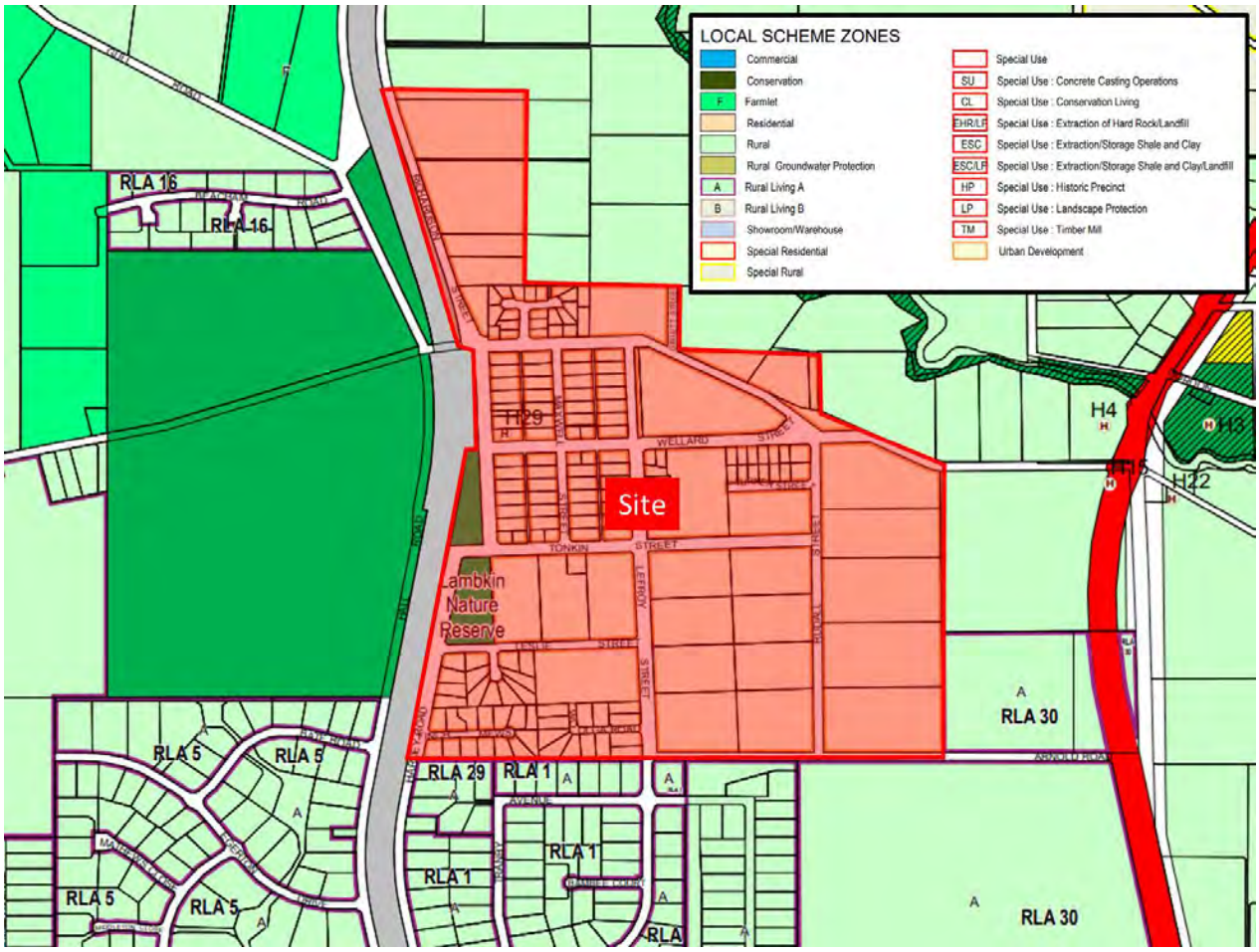
Figure 2-2 Site Location

Source: Metro Map

2.2 Surrounding Land Uses

As per the *Shire of Serpentine-Jarrahdale Town Planning Scheme No. 21*, subject site is zoned 'Urban Development' as shown in **Figure 2-3.** The site is predominantly surrounded by 'rural developments.

Figure 2-3 Zoning Map



Source: Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2

2.3 Existing Road Network

Road classifications are defined in the Main Roads Functional Hierarchy as follows:

- **Primary Distributors (light blue):** Form the regional and inter-regional grid of Main Roads WA traffic routes and carry large volumes of fast-moving traffic. Some are strategic freight routes and all are National or State roads. They are managed by Main Roads.
- **Regional Distributors (red):** Roads that are not Primary Distributors, but which link significant destinations and are designed for efficient movement of people and goods within and beyond regional areas. They are managed by Local Government.
- **District Distributor A (green):** These carry traffic between industrial, commercial and residential areas and connect to Primary Distributors. These are likely to be truck routes and provide only limited access to adjoining property. They are managed by Local Government.
- **District Distributor B (dark blue):** Perform a similar function to District Distributor A but with reduced capacity due to flow restrictions from access to and roadside parking alongside adjoining property. These are often older roads with traffic demand in excess of that originally intended. District Distributor A and B roads run between land-use cells and not through them, forming a grid that would ideally be around 1.5 kilometres apart. They are managed by Local Government.
- **Local Distributors (orange):** Carry traffic within a cell and link District Distributors at the boundary to access roads. The route of the Local Distributor discourages through traffic so that the cell formed by the grid of District Distributors only carries traffic belonging to or serving the area. These roads should accommodate buses but discourage trucks. They are managed by Local government.
- **Access Roads (grey):** Provide access to abutting properties with amenity, safety and aesthetic aspects having priority over the vehicle movement function. These roads are bicycle and pedestrian friendly. They are managed by Local government.

The site is bounded to the west by Richardson Street and Hardey Road and is easily accessible by South Western Highway via Karnup Road, while it is bounded to the south by Arnold Road. **Figure 2-4** shows the surrounding area road hierarchy and the characteristics of the surrounding road network are summarised in **Table 2-1**

Table 2-1 Road Network Classification

Road Name	Road Hierarchy	Jurisdiction	No. Lanes	Pavement Width (m)	Footpaths	Posted Speed Limit (km/h)
Arnold Road	Access Road	Local Government	2	11.4 (unsealed road)	-	50
Hall Road	Local Distributor (South of Karnup Rd) Access Road (North of Karnup Rd)	Local Government	2	6.6	1	50, 80 (South of Leslie Street)
Hardey Road	Access Road	Local Government	2	5.3	1	50
Karnup Road	Regional Distributor	Local Government	2	9.9	1	60 (Before Hall Road), 70 (after Wellard Street)
Leslie Street	Access Road	Local Government	2	5.6	1	50
Maxwell Street	Access Road	Local Government	2	6.0	-	50
Richardson Street	Access Road	Local Government	2	8.2	1	60 (North of Karnup Road) 80 (Before Summerfield Rd)
Rudall Street	Access Road	Local Government	2	6.5 (Gravel road)	-	50
Tonkin Street	Access Road	Local Government	2	5.0 (East of Lefroy Street is an unsealed road)	-	50
Wellard Street	Access Road	Local Government	2	7.0	1	50

Figure 2-4 Road Hierarchy

Source: MRWA, Road Information Mapping System.

2.4 Existing Traffic Volumes

Existing traffic volumes were sourced from Shire of Serpentine-Jarrahdale as shown below in **Table 2-2.**

Table 2-2 Existing Traffic Volumes

Road Name	Year	Average Daily Traffic	AM Peak	PM Peak
Hall Road 100m North of Leslie Street	2022	890 (HV% = 11%)	63 (7:00)	74 (17:00)
Hall Road 100m South of Leslie Street	2022	1,068 (HV% = 10.9%)	73 (8:00)	94 (16:00)
Hall Road 100m South of Karnup Road	2022	889 (HV% = 9.9%)	60 (7:00)	74 (17:00)
Hardey Road 100m North of Leslie Street	2022	441 (HV% = 9.6%)	37 (10:00)	48 (16:00)
Hardey Road 100m South of Leslie Street	2022	354 (HV% = 12.8%)	28 (8:00)	33 (15:00)
Karnup Road 100m West of Hall Road	2022	2,122 (HV% = 12.4%)	158 (7:00)	200 (15:00)
Karnup Road 200m East of Wellard Road	2022	2,103 (HV% = 14.0%)	155 (7:00)	190 (15:00)
Karnup Road 200m West of Wellard Road	2022	1,523 (HV% = 13.6%)	123 (7:00)	132 (15:00)

Karnup Road Between Richardson Street & Wundowie Place	2022	1,889 (HV% = 19.7%)	153 (7:00)	173 (15:00)
Lefroy Street Between Leslie Street & Arnold Road	2022	689 (HV% = 12.7%)	65 (8:00)	66 (15:00)
Lefroy Street Between Leslie Street & Tonkin Street	2022	741 (HV% = 10.8%)	79 (8:00)	74 (15:00)
Lefroy Street Between Wellard Street & Tonkin Street	2022	892 (HV% = 7.4%)	108 (8:00)	91 (15:00)
Leslie Street Between Lefroy Street & Blue Wren Close	2022	181 (HV% = 4.6%)	26 (8:00)	21 (15:00)
Maxwell Street Between Karnup Road & Wellard Street	2022	146 (HV% = 8.1%)	14 (8:00)	15 (16:00)
Maxwell Street Between Tonkin Street & Wellard Street	2022	93 (HV% = 14.2%)	10 (8:00)	12 (15:00)
Richardson Street 100m south of Karnup Road	2022	1,096 (HV% = 9.8%)	90 (8:00)	123 (15:00)
Richardson Street Between Wellard Street & Tonkin Street	2022	569 (HV% = 13.9%)	54 (8:00)	59 (15:00)
Rudall Street 100m North of Tonkin Street	2022	35 (HV% = 12.4%)	3 (11:00)	4 (14:00)
Rudall Street 100m South of Tonkin Street	2022	13 (HV% = 20.0%)	2 (9:00)	2 (12:00)
Tonkin Street Between Lefroy Street & Maxwell Street	2022	182 (HV% = 13.9%)	37 (8:00)	23 (15:00)
Tonkin Street Between Lefroy Street & Rudall Street	2022	238 (HV% = 8.6%)	60 (8:00)	42 (14:00)
Wellard Street Between Maxwell Street & Lefroy Street	2022	686 (HV% = 9.2%)	54 (8:00)	77 (15:00)
Wellard Street Between Maxwell Street & Richardson Street	2022	1,024 (HV% = 7.1%)	86 (11:00)	117 (15:00)

2.5 Existing Intersections

The following section describes the intersections in the vicinity of the site:

> **Karnup Road/ Richardson Street** is located north-west of the Site. The intersection is a roundabout controlled with the west approach near the train crossing as illustrated in **Figure 2-5**.

Figure 2-5 Karnup Road/ Richardson Street

Source: Metro map

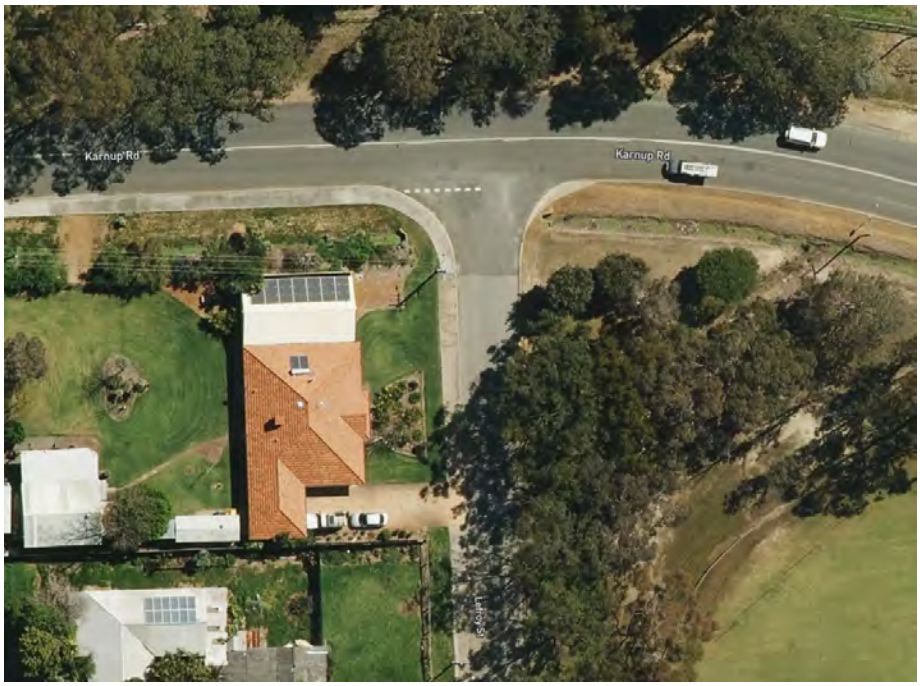
> **Karnup Road/ Maxwell Street** is a T-intersection with give-way control and priority given to Karnup Road as shown in **Figure 2-6.**

Figure 2-6 Karnup Road/ Maxwell Street

Source: Metro map

> **Karnup Road/ Lefroy Street** is a T-junction with give-way control and priority given to Karnup Road as illustrated in **Figure 2-7.**

Figure 2-7 Karnup Road/ Lefroy Street



Source: Metro map

> **Karnup Road/ Wellard Street** is located to the north-east of the site. The intersection is a T-intersection with give-way control and priority given to Karnup Road as shown in **Figure 2-8.**

Figure 2-8 Karnup Road/ Wellard Street

Source: Metro map

> **Wellard Street/ Richardson Street** is a T-intersection with give-way control and priority given to Richardson Street as shown in **Figure 2-9.**

Figure 2-9 Wellard Street/ Richardson Street

Source: Metro map

> **Wellard Street/ Maxwell Street** a 4-legged junction with give-way control and priority given to Wellard Street as illustrated in **Figure 2-10.**

Figure 2-10 Wellard Street/ Maxwell Street

Source: Metro map

> **Wellard Street/ Lefroy Street** a 4-legged junction with give-way control and priority given to Wellard Street as illustrated in **Figure 2-11.**

Figure 2-11 Wellard Street/ Lefroy Street

Source: Metro map

> **Tonkin Street/ Richardson Street** is located to the south-west of the site. The intersection is a 3-legged junction with give-way control and priority given to Richardson Street as illustrated in **Figure 2-12**

Figure 2-12 Tonkin Street/ Richardson Street

Source: Metro map

> **Tonkin Street/ Maxwell Street** – an uncontrolled T-intersection located east of Lefroy Street as shown in **Figure 2-13.**

Figure 2-13 Tonkin Street/ Maxwell Street

Source: Metro map

> **Tonkin Street/ Lefroy Street** is a 4-legged junction with give-way control and priority given to Lefroy Street as illustrated in **Figure 2-14.**

Figure 2-14 Tonkin Street/ Lefroy Street

Source: Metro map

> **Tonkin Street/ Rudall Street** a 3-leg uncontrolled intersection with gravel road as shown in **Figure 2-15.**

Figure 2-15 Tonkin Street/ Rudall Street

Source: Metro map

> **Leslie Street/ Lefroy Street** is an uncontrolled intersection located north of Arnold Road. as shown in **Figure 2-16.**

Figure 2-16 Leslie Street/ Lefroy Street

Source: Metro map

> **Leslie Street/ Hardey Road** is located to the south-west of the site. The intersection is a 4-legged with give-way control and priority given to Leslie Street as shown in **Figure 2-17.**

Figure 2-17 Leslie Street/ Hardey Road

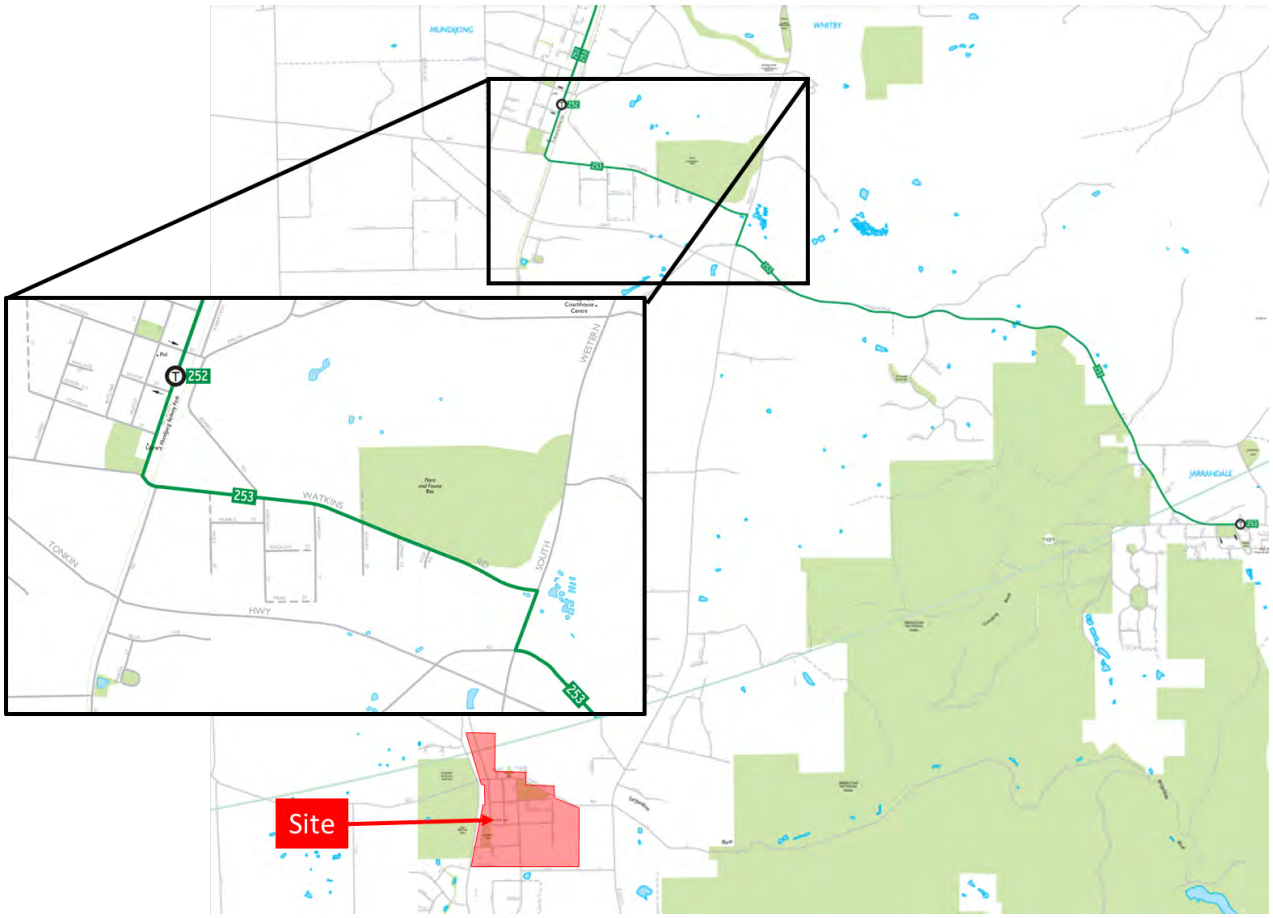
Source: Metro map

2.6 Existing Public Transport Facilities

The Serpentine Train Station, which is located within the proposed structure plan area, is the closest public transport facility. The area is serviced by a train station and trains will only stop with advanced notice in Serpentine if a specific passenger has purchased a ticket. The train station connects to the Perth City, Bunbury and Mundijong, where regular bus services from the Shire of Serpentine-Jarrahdale to Armadale Station is available.

The bus route is illustrated in **Figure 2-18** and the train service schedule is summarised in **Table 2-3**.

Figure 2-18 Nearest Bus Service



Source: Transperth

Table 2-3 Australind Timetable

Perth to Bunbury **Australind**

From Perth		B03	B55	From Bunbury		B02	B56
		Daily AM	Daily **PM**			Daily AM	Daily **PM**
Perth Station	Dep	9:30	**5:55**	**Bunbury Passenger Terminal**	Dep	6:00	**2:45**
Armadale Station	Dep	9:56	**6:25**	Brunswick Junction*	Dep	6:15	**3:02**
Byford*	Dep	10:07	**6:36**	Harvey*	Dep	6:31	**3:17**
Mundijong*	Dep	10:14	**6:43**	Cookernup*•	Dep	6:39	**3:24**
Serpentine*	Dep	10:21	**6:50**	Yarloop*	Dep	6:44	**3:29**
North Dandalup*•	Dep	10:32	**7:01**	Waroona*	Dep	6:54	**3:38**
Pinjarra*	Dep	10:42	**7:11**	Pinjarra*	Dep	7:10	**3:55**
Waroona*	Dep	11:00	**7:29**	North Dandalup*•	Dep	7:22	**4:07**
Yarloop*	Dep	11:11	**7:40**	Serpentine*	Dep	7:34	**4:18**
Cookernup*•	Dep	11:15	**7:44**	Mundijong*	Dep	7:40	**4:24**
Harvey*	Dep	11:21	**7:50**	Byford*	Dep	7:46	**4:32**
Brunswick Junction*	Dep	11:36	**8:05**	**Armadale Station**	Arr	7:52	**4:39**
Bunbury Passenger Terminal	Arr	11:55	**8:25**	**Perth Station**	Arr	8:30	**5:15**

*** Trains only stop at intermediate stations if advance bookings are made**

Source: Australind

2.7 Existing Pedestrian/Cycle Network Facilities

No cycle routes are present within and in the surrounding areas of the structure plan. However, footpaths exist within the local planning scheme area along Karnup Road, Richardson Street, Wellard Street, Maxwell Street and Lefroy Street.

2.8 Crash Analysis

A crash assessment for the surrounding road network of the site has been completed using the Main Roads WA Reporting centre. The assessment covers all the recorded accidents for the 5-year period between 1 January 2017 to 31 December 2021. **Table 2-4** to **Table 2-6** summarises the results and **Figure 2-19** shows the location and severity of the crashes.

Table 2-4 Total Crashes

Type of Crash (RUM Code)	Fatal	Hospital	Medical	Major Property Damage	Minor Property Damage	Total Crashes
Right Angle	-	-	1	8	1	**10**
Head On	-	-	1	-	-	**1**
Hit Object	-	-	-	1	-	**1**
Hit Pedestrian	-	1	-	-	-	**1**
Total	**-**	**1**	**2**	**9**	**1**	**13**

Table 2-5 Midblock Crashes

Road Name	Fatal	Hospital	Medical	Major Property Damage	Minor Property Damage	Total Crashes
Arnold Rd	-	-	-	1	-	**1**
Wellard St	-	1	-	-	-	**1**
Total	**-**	**1**	**-**	**1**	**-**	**2**

Table 2-6 Intersection Crashes

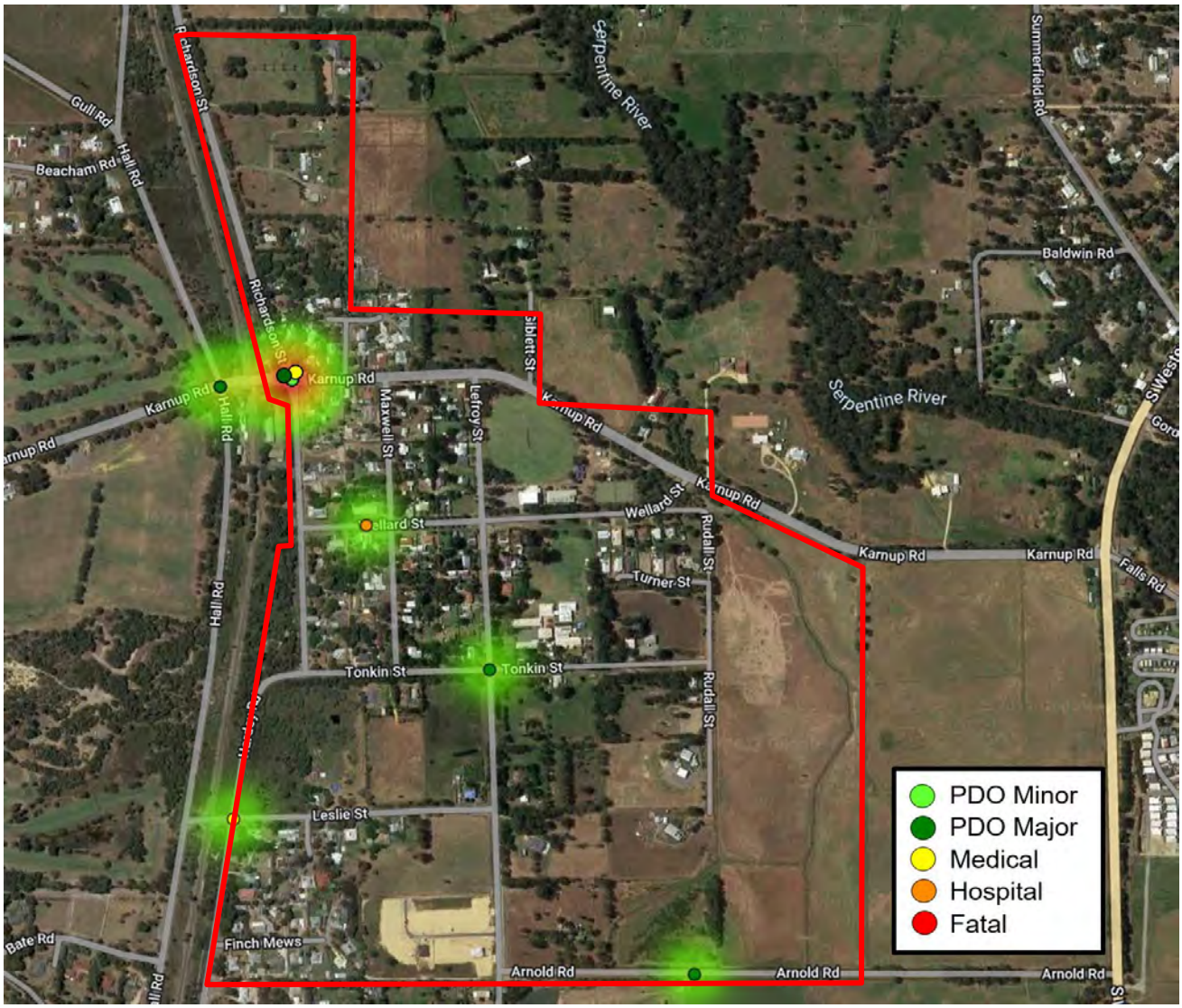
Intersection Name	Fatal	Hospital	Medical	Major Property Damage	Minor Property Damage	Total Crashes
Karnup Rd - Richardson St	-	-	1	5	1	**7**
Karnup Rd - Hall Rd	-	-	-	2	-	**2**
Hardey Rd - Leslie St	-	-	1	-	-	**1**
Lefroy St - Tonkin St	-	-	-	1	-	**1**
Total	**-**	**-**	**2**	**8**	**1**	**11**

Crashes recorded are summarised below:

- A total of 13 crashes was recorded within the surrounding road network;
- One crash resulted in hospitalisation and two crashes reported required medical attention;
- Eleven intersection crashes were recorded in the surrounding network.

Overall, the number of crashes that occurred within the surrounding area is considered to be relatively low.

Figure 2-19 Crash Map



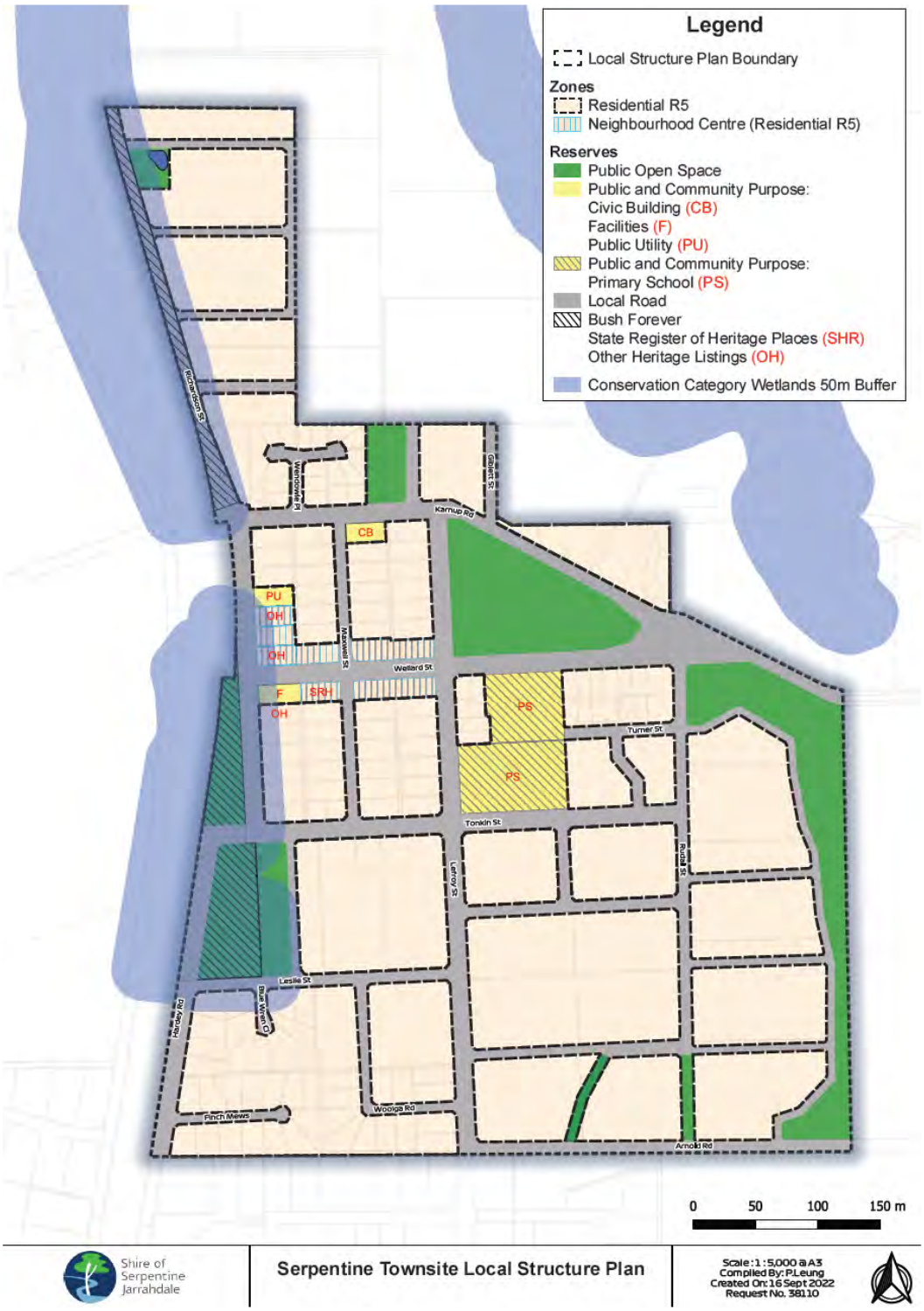
Source: Main Roads Crash Map

3 Development Proposal

3.1 Proposed Land Uses

The structure plan is proposed to include developments such as residential areas 'R5', neighbourhood centres, public and community purpose buildings and facilities. **Figure 3-1** shows the concept layout of the proposed development. Detailed site plans are provided in **Appendix B**.

Figure 3-1 Concept Layout



Source: Shire of Serpentine-Jarrahdale

Based on the information provided by the City, it is estimated that the structure plan will include 69.89ha of R5 residential area, which equates to approximately 350 dwellings, and 1.89 ha of neighbourhood centre as summarised in **Table 3-1**. The neighbourhood centre includes retail shops, convenience stores, cafes, consulting rooms, offices or similar. It is a type of neighbourhood centre that comprises retail uses that is generally limited to the sale of lower-order convenience goods to local residents.

Table 3-1 Land Uses

Premises	Lot Area	Development Yield
Residential Lots (R5)	69.89 ha	350 dwellings*
Neighbourhood Centre	1.89 ha	-

**This is based on the minimum site area for dwelling of 2000sqm for a single house (R5) – Residential Design Codes (Page 59)*

The proposed new developments consist of an increase in the number of R5 zone residential lots and a neighbourhood centre. All other land use types remain as per existing. It is also worth noting that the number of dwellings is based on a high-level review of the structure plan and does not accurately predict the actual number of dwellings that will be built on the designated vacant lot area.

3.2 Access Arrangements

The main access into this local structure plan area is via Karnup Road as illustrated in **Figure 3-2**, which runs east to west and directly connects to South Western Highway. Two parallel roads running north-south though the Site, Richardson and Hall Road which connects the Structure Plan area to other localities within the Shire.

Figure 3-2 Access Arrangements

4 Changes to Surrounding Transport Network

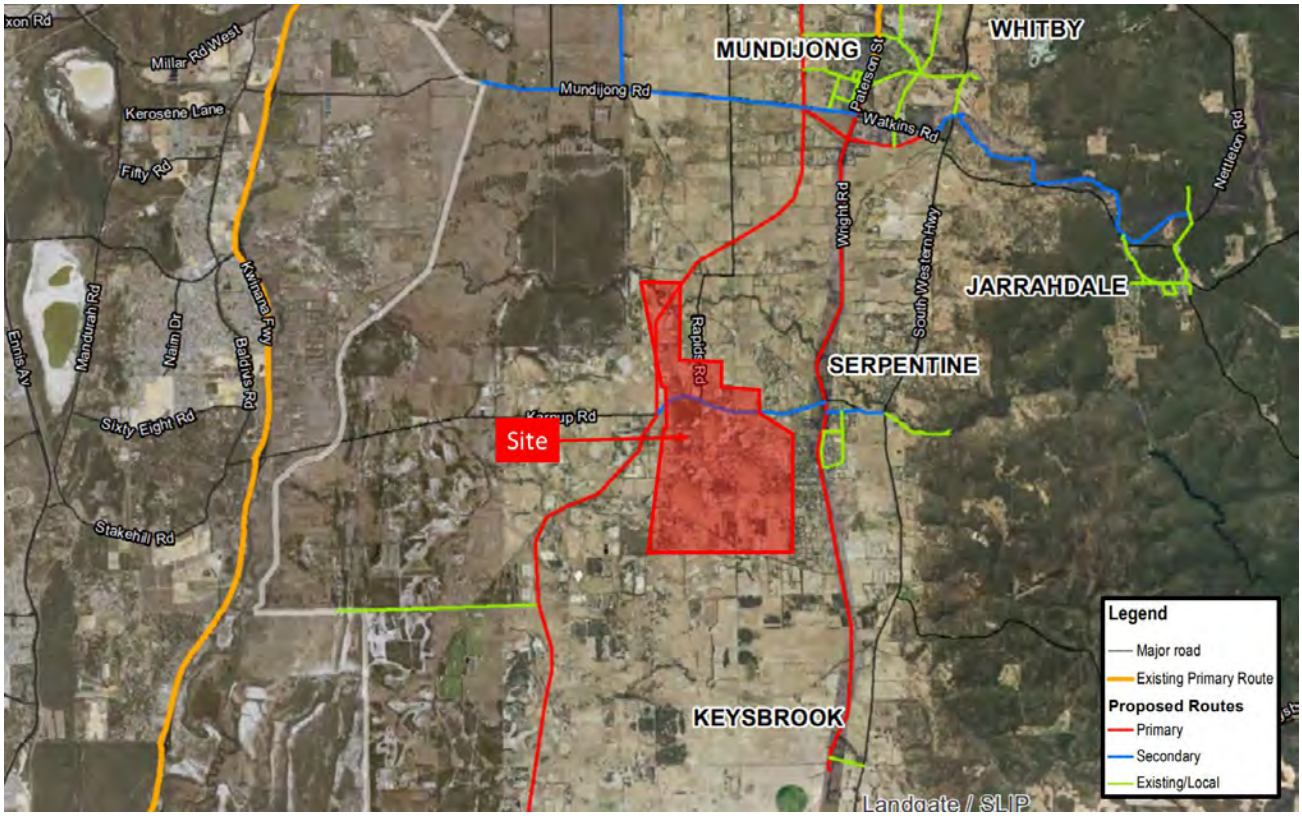
4.1 External Road Network

Arnold Road is intended to be upgraded to a sealed two-lane single carriageway, including the upgrading of the intersection of South Western Highway and Arnold Road by providing a right turning lane on South Western Highway to allow southbound through traffic to safely pass a stationary vehicle turning right into Arnold Road.

4.2 Pedestrian/Cycle Networks

The Shire of Serpentine-Jarrahdale are proposing cycle routes to link Karnup Road to Richardson Road, Lefroy Street and Wellard Street as shown in **Figure 4-1**. This will provide good cycle linkages to the local centre, school and community facilities as well as to the proposed residential lots.

Figure 4-1 Walking and Cycling Plan



Source: Walking and Cycling Plan (Shire of Serpentine-Jarrahdale)

4.3 Public Transport Services

Cardno now Stantec contacted the Public Transport Authority and were advised that there are no proposed changes or new public transport services proposals within this structure plan area.

5 Integration with Surrounding Area

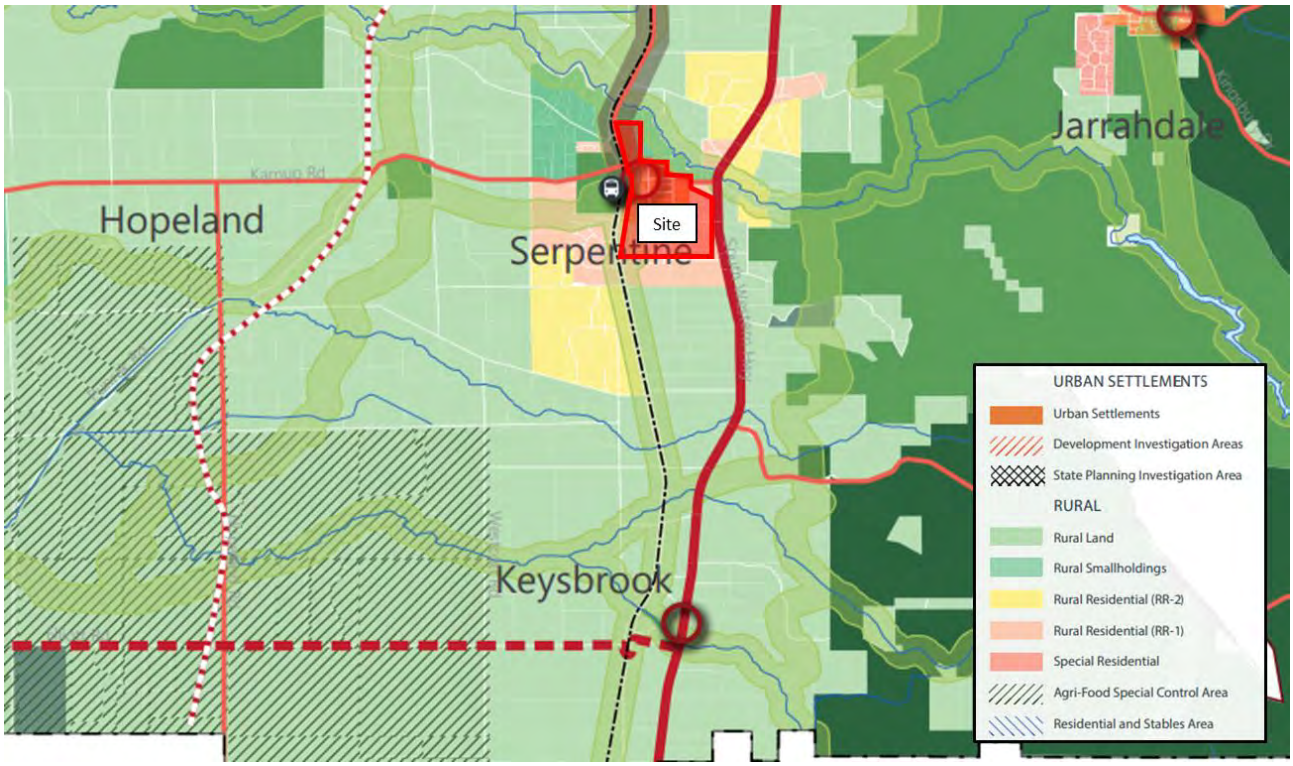
5.1 Surrounding Attractors/Generators

Trips generated by the proposed development are anticipated to be primarily journey-to-work trips since the proposed subdivisions are mainly for residential use. The anticipated destinations of these trips are anticipated to be similar to that of the existing and neighbouring residential and rural lots.

5.2 Proposed changes to Surrounding Land Uses

The Shire of Serpentine Jarrahdale have advised that there are changes with the surrounding 'rural lands' on the east of the Site to 'urban settlements.

Figure 5-1 Changes to Surrounding Land Uses



6 Analysis of Transport Network

6.1 Analysis Overview

To identify the impact of the proposed development on the surrounding network, the following intersections were identified for traffic analysis.

- Richardson Street/ Karnup Road;
- Wellard Street/ Karnup Road;
- Hardey Road/ Leslie Street; and
- Lefroy Street/ Leslie Street

6.2 Assessment Years and Time Period

The peak times selected are 8:00 AM to 9:00 AM and 3:00 PM to 4:00 PM respectively for a typical weekday morning and afternoon peak hour period.

The following modelled scenarios have been analysed as part of this assessment:

- Scenario 1 – 2022 Background Traffic (AM and PM);
- Scenario 2 – 2032 Ultimate Scenario (AM and PM), representing full build-out of the proposed structure plan area

6.3 Key Assumptions

The following assumptions were made for the traffic analysis:

- Based on the traffic data obtained from the Shire, the peak hour period during the weekday occurs between 8.00AM to 9.00AM and 3.00 PM to 4.00 PM.
- A 2.5% annual growth rate has been applied to the background traffic for the future scenarios. This growth rate has been derived based on historic traffic growth from the Main Roads WA Traffic map along Karnup Road as well as from the two-way traffic data along Karnup Road provided by Shire;
- For the purpose of a robust assessment, the traffic volumes associated with the existing Site has not been removed from the existing background traffic.
- Heavy vehicle volumes are based on the percentages provided by the Shire.

6.4 Traffic Generation

Trip generation rates from the *Institute of Transportation Engineers (ITE) Trip Gen Manual 10th edition* and Western Australian Planning Commission (WAPC)'s *Transport Impact Assessment Guidelines Volume 5* as detailed in **Table 6-1** were used to calculate the estimated trip generation for the single residential dwellings and neighbourhood centre. **Table 6-2** shows the directional distribution and **Table 6-3** summarises the total expected trips to be generated by the proposed developments in the local structure plan area.

The following assumptions were noted in order to estimate the trips to be generated by the proposed neighbourhood centre:

- The Shire has stated that the proposed neighbourhood centre primarily comprises retail uses that will generally limited to the sale of lower-order convenience products to local residents.
- A trip generation rate for the retail tenancy from WAPC Vol. 5 was used to estimate the number of trips for the neighbourhood centre because it offers a conservative retail trip rate for commercial tenancies;
- It is unlikely that the entire lot area would be fully developed as commercial floor space. There will be space set aside for pedestrian-friendly areas, and other amenities to support the commercial tenancies.
- Due to the lack of information regarding the gross leasable floor areas for the proposed commercial tenancies, a comparison of neighbouring lots in the Serpentine Townsite area shows a GFA to total lot area ratio of 30%.

As a result, the total 1.89ha area was assumed to be reduced to 30%, resulting in a 5670 sqm commercial floor area at the neighbourhood centre.

Table 6-1 Trip Generation Rate

Land Use	ITE CODE	Yield	AM Peak Rate	PM Peak Rate
Residential	ITE 210	350 dwellings	0.76 trips per dwelling	1 trip per dwelling
Commercial	WAPC Vol 5	5670 sqm	1.25 trips per 100 sqm	4.0 trips per 100 sqm

Table 6-2 Directional Distribution

Land Use	AM		PM	
	IN	OUT	IN	OUT
Residential	26%	74%	64%	36%
Commercial	80%	20%	50%	50%

Table 6-3 Estimated trips to be generated by proposed Residential dwellings

Land Use	AM		PM	
	IN	OUT	IN	OUT
Residential	69	197	224	126
Commercial	57	14	113	113
Sub-total	*126*	*211*	*337*	*239*
Total	**337**		**576**	

The proposed additional development is expected to generate approximately 337 vehicles during the AM peak and 556 vehicles during the PM peak hour respectively.

6.5 Trip Distribution

The majority of trips generated by the proposed subdivision during peak hours are expected to be journey to work trips taken by residents to nearby city centres and townsites (such as Rockingham, Mundijong, Byford and North Dardanup). The structure plan's trip distribution was determined using the assumptions listed below.

- It is assumed that the majority of trips are to/from Karnup Road, which serves as the primary access to the South Western Highway and the Kwinana Freeway.
- Turning movements at intersections were calculated using percentages of vehicular trips entering and exiting the population density area.
- According to available traffic data, it appears that more vehicles travel westbound than eastbound, implying that the majority of current residents within the structure plan area travel along Karnup Road towards the Kwinana Freeway.
- According to the traffic data, a small percentage of vehicles travel to the north of the structure plan via Richardson Street and to the south via Hardey Road and Hall Road.
- The Arnold Road connection to South Western Highway is currently being built and is expected to be completed by 2032. For a robust assessment, it was assumed that all vehicles would still exit the area via Karnup Road to reach South Western Highway.
- Furthermore, to determine the development traffic that would be generated at each key intersection, the route selection was based on the shortest path as illustrated in **Figure 6-1**.

Based on the above assumptions, it was estimated that 44% of vehicle trips travel towards the Kwinana Freeway via Karnup Road, 31% travel towards the South Western Highway, 20% to the north via Richardson Street, and the remaining 5% heading south of the structure plan area as illustrated in **Figure 6-2**.

Figure 6-1 Typical Routes

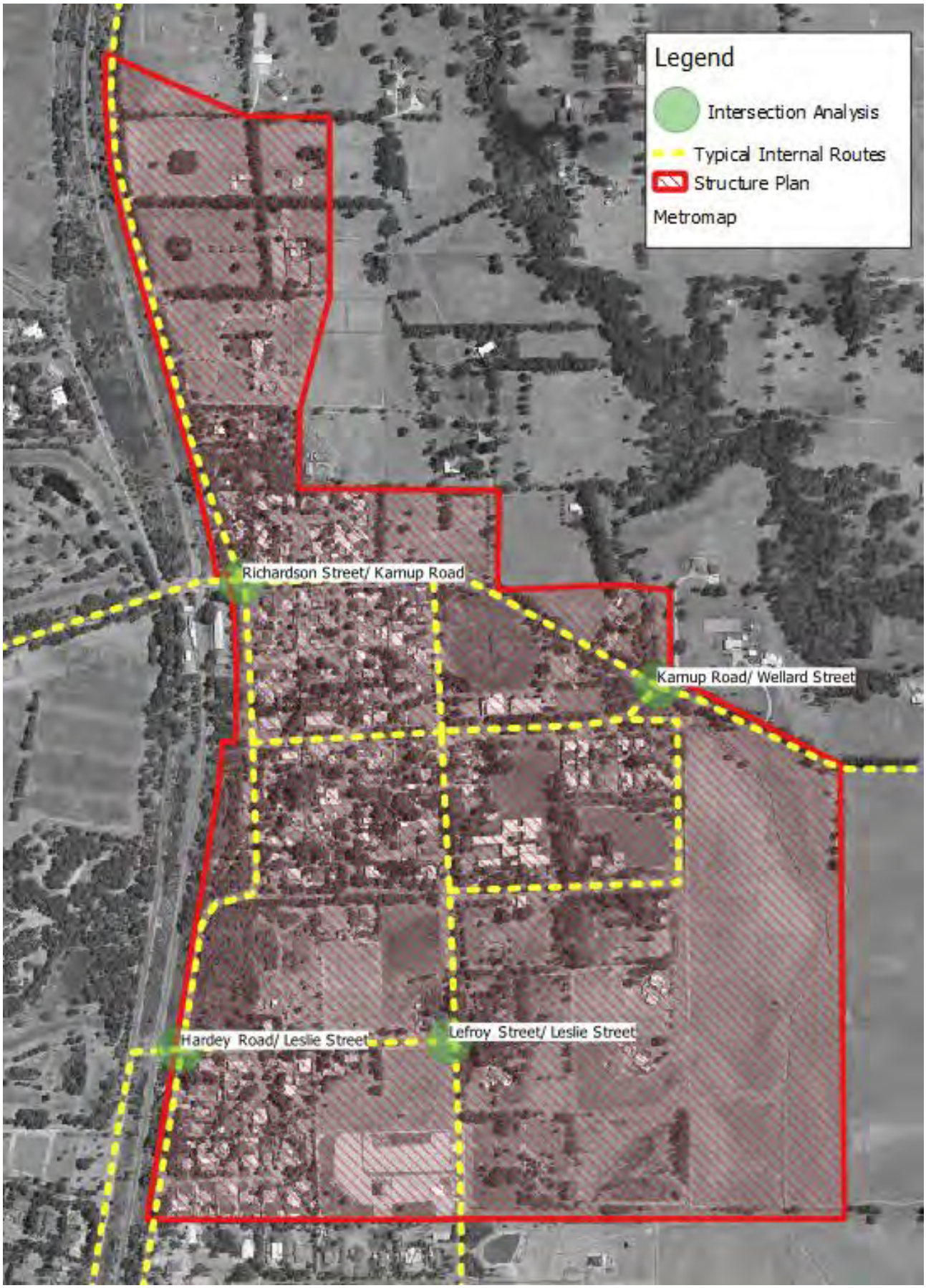
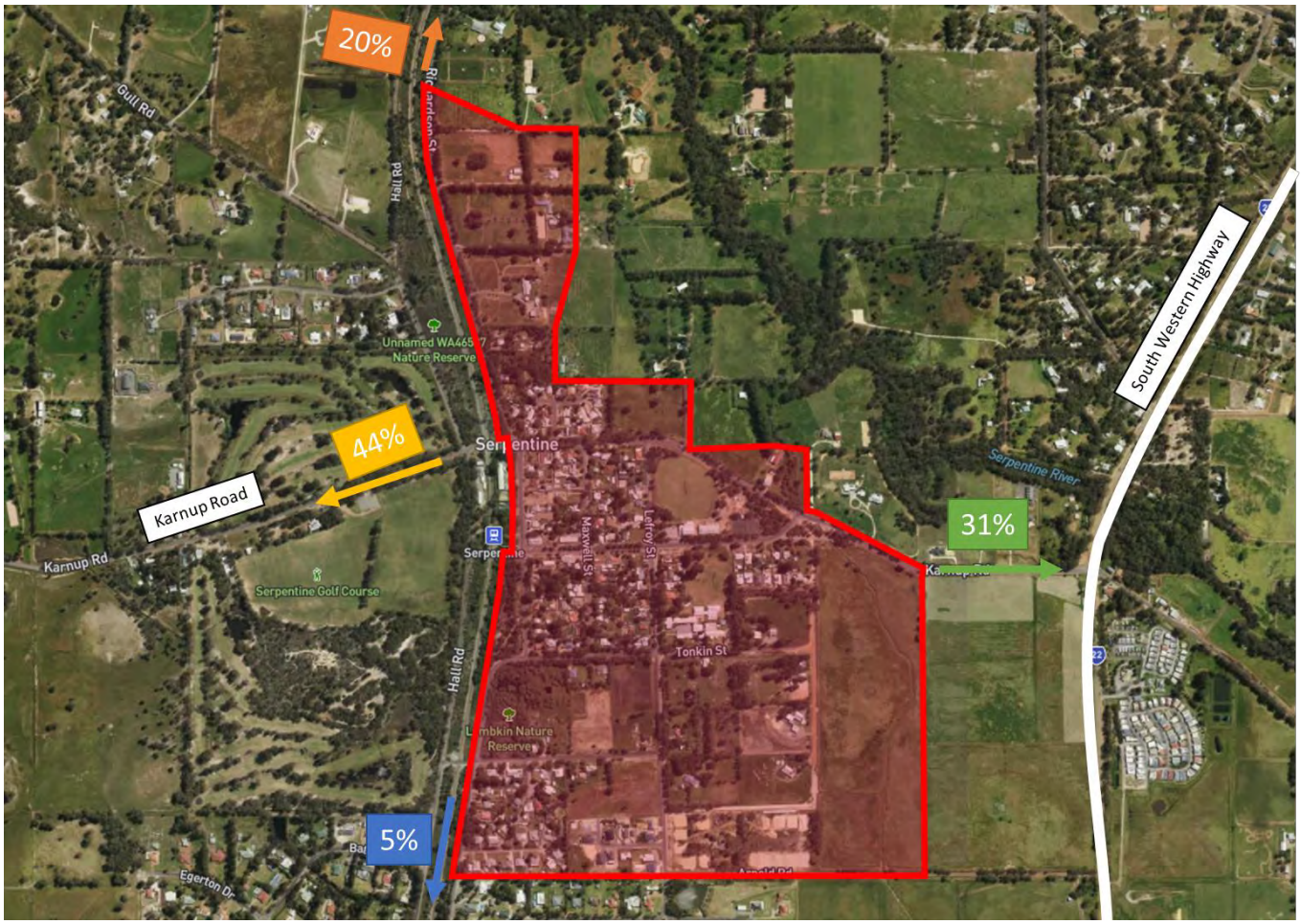


Figure 6-2 Trip Distribution



6.6 Traffic Volumes

6.6.1 2022 Background Traffic

The background traffic was obtained from the Shire of Serpentine-Jarrahdale.

Appendix C contains the detailed traffic volumes used in the analysis.

Figure 6-3 Richardson/ Karnup 2022 Background Traffic

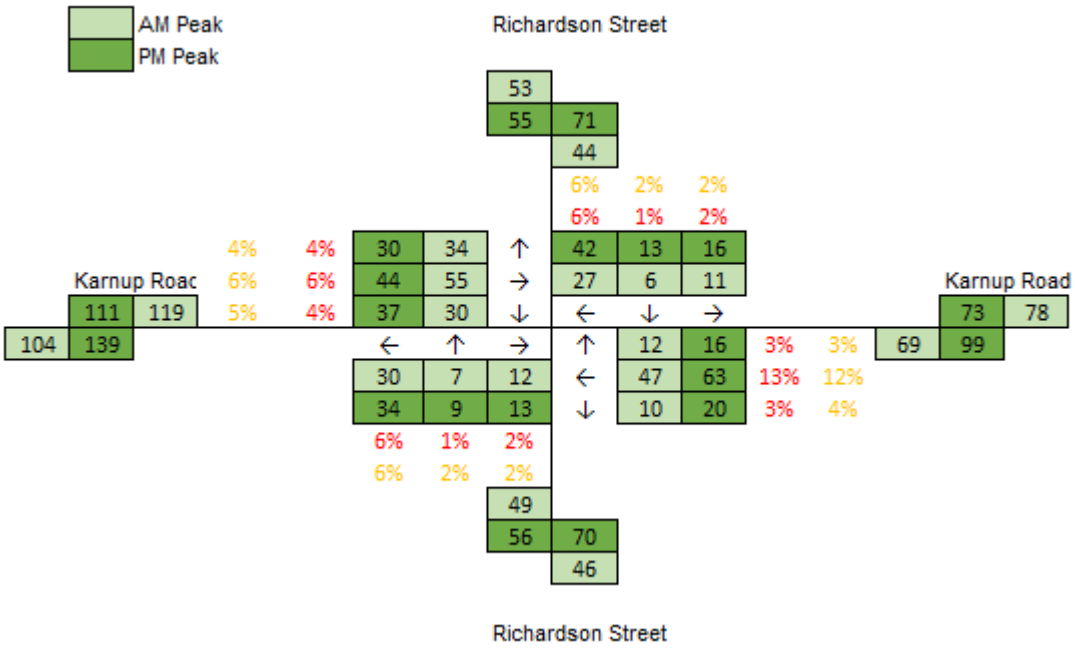


Figure 6-4 Wellard/Karnup 2022 Background Traffic

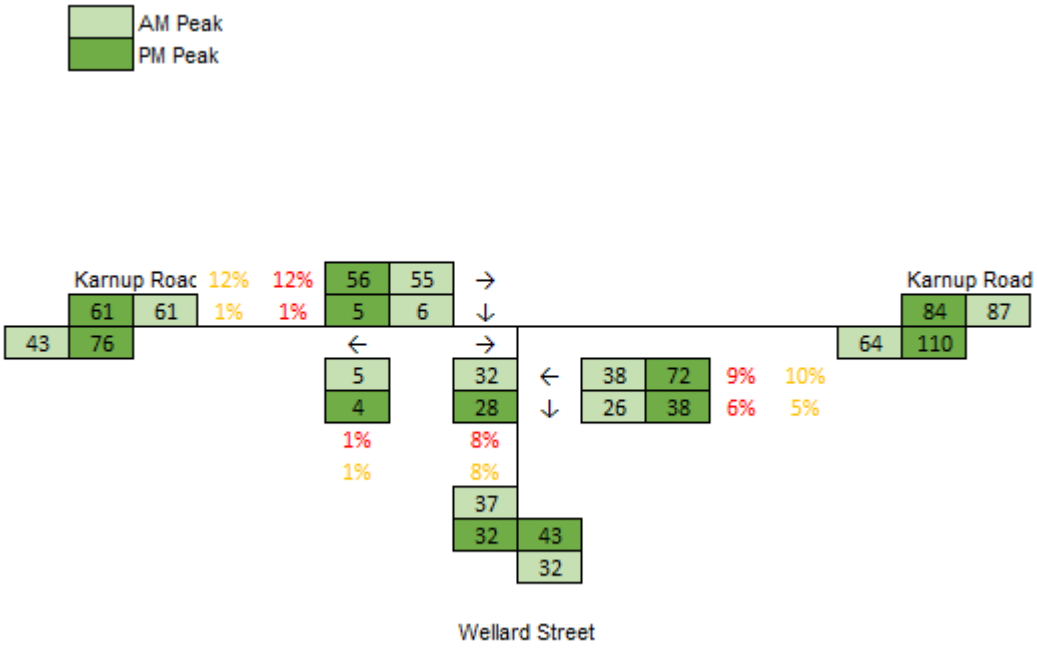


Figure 6-5 Leslie/Hardey 2022 Background Traffic

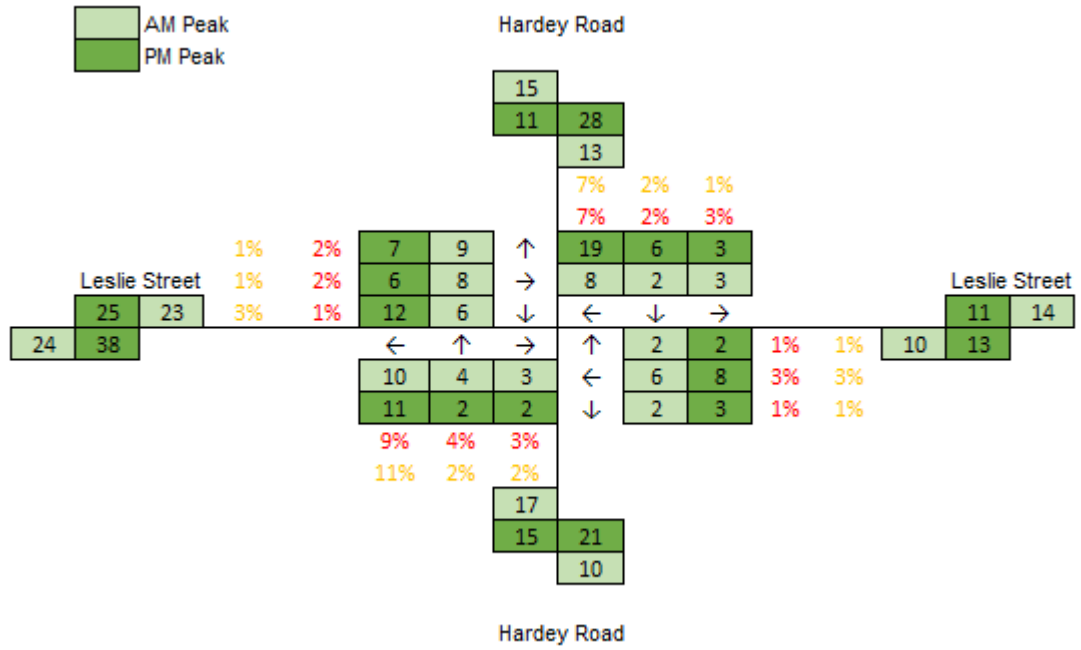
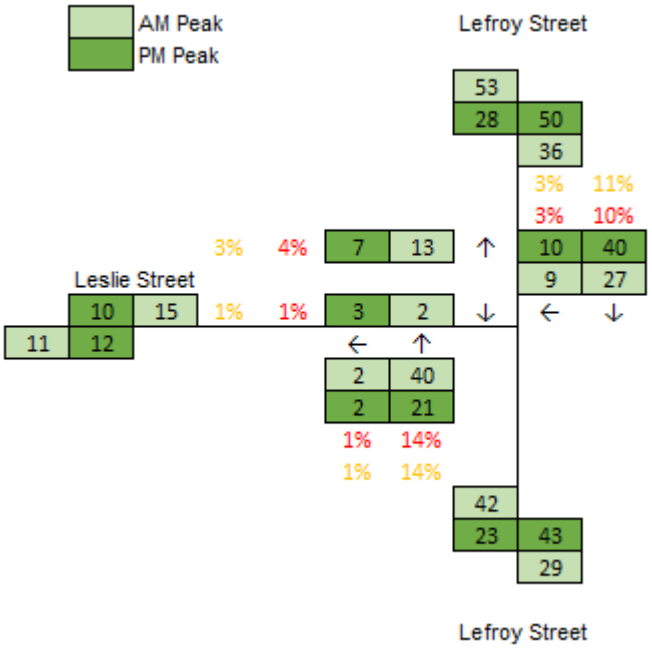


Figure 6-6 Leslie/Lefroy 2022 Background Traffic



6.6.2 2032 Ultimate Scenario

Figure 6-7 Richardson/ Karnup 2032 Ultimate Scenario

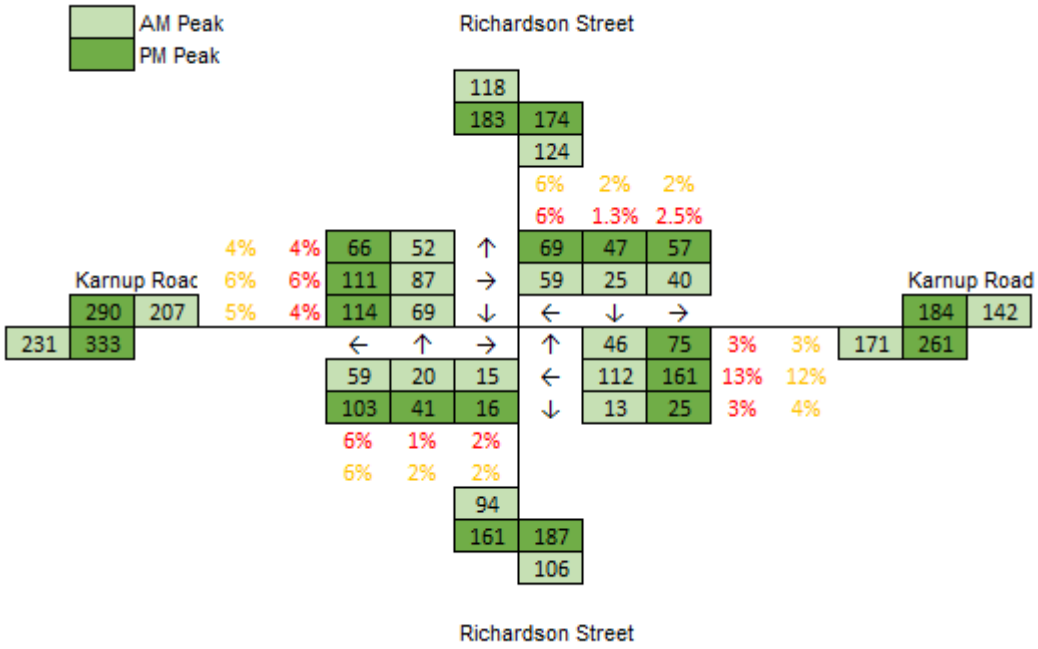


Figure 6-8 Wellard/Karnup 2032 Ultimate Scenario

Figure 6-9 Leslie/Hardey 2032 Ultimate Scenario

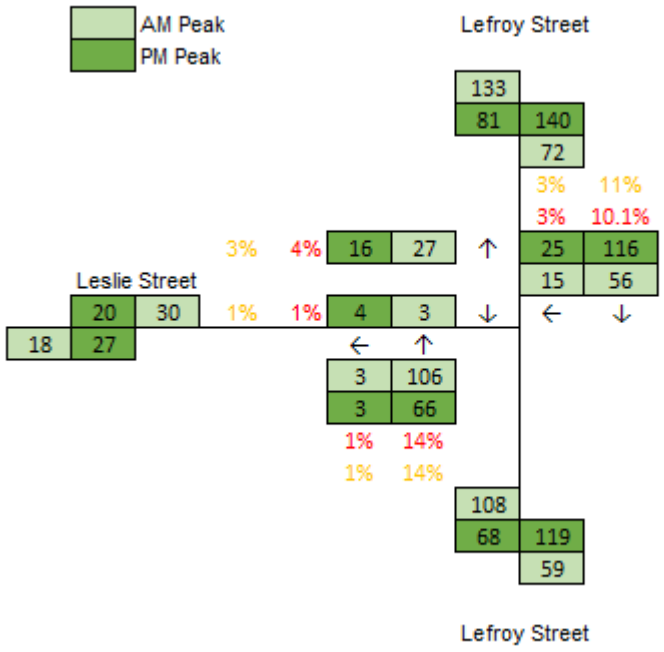
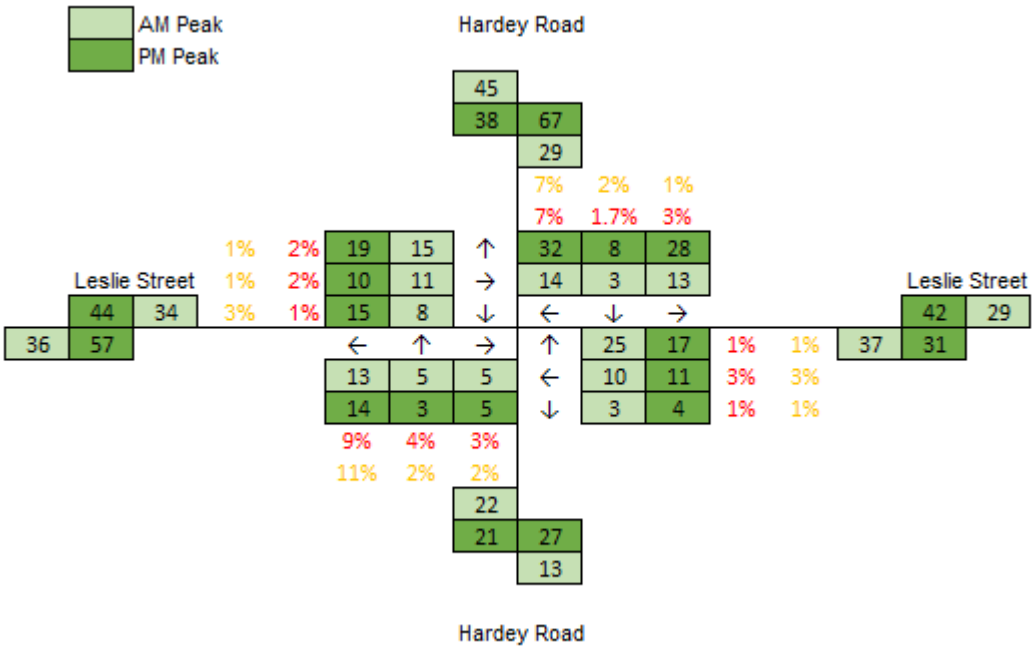


Figure 6-10 Leslie/Lefroy 2032 Ultimate Scenario



6.7 Intersection Performance

The identified intersections have been analysed using the SIDRA analysis program. This program calculates the performance of intersections based on input parameters, including geometry and traffic volumes. SIDRA results for each approach are presented below in the form of Degree of Saturation (DOS), Average Delay, Level of Service (LOS) and 95th Percentile Queue. These parameters are defined as follows:

- Degree of Saturation (DOS): is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The theoretical intersection capacity is exceeded for an un-signalized intersection where DOS > 0.80;
- 95% Queue: is the statistical estimate of the queue length up to or below which 95% of all observed queues would be expected;
- Average Delay: is the average of all travel delays for vehicles through the intersection. An unsigned intersection can be operating at capacity where the average delay exceeds 40 seconds for any movement; and
- Level of Service (LOS): is the qualitative measure describing operational conditions within a traffic system and the perception by motorists and/or passengers. The different levels of service can generally be described as shown in **Table 6-4.**

Table 6-4 Level of Service (LOS)Performance Criteria

LOS	Description	Signalized Intersection	Unsignalized Intersection
A	Free flow conditions (best condition)	≤ 10 sec	≤ 10 sec
B	Reasonable free flow operations	10 – 20 sec	10 – 15 sec
C	At or near free flow operations	20 – 35 sec	15 – 25 sec
D	Decreasing free flow levels	35 - 55 sec	25 - 35 sec
E	Operations at capacity	55 – 80 sec	35 - 50 sec
F	A breakdown in vehicular flow (worst condition)	≤ 80 sec	≤ 50 sec

A LOS exceeding these values indicates that the road section is exceeding its practical capacity. Above these values, users of the intersections are likely to experience unsatisfactory queueing and delays during the peak hour periods.

6.8 Traffic Analysis

Analysis has been undertaken using the SIDRA traffic analysis software. Details of the results are presented in **Appendix D**.

6.8.1 Scenario 1 – 2022 Background Traffic (AM and PM);

6.8.1.1 Richardson Street/ Karnup Road

Figure 6-11 shows the SIDRA layout that was modelled for the existing Richardson Street/ Karnup Road intersection. **Table 6-5** summarises the results of the AM and PM peak hour respectively.

Figure 6-11 Richardson Street/ Karnup Road

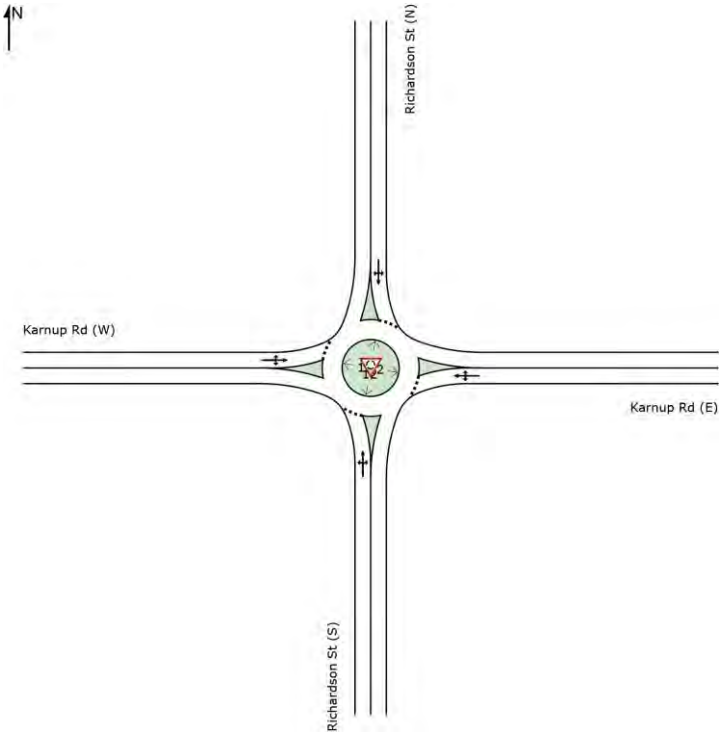


Table 6-5 SIDRA Results for Richardson Street/ Karnup Road – Scenario 1

Intersection Approach		AM peak				PM Peak			
		DOS	Delay (s)	LOS	95% Queue (m)	DOS	Delay (s)	LOS	95% Queue (m)
South: Richardson St (S)	L	0.044	4	A	1.9	0.053	4.2	A	2.2
	T	0.044	4	A	1.9	0.053	4.3	A	2.2
	R	0.044	7.6	A	1.9	0.053	7.8	A	2.2
East: Karnup Rd (E)	L	0.062	4	A	2.8	0.092	4.2	A	4.2
	T	0.062	4.4	A	2.8	0.092	4.6	A	4.2
	R	0.062	7.9	A	2.8	0.092	8.1	A	4.2
North: Richardson St (N)	L	0.04	4.9	A	1.7	0.065	4.9	A	2.7
	T	0.04	5.2	A	1.7	0.065	5.2	A	2.7
	R	0.04	8.9	A	1.7	0.065	8.9	A	2.7
West: Karnup Rd (W)	L	0.094	3	A	4.2	0.09	3	A	4
	T	0.094	3.4	A	4.2	0.09	3.5	A	4
	R	0.094	6.8	A	4.2	0.09	6.8	A	4
All Vehicles		0.094	5	A	4.2	0.092	5.4	A	4.2

6.8.1.2 Karnup Road/ Wellard Street

The existing Karnup Road/ Wellard Street intersection as shown in **Figure 6-12**. The analysis results for this intersection are presented in **Table 6-6.**

Figure 6-12 Karnup Road/ Wellard Street

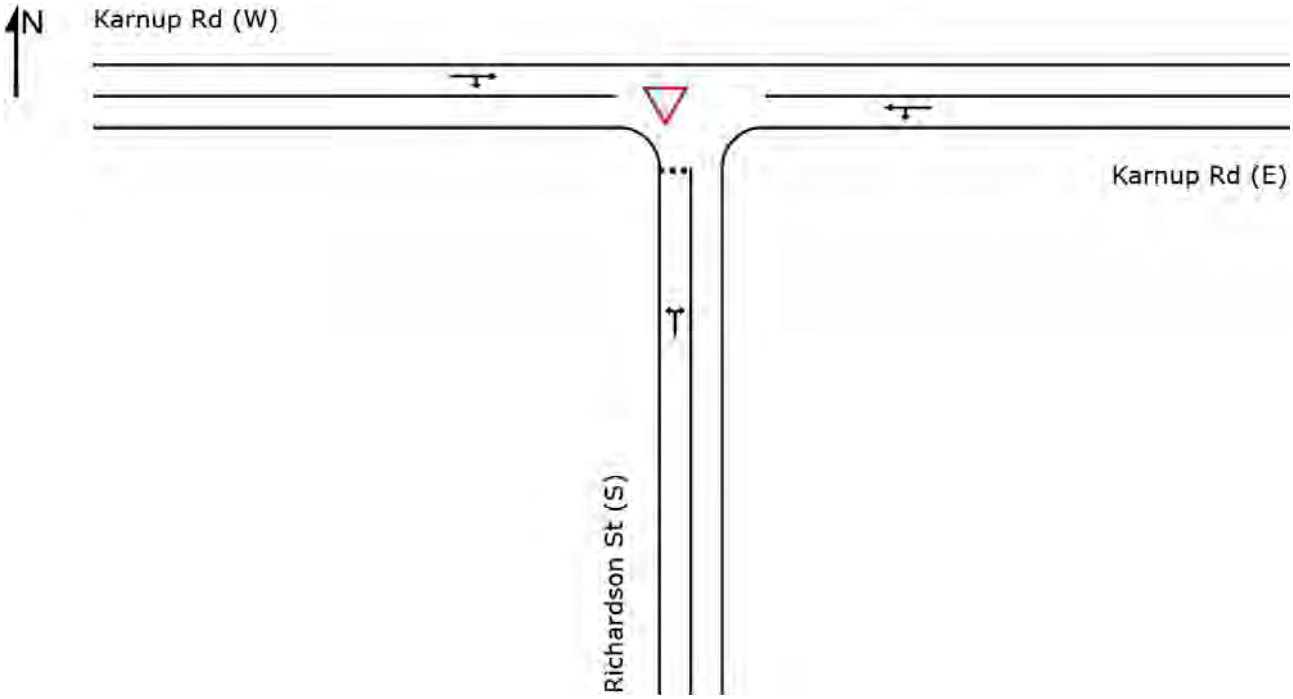


Table 6-6 SIDRA Results for Karnup Road/ Wellard Street - Scenario 1

Intersection Approach		AM peak				PM Peak			
		DOS	Delay (s)	LOS	95% Queue (m)	DOS	Delay (s)	LOS	95% Queue (m)
South: Richardson St (S)	L	0.034	4.7	A	0.9	0.03	4.8	A	0.8
	R	0.034	5.1	A	0.9	0.03	5.3	A	0.8
East: Karnup Rd (E)	L	0.038	5.6	A	0	0.065	5.6	A	0
	T	0.038	0	A	0	0.065	0	A	0
West: Karnup Rd (W)	T	0.037	0	A	0.3	0.037	0	A	0.3
	R	0.037	5.7	A	0.3	0.037	5.8	A	0.3
All Vehicles		0.038	2.3	A	0.1	0.065	2	A	0.8

6.8.1.1 *Leslie Street/ Hardey Road*

The existing layout for the Leslie Street/ Hardey Road as shown in **Figure 6-13** was modelled in SIDRA**.** The analysis results for this intersection are presented in **Table 6-7.**

Figure 6-13 Leslie Street/ Hardey Road

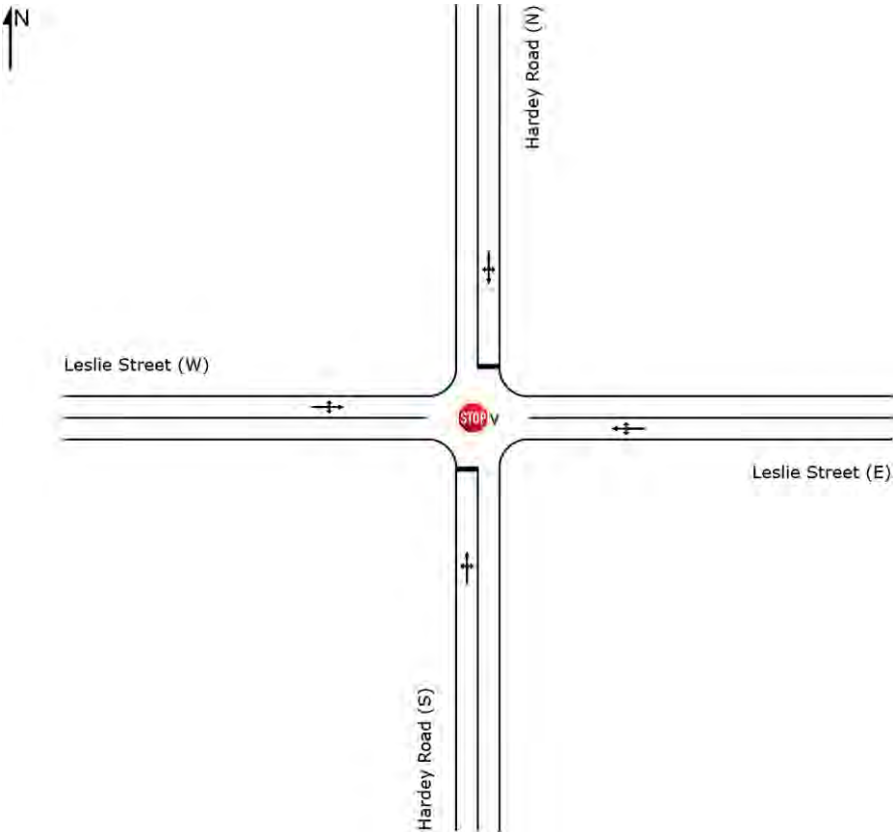


Table 6-7 SIDRA Results for Leslie Street/ Hardey Road – Scenario 1

Intersection Approach		AM peak				PM Peak			
		DOS	Delay (s)	LOS	95% Queue (m)	DOS	Delay (s)	LOS	95% Queue (m)
South: Hardey Road (S)	L	0.015	8.1	A	0.4	0.013	8.3	A	0.4
	T	0.015	7.6	A	0.4	0.013	7.5	A	0.4
	R	0.015	7.3	A	0.4	0.013	7.3	A	0.4
East: Leslie Street (E)	L	0.006	4.6	A	0.1	0.007	4.6	A	0.1
	T	0.006	0	A	0.1	0.007	0	A	0.1
	R	0.006	4.6	A	0.1	0.007	4.6	A	0.1
North: Hardey Road (N)	L	0.013	7.7	A	0.3	0.029	7.5	A	0.8
	T	0.013	7.4	A	0.3	0.029	7.5	A	0.8
	R	0.013	7.6	A	0.3	0.029	7.7	A	0.8
West: Leslie Street (W)	L	0.013	2.8	A	0.3	0.015	2.8	A	0.5
	T	0.013	0	A	0.3	0.015	0	A	0.5
	R	0.013	2.7	A	0.3	0.015	2.7	A	0.5
All Vehicles		0.015	4.6	A	0.4	0.029	5.1	A	0.8

6.8.1.2 Leslie Street/ Lefroy Street

The existing Leslie Street/ Lefroy Street intersection as shown in **Figure 6-14** was modelled in SIDRA. The analysis results for this intersection are presented in **Table 6-6.**

Figure 6-14 Leslie Street/ Lefroy Street

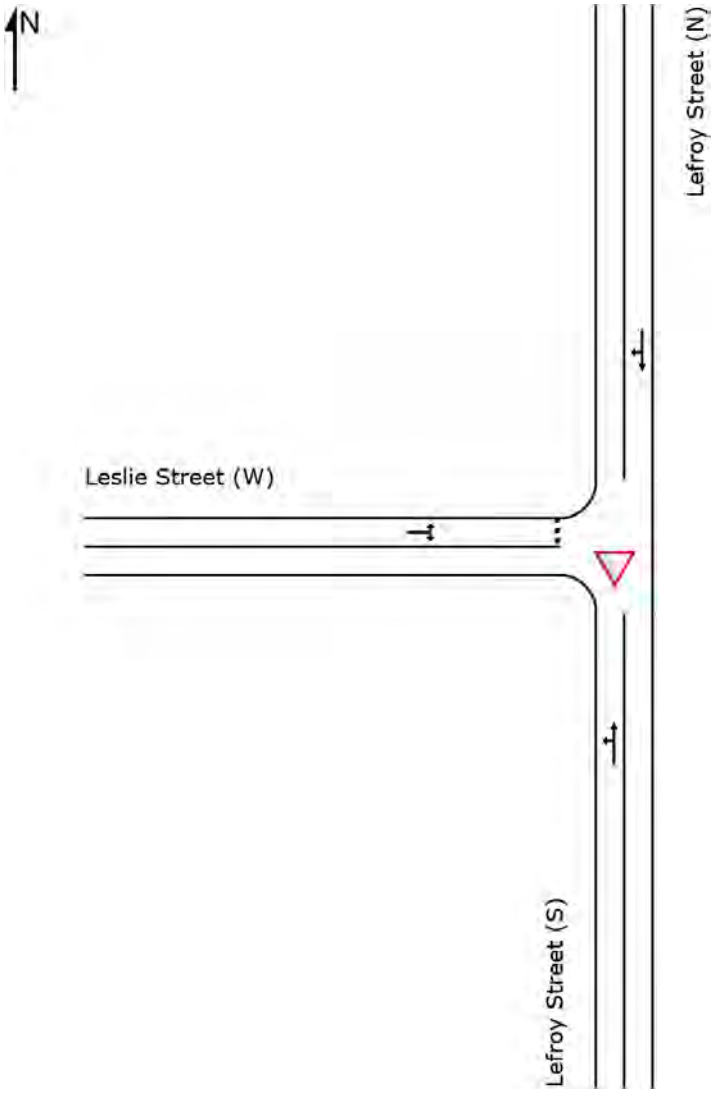


Table 6-8 SIDRA Results for Leslie Street/ Lefroy Street – Scenario 1

Intersection Approach		AM peak				PM Peak			
		DOS	Delay (s)	LOS	95% Queue (m)	DOS	Delay (s)	LOS	95% Queue (m)
South: Lefroy Street (S)	L	0.026	4.6	A	0	0.014	4.6	A	0
	T	0.026	0	A	0	0.014	0	A	0
North: Lefroy Street (N)	T	0.022	0	A	0.4	0.03	0	A	0.5
	R	0.022	4.7	A	0.4	0.03	4.7	A	0.5
West: Leslie Street (W)	L	0.011	4.6	A	0.3	0.007	4.6	A	0.2
	R	0.011	4.8	A	0.3	0.007	4.8	A	0.2
All Vehicles		0.026	1.3	A	0.1	0.03	1.2	A	0.5

Scenario 2: 2033 Future traffic with development

The SIDRA results for Scenario 2 are summarised in **Table 6-9** to **Table 6-12**.

Table 6-9 SIDRA Results for Richardson Street/ Karnup Road – Scenario 2

Intersection Approach		AM peak				PM Peak			
		DOS	Delay (s)	LOS	95% Queue (m)	DOS	Delay (s)	LOS	95% Queue (m)
South: Richardson St (S)	L	0.098	5	A	4.4	0.186	5.9	A	9
	T	0.098	5	A	4.4	0.186	5.9	A	9
	R	0.098	8.6	A	4.4	0.186	9.4	A	9
East: Karnup Rd (E)	L	0.171	4.8	A	8.4	0.283	5.6	A	14.9
	T	0.171	5.2	A	8.4	0.283	6.1	A	14.9
	R	0.171	8.7	A	8.4	0.283	9.5	A	14.9
North: Richardson St (N)	L	0.123	5.5	A	5.5	0.186	6.2	A	8.9
	T	0.123	5.8	A	5.5	0.186	6.5	A	8.9
	R	0.123	9.5	A	5.5	0.186	10.2	B	8.9
West: Karnup Rd (W)	L	0.178	3.4	A	8.6	0.267	3.9	A	14.1
	T	0.178	3.8	A	8.6	0.267	4.3	A	14.1
	R	0.178	7.2	A	8.6	0.267	7.7	A	14.1
All Vehicles		0.178	5.9	A	8.6	0.283	6.5	A	14.9

Table 6-10 SIDRA Results for Karnup Road/ Wellard Street - Scenario 2

Intersection Approach		AM peak				PM Peak			
		DOS	Delay (s)	LOS	95% Queue (m)	DOS	Delay (s)	LOS	95% Queue (m)
South: Richardson St (S)	L	0.082	4.8	A	2.2	0.106	5	A	2.9
	R	0.082	5.5	A	2.2	0.106	6	A	2.9
East: Karnup Rd (E)	L	0.073	5.6	A	0	0.146	5.6	A	0
	T	0.073	0	A	0	0.146	0	A	0
West: Karnup Rd (W)	T	0.059	0	A	0.4	0.056	0.1	A	0.4
	R	0.059	5.9	A	0.4	0.056	6.4	A	0.4
All Vehicles		0.082	2.8	A	0.3	0.146	3	A	2.9

Table 6-11 SIDRA Results for Leslie Street/ Hardey Road – Scenario 2

Intersection Approach		AM peak				PM Peak			
		DOS	Delay (s)	LOS	95% Queue (m)	DOS	Delay (s)	LOS	95% Queue (m)
South: Hardey Road (S)	L	0.022	8.2	A	0.6	0.02	8.3	A	0.6
	T	0.022	7.8	A	0.6	0.02	7.7	A	0.6
	R	0.022	7.5	A	0.6	0.02	7.6	A	0.6
East: Leslie Street (E)	L	0.022	4.6	A	0.8	0.019	4.7	A	0.6
	T	0.022	0.1	A	0.8	0.019	0.1	A	0.6
	R	0.022	4.6	A	0.8	0.019	4.7	A	0.6
North: Hardey Road (N)	L	0.029	7.7	A	0.8	0.066	7.5	A	1.8
	T	0.029	7.6	A	0.8	0.066	7.6	A	1.8
	R	0.029	7.9	A	0.8	0.066	7.9	A	1.8

West: Leslie Street (W)	L	0.02	2.8	A	0.4	0.026	2.8	A	0.7
	T	0.02	0	A	0.4	0.026	0	A	0.7
	R	0.02	2.7	A	0.4	0.026	2.7	A	0.7
All Vehicles		0.029	4.9	A	0.8	0.066	5.4	A	1.8

Table 6-12 SIDRA Results for Leslie Street/ Lefroy Street – Scenario 2

Intersection Approach		AM peak				PM Peak			
		DOS	Delay (s)	LOS	95% Queue (m)	DOS	Delay (s)	LOS	95% Queue (m)
South: Lefroy Street (S)	L	0.061	4.6	A	0	0.038	4.6	A	0
	T	0.061	0	A	0	0.038	0	A	0
North: Lefroy Street (N)	T	0.039	0.1	A	0.7	0.076	0.1	A	1.1
	R	0.039	4.9	A	0.7	0.076	4.8	A	1.1
West: Leslie Street (W)	L	0.021	4.8	A	0.6	0.014	4.7	A	0.4
	R	0.021	5.2	A	0.6	0.014	5.3	A	0.4
All Vehicles		0.061	1.2	A	0.1	0.076	1	A	1.1

6.8.2 SIDRA Results Summary

The following is a summary of the traffic analysis based on the results of the SIDRA modelling:

> All intersections are expected to operate at acceptable levels of service and capacity for all scenarios analysed.

Overall, the proposed development is not anticipated to have a material impact on the traffic operations of the key intersections in the local structure plan area.

7 Conclusions

This report has been prepared in accordance with the *Australian Planning Commission (WAPC) Transport Impact Assessment Guidelines Volume 2 – Planning Schemes, Structure Plans and Activity Centre Zones (2016).*

The following is concluded:

- The proposed Local Structure Plan comprising residential dwellings (R5), is expected to generate 337 trips during the AM Peak Hour and 556 trips during the PM Peak Hour.
- There are no high-frequency public transport services available to the local Structure Plan area. The closest station is the Serpentine Train Station, which operates on a pre-scheduled service based on demand.
- There are currently no cycle routes within or near the local structure plan area.
- According to the SIDRA assessment, the intersections of Richardson Street/Karnup Road, Karnup Road/Wellard Street, Leslie Street/Hardey Road, and Leslie Street/Lefroy Street is expected to operate at acceptable level of service and capacity for the future 2033 model year.

Overall, the proposed local structure plan is not anticipated to have a material impact on the traffic operations and safety on the surrounding road network.

Serpentine Townsite Local Structure Plan

APPENDIX A

WAPC CHECKLIST

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ITEM	PROVIDED	COMMENTS
Summary		
Introduction/Background	Section 1	
Subdivision proposal		
regional context	Section 3	
proposed land uses	Section 3	
table of land uses and quantities	Section 3	
major attractors/generators	Section 3	
specific issues	N/A	
Existing situation		
existing land uses within structure plan	Section 2	
existing land uses within 800 metres of subdivision	Section 2	
existing road network within subdivision	Section 2	
existing pedestrian/cycle networks within subdivision	Section 2	
existing public transport services within structure plan area	Section 2	
existing road network within 2 (or 5) km of subdivision	Section 2	
traffic flows on roads within subdivision area (PM and/or AM peak hours)	Section 2	
traffic flows on roads within 2 (or 5) km of within subdivision area (AM and/ or PM peak hours)	Section 2	
existing pedestrian/cycle networks within 800m of subdivision	Section 2	
existing public transport services within 800m of subdivision area	Section 2	
Proposed internal transport networks		
changes/additions to existing road network or proposed new road network	N/A	
road reservation widths	N/A	
road cross-sections & speed limits	N/A	
intersection controls	N/A	
pedestrian/cycle networks and crossing facilities	N/A	
public transport routes	N/A	
Changes to external transport networks		
road network	Section 4	
intersection controls	N/A	
pedestrian/cycle networks and crossing facilities	Section 4	
public transport services	Section 4	
Integration with surrounding area		
trip attractors/generators within 800 metres	Section 5	
proposed changes to land uses within 800 metres	N/A	
travel desire lines from structure plan to these attractors/generators	N/A	

ITEM	PROVIDED	COMMENTS
adequacy of external transport networks	N/A	
deficiencies in external transport networks	N/A	
remedial measures to address deficiencies	N/A	
Analysis of internal transport networks		
assessment year(s) and time period(s)	Section 6	
subdivision generated traffic	Section 6	
extraneous (through) traffic	Section 6	
design traffic flows (that is, total traffic)	Section 6	
road cross-sections	N/A	
intersection sight distances	N/A	
intersection operation and method of control	N/A	
frontage access strategy	N/A	
pedestrian/cycle networks	N/A	
safe walk/cycle to school assessment (residential subdivisions only)	N/A	
pedestrian permeability & efficiency	N/A	
access to public transport	N/A	
Analysis of external transport networks		
base flows for assessment year(s)	Section 6	
total traffic flows	Section 6	
road cross-sections	N/A	
intersection layouts & controls	Section 6	
pedestrian/cycle networks	N/A	
Safety issues		
Identify issues	N/A	
Remedial measures	N/A	
Conclusions	Section 7	

Serpentine Townsite Local Structure Plan

APPENDIX B

LOCAL STRUCTURE PLAN

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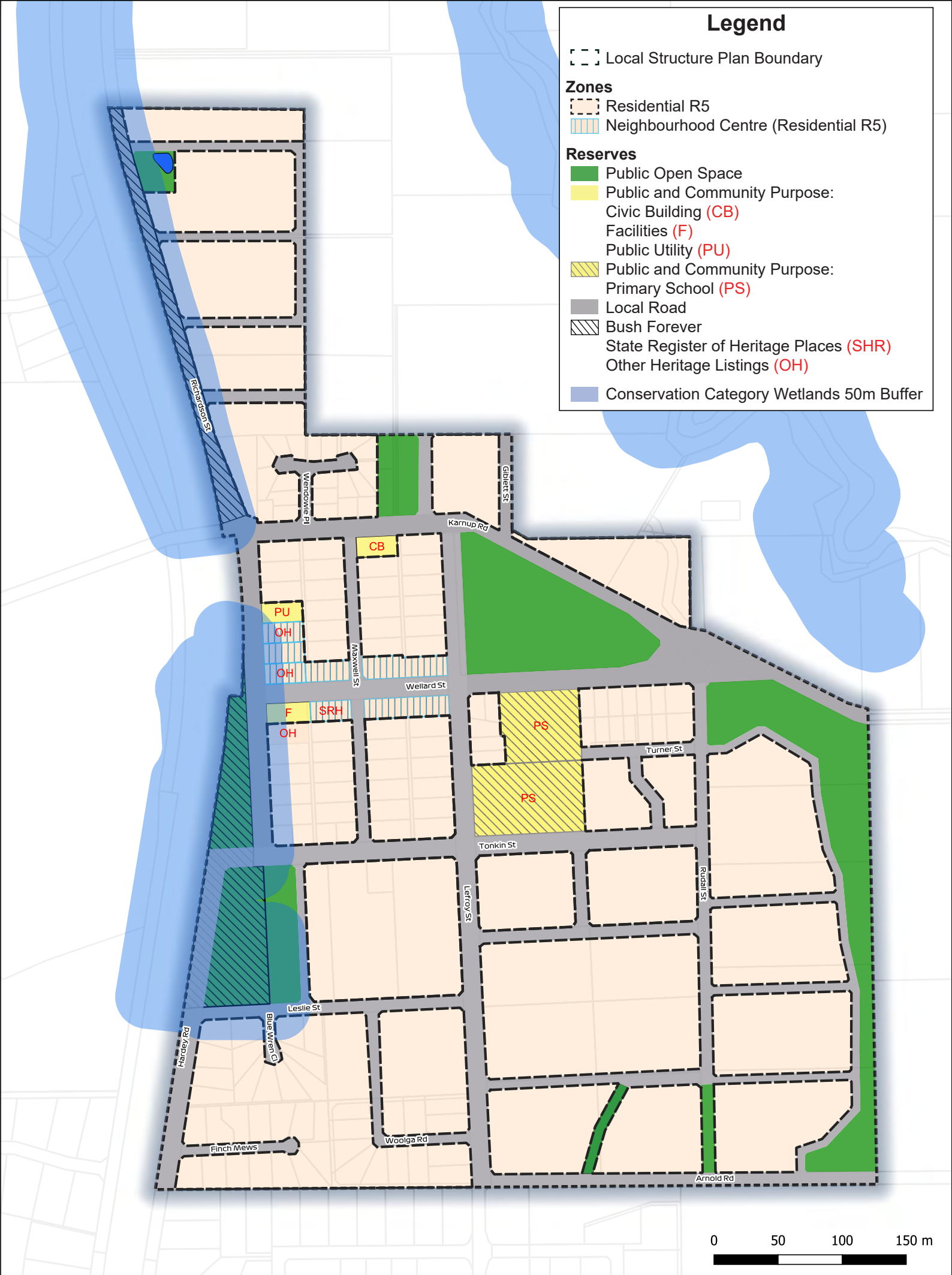

Shire of Serpentine Jarrahdale

Serpentine Townsite Local Structure Plan

Scale : 1 : 5,000 @ A3
Compiled By: P.Leung
Created On: 16 Sept 2022
Request No. 38110

Serpentine Townsite Local Structure Plan

APPENDIX C

SIDRA RESULTS

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MOVEMENT SUMMARY

Site: [Karnup Road/ Richardson Street (Site Folder: S1 - 2022 (AM))]

Site Category: -
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Richardson St (S)														
1	L2	30	6.0	32	6.0	0.044	4.0	LOS A	0.2	1.9	0.28	0.49	0.28	24.9
2	T1	7	1.0	7	1.0	0.044	4.0	LOS A	0.2	1.9	0.28	0.49	0.28	48.3
3	R2	12	2.0	13	2.0	0.044	7.6	LOS A	0.2	1.9	0.28	0.49	0.28	38.2
Approach		49	4.3	52	4.3	0.044	4.9	LOS A	0.2	1.9	0.28	0.49	0.28	31.1
East: Karnup Rd (E)														
4	L2	10	3.0	11	3.0	0.062	4.0	LOS A	0.3	2.8	0.24	0.49	0.24	40.5
5	T1	47	13.0	49	13.0	0.062	4.4	LOS A	0.3	2.8	0.24	0.49	0.24	17.7
6	R2	12	3.0	13	3.0	0.062	7.9	LOS A	0.3	2.8	0.24	0.49	0.24	47.6
Approach		69	9.8	73	9.8	0.062	4.9	LOS A	0.3	2.8	0.24	0.49	0.24	26.6
North: Richardson St (N)														
7	L2	11	2.0	12	2.0	0.040	4.9	LOS A	0.2	1.7	0.29	0.57	0.29	33.8
8	T1	6	1.0	6	1.0	0.040	5.2	LOS A	0.2	1.7	0.29	0.57	0.29	47.2
9	R2	27	6.0	28	6.0	0.040	8.9	LOS A	0.2	1.7	0.29	0.57	0.29	32.8
Approach		44	4.3	46	4.3	0.040	7.4	LOS A	0.2	1.7	0.29	0.57	0.29	35.0
West: Karnup Rd (W)														
10	L2	34	4.0	36	4.0	0.094	3.0	LOS A	0.5	4.2	0.16	0.50	0.16	47.0
11	T1	55	6.0	58	6.0	0.094	3.4	LOS A	0.5	4.2	0.16	0.50	0.16	21.2
12	R2	30	4.0	32	4.0	0.094	6.8	LOS A	0.5	4.2	0.16	0.50	0.16	42.6
Approach		119	4.9	125	4.9	0.094	4.1	LOS A	0.5	4.2	0.16	0.50	0.16	35.1
All Vehicles		281	5.9	296	5.9	0.094	5.0	LOS A	0.5	4.2	0.22	0.50	0.22	32.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Karnup Road/ Wellard Street (Site Folder: S1 - 2022 (AM))]

Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Richardson St (S)														
1	L2	5	1.0	5	1.0	0.034	4.7	LOS A	0.1	0.9	0.17	0.54	0.17	46.7
3	R2	32	8.0	34	8.0	0.034	5.1	LOS A	0.1	0.9	0.17	0.54	0.17	42.3
Approach		37	7.1	39	7.1	0.034	5.0	LOS A	0.1	0.9	0.17	0.54	0.17	43.0
East: Karnup Rd (E)														
4	L2	26	6.0	27	6.0	0.038	5.6	LOS A	0.0	0.0	0.00	0.24	0.00	50.6
5	T1	38	9.0	40	9.0	0.038	0.0	LOS A	0.0	0.0	0.00	0.24	0.00	55.5
Approach		64	7.8	67	7.8	0.038	2.3	NA	0.0	0.0	0.00	0.24	0.00	53.3
West: Karnup Rd (W)														
11	T1	55	12.0	58	12.0	0.037	0.0	LOS A	0.0	0.3	0.04	0.06	0.04	58.4
12	R2	6	1.0	6	1.0	0.037	5.7	LOS A	0.0	0.3	0.04	0.06	0.04	51.6
Approach		61	10.9	64	10.9	0.037	0.6	NA	0.0	0.3	0.04	0.06	0.04	57.4
All Vehicles		162	8.8	171	8.8	0.038	2.3	NA	0.1	0.9	0.05	0.24	0.05	51.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: v [Leslie Street/ Hardey Road (Site Folder: S1 - 2022 (AM))]

Site Category: -
Stop (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Hardey Road (S)														
1	L2	10	9.0	11	9.0	0.015	8.1	LOS A	0.1	0.4	0.04	1.03	0.04	20.4
2	T1	4	4.0	4	4.0	0.015	7.6	LOS A	0.1	0.4	0.04	1.03	0.04	40.0
3	R2	3	3.0	3	3.0	0.015	7.3	LOS A	0.1	0.4	0.04	1.03	0.04	36.1
Approach		17	6.8	18	6.8	0.015	7.9	LOS A	0.1	0.4	0.04	1.03	0.04	27.6
East: Leslie Street (E)														
4	L2	2	1.0	2	1.0	0.006	4.6	LOS A	0.0	0.1	0.04	0.21	0.04	44.5
5	T1	6	3.0	6	3.0	0.006	0.0	LOS A	0.0	0.1	0.04	0.21	0.04	41.9
6	R2	2	1.0	2	1.0	0.006	4.6	LOS A	0.0	0.1	0.04	0.21	0.04	44.6
Approach		10	2.2	11	2.2	0.006	1.9	NA	0.0	0.1	0.04	0.21	0.04	43.5
North: Hardey Road (N)														
7	L2	3	3.0	3	3.0	0.013	7.7	LOS A	0.0	0.3	0.07	0.99	0.07	39.5
8	T1	2	2.0	2	2.0	0.013	7.4	LOS A	0.0	0.3	0.07	0.99	0.07	40.7
9	R2	8	7.0	8	7.0	0.013	7.6	LOS A	0.0	0.3	0.07	0.99	0.07	34.6
Approach		13	5.3	14	5.3	0.013	7.6	LOS A	0.0	0.3	0.07	0.99	0.07	36.9
West: Leslie Street (W)														
10	L2	9	2.0	9	2.0	0.013	2.8	LOS A	0.0	0.3	0.03	0.33	0.03	44.4
11	T1	8	2.0	8	2.0	0.013	0.0	LOS A	0.0	0.3	0.03	0.33	0.03	42.3
12	R2	6	1.0	6	1.0	0.013	2.7	LOS A	0.0	0.3	0.03	0.33	0.03	41.7
Approach		23	1.7	24	1.7	0.013	1.8	NA	0.0	0.3	0.03	0.33	0.03	43.3
All Vehicles		63	3.9	66	3.9	0.015	4.6	NA	0.1	0.4	0.04	0.64	0.04	35.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Leslie Street/ Lefroy Street (Site Folder: S1 - 2022 (AM))]

Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Lefroy Street (S)														
1	L2	2	1.0	2	1.0	0.026	4.6	LOS A	0.0	0.0	0.00	0.03	0.00	28.5
2	T1	40	14.0	42	14.0	0.026	0.0	LOS A	0.0	0.0	0.00	0.03	0.00	49.7
Approach		42	13.4	44	13.4	0.026	0.2	NA	0.0	0.0	0.00	0.03	0.00	48.5
North: Lefroy Street (N)														
8	T1	27	10.0	28	10.0	0.022	0.0	LOS A	0.1	0.4	0.07	0.14	0.07	48.0
9	R2	9	3.0	9	3.0	0.022	4.7	LOS A	0.1	0.4	0.07	0.14	0.07	24.4
Approach		36	8.3	38	8.3	0.022	1.2	NA	0.1	0.4	0.07	0.14	0.07	41.4
West: Leslie Street (W)														
10	L2	13	4.0	14	4.0	0.011	4.6	LOS A	0.0	0.3	0.12	0.50	0.12	38.7
12	R2	2	1.0	2	1.0	0.011	4.8	LOS A	0.0	0.3	0.12	0.50	0.12	39.4
Approach		15	3.6	16	3.6	0.011	4.7	LOS A	0.0	0.3	0.12	0.50	0.12	38.8
All Vehicles		93	9.8	98	9.8	0.026	1.3	NA	0.1	0.4	0.04	0.15	0.04	44.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Karnup Road/ Richardson Street (Site Folder: S1 - 2022 (PM))]

Site Category: -
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Richardson St (S)														
1	L2	34	6.0	36	6.0	0.053	4.2	LOS A	0.3	2.2	0.33	0.50	0.33	24.8
2	T1	9	2.0	9	2.0	0.053	4.3	LOS A	0.3	2.2	0.33	0.50	0.33	47.8
3	R2	13	2.0	14	2.0	0.053	7.8	LOS A	0.3	2.2	0.33	0.50	0.33	38.0
Approach		56	4.4	59	4.4	0.053	5.1	LOS A	0.3	2.2	0.33	0.50	0.33	31.2
East: Karnup Rd (E)														
4	L2	20	4.0	21	4.0	0.092	4.2	LOS A	0.5	4.2	0.30	0.50	0.30	40.0
5	T1	63	12.0	66	12.0	0.092	4.6	LOS A	0.5	4.2	0.30	0.50	0.30	17.5
6	R2	16	3.0	17	3.0	0.092	8.1	LOS A	0.5	4.2	0.30	0.50	0.30	47.4
Approach		99	8.9	104	8.9	0.092	5.1	LOS A	0.5	4.2	0.30	0.50	0.30	27.3
North: Richardson St (N)														
7	L2	16	2.0	17	2.0	0.065	4.9	LOS A	0.4	2.7	0.29	0.57	0.29	33.8
8	T1	13	2.0	14	2.0	0.065	5.2	LOS A	0.4	2.7	0.29	0.57	0.29	47.1
9	R2	42	6.0	44	6.0	0.065	8.9	LOS A	0.4	2.7	0.29	0.57	0.29	32.8
Approach		71	4.4	75	4.4	0.065	7.3	LOS A	0.4	2.7	0.29	0.57	0.29	35.6
West: Karnup Rd (W)														
10	L2	30	4.0	32	4.0	0.090	3.0	LOS A	0.5	4.0	0.18	0.52	0.18	46.6
11	T1	44	6.0	46	6.0	0.090	3.5	LOS A	0.5	4.0	0.18	0.52	0.18	21.0
12	R2	37	5.0	39	5.0	0.090	6.8	LOS A	0.5	4.0	0.18	0.52	0.18	41.8
Approach		111	5.1	117	5.1	0.090	4.5	LOS A	0.5	4.0	0.18	0.52	0.18	35.9
All Vehicles		337	6.0	355	6.0	0.092	5.4	LOS A	0.5	4.2	0.26	0.52	0.26	32.7

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Karnup Road/ Wellard Street (Site Folder: S1 - 2022 (PM))]

Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Richardson St (S)														
1	L2	4	1.0	4	1.0	0.030	4.8	LOS A	0.1	0.8	0.22	0.54	0.22	46.5
3	R2	28	8.0	29	8.0	0.030	5.3	LOS A	0.1	0.8	0.22	0.54	0.22	42.1
Approach		32	7.1	34	7.1	0.030	5.2	LOS A	0.1	0.8	0.22	0.54	0.22	42.8
East: Karnup Rd (E)														
4	L2	38	5.0	40	5.0	0.065	5.6	LOS A	0.0	0.0	0.00	0.20	0.00	51.4
5	T1	72	10.0	76	10.0	0.065	0.0	LOS A	0.0	0.0	0.00	0.20	0.00	56.0
Approach		110	8.3	116	8.3	0.065	1.9	NA	0.0	0.0	0.00	0.20	0.00	54.3
West: Karnup Rd (W)														
11	T1	56	12.0	59	12.0	0.037	0.0	LOS A	0.0	0.3	0.04	0.05	0.04	58.6
12	R2	5	1.0	5	1.0	0.037	5.8	LOS A	0.0	0.3	0.04	0.05	0.04	51.7
Approach		61	11.1	64	11.1	0.037	0.5	NA	0.0	0.3	0.04	0.05	0.04	57.7
All Vehicles		203	8.9	214	8.9	0.065	2.0	NA	0.1	0.8	0.05	0.21	0.05	52.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: v [Leslie Street/ Hardey Road (Site Folder: S1 - 2022 (PM))]

Site Category: -
Stop (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Hardey Road (S)														
1	L2	11	11.0	12	11.0	0.013	8.3	LOS A	0.0	0.4	0.04	1.03	0.04	20.4
2	T1	2	2.0	2	2.0	0.013	7.5	LOS A	0.0	0.4	0.04	1.03	0.04	40.4
3	R2	2	2.0	2	2.0	0.013	7.3	LOS A	0.0	0.4	0.04	1.03	0.04	36.2
Approach		15	8.6	16	8.6	0.013	8.0	LOS A	0.0	0.4	0.04	1.03	0.04	24.9
East: Leslie Street (E)														
4	L2	3	1.0	3	1.0	0.007	4.6	LOS A	0.0	0.1	0.03	0.21	0.03	44.7
5	T1	8	3.0	8	3.0	0.007	0.0	LOS A	0.0	0.1	0.03	0.21	0.03	42.3
6	R2	2	1.0	2	1.0	0.007	4.6	LOS A	0.0	0.1	0.03	0.21	0.03	44.7
Approach		13	2.2	14	2.2	0.007	1.8	NA	0.0	0.1	0.03	0.21	0.03	43.7
North: Hardey Road (N)														
7	L2	3	1.0	3	1.0	0.029	7.5	LOS A	0.1	0.8	0.08	0.99	0.08	39.7
8	T1	6	2.0	6	2.0	0.029	7.5	LOS A	0.1	0.8	0.08	0.99	0.08	40.7
9	R2	19	7.0	20	7.0	0.029	7.7	LOS A	0.1	0.8	0.08	0.99	0.08	34.6
Approach		28	5.3	29	5.3	0.029	7.6	LOS A	0.1	0.8	0.08	0.99	0.08	36.7
West: Leslie Street (W)														
10	L2	7	1.0	7	1.0	0.015	2.8	LOS A	0.1	0.5	0.05	0.37	0.05	44.3
11	T1	6	1.0	6	1.0	0.015	0.0	LOS A	0.1	0.5	0.05	0.37	0.05	41.2
12	R2	12	3.0	13	3.0	0.015	2.7	LOS A	0.1	0.5	0.05	0.37	0.05	40.3
Approach		25	2.0	26	2.0	0.015	2.1	NA	0.1	0.5	0.05	0.37	0.05	41.9
All Vehicles		81	4.4	85	4.4	0.029	5.1	NA	0.1	0.8	0.06	0.68	0.06	35.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Leslie Street/ Lefroy Street (Site Folder: S1 - 2022 (PM))]

Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Lefroy Street (S)														
1	L2	2	1.0	2	1.0	0.014	4.6	LOS A	0.0	0.0	0.00	0.05	0.00	28.3
2	T1	21	14.0	22	14.0	0.014	0.0	LOS A	0.0	0.0	0.00	0.05	0.00	49.4
Approach		23	12.9	24	12.9	0.014	0.4	NA	0.0	0.0	0.00	0.05	0.00	47.3
North: Lefroy Street (N)														
8	T1	40	11.0	42	11.0	0.030	0.0	LOS A	0.1	0.5	0.04	0.11	0.04	48.5
9	R2	10	3.0	11	3.0	0.030	4.7	LOS A	0.1	0.5	0.04	0.11	0.04	24.6
Approach		50	9.4	53	9.4	0.030	0.9	NA	0.1	0.5	0.04	0.11	0.04	43.0
West: Leslie Street (W)														
10	L2	7	3.0	7	3.0	0.007	4.6	LOS A	0.0	0.2	0.08	0.51	0.08	39.1
12	R2	3	1.0	3	1.0	0.007	4.8	LOS A	0.0	0.2	0.08	0.51	0.08	39.6
Approach		10	2.4	11	2.4	0.007	4.6	LOS A	0.0	0.2	0.08	0.51	0.08	39.3
All Vehicles		83	9.5	87	9.5	0.030	1.2	NA	0.1	0.5	0.03	0.14	0.03	43.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Karnup Road/ Richardson Street (Site Folder: S2 - 2032+DEV (AM))]

Site Category: -
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Richardson St (S)														
1	L2	59	6.0	62	6.0	0.098	5.0	LOS A	0.6	4.4	0.47	0.55	0.47	24.6
2	T1	20	1.0	21	1.0	0.098	5.0	LOS A	0.6	4.4	0.47	0.55	0.47	47.7
3	R2	15	2.0	16	2.0	0.098	8.6	LOS A	0.6	4.4	0.47	0.55	0.47	37.5
Approach		94	4.3	99	4.3	0.098	5.6	LOS A	0.6	4.4	0.47	0.55	0.47	31.4
East: Karnup Rd (E)														
4	L2	13	3.0	14	3.0	0.171	4.8	LOS A	1.0	8.4	0.41	0.56	0.41	39.1
5	T1	112	13.0	118	13.0	0.171	5.2	LOS A	1.0	8.4	0.41	0.56	0.41	17.2
6	R2	46	3.0	48	3.0	0.171	8.7	LOS A	1.0	8.4	0.41	0.56	0.41	46.2
Approach		171	9.5	180	9.5	0.171	6.1	LOS A	1.0	8.4	0.41	0.56	0.41	27.3
North: Richardson St (N)														
7	L2	40	2.0	42	2.0	0.123	5.5	LOS A	0.7	5.5	0.42	0.60	0.42	33.7
8	T1	25	1.0	26	1.0	0.123	5.8	LOS A	0.7	5.5	0.42	0.60	0.42	47.2
9	R2	59	6.0	62	6.0	0.123	9.5	LOS A	0.7	5.5	0.42	0.60	0.42	32.7
Approach		124	3.7	131	3.7	0.123	7.5	LOS A	0.7	5.5	0.42	0.60	0.42	35.9
West: Karnup Rd (W)														
10	L2	52	4.0	55	4.0	0.178	3.4	LOS A	1.1	8.6	0.29	0.53	0.29	46.1
11	T1	87	6.0	92	6.0	0.178	3.8	LOS A	1.1	8.6	0.29	0.53	0.29	20.7
12	R2	69	4.0	73	4.0	0.178	7.2	LOS A	1.1	8.6	0.29	0.53	0.29	41.5
Approach		208	4.8	219	4.8	0.178	4.8	LOS A	1.1	8.6	0.29	0.53	0.29	34.9
All Vehicles		597	5.9	628	5.9	0.178	5.9	LOS A	1.1	8.6	0.38	0.56	0.38	32.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Karnup Road/ Wellard Street (Site Folder: S2 - 2032 +DEV (AM))]

Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Richardson St (S)														
1	L2	6	1.0	6	1.0	0.082	4.8	LOS A	0.3	2.2	0.25	0.57	0.25	46.4
3	R2	76	8.0	80	8.0	0.082	5.5	LOS A	0.3	2.2	0.25	0.57	0.25	42.0
Approach		82	7.5	86	7.5	0.082	5.4	LOS A	0.3	2.2	0.25	0.57	0.25	42.4
East: Karnup Rd (E)														
4	L2	63	6.0	66	6.0	0.073	5.6	LOS A	0.0	0.0	0.00	0.30	0.00	49.8
5	T1	59	9.0	62	9.0	0.073	0.0	LOS A	0.0	0.0	0.00	0.30	0.00	54.4
Approach		122	7.5	128	7.5	0.073	2.9	NA	0.0	0.0	0.00	0.30	0.00	51.8
West: Karnup Rd (W)														
11	T1	90	12.0	95	12.0	0.059	0.0	LOS A	0.1	0.4	0.04	0.05	0.04	58.6
12	R2	8	1.0	8	1.0	0.059	5.9	LOS A	0.1	0.4	0.04	0.05	0.04	51.7
Approach		98	11.1	103	11.1	0.059	0.5	NA	0.1	0.4	0.04	0.05	0.04	57.7
All Vehicles		302	8.6	318	8.6	0.082	2.8	NA	0.3	2.2	0.08	0.29	0.08	50.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: v [Leslie Street/ Hardey Road (Site Folder: S2 - 2032 +DEV (AM))]

Site Category: -
Stop (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Hardey Road (S)														
1	L2	15	9.0	16	9.0	0.022	8.2	LOS A	0.1	0.6	0.05	1.02	0.05	20.3
2	T1	5	4.0	5	4.0	0.022	7.8	LOS A	0.1	0.6	0.05	1.02	0.05	39.9
3	R2	5	3.0	5	3.0	0.022	7.5	LOS A	0.1	0.6	0.05	1.02	0.05	36.0
Approach		25	6.8	26	6.8	0.022	8.0	LOS A	0.1	0.6	0.05	1.02	0.05	27.2
East: Leslie Street (E)														
4	L2	3	1.0	3	1.0	0.022	4.6	LOS A	0.1	0.8	0.09	0.39	0.09	41.7
5	T1	10	3.0	11	3.0	0.022	0.1	LOS A	0.1	0.8	0.09	0.39	0.09	36.6
6	R2	25	1.0	26	1.0	0.022	4.6	LOS A	0.1	0.8	0.09	0.39	0.09	42.4
Approach		38	1.5	40	1.5	0.022	3.4	NA	0.1	0.8	0.09	0.39	0.09	41.6
North: Hardey Road (N)														
7	L2	13	3.0	14	3.0	0.029	7.7	LOS A	0.1	0.8	0.06	0.99	0.06	39.3
8	T1	3	2.0	3	2.0	0.029	7.6	LOS A	0.1	0.8	0.06	0.99	0.06	40.5
9	R2	14	7.0	15	7.0	0.029	7.9	LOS A	0.1	0.8	0.06	0.99	0.06	34.4
Approach		30	4.8	32	4.8	0.029	7.8	LOS A	0.1	0.8	0.06	0.99	0.06	37.3
West: Leslie Street (W)														
10	L2	15	2.0	16	2.0	0.020	2.8	LOS A	0.1	0.4	0.04	0.33	0.04	44.3
11	T1	11	2.0	12	2.0	0.020	0.0	LOS A	0.1	0.4	0.04	0.33	0.04	42.0
12	R2	8	1.0	8	1.0	0.020	2.7	LOS A	0.1	0.4	0.04	0.33	0.04	41.5
Approach		34	1.8	36	1.8	0.020	1.9	NA	0.1	0.4	0.04	0.33	0.04	43.2
All Vehicles		127	3.4	134	3.4	0.029	4.9	NA	0.1	0.8	0.06	0.64	0.06	36.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Leslie Street/ Lefroy Street (Site Folder: S2 - 2032+DEV (AM))]

Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Lefroy Street (S)														
1	L2	3	1.0	3	1.0	0.067	4.6	LOS A	0.0	0.0	0.00	0.02	0.00	28.5
2	T1	106	14.0	112	14.0	0.067	0.0	LOS A	0.0	0.0	0.00	0.02	0.00	49.8
Approach		109	13.6	115	13.6	0.067	0.1	NA	0.0	0.0	0.00	0.02	0.00	49.1
North: Lefroy Street (N)														
8	T1	56	10.0	59	10.0	0.043	0.1	LOS A	0.1	0.8	0.10	0.12	0.10	48.1
9	R2	15	3.0	16	3.0	0.043	5.0	LOS A	0.1	0.8	0.10	0.12	0.10	24.4
Approach		71	8.5	75	8.5	0.043	1.1	NA	0.1	0.8	0.10	0.12	0.10	42.4
West: Leslie Street (W)														
10	L2	27	4.0	28	4.0	0.023	4.9	LOS A	0.1	0.7	0.21	0.50	0.21	38.2
12	R2	3	1.0	3	1.0	0.023	5.2	LOS A	0.1	0.7	0.21	0.50	0.21	39.0
Approach		30	3.7	32	3.7	0.023	4.9	LOS A	0.1	0.7	0.21	0.50	0.21	38.3
All Vehicles		210	10.5	221	10.5	0.067	1.2	NA	0.1	0.8	0.07	0.12	0.07	45.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Karnup Road/ Richardson Street (Site Folder: S2 - 2032+DEV (PM))]

Site Category: -
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Richardson St (S)														
1	L2	103	6.0	108	6.0	0.186	5.9	LOS A	1.2	9.0	0.58	0.63	0.58	24.2
2	T1	41	2.0	43	2.0	0.186	5.9	LOS A	1.2	9.0	0.58	0.63	0.58	46.9
3	R2	16	2.0	17	2.0	0.186	9.4	LOS A	1.2	9.0	0.58	0.63	0.58	36.8
Approach		160	4.6	168	4.6	0.186	6.2	LOS A	1.2	9.0	0.58	0.63	0.58	31.3
East: Karnup Rd (E)														
4	L2	25	4.0	26	4.0	0.283	5.6	LOS A	1.9	14.9	0.54	0.63	0.54	37.9
5	T1	161	12.0	169	12.0	0.283	6.1	LOS A	1.9	14.9	0.54	0.63	0.54	16.8
6	R2	75	3.0	79	3.0	0.283	9.5	LOS A	1.9	14.9	0.54	0.63	0.54	45.2
Approach		261	8.6	275	8.6	0.283	7.0	LOS A	1.9	14.9	0.54	0.63	0.54	27.6
North: Richardson St (N)														
7	L2	57	2.0	60	2.0	0.186	6.2	LOS A	1.2	8.9	0.52	0.64	0.52	33.5
8	T1	47	2.0	49	2.0	0.186	6.5	LOS A	1.2	8.9	0.52	0.64	0.52	46.7
9	R2	69	6.0	73	6.0	0.186	10.2	LOS B	1.2	8.9	0.52	0.64	0.52	32.5
Approach		173	3.6	182	3.6	0.186	7.9	LOS A	1.2	8.9	0.52	0.64	0.52	36.6
West: Karnup Rd (W)														
10	L2	66	4.0	69	4.0	0.267	3.9	LOS A	1.8	14.1	0.42	0.57	0.42	45.3
11	T1	111	6.0	117	6.0	0.267	4.3	LOS A	1.8	14.1	0.42	0.57	0.42	20.3
12	R2	114	5.0	120	5.0	0.267	7.7	LOS A	1.8	14.1	0.42	0.57	0.42	40.3
Approach		291	5.2	306	5.2	0.267	5.5	LOS A	1.8	14.1	0.42	0.57	0.42	34.6
All Vehicles		885	5.8	932	5.8	0.283	6.5	LOS A	1.9	14.9	0.50	0.61	0.50	32.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: SIDRA Roundabout LOS.
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Karnup Road/ Wellard Street (Site Folder: S2 - 2032 +DEV (PM))]

Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Richardson St (S)														
1	L2	5	1.0	5	1.0	0.106	5.0	LOS A	0.4	2.9	0.34	0.62	0.34	46.1
3	R2	91	8.0	96	8.0	0.106	6.0	LOS A	0.4	2.9	0.34	0.62	0.34	41.7
Approach		96	7.6	101	7.6	0.106	5.9	LOS A	0.4	2.9	0.34	0.62	0.34	41.9
East: Karnup Rd (E)														
4	L2	120	5.0	126	5.0	0.146	5.6	LOS A	0.0	0.0	0.00	0.29	0.00	50.3
5	T1	126	10.0	133	10.0	0.146	0.0	LOS A	0.0	0.0	0.00	0.29	0.00	54.6
Approach		246	7.6	259	7.6	0.146	2.8	NA	0.0	0.0	0.00	0.29	0.00	52.3
West: Karnup Rd (W)														
11	T1	85	12.0	89	12.0	0.056	0.1	LOS A	0.0	0.4	0.06	0.04	0.06	58.6
12	R2	6	1.0	6	1.0	0.056	6.4	LOS A	0.0	0.4	0.06	0.04	0.06	51.7
Approach		91	11.3	96	11.3	0.056	0.5	NA	0.0	0.4	0.06	0.04	0.06	57.9
All Vehicles		433	8.4	456	8.4	0.146	3.0	NA	0.4	2.9	0.09	0.31	0.09	50.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: v [Leslie Street/ Hardey Road (Site Folder: S2 - 2032 +DEV (PM))]

Site Category: -
Stop (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Hardey Road (S)														
1	L2	14	11.0	15	11.0	0.020	8.3	LOS A	0.1	0.6	0.05	1.02	0.05	20.3
2	T1	3	2.0	3	2.0	0.020	7.7	LOS A	0.1	0.6	0.05	1.02	0.05	40.4
3	R2	5	2.0	5	2.0	0.020	7.6	LOS A	0.1	0.6	0.05	1.02	0.05	36.1
Approach		22	7.7	23	7.7	0.020	8.1	LOS A	0.1	0.6	0.05	1.02	0.05	26.2
East: Leslie Street (E)														
4	L2	4	1.0	4	1.0	0.019	4.7	LOS A	0.1	0.6	0.09	0.34	0.09	42.2
5	T1	11	3.0	12	3.0	0.019	0.1	LOS A	0.1	0.6	0.09	0.34	0.09	37.6
6	R2	17	1.0	18	1.0	0.019	4.7	LOS A	0.1	0.6	0.09	0.34	0.09	42.8
Approach		32	1.7	34	1.7	0.019	3.1	NA	0.1	0.6	0.09	0.34	0.09	41.8
North: Hardey Road (N)														
7	L2	28	1.0	29	1.0	0.066	7.5	LOS A	0.2	1.8	0.06	0.99	0.06	39.4
8	T1	8	2.0	8	2.0	0.066	7.6	LOS A	0.2	1.8	0.06	0.99	0.06	40.5
9	R2	32	7.0	34	7.0	0.066	7.9	LOS A	0.2	1.8	0.06	0.99	0.06	34.4
Approach		68	3.9	72	3.9	0.066	7.7	LOS A	0.2	1.8	0.06	0.99	0.06	37.4
West: Leslie Street (W)														
10	L2	19	1.0	20	1.0	0.026	2.8	LOS A	0.1	0.7	0.05	0.38	0.05	44.2
11	T1	10	1.0	11	1.0	0.026	0.0	LOS A	0.1	0.7	0.05	0.38	0.05	41.1
12	R2	15	3.0	16	3.0	0.026	2.7	LOS A	0.1	0.7	0.05	0.38	0.05	40.3
Approach		44	1.7	46	1.7	0.026	2.2	NA	0.1	0.7	0.05	0.38	0.05	42.5
All Vehicles		166	3.4	175	3.4	0.066	5.4	NA	0.2	1.8	0.06	0.71	0.06	37.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: [Leslie Street/ Lefroy Street (Site Folder: S2 - 2032+DEV (PM))]

Site Category: -
Give-Way (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Lefroy Street (S)														
1	L2	3	1.0	3	1.0	0.042	4.6	LOS A	0.0	0.0	0.00	0.02	0.00	28.5
2	T1	66	14.0	69	14.0	0.042	0.0	LOS A	0.0	0.0	0.00	0.02	0.00	49.7
Approach		69	13.4	73	13.4	0.042	0.2	NA	0.0	0.0	0.00	0.02	0.00	48.6
North: Lefroy Street (N)														
8	T1	116	11.0	122	11.0	0.085	0.1	LOS A	0.2	1.3	0.07	0.10	0.07	48.5
9	R2	25	3.0	26	3.0	0.085	4.8	LOS A	0.2	1.3	0.07	0.10	0.07	24.6
Approach		141	9.6	148	9.6	0.085	0.9	NA	0.2	1.3	0.07	0.10	0.07	43.6
West: Leslie Street (W)														
10	L2	16	3.0	17	3.0	0.015	4.7	LOS A	0.1	0.4	0.15	0.51	0.15	38.7
12	R2	4	1.0	4	1.0	0.015	5.4	LOS A	0.1	0.4	0.15	0.51	0.15	39.2
Approach		20	2.6	21	2.6	0.015	4.9	LOS A	0.1	0.4	0.15	0.51	0.15	38.8
All Vehicles		230	10.1	242	10.1	0.085	1.0	NA	0.2	1.3	0.06	0.11	0.06	44.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
Delay Model: SIDRA Standard (Geometric Delay is included).
Queue Model: SIDRA Standard.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Appendix 3 – Environmental Assessment

SERPENTINE TOWNSITE

ENVIRONMENTAL ASSESSMENT

Prepared for:	Serpentine Jarrahdale Shire
Report Date:	19 December 2013
Version:	2
Report No.	2013-110

pgv ENVIRONMENTAL

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1 INTRODUCTION

1.1 Site Location

Serpentine Townsite is located in Serpentine Jarrahdale Shire, approximately 50km south-south-east of the Perth Central Business District (Figure 1).

The area studied for this Environmental Assessment (hereafter referred to as 'the site') is bound by Arnold Road to the south, Richardson Street to the west, Summerfield Road to the north and Rudall Street to the east (Figure 2).

1.2 Scope of Works

The Department of Planning has prepared a Local Structure Plan in April 2013 for proposed expansion to the Serpentine Townsite (Appendix 1). Upon review of the structure plan the Serpentine Jarrahdale Shire identified some environmental attributes that were not captured. Therefore the Serpentine Jarrahdale Shire are seeking to review the Local Structure Plan to enhance the environmental outcomes for the town. The Environmental Assessment was undertaken to inform the review of the Local Structure Plan.

1.3 Legislation, Policy and Guidelines

The following legislation, policy and guidelines have been considered during this environmental assessment and will guide the required and expected management outcomes from Commonwealth, State and Local government agencies.

- *Environment Protection and Biodiversity Conservation Act 1999*
  - *The Matters of National Environmental Significance. Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (DoE, 2013a).
- *Environmental Protection Act 1986*
- *Wildlife Conservation Act 1950*
- *Aboriginal Heritage Act 1972*
- State Policy
  - State Planning Policy No. 2.1 *Peel-Harvey Coastal Plain Catchment* (WAPC, 2003);
  - State Planning Policy No. 2.8 *Bushland Policy for the Perth Metropolitan Region* (WAPC, 2010);
  - State Planning Policy No. 2.9 *Water Resources* (WAPC, 2006);
  - State Planning Policy No. 5.4 *Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (WAPC, 2009b);
  - Environmental Protection Authority Position Statement No. 4 *Environmental Protection of Wetlands* (EPA, 2004);
  - EPA Guidance Statement No. 3: *Separation Distances between Industrial and Sensitive Land Uses* (EPA, 2005); and
  - Environmental Protection Authority Guidance Statement No 33 *Environmental Guidance for Planning and Development* (EPA, 2008).

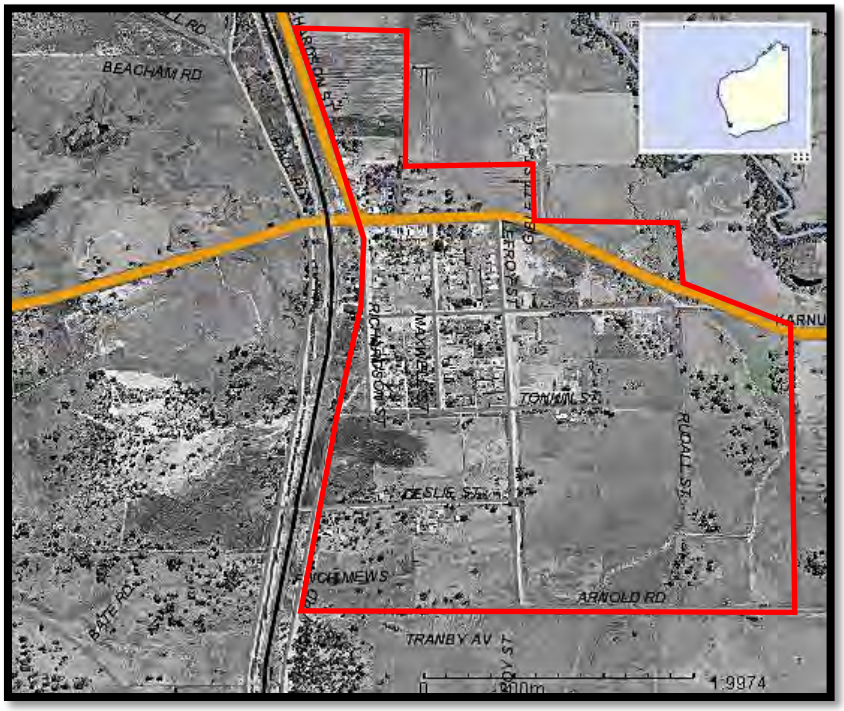
- Serpentine Jarrahdale Shire
  - Local Biodiversity Strategy (Ironbark, 2008);
  - Local Planning Policy (LPP) 4 *Revegetation Strategy* (SJS, 2010);
  - LPP 6 *Water Sensitive Design* (SJS, 2001);
  - LPP 8 *Landscape Protection* (SJS, 2002);
  - LPP 22 *Water Sensitive Urban Design* (SJS, 2009a);
  - LPP 26 *Biodiversity Planning* (SJS, 2009b); and
  - LPP 67 *Landscape and Vegetation* (SJS, 2012).

2 EXISTING ENVIRONMENT

2.1 Past and Existing Land Use

The Townsite of Serpentine was established on the South Western Railway between Perth and Bunbury, and was one of the original stations when the line was opened in 1893. Development and main streets within the town were established prior to 1965 as shown in historical aerial photography (Plate 1).

Plate 1: Historical Aerial Photography from 1965 (Landgate, 2013a)



Currently the Townsite has a small area of commercial land along Wellard Street and several existing public open spaces. The remainder of the Townsite is utilised for rural and residential purposes.

2.2 Surrounding Land Use

The Serpentine Townsite is adjacent to the South Western Railway and some industrial development such as Steelkit Homes off Karnup Road and Richardson Street. The site is surrounded to the south, north and east by land developed for 'rural living' and rural grazing land.

2.3 Topography

The site is generally flat to very gently undulating with elevations ranging from approximately 36m AHD to 30m AHD (Figure 2).

2.4 Geology and Soils

The site is located on the eastern side of the Swan Coastal Plain. The site is mapped as part of the Pinjarra Plain System. The Pinjarra Plain extends from the eastern side of the Bassendean Dunes to the western edge of the Darling Scarp, which joins the Ridge Hill Shelf and forms the denuded slope of the Darling Fault (Beard 1990). The Pinjarra Plain System consists of a broad low relief plain west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. The major soils are naturally poorly drained and many swamps occur.

The description of the soil phases mapped by the Department of Agriculture and Food Western Australia (DAFWA) on the site is provided in Table 1 (Figure 3).

Table 1: Soil Landscape Sub-Systems Found Within the Site

Reference	Description*
213Pj_B1	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises. Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at generally >2m.
213Pj_B2	Well to moderately well drained flat to very gently undulating sandplain. Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2m.
213Pj_B3	Very poorly drained closed depressions and poorly defined stream channels. Moderately deep bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand.
213Pj_P1a	Flat to very gently undulating plain. Imperfect to poorly drained and generally not susceptible to salinity. Deep acidic mottled yellow duplex soils. Shallow pale sand to sandy loam over clay.
213Pj_P1d	Pale grey sand to sandy loam over clay; imperfect to poorly drained and moderately susceptible to salinity
213Pj_P3	Flat to very gently undulating plain. Imperfect to poorly drained. Deep acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.
213PjSWP6a	Very gently undulating alluvial terraces and low rises contiguous with the plain. Associated with major current river systems and larger streams. Deep moderately well to well drained acidic red and yellow duplex and less commonly, gradational soils.

* From van Gool, 1990

2.5 Acid Sulphate Soils

Acid sulphate soils (ASS) are wetland soils and unconsolidated sediments that contain iron sulphides which, when exposed to atmospheric oxygen in the presence of water, form sulphuric acid. ASS form in protected low energy environments such as barrier estuaries and coastal lakes and commonly occurs in low-lying coastal lands such as Holocene marine muds and sands. When disturbed, these soils are prone to produce sulphuric acid and mobilise iron, aluminium, manganese and other heavy metals. The release of these reaction products can be detrimental to biota, human health and built infrastructure.

The ASS Risk on the site has been mapped by the Department of Parks and Wildlife (DPaW) (previously the Department of Environment and Conservation, DEC) (Landgate, 2013b) as being Moderate to Low (<3m from the surface) over most of the site with a small area of High to Moderate (<3m from the surface) on the western boundary (Figure 4).

2.6 Hydrology

2.6.1 Groundwater

The Superficial Swan aquifer overlays the Leederville aquifer and consists of poorly sorted fine- to medium-grained quartz with feldspar and occasionally trace heavy minerals. This overlays the Cattamara Coal Measures (DoW, 2013). The Perth Groundwater Atlas indicates that the groundwater in this area is 'unsuitable for additional garden bores' due to the characteristics of the regional aquifer potentially resulting in poor groundwater quality and/or quantity (DoW, 2013).

Groundwater flows from east to west across the region (GHD, 2013). The depth to groundwater from the natural surface is very shallow under the whole site and ranges from approximately 0 to 5m (GHD, 2013). Groundwater is generally perched at surface level in low lying areas during the winter months (GHD, 2013).

2.6.2 Surface Water

The site is within the Serpentine River Catchment. Surface water in the Serpentine Jarrahdale Shire drains to the Serpentine River and ultimately the Peel Harvey Estuary.

Much of the area within the Townsite is prone to waterlogging in the wetter winter period due to the high groundwater table and poor internal drainage of the soils on the site (GHD, 2013).

Surface runoff from the site is via overland flow, following the natural topography and Water Corporation drainage systems. There are some development related detention basins which water drains into such as that near Blue Wren Close (Plate 2).

Plate 2: Water Drainage Termination on Blue Wren Close

There are some shallow drains (approximately 0.2 - 0.5m deep) which help to drain the site. Located in the eastern part of the site is Water Corporation Hardey's Creek Main Drain which drains a small area in the south-east of the development area near Arnold Rd, intersects the eastern site boundary near Wellard St and conveys runoff north to the Serpentine River (Plate 3; Figure 5).

Plate 3: Hardey's Creek Main Drain

Hardey's Creek Main Drain has a second branch to the west. This drains water from the south west into the other branch of the Main Drain and then into the Serpentine River (Figure 5). The western side of the LSP area drains in a westerly direction across the Railway Reserve.

2.7 Wetlands

There are seven wetlands mapped on the site. These include three Multiple Use, two Resource Enhancement and two Conservation Category wetlands according to the Department of Parks and Wildlife (DPaW) *Geomorphic Wetlands of the Swan Coastal Plain* dataset. The definitions of these categories are outlined in Table 2.

Table 2: Management Categories of Wetlands

Management Category	General Description	EPA Management Objectives (EPA, 2008)
Conservation Category Wetland (CCW)	Wetlands which support high levels of attributes and functions.	Highest priority wetlands. Objective is to preserve and protect the existing conservation values of the wetlands through various mechanisms including: • reservation in national parks; • crown reserves and State owned land; • protection under Environmental Protection Policies; and • wetland covenanting by landowners. No development or clearing is considered appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is inappropriate.
Resource Enhancement Wetland (REW)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Ultimate objective is to manage, restore and protect towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland function, structure and biodiversity. Protection is recommended through a number of mechanisms.
Multiple Use Wetland (MUW)	Wetlands with few attributes which still provide important wetland functions	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare.

A significant portion of the site is mapped as Multiple Use Palusplains (Unique Feature Identifiers (UFI) 15785 and 14974) (Landgate, 2013b) (Figure 5). A Palusplain is defined as seasonally waterlogged flats. In the western part of the site there is a Multiple Use Dampland (UFI 14989) (Figure 5). A Dampland is defined as seasonally waterlogged basin.

A Resource Enhancement Dampland (IFI 14984) is mapped in the north-east of the site. A small Resource Enhancement Sumpland (seasonally inundated basin) (UFI 15204) occurs on the western side of the site, just south of Tonkin Street (Figure 5).

A Conservation Category Sumpland (UFI 15205) occurs in the area within and surrounding Lambkin Reserve in the western part of the site. Immediately adjacent is a Conservation Category Dampland (UFI 15002). The site is also adjacent to the Conservation Category Palusplain (UFI 14989) and in proximity to Conservation Category Palusplain which is to the north of the site (UFI 14989) (Figure 5).

2.8 Vegetation

2.8.1 Bioregional Data

Most of the site has been cleared for the Serpentine Townsite. Remnant native vegetation occurs in Lambkin Reserve and in fragmented parcels on private property, Council Reserves, the Railway

Reserve to the west of the LSP area and along Serpentine River to the north east. The site is in the Southwest Botanical Province within the Swan Coastal Plain Bioregion and is dominated by vegetation of the Pinjarra Plain and Bassendean System. According to Beard (1990) the vegetation on the site is located within the Drummond Botanical Subdistrict of the Swan Coastal Plain Subregion. The Drummond Botanical Subdistrict is mainly comprised of *Banksia* low woodland on leached sands with *Melaleuca* swamps where ill-drained; woodland of *Eucalyptus gomphocephala* (Tuart), *Eucalyptus marginata* (Jarrah) and *Corymbia calophylla* (Marri) on less leached soils. This is a general description of the botanical sub-district. Tuart does not occur on the site.

According to mapping of the Swan Coastal Plain by Heddle *et al*. (1980), the site falls within the Guildford Vegetation Complex. The pre-European structure of this complex is described as consisting of a mixture of Marri (*Corymbia calophylla*) – Wandoo (*Eucalyptus wandoo*) – Jarrah (*Eucalyptus marginata*) open forest (in places tall open forest) and Wandoo woodland, with a small number of locations fringed by *Eucalyptus rudis-Melaleuca rhaphiophylla* woodlands along streams. Occasional areas of *Eucalyptus lane-poolei* are also found within the Guildford complex, now restricted to an area between Cardup and Keysbrook in the Darling System (Heddle *et al*., 1980). This is a general description of the vegetation complex. Wandoo does not occur on the site

The Guildford Complex is considered to be poorly reserved with 5% of the original extent of the vegetation remaining and 0.2% (143ha) of the original extent in secure tenure (EPA, 2006).

2.8.2 Vegetation Types

Most of the native vegetation has been cleared and these areas are covered with pasture species. Some stands of Marri (*Corymbia calophylla*) occur in paddocks with clay soils. Many of the trees around the creeklines and in existing lots are exotic species.

Remnant vegetation occurs in the following locations:

- Lambkin Reserve north of Leslie Street;
- Part of Bush Forever Site 375 to the north of Tonkin Street;
- Road reserve in Turner Street; and
- In the east of the site to the south of Karnup Road (Shire Reserve R 9157).
- Railway Reserve to the west of the LSP area.

A survey of these areas was undertaken by Coffey Environments (2009) who mapped the vegetation as follows:

> ***CcLWAhPsOS*** *- Corymbia calophylla (Marri) Low Woodland to 6m over Allocasuarina humilis and Petrophile squamata Open Shrubland to 1.9m over *Watsonia meriana var. bulbillifera and Stylidium repens Very Open Herbland to 1.7m and Mesomelaena tetragona Very Open Sedgeland to 0.7m.*
>
> ***CcLWAhXpKaOS*** *- Corymbia calophylla Low Woodland to 7m over Allocasuarina humilis, Xanthorrhoea preissii and Kingia australis Open Shrubland to 1.8m over Banksia nivea Low Open Shrubland to 0.4m over Desmocladus fasciculatus Very Open Sedgeland to 0.25m and Stylidium repens Very Open Herbland to 0.15m.*

CcOF *- Corymbia calophylla Open Forest to 10m over Xanthorrhoea preissii Open Shrubland to 1.5m over Cyathochaeta avenacea Very Open Sedgeland to 1m.*

HaXpOS *- Hypocalymma angustifolium and Xanthorrhoea preissii Open Shrubland to 1m over Kunzea micrantha and Banksia nivea Low Open Shrubland to 0.7m over Schoenus clandestinus Very Open Sedgeland to 0.1m.*

HtOS *- Hakea trifurcata Open Shrubland to 1.7m over Hypocalymma angustifolium, Kunzea micrantha and Xanthorrhoea preissii Low Shrubland to 0.9m over *Watsonia meriana var. bulbillifera Very Open Herbland to 1.8m.*

The vegetation mapping from Coffey is shown in Appendix 2.

2.8.3 Threatened Ecological Communities

A search of the DPaW's Threatened (TEC) and Priority Ecological Communities (PEC) database was conducted for the site (Appendix 3; 04-0913EC) (Table 3). Eight ecological communities were identified in the database search as occurring or potentially occurring on the site (Table 3).

Table 3: Threatened and Priority Ecological Communities known to occur in the Serpentine Area

Ecological Community	Description	Status under the Wildlife Conservation Act	Status under the EPBC Act
SCP3a	*Eucalyptus calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	Endangered
SCP3c	*Eucalyptus calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	Critically Endangered	Endangered
SCP10a	Shrublands on dry clay flats (Clay Pans of the Swan Coastal Plain)	Endangered	Critically Endangered
SCP20b	*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	Endangered	
SCP7	Herb rich saline shrublands in clay pans (Clay Pans of the Swan Coastal Plain)	Vulnerable	Critically Endangered
SCP8	Herb rich shrublands in clay pans (Clay Pans of the Swan Coastal Plain)	Vulnerable	Critically Endangered
SCP3b	*Eucalyptus calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	
SCP1a	*Eucalyptus haematoxylon - E. marginata* woodlands on Whicher foothills	Priority 3	
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	Priority 3	

Definitions of the Conservation Codes are in Appendix 4.

The remnant vegetation some of in the areas in the LSP area was identified by Coffey Environments (2009) as resembling the Critically Endangered SCP3a *Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain and Critically Endangered SCP3c *Eucalyptus calophylla - Xanthorrhoea preissii* woodlands and shrublands (Appendix 2).

The description of the Bush Forever Site 365 Byford to Serpentine Rail/Road Reserves and Adjacent Bushland (which is partially located in the LSP Area) as containing FCTs 3a, 3b, 3c, 20b, 10a and 8.

The vegetation to the south of Lambkin Reserve within Bush Forever Site 375 has vegetation similar to SCP3a although it possibly contains a mosaic of different TECs (Val English, DPaW, Pers Comm, 2013).

2.8.4 Vegetation Condition

The vegetation on the site has been largely historically cleared for the Townsite and rural purposes and is currently used as pasture for fodder conservation or grazing The condition of the vegetation was assessed by Coffey Environments (2009) according to the system devised by Keighery and described in Bush Forever (Government of Western Australia, 2000a). Keighery's condition rating scale ranges from Pristine where the vegetation exhibits no visible signs of disturbance to Completely Degraded where the vegetation structure in no longer intact and without native plant species (Table 4).

Table 4: Vegetation Condition Rating Scale.

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

Source: Government of Western Australia, 2000.

The bushland vegetation on the site is considered to be in Excellent to Very Good condition (Coffey, 2009; Government of Western Australia, 2000). The remainder of the site would be considered Completely Degraded as the areas of native trees are parkland cleared and the pasture areas have very few native species present.

2.8.5 Regional Significance of Vegetation

The remnant vegetation on the site is representative of the poorly reserved Guildford Complex, contains TECs listed under Western Australian and Commonwealth Environmental Legislation and is

known to contain at least several conservation significant plant species. Therefore it would be considered that the remnant vegetation areas in Very Good to Excellent Condition on the site are considered to be regionally significant.

Bush Forever Site 375 includes Lambkin Reserve which is located within the site. Bush Forever Site 375 is part of the Byford to Serpentine Rail/Road Reserves and Adjacent Bushland. Bush Forever Site 365 is also part of Byford to Serpentine Rail/Road Reserves and Adjacent Bushland and is adjacent to the western boundary of the Local Structure Plan Area (Figure 6).

Bush Forever Site 371 is the Serpentine River, Lowlands to Serpentine and is in close proximity to the northern boundary of the site (Figure 6). Bush Forever Site 371 is the Serpentine River, Lowlands to Serpentine and is in close proximity to the northern boundary of the site (Figure 6). There are three Regional Ecological Linkages identified within the LSP area. These include Regional Ecological Linkage #88 which links from the LSP area in a westerly direction, Regional Ecological Linkage #90 which extends along the railway line and Regional Ecological Linkage #71 which follows the path of the Serpentine River.

2.9 Flora

2.9.1 Database Searches

A search of the DPaW Threatened Flora Database (DEFL), the WA Herbarium database (WAHerb), the Declared Rare and Priority Flora Species List (TFPL) (Appendix 5), Naturemap (Appendix 6) and the EPBC Act Protected Matters Search Tool (Appendix 7) indicates a number of species listed as Endangered, Threatened or Priority have been located within a 5km radius of the site. The results from the database searches are shown in Table 5.

Table 5: Conservation Significant Flora known to occur in the Serpentine Area

Species	Common Name	Status Under Wildlife Conservation Act 1950	Status Under EPBC Act 1999
Andersonia gracilis	Slender Andersonia	Threatened	Endangered
Anthocercis gracilis	Slender Tailflower	Threatened	Vulnerable
Caladenia huegelii	Grand Spider Orchid	Threatened	Endangered
Darwinia foetida	Muchea Bell	Threatened	Critically Endangered
Diuris micrantha	Dwarf Bee Orchid	Threatened	Vulnerable
Diuris purdiei	Purdie's Donkey Orchid	Threatened	Endangered
Drakaea elastica	Glossy-leaved Hammer Orchid	Threatened	Endangered
Drakaea micrantha	Dwarf Hammer Orchid	Threatened	Vulnerable
Eucalyptus balanites	Cadda Road Mallee	Threatened	Endangered
Lasiopetalum pterocarpum	Wing-fruited Lasiopetalum	Threatened	Endangered
Ornduffia calthifolia	Mountain Villarsia	Threatened	Endangered
Synaphea sp. Fairbridge Farm (D Papenfus 696)		Threatened	Critically Endangered
Synaphea sp. Pinjarra Plain (A.S. George 17182)		Threatened	

Species	Common Name	Status Under Wildlife Conservation Act 1950	Status Under EPBC Act 1999
Synaphea sp. Serpentine (G.R. Brand 103)		Threatened	
Tetraria australiensis	Southern Tetraria	Threatened	Vulnerable
Thelymitra dedmaniarum (Previously *manginii*)	Cinnamon Sun Orchid	Threatened	Endangered
Thelymitra stellata	Star Sun-orchid	Threatened	Endangered
Verticordia fimbrilepis subsp. *fimbrilepis*	Shy Feather-flower	Threatened	Endangered
Verticordia plumosa var. *ananeotes*	Tufted Plumed Feather-flower	Threatened	Endangered
Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026)		Priority 1	
Stachystemon sp. Keysbrook		Priority 1	
Synaphea odocoileops		Priority 1	
Johnsonia pubescens subsp. *cygnorum*		Priority 2	
Acacia horridula		Priority 3	
Acacia oncinophylla subsp. *oncinophylla*		Priority 3	
Dillwynia dillwynioides		Priority 3	
Eryngium pinnatifidum subsp. Palustre		Priority 3	
Isopogon drummondii		Priority 3	
Centrolepis caespitosa		Priority 4	Endangered
Drosera occidentalis subsp. *occidentalis*		Priority 4	
Eucalyptus rudis subsp. *cratyantha*		Priority 4	
Parsonsia diaphanophleba		Priority 4	
Senecio leucoglossus		Priority 4	
Stylidium ireneae		Priority 4	
Verticordia lindleyi subsp. *lindleyi*		Priority 4	

Conservation Codes are defined in Appendix 4

2.9.2 Likelihood of Significant Flora to Occur

Table 6 examines the preferred habitat of each species and the likelihood of the species listed in Table 5 to occur on the site as well as previous studies undertaken on the site.

Table 6: Likelihood of Identified Significant Flora Species occurring on the Site

Scientific Name	Preferred Habitat*	Likelihood of Presence on site
Andersonia gracilis	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps	Possible
Anthocercis gracilis	Sandy or loamy soils. Granite outcrops	Unlikely
Caladenia huegelii	Grey or brown sand, clay loam	Possible
Darwinia foetida	Grey-white sand on swampy, seasonally wet sites	Highly Unlikely
Diuris micrantha	Brown loamy clay. Winter-wet swamps, in shallow water	Possible
Diuris purdiei	Grey-black sand, moist. Winter-wet swamps	Possible
Drakaea elastica	Low-lying situations adjoining winter-wet swamps. Does not survive in disturbed areas	Possible
Drakaea micrantha	White-grey sand	Possible
Eucalyptus balanites	Sandy soils with lateritic gravel	Possible
Lasiopetalum pterocarpum	Dark red-brown loam or clayey sand over granite. On sloping banks near creeklines.	Possible
Ornduffia calthifolia	Occurs in moist sheltered positions on the upper slopes of granite outcrops	Unlikely
Synaphea sp. Fairbridge Farm	Sandy with lateritic pebbles. Near winter-wet flats, in low woodland with weedy grasses	Possible
Synaphea sp. Pinjarra Plain (A.S. George 17182)	Grey sandy loam or clay, grey-brown clayey sand, brown clayey loam, laterite. Flats, seasonally wet	Recorded
Synaphea sp. Serpentine (G.R. Brand 103)	Brown sandy clay	Recorded
Tetraria australiensis	Grey sand over clay; sandy or clayey lateritic soils. Winter-wet swampy depressions	Recorded
Thelymitra dedmaniarum (Previously *manginii*)	Granite	Unlikely
Thelymitra stellata	Sand, gravel, lateritic loam.	Possible
Verticordia fimbrilepis subsp. *fimbrilepis*	Gravelly sandy or clayey soils. Flats, road verges	Possible
Verticordia plumosa var. *ananeotes*	Sandy loam. Seasonally inundated plains	Possible
Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026)	Grey or black sand over clay. Swampy areas, winter wet lowlands	Possible
Stachystemon sp. Keysbrook	Sandy soils	Possible
Synaphea odocoileops	Brown-orange loam & sandy clay, granite. Swamps, winter-wet areas	Possible
Johnsonia pubescens subsp. *cygnorum*	Grey-white-yellow sand. Flats, seasonally-wet sites	Possible

Scientific Name	Preferred Habitat*	Likelihood of Presence on site
Acacia horridula	Gravelly soils over granite, sand. Rocky hillsides	Possible
Acacia oncinophylla subsp. *oncinophylla*	Granitic soils	Possible
Dillwynia dillwynioides	Sandy soils. Winter-wet depressions	Possible
Eryngium pinnatifidum subsp. Palustre	Sandy soils or seasonally wet flats	Possible
Isopogon drummondii	White, grey or yellow sand, often over laterite.	Possible
Centrolepis caespitosa	White sand, clay. Salt flats, wet areas	Possible
Drosera occidentalis subsp. *occidentalis*	Sandy and clayey soils. Swamps and wet depressions	Possible
Eucalyptus rudis subsp. *cratyantha*	Loam. Flats, hillsides	Possible
Parsonsia diaphanophleba	Alluvial soils. Along rivers	Unlikely
Senecio leucoglossus	Gravelly lateritic or granitic soils. Granite outcrops, slopes	Unlikely
Stylidium ireneae	Sandy loam. Valleys near creek lines, woodland, often with *Agonis*.	Unlikely
Verticordia lindleyi subsp. *lindleyi*	Grey, black or peaty sand. Winter-wet depressions	Possible

* sourced from Florabase (DEC, 2013), SEWPaC SPRAT Database (SEWPaC, 2013a) as well as the DEC database searches.

The pockets of remnant vegetation are mostly wetland areas and many of the significant flora species identified are found in wetland habitats. Therefore it is possible many of the species could be present in these areas. However the site has been extensively cleared and grazed/developed for over 100 years. Therefore species on the list that may have once occurred on the site are only possibly present now. Significant vegetation has been identified to occur within Lambkin Reserve and in the Railway Reserve.

2.10 Fauna

2.10.1 Fauna Habitat

The site contains four habitat types:

- Completely cleared pasture (Plate 4);
- Parkland cleared Marri (Plate 4);
- Parkland cleared creeklines with exotic *Eucalyptus* Species (Plate 5);
- Native Woodland over Low Heath (Plate 6); and
- Low Heath and Weeds (Railway Reserve).

These provide habitat for terrestrial species, amphibians, and avifauna. The habitat on the site may provide 'foraging habitat' or food sources, 'roosting habitat' and 'breeding habitat' for birds.

Plate 4: Pasture habitat and Parkland Cleared Marri

Plate 5: Parkland cleared creeklines with exotic *Eucalyptus* Species

Plate 6: Native Woodland over Low Heath

The completely cleared pasture dominates the site in areas that are not developed. The Parkland cleared *Corymbia calophylla* occurs in scattered areas in the site with a larger stand in the south-east of the site.

Fauna habitat can be assessed according to the following categories:

High quality fauna habitat *– These areas closely approximate the vegetation mix and quality that would have been in the area prior to any disturbance. The habitat has connectivity with other habitats and is likely to contain the most natural vertebrate fauna assemblage.*

Very good fauna habitat *- These areas show minimal signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) and generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be minimally effected by disturbance.*

Good fauna habitat *– These areas showed signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) but generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be affected by disturbance.*

Disturbed fauna habitat *– These areas showed signs of significant disturbance. Many of the trees, shrubs and undergrowth are cleared. These areas may be in the early succession and regeneration stages. Areas may show signs of significant grazing, contain weeds or have been damaged by vehicle or machinery. Habitats are fragmented or have limited connectivity with other fauna habitats. Fauna assemblages in these areas are likely to differ significantly from what might be expected in the area had the disturbance not occurred.*

Highly degraded fauna habitat *– These areas often have a significant loss of vegetation, an abundance of weeds, and a large number of vehicle tracks or are completely cleared. Limited or no fauna habitat connectivity. Faunal assemblages in these areas are likely to be significantly different to what might have been in the area pre-disturbance.* (Coffey Environments, 2009)

Lambkin Reserve is considered to be Very Good Fauna Habitat as it has connectivity to the bushland along the rail and is in Very Good condition. The low heath and weeds present in the Railway Reserve is considered to be Good Fauna Habitat for bandicoots, reptiles and a suite of insects. The remaining pockets of native woodland over low heath are more fragmented and considered to be Good Fauna Habitat. The parkland cleared stands of trees are considered Disturbed Fauna Habitat. The remainder of the site that is completely cleared pasture is considered to be Highly Degraded Fauna Habitat.

2.10.2 Ecological Linkages

The site is mostly cleared. There are three Regional Ecological Linkages identified within the LSP area. These include Regional Ecological Linkage #88 which links from the LSP area in a westerly direction, Regional Ecological Linkage #90 which extends along the railway line and Regional Ecological Linkage #71 which follows the path of the Serpentine River. The scattered trees on the site also provide some linkage for avifauna, including Black Cockatoos, flying from the Scarp to the Swan Coastal Plain and back.

The rehabilitation of drainage lines within the Townsite would improve the connectivity and thereby the ecological linkage values over the site. Also the use of native endemic plants within POS and other public areas would improve the linkage values around the Townsite.

2.10.3 DEC Database Search Results

A search of the DPaW Threatened Fauna Database (Appendix 8) shows eight species listed as rare or priority have been located in the vicinity of the site. No additional species were identified in the Naturemap database searches (Appendix 6) and eleven additional species were identified in the Protected Matters Search Tool (Appendix 7). Table 7 lists the species identified in these database searches.

Table 7: List of Fauna Species Identified from Database Searches.

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Calyptorhynchus banksii subsp. *naso*	Forest Red-tailed Black-Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus baudinii	Baudin's Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus latirostris	Carnaby's Cockatoo	Schedule 1	Endangered
Dasyurus geoffroii	Chuditch, Western Quoll	Schedule 1	Vulnerable
Leipoa ocellata	Mallee Fowl	Schedule 1	Vulnerable
Phascogale tapoatafa subsp. *tapoatafa*	Brush-tailed Phascogale	Schedule 1	
Pseudocheirus occidentalis	Western Ringtail Possum	Schedule 1	Vulnerable
Rostratula benghalensis	Painted Snipe	Schedule 1	Vulnerable

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Setonix brachyurus	Quokka	Schedule 1	
Apus pacificus	Fork-tailed Swift	Schedule 3	Migratory
Ardea alba	Great Egret	Schedule 3	Migratory/ Wetland
Ardea ibis	Cattle Egret	Schedule 3	Migratory/ Wetland
Haliaeetus leucogaster	White-bellied Sea-eagle	Schedule 3	Migratory
Meeorps ornatus	Rainbow Bee-eater	Schedule 3	Migratory
Pandion haliaetus	Osprey		Marine/ Migratory
Rostratula australis	Australian Painted Snipe	Schedule 3	
Falco peregrinus	Peregrine Falcon	Schedule 4	
Westralunio carteri	Fresh water mussel	Priority 4	
Isoodon obesulus subsp. *fusciventer*	Southern Brown Bandicoot	Priority 5	

The DEC classifies fauna under five different Priority codes and rare and endangered fauna are classified under the *Wildlife Conservation (Specially Protected Fauna) Notice 2008* into four schedules of taxa (DEC, 2011). The definitions of these codes are in Appendix 4.

2.10.4 Conservation Significant Species

Outlined below is a short description of each of the species that were identified in the DEC database searches and Protected Matters Search Tool search and their preferred habitat. The preferred habitat has been compared to the habitats on the site described above and the likelihood of each species to be present on the site determined.

Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)

Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of *Banksia, Dryandra, Hakea, Eucalyptus, Grevillea, Pinus* and *Allocasuarina* spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 – 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell). Eggs are laid from July to October, with incubation lasting 29 days (DoE, 2013b).

The site contains some Marri (*Corymbia calophylla*) which are known feeding trees for Carnaby's Black Cockatoo (Higgins, 1999). Carnaby's Black-Cockatoos have been recorded during other fauna surveys in the general area and are likely to feed and potentially roost on the site. The likelihood of this species breeding on the site is low, though there are known breeding sites within foraging distance from the LSP area.

Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)

This species is most common in the far south-west of Western Australia. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Black Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species.

This species are seasonally present on the Swan Coastal Plain, therefore Baudin's Black Cockatoo will potentially use trees on the site for foraging, and particularly the Marri trees (Garnett *et al.* 2011).

Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)

Forest Red-tailed Black Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (DoE, 2013b). It nests in tree hollows with a depth of 1-5m, that are predominately Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*) and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri.

Red-Tailed Black Cockatoos have been recorded during other fauna surveys in the general area. They may occasionally roost in the large trees on-site. There is no record to indicate that they breed in the vicinity of the site (Johnstone and Kirkby, 2011).

Chuditch, Western Quoll (*Dasyurus geoffroii*)

The Chuditch was originally found in over 70% of Australian woodlands; however, since European settlement its range has diminished to a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of south-west WA. They have been known to occupy a wide range of habitats including woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. The Chuditch creates dens in hollow logs or burrows and have also been recorded in tree hollows and cavities. They are opportunistic feeders, and forage on the ground at night, feeding on invertebrates, small mammals, birds and reptiles (DoE, 2013b).

The Chuditch is highly unlikely to occur within the site as the pastures do not provide adequate cover for protection, the bushland areas are relatively fragmented and the proximity of human habitation increases the pressure of domestic predators.

Malleefowl (*Leipoa ocellata*)

Malleefowl have been found in mallee regions of southern Australia from approximately the 26th parallel of latitude southwards. Malleefowl are now only found throughout these regions in fragmented patches due to clearing of land for agriculture, increased fire frequency, competition with exotic herbivores (sheep, rabbits, goats and cattle) and kangaroos, predation by foxes and cats, inbreeding as a result of fragmentation and possibly hunting for food (DoE, 2013b).

Malleefowl are highly unlikely to be found on the site due the lack of appropriate Mallee habitat.

Southern Brush-tailed Phascogale (*Phascogale tapoatafa*)

Southern Brush-tailed Phascogales are arboreal marsupials which require tree hollows in suitable woodland or forest and rely on abundant invertebrate prey to sustain populations (Pescott, 2012).

This species is highly unlikely to occur on the site as the woodland areas are disturbed from the proximity of human development and due to the presence of domestic and feral predators.

Western Ringtail Possum (*Pseudocheirus occidentalis*)

The Western Ringtail Possum is a medium sized nocturnal marsupial. This species occurs in and near coastal Peppermint Tree (*Agonis flexuosa*) forest and Tuart (*Eucalyptus gomphocephala*) dominated forest with a Peppermint Tree understorey.

There are some *Agonis* trees scattered around the Townsite but it is considered highly unlikely this species would be present due to the Townsite development.

Painted Snipe (*Rostratula benghalensis*)

The Painted Snipe predominately occurs on the eastern coast of Australia and inhabits inland and coastal shallow ephemeral and permanent freshwater wetlands particularly where there is a cover of vegetation, including grasses.

The wetlands on the site are largely exposed and this species is unlikely to be present for a lengthy period of time or rely on the site.

Quokka (*Setonix brachyurus*)

Quokkas were originally very common on the Swan Coastal Plain, however, their distribution is now limited to Rottnest Island and a few isolated areas in the south-west of WA. On the mainland, they prefer densely vegetated areas around wetlands and streams, whereas on Rottnest Island they inhabit low scrubby coastal vegetation where water is not readily available year-round. Quokkas breed once a year and produce a single joey. They are herbivorous, and feed on leaves, bark, succulent plants and grasses.

The Quokka is considered not to occur on the site due to a lack of suitable habitat and a lack of recent records of this species in the area.

Fork-tailed Swift (*Apus pacificus*)

The Fork-tailed Swift is almost exclusively aerial and is not known to breed in Australia. They are seen in inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities (DoE, 2013b).

It is unlikely this species would visit or rely on the site.

Great Egret, White Egret (*Ardea alba* (*modesta*))

The Eastern Great Egret has been reported in a wide range of wetland habitats and usually frequents shallow waters (DoE, 2013b). This species feeds on fish, insects, crustaceans, molluscs, frogs, lizards, snakes and small birds and mammals (DoE, 2013b).

This species may visit the site but is not likely to rely on the site for survival.

Cattle Egret (*Ardea ibis*)

The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands with breeding in Western Australia recorded in the far north in Wyndham in colonies in wooded swamps such as mangrove forests (DoE, 2013b). This species forages away from water on low lying grasslands, improved pastures and croplands generally in areas that have livestock eating insects, frog, lizards and small mammals (DoE, 2013b).

This species may visit the site but is not likely to rely on the site for survival.

White-bellied Sea-Eagle (*Haliaeetus leucogaster*)

The White-bellied Sea-Eagle is found in coastal habitats with large areas of open water, especially those close to the sea-shore. This species feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal (DoE, 2013b).

The habitat on site is not suitable for this species.

Rainbow Bee-eater (*Merops ornatus*)

The Rainbow Bee-eaters that breed in southern Australia are migratory. After breeding, they move north and remain there for the duration of the Australian winter. However, populations that breed in northern Australia are considered to be resident, and in many northern localities the Rainbow Bee-eater is present throughout the year (DoE, 2013b). The Rainbow Bee-eater nests in a burrow dug in the ground. It is found across the better-watered parts of WA including islands preferring lightly wooded, sandy country near water (DoE, 2013b).

The habitat disturbance and low lying areas that are not sandy on the site means the Rainbow Bee-eater is unlikely to be nesting within the site. It is however likely that they will be feeding in the area due to the nesting sites in the vicinity on sandy rises in Serpentine Downs.

Osprey (*Pandion haliaetus*)

Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They feed on fish, especially mullet where available, and rarely take molluscs, crustaceans, insects, reptiles, birds and mammals (DoE, 2013b).

This species is highly unlikely to be present on the site due to the lack of appropriate food sources.

Australian Painted Snipe (*Rostratula australis*)

The Australian Painted Snipe is a stocky wading bird that generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (DoE, 2013b).

This species may occur on the site intermittently but is unlikely to rely on the area for survival.

Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is found in a variety of habitats from woodlands to open grasslands and coastal cliffs. It feeds almost entirely on other birds and sometimes rabbits and other moderate sized mammals, bats and reptiles (DEC, 2013c).

This species is known to be easily frightened and flighty (DoE, 2013b) and therefore is highly unlikely to utilise the site due to the proximity of human activity.

Fresh Water Mussel (*Westralunio carteri*)

Westralunio carteri is a freshwater mussel and is found in ponds, lakes, rivers and streams, and has been collected from a dam in Western Australia. It is tolerant to human disturbance and organic pesticides but sensitive to salinity (ICUN, 2013).

There are no permanent water bodies on the site that are likely to be suitable for this species so this species is highly unlikely to be present. They are however present in the Serpentine River downstream of the LSP drainage systems.

Southern Brown Bandicoot (*Isoodon obesulus* subsp. f*usciventer*)

Southern Brown Bandicoots are small grey marsupials that prefer dense scrub (up to one metre high), often in or near swampy vegetation. Their diet includes invertebrates (including earthworms, adult beetles and their larvae), underground fungi, subterranean plant material, and very occasionally, small vertebrates (DEC, 2002).

This species prefers dense scrub and therefore is not likely to be present on most of the site except in the remnant bushland areas. Southern Brown Bandicoots have been recorded in the Railway Reserve, Shire Reserves and along the Serpentine River.

The likelihood of each species identified in the database searches being present on the site is summarised in Table 8.

Table 8: Likelihood of Conservation Significant species being present on the site

Scientific Name	Common Name	Likelihood to occur on the site
Calyptorhynchus banksii subsp. *naso*	Forest Red-tailed Black-Cockatoo	Likely
Calyptorhynchus baudinii	Baudin's Cockatoo	Possible
Calyptorhynchus latirostris	Carnaby's Cockatoo	Likely
Dasyurus geoffroii	Chuditch, Western Quoll	Highly Unlikely
Leipoa ocellata	Mallee Fowl	No
Phascogale tapoatafa subsp. *tapoatafa*	Brush-tailed Phascogale	Possible
Pseudocheirus occidentalis	Western Ringtail Possum	Highly Unlikely
Rostratula benghalensis	Painted Snipe	Unlikely
Setonix brachyurus	Quokka	No
Apus pacificus	Fork-tailed Swift	Highly Unlikely
Ardea alba	Great Egret	Unlikely
Ardea ibis	Cattle Egret	Possible

Scientific Name	Common Name	Likelihood to occur on the site
Haliaeetus leucogaster	White-bellied Sea-eagle	Highly Unlikely
Meeorps ornatus	Rainbow Bee-eater	Likely
Pandion haliaetus	Osprey	Highly Unlikely
Rostratula australis	Australian Painted Snipe	Highly Unlikely
Falco peregrinus	Peregrine Falcon	Highly Unlikely
Westralunio carteri	Fresh water mussel	Highly Unlikely
Isoodon obesulus subsp. *fusciventer*	Southern Brown Bandicoot	Likely

Therefore *Calyptorhynchus banksii* subsp. *naso*, *Calyptorhynchus baudinii* (Baudin's Cockatoo) and *Calyptorhynchus latirostris* (Carnaby's Black Cockatoo) likely to be present on the site at some times of the year. The Brush-tailed Phascogale may be present. The Schedule 3 Marine/Migratory listed Cattle Egret and Rainbow Bee-eater may also be an irregular visitor to the site. The Priority 4 Southern Brown Bandicoot may also be present in bushland areas of the site.

2.10.5 Biodiversity Value

The cleared pasture has almost no ecological value from a native fauna perspective. There are a few mature trees in the paddocks which provide foraging habitat.

The small pockets of remnant bushland may provide habitat to a greater number of species however the proximity of human habitation and therefore the likelihood of impacts on native fauna due to domestic predators would adversely impact on the fauna assemblage in these areas.

2.11 Heritage Values

2.11.1 Indigenous Heritage

A search of the Department of Aboriginal Affairs Aboriginal Heritage Inquiry System (DAA, 2013) recorded one registered site listed within the Serpentine Townsite (Appendix 9). This is listed as site 3582 and is the area associated with the Serpentine River.

2.11.2 Cultural Heritage

Heritage sites can be listed under the following lists/registers:

- World Heritage Sites;
- National Heritage Sites;
- Commonwealth Heritage Sites;
- Sites on the register of the National Estate;
- Sites on the State Register; and
- Sites listed in the Serpentine Jarrahdale Shire Municipal Heritage Inventory List.

There are no Listed, Registered or Interim Heritage Sites under Commonwealth Legislation on the site (DoE, 2013c). There are four sites in the Serpentine Townsite that are listed with the Heritage Council of Western Australia and on the Serpentine Jarrahdale Shire Municipal Inventory (Landgate, 2013b; Heritage Council of Western Australia, 2013; Serpentine Jarrahdale Shire, 2013) (Table 8).

Table 8: Heritage Sites within the Structure Plan Area

Names	Location
Serpentine Butcher Shop	19 Richardson St Serpentine
Old Serpentine Inn (Serpentine Falls Hotel, The Old Serpentine Tavern)	Cnr Richardson and Wellard Sts Serpentine
Serpentine General Store (Middleton's Store, Middleton's Tearooms)	6 Wellard St Serpentine
St Kevin's Church	Richardson St Serpentine

These sites have been identified in the current LSP.

3 IMPACT OF DEVELOPMENT

3.1 Past and Existing Land Use

The site has been largely cleared with the Townsite established over 100 years previously. The surrounds have been cleared for agriculture for a similar period of time.

If any areas to be developed in the future have previously had sheds or other structures a Preliminary Site Investigation is recommended prior to development to ensure there are no contaminated areas. The past and existing land use does not impede development. Any contaminated areas that may be located on the site such as leaking fuel tanks, pesticide/herbicide dumps or spills, asbestos in existing structures can be managed under the *Contaminated Sites Act 2003*.

The existing residential development and industry in and adjacent to the Townsite need to be considered when developing the LSP to accommodate existing land uses and ensuring that additional land uses do not conflict with existing land uses. This will require the application of *Separation Distances between Industrial and Sensitive Land Uses –Guidance Statement No. 3* (EPA, 2005).

EPA Guidance Statement No. 3: Separation Distances between Industrial and Sensitive Land Uses provides generic buffer distances required for different land uses and those defined as Sensitive Land Uses (EPA 2004). Residential development is considered a sensitive land use for the purpose of the guidance statement. The guidance statement recommends a generic buffer distances which are:

> *Not intended to be absolute separation distances, rather they are a default distance for the purposes of:*
>
> - *identifying the need for specific separation distance or buffer definition studies; and*
> - *providing general guidance on separation distances in the absence of site specific technical studies.*

Buffer studies may be required for future development proposals close to existing industry.

3.2 Surrounding Land Use

Surrounding Parks and Recreation, Rural and Rural Living land use will require consideration when developing the LSP to ensure remnant vegetation and rural amenity of the area is maintained. This should include appropriate density of housing adjacent to rural living areas and management of vegetation interfaces as per Section 3.8.

Environmental noise from the railway is likely to impact on the amenity of some parts of the site. Generally the areas along the railway have been developed however in the north of the site some new lots may be created. Under State Planning Policy No. 5.4 *Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (SPP 5.4) (WAPC, 2009) transport noise from within

major transport corridors, including freight routes, and its impact on noise sensitive land uses must be investigated. The policy aims to:

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

There are a variety of mitigation measures available to mitigate noise from walls to bunds etc. An acoustic assessment at the subdivision stages of planning in the northern part of the Serpentine Townsite should be undertaken and, if required, mitigation measures put into place.

There is also some industry adjacent to the site

3.3 Geomorphology and Soils

The site does not contain any unique topographical or geological formations and therefore these factors are not an impediment to the development of the site. Some of the soil types on the site are prone to waterlogging and ponding (DAFWA, 2013; GHD, 2013). Surface water management will be required to manage these soil types.

To minimise potential for soil erosion to occur the following management measures are recommended:

- Earthworks have the potential to add clay 'fines' into the drainage channels (Hardey's Creek Main Drain) or the Conservation Category Wetlands/remnant bushland areas (Lambkin Reserve) and the installation of temporary drop-out basins to capture and aid in the settling of clay fines should be considered.
- There may be a requirement for the filling of the landscape to address water sensitive urban design principles.

3.4 Acid Sulphate Soils

The ASS Risk on the site is mapped as being Moderate to Low (<3m from the surface) with a small area of High to Moderate associated with the wetland in Lambkin Reserve. WAPC *Acid Sulphate Soils Planning Guidelines* (WAPC, 2009c) indicate that "*acid sulphate soils are technically manageable in the majority of cases*" which would be applicable to the areas mapped Moderate to Low risk.

ASS Investigation and, if required, Management Plans should be prepared at subdivision stage once the detailed design of the site is finalised. This should be undertaken in accordance with the *Acid Sulphate Soils Guideline Series: Identification and Investigation of Acid Sulphate Soils and Acidic Landscapes* (DEC, 2009) and *Treatment and Management of Soils and Water in Acid Sulphate Soil Landscapes* (DEC, 2011).

3.5 Groundwater

Groundwater management has been outlined in the Local Water Management Strategy (GHD, 2013) and further details will be provided in Urban Water Management Plans (UWMP) that will be prepared for each subdivision as per *Better Urban Water Management* (WAPC, 2008). The Department of Water is currently developing a groundwater allocation plan for the area. The plan will include revised groundwater allocation limits and polices for managing water abstraction and use. The allocation plan will need to be considered when preparing UWMPs for future development.

Therefore potential impacts on groundwater can be mitigated and managed and does not impede further development of the Serpentine Townsite.

3.6 Surface Water

The management of surface water has been detailed in the Local Water Management Strategy (GHD, 2013) and will be further detailed in the Urban Water Management Plans that will be prepared for development within the site.

The LWMS shows the Water Corporation Hardey's Creek Main Drain to be partially re-routed and incorporated into a drainage corridor. The eastern part of the drain is proposed to be maintained in POS to the east of the site. The drain is close to the boundary of the POS on the Townsite (western) side of the POS.

Development of the site has the potential to increase the ecological value of the degraded channels through rehabilitation. This could be with the introduction of sedges to stabilise the banks and native species. Existing exotic vegetation should be retained until native endemic species are established to provide bank stabilisation.

3.7 Wetlands

A large proportion of the site is mapped as a palusplain Multiple Use Wetland with smaller areas mapped as Resource Enhancement. These wetlands have largely been developed or are Completely Degraded and could be used as detention basins or recharge areas.

The Conservation Category Wetlands on the site are within existing Conservation Reserves and are within the existing developed areas. Therefore management of the wetlands will need to be active to ensure weeds and other deleterious impacts are managed appropriately. Management of development to reduce potential impacts on wetland hydrologic regimes and attributes will be guided by the Western Australian Planning Commission Guidelines for Determination of Wetland Buffer Requirements.

3.8 Vegetation

The vegetation on the majority of the site is Completely Degraded and in small areas Degraded to Completely Degraded. There are several stands of Marri that could be retained within POS or alongside road reserves. In particular there is a stand of Marri in the south east of the site along the unmade Rudall Street Reserve that is dense and would be recommended to be retained.

During the detailed design process it is recommended that the retention of any trees that can be retained in landscaped areas, parking areas and in road/entry areas should be included in the plans for the area. All trees should be located on a site plan that shows canopy and trunk diameters and the natural ground level at the base of each trunk. Mature trees to be retained or transplanted must be identified and marked appropriately prior to commencement of any pre-construction activities. In some areas it may potentially be appropriate to create tree protection zones.

In development areas adjacent to the bushland areas, construction to provide services or to upgrade roads should be undertaken with minimal disturbance to the vegetation and be in accordance with the Australian Standards for Protection of Trees on Development Sites. Management procedures should be in place to ensure that the vegetation is protected.

3.9 Flora

There are Declared Rare Flora and priority species within the small pockets of bushland areas on the site. These species are highly unlikely to be present on the remainder of the Townsite. It is recommended that all areas of remnant vegetation subject to development are surveyed for significant flora and vegetation.

3.10 Fauna

Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii* subsp. *naso*), and possibly Baudin's Cockatoo (*Calyptorhynchus baudinii*) and Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) could be impacted by the development of the site if mature trees will be cleared.

The three species of black cockatoo that do or may occur on the site are listed under Section 18 of the EPBC Act. Under the EPBC Act, a significant impact is determined by the sensitivity, value and quality of the environment which is to be impacted and the intensity, duration, magnitude and geographic extent of the impacts. If a proposed action is deemed to have a significant impact, this action should be referred to the Minister. Therefore the potential impact of development of the site in the context of the Local Structure Plan will need to be examined in the context of the *Matters of National Environmental Significance. Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (SEWPaC, 2013c). If, according to the Significant Impact Guidelines 1.1, an action is likely to have a significant impact on an endangered and vulnerable species it will need to be referred under the EPBC Act.

The habitat requirements for the Black Cockatoos include foraging (Marris, Flooded Gums, *Banksia* species, Parrot Bush and other Proteaceous shrubs), roosting (tall eucalypts and pines) or breeding habitat (specific Eucalypt trees). There are very few Proteaceous shrubs outside of the bushland areas and scattered Marri trees on the site. The bushland areas contain the best quality habitat and therefore should be retained. However each individual subdivision will need to make its own assessment to determine the implications of the proposed development under the EPBC Act.

To mitigate potential impact on Black Cockatoos it is suggested that in future planning phases as many Marri and Flooded Gum trees and significant trees (those greater than 500mm in diameter at breast height) be retained. There is also the potential to improve the Black Cockatoo habitat by planting appropriate species in drainage corridors, open space and road reserves.

The Cattle Egret is potentially a brief visitor to the site but would not be impacted by development in the Local Structure Plan Area. There are no other conservation species identified that are likely to be impacted by development in the Local Structure Plan Area.

3.11 Heritage

Aboriginal Heritage Site 3582, Serpentine River is mapped over much of the site, is registered with the Department of Aboriginal Affairs and as such advice on the implications under the *Aboriginal Heritage Act 1976* of the Heritage Site will need to be investigated.

The State and Locally listed sites that are within the Serpentine Townsite should not be impacted by the development of the town in accordance with the Local Structure Plan.

4 SUMMARY AND CONCLUSIONS

The Environmental Factors that were studied in this environmental assessment were:

- Past and Existing Land Use;
- Surrounding Land Use;
- Topography;
- Geomorphology and Soils;
- Surface and Groundwater;
- Vegetation;
- Flora;
- Fauna; and
- Heritage.

The desktop studies resulted in the following conclusions and recommendations:

- Past land uses indicate that rural activities may have some small localised areas that are contaminated. Therefore it is suggested that a Preliminary Site Investigation may be required at subdivision stage to identify if there is any potential contamination present that may require further investigation and remediation in order for the site to be suitable for development.
- Buffer studies may be required for future development proposals close to existing industry.
- The adjacent rail alignment may require acoustic studies to buffers and management during subdivision in the northern part of the site.
- The topography and geology on the site does not constrain the LSP design.
- The soils have a Low to Moderate risk of ASS. Therefore this is not considered a constraint to the design of the LSP. Site specific studies will be required for ASS risk at subdivision or development application stage.
- Surface water and groundwater will be managed under the hierarchy outlined in *Better Urban Water Management* (WAPC, 2008).
- Rehabilitation of the existing and proposed constructed drainage channels (Hardey's Main Drain) has the potential to increase the ecological value and linkage over the site.
- Native endemic species should be established in drainage channels prior to the present exotic species being removed to ensure the banks remain stable.
- The site has two Conservation Category Wetlands on the site and one adjacent that could be impacted by development.
- The generic 50m buffers to the Conservation Category Wetlands already contain established home-sites and therefore the existing boundaries for the retained vegetation should be maintained. Development adjacent to wetlands and wetland vegetation should meet Bushfire Attack Levels that do not require any change to the Wetland vegetation attributes and drainage controls that do not significantly alter the current wetland hydrology.
- The site is not in a priority surface or groundwater area. Therefore these factors do not constrain the design of the LSP.

- Drainage corridors open space and road reserves can be enhanced by planting native species.
- The current LSP retains the majority of remnant vegetation within the Townsite and this should not change in any updated LSP.
- Wherever possible, trees should be retained in the LSP area particularly in road reserves and POS.
- The patch of Marris in the south east of the site in the Rudall Street Road Reserve should be retained which will involve the road reserve being closed and designated as POS.
- There are Declared Rare and Priority Flora within the bushland areas on the site which are to be retained.
- It is highly unlikely any Declared Rare and Priority Flora are present outside of the bushland areas.
- There are TECs present on the site in the bushland areas to be retained.
- There are no TECs or PECs present outside of these areas in the LSP therefore the LSP does not have to be revised to protect TEC.
- Development is highly unlikely to have a significant impact according to the Significant Impact Guidelines 1.1 however each individual development should do its own assessment to determine the degree of impact under the EPBC Act.
- Consideration will need to be given to retaining Marri trees to protect habitat for the three species of Black Cockatoo.
- There is a registered Aboriginal heritage site (Site ID 3582) mapped over much of the LSP area and therefore advice will need to be sought to determine what approvals, if any, are required under the *Aboriginal Heritage Act, 1976*.
- There are three State and Locally listed heritage sites that will not be impacted by the LSP and any redesign should protect these areas.

The results of desktop assessment, preliminary field investigations and mitigation measures identified, concludes the potential for deleterious impacts of development of the Serpentine Townsite in accordance with the LSP as proposed by the Department of Planning is Low.

There are some adjustments that are recommended for the LSP to enhance the environmental outcome for the Townsite. These include:

- Realigning or removing the southern part of Rudall Street to retain the thick stand of Marri trees which currently exists in the road reserve. To facilitate this, the road reserve would be converted to public open space.
- Retention of trees to be encouraged during subdivision.

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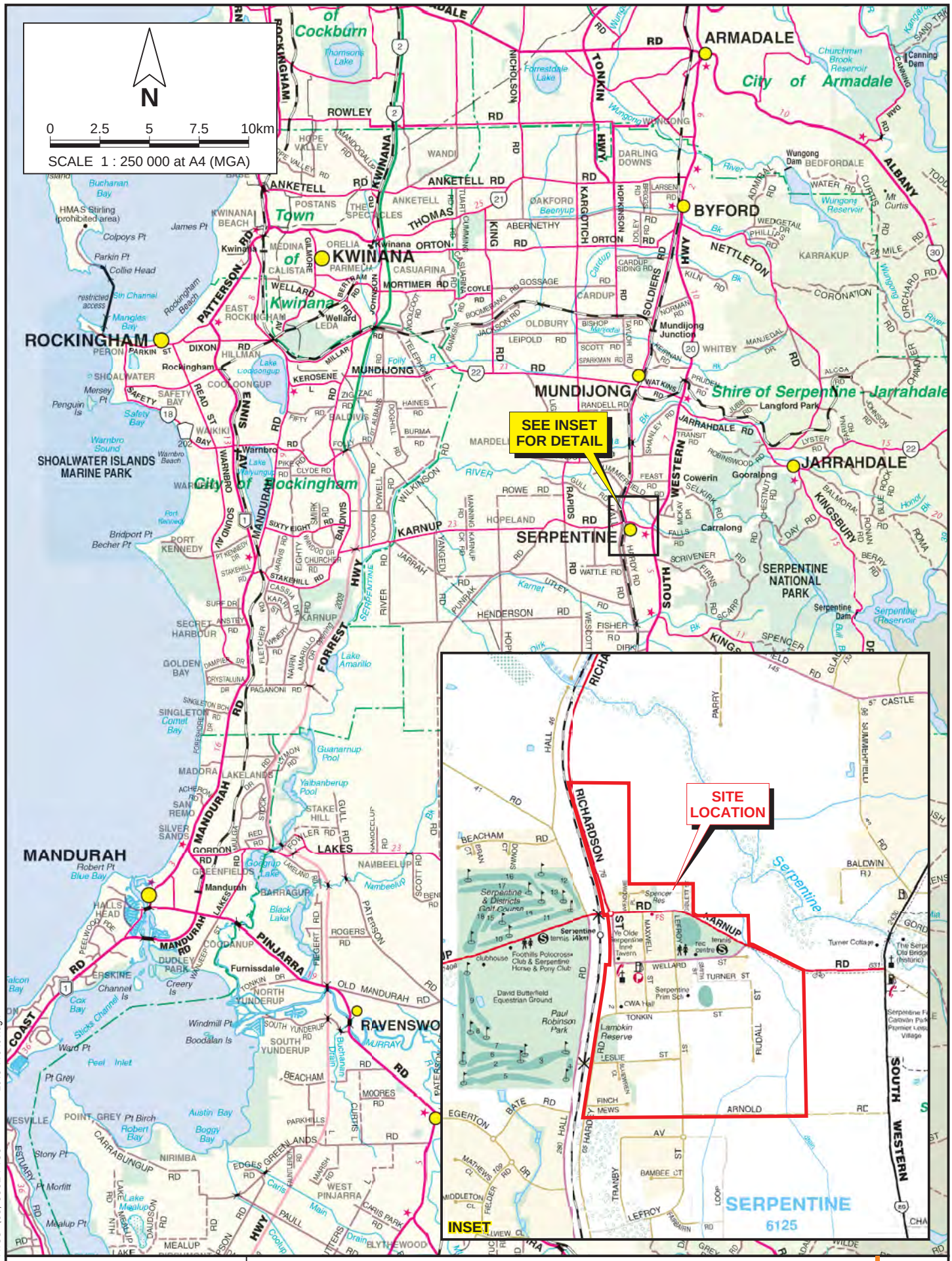
FIGURES



PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-110-f01.dgn

pgv ENVIRONMENTAL

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

Drawn: J. Hams	Date: 28 Nov 2013
Job: 10154 Rpt: 2013-110	Revision: A

SITE LOCATION

Figure 1

PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-110-f02.dgn

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary
- Topographic Contour

RICHARDSON ROAD
SERPENTINE
RIVER
KARNUP ROAD
MAXWELL STREET
WELLARD STREET
TONKIN STREET
LEFROY STREET
RUDALL STREET
HARDEY ROAD
LESLIE STREET
ARNOLD ROAD

6 419 500mN
6 419 000mN
6 418 500mN
6 418 000mN
403 500mE
404 000mE
404 500mE

CADASTRAL SOURCE: Landgate, November 2013.
CONTOUR SOURCE: Landgate 1:50 000 Topographic Mapping.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

pgv ENVIRONMENTAL

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

Drawn: J. Hams | Date: 28 Nov 2013
Job: 10154 Rpt: 2013-110 | Revision: A

SITE BOUNDARY

Figure 2

PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-110-f03.dgn

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary
- Soil Type Boundary
- 213Pj Soil Type

Soils

213Fo__F2b - Moderately deep to deep, gravelly acidic yellow duplex soils and rare laterite.

213Pj__B1 - Deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at generally > 2m.

213Pj__B2 - Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.

213Pj__B3 - Moderately deep bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand.

213Pj__P1a - Deep acidic mottled yellow duplex soils. Shallow pale sand to sandy loam over clay.

213Pj__P1b - Deep acidic mottled yellow duplex (or effective duplex) soils. Moderately deep pale sand to loamy sand over clay.

213Pj__P1d - Deep acidic mottled yellow duplex soils. Shallow pale sand to sandy loam over clay.

213Pj__P3 - Deep acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.

213Pj__P4 - Moderately deep to deep black, olive grey and some yellowish brown cracking clays and less commonly non-cracking friable clays with generally acidic.

213Pj__P8 - Moderately deep to deep sands over mottled clays. These may be acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached.

213PjSWP10 - Deep well drained uniform brownish sands or loams.

213PjSWP6a - Deep moderately well to well drained acidic red and yellow duplex and less commonly, gradational soils.

213Pj__P3
213PjSWP10
213PjSWP6a
213Pj__P3
213Pj__P8
213Pj__B1
213Pj__B1
213Pj__P4
213Pj__B3
213Pj__B2
213Pj__P1d
213Pj__P1a
213Pj__B1
213Pj__P1b

6 419 500mN
6 419 000mN
6 418 500mN
6 418 000mN
404 000mE
404 500mE
403 500mE

RICHARDSON ROAD
KARNUP ROAD
MAXWELL STREET
WELLARD STREET
TONKIN STREET
LEFROY STREET
RUDALL STREET
HARDEY ROAD
LESLIE STREET
ARNOLD ROAD

CADASTRAL SOURCE: Landgate, November 2013.
SOILS SOURCE: Department of Agriculture, November 2004.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

pgv ENVIRONMENTAL

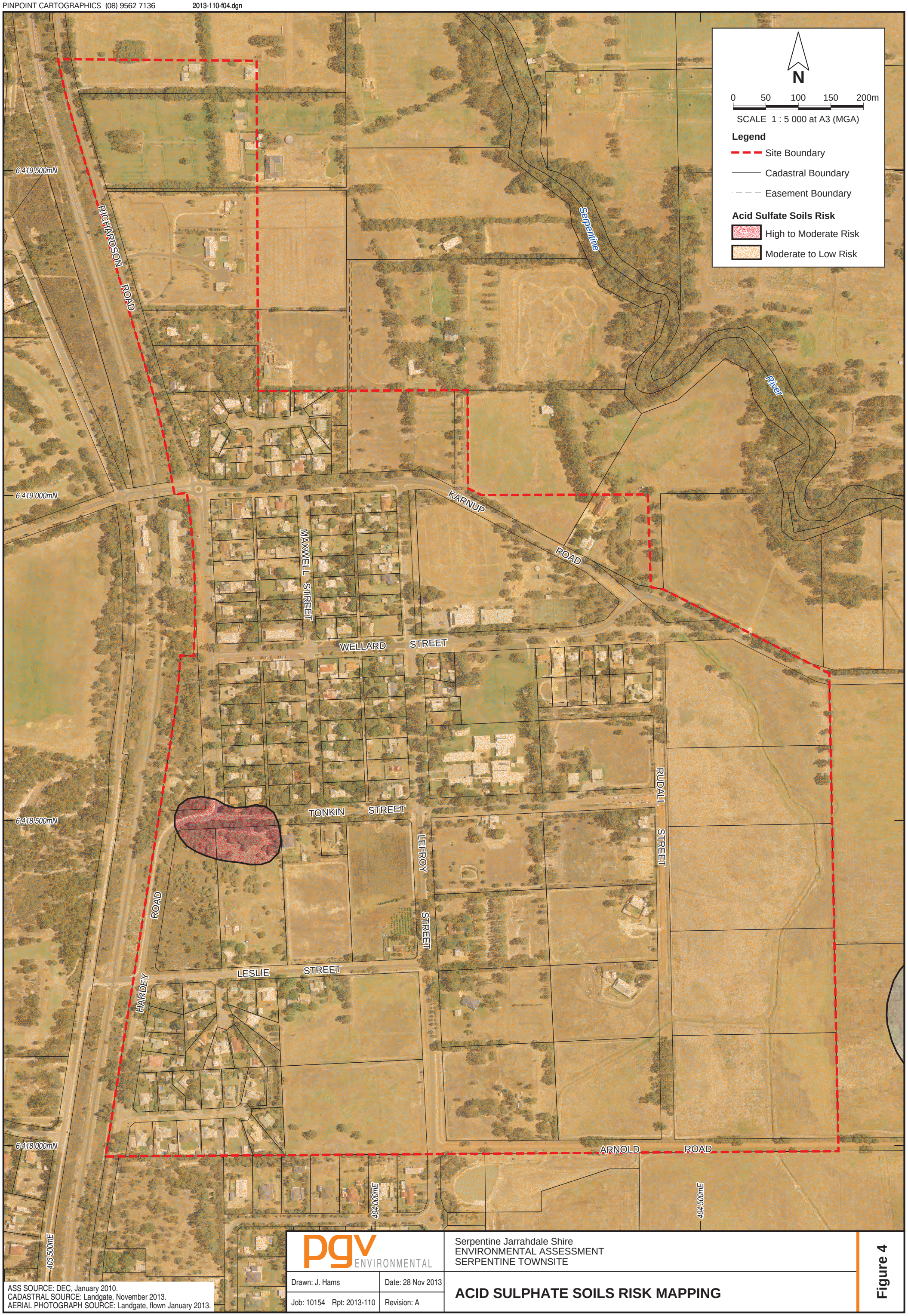
Drawn: J. Hams | Date: 28 Nov 2013
Job: 10154 Rpt: 2013-110 | Revision: A

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

SOIL MAPPING

Figure 3

PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-110-f04.dgn



ASS SOURCE: DEC, January 2010.
CADASTRAL SOURCE: Landgate, November 2013.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

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Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

ACID SULPHATE SOILS RISK MAPPING

Figure 4

PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-110-f05.dgn

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary

Geomorphic Wetlands

- Conservation Category
- Resource Enhancement
- Multiple Use
- 15004 Wetland UFI

15785
14984
14987
15004
15364
15878
15002
14974
15205
15204
15001
14989
7879
16

Serpentine River

RICHARDSON ROAD
KARNUP ROAD
MAXWELL STREET
WELLARD STREET
TONKIN STREET
LEFROY STREET
RUDALL STREET
LESLIE STREET
HARDEY ROAD
ARNOLD ROAD

6 419 500mN
6 419 000mN
6 418 500mN
6 418 000mN
403 500mE
404 000mE
404 500mE

WETLANDS SOURCE: DEC, November 2013.
CADASTRAL SOURCE: Landgate, November 2013.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

pgv ENVIRONMENTAL

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Job: 10154 Rpt: 2013-110 | Revision: A

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

WETLANDS MAPPING

Figure 5

PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-110-f06.dgn

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary
- Bush Forever Site
- 371 Bush Forever Site Number

6 419 500mN
6 419 000mN
6 418 500mN
6 418 000mN
403 500mE
404 000mE
404 500mE

RICHARDSON ROAD
365
371
Serpentine River
KARNUP ROAD
MAXWELL STREET
WELLARD STREET
TONKIN STREET
LEFROY STREET
RUDALL STREET
375
HARDEY ROAD
LESLIE STREET
ARNOLD ROAD

BUSH FOREVER SOURCE: DoP, 2007.
CADASTRAL SOURCE: Landgate, November 2013.
AERIAL PHOTOGRAPH SOURCE: Landgate, flown January 2013.

pgv ENVIRONMENTAL

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Job: 10154 Rpt: 2013-110 | Revision: A

Serpentine Jarrahdale Shire
ENVIRONMENTAL ASSESSMENT
SERPENTINE TOWNSITE

BUSH FOREVER SITES

Figure 6

APPENDIX 1

DPI Proposed Local Structure Plan

3.1 Main Land Uses

Figure 9: Land Use Plan.

APPENDIX 2

Vegetation Mapping – Coffey Environments (2009)

AERIAL PHOTOGRAPH SOURCE: Landgate, flown Dec 2008.

PRINTED: Thu 28 May 09 CHECKED: BL 28-05-09 DRAWN: CR 28-05-09 DATUM: MGA zn50 ENVI/PERT/00643AA/EPBC Act Assessment/EP2009-050F03.dgn

VEGETATION ASSESSMENT - LOTS 6-10 TURNER STREET, SERPENTINE

coffey environments
SPECIALISTS IN LIVING AND WORKING PLACES

LOCATION OF SIMILAR HABITAT IN THE SERPENTINE TOWNSITE

FIGURE 3

APPENDIX 3

TEC/PEC Database Search (04-0913EC)

BDY_ID	OCC_UNIQUE	COM_ID	COM_NAME	CT_DESC	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	OCC_CONFID
370	757	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	2	FHALL01	HALL05	500	No
372	113	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	1	PUNR02		500	No
1325	3239	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	2	Turner01	Turner03	500	No
359	510	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	MYBYFORD01		500	No
0	5067	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	BYFrail07		500	No
0	4043	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered	1	RAPID05		500	No
367	754	SCP10a	Shrublands on dry clay flats	Endangered	1	HALL02		500	No
369	756	SCP10a	Shrublands on dry clay flats	Endangered	1	HALL04		500	No
371	761	SCP10a	Shrublands on dry clay flats	Endangered	1	PUNR03		500	No
0	5069	SCP10a	Shrublands on dry clay flats	Endangered	1	BYFrail09		500	No
366	753	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	HALL01		500	No
368	755	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	HALL03		500	No
382	750	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	PAUL06		500	No
383	733	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	PAUL01		500	No
386	751	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	xLamb02		500	No
391	752	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	xLamb01		500	No
0	4041	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	RAPID01		500	No
0	4044	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered	1	RAPID06		500	No
0	5106	SCP1a	Eucalyptus haematoxylon - E. marginata woodlands on Whicher foothills	Priority 3	1	WattleRd01		500	No
0	4042	SCP21c	Low lying Banksia attenuata woodlands or shrublands	Priority 3	1	RAPID02		500	No
373	760	SCP07	Herb rich saline shrublands in clay pans	Vulnerable	1	PUNR01		500	No
374	762	SCP07	Herb rich saline shrublands in clay pans	Vulnerable	1	PUNR04		500	No
381	740	SCP07	Herb rich saline shrublands in clay pans	Vulnerable	1	PAUL04		500	No
379	749	SCP08	Herb rich shrublands in clay pans	Vulnerable	1	PAUL05		500	No
384	734	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	1	PAUL02		500	No
390	735	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	1	PAUL03		500	No
404	451	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	5	MYSERP01	serp04	500	No
599	457	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	2	MYTRANSPLOT1	MYTRANS01	500	No
0	5068	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	1	BYFrail08		500	No
0	5196	SCP3b	Eucalyptus calophylla - Eucalyptus marginata woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	1	WattleRd01Serp		500	No

APPENDIX 4

Conservation Codes

Western Australian and Commonwealth of Australia Conservation Codes

Flora

Definitions of the Conservation Codes for the Status of Flora under the Wildlife Conservation Act 1950 follow:

T: Threatened Flora (Declared Rare Flora — Extant)

Taxa1 which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the Wildlife Conservation Act 1950).

Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria:

CR: Critically Endangered

Considered to be facing an extremely high risk of extinction in the wild

EN: Endangered

Considered to be facing a very high risk of extinction in the wild

VU: Vulnerable

Considered to be facing a high risk of extinction in the wild.

X: Presumed Extinct Flora (Declared Rare Flora — Extinct)

Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the Wildlife Conservation Act 1950).

Taxa that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora List under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Taxa that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

Priority One: Poorly-known taxa

Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or

more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

Priority Two: Poorly-known taxa

Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

Priority Three: Poorly-known taxa

Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

Priority Four: Rare, Near Threatened and other taxa in need of monitoring

Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Priority Five: Conservation Dependent taxa

Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years.

Vegetation

Definitions and criteria for presumed totally destroyed, critically endangered, endangered and vulnerable ecological communities are outlined below.

Presumed Totally Destroyed (PD)

An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence

of it is likely to recover its species composition and/or structure in the foreseeable future.

Critically Endangered (CR)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

Endangered (EN)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

Vulnerable (VU)

An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

Possible threatened ecological communities that do not meet survey criteria are added to DEC's Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly-known ecological communities

Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤ 100ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly-known ecological communities

Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200ha). At least some occurrences are

not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority 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. These communities require regular monitoring.

(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(iii) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities

Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Fauna

In Western Australia, all native fauna species are protected under the *Wildlife Conservation Act 1950-1979*. Fauna species that are considered rare, threatened with extinction or have a high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA). In addition to the above classification, DEC also classify fauna under five different Priority codes and rare and endangered fauna are classified under the Wildlife Conservation (Specially Protected Fauna) Notice 2006 into four schedules of taxa.

Schedule 1

Fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection.

Schedule 2

Fauna which are presumed to be extinct and are declared to be fauna in need of special protection.

Schedule 3

Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction which are declared to be fauna in need of special protection.

Schedule 4

Fauna that are in need of special protection, otherwise than for the reasons mentioned in Schedule 1, 2 or 3.

In addition to the above classification, the DEC also classifies fauna under five different priority codes:

Priority One: Taxa with few, poorly known populations on threatened lands

Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Two: Taxa with few, poorly known populations on conservation lands

Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Three: Taxa with several, poorly known populations, some on conservation lands

Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority Four: Taxa in need of monitoring

Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

Priority Five: Taxa in need of monitoring (conservation dependent)

Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Commonwealth of Australia Conservation Codes

The Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* has the following nine conservation codes for Flora and Fauna.

Extinct

Taxa not definitely located in the wild during the past 50 years

Extinct in the Wild

Taxa known to survive only in captivity

Critically Endangered

Taxa facing an extremely high risk of extinction in the wild in the immediate future

Endangered

Taxa facing a very high risk of extinction in the wild in the near future

Vulnerable

Taxa facing a high risk of extinction in the wild in the medium-term

Near Threatened

Taxa that risk becoming Vulnerable in the wild

Conservation Dependent

Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.

Data Deficient (Insufficiently Known)

Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

Least Concern

Taxa that are not considered Threatened

APPENDIX 5

DPaW Flora Database Searches

Taxon	Status	Rank	IUCN Criteria	EPBC	DECRegion	DECDistrict	Distribution	Flowering Period	Recovery Plan
Acacia horridula	3				SWAN	PERTH HILLS	Helena Valley - Serpentine	May-Aug	
Acacia lasiocarpa var. bracteolata long peduncle variant (G.J. Keighery 5026)	1				SWAN	PERTH HILLS,SWAN COASTAL	North Dandalup, Mundijong, Gosnells, Jandakot, Serpentine, Mundijong	My,Aug	
Acacia oncinophylla subsp. oncinophylla	3				MWST,SWAN,WARR	PERTH HILLS,DONNELLY,MOORA	Mogumber, Mundaring, John Forrest NP, Serpentine, Mt Lennard, Dwellingup, Winnejup		
Dillwynia dillwynioides	3				SWAN	SWAN COASTAL	Harvey, Pinjarrah, Yunderup, Gingin, Perth, Karnup, Mundijong, Serpentine	Aug-Oct	
Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459) PN	3				SWAN	SWAN COASTAL	Serpentine, Kenwick, Upper Swan, Gingin, Forrestdale, Bullsbrook, Mandurah, Arrowsmith, Capel	-	
Eucalyptus rudis subsp. cratyantha	4				SWAN,SWST	SWAN COASTAL,BLACKWOOD	Yallingup, Eagle Bay, Mandurah, Cape Naturaliste, Meelup, Busselton, Serpentine	-	
Johnsonia pubescens subsp. cygnorum	2				SWAN	SWAN COASTAL	Serpentine, Cardup, Lowlands	Sep-Nov	
Lasiopetalum pterocarpum	T	CR	Ba1b(iii) +2ab(iii); C2a(i,ii); D	EN	SWAN	PERTH HILLS	Serpentine Falls	Aug	IRP
Parsonsia diaphanophleba	4				SWAN	PERTH HILLS,SWAN COASTAL	Murray River, Coolup, Serpentine	Jan-Feb,May-	
Stachystemon sp. Keysbrook (R. Archer 17/11/99)	1				SWAN	SWAN COASTAL	Keysbrook, Whiteman	Oct	
Stylidium ireneae	4				SWAN,SWST	SWAN COASTAL,BLACKWOOD,WELLINGTON	Waroona, Lane Poole, Serpentine Dam, North Dandalup, Augusta, Kwinana	Oct-Nov	
Synaphea odocoileops	1				SWAN,SWST	PERTH HILLS,SWAN COASTAL,BLACKWOOD	Serpentine, Elgin, Byford, Wagerup	Aug-Oct	
Synaphea sp. Pinjarra Plain (A.S. George 17182)	1				SWAN	SWAN COASTAL	Mundijong, Serpentine	Oct	IRP
Synaphea sp. Serpentine (G.R. Brand 103)	3				SWAN,SWST	SWAN COASTAL,WELLINGTON	Serpentine, Mundijong, Byford, Yarloop	Aug-Nov	
Tetraria australiensis	T	VU	B1ab(iii)	VU	SWAN,SWST	PERTH HILLS,SWAN COASTAL,BLACKWOOD	Mundijong, Busselton, (Cannington, Serpentine River)	Dec	
Verticordia lindleyi subsp. lindleyi	4				MWST,SWAN	PERTH HILLS,SWAN COASTAL,MOORA	Gillingarra-Forrestdale, Cannington, Guildford, Muchea, Gingin, Murray River, Moore River, Serpentine	Nov-Jan	
Verticordia plumosa var. ananeotes	T	CR	B1ab(iii,v)+2ab(iii,v)	EN	SWAN,SWST	SWAN COASTAL,BLACKWOOD	Busselton, Serpentine - Blackwood	Dec	IRP

FID_	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Vesting	Purpose1	Purpose2	CountDate
	86383	3373	Acacia horridula	3		1		LGA	VER		7/12/1976 0:00
	98539	3373	Acacia horridula	3		4	A	LGA	VER		12/06/1996 0:00
	98540	3373	Acacia horridula	3		4	B	CC	NPK		12/06/1996 0:00
	98541	3373	Acacia horridula	3		4	C	CC	NPK		13/06/1996 0:00
	98542	3373	Acacia horridula	3		4	D	CC	NPK		14/06/1996 0:00
	98543	3373	Acacia horridula	3		4	E	CC	NPK		20/06/1996 0:00
	98544	3373	Acacia horridula	3		4	F	CC	NPK		20/06/1996 0:00
	98545	3373	Acacia horridula	3		4	G	CC	NPK		25/06/1996 0:00
	98546	3373	Acacia horridula	3		4	H	CC	NPK		8/07/1996 0:00
	98547	3373	Acacia horridula	3		4	I	CC	NPK		13/11/1996 0:00
	86389	3373	Acacia horridula	3		5		LGA	VER		2/07/1991 0:00
	91850	14129	Acacia oncinophylla subsp. oncinophylla	3		1		UNKNOWN			18/07/1976 0:00
	84967	1596	Caladenia huegelii	T	CR	75		PRI			23/09/2010 0:00
	101638	13191	Drosera occidentalis subsp. occidentalis	4		20	A	RAI	RRE		27/11/1990 0:00
	101639	13191	Drosera occidentalis subsp. occidentalis	4		20	B	LGA	VER		27/11/1990 0:00
	101641	13191	Drosera occidentalis subsp. occidentalis	4		22	A	LGA	VER		27/11/1990 0:00
	101642	13191	Drosera occidentalis subsp. occidentalis	4		22	B	RAI	RRE		27/11/1990 0:00
	94661	19272	Johnsonia pubescens subsp. cygnorum	2		3		RAI	RRE		19/10/1983 0:00
	103518	17000	Lasiopetalum pterocarpum	T	CR	1	A	CC	NPK		30/11/2007 0:00
	103519	17000	Lasiopetalum pterocarpum	T	CR	1	B	CC	NPK		30/11/2007 0:00
	103520	17000	Lasiopetalum pterocarpum	T	CR	1	C	CC	NPK		19/12/2000 0:00
	103521	17000	Lasiopetalum pterocarpum	T	CR	1	D	CC	NPK		8/10/2003 0:00
	103522	17000	Lasiopetalum pterocarpum	T	CR	1	E	CC	NPK		5/04/2006 0:00
	103523	17000	Lasiopetalum pterocarpum	T	CR	1	F	CC	NPK		30/11/2007 0:00
	93503	16865	Synaphea odocoileops	1		3		UNKNOWN	UNKNOWN		21/09/1998 0:00
	103965	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	A	RAI	RRE		16/09/2010 0:00
	103966	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	B	RAI	RRE		16/09/2010 0:00
	103967	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	C	RAI	RRE		21/09/2010 0:00
	103968	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	D	RAI	RRE		21/09/2010 0:00
	103969	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	E	RAI	RRE		21/09/2010 0:00
	107083	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	F	LGA	VER		16/09/2010 0:00

FID_	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Vesting	Purpose1	Purpose2	CountDate
	107084	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	G	LGA	VER		21/09/2010 0:00
	107086	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	3	H	LGA	VER		21/09/2010 0:00
	103971	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	6	A	CC	CFF		11/10/2010 0:00
	103972	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	6	B	LGA	VER		11/10/2010 0:00
	103973	18590	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	CR	6	C	LGA	VER		11/10/2010 0:00
	107453	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		6	A	RAI	RRE		5/10/2012 0:00
	107455	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		6	B	LGA	VER		5/10/2012 0:00
	107456	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		7	A	CC	NRE		8/10/2012 0:00
	107458	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		7	B	LGA	VER		8/10/2012 0:00
	107459	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		7	C	RAI	RRE		8/10/2012 0:00
	107462	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		8	A	LGA	VER		8/11/2011 0:00
	107464	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		8	B	RAI	RRE		9/10/2012 0:00
	107465	30751	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1		9		RAI	RRE		9/10/2012 0:00
	96982	1033	Tetraria australiensis	T	VU	7	A	CC	CFF		26/10/2009 0:00
	96983	1033	Tetraria australiensis	T	VU	7	B	NON	UCL		26/10/2009 0:00
	96984	1033	Tetraria australiensis	T	VU	7	C	LGA	VER		26/10/2009 0:00
	96985	1033	Tetraria australiensis	T	VU	7	D	RAI	RRE		26/10/2009 0:00
	96973	1033	Tetraria australiensis	T	VU	11	A	LGA	REC		26/08/2009 0:00
	96974	1033	Tetraria australiensis	T	VU	11	B	LGA	VER		1/11/2009 0:00
	84541	1033	Tetraria australiensis	T	VU	14		PRI			19/10/2010 0:00
	106361	1033	Tetraria australiensis	T	VU	15		RAI	RRE		29/09/2011 0:00
	92652	14714	Verticordia lindleyi subsp. lindleyi	4		10		LGA	VER	DRA	27/12/1988 0:00
	92666	14714	Verticordia lindleyi subsp. lindleyi	4		25		LGA	VER		9/11/1995 0:00
	90083	12452	Verticordia plumosa var. pleiobotrya	T	VU	4		LGA	OTH		24/11/1999 0:00

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 01188445	Acacia horridula	3	Red soil over granite.	Wandoo-Marri overstorey, Hakea sp. and Blackboy midstorey, Hibbertia, Grevillea sp. understorey.	700 m East on Scrivner Road on verge and extending into National Park	MAN	4	09 07 1990
	PERTH 04366263	Acacia horridula	3	WSW aspect. Slope. Dry brown/yellow sand/clay/gravel over granite.	With Eucalyptus calophylla, E. wandoo, E. marginata, Hakea trifurcata, H. cristata, H. lissocarpa, Blackboys, Dryandra nivea, Eucalyptus laeliae, Zamia, Hibbertia sp., Acacia pulchella, Daviesia sp.	Serpentine National Park	MAN	0	12 06 1996
	PERTH 04366220	Acacia horridula	3	Dry brown sand/clay/gravel. WNW aspect. Slope.	Very open vegetation with scattered Marri saplings, Hakea trifurcata, H. cristata, Blackboys, Dryandra armata, D. nivea, Calothamnus sp.	Serpentine National Park	MAN	0	25 06 1996
	PERTH 126179	Acacia horridula	3	Among granite rocks on hillside.	Low dense sclerophyll scrub.	Serpentine, Spring Valley Road	MAN	3	18 07 1976
	PERTH 04366255	Acacia horridula	3	WNW aspect. Slope. Dry brown/yellow sand/clay/gravel.	Very open vegetation with Eucalyptus laeliea, E. calophylla, Hakea trifurcata, H. lissocarpha, H. cristata, H. stenocarpa, Blackboys, Dryandra armata, D. nivea, Calothamnus sp.	Serpentine National Park	MAN	0	20 06 1996
	PERTH 04366212	Acacia horridula	3	WSW aspect. Slope. Dry yellow sand/clay/gravel over sheet boulder/granite with quartz rubble.	Very open vegetation with stunted Jarrah and Nuytsia floribunda, Hakea trifurcata, H. cristata, Blackboys, Lambertia multiflora, Dryandra nivea, Calothamnus sp., Hibbertia hypericoides.	Serpentine National Park	GPS	1	08 07 1996
	PERTH 05114209	Acacia horridula	3	Grey-brown gritty clay loam, with surface gravel and granitic cobbels, on a steep western lower slope.	Eucalyptus lane-poolei Low Woodland, over Kingia australis Open Low Scrub, over Xanthorrhoea acanthostachya Dwarf Scrub, over Melaleuca scabra Low Heath, over Neurachne alopecuroidea Very Open Low Grass.	Serpentine National Park, on NE corner of crossroads about 400 m ESE from Chatfield Rd. (Plot-SERP01)	GPS	1	13 11 1996
	PERTH 04366247	Acacia horridula	3	Westerly aspect. Slope. Dry light brown sand/clay/gravel over granite boulder/ dolerite and quartz rubble.	Very open vegetation with stunted Eucalyptus calophylla, E. marginata, Hakea trifurcata, H. cristata, H. lissocarpa, Blackboys, Dryandra armata, D. nivea, Eucalyptus laeliea, Hibbertia sp.	Serpentine National Park	GPS	1	13 06 1996
	PERTH 04366271	Acacia horridula	3	WNW aspect. Slope. Dry red/brown loam over granite boulder.	Open vegetation but very scrubby site with Eucalyptus laeliae, Hakea trifurcata, H. lissocarpha, H. cristata, H. stenocarpa, Acacia pulchella, A. marginata, Dryandra armata, D. nivea, Grevillea bipinnatifida.	Serpentine National Park	GPS	1	20 06 1996
	PERTH 04366239	Acacia horridula	3	Dry brown/yellow sand/clay/gravel over granite boulder/dolerite and quartz rubble. Westerly aspect. Slope.	Open vegetation with Eucalyptus laeliea, E. calophylla, E. marginata, Hakea trifurcata, H. cristata, H. lissocarpha, Blackboys, Zamia, Dryandra armata, D. nivea, Isopogon sp., Hibbertia sp., Calothamnus sp.	Serpentine National Park	GPS	1	14 06 1996
	PERTH 126195	Acacia horridula	3			About 1 km E of South West Highway on Scrivener Road (S of Serpentine)	MAN	2	07 12 1976
	PERTH 00607487	Acacia oncinophylla subsp. oncinophylla	3			Serpentine, Spring Valley Road	AUTO	3	18 07 1976
	PERTH 05811929	Drosera occidentalis subsp. occidentalis	4	Low lying flat. Grey sandy clay. Disturbed.	In Low Heath C of Kunzea micrantha over Leptocarpus sp., low sedges.	250 m N of Karnup Road on Hall Road, Serpentine, between Hall Road and railway,	MAN	3	27 11 1990
	PERTH 05811961	Drosera occidentalis subsp. occidentalis	4	Damp flat. Grey brown clayey sand.	Edge of Pericalymma ellipticum Low Heath C.	400 m S of Karnup Road on Hall Road, Serpentine, between Hall Road and railway,	MAN	3	27 11 1990
	PERTH 06428304	Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459)	3	Dry Flat, brown sand, well drained.	Associated species: Eucalyptus calophylla.	Karnup Road Reserve just to SW of intersection with Rapids Road in Karnup Road Bushland (Bush Forever Site 74), Peel Estate, in System 6 Update quadrat punr02	GPS	1	09 11 1995

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 03418731	Isopogon drummondii	3			Serpentine	AUTO	3	02 1901
	PERTH 08470944	Isopogon drummondii	3	Sand slope of yellow colluvial sand.	Banksia low woodland. Associated vegetation Banksia attenuata and B. menziesii.	Paul Robertson Reserve, Serpentine	GPS	1	26 02 2003
	PERTH 04781643	Johnsonia pubescens subsp. cygnorum	2	Flat site, rather low lying; recently burnt; grey sand.	Low woodland of Eucalyptus marginata and Coymbia calophylla with Kingia and Xanthorrhoea.	Between Tonkin Road and railway in SW corner of Serpentine townsite,	MAN	0	19 10 1983
	PERTH 01969501	Johnsonia pubescens subsp. cygnorum	2	Grey sand.	Open Banksia - Casuarina woodland.	2 km W of Serpentine	AUTO	3	29 09 1982
	PERTH 07319193	Lasiopetalum pterocarpum	T	In gently undulating area.	In an open woodland with Eucalyptus calophylla, Darwinia, Lepidosperma, Acacia.	Off the first track W of the Serpentine Falls, ca 150 m from the carpark	GPS	1	26 10 2005
	PERTH 05118379	Lasiopetalum pterocarpum	T	Dark brown loam, with dolerite cobbels at surface, on a creekline.	Eucalyptus rudis, E. calophylla Low Forest, over Trymalium floribundum, Grevillea manglesii spp manglesii Thicket, over Watsonia meriana Open Herbs, over Baumea vaginalis Open Tall Sedges.	Serpentine National Park, to SE of Falls Rd Car Park, on S side of creek. (Plot-SERP15)	GPS	1	08 12 1996
	PERTH 07220200	Lasiopetalum pterocarpum	T	Dark brown sandy clay over granite. 5 m from creek.	With riparian vegetation of open woodland and tall shrubs. Eucalyptus rudis, E. calophylla, Acacia sp., Lepidosperma sp., Agonis sp.	On track verge, in fence area approximately 160 m from the Serpentine Falls carpark, walking towards the Falls on N bank of creek	GPS	1	12 05 2006
	PERTH 05414172	Lasiopetalum pterocarpum	T	Riverbank. Organic litter cover. Brown clay-sand over granite.	Woodland over Heath A. Associated species: Eucalyptus rudis, Acacia alata (<2 m), A. saligna, Grevillea ?diversifolia, Blackberry (Rubus ulmifolius), Watsonia.	Serpentine National Park, E of Serpentine Falls following river course,	GPS	1	24 09 1999
	PERTH 04930363	Lasiopetalum pterocarpum	T	Valley. Northerly aspect. Moist, dark brown loam.	M.LA.c. S.SA.SB.SC.c.i. Eucalyptus calophylla/rudis overstorey. Associated with Agonis linearifolia, Acacia urophylla, Darwinia citriodora, Trymalium floribundum, Blackberry and Watsonia.	Serpentine National Park, situated 35 m E from the junction of the large water pipeline and the first walk trail that parallels the River	GPS	1	30 07 1997
	PERTH 2715031	Lasiopetalum pterocarpum	T		In shade amongst thick shrub layer with overhanging trees.	Near base of Serpentine Falls	AUTO	2	05 08 1972
	PERTH 07220219	Lasiopetalum pterocarpum	T	Dark brown sandy clay over granite. Gently undulating area near the base of the falls.	Riparian vegetation with Eucalyptus rudis, Acacia sp., Lepidosperma sp., Agonis sp.	Approximately 160 m from the Serpentine Falls carpark walking towards the Falls, near a small track to Falls	GPS	1	26 09 2004
	PERTH 05409624	Lasiopetalum pterocarpum	T	Moist, brown loam over granite. Riverbank.	Woodland over Heath A. Associated species: Dense Grevillea diversifolia, Eucalyptus calophylla, Darwinia citriodora, Acacia nervosa, Eucalyptus rudis, Lasiopetalum floribundum, Hemigenia sp., Watsonia.	ca 100 m W of Serpentine Falls car park, ca 5 m N of N bank of Serpentine River, Serpentine National Park,	MAN	2	07 09 1999
	PERTH 07968825	Lasiopetalum pterocarpum	T	Unburnt site with open area and deep leaf litter. Brown clayey sand over granite.		Site 3 DEC report. Behind ticket entry box Serpentine Falls National Park	GPS	1	06 05 2006
	PERTH 07968833	Lasiopetalum pterocarpum	T	Creek bank with dark brown, sandy clay over granite.	With riparian vegetation of open woodland and tall shrubs. Eucalyptus rudis, E. calophylla, Acacia sp, Lepidosperma sp and Agonis sp.	Over pipe Bridge near Serpentine Falls carpark, walking towards the Falls on S bank of creek. Site 4 DEC report	GPS	1	11 2004
	PERTH 03017656	Parsonsia diaphanophleba	4	Light brown sandy clay, river edge.		Lowlands, Mardella, N side of Serpentine River, NE of old house	AUTO	3	31 05 1993
	PERTH 06739016	Senecio leucoglossus	4			Serpentine	MAN	3	24 09 1899
	PERTH 06739024	Senecio leucoglossus	4			Serpentine	MAN	3	22 10 1899
	PERTH 05424585	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Flat. Road-rail reserve. Moist, liiter. Grey sandy clay. Pinjarra plain.	Heath, scattered Marri.	Hall Road, 200 m N of Utley Road-Rail Reserve, Serpentine,	MAN	0	15 09 1999

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 07469195	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Winter wet railway reserve. Light brown red gravelley clay loam.	Open Pericalymma sp., Leptospermum shrubland with Leschenaultia biloba, Allocasuarina humilis, Briza sp., Watsonia sp., grasses and scattered emergent Eucalyptus sp.	200 m N of Utley road on Hall road, S of Serpentine	TOPO	3	26 10 1999
	PERTH 07469225	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail Reserve. Compacted light brown clayey sand.	Pericalymma ellipticum low shrubland with Adenanthos meisneri, Synaphea charisma ms., Leptospermum sp., Hakea spp. and Watsonia bulbillifera weed invasion.	1.1 km S of Karnup road on Hall road, S of Serpentine, E side of road in rail reserve	GPS	1	10 10 2003
	PERTH 07469233	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail Reserve. Grey clayey sand with areas of compacted grey to red - brown clay.	Kunzea recurva shrubland with Hypocalymma angustifolium, Leschenaultia biloba, Mesomelaena tetragona, Synaphea petiolaris, Synaphea xela ms., Grevillea sp., and scattered emergent Corymbia calophylla as well as Neurachne allopecuroidea and Watsonia bulbi	3.85 km S of Karnup road on Hall road, S of Serpentine, E side of road in rail reserve	GPS	1	22 10 2003
	PERTH 07469241	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail Reserve. Grey clayey sand with areas of compacted grey to red - brown clay.	Kunzea recurva shrubland with Hypocalymma angustifolium, Leschenaultia biloba, Mesomelaena tetragona, Synaphea petiolaris, Synaphea xela ms., Grevillea sp., and scattered emergent Corymbia calophylla as well as Neurachne allopecuroidea and Watsonia bulbi	3.85 km S of Karnup road on Hall road, S of Serpentine, E side of road in rail reserve	GPS	1	22 10 2003
	PERTH 07463642	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail reserve. Grey clayey sand with areas of compacted grey to red-brown clay.	Kunzea recurva shrubland with Hypocalymma angustifolium, Leschenaultia biloba, Mesomelaena tetragona, Synaphea petiolaris, S. sp. Pinjarra Plain (A.S. George 17182), Grevillea sp. and scattered emergent Corymbia calophylla, as well as Neurachne alopecuro	3.85 km S of Karnup Road on Hall Road, S of Serpentine; E side of road in rail reserve	GPS	1	22 10 2003
	PERTH 07463650	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail reserve. Compacted light brown sandy loam with lateritic gravel.	Kunzea recurva thicket with some Pericalymma ellipticum over Adenanthos meisneri Mesomelaena tetragona, Synaphea sp. Serpentine (G.R. Brand 103), Synaphea sp. (RB 1082) and Leschenaultia biloba with Watsonia meriana var. bulbillifera, Ehrharta calycina a	2.2 km S of Karnup Road on Hall Road, S of Serpentine; E side of road in rail reserve	GPS	1	18 10 2003
	PERTH 07463669	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Rail reserve. Compacted light brown clayey sand.	Pericalymma ellipticum low shrubland with Adenanthos meisneri, Synaphea sp. Serpentine (G.R. Brand 103), Leptospermum sp., Hakea spp. and Watsonia meriana var. bulbillifera weed invasion.	0.9 km S of Karnup Road on Hall Road, S of Serpentine; E side of road in rail reserve	GPS	1	10 10 2003
	PERTH 07463677	Synaphea sp. Fairbridge Farm (D. Papenfus 696)	T	Compacted pinkish-light brown clayey sand with lateritic gravel over grey-light brown sandy loam. The earth was distubed with a large number of small mounds and dips.	Very sparse, open Kunzea recurva shrubland with Adenanthos meisneri, Leschenaultia biloba and Synahea gracillima (1 plant near railway line). Weeds included Watsonia meriana var. bulbillifera, Briza maxima, Eragrostis curvula and other grasses.	3.1 km S of Karnup Road on Hall Road, S of Serpentine; E side of road in rail reserve	GPS	1	22 10 2003
	PERTH 05427452	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Flat. Moist, grey, sandy clay. Pinjarra Plain?	Heath. Characteristic species: Marri, other Synaphea.	Hall Road, Serpentine	MAN	0	01 09 1999
	PERTH 07463685	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Degraded railway reserve. Grey, moist clay/sand.	Scattered Marri and Nuytsia floribunda with Eremaea, Mesomelaena tetragona and Xanthorrhoea preissii.	Ca 50 m N of roundabout at Serpentine, rail reserve, E side of line	TOPO	3	26 10 1999
	PERTH 07463707	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Rail/road reserve with grey sand and lateritic gravel.	Shrubland. Leptospermum, Leschenaultia and weeds - Eragrostis curvula, Watsonia bulbillifera and Briza spp.	100 m N of Utley Road on Hall Road, S of Serpentine	TOPO	3	26 10 1999
	PERTH 07463715	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Degraded railway reserve. Grey, moist clay/sand.	Scattered Marri and Nuytsia floribunda with Eremaea, Mesomelaena tetragona and Xanthorrhoea preissii.	Ca 50 m N of roundabout at Serpentine, rail reserve, E side of line	GPS	3	26 10 1999

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 07463766	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Reserve between road and rail. Greyish clay.	Low shrubland of Pericalymma ellipticum and Kunzea, with Hakea spp., Synaphea sp. Serpentine (G.R. Brand 103), Adenanthos and Watsonia meriana var. bubillifera.	600 m S of Karnup Road on Hall Road, E side of road, S of Serpentine	GPS	3	10 10 2003
	PERTH 07463847	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Rail reserve. Compacted greyish red-brown clay.	Kunzea shrubland with some Hypocalymma angustifolium, Lechenaultia biloba, Mesomelaena tetragona, Allocasuarina, Grevillea, Neurachne alopecuroidea, some Watsonia meriana var. bulbillifera, Synaphea petiolaris and S. sp. Fairbridge Farm (D. Papenfus DP 6	3.9 km S along Hall Road from Karnup Road, E side of road; S of Serpentine	GPS	1	22 10 2003
	PERTH 07463731	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Area between road and rail. Light yellow-pinkish brown gravelly clay-sand with lateritic gravel, over light brown clayey sand.	Corymbia calophylla and Eucalyptus sp. woodland remnant with Synaphea petiolaris Xanthorrhoea preissii, Kunzea and Watsonia meriana var. bulbillifera and grass weeds.	4 km S of Karnup Road on Hall Road, E side of road; S of Serpentine	GPS	3	22 10 2003
	PERTH 08187479	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Flat adjacent to wetland area. Brown loam.	Hakea sp., Kingia, Melaleuca sp., Nuytsia floribunda, Stirlingia latifolia. Occurs with Synaphea sp. Serpentine.	Within Lambkin Nature Reserve, Serpentine. Plants occur on the E side of Tonkin Street (also Hardey Street). Beside fencing	GPS	1	23 12 2008
	PERTH 05251400	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat, wet grey sandy clay. Pinjarra plain.	Heath. Marri adjacent. Dodder.	Serpentine, Hall Road, .5 km S of Karnup Road on E side of road and into rail reserve	MAN	0	06 09 1998
	PERTH 05251397	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat, winter wetland. Wet grey sandy clay.	Heathland, Marri adjacent.	Serpentine,	MAN	0	06 09 1998
	PERTH 05298865	Synaphea sp. Serpentine (G.R. Brand 103)	3	Brown loam. Swamp.		Serpentine, 3.3 km along Karnup Road from Hall Road,	GPS	1	24 09 1998
	PERTH 05298881	Synaphea sp. Serpentine (G.R. Brand 103)	3	Brown loam. Swamp.		Serpentine, N along Richardson Road from Karnup	GPS	1	21 09 1998
	PERTH 05297192	Synaphea sp. Serpentine (G.R. Brand 103)	3	Swamp. Brown loam.	Pericalymma.	Serpentine, 100 m S along Hall Road from Egerton Road	GPS	1	21 09 1998
	PERTH 05297206	Synaphea sp. Serpentine (G.R. Brand 103)	3	Swamp. Brown loam.		Serpentine, Lambkin Reserve at junction of Richardson Road and Tonkin Road	GPS	1	21 09 1998
	PERTH 05298903	Synaphea sp. Serpentine (G.R. Brand 103)	3	Brown loam. Swamp.	Eragrostis curvula, Watsonia.	Serpentine, 2.8 km along Karnup Road from Hall Road	GPS	1	24 09 1998
	PERTH 05427487	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat. Wet, grey sand clay. Pinjarra Plain?	Heath. Characteristic species: Marri, Synaphea petiolaris?	Hall Road, Serpentine,	MAN	0	01 09 1999
	PERTH 05055911	Synaphea sp. Serpentine (G.R. Brand 103)	3	Winter wetland, flat, sand/clay.	Heathland.	Lot 783, 0.5 km from Karnup Road along Hall Road, Serpentine	AUTO	3	17 09 1994
	PERTH 06982387	Synaphea sp. Serpentine (G.R. Brand 103)	3	Coastal plain, edge of winter wet site. Seasonally damp. Grey loamy sand.	Open Marri woodland. With Viminaria juncea, Xanthorrhoea preissii, Mesomelaena tetragona.	Southern boundary of Bradby Nature Reserve off Hall Road, Serpentine	GPS	1	28 11 2003
	PERTH 4263308	Synaphea sp. Serpentine (G.R. Brand 103)	3			Cockburn Sound: Serpentine	AUTO	3	12 1900
	PERTH 07469098	Synaphea sp. Serpentine (G.R. Brand 103)	3	Embankment. Brown sandy loam.	Small patch of remnant bush. Corymbia calophylla open woodland with very low shrub layer.	Embankment in front of the Serpentine Tractor Museum, Serpentine	GPS	1	19 09 2003
	PERTH 07469128	Synaphea sp. Serpentine (G.R. Brand 103)	3	Compacted light brown clayey sand.	Pericalymma ellipticum low shrubland with Adenanthos meisneri, Synaphea selenae ms., Leptospermum sp., Hakea sp., and Watsonia bulbillifera weed invasion.	900 m S of Karnup road, E of side of road, S of Serpentine	GPS	1	10 10 2003

FID_	Sheet_no	Taxon	Cons_code	Site	Vegetation	Locality	Geocode_me	Prec	Coll_Date
	PERTH 07469136	Synaphea sp. Serpentine (G.R. Brand 103)	3	Rail reserve. Yellow - grey to grey clayey sand.	Open Corymbia calophylla woodland remnant with Dryandra nivea, Kingia australis, Xanthorrhoea preissii, Kenedia prostrata, Hakea prostrata, Hypocalymma angustifolium, Synaphea petiolaris, Dampiera sp., Poaceae sp., Restionaceae sp., Watsonia bulbillifera	6.8 km S along Richardson road from rail crossing at Watkins road, E of railway line, Serpentine	GPS	1	09 10 2003
	PERTH 07469144	Synaphea sp. Serpentine (G.R. Brand 103)	3	Degraded railway reserve. Grey moist clay sand.	Scattered Marri and Nuytsia floribunda with Eremaea sp., Mesomelaena tetragona, and Xanthorrhoea preissii.	Ca 50 km N of roundabout at Serpentine. Rail reserve E side of line	TOPO	3	26 10 1999
	PERTH 07469152	Synaphea sp. Serpentine (G.R. Brand 103)	3	Degraded rail reserve. Compacted grey clay sand with gravel.	Degraded shrubland. Macrozamia sp., Synaphea xela, Eragrostis curvula, Watsonia bulbillifera, Stipa sp.	Hall road, opposite entrance to Paul Robinson Reserve, ca 100 m N of Leslie st, S of Serpentine	TOPO	3	26 10 1999
	PERTH 07469160	Synaphea sp. Serpentine (G.R. Brand 103)	3	Seasonally wet rail reserve.	Edge of Pericalymma ellipticum, Leptospermum sp., Adenanthos low shrubland with Synaphea ? petiolaris (RB 1061).	800 m S of Karnup road on Hall road, E side of road, S of Serpentine	GPS	1	10 10 2003
	PERTH 07463596	Synaphea sp. Serpentine (G.R. Brand 103)	3	Rail reserve. Brown loam.	Low shrubland of Pericalymma ellipticum, Leptospermum, Adenanthos, Hakea prostrata, Synaphea ?sp. Pinjarra Plain (A.S. George 17182), Grevillea sp., Drosera sp., Watsonia meriana var. bulbillifera.	600 m S of Karnup Road on Hall Road, E side of road, S of Serpentine	GPS	1	10 10 2003
	PERTH 07469101	Synaphea sp. Serpentine (G.R. Brand 103)	3	Very degraded rail reserve. Compacted grey clayey - sand with gravel.	Degraded shrubland of Macrozamia sp., Synaphea xela, Eragrostis curvula, Watsonia bulbillifera, Stipa sp.	Hall road, opposite entrance to Paul Robinson Reserve, ca 100 m N of Leslie street, S of Serpentine	TOPO	3	26 10 1999
	PERTH 05298873	Synaphea sp. Serpentine (G.R. Brand 103)	3	Swamp. Brown loam.	Pericalymma.	S of Serpentine at junction of Hall Road and Bate Road	GPS	1	21 09 1998
	PERTH 07469187	Synaphea sp. Serpentine (G.R. Brand 103)	3	Winter wet rail reserve. Compacted light brown sandy loam with lateritic gravel.	Kunzea recurva thicket with some Pericalymma ellipticum over Adenanthos meisneri, Mesomelaena tetragona, Synaphea selenae, Synaphea sp. (RB 1082) and Leschenaultia biloba, Watsonia bulbillifera, Ehrharta calycina and Eragrostis curvula weed invasion.	2.25 km S of Karnup road on Hall road, E side of road, S of Serpentine	GPS	1	18 10 2003
	PERTH 08187487	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat, gentle slope to wetland. Yellow/brown sand.	Grevillea sp., Haemodorum sp., Hakea prostrata, Kingia, Nuytsia floribunda, Stirlingia.	Within Lambkin Nature Reserve, Serpentine. Population is off Tonkin Street (or could be Hardey Road), E of the railway	GPS	1	07 01 2009
	PERTH 04528913	Tetraria australiensis	T	Grey sand over clay.	Eucalyptus calophylla woodland.	Lambkin Reserve, Serpentine,	MAN	0	21 04 1996
	PERTH 08321000	Tetraria australiensis	T	Well drained. Flat. Moist grey sandy loam/light clay. Boundary of Ridge Hill Shelf and Guildford Clay.	20% cover Corymbia calophylla, 25% cover grasses: Neurachne allopecuroidea, 30% cover sedges: Tetraria australis, Lomandra spp. Associated species: Corymbia calophylla, Kingia australis, Tricoryne elatior, Xanthorrhoea preissii, Burchardia congesta, Tetr	E side of Byford to Serpentine Rail Line; ca 80 m S of gravel 'parking area' at S end of Hardey Road, Serpentine (Quadrat Byford 08)	GPS	1	29 09 2011
	PERTH 06428312	Verticordia lindleyi subsp. lindleyi	4	Wet Flat, orange brown sandy clay, poor drainage, wet during winter/spring.	Associated species: Viminaria juncea.	Karnup Road Reserve just to SW of intersection with Rapids Road in Karnup Road Bushland (Bush Forever Site 74), Peel Estate, in System 6 Update quadrat punr03	GPS	1	09 11 1995
	PERTH 1894196	Verticordia lindleyi subsp. lindleyi	4	On clay flat near drain.	In open scrub.	Near junction of Karnup Road and Punrack Road, W of Serpentine	MAN	0	27 12 1988
	PERTH 1026526	Verticordia plumosa var. ananeotes	T			Serpentine, between Perth and Pinjarra.	MAN	3	11 1900
	PERTH 1026518	Verticordia plumosa var. ananeotes	T			Cockburn Sound, Serpentine District	MAN	3	12 1900

APPENDIX 6

Naturemap Report

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Jackalyn Hams on 15/10/2013

Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	115°58' 41" E,32°21' 48" S
Buffer	5km
Group By	Conservation Status

Conservation Status	Species	Records
Rare or likely to become extinct	10	77
Other specially protected fauna	1	1
Priority 1	2	17
Priority 2	1	3
Priority 3	5	50
Priority 4	5	16
Priority 5	1	13
Non-conservation taxon	573	2753
TOTAL	**598**	**2930**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	1596	*Caladenia huegelii (Grand Spider Orchid)*		T	
2.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black-Cockatoo)*		T	
3.	24733	*Calyptorhynchus baudinii (Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo)*		T	
4.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo)*		T	
5.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
6.	17000	*Lasiopetalum pterocarpum*		T	
7.	24099	*Phascogale tapoatafa subsp. tapoatafa (Southern Brush-tailed Phascogale, Wambenger)*		T	
8.	18590	*Synaphea sp. Fairbridge Farm (D. Papenfus 696)*		T	
9.	1033	*Tetraria australiensis*		T	
10.	12448	*Verticordia plumosa var. ananeotes*		T	
Other specially protected fauna					
11.	24475	*Falco peregrinus subsp. macropus (Australian Peregrine Falcon)*		S	
Priority 1					
12.	16865	*Synaphea odocoileops*		P1	
13.	30751	*Synaphea sp. Pinjarra Plain (A.S. George 17182)*		P1	
Priority 2					
14.	19272	*Johnsonia pubescens subsp. cygnorum*		P2	
Priority 3					
15.	3373	*Acacia horridula*		P3	
16.	14129	*Acacia oncinophylla subsp. oncinophylla*		P3	
17.	41801	*Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459)*		P3	
18.	2228	*Isopogon drummondii*		P3	
19.	28354	*Synaphea sp. Serpentine (G.R. Brand 103)*		P3	
Priority 4					
20.	13191	*Drosera occidentalis subsp. occidentalis*		P4	
21.	6573	*Parsonsia diaphanophleba*		P4	
22.	8212	*Senecio leucoglossus*		P4	
23.	14714	*Verticordia lindleyi subsp. lindleyi*		P4	
24.	34113	*Westralunio carteri (Carter's Freshwater Mussel)*		P4	
Priority 5					
25.	24153	*Isoodon obesulus subsp. fusciventer (Quenda, Southern Brown Bandicoot)*		P5	
Non-conservation taxon					
26.	-13853	*? ?*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
27.	15429	*Acacia alata var. alata*			
28.	3294	*Acacia dentifera*			
29.	11192	*Acacia drummondii subsp. elegans*			
30.	3382	*Acacia incrassata*			
31.	3383	*Acacia incurva*			
32.	3410	*Acacia lateriticola*			
33.	3454	*Acacia nervosa (Rib Wattle)*			
34.	3464	*Acacia obovata*			
35.	3502	*Acacia pulchella (Prickly Moses)*			
36.	15483	*Acacia pulchella var. pulchella*			
37.	3527	*Acacia saligna (Orange Wattle, Kudjong)*			
38.	30032	*Acacia saligna subsp. saligna*			
39.	3541	*Acacia sessilis*			
40.	3557	*Acacia stenoptera (Narrow Winged Wattle)*			
41.	3574	*Acacia teretifolia*			
42.	3591	*Acacia urophylla*			
43.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
44.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
45.	24262	*Acanthiza inornata (Western Thornbill)*			
46.	1205	*Acanthocarpus canaliculatus*			
47.	1208	*Acanthocarpus preissii*			
48.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
49.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
50.	25536	*Accipiter fasciatus (Brown Goshawk)*			
51.	6205	*Actinotus leucocephalus (Flannel Flower)*			
52.	14970	*Adenanthos barbiger*			
53.	1790	*Adenanthos meisneri*			
54.	23474	*Agrostocrinum hirsutum*			
55.	1261	*Agrostocrinum scabrum (Blue Grass Lily)*			
56.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
57.	1731	*Allocasuarina huegeliana (Rock Sheoak, Kwowl)*			
58.	1732	*Allocasuarina humilis (Dwarf Sheoak)*			
59.	-11863	*Allothereua maculata*			
60.	13380	*Amphibromus nervosus*			
61.	197	*Amphipogon debilis*			
62.	20184	*Amphipogon laguroides subsp. laguroides*			
63.	199	*Amphipogon strictus (Greybeard Grass)*			
64.	200	*Amphipogon turbinatus*			
65.	-12196	*Aname mainae*			
66.	24312	*Anas gracilis (Grey Teal)*			
67.	24316	*Anas superciliosa (Pacific Black Duck)*			
68.	6300	*Andersonia aristata (Rice Flower)*			
69.	6314	*Andersonia lehmanniana*			
70.	7833	*Angianthus preissianus*			
71.	1411	*Anigozanthos manglesii (Mangles Kangaroo Paw, Kurulbrang)*			
72.	1416	*Anigozanthos viridis (Green Kangaroo Paw, Kurulbardang)*			
73.	11566	*Anigozanthos viridis subsp. viridis*			
74.	24561	*Anthochaera carunculata (Red Wattlebird)*			
75.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
76.	12724	*Anthotium junciforme*			
77.	-12101	*Antichiropus variabilis*			
78.	24285	*Aquila audax (Wedge-tailed Eagle)*			
79.	-12899	*Araneus senicaudatus*			
80.	7838	*Arctotheca calendula (Cape Weed)*	Y		
81.	24341	*Ardea pacifica (White-necked Heron)*			
82.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
83.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
84.	20350	*Astartea affinis*			
85.	20249	*Astartea leptophylla*			
86.	6323	*Astroloma ciliatum (Candle Cranberry)*			
87.	6334	*Astroloma pallidum (Kick Bush)*			
88.	-12131	*Australotiphys barmutai*			
89.	17233	*Austrostipa campylachne*			
90.	17234	*Austrostipa compressa*			
91.	233	*Avena barbata (Bearded Oat)*	Y		
92.	36441	*Babingtonia camphorosmae (Camphor Myrtle)*			
93.	1800	*Banksia attenuata (Slender Banksia, Piara)*			
94.	1852	*Banksia telmatiaea (Swamp Fox Banksia)*			
95.	32054	*Banksia undata var. undata*			
96.	32315	*Barbula calycina*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
97.	32321	*Bartramia breutelii*			
98.	32323	*Bartramia pseudostricta*			
99.	15037	*Bartsia trixago*	Y		
100.	743	*Baumea juncea (Bare Twigrush)*			
101.	745	*Baumea preissii*			
102.	748	*Baumea vaginalis (Sheath Twigrush)*			
103.	4598	*Beyeria lechenaultii (Pale Turpentine Bush)*			
104.	25788	*Billardiera fraseri (Elegant Pronaya)*			
105.	1417	*Blancoa canescens (Winter Bell)*			
106.	11503	*Boronia crenulata var. crenulata*			
107.	4429	*Boronia molloyae (Tall Boronia)*			
108.	11564	*Boronia ramosa subsp. ramosa*			
109.	1273	*Borya sphaerocephala (Pincushions)*			
110.	14396	*Bossiaea aquifolium subsp. aquifolium*			
111.	3710	*Bossiaea eriocarpa (Common Brown Pea)*			
112.	3714	*Bossiaea ornata (Broad Leaved Brown Pea)*			
113.	3718	*Bossiaea rufa*			
114.	18497	*Bossiaea sp. Waroona (B.J. Keighery & N. Gibson 229)*			
115.	-15786	*Bostockia porosa*			
116.	8661	*Brachypodium distachyon (False Brome)*	Y		
117.	7871	*Brachyscome ciliaris*			
118.	32327	*Breutelia affinis*			
119.	244	*Briza maxima (Blowfly Grass)*	Y		
120.	245	*Briza minor (Shivery Grass)*	Y		
121.	247	*Bromus arenarius (Sand Brome)*			
122.	250	*Bromus hordeaceus (Soft Brome)*	Y		
123.	12770	*Burchardia congesta*			
124.	1385	*Burchardia multiflora (Dwarf Burchardia)*			
125.	25716	*Cacatua sanguinea (Little Corella)*			
126.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
127.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
128.	1276	*Caesia micrantha (Pale Grass Lily)*			
129.	1277	*Caesia occidentalis*			
130.	1590	*Caladenia ferruginea (Rusty Spider Orchid)*			
131.	1592	*Caladenia flava (Cowslip Orchid)*			
132.	1605	*Caladenia marginata (White Fairy Orchid)*			
133.	16365	*Calandrinia sp. Kenwick (G.J. Keighery 10905)*			
134.	19307	*Calectasia grandiflora subsp. grandiflora*			
135.	4717	*Callitriche stagnalis (Common Starwort)*	Y		
136.	36600	*Callitris pyramidalis (Swamp Cypress)*			
137.	5431	*Calothamnus torulosus*			
138.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
139.	5437	*Calytrix acutifolia*			
140.	2952	*Cassytha glabella (Tangled Dodder Laurel)*			
141.	2956	*Cassytha pomiformis (Dodder Laurel)*			
142.	2957	*Cassytha racemosa (Dodder Laurel)*			
143.	6539	*Centaurium erythraea (Common Centaury)*	Y		
144.	1121	*Centrolepis aristata (Pointed Centrolepis)*			
145.	1125	*Centrolepis drummondiana*			
146.	1134	*Centrolepis polygyna (Wiry Centrolepis)*			
147.	-12810	*Cercophonius sulcatus*			
148.	1280	*Chamaescilla corymbosa (Blue Squill)*			
149.	31	*Cheilanthes austrotenuifolia*			
150.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
151.	8971	*Chorizema cordatum*			
152.	3753	*Chorizema dicksonii (Yellow-eyed Flame Pea)*			
153.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
154.	4550	*Comesperma calymega (Blue-spike Milkwort)*			
155.	4551	*Comesperma ciliatum*			
156.	4564	*Comesperma virgatum (Milkwort)*			
157.	1875	*Conospermum huegelii (Slender Smokebush)*			
158.	1882	*Conospermum stoechadis (Common Smokebush)*			
159.	15611	*Conospermum stoechadis subsp. stoechadis (Common Smokebush)*			
160.	12109	*Conostylis aculeata subsp. preissii*			
161.	1454	*Conostylis setigera (Bristly Cottonhead)*			
162.	1455	*Conostylis setosa (White Cottonhead)*			
163.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
164.	-1758	*Cormocephalus aurantiipes*			
165.	-1711	*Cormocephalus turneri*			
166.	25592	*Corvus coronoides (Australian Raven)*			

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167.	17104	*Corymbia calophylla (Marri)*			
168.	7947	*Cotula turbinata (Funnel Weed)*	Y		
169.	25595	*Cracticus tibicen (Australian Magpie)*			
170.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
171.	25596	*Cracticus torquatus (Grey Butcherbird)*			
172.	13354	*Craspedia variabilis*			
173.	29054	*Crepis foetida subsp. foetida*	Y		
174.	25398	*Crinia georgiana (Quacking Frog)*			
175.	25401	*Crinia pseudinsignifera (Bleating Froglet)*			
176.	35838	*Cristonia biloba subsp. biloba*			
177.	30893	*Cryptoblepharus buchananii*			
178.	24883	*Ctenophorus ornatus (Ornate Crevice-Dragon)*			
179.	25049	*Ctenotus labillardieri*			
180.	6663	*Cuscuta epithymum (Lesser Dodder, Greater Dodder)*	Y		
181.	768	*Cyathochaeta avenacea*			
182.	815	*Cyperus tenellus (Tiny Flatsedge)*	Y		
183.	17692	*Cytogonidium leptocarpoides*			
184.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
185.	7420	*Dampiera alata (Winged-stem Dampiera)*			
186.	7454	*Dampiera linearis (Common Dampiera)*			
187.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
188.	5508	*Darwinia citriodora (Lemon-scented Darwinia)*			
189.	5531	*Darwinia thymoides*			
190.	1218	*Dasypogon bromeliifolius (Pineapple Bush)*			
191.	6960	*Datura ferox (Fierce Thornapple)*	Y		
192.	6218	*Daucus glochidiatus (Australian Carrot)*			
193.	15656	*Daviesia brachyphylla*			
194.	16579	*Daviesia decipiens*			
195.	3805	*Daviesia decurrens (Prickly Bitter-pea)*			
196.	3815	*Daviesia horrida (Prickly Bitter-pea)*			
197.	3835	*Daviesia preissii*			
198.	38782	*Dermocybe globuliformis*			
199.	17663	*Desmocladus asper*			
200.	15831	*Desmocladus castaneus*			
201.	17691	*Desmocladus fasciculatus*			
202.	11636	*Dianella revoluta var. divaricata*			
203.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
204.	306	*Dichelachne crinita (Longhair Plumegrass)*			
205.	1287	*Dichopogon capillipes*			
206.	17838	*Dielsia stenostachya*			
207.	-11742	*Dinocambala ingens*			
208.	1509	*Dioscorea hastifolia (Warrine, Wararn)*			
209.	24939	*Diplodactylus polyophthalmus*			
210.	18589	*Diplopeltis huegelii subsp. lehmannii*			
211.	4757	*Dodonaea ceratocarpa*			
212.	24470	*Dromaius novaehollandiae (Emu)*			
213.	3095	*Drosera erythrorhiza (Red Ink Sundew)*			
214.	3106	*Drosera macrantha (Bridal Rainbow)*			
215.	12243	*Drosera mannii*			
216.	3109	*Drosera menziesii (Pink Rainbow)*			
217.	13216	*Drosera menziesii subsp. penicillaris*			
218.	3118	*Drosera pallida (Pale Rainbow)*			
219.	8911	*Drosera rosulata*			
220.	3131	*Drosera stolonifera (Leafy Sundew)*			
221.	25096	*Egernia kingii (King's Skink)*			
222.	349	*Ehrharta longiflora (Annual Veldt Grass)*	Y		
223.	25250	*Elapognathus coronatus (Crowned Snake)*			
224.	1643	*Elythranthera brunonis (Purple Enamel Orchid)*			
225.	24652	*Eopsaltria georgiana (White-breasted Robin)*			
226.	379	*Eragrostis elongata (Clustered Lovegrass)*			
227.	6219	*Eryngium pinnatifidum (Blue Devils)*			
228.	15446	*Eryngium pinnatifidum subsp. pinnatifidum*			
229.	5616	*Eucalyptus decurva (Slender Mallee)*			
230.	5688	*Eucalyptus laeliae (Darling Range Ghost Gum)*			
231.	5690	*Eucalyptus lane-poolei (Salmon White Gum)*			
232.	5708	*Eucalyptus marginata (Jarrah, Djara)*			
233.	13547	*Eucalyptus marginata subsp. marginata (Jarrah)*			
234.	5763	*Eucalyptus rudis (Flooded Gum, Kulurda)*			
235.	13511	*Eucalyptus rudis subsp. rudis*			
236.	5797	*Eucalyptus wandoo (Wandoo, Wondu)*			

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237.	12906	*Eucalyptus wandoo subsp. wandoo*			
238.	3872	*Euchilopsis linearis (Swamp Pea)*			
239.	-12122	*Eucyrtops latior*			
240.	4627	*Euphorbia helioscopia (Sun Spurge)*	Y		
241.	4648	*Euphorbia terracina (Geraldton Carnation Weed)*	Y		
242.	3880	*Eutaxia virgata*			
243.	25621	*Falco berigora (Brown Falcon)*			
244.	25622	*Falco cenchroides (Australian Kestrel)*			
245.	1747	*Ficus carica (Common Fig)*	Y		
246.	32365	*Fissidens leptocladus*			
247.	32367	*Fissidens megalotis*			
248.	32469	*Fissidens taylorii var. taylorii*			
249.	2969	*Fumaria capreolata (Whiteflower Fumitory)*	Y		
250.	34028	*Galaxias occidentalis (Western Minnow)*			
251.	7321	*Galium divaricatum*	Y		
252.	7323	*Galium murale (Small Goosegrass)*	Y		
253.	20513	*Gastrolobium dilatatum*			
254.	20473	*Gastrolobium ebracteolatum*			
255.	3924	*Gastrolobium spinosum (Prickly Poison)*			
256.	32383	*Gemmabryum sullivanii*			
257.	25404	*Geocrinia leai (Ticking Frog)*			
258.	25530	*Gerygone fusca (Western Gerygone)*			
259.	1524	*Gladiolus undulatus (Wild Gladiolus)*	Y		
260.	3945	*Gompholobium aristatum*			
261.	10909	*Gompholobium confertum*			
262.	3950	*Gompholobium knightianum*			
263.	3951	*Gompholobium marginatum*			
264.	3954	*Gompholobium polymorphum*			
265.	6149	*Gonocarpus cordiger*			
266.	29362	*Goodenia coerulea*			
267.	24443	*Grallina cyanoleuca (Magpie-lark)*			
268.	1964	*Grevillea bipinnatifida (Fuchsia Grevillea)*			
269.	19628	*Grevillea bipinnatifida subsp. bipinnatifida*			
270.	13429	*Grevillea diversifolia subsp. diversifolia*			
271.	1997	*Grevillea endlicheriana (Spindly Grevillea)*			
272.	13450	*Grevillea manglesii subsp. manglesii*			
273.	2066	*Grevillea pilulifera (Woolly-flowered Grevillea)*			
274.	2122	*Grevillea wilsonii (Native Fuchsia)*			
275.	32473	*Grimmia pulvinata var. africana*			
276.	1465	*Haemodorum discolor*			
277.	1468	*Haemodorum laxum*			
278.	1472	*Haemodorum simplex*			
279.	1474	*Haemodorum sparsiflorum*			
280.	2128	*Hakea amplexicaulis (Prickly Hakea)*			
281.	2137	*Hakea ceratophylla (Horned Leaf Hakea)*			
282.	2152	*Hakea cyclocarpa (Ramshorn)*			
283.	2166	*Hakea incrassata (Marble Hakea)*			
284.	2175	*Hakea lissocarpha (Honey Bush)*			
285.	2203	*Hakea ruscifolia (Candle Hakea)*			
286.	2206	*Hakea stenocarpa (Narrow-fruited Hakea)*			
287.	2212	*Hakea sulcata (Furrowed Hakea)*			
288.	2214	*Hakea trifurcata (Two-leaf Hakea)*			
289.	2215	*Hakea undulata (Wavy-leaved Hakea)*			
290.	32392	*Hedwigidium integrifolium*			
291.	439	*Hemarthria uncinata (Matgrass)*			
292.	25115	*Hemiergis initialis subsp. initialis*			
293.	6856	*Hemigenia incana (Silky Hemigenia)*			
294.	-11740	*Henicops dentatus*			
295.	1293	*Hensmania turbinata*			
296.	5108	*Hibbertia acerosa (Needle Leaved Guinea Flower)*			
297.	5114	*Hibbertia commutata*			
298.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
299.	5148	*Hibbertia mylnei*			
300.	5150	*Hibbertia nymphaea*			
301.	5155	*Hibbertia pilosa (Hairy Guinea Flower)*			
302.	5169	*Hibbertia serrata (Serrate Leaved Guinea Flower)*			
303.	11481	*Hibbertia spicata subsp. spicata*			
304.	5173	*Hibbertia subvaginata*			
305.	24491	*Hirundo neoxena (Welcome Swallow)*			
306.	6222	*Homalosciadium homalocarpum*			

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307.	3964	*Hovea chorizemifolia (Holly-leaved Hovea)*			
308.	3966	*Hovea pungens (Devil's Pins, Puyenak)*			
309.	3968	*Hovea trisperma (Common Hovea)*			
310.	12741	*Hyalosperma cotula*			
311.	12007	*Hybanthus floribundus subsp. floribundus*			
312.	6226	*Hydrocotyle callicarpa (Small Pennywort)*			
313.	5817	*Hypocalymma angustifolium (White Myrtle, Kudjid)*			
314.	5825	*Hypocalymma robustum (Swan River Myrtle)*			
315.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		
316.	9352	*Hypochaeris radicata (Flat Weed)*	Y		
317.	1070	*Hypolaena exsulca*			
318.	-13273	*Idiommata blackwalli*			
319.	20200	*Isolepis cernua var. setiformis*			
320.	917	*Isolepis marginata (Coarse Club-rush)*	Y		
321.	919	*Isolepis oldfieldiana*			
322.	-1666	*Isometroides vescus*			
323.	-12192	*Isopeda leishmanni*			
324.	2221	*Isopogon asper*			
325.	7396	*Isotoma hypocrateriformis (Woodbridge Poison)*			
326.	4018	*Jacksonia lehmannii*			
327.	4025	*Jacksonia restioides*			
328.	1180	*Juncus capitatus (Capitate Rush)*	Y		
329.	11922	*Juncus kraussii subsp. australiensis*			
330.	1196	*Juncus usitatus (Common Rush)*	Y		
331.	-12097	*Karaops ellenae*			
332.	4037	*Kennedia coccinea (Coral Vine)*			
333.	4045	*Kennedia stirlingii (Bushy Kennedia)*			
334.	1221	*Kingia australis (Kingia, Pulonok)*			
335.	5835	*Kunzea micrantha*			
336.	17461	*Kunzea micrantha subsp. micrantha*			
337.	3667	*Labichea lanceolata (Tall Labichea)*			
338.	11289	*Labichea lanceolata subsp. lanceolata*			
339.	3669	*Labichea punctata (Lance-leaved Cassia)*			
340.	18585	*Lagenophora huegelii*			
341.	14083	*Lambertia multiflora var. darlingensis*			
342.	11911	*Laxmannia ramosa subsp. ramosa*			
343.	1309	*Laxmannia squarrosa*			
344.	7568	*Lechenaultia biloba (Blue Leschenaultia)*			
345.	41620	*Lepidosperma asperatum*			
346.	936	*Lepidosperma leptostachyum*			
347.	940	*Lepidosperma pubisquameum*			
348.	29141	*Lepidosperma sp. Gosnells (A. Markey 1145)*			
349.	29150	*Lepidosperma sp. Margaret River (B.J. Lepschi 1841)*			
350.	949	*Lepidosperma tuberculatum*			
351.	2342	*Leptomeria cunninghamii*			
352.	1085	*Lepyrodia glauca*			
353.	25131	*Lerista distinguenda*			
354.	6367	*Leucopogon capitellatus*			
355.	6400	*Leucopogon gracillimus*			
356.	6436	*Leucopogon propinquus*			
357.	6439	*Leucopogon pulchellus (Beard-heath)*			
358.	6447	*Leucopogon strictus*			
359.	7676	*Levenhookia pusilla (Midget Stylewort)*			
360.	7677	*Levenhookia stipitata (Common Stylewort)*			
361.	25661	*Lichmera indistincta (Brown Honeyeater)*			
362.	4363	*Linum trigynum (French Flax)*	Y		
363.	9289	*Lobelia anceps (Angled Lobelia)*			
364.	7402	*Lobelia gibbosa (Tall Lobelia)*			
365.	7403	*Lobelia heterophylla (Wing-seeded Lobelia)*			
366.	478	*Lolium rigidum (Wimmera Ryegrass)*	Y		
367.	1222	*Lomandra brittanii*			
368.	1223	*Lomandra caespitosa (Tufted Mat Rush)*			
369.	1228	*Lomandra hermaphrodita*			
370.	1229	*Lomandra integra*			
371.	1232	*Lomandra micrantha (Small-flower Mat-rush)*			
372.	14542	*Lomandra micrantha subsp. micrantha*			
373.	1234	*Lomandra nigricans*			
374.	1236	*Lomandra odora (Tiered Matrush)*			
375.	1239	*Lomandra preissii*			
376.	1240	*Lomandra purpurea (Purple Mat Rush)*			

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377.	1243	*Lomandra sericea (Silky Mat Rush)*			
378.	1244	*Lomandra sonderi*			
379.	1245	*Lomandra spartea*			
380.	4059	*Lotus angustissimus (Narrowleaf Trefoil)*	Y		
381.	8564	*Lotus subbiflorus*	Y		
382.	85	*Macrozamia riedlei (Zamia, Djiridji)*			
383.	25650	*Malurus elegans (Red-winged Fairy-wren)*			
384.	25654	*Malurus splendens (Splendid Fairy-wren)*			
385.	17630	*Marianthus tenuis*			
386.	17747	*Meeboldina decipiens*			
387.	18394	*Melaleuca parviceps*			
388.	5958	*Melaleuca radula (Graceful Honeymyrtle)*			
389.	5959	*Melaleuca rhaphiophylla (Swamp Paperbark)*			
390.	5964	*Melaleuca seriata*			
391.	5983	*Melaleuca trichophylla*			
392.	13280	*Melaleuca viminea subsp. viminea*			
393.	953	*Mesomelaena graciliceps*			
394.	955	*Mesomelaena pseudostygia*			
395.	11473	*Mesomelaena stygia subsp. stygia*			
396.	957	*Mesomelaena tetragona (Semaphore Sedge)*			
397.	485	*Microlaena stipoides (Weeping Grass)*			
398.	11747	*Microlaena stipoides var. stipoides*			
399.	15419	*Microtis media subsp. media*			
400.	14344	*Millotia tenuifolia var. tenuifolia (Soft Millotia)*			
401.	4090	*Mirbelia dilatata (Holly-leaved Mirbelia)*			
402.	4091	*Mirbelia floribunda (Purple Mirbelia)*			
403.	4100	*Mirbelia spinosa*			
404.	37440	*Monopsis debilis var. depressa*	Y		
405.	24738	*Neophema elegans (Elegant Parrot)*			
406.	-15725	*Neosilurus hyrtlii*			
407.	492	*Neurachne alopecuroidea (Foxtail Mulga Grass)*			
408.	25252	*Notechis scutatus (Tiger Snake)*			
409.	-12530	*Nunciella aspera*			
410.	-12547	*Occiperipatoides gilesii*			
411.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
412.	2365	*Olax benthamiana*			
413.	8143	*Olearia paucidentata (Autumn Scrub Daisy)*			
414.	18254	*Opercularia apiciflora*			
415.	7346	*Opercularia echinocephala (Bristly Headed Stink Weed)*			
416.	18255	*Opercularia vaginata (Dog Weed)*			
417.	11749	*Orthrosanthus laxus var. laxus (Morning Iris)*			
418.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
419.	4355	*Oxalis perennans*			
420.	25679	*Pachycephala pectoralis (Golden Whistler)*			
421.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
422.	25253	*Parasuta gouldii*			
423.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
424.	25682	*Pardalotus striatus (Striated Pardalote)*			
425.	7089	*Parentucellia latifolia (Common Bartsia)*	Y		
426.	7090	*Parentucellia viscosa (Sticky Bartsia)*	Y		
427.	27922	*Parmotrema chinense*			
428.	527	*Paspalum dilatatum*	Y		
429.	1542	*Patersonia babianoides*			
430.	1550	*Patersonia occidentalis (Purple Flag, Koma)*			
431.	1551	*Patersonia pygmaea (Pygmy Patersonia)*			
432.	11550	*Patersonia umbrosa var. xanthina (Yellow Flags)*			
433.	6245	*Pentapeltis peltigera*			
434.	39058	*Perichaena depressa*			
435.	2267	*Persoonia longifolia (Snottygobble)*			
436.	2273	*Persoonia saccata (Snottygobble)*			
437.	2284	*Petrophile biloba (Granite Petrophile)*			
438.	2312	*Petrophile striata*			
439.	24409	*Phaps chalcoptera (Common Bronzewing)*			
440.	32409	*Philonotis australiensis*			
441.	18529	*Philotheca spicata (Pepper and Salt)*			
442.	1173	*Philydrella pygmaea (Butterfly Flowers)*			
443.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
444.	16177	*Phyllangium paradoxum*			
445.	4675	*Phyllanthus calycinus (False Boronia)*			
446.		*Phytophthora cinnamomi*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
447.	11667	*Pimelea brevistyla subsp. brevistyla*			
448.	5251	*Pimelea imbricata*			
449.	11402	*Pimelea imbricata var. piligera*			
450.	5259	*Pimelea preissii*			
451.	12041	*Pimelea suaveolens subsp. suaveolens*			
452.	8165	*Pithocarpa pulchella (Beautiful Pithocarpa)*			
453.	25720	*Platycercus icterotis (Western Rosella)*			
454.	6253	*Platysace filiformis*			
455.	32413	*Pleuridium ecklonii*			
456.	573	*Poa drummondiana (Knotted Poa)*			
457.	8175	*Podolepis gracilis (Slender Podolepis)*			
458.	-13158	*Poecilipta smaragdinea*			
459.	2419	*Polygonum aviculare (Wireweed)*	Y		
460.	25722	*Polytelis anthopeplus (Regent Parrot)*			
461.	4691	*Poranthera microphylla (Small Poranthera)*			
462.	1677	*Prasophyllum macrostachyum (Laughing Leek Orchid)*			
463.	10853	*Prasophyllum plumiforme*			
464.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
465.	25433	*Pseudophryne guentheri (Crawling Toadlet)*			
466.	13255	*Pterochaeta paniculata*			
467.	24173	*Pteropus scapulatus (Little Red Flying-fox)*			
468.	2742	*Ptilotus manglesii (Pom Poms, Mulamula)*			
469.	32480	*Racopilum cuspidigerum var. convolutaceum*			
470.	25285	*Ramphotyphlops pinguis*			
471.	-12205	*Raveniella cirrata*			
472.	6012	*Regelia ciliata*			
473.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
474.	15035	*Rhodanthe corymbosa*			
475.	13234	*Rhodanthe manglesii*			
476.	1556	*Romulea rosea (Guildford Grass)*	Y		
477.	20506	*Rubus anglocandicans*	Y		
478.	23990	*Rubus ulmifolius var. ulmifolius*	Y		
479.	2433	*Rumex crispus (Curled Dock)*	Y		
480.	40427	*Rytidosperma setaceum*			
481.	7602	*Scaevola calliptera*			
482.	7613	*Scaevola glandulifera (Viscid Hand-flower)*			
483.	7635	*Scaevola pilosa (Hairy Fan-flower)*			
484.	6263	*Schoenolaena juncea*			
485.	975	*Schoenus bifidus*			
486.	978	*Schoenus brevisetis*			
487.	979	*Schoenus caespititius*			
488.	991	*Schoenus grammatophyllus*			
489.	1002	*Schoenus nanus (Tiny Bog Rush)*			
490.	17614	*Schoenus plumosus*			
491.	1013	*Schoenus sculptus (Gimlet Bog-rush)*			
492.	18164	*Schoenus sp. smooth culms (K.R. Newbey 7823)*			
493.	1023	*Schoenus tenellus*			
494.	1026	*Schoenus unispiculatus*			
495.	17409	*Schoenus variicellae*			
496.	-1669	*Scolopendra laeta*			
497.	32433	*Sematophyllum homomallum*			
498.	8203	*Senecio diaschides*	Y		
499.	20663	*Senecio multicaulis subsp. multicaulis*			
500.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
501.	8225	*Siloxerus humifusus (Procumbent Siloxerus)*			
502.	30948	*Smicrornis brevirostris (Weebill)*			
503.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
504.	617	*Sorghum halepense (Johnson Grass)*	Y		
505.	1312	*Sowerbaea laxiflora (Purple Tassels)*			
506.	4207	*Sphaerolobium medium*			
507.	41623	*Sphaeromorphaea australis*			
508.	4716	*Stachystemon vermicularis*			
509.	4733	*Stackhousia monogyna*			
510.	24645	*Stagonopleura oculata (Red-eared Firetail)*			
511.	39083	*Stemonitis fusca*			
512.	2316	*Stirlingia latifolia (Blueboy)*			
513.	25597	*Strepera versicolor (Grey Currawong)*			
514.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
515.	7693	*Stylidium brunonianum (Pink Fountain Triggerplant)*			
516.	7694	*Stylidium bulbiferum (Circus Triggerplant)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
517.	7696	*Stylidium calcaratum (Book Triggerplant)*			
518.	7699	*Stylidium carnosum (Fleshy-leaved Triggerplant)*			
519.	7721	*Stylidium emarginatum (Biddy-four-legs)*			
520.	7736	*Stylidium hispidum (White Butterfly Triggerplant)*			
521.	7745	*Stylidium junceum (Reed Triggerplant)*			
522.	7783	*Stylidium pycnostachyum (Downy Triggerplant)*			
523.	33106	*Stylidium recurvum*			
524.	7790	*Stylidium roseoalatum (Pink-wing Triggerplant)*			
525.	25806	*Stylidium scariosum*			
526.	25830	*Stylidium sp. Darling Range (H. Bowler 371)*			
527.	23511	*Stylidium thesioides (Delicate Triggerplant)*			
528.	7806	*Stylidium utricularioides (Pink Fan Triggerplant)*			
529.	1260	*Stypandra glauca (Blind Grass)*			
530.	6476	*Styphelia tenuiflora (Common Pinheath)*			
531.	2323	*Synaphea gracillima*			
532.	2324	*Synaphea petiolaris (Synaphea)*			
533.	-13287	*Synsphyronus mimulus*			
534.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
535.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
536.	-16332	*Tandanus bostocki*			
537.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
538.	20135	*Taxandria linearifolia*			
539.	-11829	*Tetragnatha maeandrata*			Y
540.	1034	*Tetraria capillaris (Hair Sedge)*			
541.	1036	*Tetraria octandra*			
542.	667	*Tetrarrhena laevis (Forrest Ricegrass)*			
543.	4535	*Tetratheca hirsuta (Black Eyed Susan)*			
544.	4537	*Tetratheca nuda*			
545.	1705	*Thelymitra crinita (Blue Lady Orchid)*			
546.	1707	*Thelymitra flexuosa (Twisted Sun Orchid)*			
547.	11053	*Thelymitra macrophylla*			
548.	1715	*Thelymitra spiralis (Curlylocks)*			
549.	5080	*Thomasia foliosa*			
550.	5083	*Thomasia glutinosa (Sticky Thomasia)*			
551.	11194	*Thomasia glutinosa var. latifolia*			
552.	24844	*Threskiornis molucca (Australian White Ibis)*			
553.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
554.	32486	*Thuidium sparsum var. hastatum*			
555.	1328	*Thysanotus dichotomus (Branching Fringe Lily)*			
556.	1338	*Thysanotus manglesianus (Fringed Lily)*			
557.	1351	*Thysanotus sparteus*			
558.	1354	*Thysanotus tenellus*			
559.	1357	*Thysanotus thyrsoideus*			
560.	1358	*Thysanotus triandrus*			
561.	25207	*Tiliqua rugosa subsp. rugosa*			
562.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
563.	8248	*Tolpis barbata (Yellow Hawkweed)*	Y		
564.	19041	*Trachymene coerulea subsp. coerulea*			
565.	6280	*Trachymene pilosa (Native Parsnip)*			
566.	1482	*Tribonanthes brachypetala*			
567.	39098	*Trichia favoginea*			
568.	8251	*Trichocline spathulata (Native Gerbera)*			
569.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
570.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
571.	4292	*Trifolium campestre (Hop Clover)*	Y		
572.	4293	*Trifolium cernuum (Drooping Flower Clover)*	Y		
573.	4304	*Trifolium ornithopodioides (Birdsfoot Fenugreek)*	Y		
574.	4737	*Tripterococcus brunonis (Winged Stackhousia)*			
575.	13479	*Trymalium ledifolium var. rosmarinifolium*			
576.	33418	*Trymalium odoratissimum subsp. odoratissimum*			
577.	-12778	*Urodacus novaehollandiae*			
578.	-12796	*Urodacus planimanus*			
579.	8255	*Ursinia anthemoides (Ursinia)*	Y		
580.	12411	*Verticordia densiflora var. cespitosa*			
581.	6107	*Verticordia pennigera*			
582.	12449	*Verticordia plumosa var. brachyphylla*			
583.	4325	*Viminaria juncea (Swishbush, Koweda)*			
584.	722	*Vulpia bromoides (Squirrel Tail Fescue)*	Y		
585.	724	*Vulpia myuros (Rat's Tail Fescue)*	Y		
586.	7389	*Wahlenbergia preissii*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
587.	1567	*Watsonia meriana (Bulbil Watsonia)*	Y		
588.	18108	*Watsonia meriana var. bulbillifera*	Y		
589.	32456	*Weissia rutilans*			
590.	-11697	*Wheenyoides cooki*			
591.	1394	*Wurmbea dioica (Early Nancy)*			
592.	12072	*Wurmbea dioica subsp. alba*			
593.	1249	*Xanthorrhoea acanthostachya*			
594.	1253	*Xanthorrhoea gracilis (Graceful Grass Tree, Mimidi)*			
595.	1256	*Xanthorrhoea preissii (Grass tree, Palga)*			
596.	6284	*Xanthosia candida*			
597.	6289	*Xanthosia huegelii*			
598.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

APPENDIX 7

Protected Matters Search Tool Report

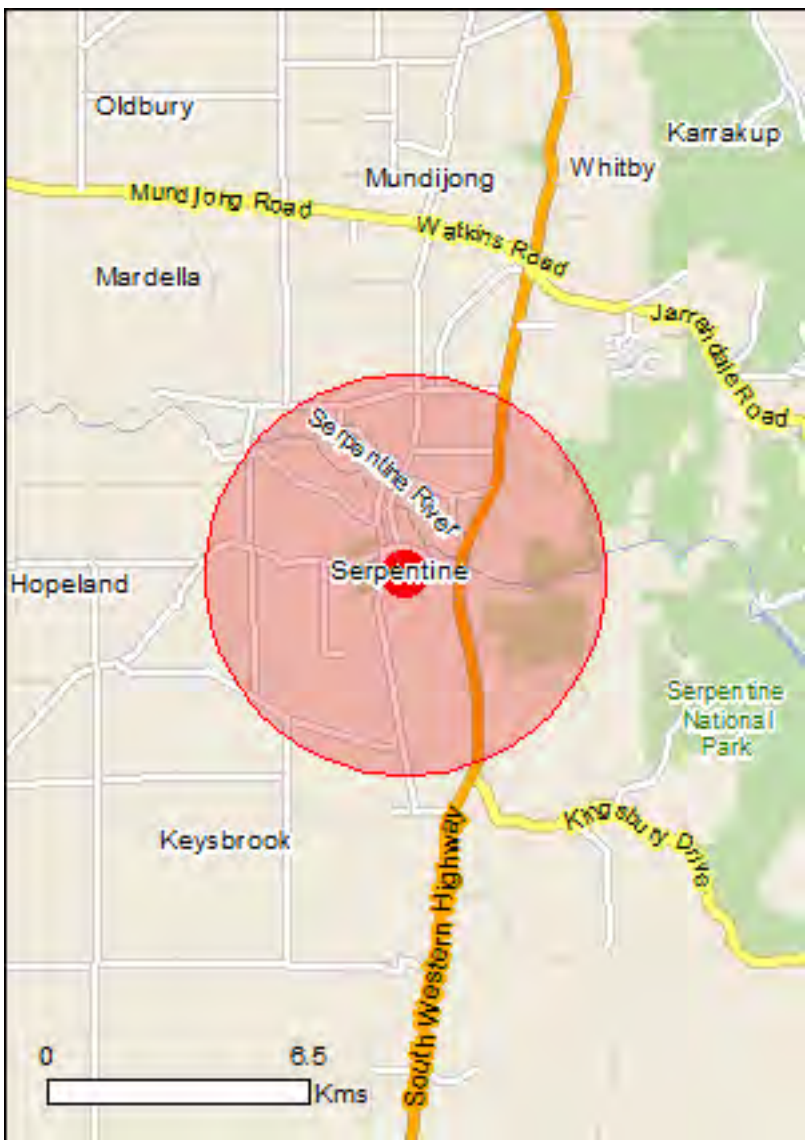
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

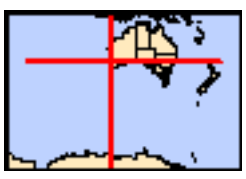
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 15/10/13 13:07:50



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	24
Listed Migratory Species:	7

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	7
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	3
State and Territory Reserves:	4
Regional Forest Agreements:	1
Invasive Species:	38
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (RAMSAR) [Resource Information]

Name	Proximity
Peel-yalgorup system	Upstream from Ramsar

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan Coastal Plain	Endangered	Community known to occur within area
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Endangered	Community known to occur within area
Claypans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calyptorhynchus banksii naso		
Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii		
Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Roosting known to occur within area
Calyptorhynchus latirostris		
Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Leipoa ocellata		
Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii		
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Pseudocheirus occidentalis Western Ringtail Possum [25911]	Vulnerable	Species or species habitat likely to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat may occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Anthocercis gracilis Slender Tailflower [11103]	Vulnerable	Species or species habitat likely to occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus balanites Cadda Road Mallee, Cadda Mallee [24264]	Endangered	Species or species habitat likely to occur within area
Lasiopetalum pterocarpum Wing-fruited Lasiopetalum [64922]	Endangered	Species or species habitat known to occur within area
Synaphea sp. Fairbridge Farm (D.Papenfus 696) Selena's Synaphea [82881]	Critically Endangered	Species or species habitat known to occur within area
Thelymitra manginii K.Dixon & Batty ms. [67443]	Endangered	Species or species habitat may occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat may occur within area
Verticordia fimbrilepis subsp. fimbrilepis Shy Featherflower [24631]	Endangered	Species or species habitat may occur within area
Villarsia calthifolia Mountain Villarsia [10886]	Endangered	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Pandion haliaetus		
Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Karnet Nature Reserve	WA	Registered
Serpentine National Park	WA	Registered
Historic		
Turner Cottage	WA	Indicative Place

State and Territory Reserves [Resource Information]

Name	State
Karnet	WA
Lambkin	WA
Serpentine	WA
Unnamed WA46587	WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis		
Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos		
Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis		
European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus		
House Sparrow [405]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within

Name	Status	Type of Presence
		area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Coordinates

-32.36599 115.97914

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX 8

DPaW Fauna Database Search Results

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRARANK	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSV_CODE	CLASS	SITE_NAME	DAY	MONTH	YEAR	LOCALITY_NAME
Calyptorhynchus banksii subsp. naso	WAM_BIRDS	urn:lsid:taxonomy.org.au:AVIF:38464	24731	Psittacidae	Calyptorhynchus	banksii	subsp.	naso	Gould	Forest Red-tailed Black-Cockatoo	Animalia	T	BIRD	Serpentine	19	09	2012	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	430818|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	08	04	2004	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	218474|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Serpentine Sports Reserve	17	03	2004	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	751645|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Serpentine	13	10	2008	SERPENTINE
Calyptorhynchus baudinii	TFAUNA	12198	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Serpentine	01	01	2005	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	18709|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	11	06	1999	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	454853|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	11	07	2005	SERPENTINE
Calyptorhynchus baudinii	BIRDATLAS2	18699|266	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo (long-billed black-cockatoo), Baudin's Cockatoo	Animalia	T	BIRD	State Forest, Serpentine	16	05	1999	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	18700|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	16	05	1999	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	754818|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Serpentine Nat Park	22	01	2009	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	489847|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	03	08	2007	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	487068|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	14	01	2007	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	489877|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	15	11	2007	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	218474|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Serpentine Sports Reserve	17	03	2004	SERPENTINE
Calyptorhynchus latirostris	WAM_BIRDS	urn:lsid:taxonomy.org.au:AVIF:35753	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Serpentine	05	10	2003	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	487083|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	Budhist Monastery, Serpentine	17	03	2007	SERPENTINE
Calyptorhynchus latirostris	BIRDATLAS2	5013375|794	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo	Animalia	T	BIRD	John's house	23	04	2007	JARRAHDALE
Dasyurus geoffroii	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M1291	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Chuditch, Western Quoll	Animalia	T	MAMMAL					SERPENTINE
Dasyurus geoffroii	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M1326	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Chuditch, Western Quoll	Animalia	T	MAMMAL					SERPENTINE
Dasyurus geoffroii	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M1736	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Chuditch, Western Quoll	Animalia	T	MAMMAL					SERPENTINE
Dasyurus geoffroii	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M1234	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Chuditch, Western Quoll	Animalia	T	MAMMAL					SERPENTINE
Phascogale tapoatafa subsp. tapoatafa	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M48842	24099	Dasyuridae	Phascogale	tapoatafa	subsp.	tapoatafa	(Meyer)	Southern Brush-tailed Phascogale, Wambenger	Animalia	T	MAMMAL	HOPELANDS RD	17	12	2000	SERPENTINE
Phascogale tapoatafa subsp. tapoatafa	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M11954	24099	Dasyuridae	Phascogale	tapoatafa	subsp.	tapoatafa	(Meyer)	Southern Brush-tailed Phascogale, Wambenger	Animalia	T	MAMMAL	POST OFFICE	13	12	1972	SERPENTINE
Phascogale tapoatafa subsp. tapoatafa	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M48843	24099	Dasyuridae	Phascogale	tapoatafa	subsp.	tapoatafa	(Meyer)	Southern Brush-tailed Phascogale, Wambenger	Animalia	T	MAMMAL	MANNING ROAD	22	03	2001	SERPENTINE
Phascogale tapoatafa subsp. tapoatafa	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M49942	24099	Dasyuridae	Phascogale	tapoatafa	subsp.	tapoatafa	(Meyer)	Southern Brush-tailed Phascogale, Wambenger	Animalia	T	MAMMAL	MANNING ROAD		02	2002	SERPENTINE
Falco peregrinus subsp. macropus	TFAUNA	9798	24475	Falconidae	Falco	peregrinus	subsp.	macropus	Swainson	Australian Peregrine Falcon	Animalia	S	BIRD	Serpentine	01	01	1975	SERPENTINE
Westralunio carteri	FAUNASURVEY	138703	34113	Hyriidae	Westralunio	carteri				Carter's Freshwater Mussel	Animalia	4	INVERT	Serpentine Falls	15	12	2009	SERPENTINE
Westralunio carteri	FAUNASURVEY	432561	34113	Hyriidae	Westralunio	carteri				Carter's Freshwater Mussel	Animalia	4	INVERT	Serpentine River	17	03	2011	SERPENTINE

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRARANK	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSV_CODE	CLASS	SITE_NAME	DAY	MONTH	YEAR	LOCALITY_NAME
Westralunio carteri	FAUNASURVEY	432674	34113	Hyriidae	Westralunio	carteri				Carter's Freshwater Mussel	Animalia	4	INVERT	Serpentine River	23	11	2010	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6579	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	07	12	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M34374	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	SW HIGHWAY SERPENTINE	13	04	1990	SERPENTINE
Isoodon obesulus subsp. fusciventer	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M8445	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	GARDEN	09	03	1970	SERPENTINE
Isoodon obesulus subsp. fusciventer	WAM_MAMMALS	urn:lsid:taxonomy.org.au:MAMM:M12185	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	FALLS RD/S.W.H`WAY,POST OFFICE	30	05	1972	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6576	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	01	06	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6578	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	04	12	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	7290	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	South Western Hwy, <100m N of the Mundjedal Brook bridge	26	07	2003	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6582	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	19	04	2002	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6577	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	21	05	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6580	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	16	04	2002	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	5563	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine. West of Hall Road.	15	11	2000	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6575	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	29	05	2001	SERPENTINE
Isoodon obesulus subsp. fusciventer	TFAUNA	6581	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Quenda, Southern Brown Bandicoot	Animalia	5	MAMMAL	Paul Robinson Reserve, Serpentine	18	04	2002	SERPENTINE

APPENDIX 9

Aboriginal Heritage Inquiry System Report

Search Criteria

1 Registered Aboriginal Sites in Custom search area (2); 403496.8mE, 6417826.06mN (zone 50) : 404754.47mE, 6419407.69mN (zone 50)

Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

Copyright

Coordinate Accuracy

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

Terminology (NB that some terminology has varied over the life of the legislation)

ID/Site ID: This a unique ID assigned by the Department of Aboriginal Affairs to the place

Status:

- **Registered Site**: The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972*
- **Other Heritage Place which includes:**
  - **Stored Data:** The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972*
  - **Insufficient Information:** There is not enough information presented to determine if the place meets Section 5 of the *Aboriginal Heritage Act 1972*
  - **Lodged:** Information has been received in relation to the place, but an assessment has not been completed at this stage to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972*

Access and Restrictions:

- **Open:** Availability of information that the Department of Aboriginal Affairs holds in relation to the place is not restricted in any way.
- **Closed:** Some of the information that the Department of Aboriginal Affairs holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Aboriginal Affairs receives written approval from the informants who provided the information. Download the Request to Access Restricted Information letter and form.
  The Department of Aboriginal Affairs maps the locations of all sites and heritage places, including Closed sites, as accurately as the information lodged with the Registrar allows. However, to preserve the confidentiality of Closed sites their locations are published in reports from the Register and displayed on the Aboriginal Heritage Inquiry System within one or more two-kilometre-square boxes. These 2 km boxes act as indicators for the presence of sites or heritage places rather than the exact location of the place.
- **Restriction:**
  - **No Restrictions:** Anyone can view the information.
  - **Male Access Only:** Only males can view restricted information.
  - **Female Access Only:** Only females can view restricted information

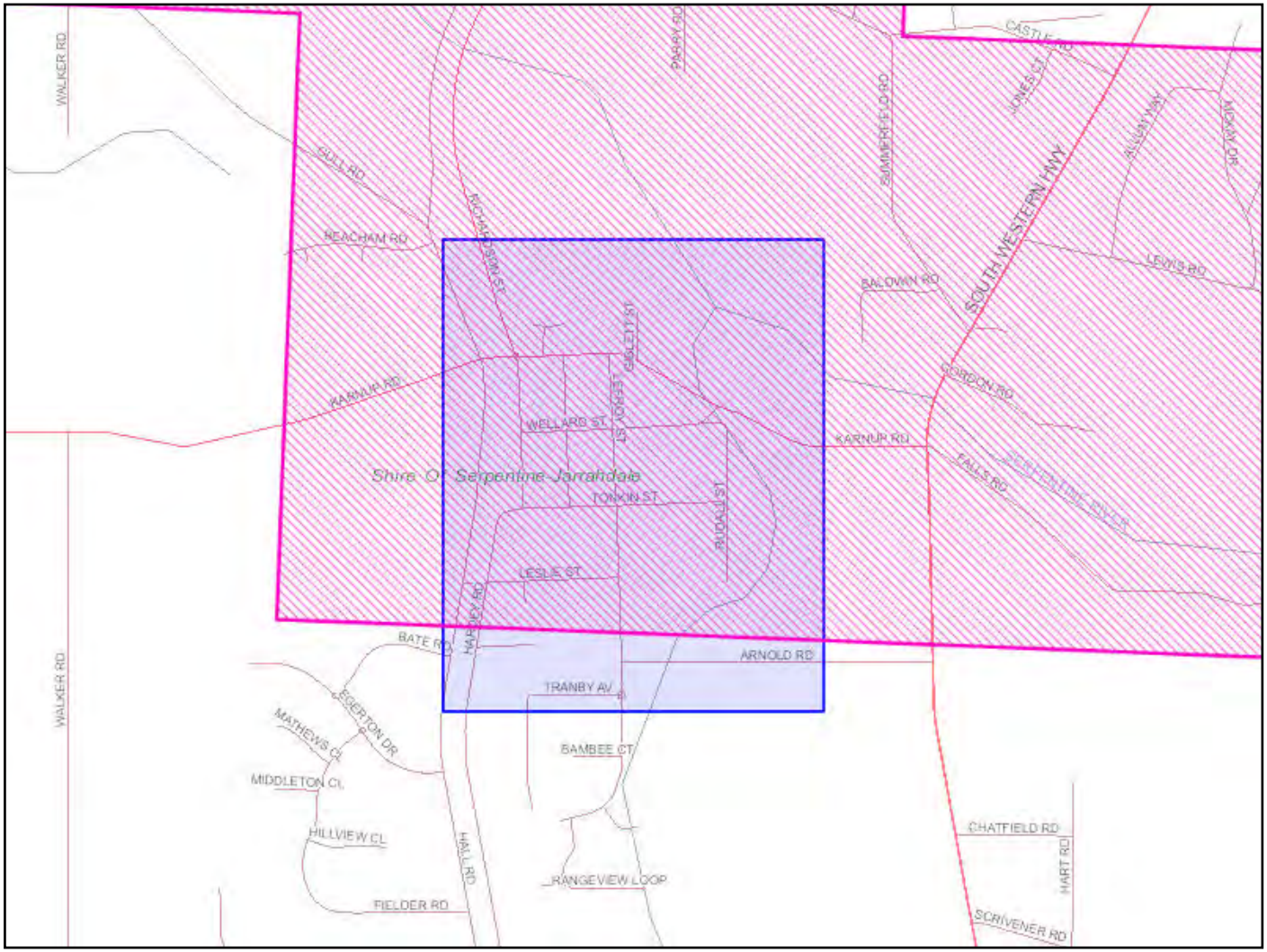
Reliability:

- **Reliable:** The spatial information recorded about the place is deemed to be reliable, due to methods of capture.
- **Unreliable:** The spatial information recorded about the place is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information recorded.

Number/No./Site No: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the ID/SiteID

List of Registered Aboriginal Sites with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
3582	Registered Site	Closed	No Gender Restrictions	SERPENTINE RIVER	Ceremonial, Mythological		*Registered Informant names available from DAA	Not available for closed Sites	S02407



Legend

Selected Heritage Sites

- Registered Sites
- Aboriginal Community Occupied
- Aboriginal Community Unoccupied
- Town
- Search Area

Search Criteria

1 Survey Areas in Custom search area (3); 403867.68mE, 6418957.78mN (zone 50) : 403867.68mE, 6418957.78mN (zone 50)

Disclaimer

Heritage Surveys have been mapped using information from the reports and / or other relevant data sources. Heritage Surveys consisting of small discrete areas may not be visible except at large scales. Reports shown may not be held at DAA. Please consult report holder for more information. Refer to www.daa.wa.gov.au/heritage for information on requesting reports held by DAA.

Copyright

Legend

Access

Some reports are restricted. The type of restriction is shown as a code in brackets following the catalogue number. No code indicates an unrestricted report.

[CLOSED]	Closed
[OWE]	Open with exception
[TBD]	To be determined
[RESTRICTED PENDING]	Restricted pending

Spatial Accuracy

The following legend strictly applies to the spatial accuracy of heritage survey boundaries as captured by DIA.

Very Good	Boundaries captured from surveyed titles, GPS (2001 onwards) submitted maps georeferenced to within 20m accuracy.
Good	Boundaries captured from GPS (pre 2001) submitted maps georeferenced to within 250m accuracy.
Moderate	
Unreliable	Boundaries captured from submitted maps georeferenced to an accuracy exceeding 250m.
Indeterminate	Surveys submitted with insufficient information to allow boundary capture.

Survey 2274

Project The Perth Area.

Start Date Wednesday, April 01, 1970

Proponents University of Western Australia

Consultants University of Western Australia

Survey Types Archaeological, Archaeological and Ethnographic

Aboriginal People Consulted? No

Related Reports for Survey 2274

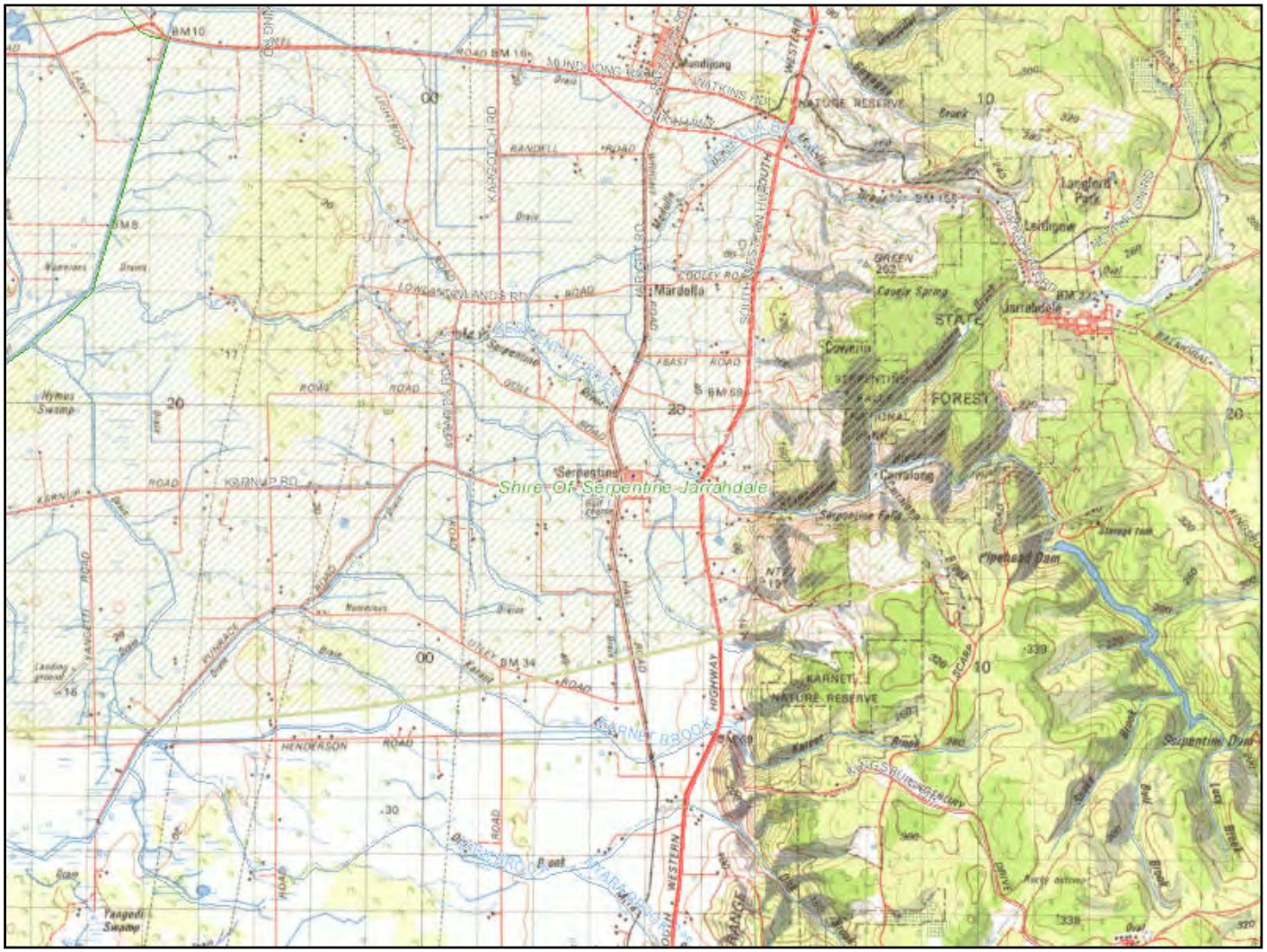
Report ID	Catalogue Number	Title	Recorders	Held at
104023		An Archaeological Survey Project. The Perth Arch. Area. Western Australia Report no.4 April 1971.	Unknown H. Polach	DAA
103564	HSR MW 1972 UWA	An Archaeological Survey Project: The Perth Area, Western Australia. Apr 1972.	Unknown H. Polach	DAA

Related Survey Areas for Survey 2274

Area Number	Survey Type	Area Description	Survey Methodology	Spatial Accuracy	Field / Desktop
1	Archaeological	The Perth Area. 103 site locations in 67 site groups were investigated.	Site Identification	Indeterminate	Field and Desktop
2	Archaeological	The Perth Area. Sites included id's 3350, 4404, 3846	Site Identification	Unreliable	Field and Desktop
3	Archaeological and Ethnographic	The Perth Area. Closed site id 2887	Site Identification	Indeterminate	Field and Desktop

Aboriginal Heritage Inquiry System

Heritage Survey Database



Legend

Selected Heritage Surveys

- Heritage Survey
- Aboriginal Community Occupied
- Aboriginal Community Unoccupied
- Town
- Search Area

Appendix 4 –

Wastewater Management Strategy

Shire of Serpentine Jarrahdale

Serpentine Local Structure Plan

Wastewater Management Strategy

December 2015

Executive summary

The Draft Local Structure Plan (LSP) for the Serpentine Townsite provides the layout for development of the structure plan area. The structure plan area is approximately 119 hectares and allows for the creation of residential lots zoned R10 and R5.

The Local Water Management Strategy (LWMS) was produced by GHD as a supporting document to the LSP. Regarding wastewater, the LWMS dealt only with the new lots proposed in the LSP, all of which were zoned R5. The LWMS proposed on-site treatment using aerobic treatment units and disposal via subsurface drip irrigation within the lot boundary. Imported fill was proposed to ensure appropriate vertical separation to groundwater from the treatment tanks and the irrigation areas.

As part of the stakeholder review process, comments on the LSP were received from the Department of Health (DoH) to the effect that they did not support the LSP because of concerns regarding wastewater management. The DoH noted that the proposed residential development of R10 density lots exceeds the maximum density of R5 allowed for unsewered development as per the *Government Sewerage Policy – Perth Metropolitan Region*. The DoH also raised concerns that the R5 lots to be developed would not be able to achieve the minimum clearance of 500mm between winter water table and natural ground surface as required for unsewered development. The DoH stated that the proposed use of fill to achieve the required clearance was not acceptable, and that drainage of the land to lower the water table to achieve the clearance would be required before the DoH would support unsewered development in the LSP area.

GHD was engaged by the Shire of Serpentine Jarrahdale to undertake a review of the options for the management of wastewater for R5 and R10 residential lots within the LSP area of Serpentine and recommend a strategy for future wastewater management, and this report documents the findings of this study.

Wastewater management in the townsite of Serpentine has historically been achieved using on-site systems installed at each lot. The current study assessed potential future wastewater management strategies at three scales:

- Lot – wastewater is managed within each lot through the use of on-site systems and is disposed within the lot boundary;
- Cluster – wastewater is collected from groups of lots using small (local) sewer pipes and wastewater is treated and recycled and provided via a “third pipe supply” to those lots for non-potable uses such as toilet flushing and garden irrigation;
- Village – a wastewater collection system is installed to cover the entire townsite, and wastewater is treated and recycled for non-potable uses or disposal.

Assessment of the opportunities and constraints of the site, the water balance at each scale of wastewater management, and the regulatory requirements for wastewater management allowed for the (qualitative) comparison of options against triple bottom line criteria. The criteria should be reviewed by the Shire based on their perspective and objectives for wastewater management within Serpentine and the greater local government area.

The lot-scale option was preferred against most financial criteria, due to the small scale of the project and the low financial risk for a project of this scale. However, a more equitable financial assessment based on whole of life costs for each option and the cost per connection is highly recommended and reference is made in this report to recommended approaches for this.

Against social criteria, the lot-scale option scored poorly due to the health risks, land use and maintenance burden for the landowner. The village scale wastewater management option was preferred against most of the social criteria, due to the low risk to public health and the acceptance of this method by stakeholders. The cluster scale option presents an alternative approach, and while it could achieve a number of beneficial outcomes, its acceptability to stakeholders is relatively untested in Western Australia.

The comparison of options against environmental criteria suggests that the cumulative impacts of wide-scale use of on-site systems in Serpentine is likely to be higher than for the alternative options, and highlights the need for mitigation of risks. The study was limited by the lack of data on groundwater and soils, and by the assumptions made in conceptualising options. Many of the impacts of the alternative wastewater management options cannot be measured because the concepts are inadequately defined. Environmental impacts should be reviewed and mitigated following refinement of preferred wastewater management strategies.

Based on the assessment of options and the current position of the Shire in the LSP approval process, a pathway for decision making on wastewater management has been proposed. If on-site systems are the preferred approach across residential areas of the townsite, then the Shire should seek collaborative discussion with the DoH on further work required to adequately demonstrate the sustainability of on-site effluent disposal across the LSP area. Depending on the outcomes of this or the Shire's preference for analysis of other options, recommended next steps are provided. Priority actions are to clarify who would lead the investigation into alternative wastewater management options, and to refine concepts. Further work can then be scoped to elucidate the technical feasibility, costs and funding, institutional arrangements and regulatory approval requirements of the options.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.3 and the assumptions and qualifications contained throughout the Report.

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Glossary

Terms frequently abbreviated in this report are shown below for reference.

ASS	acid sulfate soil
ASR	aquifer storage and Recovery
AS/NZS	Australian/New Zealand Standard
ATU	aerobic treatment unit
AGWR	Australian Guidelines for Water Recycling
AWRCE	Australian Water Recycling Centre of Excellence
BOD	Biochemical oxygen demand
CWMS	Community Wastewater Management System
DoH	Department of Health
DoW	Department of Water
ERA	Economic Regulatory Authority
LAA	land application area
LGA	Local Government Association
LSP	Local Structure Plan
LWMS	Local Water Management Strategy
MBR	membrane bioreactor
MBBR	moving bed biofilm reactor
NBA	nutrient buffer area
POS	public open space
SS	suspended solids
TN	total nitrogen
TP	total phosphorus
WWTP	wastewater treatment plant

1. Introduction

1.1 Background

The Draft Local Structure Plan (LSP) for the Serpentine Townsite provides the layout for development of the structure plan area. Within the LSP area, residential lots are zoned R10 and R5 and there are lots in both zoning categories yet to be developed.

The Local Water Management Strategy (LWMS) was produced by GHD as a supporting document to the LSP. It sets out the objectives, criteria and requirements for water cycle management based on the water resource opportunities and constraints within the LSP area. Regarding wastewater, the LWMS dealt only with the new lots proposed in the LSP, all of which were zoned R5. The LWMS proposed on-site treatment using aerobic treatment units and disposal via subsurface drip irrigation within the lot boundary. Imported fill was proposed to ensure appropriate vertical separation to groundwater from the treatment tanks and the irrigation areas. It was noted that seasonally high groundwater, which can be at natural ground level, was a development constraint for the LSP. Imported fill and subsurface drains at natural ground level were proposed as part of the LWMS.

As part of the stakeholder review process, comments on the LSP were received from the Department of Health (DoH) to the effect that they did not support the LSP because of concerns regarding wastewater management. The DoH noted that the proposed residential development of R10 density lots exceeds the maximum density of R5 allowed for unsewered development as per the *Government Sewerage Policy – Perth Metropolitan Region*. The DoH also raised concerns that the R5 lots to be developed would not be able to achieve the minimum clearance of 500mm between winter water table and natural ground surface as required for unsewered development. The DoH stated that the proposed use of fill to achieve the required clearance was not acceptable, and that drainage of the land to lower the water table to achieve the clearance would be required before the DoH would support unsewered development in the LSP area.

GHD was engaged by the Shire of Serpentine Jarrahdale to undertake a review of the options for managing wastewater within the townsite of Serpentine and recommendations for a strategy for future wastewater management.

1.2 Purpose of this report

The purpose of this report is to summarise the review undertaken by GHD of the suitability of wastewater management options for future residential development within the townsite of Serpentine.

1.3 Scope and limitations

The scope of this study is to review wastewater management options for R5 and R10 residential lots within the LSP area of Serpentine. Wastewater management options are to be compared and an approach for lots zoned R5 and R10 recommended. This study excludes commercial lots, community facilities, schools, and any other non-residential landuse types in the LSP area.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD as listed below (section 0) and described together with the discussion of analyses contained in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Shire of Serpentine Jarrahdale and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has not been involved in the preparation of the Local Structure Plan and has had no contribution to, or review of the Local Structure Plan other than in the Local Water Management Strategy and the current report. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of the Local Structure Plan.

1.4 Assumptions

Given the high level nature of this study it was necessary to make various assumptions for the purposes of developing and comparing options. Assumptions are highlighted and referenced throughout the report. Of note, it was assumed that discharge of wastewater generated in Serpentine to the Water Corporation sewer network was not a viable option, based on the distance to the nearest existing services. It was also assumed that development of Serpentine will occur within a timeframe that would be manageable within the context of designing infrastructure for wastewater servicing within the townsite, and that development occurs according to the Draft Local Structure Plan. It was assumed that any proposed scheme would be assessed against current and published guidelines and referral to such guidelines has been stated throughout the report. There exists potential for regulators and other stakeholders to review and update their positions in the future (e.g. in light of changes to political, climatic and economic conditions) and this has not been considered. Assumptions on the objectives of wastewater management in Serpentine were made in order to compare the options presented against a set of criteria, and this assessment should be reviewed by the Shire based on their perspective and objectives.

2. Site context

2.1 Location

Serpentine is located approximately 50 kilometres south-east of Perth, at the foot of the Darling Scarp, within the Shire of Serpentine-Jarrahdale local government area. The Serpentine River flows to the west past the north-east of the townsite, which is bounded on the west by the Australind railway that links Perth to Bunbury.

2.2 Local structure plan

The local structure plan (LSP) presents the proposed residential design codes (R-codes) for residential areas of Serpentine. The structure plan proposed R10 and R5 lot densities, as shown in the LSP map presented in Appendix A. The area of each block was divided by the minimum lot area for R10 and R5 zoned areas to determine the potential lot yield for the LSP area, as presented in Table 1. In total, the LSP area has an ultimate yield of 405 lots. It is expected that the subdivision of the LSP area will be initiated by individual landowners over time.

Table 1 Development potential R10 and R5 lots - local structure plan area

Local structure plan areas	R10	R5
Potential lot yield – areas with development potential	133	201
Lots already subdivided, developed to potential	44	27
Total lots if developed to potential	**177**	**228**

2.3 Local water management strategy

The Local Water Management Strategy (LWMS) was prepared by GHD to support the LSP, in accordance with Better Urban Water Management (Western Australian Planning Commission, 2008).

2.4 Existing wastewater management

The town is not connected to the Water Corporation sewer network and wastewater generated within the town has historically been managed by landowners within their lot boundary through the use of on-site wastewater systems such as septic tanks, aerobic treatment units (ATUs) and alternative treatment systems employing amended soil mounds, with treated effluent typically disposed of via discharge to leach drains or irrigation of dedicated disposal areas (ATUs only).

The nearest Water Corporation wastewater treatment plant (WWTP) is located on the coast at East Rockingham, approximately 23 km from Serpentine. The Water Corporation advised that while Serpentine is within their wastewater operating licence area, there are no long-term plans or funding to provide sewerage services to the townsite[1].

The wastewater services operating licence held by the Water Corporation covering the Serpentine area is non-exclusive, meaning that another party could potentially provide wastewater services to the townsite (if licenced to do so).

[1] Brett Coombes, pers. comm., Water Corporation Development Services Branch, 15 April 2015

There is some history of on-site system failure within the Shire, however the Shire advised[2] that failures were found to be related primarily to certain wastewater system technologies and providers that are no longer in business.

2.5 Environment

2.5.1 Topography

The LWMS (GHD, 2013) characterises the LSP area as a relatively flat palusplain (seasonally waterlogged land). Natural ground levels range from 30 mAHD in the north-west corner of the LSP area, closest to the Serpentine River, to 35 mAHD in the central and south west portion of the LSP area.

2.5.2 Soils

The LWMS (GHD, 2013) presents soil mapping for the LSP area, which is dominated by fine to medium-grained sandy soils and fine to coarse sandy clay soils. A pocket of land with soils described as clayey peaty sand is located in the west of the LSP area within a reserve, and is associated with a wetland.

Acid sulfate soil (ASS) risk mapping was also presented in the LWMS (GHD, 2013). The majority of the LSP area is classified as having moderate to low risk of ASS disturbance, but there is a pocket of land classified as having high to moderate risk in the west of the LSP area, near the wetland area with clayey peaty sand. ASS disturbance that causes oxidation of the iron sulphides within the soils can result in the generation of acidic soil, surface water and groundwater, and the release of potentially toxic heavy metals.

2.5.3 Groundwater

The LWMS (GHD, 2013) presents limited available information on groundwater in the Serpentine area. Department of Water (DoW) historic maximum groundwater contours show the groundwater level at 30 mAHD which is approximately natural ground level in the eastern and northern parts of the LSP area (GHD, 2013). Anecdotal evidence suggests that groundwater is perched at the surface in low lying areas of the townsite during the winter months (GHD, 2013).

The groundwater management strategy presented in the LWMS is to achieve 1.2 m clearance between the building finished floor levels (and effluent disposal areas) and the maximum groundwater level through the use of subsurface drains and imported fill. Subsurface drains would be installed at the controlled groundwater level, endorsed by DoW, which could be the natural surface level in areas where perched groundwater currently presents at the surface. It is envisaged that subsurface drains would be installed within road reserves (GHD, 2013). The LWMS recommends that imported fill with a band of phosphorus retaining material be installed to meet the 1.2 m vertical separation requirement (GHD, 2013).

The LWMS states that developers will be required to undertake groundwater monitoring and a geotechnical assessment at a local scale, and adopt appropriate groundwater management measures such as the subsurface drainage and imported fill discussed above prior to commencing development (GHD, 2013). Reports will be required to be submitted to the DoW and the Shire prior to development.

2.5.4 Serpentine River

The Serpentine River is located less than 400 metres from the north-western boundary of the LSP area. The river flows west and then south to eventually discharge into the Peel-Harvey

[2] Tony Turner pers. comm. Shire of Serpentine-Jarrahdale, 12 March 2015

Estuary. Water Corporation main drains near the west and east boundaries of the LSP area convey runoff to the Serpentine River (GHD, 2013).

3. Considerations for wastewater management options

3.1 Scale

Wastewater is generated at each lot but can be managed at a range of scales, with typical scales outlined below.

- **Lot** – wastewater is managed within each lot through the use of on-site systems and is disposed within the lot boundary, usually via leach drains or sub-surface irrigation of a dedicated wastewater disposal area.
- **Cluster** – wastewater is collected from groups of lots using small (local) sewer pipes and wastewater is treated and recycled for uses such as irrigation of public open space or residential non-potable uses such as toilet flushing and garden irrigation.
- **Village** – a wastewater collection system is installed to cover the entire townsite, and wastewater is treated and recycled for non-potable uses or disposal.
- **City** – in much of Perth, wastewater is collected in Water Corporation sewers and conveyed to large wastewater treatment plants, where it is treated for ocean disposal. This scale of wastewater management is not available to Serpentine as the Water Corporation sewer network does not extend to the area as discussed previously. The city scale will not be considered further in this study 3.

3.2 Costs and funding

Direct costs of wastewater management and water recycling schemes include the following, adapted from (Marsden Jacob Associates, 2013):

- Design and construction of wastewater and recycled water infrastructure;
- Variable and fixed operating costs associated with wastewater conveyance, treatment and recycling systems (labour, power, chemicals and other consumables, maintenance, laboratory analysis, equipment renewal etc.);
- The cost of carbon emissions; and
- Land requirements for the infrastructure and odour buffers.

Depending on the scale, end use (or disposal) of the treated effluent and associated level of treatment, the costs of wastewater management will vary greatly.

The funding (allocation of costs) of wastewater management options depends on the scale and the end use of the effluent. The various beneficiaries of the wastewater management scheme should share the costs of the scheme, according to the Australian Water Recycling Centre of Excellence's (AWRCE) Non-potable Recycled Water Pricing Framework (Marsden Jacob Associates, 2013). Beneficiaries of wastewater and recycled water schemes and the potential methods of contribution have been considered with reference to the AWRCE Pricing Framework (Marsden Jacob Associates, 2013) and are presented in Table 2.

[3] The nearest available Water Corporation sewers are 15 km north of Serpentine in Byford, and more than 15 km west in Baldivis. Although the Water Corporation has no plans to extend the sewer network to Serpentine, the Shire could apply for permission to discharge into the existing sewer via a private pump station and pressure main. However, the pumping of wastewater to one of these locations is likely to be cost prohibitive and there are difficulties with this option considering the development of Serpentine is likely to occur over a long time period and under the management of and with funding from various land developers.

Table 2 Beneficiaries and cost contribution methods

Beneficiary	Potential method of contribution
Wastewater customer	Wastewater charges
Recycled water user (may be residential or other)	Fixed charges, volume charges
Land developer	Cash contributions, contributed headworks, contributed reticulation
Community/environment	Environmental/health agency funding, government grant/subsidy

Under the South Australian Community Wastewater Management System (CWMS) model, the whole of life costs are determined for a project are often assessed and used to set annual fees based on the number of connections. Funding is also provided through the provision of grants/subsidies by the South Australian state government. The Local Government Association (LGA) of South Australia provides support to the management of CWMS matters including the terms under which CWMS projects will be funded, through the CWMS Management Committee (comprising representatives from the LGA, councils and regulatory authorities).

The complex nature of implementing equitable and sustainable financial arrangements in recycled water projects is well documented. It is necessary to ensure that the financing model takes account of the full spectrum of costs and benefits, and that consideration is given to the long-term sustainability of funding sources (Institute for Sustainable Futures, 2013). A valuable resource on water costing principles is *Costing for Sustainable Outcomes in Urban Water Systems* (The Cooperative Research Centre for Water Quality and Treatment, 2007), which provides guidance on the assessment of the relative cost effectiveness of options.

3.3 Governance and institutional arrangements

Wastewater schemes are owned and operated by different parties depending on the scale and complexity of the scheme.

For wastewater management at the lot scale, the landowner is responsible for the installation of a system to treat and dispose of wastewater generated within the lot. The landowner is required to install a system from a DoH approved supplier, and employ an authorised person to undertake regular maintenance activities. Depending on the size of the system, the local government or the DoH must approve the system prior to installation and also review maintenance reports submitted following each inspection.

For cluster or village scale wastewater management schemes, a service provider licenced by the Economic Regulatory Authority (ERA) would be required to operate the scheme. In the vast majority of cases in Australia, wastewater services are provided by government-owned service providers (the Water Corporation or local governments). However, there is scope for the private sector to be involved in the provision of wastewater (and recycled water) services, for example:

- A private water service provider may take a role as a contractor to a government-owned service provider, for example as the operator of a treatment plant;
- Property developers may design and construct wastewater services for handover to a water service provider (private or government-owned);

- Private water service providers may own and operate the wastewater service; and
- Property developer may own and operate the wastewater service by becoming a licenced provider.

The Water Corporation specifies minimum criteria for the size of dual reticulation schemes for which they will consider being the water service provider as follows:

- Metropolitan residential – 2,500 connections; and
- Non-metropolitan residential – 50 connections (Water Corporation, 2013).

Serpentine is likely to be considered as part of the Perth Metropolitan Region.

3.4 Effluent disposal methods

The disposal of treated effluent is a key factor of any wastewater management option. Methods of disposal at the scales of wastewater schemes considered as part of this study may include irrigation (e.g. on residential lots, public open space, golf courses, school ovals), or other reuse options (e.g. third-pipe schemes where recycled water is supplied to households for toilet flushing).

The seasonality of disposal methods must be considered and a reliable scheme conceptualised that will not result in unacceptable risk to the environment or public health. The land area required for effluent disposal must be considered at the planning stage of a wastewater scheme development and this land set aside for that use.

Discharge to the environment may be considered where the impact to the environment is deemed acceptable and is approved by regulatory authorities.

The effluent disposal method/s appropriate to each wastewater management option is presented in Section 4.

3.5 Treatment requirements

The level of treatment required (and subsequent effluent quality) for the wastewater scheme is driven by the disposal method adopted, and the water quality objectives are dependent on an assessment of the environmental and health risks of the scheme in question.

Effluent from individual household systems must meet the requirements of the DoH. Effluent quality from aerobic treatment units (ATUs) is required to meet compliance testing requirements as per the DoH ATU Code of Practice (Department of Health, 2001).

For larger schemes involving wastewater recycling, the Australian Guidelines for Water Recycling (AGWR) (NRMMC, EPHC, AHMC, 2006) and the WA DoH Guidelines for the Non-potable Uses of Recycled Water (Department of Health, 2011) recommend a risk based approach to the assessment of water recycling schemes. Minimum water quality objectives for schemes classified according to the risk of exposure (of the public to the recycled water) are provided in the DoH Guidelines.

Water quality objectives for environmental risks depend on the receiving environment that could be impacted by the scheme. For reuse schemes involving irrigation, the Department of Water (DoW) Water Quality Protection Note for Irrigation with Nutrient Rich Wastewater (Department of Water, 2008) recommends maximum loading rates for nitrogen and phosphorus for various soil types and areas with different eutrophication risks. These loading rates can influence treated effluent water quality targets for nitrogen and phosphorus where irrigation is the primary disposal method.

Effluent quality targets are discussed for various wastewater management options presented in Section 4.

3.6 Nuisance odours

Whilst there is potential for nuisance odours emissions from all elements of wastewater systems, this report focuses on potential odour emissions from wastewater treatment facilities only on the basis that:

- Wastewater collection infrastructure: if wastewater collection systems are well designed and maintained, and wastewater pump stations are appropriately located (e.g. minimum buffer of 10m to sensitive landuse [e.g. residence]) as per Environmental Protection Authority (EPA) guidelines (EPA, 2005), any nuisance odours from these systems should be rare, generally limited to infrequent maintenance or emergency response activities; and
- Effluent reuse/disposal facilities: based on the type of WWTPs considered in this report, nuisance odour emissions from effluent storage tanks or irrigation systems would not be expected assuming that the WWTPs and effluent storage tanks are appropriately operated and maintained.

In relation to wastewater treatment facilities, the potential for generation of odour emissions is related to numerous factors including:

- WWTP load;
- Quality of (raw) wastewater;
- Treatment process(s);
- Level of odour control incorporated in WWTP; and
- Local meteorological conditions.

It is important that WWTPs are adequately separated from sensitive landuses (e.g. residential areas, caravan parks, hospitals, schools, shopping centres, playgrounds etc) so as to minimise the risk of nuisance odour levels being experienced at these locations. Whilst ideally the area within which nuisance odour levels could be experienced does not extend beyond the boundary of the WWTP site, in many situations this is not possible. In this event buffer zones are typically defined for the WWTP, and measures are applied, generally through the land use planning process, to ensure that only compatible landuses (e.g. rural areas, industrial areas) occur within the buffer zone.

For larger WWTP's where there is potential for impacts on existing or potential future sensitive landuses, buffer zones are typically defined based on the results from sophisticated odour modelling studies. The buffer zones for the larger WWTP's in the Perth-Peel region and major regional centres of WA have been defined using this approach (Water Corporation, 2015). For the majority of the other WWTPs in WA, which typically service smaller communities, generic buffer zones are typically defined by drawing a line with a consistent radius around the operational area of the WWTP (Water Corporation, 2015). EPA guidelines (EPA, 2005) provide general guidance on separation distances required between industrial and sensitive land uses, but do not include any information on what distance is typically required for WWTPs. There are however other state guidelines that do provide such information.

For the cluster and village scale WWTPs considered in this report (Sections 4.3 and 4.4) it is assumed that:

- the generic separation distances defined in the South Australian EPA's *Guidelines for Separation Distances* (SA EPA, 2007) can be used to estimate buffer zones; and
- smaller buffer zones could be achieved if the WWTP incorporates 'best available technology' odour control systems.

4. Options for wastewater management

4.1 Overview

Options were conceptualised based on the three potential scales of wastewater management in Serpentine: lot, cluster and village scale. In the following sections, a concept for each scale is developed, and the options are then compared in Section 1.1. The three options proposed here are by no means the only options possible, and a combination of options may prove the most feasible. The options are intended as an exploration of three very different approaches to wastewater management based on scale.

4.2 Lot-scale: on-site treatment and disposal

4.2.1 Concept description

Each lot has an on-site wastewater treatment unit and effluent is disposed of via subsurface irrigation of a landscaped area within the lot. It is assumed that on-site treatment systems would be aerobic treatment units (ATUs).

4.2.2 Disposal area sizing

The disposal area required for on-site treatment systems is a major constraint to this option in that minimum areas are required to ensure that:

- The infiltration rate of effluent exceeds the application rate (to avoid waterlogging or pooling at the surface); and
- The application rate is matched to the nutrient attenuation capacity of the soil (to avoid nutrient contamination of groundwater and downstream water resources).

Hydraulic load

The hydraulic load of on-site systems (and disposal areas), was calculated for residential houses with different numbers of bedrooms, and the results are displayed in Table 3. The DoH require that ATUs have a minimum design capacity equivalent to 8 persons and a maximum capacity of 10 persons (Department of Health, 2001). AS/NZS 1547:2012 *On-site domestic wastewater management* (Standards Australia, 2012) was referred to for wastewater flow rates per person and persons per household.

Table 3 Hydraulic load for houses with different numbers of bedrooms

Number of bedrooms	3 or less	4	5	6	Reference/notes
Number of persons per household	5	7	8	10	AS/NZS 1547:2012
Average wastewater flow [1]	150 L/p/day – assuming systems take all wastewater				AS/NZS 1547:2012
Hydraulic load (L/day)	750	1050	1200 [2]	1500 [2]	Calculation

Table notes

1 Average wastewater flow per person adopted from AS/NZS 1547:2012 as 150 L/p/d. It is noted that the DoH Code of Practice for ATUs (Department of Health, 2001) stipulates an average daily per capita design flow of 180 L/p/d

2 Code of Practice for ATUs requires that the minimum design capacity of ATUs is 8 persons, maximum is 10 persons (Department of Health, 2001)

Site and soil evaluation

The LWMS (GHD, 2013) included a review of local geology and lots within the LSP area and all lots are classified as having sand or sandy clay surface soils. According to definitions within AS/NZS 1547:2012 *On-site domestic wastewater management* (Standards Australia, 2012), it is expected that natural surface soils within the LSP area would be classified as soil category 2 or 5 depending on the lot location. However, it is also noted that due to the seasonal high groundwater experienced in the area, it is expected that fill would be applied prior to lot development, and the nature of this fill would be more relevant than the existing natural soils for sizing irrigation disposal areas. Ideally, this fill would contain a layer of soil with a high capacity to absorb phosphorus (i.e. soil with a high phosphorus retention index, PRI).

However, without information on the soil types to be applied as fill, the existing natural soils types as categorised above were carried forward and used to calculate disposal areas for the hydraulic loads associated with 8 and 10 person households (the minimum and maximum design capacity for ATUs as discussed previously).

Disposal area calculations

The DoH's Code of Practice for ATUs (Department of Health, 2001) states that a minimum of 150 m^2 is required for surface irrigation. The current DoH Government Sewerage Policy (Department of Health, 1996) also states that an area of 150 m^2 must be set aside for the disposal of wastewater. The DoH Government Sewerage Policy – Second Consultation Draft (Department of Health, 2013) states minimum land application areas of 180 m^2 and 300 m^2 for soil categories 2 and 5 respectively for a hydraulic load of 900 L/d (based on a 6 person household and design flow of 150 L/p/d), and secondary treatment of effluent for nutrient removal . It is noted that this hydraulic load is less than that allowed as a minimum under the DoH Code of Practice for the design of ATUs (Department of Health, 2001).

Given the history of the project with regard to DoH approval, the environmental constraints of the area, the small lot sizes proposed (R10 development density) and the discrepancies in advice from various documents, calculations were undertaken to assess the likely areas required for effluent disposal in Serpentine rather than adopting any of the stated minimum areas in the guideline documents as listed above.

The disposal area required for each hydraulic load, soil type, effluent quality and limiting factor (infiltration or nutrient retention) are presented below in Table 4. Calculations were conducted based on the methods described in the DoH Government Sewerage Policy – Second Consultation Draft[4] (Department of Health, 2013). The likely sources of conversion factors stated in the Policy are described in the notes to Table 4. The land application area (LAA) is the horizontal plan area of an on-site disposal area to which treated effluent is distributed (Department of Health, 2013), and is based on the infiltration capacity or permeability of the site soil type. The nutrient buffer area (NBA) is the horizontal plan area required for nutrient management (Department of Health, 2013) and is based on the nutrient retention capacity of the site soil type and proximity to sensitive receiving waters, as per the DoW Water Quality Protection Note for Irrigation with Nutrient Rich Wastewater (Department of Water, 2008). The higher of the LAA and NBA for a particular scenario is to be adopted as the disposal area for the on-site wastewater treatment system.

For soil category 2 (sandy loams), the NBA is higher than the LAA. The NBA required for secondary treated effluent with nutrient concentrations of TN 30 mg/L and TP 8 mg/L are considered prohibitively large for this soil type (the NBA for P would be adopted as the larger area), at 1757 m^2 for a hydraulic load of 1200 L/d (5 bedroom house with 8 occupants). Therefore it is assumed that for soil category 2 lots, wastewater would be treated for nutrient removal. Therefore the **effluent disposal area required for soil category 2 is 244 m^2** for a hydraulic load of 1200 L/d (8 person household).

For soil category 5 (clay loam), the LAA is higher than the NBA due to the low permeability of the soil. The **effluent disposal area required for soil category 5 is 400 m^2** for a hydraulic load of 1200 L/d (8 person household).

Areas were also calculated based on a hydraulic load of 450 L/d (for a 3 person household at 150 L/p/d[5]) for comparison and discussion with reference to available land area for effluent disposal in Section 4.2.3. The results are as follows:

- For lots with soil category 2, assuming effluent is secondary treated with nutrient removal, an effluent disposal area of 91 m2 is required; and
- For lots with soil category 5, an effluent disposal area of 150 m2 is required.

[4] The Second Consultation Draft was provided by the Shire of Serpentine Jarrahdale for use in this study. The document is a draft only and no final policy has been released by the Department of Health. The DoH advised (Allen Tan, pers. comm. 12 Feb 2015) that substantial changes have been made to the document following the consultation period and it is possible that another draft will be released for public consultation. The DoH advised that the current Government Sewerage Policy – Perth Metropolitan Region (Department of Health, 1996) can be referred to. This policy states that in the Outer Metropolitan Area, unsewered development is not appropriate at lot densities exceeding R5, or for lots less than 2000m^2.

[5] The average number of persons per household in Serpentine was 2.8 in the 2011 census (Australian Bureau of Statistics, 2013) and 150 L/p/d is the hydraulic load suggested in AS/NZS 1547:2012 (Standards Australia, 2012)

Table 4 Disposal area assessment

Parameter	Reference	8 persons per household	10 persons per household
Hydraulic load (L/d)	Calculated in Table 3	1200	1500
Land application area (LAA) – secondary treated effluent			
LAA (m^2) – soil category 2	Conversion factors used to calculate area from hydraulic load taken from Government Sewerage Policy - Second Consultation Draft (Department of Health, 2013) [1]	240	300
LAA (m^2) – soil category 5		400	500
Nutrient buffer area (NBA) – secondary treated effluent			
NBA for N (m^2) – soil category 2	Nutrient concentrations assumed to be TN 30 mg/L, TP 8 mg/L Conversion factors used to calculate area from hydraulic load taken from Government Sewerage Policy - Second Consultation Draft (Department of Health, 2013) [2]	731	914
NBA for N (m^2) – soil category 5		274	342
NBA for P (m^2) – soil category 2		1757	2196
NBA for P (m^2) – soil category 5		292	365
Nutrient buffer area (NBA) – secondary treated effluent with nutrient removal			
NBA for N (m^2) – soil category 2	Nutrient concentrations assumed to be TN 10 mg/L, TP 1 mg/L Conversion factors used to calculate area from hydraulic load taken from Government Sewerage Policy - Second Consultation Draft (Department of Health, 2013) [2]	244	305
NBA for N (m^2) – soil category 5		91	114
NBA for P (m^2) – soil category 2		220	275
NBA for P (m^2) – soil category 5		36	46

Table notes:

1 Irrigation application rates were back-calculated and found to be 5 mm/d for soil category 2, and 3 mm/d for soil category 5, which are in line with recommended rates for drip irrigation in AS/NZS 1547:2012 (Standards Australia, 2012).

2 Nutrient loading rates were back-calculated and found to be 180 and 480 kg/ha/y for nitrogen for soil categories 2 and 5 respectively, and 20 and 120 kg/ha/y for phosphorus for soil categories 2 and 5 respectively, which are in line with the maximum loading rates stated in the DoW Water Quality Protection Note for Irrigation with Nutrient Rich Wastewater (Department of Water, 2008) for these soils and for sites classified as having a low risk of eutrophication of surface waters within 500 m of the irrigation site. .

4.2.3 Disposal area availability on R5 and R10 lots

The available area within the R5 (2000 m^2) and R10 (1000 m^2) lot sizes for an effluent disposal area was considered with reference to the area required for dwellings and other purposes as well as various minimum setback requirements. The following land areas were considered with reference to the Residential Design Codes of Western Australia (Western Australian Planning Commission, 2013), the DoH Code of Practice for ATUs (Department of Health, 2001), and AS/NZS 1547:2012 (Standards Australia, 2012):

- Dwellings;
- Outbuildings;
- Setbacks of buildings to street and boundaries;
- Paved surfaces including driveways, verandas and alfresco areas;
- Social/recreation area separate to effluent disposal area of 100 m2;
- Sewage apparatus and setbacks;
- Onsite stormwater soakwells; and
- Rainwater tanks.

Schematics showing the lot area assessments are provided in Appendix B. The broad assessment undertaken based on the above determined that for an R5 lot, approximately 940 m^2 is available for a dedicated effluent disposal area. For an R10 lot, approximately 175 m^2 is available or 240 m^2 if a small house footprint is considered[6].

Based on the disposal areas required as calculated in Section 4.2.2 for an ATU servicing an 8 person household, and the assessment of areas available on R5 and R10 lots above, the outcomes are as follows:

- R5 lots with soils classified as category 2 or 5 have sufficient land available for the required dedicated effluent disposal area (even for the maximum hydraulic load assessed of 1500 L/d); and
- R10 lots do not have sufficient land available for the required dedicated effluent disposal area (even for the minimum hydraulic load assessed of 1200 L/d, and favourable soil types).

For R10 lots with favourable soil types (which may be achieved using fill to raise the area above groundwater levels – see Section 4.2.2), it is possible that with a smaller hydraulic load, such as the 3 person household load discussed in the presentation of results in Section 4.2.2, the disposal area would fit on the lot. However, as noted previously, current DoH regulations state that the minimum allowable design capacity for ATUs is 8 persons (Department of Health, 2001). This is significantly higher than the average number of persons per household in Serpentine (2.8 persons), according to census data from 2011 (Australian Bureau of Statistics, 2013). The Shire may want to consider this in negotiations with the DoH following review of this options study.

[6] This assessment considered a standard house footprint of 300 m^2 and a small house footprint of 240 m^2. New houses in WA had average floor areas of 234-244 m^2 in the ten year period 2003-2012 reported in the Building Activity Survey by the Australian Bureau of Statistics (Australian Bureau of Statistics, 2013)

4.2.4 Considerations for implementation in Serpentine

Groundwater

On-site wastewater systems are considered unsuitable for sites where waterlogging, pooling, or runoff of effluent from the disposal area may occur, due to risk to public health and the environment. The Serpentine LSP area has favourable topography and is outside of the flood zone of the Serpentine River (based on 100 year ARI flood map from SKM flood study, reported in the LWMS (GHD, 2013)). However, as previously discussed, the Serpentine area experiences seasonally high groundwater, with the maximum groundwater level defined as natural ground level. The current DoH Government Sewerage Policy (Department of Health, 1996) requires that the minimum depth to the seasonal water table from the natural ground surface be at least 0.5 metres, and this requirement was reinforced in the DoH submission to the Shire in response to the Draft LSP. The DoH stated that fill to achieve the required clearance was not an acceptable mitigation.

The Australian Standard for on-site domestic wastewater management (Standards Australia, 2012) recommends a number of mitigations for sites with a seasonally high watertable:

- Raise ground level by importing suitable topsoil;
- Improve effluent treatment;
- Partially mound the soil to increase the flow path length;
- Plant trees and shrubs to encourage evapotranspiration;
- Increase the land application area or reduce the design loading rate; and/or
- Assess the feasibility of a land-drainage scheme.

If the on-site system option is to be pursued, a plan for ensuring vertical separation between the land disposal areas and the seasonally high groundwater level will need to be developed. The LWMS suggests that the importing of fill combined with subsoil drainage installed at natural ground level should be used (GHD, 2013), but recommended that further investigations take place to determine the local groundwater levels and mitigations for individual developments.

Costs and funding

Costs for this option may include the costs of investigations to support regulatory approval of an on-site system, the capital costs of the treatment unit and the effluent disposal (irrigation) infrastructure, commissioning costs associated with the treatment unit, ongoing maintenance of the treatment and disposal systems and the energy plus chemical (for ATUs designed to achieve nutrient removal) costs of running the systems. Individual land owners would be responsible for these costs.

Timing of development

Development within the LSP area is expected to occur following subdivision of existing lots. There is no timeline for this development and, depending on market conditions and individual's situations, it may occur in a fragmented fashion over a long period of time. The use of on-site systems for wastewater management suits this development – individual landowners can install systems as they build on their lots, and the rate of development in the surrounding area does not affect the feasibility of their system.

Planning for on-site effluent disposal

Approval is required from local government or the DoH (depending on the hydraulic load) prior to the installation of an ATU. There is a need for the early assessment of lots for their suitability

for on-site wastewater management, and the planning for a suitable and dedicated disposal area for treated effluent so that appropriate areas of the lot are reserved.

Governance and institutional arrangements

The land owner is responsible for the ongoing maintenance and management of the on-site system, and must employ an authorised person to carry out quarterly maintenance services.

The maintenance report from each quarterly service is forwarded to the local government (and the DoH if they approved the system).

Environmental and health risks

The various documents cited here that provide guidance on the use of on-site wastewater management systems have a common goal – to minimise the risks to public health and the environment. Several key recommendations in these documents that relate to the disposal area are:

- Signage at disposal area – within the disposal area, the DoH require the positioning of at least 2 warning signs to inform the occupants that reclaimed effluent is used for irrigation (Department of Health, 2001);
- Effluent disposal takes place in a dedicated area – not used for other purposes (Department of Health, 2001); and
- Nutrient absorption – soils and plantings to support take up/retention of nutrients to protect downstream environmental receptors.

4.3 Cluster scale: decentralised wastewater treatment and recycling

4.3.1 Concept description

Small groups of lots that are developed at the same time are connected via small local sewers to nearby WWTPs, and treated effluent from each is recycled for non-potable uses to the same lots via a dedicated “third pipe” for recycled water supply.

This option removes wastewater from the source for treatment off-site, and returns it to the lot based on demand. The recycled water is treated to a high quality so that it can be used for multiple uses, including in-house uses which have a year-round demand, and garden irrigation. This recycled water supply takes pressure off the potable water supply, and therefore is of benefit to the landowner in the form of cost savings on their water bill.

The WWTP needs to be located close to the lots connected to it to minimise piping of effluent, especially if this option was adopted across multiple small developments (groups of lots), each with their own small sewer network and WWTP. The main sewers and recycled water pipework (the third pipe) would be installed at the start of the development, and each lot would be connected as it was developed. At this small scale, for the system to be viable (technically and economically), there would probably be a need to mandate connection of all lots to the system.

4.3.2 Water balance

The water balance has been considered for one WWTP, and assumes the following:

- the catchment consists of 20 residential lots;
- all wastewater is connected to sewer; and

- treated effluent is recycled to lots for toilet flushing, cold water inlets to washing machines, and garden irrigation.

The monthly inflow and demand balance is graphed in Figure 1.

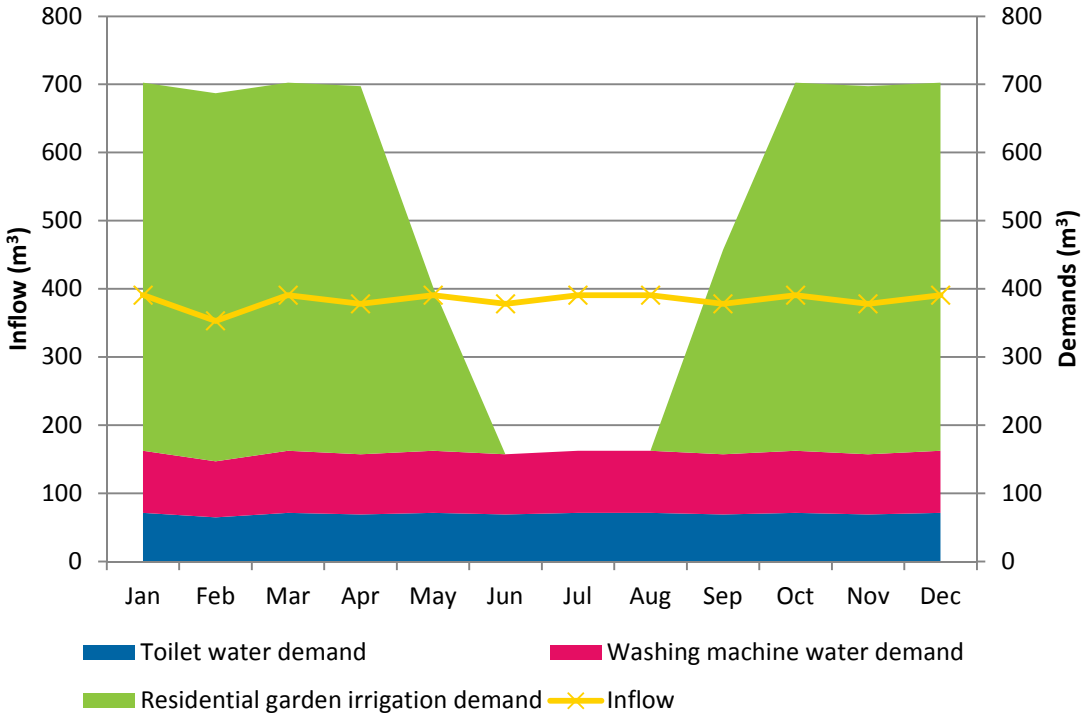
It was conservatively assumed that the volume of recycled water produced by the WWTP would be equal to the volume of inflows. The inflow to the WWTP was calculated from an assumed hydraulic load of180 litres per person per day and a rate of 3.5 equivalent persons per lot, both as recommended by the Sewerage Code of Australia (WSAA, 2002). The annual inflow to the WWTP was calculated as approximately 4600 kL.

Demands for recycled water were calculated using estimates of daily water use per person associated with the toilet and washing machine, adopted from assumptions contained within the 2007 version of the H2Options water balance tool (Water Corporation, 2007). In-house recycled water demand annually totalled approximately 1,900 kL.

Residential garden irrigation was estimated based for 300 m^2 per lot at a rate of 10 mm per irrigation event, and 9 irrigation events per month for 8 months of the year (mid-September to mid-May). The rate is as per the assumptions contained within the 2007 version of the H2Options water balance tool (Water Corporation, 2007). This irrigation demand is applicable assuming the area contains a mix of plantings (not all turf), including native species with low water demands.

Where recycled water demands exceed the inflow in any given month, there is a deficit of recycled water, and part of the demand would need to be met with another water supply, for example, rainwater could be used to top-up irrigation. Where inflows exceed demands, there is an oversupply of recycled water, and an alternative disposal method is required, or the water could be stored and used to top-up supply over summer. The total volume of excess recycled water that would need to be disposed of via an alternative method or be sent to storage in the months June-August is approximately 700 kL. It has been assumed that storage of this volume of water would most likely be in one or more enclosed tanks and incident rainfall and evaporation have not been considered in the water balance.

Figure 1 Water balance result for cluster scale wastewater treatment and recycling



4.3.3 Treatment requirements

The Australian Guidelines for Water Recycling state that recycled water quality objectives should be set as an outcome of risk assessments that consider the risks to public health and the environment (NRMMC, EPHC, AHMC, 2006). The potential risk profile and water quality objectives of the proposed water recycling scheme are discussed below.

Treatment for mitigation of health risks

The use of recycled wastewater inside houses is classified as having a high risk of exposure by the DoH and the minimum standards for recycled water quality (for health related parameters) are set by the Guidelines for the Non-potable Uses of Recycled Water in Western Australia (Department of Health, 2011). The recycled water quality compliance values for high exposure risk level applications is shown in Table 5 and is as per the DoH Guidelines (Department of Health, 2011).

Table 5 Recycled water quality compliance values – in-house reuse

Parameter	Recycled water compliance value
E. coli	<1 cfu/100mL
BOD	<10 mg/L
SS	<10 mg/L
pH	6.5-8.5 mg/L
Turbidity	<2 NTU (95%ile), <5 NTU (maximum)
Disinfection	Cl: 0.2 – 2.0 mg/L, or UV, or ozone
Coliphages	<1 pfu/100mL
Clostridia	<1 cfu/100mL

Treatment for mitigation of environmental risks

As discussed in Section 4.2.2 and as per the DoW WQPN for Irrigation with Nutrient Rich Wastewater (Department of Water, 2008), the wastewater treatment system may have specific recycled water quality objectives for nutrients. The level of nutrient removal required will be dependent on soils used for fill during land development. If the native soils were considered, then as per Section 4.2.2, enhanced nutrient removal (e.g. targeting TN 10 mg/L, TP 1 mg/L) may be required in areas with soil classified as category 2 (sandy loams). In areas with heavier soils, such as those classified as category 5 (clay loam), less stringent water quality objectives for nutrient removal may be considered acceptable, because the soils would act to retain nutrients applied through irrigation water.

Treatment technologies

This option requires the WWTP to have a small footprint and produce high quality effluent. A membrane bioreactor (MBR) type activated sludge treatment process is likely to be an appropriate treatment technology for this application, and there are several vendors in Western Australia that offer these systems.

There may be a need to provide for retreatment of water that has been stored for long periods of time, and for consideration of the retreatment or otherwise disposal of treated effluent that does not meet treated water quality objectives.

4.3.4 Considerations for implementation in Serpentine

Land requirements

This option necessitates the reservation of a parcel of land for the WWTP and recycled water storage for each group of lots to be developed and connected. Considering the use of small footprint wastewater treatment technologies, and the storage of recycled water in tanks, it is conceptualised that the wastewater treatment and storage infrastructure could be contained to one small lot, or within a POS area. The need for buffer areas between residential lots and the WWTP site need to be considered, with respect to the potential for nuisance noise and odour (refer below), and visual impacts. The appropriate scale for the cluster wastewater management option (i.e. how many lots to be connected to each treatment and recycling system) may need to be optimised to increase the financial viability of this option for developers.

Land for effluent disposal does not need to be reserved, but there may be a need to ensure that gardens are planted and reticulation systems installed on individual lots so that the garden irrigation water demand is realised.

Buffer zone

A conservative estimate of the required buffer zone for cluster scale WWTPs, derived from the separation distance recommended in the South Australian EPA Guidelines (SA EPA, 2007)] for mechanical/biological treatment plants of capacity up to 1,000 equivalent persons, is 100 to 150m. For this concept it is expected the WWTPs would incorporate a high level of odour control (e.g. covered inlet works and process tanks with treatment of foul air using an odour scrubbing system [e.g. biological or activated carbon filter]), and that waste activated sludge would not be dewatered on-site but rather stored in an aerated tank (aerobic digester) for periodic tankering to an appropriately licensed facility (e.g. the Water Corporation's Woodman Point WWTP). Given this, and noting that the capacity of each WWTP is likely to be significantly lower than 1,000 EP, the required buffer distance is likely to be significantly smaller than this conservative range.

For planning purposes it is suggested that a buffer zone of 25 to 50m would be appropriate for cluster scale WWTPs.

Wastewater collection and recycled water supply

The collection pipe network (sewers) accumulate wastewater from each lot and convey it to the WWTP. Consideration of the appropriate collection system for each cluster of lots will be required. Although the network for each WWTP will be small, the flat terrain and the high groundwater at the site may pose issues for conventional gravity collection, and a pressure system may be preferred.

The recycled water (third pipe) supply will be piped from the WWTP/storage to each lot via supply mains and a connection point at each lot boundary. The third pipe recycled water distribution system must be separated from potable water supplies and clearly identified as recycled water to prevent cross contamination as per the National Plumbing Code (AS 3500). Pipe work and fittings should be colour coded (purple) and signage must be provided to all fixtures and storage tanks to indicate that the water is not fit for drinking (Department of Health, 2011).

Approval framework

The DoW is the lead agency for the approval of non-drinking water schemes in WA, and the staged process for the planning, design and approval of schemes is outlined in the *Guideline for the Approval of Non-drinking Water Systems in Western Australia* (Department of Water, 2013). The approval process is linked to the Better Urban Water Management framework. The DoW refer applications for non-drinking water schemes to various regulatory agencies for assessment.

One of the key agencies that would assess the proposed scheme would be the DoH, and this would be in line with the *Guidelines for the Non-potable Uses of Recycled Water in Western Australia* (Department of Health, 2011).

Institutional arrangements

Consideration of who will manage the wastewater treatment and recycling scheme is required. A water service provider licenced by the Economic Regulation Authority will be required to operate and maintain the scheme.

The Water Corporation require schemes to have a minimum of 2,500 connections (for metropolitan residential dual reticulation schemes) before they will consider being the water service provider (Water Corporation, 2013).

For the cluster scale wastewater management option, there is potential for the scheme to be managed by the developer during planning, design and installation, and then the responsibility passed on to the water service provider (who may be the treatment plant provider) for ongoing management.

Timing of development

The cluster scale wastewater management option may be an appropriate option for land development that is expected to occur as existing large lots are divided over time by landowners or developers, and developed as small subdivisions. Each cluster scale wastewater treatment and recycling scheme could be planned for and installed as land development is initiated in a discrete block of the LSP area.

The cluster scale wastewater management option requires that all lots within the cluster connect to the system over a relatively short time period, so that the infrastructure can be designed and constructed to accommodate the ultimate hydraulic load without having long periods of operation below its capacity (which is not economically viable but can also be problematic for the biological treatment system).

Costs and funding

Costs for this option, for each individual scheme, may include the costs of investigations to support the planning, design and regulatory approval of the collection, treatment and recycling of wastewater, the capital costs of the collection system, WWTP, recycled water storage and conveyance, commissioning costs associated with the treatment unit, ongoing maintenance of the treatment and recycling system and energy costs, and replacement of parts over time.

Developers are likely to benefit from increased lot values under this option, due to the provision of wastewater services and a recycled water supply. The developer may fund the upfront costs of the scheme if financial analysis indicates that the option is viable.

Individual land owners benefit from the scheme due to the wastewater services and the secondary water supply they receive. Landowners may fund the ongoing costs through the payment of fees to the water services provider, and these fees could include a fixed fee and volume charge.

Water recycling schemes have in the past been the beneficiaries of federal and/or state grants, but the future availability of this type of funding is unlikely (Institute for Sustainable Futures, 2013). It is recommended that before any funding sources are investigated, a thorough analysis of the costs, benefits and risks of the scheme is undertaken.

4.4 Village scale: centralised wastewater treatment and recycling

4.4.1 Concept description

A single WWTP is constructed with the objective of providing centralised wastewater treatment services for the entire townsite of Serpentine.

Reticulated sewer is installed as land development occurs, and all new lots are connected to the system. The collection system can be extended to existing lots over time based on demand or funding.

Treated wastewater from the WWTP is recycled for irrigation of public open space (POS) within the townsite, or supplied to others for irrigation purposes, such as the golf course and equestrian ground west of (and adjacent to) the town.

4.4.2 Water balance

Hydraulic load to WWTP

The hydraulic load to the WWTP for the ultimate development scenario (all lots developed to the full potential of the LSP) was assessed based on the following assumptions:

- All wastewater is connected to sewer from residential lots within the LSP area;
- There are 405 residential (R5 and R10) lots within the LSP area (see Section 2.2); and
- There are 3.5 equivalent persons per lot, and 180 L/p/d of wastewater is generated as per the cluster scale wastewater option (see Section 4.3.2) and in line with the Sewerage Code of Australia (WSAA, 2002).

The ultimate annual hydraulic load to the WWTP calculated based on the above is 93.1 ML. It should be noted that the hydraulic load assumptions adopted here are different to those used in the lot-scale wastewater management option. The assumptions for each were based on relevant standards/guidelines but the water balance for the chosen option should be reviewed once a wastewater management strategy is adopted.

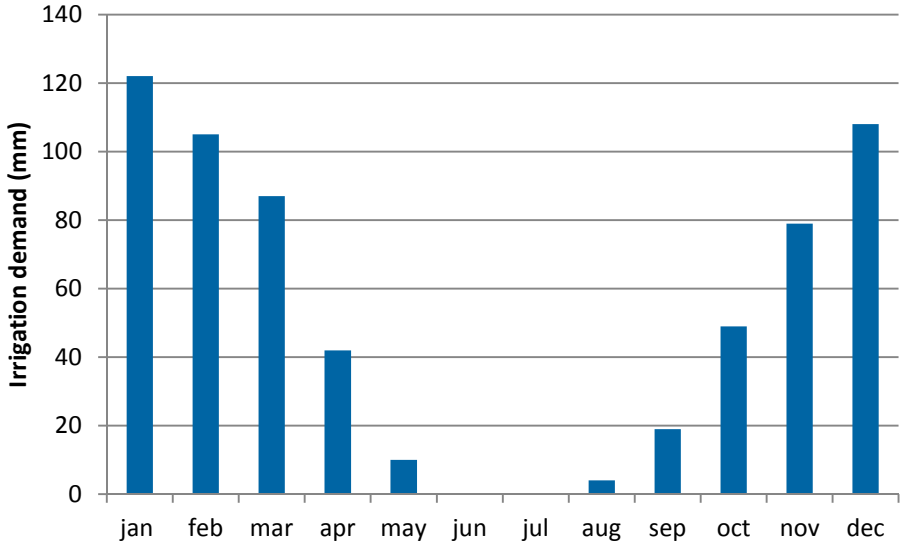
Irrigation demand

The unit irrigation demand for POS turf was assessed using the Irrigation Calculator v4.0 developed by the Western Australian Department of Agriculture. The model was set up as follows:

- Armadale was selected as the location (with Armadale average historical rainfall and evaporation data used in calculations by the model), being the nearest location to Serpentine available in the model;
- The irrigation efficiency was 1.1 (10% of the water applied is not available to the plant due to losses);
- The crop type was selected as “recreation low”; and
- The soil type selected was loams and clays.

The irrigation demand (mm per unit area) predicted by the model is presented in Figure 2. The model predicts a highly seasonal demand pattern, with zero demand for irrigation in June and July. This has implications for the need to store treated effluent over winter for use in summer. To minimise the storage requirements, a large recycled water irrigation system would be developed, but then there would be supply issues in summer (potentially requiring other irrigation water sources) and the cost of the irrigation infrastructure and its management would be high.

Figure 2 Irrigation demand for POS as predicted by Irrigation Calculator



There exists multiple potential irrigation sites within and adjacent to the LSP area, and these are listed together with a rough estimation of area based on aerial imagery in Table 6. It is understood that POS is currently irrigated with groundwater (GHD, 2013) and that the golf course is irrigated with water from two dams within the course (based on information provided on their website), although the source of water within the dams is unknown.

Table 6 Potential irrigation areas within or close to Serpentine LSP area

Irrigation site	Area (ha)
Serpentine cricket/football oval (between Karnup Road, Wellard Street and Lefroy Street)	1.7
Spencer Park	0.9
Primary school oval	0.8
Equestrian ground and showground (Karnup Road)	12.0
Golf course (fairways only – assumed 18 holes, 300 m long and 20 m wide)	10.8
TOTAL	**26.2 ha**

An irrigation area of 15 ha has an annual irrigation demand of 93.8 ML based on the assumptions outlined above, roughly equivalent to the ultimate inflow to the WWTP. For this irrigation area, if winter effluent flows are stored for reuse the following irrigation season it is calculated that a minimum storage capacity of 36,000 kL would be required to reuse 100% of the effluent in an average rainfall year. As the local aquifers are unlikely to be suitable for Aquifer Storage and Recovery (ASR), storage of this volume would likely take the form of one or more dedicated storage ponds. The effect on the storage volume of incident rainfall or evaporation has not been considered here.

4.4.3 Treatment requirements

Treatment for mitigation of health risks

The use of recycled wastewater for irrigation of public open space is considered as having a low or medium risk of exposure by the DoH depending on the access restrictions in place to prevent unintended public contact with recycled water. Assuming that some access restriction was put in place (such as irrigating at night-time only), then the scheme would be classified as medium risk and the recycled water quality compliance values would be as per Table 7 in line with the DoH Guidelines for the Non-potable Uses of Recycled Water in Western Australia (Department of Health, 2011). For the scheme to be classified as low risk, and thus have lesser water quality objectives, enhanced restricted access measures would be required such as fencing or withholding periods. The risk classification is ultimately decided by the DoH based on their assessment of the proposed scheme.

Table 7 Recycled water quality compliance values – medium risk exposure level - urban irrigation

Parameter	Recycled water compliance value
E. coli	<10 cfu/100mL
BOD	<20 mg/L
SS	<30 mg/L
pH	6.5-8.5 mg/L
Turbidity	<5 NTU (95%ile)
Disinfection	Cl: 0.2 – 2.0 mg/L, or UV

Treatment for mitigation of environmental risks

Water quality objectives for nutrients are required based on the potential for impacts to downstream environmental receptors. This has been discussed previously in the investigation of the lot and cluster scale wastewater management options. It is likely that for a village scale effluent irrigation scheme, the DoW would require a Nutrient and Irrigation Management Plan to be produced. The level of treatment for nutrients will be dependent on the irrigation application rate, the soils and their capacity to retain nutrients, and the matching of nutrient application (based on the effluent water quality and application rate) to the rate of uptake of nutrients by turf.

Treatment technologies

For wastewater treatment at this scale, there are multiple options for the treatment type, and these may include pond type treatment plants (low operational requirements, large footprint, limited potential for nitrogen reduction), activated sludge or moving bed biofilm reactor (MBBR) plants (high operational requirements, small footprint, can be configured to achieve high levels of biological nutrient reduction, can be designed to achieve high level of odour control) and a variety of other treatment technologies (e.g. trickling filter type plants, wetland systems).

An appropriate wastewater treatment system should be investigated if this option is to be considered further, based on:

- recycled water quality objectives adopted following assessment of the health and environmental risks;

- the land area/s available for the WWTP and recycled water storage infrastructure (which may be at the WWTP site or at one or more of the irrigation sites, and may incorporate additional treatment of stored water through filtration and disinfection prior to use);
- the footprint of the WWTP for treatment technology options and the requirement for buffer areas for odour;
- the ongoing management and maintenance requirements of the treatment technology options, and the availability/cost of suitably qualified operators to run the system; and
- the total life cycle costs of the different options.

4.4.4 Considerations for implementation in Serpentine

Land requirements

The WWTP and recycled water storage and treatment infrastructure require siting at an appropriate location that gives consideration to topography and ground conditions, minimising the distances over which raw wastewater and recycled water have to be conveyed (likely pumped), and to the requirement for adequate buffers to existing houses, land zoned for residential development, etc. The land area required would depend on the chosen treatment technology as discussed above. If the site does not encompass the 'buffer zone' (refer below), planning controls need to be imposed to prevent future development of land within this zone.

Buffer zone

An estimate of the required separation distance for a village scale WWTP designed to serve the Serpentine Townsite, derived from the separation distance recommended in the South Australian EPA Guidelines (SA EPA, 2007)] for mechanical/biological treatment plants of capacity between 1,000 and 5,000 EPs, is 200 to 300m.

Wastewater collection and recycled water supply

Connection of the entire townsite to the WWTP requires the installation of a reticulated gravity sewer network across the town. It is envisaged that sewers would be installed in new subdivisions as land development occurs, with connections supplied to all new lots. The sewers could be extended over time to the existing (already subdivided) areas of the townsite, based on an assessment (survey) of the willingness of existing residents to connect to the centralised scheme.

Approval framework

As per the cluster scale wastewater management option, the DoW would be the lead agency for the approval of this non-drinking water schemes, and the proposal would be assessed in stages as outlined in the *Guideline for the Approval of Non-drinking Water Systems in Western Australia* (Department of Water, 2013), and referred to relevant regulatory agencies for assessment.

Institutional arrangements

Just who will manage the wastewater treatment and recycling scheme through the planning and design process, construction, and who will operate and maintain the scheme needs to be considered. A water services provider licenced by the ERA will be required to operate the system. The Water Corporation could be approached to be the water services provider under this option, and there are many advantages to having them operate the scheme, including that they are a trusted provider of water services in WA. Alternatively, the Shire may wish to become licenced as the water services provider and contract out services for which there is no

experience in house, such as the operation and maintenance of the WWTP. There may also be parties in the private sector that would be interested in being the water service provider.

Depending on who operates the WWTP, and what sites are to be used for effluent irrigation, an agreement for the supply of recycled water for irrigation may be required. This sets out the roles and responsibilities of the parties involved in the recycled water scheme (for example, who is the recycled water scheme manager and who are the recycled water customers), and is required by the DoH to ensure ownership of risks associated with the use of recycled water in WA.

Timing of development

The timeframe over which development of the town is to occur has implications for the devlopment of the centralised wastewater treatment and recycling system.

If development is to occur over a long time period, the staging of the development of the WWTP, recycled water storage and irrigation scheme will be required. The capacity of the scheme can be increased in stages as the population of Serpentine grows. This approach is particularly relevant to certain WWTP technologies that do not operate as effectively if the hydraulic load is smaller than the design load.

The expected timeframe for development would be used to develop flow projections and plan for a centralised wastewater management scheme. The flow projections should consider the take up of the sewerage services by the existing (already subdivided) lots, which may not occur until major works or replacement of onsite treatment systems is required, or there is a change in ownership.

Costs and funding

The costs for this option, similar to the cluster scale wastewater management option, include the costs of investigations to support the planning, design and regulatory approval of the collection, treatment and recycling of wastewater, the capital costs of the collection system, WWTP, recycled water storage and conveyance, costs associated with commissioning the WWTP, ongoing maintenance of the treatment and recycling system and energy costs, and replacement of parts over time.

Beneficiaries of a centralised wastewater treatment and recycling scheme include:

- New landowners, who benefit from wastewater services being managed by others off site;
- Existing landowners, who can connect to the new wastewater collection system;
- Land developers, who may benefit from increased land values;
- Recycled water users, who benefit from a climate independent irrigation water source; and
- Regulatory authorities, who will be responsible for one (rather than many) systems.

Different funding arrangements can be considered with the aim of getting all beneficiaries to contribute to the costs of the scheme.

Funding of the upfront costs of the scheme is one of the challenges of this option. Given the scale of the proposal; the capital expenditure could be sizeable, and obtaining funding and appropriate terms and conditions under which it is provided are likely to be key determinants on the likelihood of the project proceeding.

4.5 Comparison of options

The options presented have been compared against triple bottom line criteria. The assessment is qualitative only and designed to compare the known benefits and challenges of each option against financial, social and environmental objectives. The criteria presented are examples only and were formulated with reference to a national guide to evaluating water sensitive urban design options (Joint Steering Committee for Water Sensitive Cities, 2009).

It is recommended that this assessment should be revised by the Shire based on a set of agreed objectives for the management of wastewater in Serpentine. A thorough assessment of options would include quantifying the financial impacts of options, including determining the whole of life costs per connection.

The assessment is presented in Table 8.

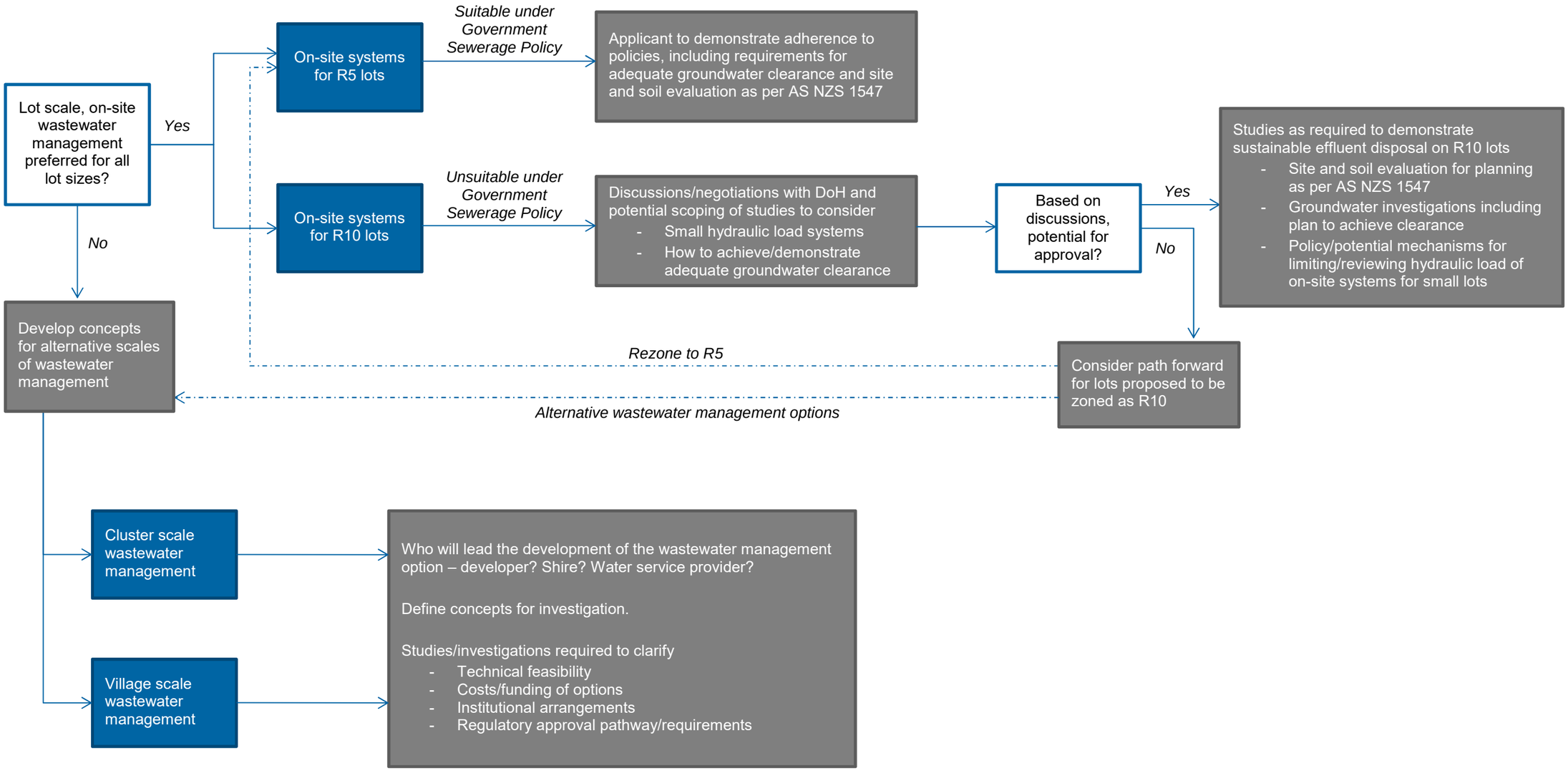
Table 8 Triple bottom line options comparison

Category	Objective/criteria	Lot scale wastewater management	Cluster scale wastewater management	Village scale wastewater management
Financial	Total life cycle costs of the option	This could not be assessed at this stage, but is a recommended approach to comparing the financial impact of options. For an equitable assessment, the options should be compared over the same time period and same scale (i.e. provision of wastewater treatment and disposal for the entire townsite of Serpentine as it develops over the next 30 years).		
	Capital cost	Low compared to other options but may be a considerable expense for individual landowners who must fund this at the time of lot development.	Potentially high given cost of reticulated wastewater collection and recycled water distribution networks , but price per lot may not be prohibitive given economies of scale that would apply to treatment plant. Funding method to be determined but could be paid by developer. Costs associated with regulatory approval must be included.	Very high due to scale of development. Staging to be considered to delay capital expenditure, but up-front costs likely greatest for this approach. Development of acceptable funding arrangement complicated by number of landowners involved. Potential to obtain federal or state government funding should be investigated. Costs associated with regulatory approval need to be included.
	Annual maintenance and management costs, including energy costs	Low compared to other options, solely borne by landowner. If costs considered per connection, other options may be competitive.	To be determined and will be dependent on treatment technology adopted. Costs likely to be shared by landowners connected.	To be determined and dependent on treatment technology adopted. Costs likely to be shared by landowners and recycled water customers.
	Potential impact on land value	No impact - business as usual case.	Likely to increase value of lots serviced by a WWTP/recycling scheme	Likely to increase value of lots across the townsite
	Financial risk (to proponent of option)	Landowner as proponent - financial risk is low - if feasibility of system on the lot is adequately assessed prior to installation.	Developer as proponent - financial risk is higher - success of scheme and recuperation of capital expenditure dependent on development of lots connected to the scheme.	LGA is (potential) proponent - financial risk is high - success of scheme and recuperation of capital expenditure dependent on wide scale adoption of (connection to) the scheme and the demand for recycled water.
Social	Potential uncontrolled risk to health of residents	Medium - there is a risk of failure of system and subsequent impact on the health of residents. Strict control is required to ensure regular maintenance is carried out and disposal areas are maintained and not used for other purposes.	High – due to recycled water being supplied for in-house uses. Treatment processes reduce risk.	Low – wastewater removed and treated offsite. Recycled water used for applications with low risk. This depends on controls to minimise public contact with recycled water and treatment processes employed.
	Impact on amenity/use of land within individual lots	Negative - land area required for treatment unit and dedicated disposal area for effluent required and this may be a significant area of lot for smaller lot size.	High and positive - high quality recycled water supply for garden irrigation, no other land required on lot.	Positive - no land required on lot for wastewater management.
	Maintenance burden for individual landowners	High - likely quarterly maintenance of on- site systems required, as well as maintenance of disposal area. Periodic desludging.	Low/none - backflow prevention device maintenance and monitoring for leaks, although these services may be provided by the water service provider.	None.
	Acceptability to stakeholders	Regulators - this option may be unacceptable to regulators for small R10 lots. Suitable for R5 lots following assessments. Public/landowners - accepted based on standard in the area. Developers - accepted based on the history of wastewater servicing in area but probably not preferred.	Regulators - framework exists for approval process but there are few precedents for this scale of wastewater management. Theoretically acceptable if requirements met for assessment and mitigation of risks. Public/landowners - acceptable but education may be required to sell the benefits of water recycling. Developers - dependent on desire to be a trailblazer for cluster WWMS and third pipe recycling in WA.	Regulators - acceptable and precedents exist although unusual in metropolitan setting - in rural WA there are a number of schemes run by LGAs. Public/landowners - very acceptable to most, but landowners near proposed site for WWTP may object to proposed scheme, for example on basis of potential odour impacts, or potential that WWTP could affect the value of their land or constrain their future development plans. Developers - acceptable if funding arrangement is financially viable for them.
Environmental	Potential impact on health of local/regional ecosystems	High - due to shallow groundwater and location of the site close to the Serpentine River, there is a risk of contamination of downstream water bodies with nutrients (eutrophication) and impact on environmental receptors. This risk needs to be mitigated through assessment of risks – with the adoption of this option only when the site can safely accommodate it, and amending native soils as required to retain nutrients on-site.	Medium - risks associated with irrigation and application of nutrients to be assessed and managed. Preferable to lot-scale system because irrigation occurs based on demand rather than year-round (disposal).	Medium - risks associated with irrigation and application of nutrients to be assessed and managed. Preferable to lot-scale system because irrigation occurs based on demand rather than year-round (disposal). Potential impact due to leaching from storage ponds to be assessed and controlled (prevented). Land clearing for WWTP and other infrastructure to be assessed.
	Ecological impacts associated with materials, energy, wastes over life cycle of project	Materials cost is high due to every lot requiring infrastructure. No/minimal materials required for storage. Energy low - wastewater treated at source. Waste sludge to be disposed - similar in all cases although the ecological impact of collection and transport of sludge is highest in this option due to the scale (many small treatment units requiring servicing).	Savings in materials for WWTP but conveyance systems required. Materials for storage to be considered. Energy higher as pumping required for wastewater collection and/or recycled water distribution - but conveyance distances small.	Savings in materials for WWTP. Larger conveyance systems required. Large recycled water storage required. Energy use dependent on treatment system adopted. Higher use of energy for pumping of raw and treated wastewater.

5. Wastewater management - decision making pathway

Based on the assessment of options for wastewater management, and the discussions on each provided in this report, a decision making pathway has been proposed in Figure 3. The proposed approach should be reviewed by the Shire based on the information contained within this report, and the Shire's (and other stakeholders) objectives for wastewater management within Serpentine.

Figure 3 Potential pathways to decision making on wastewater management strategy for Serpentine



6. Conclusions and recommendations

Wastewater management in the townsite of Serpentine has historically been achieved using on-site systems installed at each lot. The current study assessed potential future wastewater management strategies at three scales:

- **Lot** – wastewater is managed within each lot through the use of on-site systems and is disposed within the lot boundary;
- **Cluster** – wastewater is collected from groups of lots using small (local) sewer pipes and wastewater is treated and recycled and provided via a “third pipe supply” to those lots for non-potable uses such as toilet flushing and garden irrigation;
- **Village** – a wastewater collection system is installed to cover the entire townsite, and wastewater is treated and recycled for non-potable uses or disposal.

Assessment of the opportunities and constraints of the site, the water balance at each scale of wastewater management, and the regulatory requirements for wastewater management allowed for the (qualitative) comparison of options against triple bottom line criteria. The criteria should be reviewed by the Shire based on their perspective and objectives for wastewater management within Serpentine and the greater local government area.

The lot-scale option was preferred against most financial criteria, due to the small scale of the project and the low financial risk for a project of this scale. However, a more equitable financial assessment based on whole of life costs for each option and the cost per connection is highly recommended and reference is made in this report to recommended approaches for this.

Against social criteria, the lot-scale option scored poorly due to the health risks, land use and maintenance burden for the landowner. The village scale wastewater management option was preferred against most of the social criteria, due to the low risk to public health and the acceptance of this method by stakeholders. The cluster scale option presents an alternative approach, and while it could achieve a number of beneficial outcomes, its acceptability to stakeholders is relatively untested in Western Australia.

The comparison of options against environmental criteria suggests that the cumulative impacts of wide-scale use of on-site systems in Serpentine is likely to be higher than for the alternative options, and highlights the need for mitigation of risks. The study was limited by the lack of data on groundwater and soils, and by the assumptions made in conceptualising options. Many of the impacts of the alternative wastewater management options cannot be measured because the concepts are inadequately defined. Environmental impacts should be reviewed and mitigated following refinement of preferred wastewater management strategies.

Based on the assessment of options and the current position of the Shire in the LSP approval process, a pathway for decision making on wastewater management has been proposed. If on-site systems are the preferred approach across residential areas of the townsite, then the Shire should seek collaborative discussion with the DoH on further work required to adequately demonstrate the sustainability of on-site effluent disposal across the LSP area. Depending on the outcomes of this or the Shire’s preference for analysis of other options, recommended next steps are provided. Priority actions are to clarify who would lead the investigation into alternative wastewater management options, and to refine concepts. Further work can then be scoped to elucidate the technical feasibility, costs and funding, institutional arrangements and regulatory approval requirements of the options.

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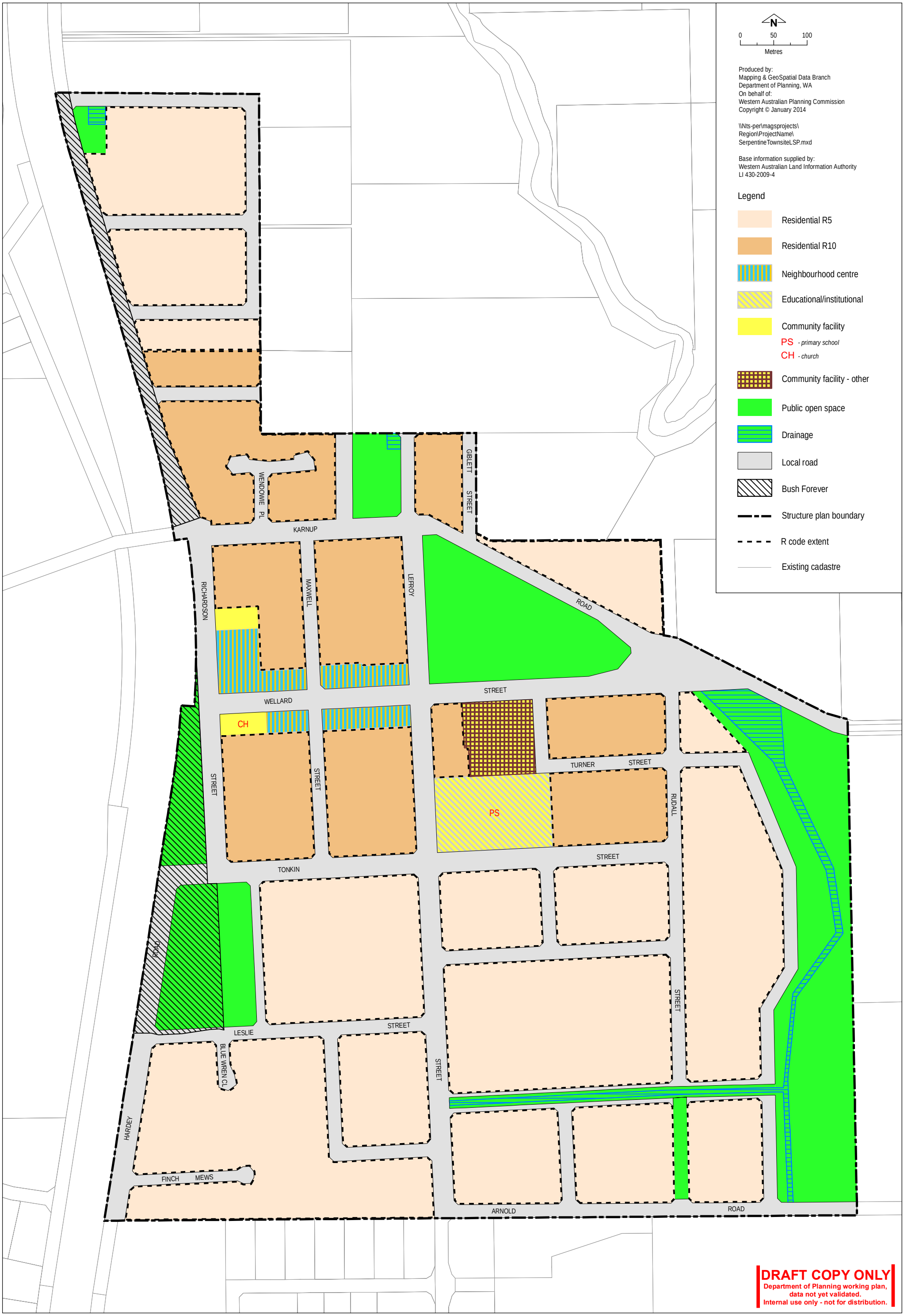
Appendices

Appendix A – Local structure plan area map

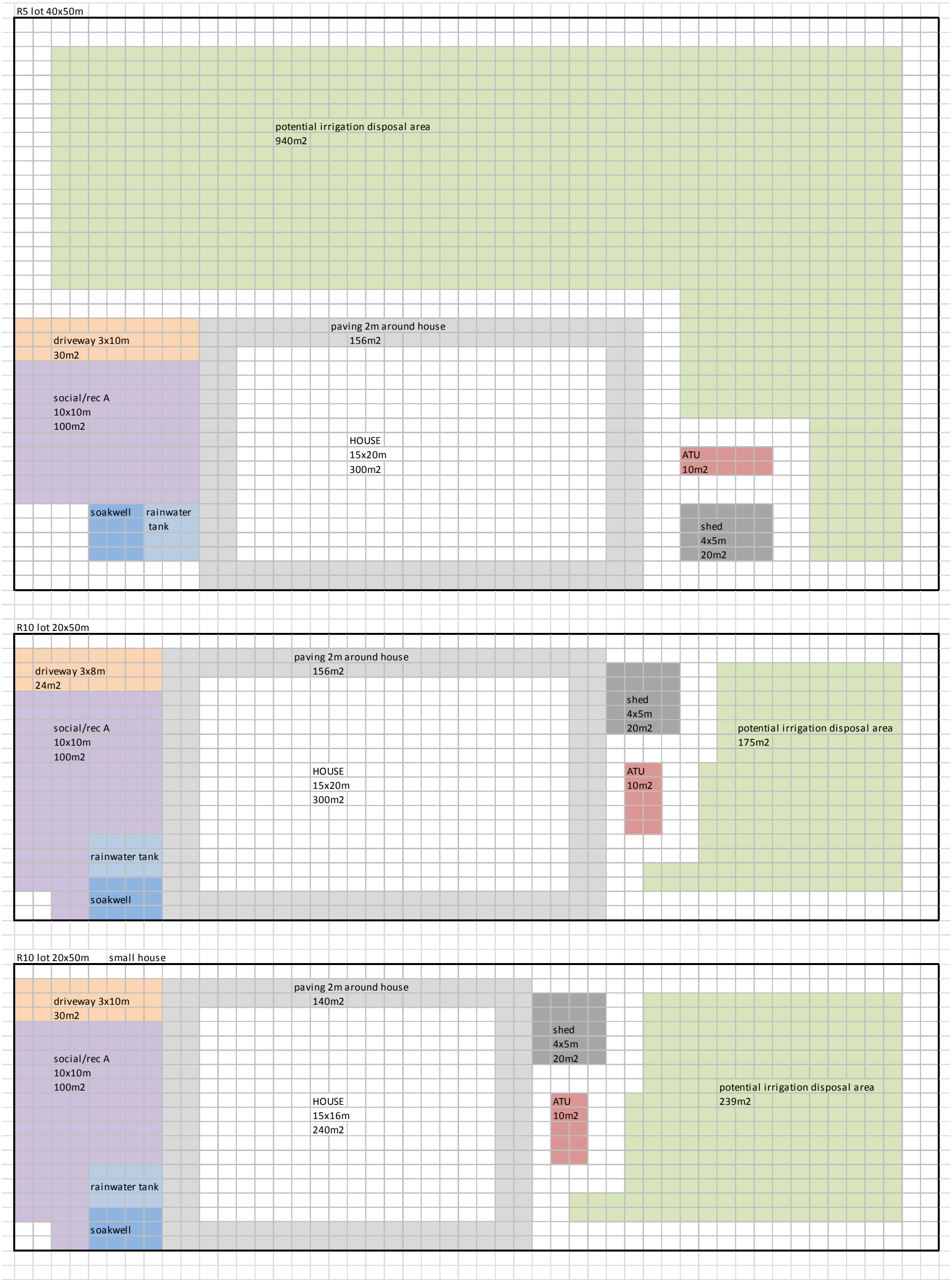
Serpentine Townsite Local Structure Plan



Serpentine Townsite Local Structure Plan

Figure X

Appendix B – Analysis of lot sizes and potential irrigation disposal areas


R5 lot 40x50m
potential irrigation disposal area
940m2
paving 2m around house
156m2
driveway 3x10m
30m2
social/rec A
10x10m
100m2
HOUSE
15x20m
300m2
ATU
10m2
soakwell
rainwater tank
shed
4x5m
20m2
R10 lot 20x50m
paving 2m around house
156m2
driveway 3x8m
24m2
shed
4x5m
20m2
social/rec A
10x10m
100m2
potential irrigation disposal area
175m2
HOUSE
15x20m
300m2
ATU
10m2
rainwater tank
soakwell
R10 lot 20x50m small house
paving 2m around house
140m2
driveway 3x10m
30m2
shed
4x5m
20m2
social/rec A
10x10m
100m2
potential irrigation disposal area
239m2
HOUSE
15x16m
240m2
ATU
10m2
rainwater tank
soakwell

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	L Thomas	D Edgar	[DME]	D Edgar	[DME]	15/04/15
0	L Thomas D Edgar	D Edgar		D Edgar		21/12/2015

www.ghd.com

Appendix 5 –
Bushfire Management Plan

Shire of Serpentine Jarrahdale

Bushfire Management Plan

Serpentine Townsite

Local Structure Plan



LUSH FIRE & PLANNING
No 3 Paterson Rd
Pinjarra WA 6208
0418 954 873
ABN 74 232 678 543

BPAD Bushfire Planning & Design Accredited Practitioner Level 2

Ref No 19-043
Version E
December 2022

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:	Serpentine Townsite				
Suburb:	Serpentine	State:	WA	P/code:	6123
Local government area:	Serpentine Jarrahdale				
Description of the planning proposal:					
BMP Plan / Reference Number:	19-043	Version:	E	Date of Issue:	12/12/2022
Client / Business Name:	Shire of Serpentine Jarrahdale				

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 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.)?

Local structure plan

Note: The decision maker (e.g. the 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
Geoffrey Lush	Level 2	BPAD 27682	28/02/2023
Company		Contact No.	
Lush Fire & Planning		0418 954 873	

I declare that the information provided in this bushfire management plan is to the best of my knowledge true and correct.

Signature of Practitioner  **Date** 12/12/2022

This Bushfire Management Plan has been prepared to assist in the formulation of the Shire of Serpentine Jarrahdale Local Structure Plan for the Serpentine townsite. The structure plan area covers approximately 119 hectares of land. It is bounded by the railway line to the west, Arnold Street to the south, Lots 102-106 Rudall Street to the east and private land to the north.

The aim of this assessment is to identify bushfire hazard issues, and to clearly demonstrate that compliance with State Planning Policy 3.7 - Planning in Bushfire Prone Areas can be achieved at subsequent planning stages.

The townsite is predominantly residential with a small commercial area, service industry and community facilities. The existing residential lots are generally 2,000sqm in size. There are a number of crown reserves for a variety of purposes including bushland areas such as the Lambkin, Bradey and Paul Robinson nature reserves.

Most of the study area has been cleared with remnant native vegetation located in reserves, the railway line corridor and fragmented parcels in private property. The topography is characterised as being relatively flat (less than 1 degree) varying between approximately 30m AHD in the north-west corner to 35m AHD in the middle of the site.

While the existing road reserves within the study area are generally 20m wide it is noted that Wellard Road, Lefroy Street, Tonkin Street and Richardson/Hardey Roads all have 30m wide reservations.

The study area is predominantly zoned 'Urban Development' with some land reserved for 'Parks and Recreation' under Town Planning Scheme No. 2. The majority of the study area is designated as being Bushfire Prone Land.

There are multiple environmental issues within the structure plan area including:

- Declared Rare and Priority Flora sites;
- Bush Forever Sites;
- Conservation category wetlands;
- Environmentally Sensitive Areas;
- Crown reserves for conservation;
- Areas with high quality vegetation; and
- An environmentally sensitive area covering most of the site.

The proposed subdivision will create approximately 250 additional residential lots with a R5 density coding. This has a minimum lot size of 2,000sqm and a frontage of 30m. The design promotes the existing grid road layout and providse a highly connected and walkable local movement network. There is a presumption against the use of cul-de-sacs.

The creation of the subdivision roads, provision of services, and filling of land is likely to result in the removal of the existing vegetation in these areas.

There are no specific revegetation plans within the structure plan other than general references to vegetation protection and undertaking a boundary definition study for the conservation category wetland. Revegetation, landscaping measures are expected to include:

- A 50m wide revegetated for the conservation category wetland;
- The wider road reserves;
- Local public open space; and
- Drainage lines and basins.

The existing vegetation has been classified in accordance with the Guidelines. The primary area of vegetation hazard is on the western side of the study area being the land on both sides of the railway line. This has all the major vegetation types with some large areas of shrubland being less than 2m in

height. To the north the main vegetation is grassland/pasture with boundary windbreaks. The Serpentine River has a corridor of forest vegetation but it is outside of the study area.

The central and eastern portions of the study area also have areas of grassland/pasture, with more significant bushland within many of the lots. The developed townsite lots are considered to be low threat vegetation as they contain managed gardens.

A BAL Contour Map has been prepared on the basis of the proposed structure plan design identifying both areas to be cleared and/or revegetated. There are a number of instances adjacent vegetation (including on existing road reserves) means that the BAL-FZ/40 ratings encroach into the development cells.

The vegetation on the existing road corridors has been identified as a specific issue as the BAL-29 setback is 21m for Class A Forest vegetation on flat land. The residential R5 density coding has a minimum front setback of 12m which can be averaged or reduced to 6m. Several options have been identified to address this including:

- The preparation of Local Development Plans to require a greater setback with a BAL-29 rating; or
- The use of Model Subdivision Condition F3 to require the preparation of a definition plan and restrictive covenant so as to exclude development from that portion of a lot with a BAL-FZ/40 rating.

In order to comply with these objectives of SPP3.7 Planning in Bushfire Prone Areas, subdivision and development within the Study Area will need to balance both bushfire management and environmental issues while recognising community expectation for high levels of amenity.

The most critical issue is to define where revegetation will occur, especially in the road reserves and the specifications for this. This will require Bushfire Management Plans for subdivision applications and these will have to define both clearing and revegetation.

Generally, the structure plan design complies with the objectives of State Planning Policy 3.7 as:

1. It avoids any increase in the threat of bushfire to people, property and infrastructure.

   The structure plan area is located within a developed townsite. The main hazard vegetation is located along the railway corridor, while the main development areas are physically separated from this. The proposed lots will be large enough to have internal development sites with a BAL-29 rating provided that there is an appropriate mechanism to increase the minimum R5 setback. Development with a BAL rating below BAL-29 and which complies with the Bushfire Protection Criteria; and does not increase the threat of bushfire.

2. It reduces vulnerability to bushfire through the identification and consideration of bushfire risks in the design of the development and the decision-making process.

   The bushfire hazard and risks have been identified and assessed in this report.

3. The design of the subdivision and the development takes into account bushfire protection requirements and includes specific bushfire protection measures.

   The proposed subdivision design will be able to comply with the Bushfire Protection Criteria.

4. Achieves an appropriate balance between bushfire risk management measures and biodiversity, conservation values, and environmental protection.

   The areas with environmental importance will be excluded from development. Clearing of vegetation for the construction of the subdivision and development will need to occur but this is relatively small given the overall size of the structure plan area. Landscape and biodiversity values will be enhanced by the proposed revegetation of road reserves and the landscaping of Public Open Space and drainage corridors.

Document Control

Ref No 19-043

Locality	Serpentine Townsite	**State** WA	**Postcode**	6170
Local Government Area		Serpentine Jarrahdale		
Project Description		Local Structure Plan		
Prepared for		Shire of Serpentine Jarrahdale		

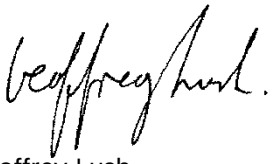
Revision	Date	Purpose
A	4/10/2019	For review
B	13/01/2020	Edits & reference Position Statements
C	10/02/2020	Council comments
D	07/11/2022	WAPC Final Approval modifications. Reference Version 1.4 of the Guidelines
E	12/12/2022	Plan corrections

Name	Geoffrey Lush	**Company**	Lushfire & Planning
BPAD	Level 2 Practitioner	**Accreditation No** Expiry	27682 February 2023

Disclaimer

The measures contained in this report do not guarantee that a building will not be damaged in a bushfire. The ultimate level of protection will be dependent upon the design and construction of the dwelling and the level of fire preparedness and maintenance under taken by the landowner. The severity of a bushfire will depend upon the vegetation fuel loadings; the prevailing weather conditions and the implementation of appropriate fire management measures.

All information and recommendations made in this report are made in good faith based on information and accepted methodology used at that time. All plans are subject to survey and are not to be used for calculations. Notwithstanding anything contained therein, Lushfire & Planning will not, except as the law may require, be liable for any loss claim, damage, loss or injury to any property and any person caused by fire or by errors or omissions in this report.



Geoffrey Lush
12 December 2022
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BPAD
Bushfire
Planning & Design
Accredited Practitioner
Level 2

CONTENTS

APPENDICES

TABLES

FIGURES

1.0 Proposal Details

1.1 Introduction

This Bushfire Management Plan has been prepared to assist in the formulation of the Shire of Serpentine Jarrahdale Local Structure Plan for the Serpentine townsite. This is a strategic report which includes a bushfire hazard level assessment.

The Serpentine Townsite Local Structure Plan (STLSP) aims to create an urban settlement which respects the historic environment of the Serpentine Townsite. It outlines future land use, zones and reserves applicable within the structure plan area.

The Local Structure Plan area covers approximately 119 hectares of land as shown in Figure 1. It is bounded by the railway line to the west, Arnold Street to the south, Lots 102-106 Rudall Street to the east and Lot 10 Richardson Street, Lot 15 Giblett Street and part of Lots 17 and 18 Karnup Road to the north.

The aim of this assessment is to identify bushfire hazard issues, and to clearly demonstrate that compliance with State Planning Policy 3.7 - Planning in Bushfire Prone Areas can be achieved at subsequent planning stages. Compliance with SPP3.7 Planning in Bushfire Prone Areas includes compliance with:

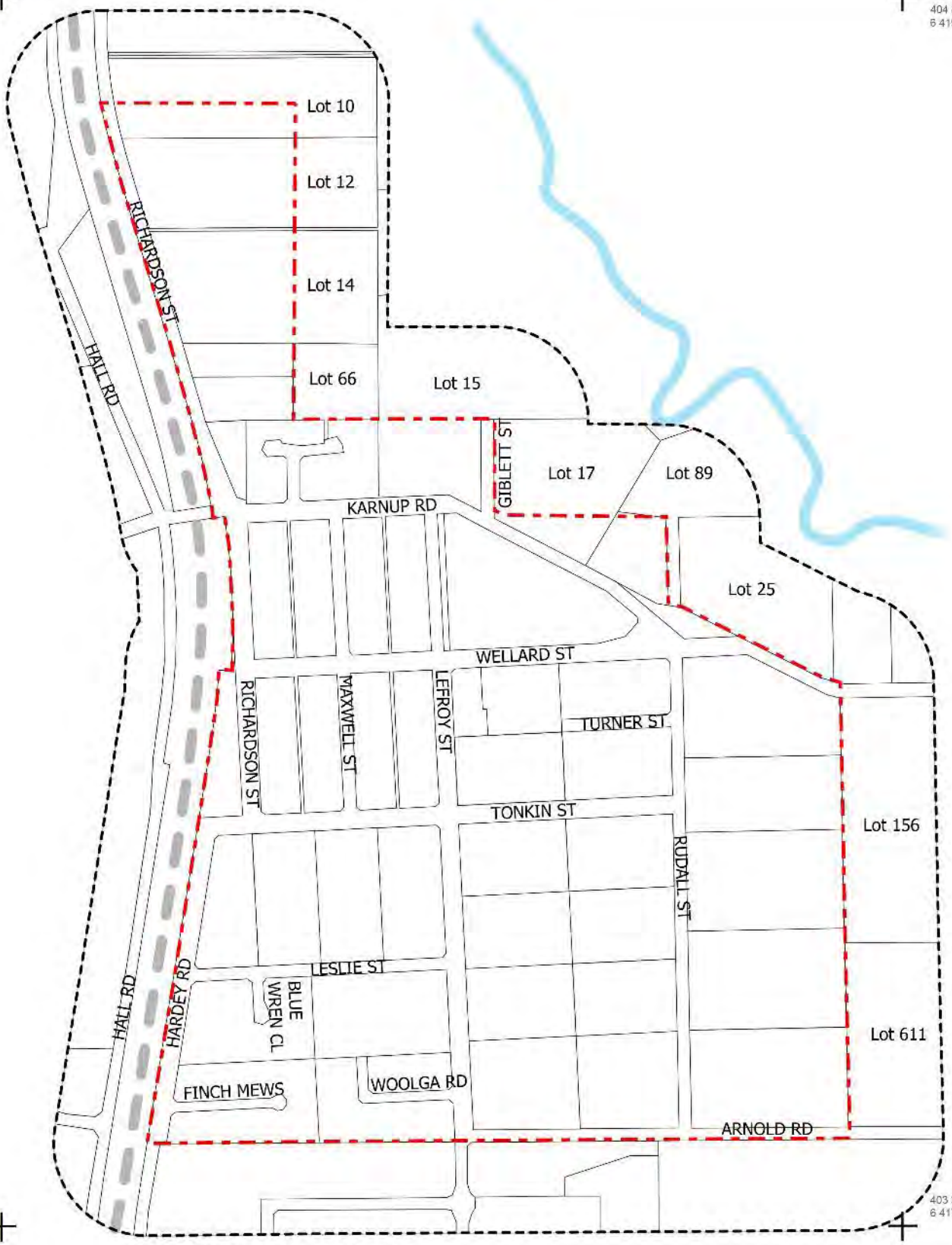
- The Guidelines for Planning in Bushfire Prone Areas Version 1.3 (December 2017); and
- The Bushfire Protection Criteria being Appendix 4 of the Guidelines.

The objectives for this assessment are:

1) To examine and determine the suitability of areas for development;
2) To identify areas that require a more detailed analysis before any development / subdivision occurs;
3) To identify any bushfire management issues and any spatial impact of such issues which should be considered in the preparation of a structure plan; and
4) To document how the recommendations of this assessment can be implemented in the relevant planning stages.

The assessment has been prepared in accordance with the Guidelines and this has included site inspections, review of background material and previous reports. It is noted that the consultant did not have any authority to enter private property and all inspections were conducted from public areas. Where an area could not be physically inspected the vegetation type and hazard rating has been assigned on the basis of the surrounding complexes.

The Study Area includes the subject land for the STLSP and a 150m radius / buffer of the structure plan boundary.



LEGEND

STRUCTURE PLAN BOUNDARY

STUDY AREA

GEO REFERENCE

SERPENTINE RIVER

RAILWAY LINE

FIGURE 1
SUBJECT LAND

BPAD Bushfire Planning & Design Accredited Practitioner Level 2

N

Job No 19-043

Rev	Description	Date
A	Preliminary	06/09/2019

LUSHfire and planning
geoffrey@lushfire.com.au
0418 954873

1.2 Existing Conditions

The existing conditions are shown in Figures 2 and 3.

The townsite is predominantly residential with a small commercial area, service industry and community facilities. The Serpentine Primary School and the nearby Clem Kentish Reserve occupy a large portion of the townsite.

The existing residential lots are generally 2,000sqm in size, except in Wendowie Place on the northern side of Karnup Road which has 1,000sqm lots. The southern portion of the study area has 2 hectare lots with the lots on the eastern side of Rudall Street being 4 hectares. The northern portion of the study area has large lots varying between 1 and 10 hectares.

There are a number of crown reserves as documented in Table 1. These are for a variety of purposes including bushland areas such as the Lambkin, Bradey and Paul Robinson nature reserves. The Serpentine golf course, and showgrounds / pony club provide a large open space on the western boundary of the study area. The Serpentine River is situated to the north and north east of the study area providing a natural demarcation boundary. Hardey's Creek drain is situated on the eastern side of Rudall Street. There is also a 1.1ha area of Unallocated Crown Land on the corner of Richardson Street and Hardey Road.

The study area contains five types of habitat being:

- Completely cleared pasture;
- Parkland cleared Marri;
- Parkland cleared creeklines with exotic Eucalyptus Species;
- Native Woodland over Low Heath; and
- Low Heath and Weeds (Railway Reserve).

Most of the study area has been cleared with remnant native vegetation located in reserves, the railway line corridor and fragmented parcels in private property. There is prominent planted vegetation on private property such as windbreaks. The larger lots within and adjacent to the study area are generally cleared grazing land. The vegetation classifications are documented in Section 3.1 with the vegetation generally being forest, shrubland, grasslands with some smaller areas of woodland and scrub.

The topography is characterised as being relatively flat (less than 1 degree) varying between approximately 30m AHD in the north-west corner to 35m AHD in the middle of the site. Much of the study area is low lying and subject to water logging and there are defined wetlands within the study area.

The townsite is not sewered but has other services including fire hydrants as shown in Figure 3.

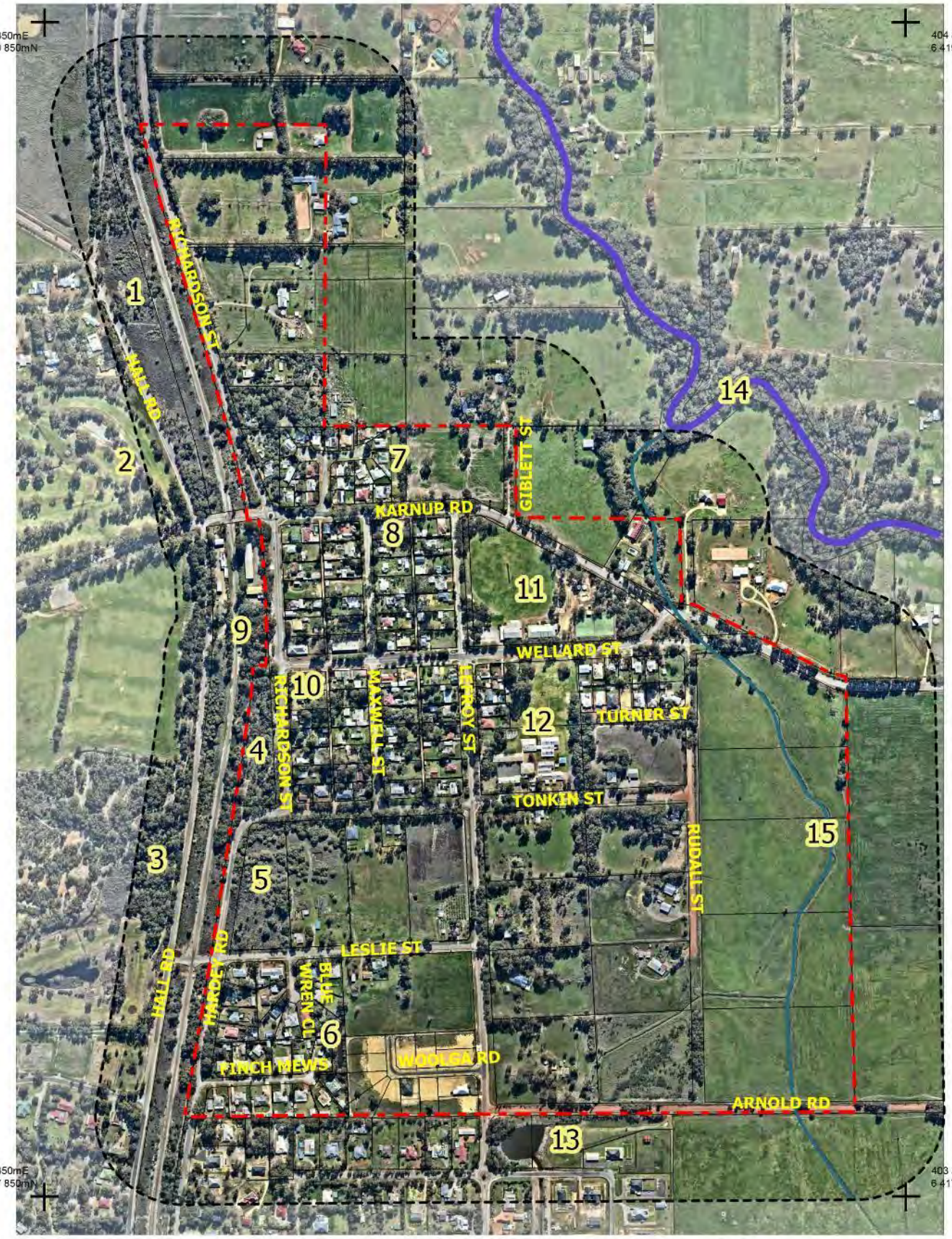
The study area has excellent district access with the South Western Highway being located 1km east of the town centre. Karnup Road is a regional distributor road extending from the South Western Highway, west to the Kwinana Freeway and Baldivis. Arnold Road on the southern boundary is a formed gravel road which also connects to the South Western Highway. Richardson Road north of the study area connects into Wright Road which provides district access to Mundijong. Hall Road extends for 5kms south of the study area along the western side of the railway line before connecting into Fischer Road which then extends east to the South Western Highway.

While the existing road reserves within the study area are generally 20m wide it is noted that Wellard Road, Lefroy Street, Tonkin Street and Richardson/Hardey Roads all have 30m wide reservations.

Table 1 Reserves with the Study Area

No	Class	Purpose	Name	Managing Agency	Area (ha)
9046	C	Bush Fire Brigade		Shire of Serpentine Jarrahdale	0.2023
9157	C	Recreation		Shire of Serpentine Jarrahdale	4.5254
23619	C	School		Department of Education	3.291
32352	C	Conservation	Lambin	Conservation Commission	1.7553
42543*	C	Recreation		Shire of Serpentine Jarrahdale	3.9205
43564	C	Recreation	Spencer	Shire of Serpentine Jarrahdale	0.3196
43911	C	Recreation & Drainage		Shire of Serpentine Jarrahdale	0.3649
46587*	C	Conservation	Bradby	Conservation Commission	2.1721
51259	C	Community Centre		Shire of Serpentine Jarrahdale	0.2023
51302*	C	Drainage		Shire of Serpentine Jarrahdale	1.9333

(*) Located in the adjacent 150m buffer area.



LEGEND

STRUCTURE PLAN BOUNDARY

STUDY AREA

GEO REFERENCE

1) BRADEY RESERVE
2) GOLF COURSE
3) PAUL ROBINSON RESERVE
4) UCL
5) LAMBKIN RESERVE
6) DRAINAGE
7) SPENCER RESERVE
8) FIRE BRIGADE
9) RAILWAY STATION
10) COMMUNITY CENTRE
11) SPORTS OVAL & HALL
12) SCHOOL
13) DRAINAGE
14) SERPENTINE RIVER
15) HARDEY CREEK

FIGURE 2
EXISTING CONDITIONS

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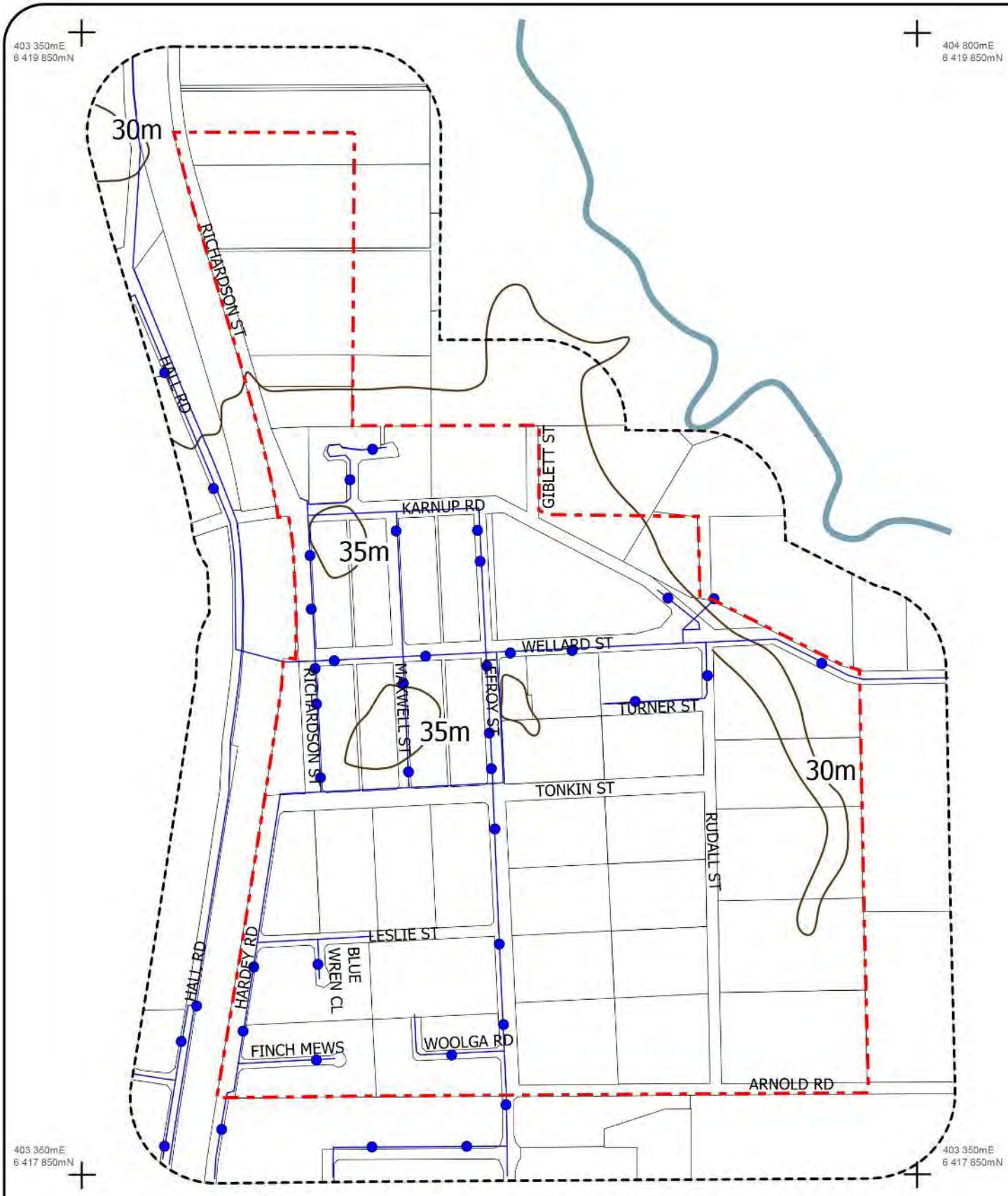

LEGEND

STRUCTURE PLAN BOUNDARY

STUDY AREA

GEO REFERENCE

WATER MAIN AND HYDRANT

5m CONTOUR

FIGURE 3
WATER AND CONTOURS

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Forest vegetation

Shrubland less than 2m height

Grassland, pasture

1.3 Town Planning (Local)

The study area is predominantly zoned 'Urban Development' with some land reserved for 'Parks and Recreation' under Town Planning Scheme No. 2. The surrounding land is a mixture of 'Rural', 'Rural Living A', and 'Parks and Recreation'.

The Draft Local Planning Strategy and Local Planning Scheme No 3 were advertised for public comment until the 18th December. The study area maintains similar zoning provisions noting that the 'Rural Living A' areas are to be zoned 'Rural Residential' and that Special Control Area No 2 (Darling Scarp Landscape Protection) extends along the Serpentine River corridor to Karnup Road.

There are number of Local Planning Policies which are applicable to the proposal and this report as summarised below:

- Local Planning Policy No. 4 - Revegetation (LPP 4) which seeks to facilitate the revegetation of cleared land, encouraging the use of local native flora. It emphasises the importance of revegetation as a planning consideration when determining planning proposals. The policy applies to all development and subdivision proposals in the Shire.
- Local Planning Policy No. 6 - Water Sensitive Design (LPP 6) which seeks to ensure that best practice in water sensitive design is incorporated in structure planning, subdivision design and development. The implementation of this objective depends upon networks of Multiple Use Corridors, which serve an environmental function incorporating water quantity and quality management, nature conservation, ecological preservation, recreation, and education.
- Local Planning Policy No. 8 - Landscape Protection (LPP 8) which aims to maintain the integrity and preserve the amenity of landscape considered to be of high value, identifying a Landscape Protection Area.
- Local Planning Policy No. 26 - Biodiversity Planning (LPP 26) which seeks to recognise the importance of biodiversity conservation as a consideration in the planning process. When a structure plan or changes to a structure plan is proposed, consideration must be given to the impact on local biodiversity targets which are outlined by LPP 26.
- Local Planning Policy No. 67 - Landscape and Vegetation (LPP 67) which seeks to integrate landscape and vegetation with land use planning processes to ensure that the required information and detail is provided throughout the process. The policy also provides guidance regarding the Shire's expectations of landscaping.

The Shire has also prepared an Urban and Rural Forest Strategy 2018 - 2028 which seeks to maintain and improve tree canopy and vegetation as a key component of the natural environment and lifestyle of the municipality.

There are no Local Planning Policies relating to bushfire management and development.

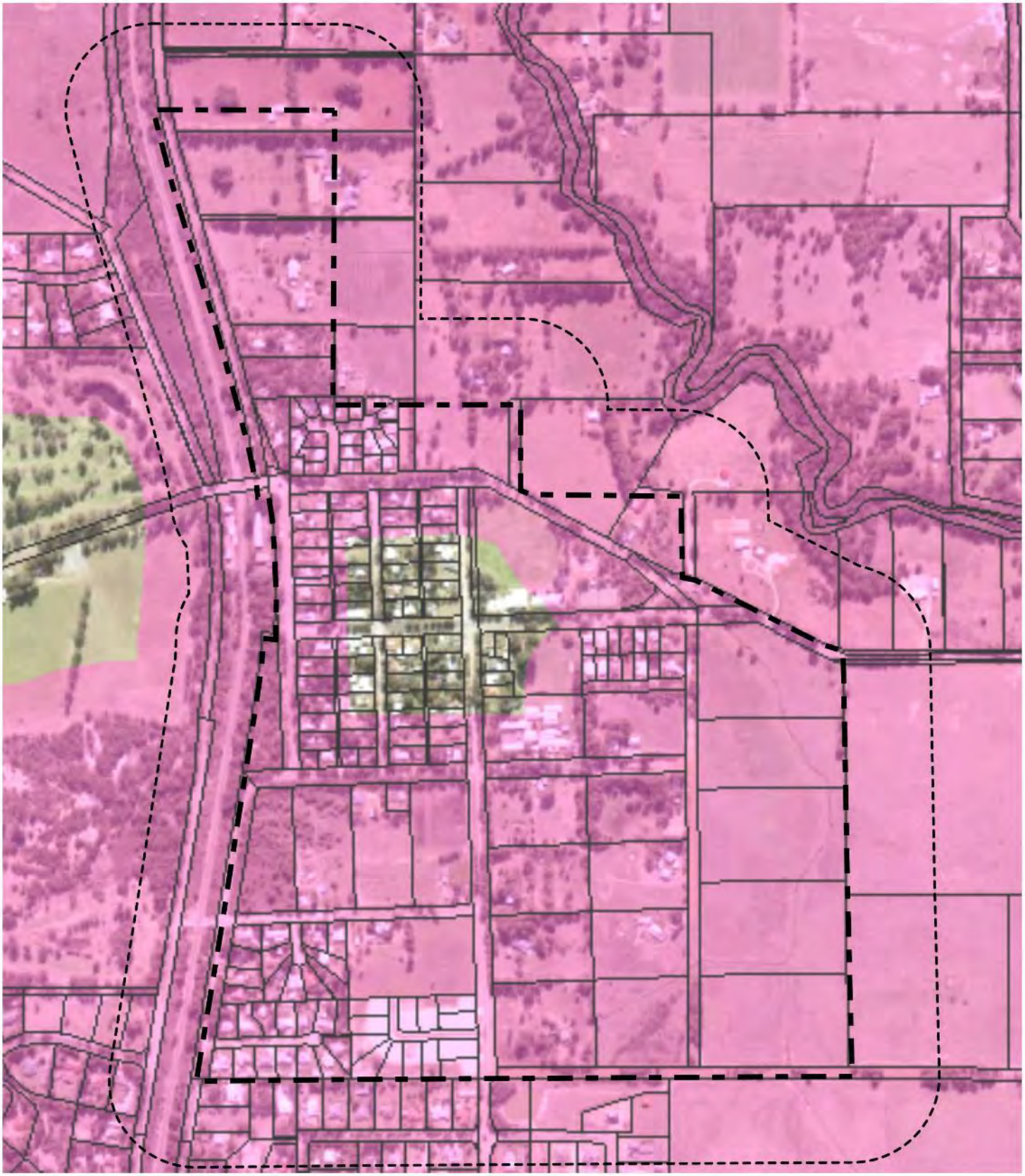
1.4 SPP3.7 Planning in Bushfire Prone Areas

The majority of the study area is designated as being Bushfire Prone Land as shown in Figure 4. Bushfire prone areas are comprised of:

- Bushfire prone vegetation; and
- A 100m wide bushfire prone buffer.

The designation of bushfire prone areas triggers:

- The application of Australian Standard AS3959 Construction of Buildings in Bushfire Prone Areas under the Building Code of Australia;
- The provisions of the Planning and Development (Local Planning Schemes) Regulations 2015; and
- The application of SPP3.7 Planning in Bushfire Prone Areas.



LEGEND

STRUCTURE PLAN BOUNDARY

STUDY AREA

BUSHFIRE PRONE LAND 2019

FIGURE 4
BUSHFIRE PRONE LAND

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Clause 6.2 of SPP 3.7 provides that any strategic planning proposal (structure plan) or subdivision may be considered for approval where on completion, it will have a moderate Bushfire Hazard Rating and/or where BAL-12.5 to BAL-29 rating applies.

Clause 6.3 and 6.4 then set out the information which is to accompany a structure plan or subdivision application being:

a) a Bushfire Hazard Level (BHL) assessment or a BAL Contour Map to determine the indicative acceptable BAL ratings across the subject site, in accordance with the Guidelines;

b) the identification of any bushfire hazard issues arising from the BHL and/or BAL Contour Map; and

c) an assessment against the bushfire protection criteria requirements contained within the Guidelines demonstrating that the proposal can comply with the criteria in subsequent planning stages, including a subdivision application.

Table 7 (Appendix 5) in the Guidelines provides a checklist and the level of detail that a Bushfire Management Plan is required to provide at the different planning stages. The requirements for structure plans and subdivision applications are documents in Table 2.

Table 2 BMP Requirements

SECTIONS		**Structure Plans**	**Subdivision**
Coversheet		**Yes**	**Yes**
Executive Summary		**Optional**	**Optional**
1.0	**Proposal details**	**Yes**	**Yes**
2.0	**Environmental considerations**		
2.1	Vegetation clearing	**Yes**	**Yes**
2.2	Landscaping	**Yes**	**Yes**
3.0	**Bushfire assessment results**		
3.1	Assessment inputs	**Yes**	**Yes**
3.2	Assessment outputs		
	BHL assessment	**Yes**	
		or	
	BAL contour map	**Yes**	**Yes**
			or
	BAL assessment		**Yes**
4.0	**Bushfire hazard issues**		
		Yes	**Yes**
5.0	**Assessment against Bushfire Protection Criteria**		
5.1	Compliance Table	**Yes**	**Yes**
5.2	Additional Management Strategies	**Optional**	**Optional**
6.0	**Implementation**	**Yes**	**Yes**

1.5 Position Statement - Elements 1 and 2

In November 2019, the Western Australian Planning Commission published a Position Statement for demonstrating compliance with Element 1: Location and Element 2: Siting and design of the Bushfire Protection Criteria. The intent of the Position Statement is to provide clarity and guidance for planning proposals in an area with a bushfire hazard level (BHL) of extreme and/or where the lot(s) is impacted with a bushfire attack level (BAL) rating of BAL-40 or BAL-Flame Zone (BAL-FZ).

Policy measure 6.7 of SPP 3.7 states strategic planning proposals, which will result in the introduction or intensification of development or land use in an area that has or will, on completion, have a BHL of extreme and/or a BAL of BAL-40 or BAL-FZ, will not be supported unless the proposal is considered to be minor or unavoidable development. The Position Statement addresses the situation where a development site might have a BAL-29 or lower rating but there is still a BAL-40 or BAL-FZ rating on portions of the property.

To demonstrate compliance with acceptable solution A1.1 consideration should be given to the site context. The hazards remaining within the site should not be considered in isolation of the hazards adjoining the site.

The areas of BAL-40 or BAL-FZ, within the study area should not create isolated pockets of developable land.

In relation to a structure plan where Element 1 is satisfied, the decision-maker may consider approving lot(s) containing BAL-40 or BAL-FZ in specific circumstances and these are documented in in Section 4.6. This Position Statement has now been superseded by the introduction of Version 1.4 of the Guidelines in December 2021.

1.6 Bushfire Framework Review 2019

The State Government is currently undertaking a review of the Bushire Policy Framework which includes:

- A new mapping methodology for bushfire prone land; and
- A review of State Planning Policy 3.7 Planning in Bushfire Prone Areas and the Guidelines for Planning in Bushfire Prone Areas.

The review will also finalise the current revisions to Element 3 Access which was released in early 2019. One of the key features of this is that DFES is seeking to have an increased horizontal clearance for all public roads which will include a 2.5m wide "traversable verge" on either side of the carriage way. The minimum road reserve width will be 12m. However, the "traversable verge" would have to be kept clear of any obstructions which may potentially include street trees, landscaping, swale drains or footpaths. There are significant implications for this in terms of urban design.

While the review is not expected to be completed until the end of 2020, information relating to this will be progressively released for public comment. The Planning Commission is expected to release a strategic directions paper early in 2020.

The review is considering the recommendations from the Buti Report (1) which recognised that the contextual risk to human life in the built-up urban areas on the Swan Coastal Plain is not the same as largescale heavily vegetated areas on the urban fringe. This is because in built-up urban areas there are multiple points of access/egress, increased opportunities for surveillance and early detection, greater ability for emergency services to respond, greater access to water and fewer and more restricted areas where bushfires with large fire runs can become established.

1 Dr Tony Buti MLA (2019) Bushfire Planning and Policy Review State Government Printer Perth

1.7 Firebreak and Fuel Hazard Reduction Notice

The 2019 / 2020 Firebreak and Fuel Hazard Reduction Notice requires that on land less than 4,047m² (1 acre) landowners shall by the 1st December either:

(a) Cut all grass to less than 25mm in height and trim all trees and bushes that overhang driveways, access ways and firebreaks to leave a 4 metre wide clearance and a clear vertical axis; or

(b) Install firebreaks that are:
- Immediately inside all external boundaries.
- Immediately surrounding all agricultural buildings, sheds or group of buildings.
- A minimum of 3 metres wide, but not wider than 5 metres.
- Trim all trees and bushes that overhang driveways, access ways and firebreaks to leave a 4 metre wide clearance and a clear vertical axis.

All dwellings are to maintain 20m asset protection zones or as per your approved BAL/FMP assessment; with all trees overhanging buildings trimmed back.

The Notice also stipulates that any applicable Bushfire Management Plan; Emergency Management Plan; or Bushfire Attack Level (BAL) assessment are to be complied with throughout the entire year. This includes maintenance of low threat vegetation.

1.8 Proposed Development

The draft structure plan design for the subject land is shown in Figure 6 and a revised layout for Lots 102-106 Rudall Street is shown in Figure 7. It is estimated that approximately 250 additional residential lots will be created at a residential density of R5. This has a minimum lot size of 2,000sqm and a frontage of 30m as the development will not be sewered.

The subdivision design promotes the existing grid road layout and provide a highly connected and walkable local movement network. There is a presumption against the use of cul-de-sacs. Development proposals within the Local Structure Plan area shall consider and seek to preserve view corridors and visual amenity.

Local Development Plans are proposed for the following areas:

a) Richardson Street (Lot 84; Lot 1; Lot 82; part of Lot 14; part of Lot 12; part of Lot 10). This area is adjacent to Bush Forever, proximity to railway line and abuts public open space / drainage.

b) Karnup Road (part of Lot 17; part of Lot 18). This area has an irregular lot shape.

c) Rudall Street (part of Lot 102). This area abuts public open space / drainage.

d) Arnold Road (Lot 98; part of Lot 106). This area abuts public open space / drainage.

The following investigations and management plans may be required at time of subdivision:

- Urban Water Management Plan/s (aligning with the Local Water Management Strategy);
- Environmental Management Plan/s;
- Public Open Space Management Plan/s;
- Fire Management Plan/s;
- Acoustic Report (addressing noise impacts from the railway line);
- Wetland Assessment/s and/or Wetland Management Plan/s; and
- Site specific (buffer) study/technical information if required in accordance with the Environmental Protection Agency's 'Guidance for the Assessment of Environmental Factors - Separation Distances between Industrial and Sensitive Land Uses'.

A detailed wetland assessment is to be undertaken to determine the values and boundaries of existing wetland environments. In addition, a site specific wetland buffer study should be undertaken to determine the necessary buffer to protect the Conservation Category Wetland on Lot 122 Tonkin Street.

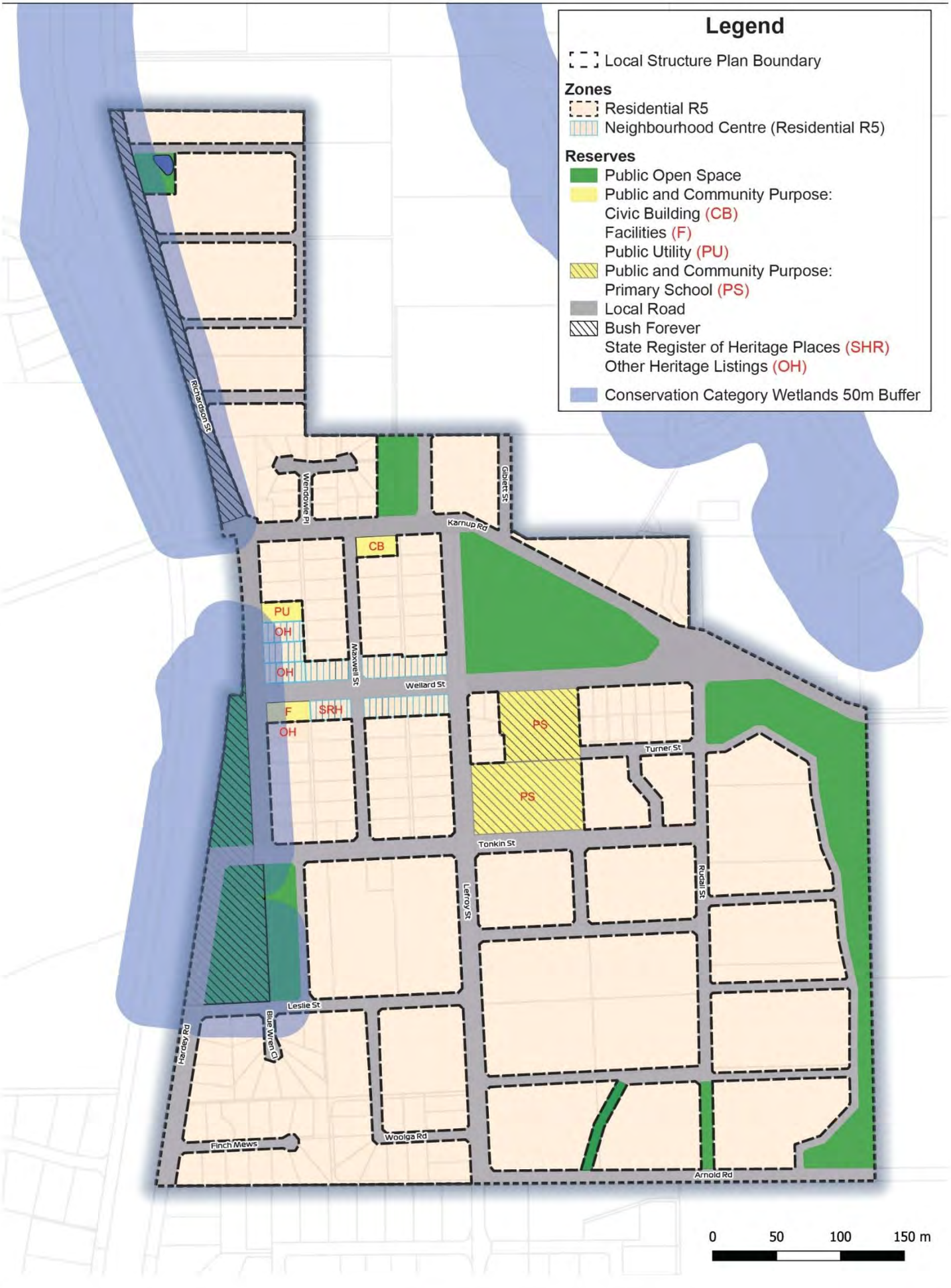

FIGURE 5
STRUCTURE PLAN MAP 1

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A	Preliminary	06/09/2019
B	Final App Mods	02/11/2022

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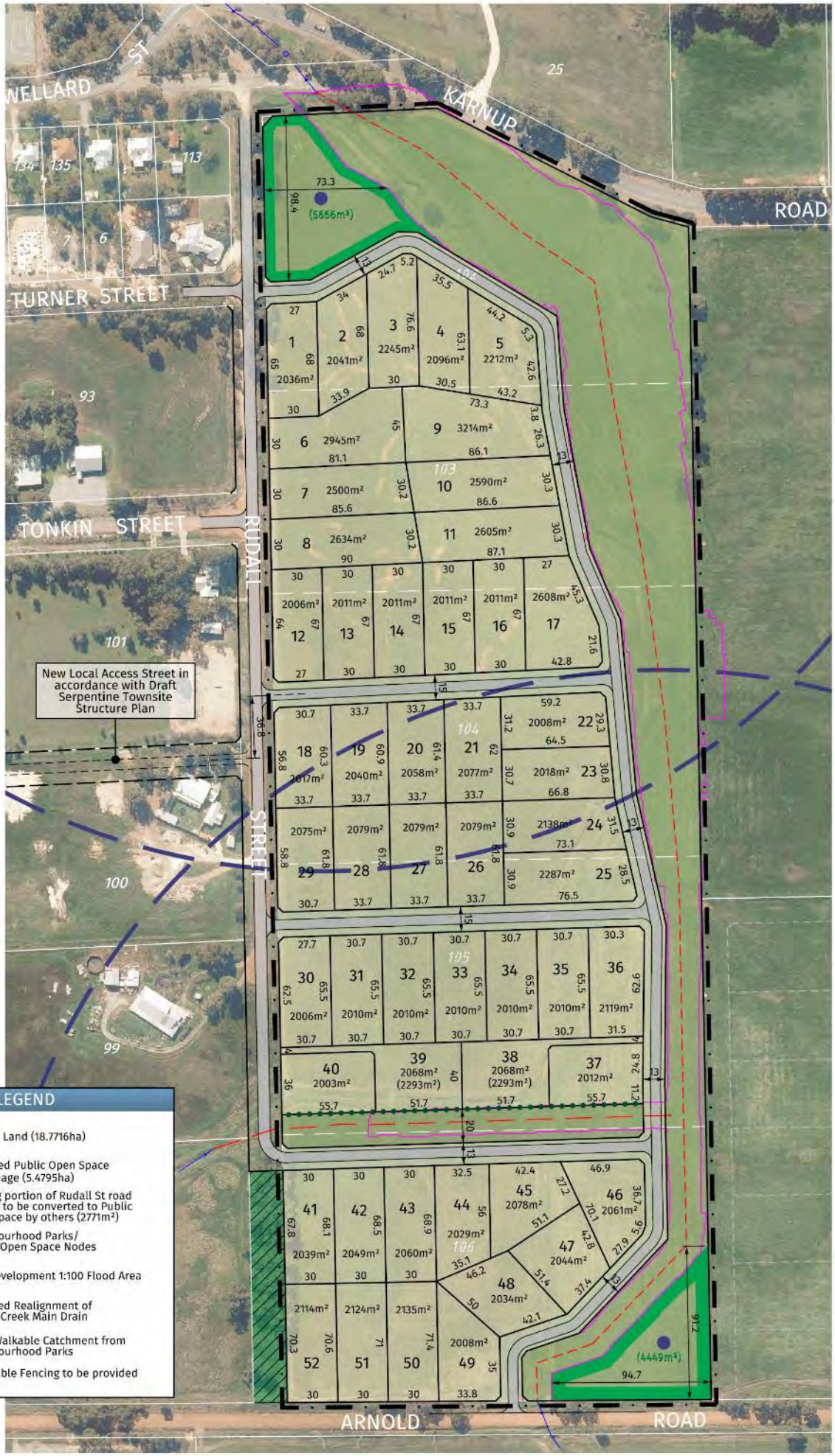

FIGURE 6
STRUCTURE PLAN MAP 2

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Job No 19-043

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2.0 Environmental Considerations

2.1 General

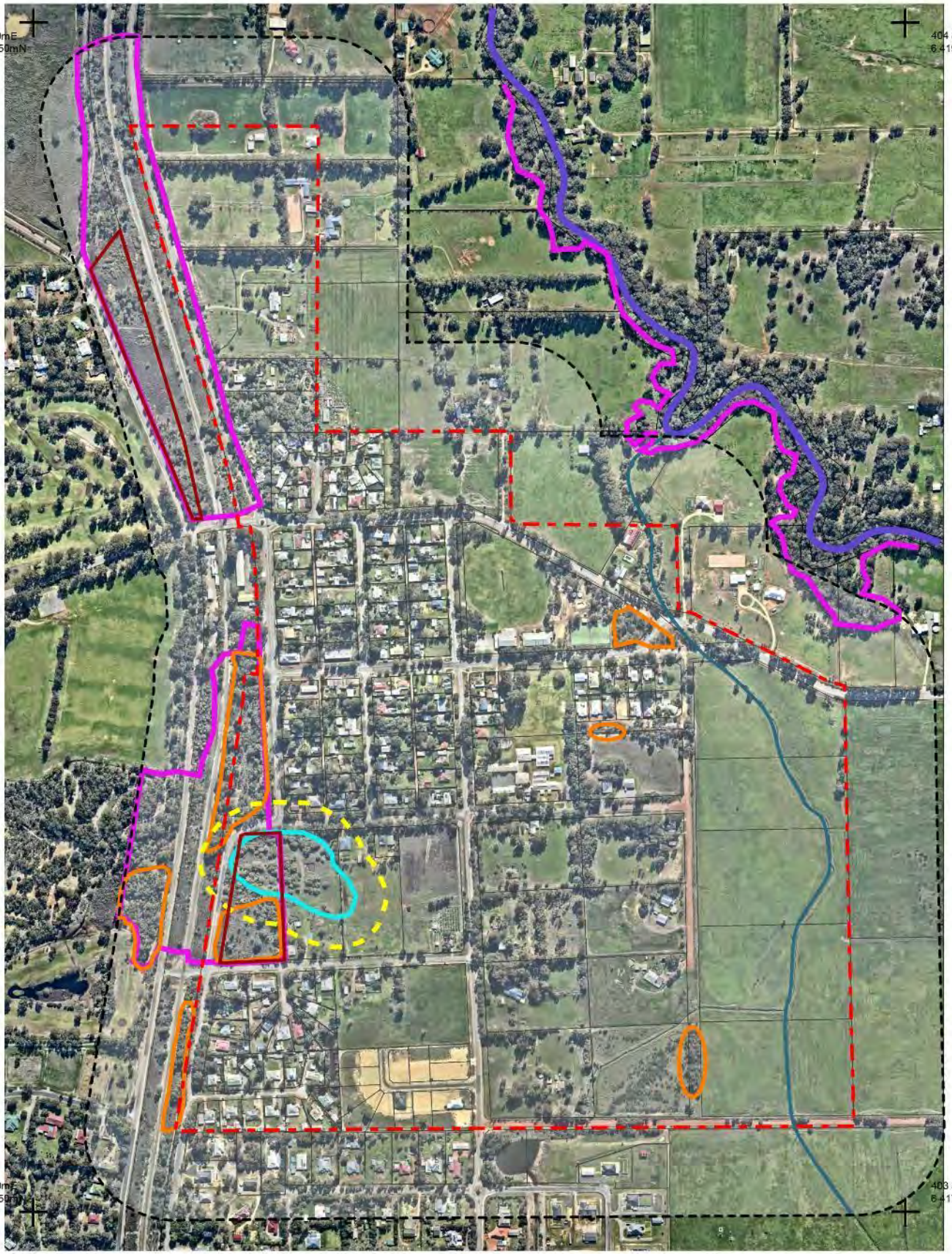
The identified environmental issues are shown in Figure 8 and these include:

- Declared Rare and Priority Flora sites;
- Multiple Bush Forever Sites;
- Conservation category wetlands;
- Environmentally Sensitive Areas;
- Crown reserves for conservation (see Table 1); and
- Areas with high quality vegetation.

The vast majority of the study area is an Environmentally Sensitive Area which limits the clearing of vegetation under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (Regulations). Other exemptions as contained in Schedule 6 of the Environmental Protection Act 1986, still apply.

The features have been documented in the environmental report prepared by PGV Environmental December 2013. The conclusions and recommendations which are relevant to this BMP are:

1) Rehabilitation of the existing and proposed constructed drainage channels (Hardey's Main Drain) has the potential to increase the ecological value and linkage over the site.
2) Native endemic species should be established in drainage channels prior to the present exotic species being removed to ensure the banks remain stable.
3) The site has two Conservation Category Wetlands on the site and one adjacent that could be impacted by development.
4) The generic 50m buffers to the Conservation Category Wetlands already contain established home-sites and therefore the existing boundaries for the retained vegetation should be maintained. Development adjacent to wetlands and wetland vegetation should meet Bushfire Attack Levels that do not require any change to the Wetland vegetation attributes and drainage controls that do not significantly alter the current wetland hydrology.
5) Drainage corridors open space and road reserves can be enhanced by planting native species.
6) The current LSP retains the majority of remnant vegetation within the Townsite and this should not change in any updated LSP.
7) Wherever possible, trees should be retained in the LSP area particularly in road reserves and POS.
8) The patch of Marris in the south east of the site in the Rudall Street Road Reserve should be retained which will involve the road reserve being closed and designated as POS.
9) There are Declared Rare and Priority Flora within the bushland areas on the site which are to be retained.
10) It is highly unlikely any Declared Rare and Priority Flora are present outside of the bushland areas.
11) There are TECs present on the site in the bushland areas to be retained.
12) Consideration will need to be given to retaining Marri trees to protect habitat for the three species of Black Cockatoo.
13) Retention of trees to be encouraged during subdivision.



LEGEND

STRUCTURE PLAN BOUNDARY	BUSH FOREVER SITE	IMPORTANT VEGETATION
STUDY AREA 150m Buffer	CONSERVATION RESERVE	SERPENTINE RIVER
GEO REFERENCE	CONSERVATION WETLAND	HARDEY'S DRAIN
	50m BUFFER	

FIGURE 7
ENVIRONMENTAL FEATURES

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2.2 Native Vegetation Modification and Clearing

The potential subdivision and development will be focus on the large lots within the study area, rather than the 2,000sqm lots in the existing town centre. The creation of the subdivision roads, provision of services, and filling of land is likely to result in the removal of the existing vegetation in these areas as shown in Figure 8. This is a mixture of both remnant vegetation and planted species especially where being used as boundary windbreaks.

2.3 Re-vegetation / Landscape Plans

There are no specific revegetation plans within the structure plan other than general references to vegetation protection, the biodiversity strategy and areas and in road/entry areas.

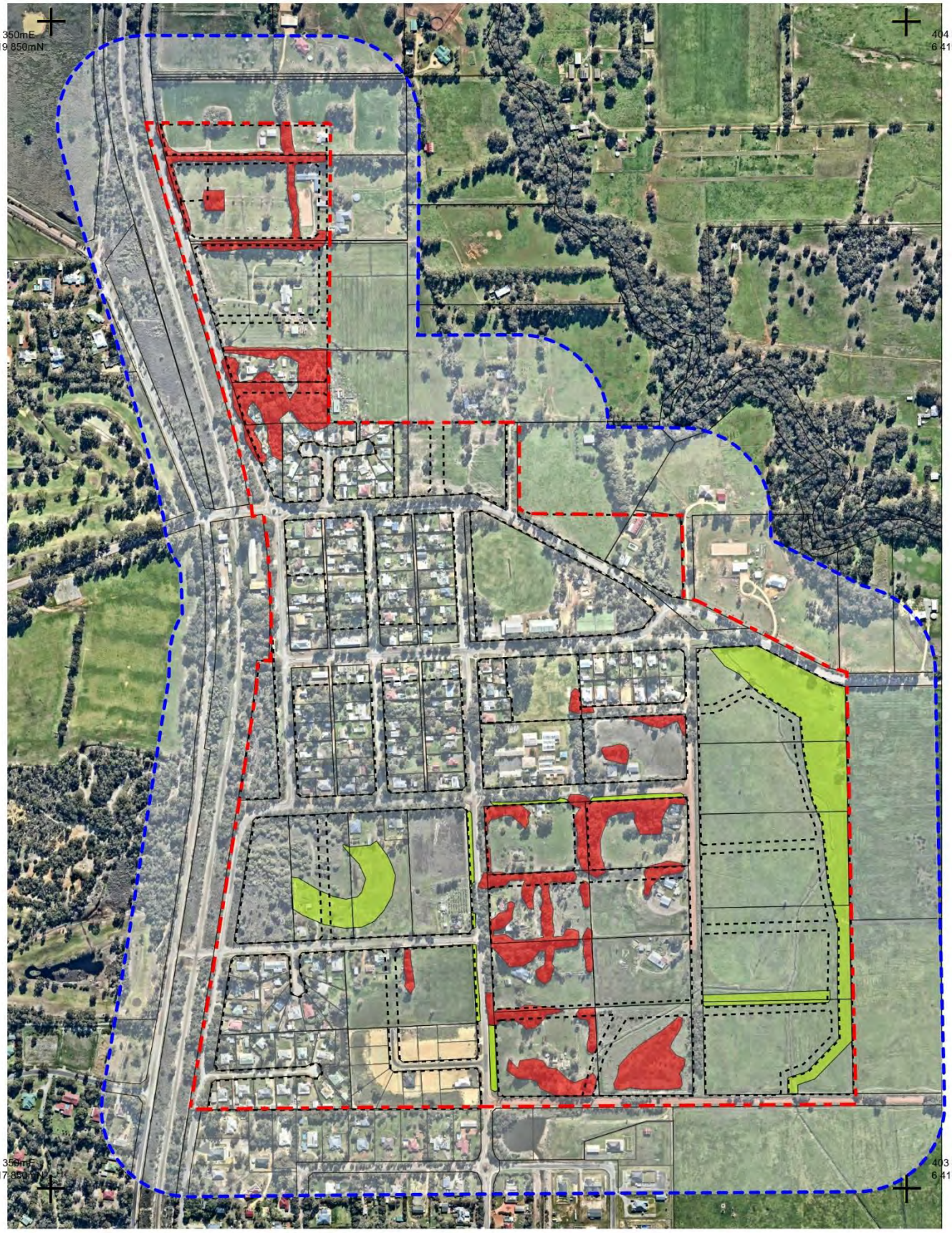
A wetland buffer study is recommended to be undertaken to determine the necessary buffer to protect the Conservation Category Wetland on Lot 122 Tonkin Street.

The promotion of Water Sensitive Urban Design principles includes the use of plants features in roads and public open spaces. The recommended plants for biorientation swales are predominantly sedges. The recommended plants for infiltration/detention basins include:

- *Melaleuca preissana* - Stout paperbark;
- *Melaleuca rhaphiophylla* - Freshwater paperbark;
- *Melaleuca cuticularis* - Saltwater paperbark;
- *Melaleuca lateritia* - Robin redbreast bush;
- *Banksia littoralis* - Swamp banksia;
- *Banksia seminuda* - River banksia;
- *Eucalyptus rudis* - Flooded gum;
- *Casuarina cunninghamiana* - Casuarina; and
- Various sedges.

The landscaping design of public areas is to enhance and protect the distinctive rural (visual) landscape character and amenity of Serpentine. Tree planting specifications (including species and density) must take into consideration the assigned BAL rating for the nearby residential lots and ensure that the proposed landscaping will not result in any increase in the BAL rating above BAL-29.

Wellard Road, Lefroy Street, Tonkin Street and Richardson/Hardey Road all have 30m wide reservations which offer an opportunity for additional planting. This is likely to be considered as classified vegetation and may result in a BAL rating being applied on the adjoining land.



LEGEND

STRUCTURE PLAN BOUNDARY

STUDY AREA 150m Buffer

GEO REFERENCE

PROPOSED BOUNDARIES

VEGETATION TO BE REMOVED

REVEGETATION

FIGURE 8
VEGETATION MODIFICATION

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3.0 Bushfire Assessment Results

3.1 Assessment Inputs - Vegetation Classification

The classification of the vegetation on and adjacent to the site is shown in Figure 9 and the photographs in Appendix 1. For clarity, Figure 10 shows the vegetation classification without the aerial.

The vegetation within 150m of the subject land has been classified in accordance with:

- Australian Standard AS3959 Construction of Buildings in Bushfire Prone Areas;
- The Visual Guide for Bushfire Risk Assessment in Western Australia; and
- Applicable Fire Protection Australia BPAD Practice Notes.

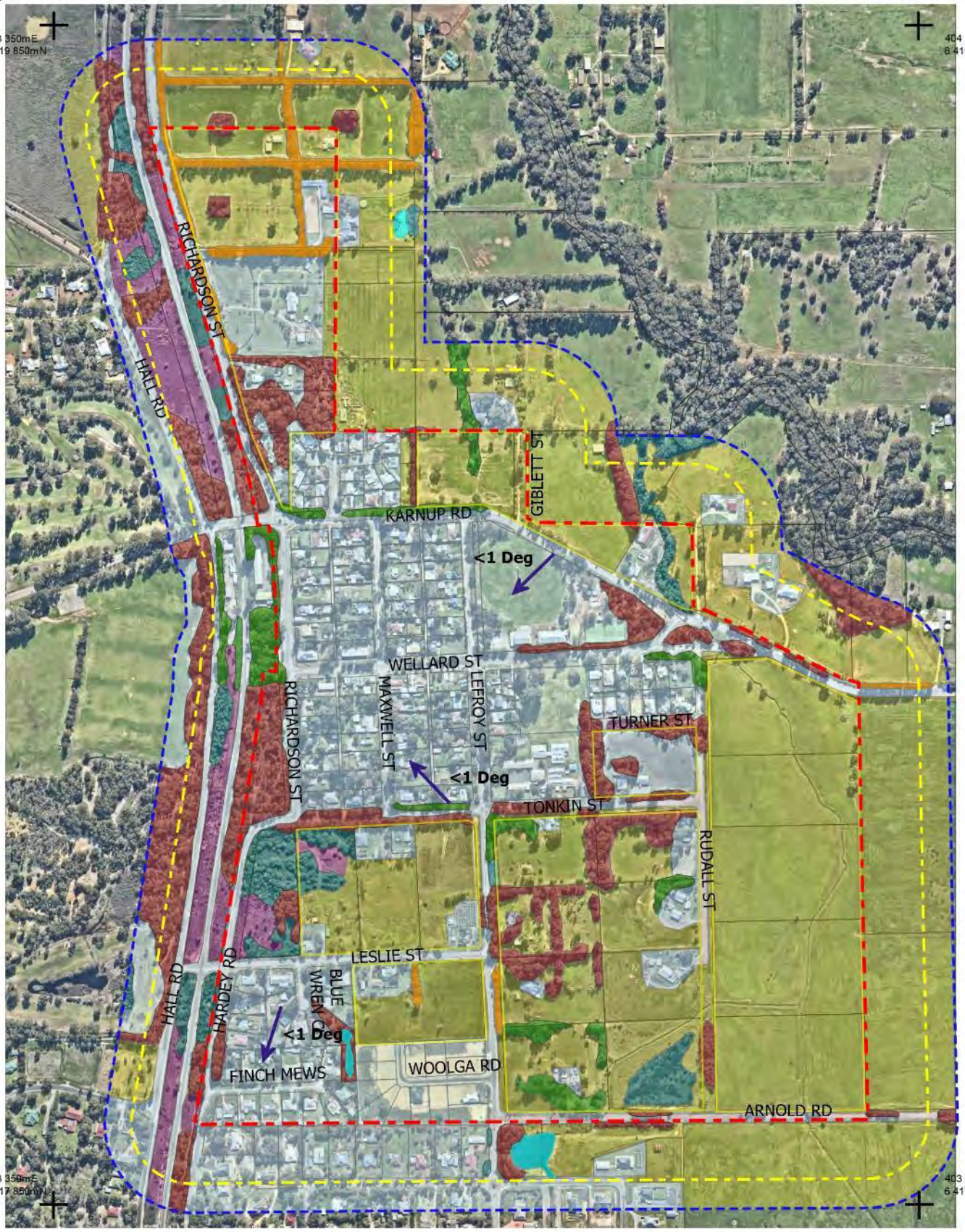
The vegetation classifications are based upon the mature state of the vegetation and associated fuel loads. This is referenced further in Section 4.3.

Given the large size of the study area and that this is a strategic assessment, the vegetation classification is generalised even though it is based upon site inspections. As there was no access to private land some classifications are based upon the surrounding conditions.

It is noted that AS3959 (2018) commenced from the 1st May 2019 and this alters the classification of woodland and scrub. Woodlands are now defined as having a grassy understorey with isolated shrubs while Scrub vegetation (tall heath) has been increased from 4 to 6m height. The classification still has regard to the overstorey height, foliage coverage, flammability, moisture content and fuel load.

The primary area of vegetation hazard is on the western side of the study area being the land on both sides of the railway line. This has all the major vegetation types with some large areas of shrubland being less than 2m in height. To the north the main vegetation is grassland/pasture with boundary windbreaks. The Serpentine River has a corridor of forest vegetation but it is outside of the study area.

The central and eastern portions of the study area also have areas of grassland/pasture, with more significant bushland within many of the lots. The developed townsite lots are considered to be low threat vegetation as they contain managed gardens.



LEGEND

SUBJECT LAND

VEGETATION ASSESSMENT AREA (150m from the external boundary of the study area)

UPSLOPE

VEGETATION CLASS

- A FOREST
- B WOODLAND
- C SHRUBLAND
- D SCRUB
- G GRASSLAND

EXCLUDED Cl 2.2.3.2

- MANAGED LAND
- WINDBREAK
- WATER

Location Details:	Serpentine
Assessment Date:	29/08/2019
Prepared by:	G Lush
Accreditation Level:	Level 2
Accreditation Number:	BPAD 27682
Accreditation Expiry Date:	February 2020
Date of Aerial Photo:	July 2019

FIGURE 9
EXISTING VEGETATION CLASSIFICATION

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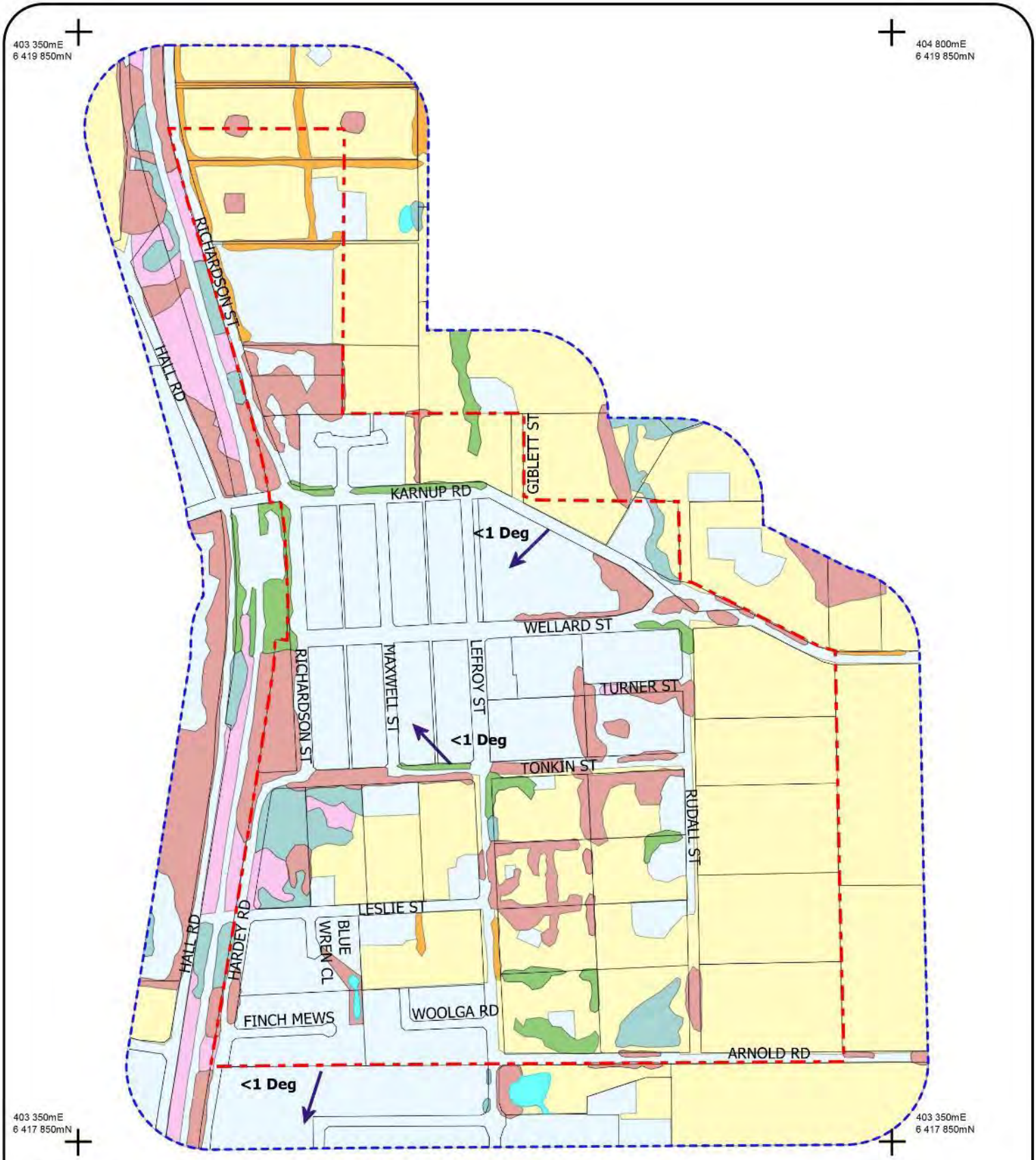

LEGEND

SUBJECT LAND

VEGETATION ASSESSMENT AREA (150m from the external boundary of the study area)

UPSLOPE

VEGETATION CLASS

- A FOREST
- B WOODLAND
- C SHRUBLAND
- D SCRUB
- G GRASSLAND

EXCLUDED Cl 2.2.3.2

- MANAGED LAND
- WINDBREAK
- WATER

Location Details:	Serpentine
Assessment Date:	29/08/2019
Prepared by:	G Lush
Accreditation Level:	Level 2
Accreditation Number:	BPAD 27682
Accreditation Expiry Date:	February 2020
Date of Aerial Photo:	July 2019

FIGURE 10
VEGETATION CLASSIFICATION
NO AERIAL

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Job No 19-043

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3.2 Assessment Outputs

3.2.1 Vegetation Modification

The potential vegetation clearing and revegetation is shown in Figure 8. The revised vegetation classification reflecting the proposed vegetation clearing and revegetation is shown in Figure 11.

This is based upon the following assumptions:

a) It is normally assumed that any designated Bush Forever sites are likely to be rehabilitated and have bushfire prone vegetation extending to their boundaries. Site 365 along the railway line in the northern portion of the site, extends to the eastern boundary of Richardson Road. However, the road verge in the location is very narrow and most of the existing vegetation/windbreaks is located on private property. It has been assumed that there will not be any additional revegetation on the eastern side of Richardson Road.

b) The conservation category wetland in Lambkin Reserve is shown in the environmental report extending into the adjoining Lot 123. This conservation category wetland is normally required to have a 50m revegetated buffer. The wetland is still subject to a boundary definition study and no specifications have been provided for the buffer revegetation. Based upon the existing surrounding vegetation a Scrub classification has been applied to the buffer area.

c) Hardey's Drain is likely to predominantly have reeds and sedges (grassland) as it is an active floodway.

d) Wellard Road, Lefroy Street, Tonkin Street and Richardson/Hardey Road all 30m wide road reserves and provide more opportunity for revegetation in accordance with the Shire Local Planning Policies. While the specifications of this have not been prepared, it has been assumed that this is likely to include understorey vegetation and is likely may have an overall Forest classification.

e) Similarly, some windbreaks may also be further revegetated also then being classified as Forest.

f) Reserve 43911 is the drainage reserve between Woolga Road and Finch Mews. When the area is developed it will not adjoin any classified vegetation and so has been excluded.

3.2.2 BAL Contour Map

A BAL Contour Map is a plan of the subject lot/s illustrating the potential radiant heat impacts and associated indicative BAL ratings in reference to any classified vegetation remaining within 100 metres of the assessment area after the development is completed.

The BAL Contour Map for the study area is shown in Figure 12 and for clarity Figure 13 shows the BAL Contours without the aerial photograph.

In addition to the assumptions outlined above for the vegetation modifications it should also be noted that the BAL Contours are indicative and that:

- The vegetation classification shown in Figure 9, typically includes the tree canopy. A formal BAL assessment may, depending upon the understorey vegetation, be taken from the tree trunk rather than the edge of the canopy. The most common occurrence of this is where the tree canopy overhangs a property boundary including a road reserve. Hence the actual setbacks for the BAL ratings may be closer than as shown.
- Given the large size of the study area and very low slopes of less than 1 degree, an overall effective slope of 'flat land' has been used.
- The BAL Contour Map is a strategic assessment to assist in the identification of relevant issues and the formulation of the structure plan. Any subsequent subdivision application must confirm the actual vegetation and relevant revegetation/landscape specifications. The BAL Contour Map is not to be used for BAL Assessments for individual development applications.

There are a number of instances where the BAL-FZ/40 ratings encroach into the development cells and the issues associated with these are discussed in Section 4.0.

LEGEND

SUBJECT LAND

VEGETATION ASSESSMENT AREA (150m from the external boundary of the study area)

UPSLOPE

VEGETATION CLASS

- A FOREST
- B WOODLAND
- C SHRUBLAND
- D SCRUB
- G GRASSLAND

EXCLUDED Cl 2.2.3.2

- MANAGED LAND
- WINDBREAK
- WATER

Location Details:	Serpentine
Assessment Date:	29/08/2019
Prepared by:	G Lush
Accreditation Level:	Level 2
Accreditation Number:	BPAD 27682
Accreditation Expiry Date:	February 2020
Date of Aerial Photo:	July 2019

FIGURE 11
MODIFIED VEGETATION CLASSIFICATION

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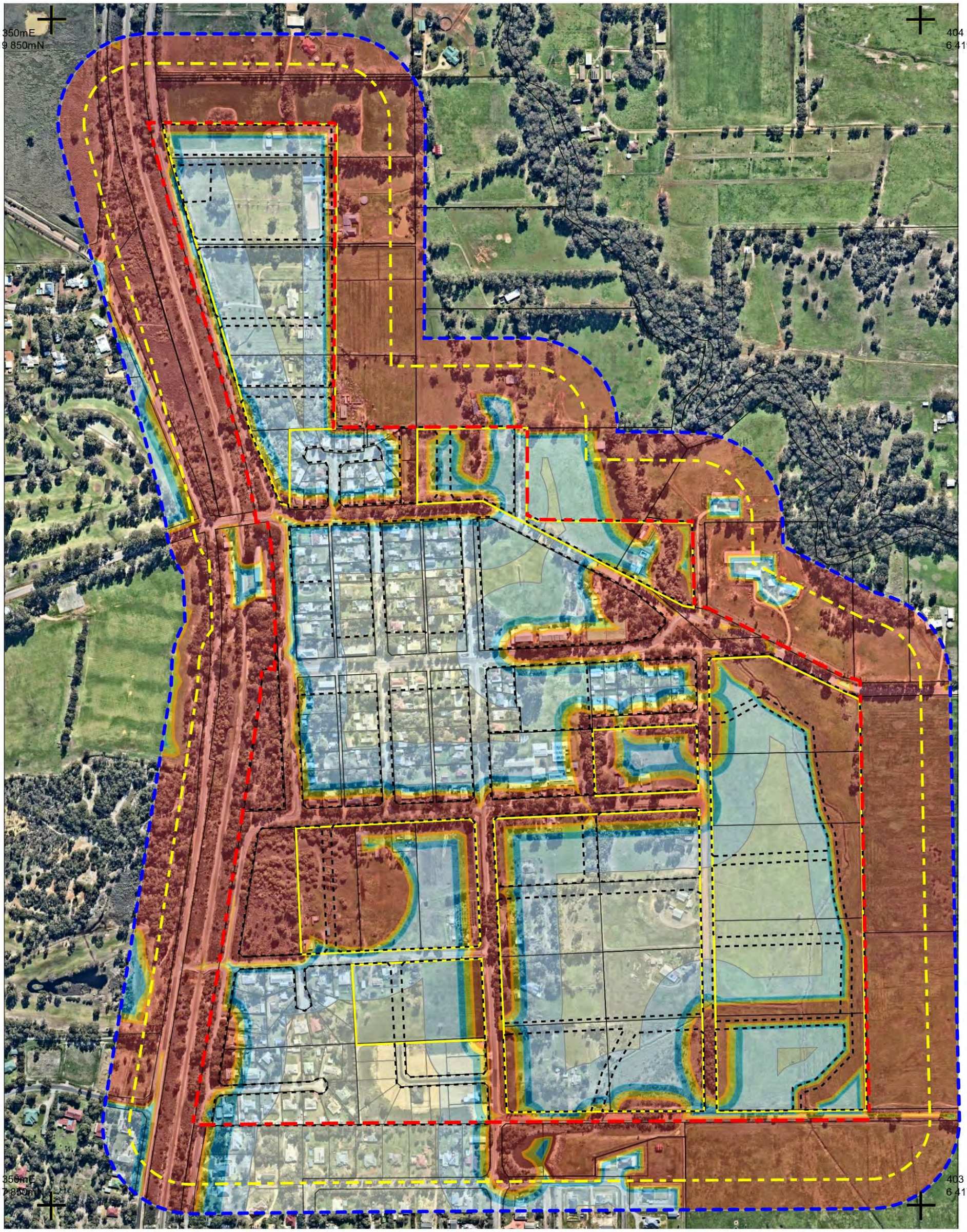

LEGEND

SUBJECT LAND

VEGETATION ASSESSMENT AREA (150m from the external boundary of the subject land)

BAL ASSESSMENT AREAS (100m from the external boundary of the subject land)

PRIMARY DEVELOPMENT CELLS

PROPOSED BOUNDARIES

VEGETATION PLOTS

NOT TO BE USED FOR INDIVIDUAL BAL ASSESSMENTS.

INDICATIVE BUSHFIRE ATTACK LEVELS

BAL - FZ		BAL - 19	
BAL - 40		BAL - 12.5	
BAL - 29		BAL - Low	

FIGURE 12
BAL CONTOUR MAP

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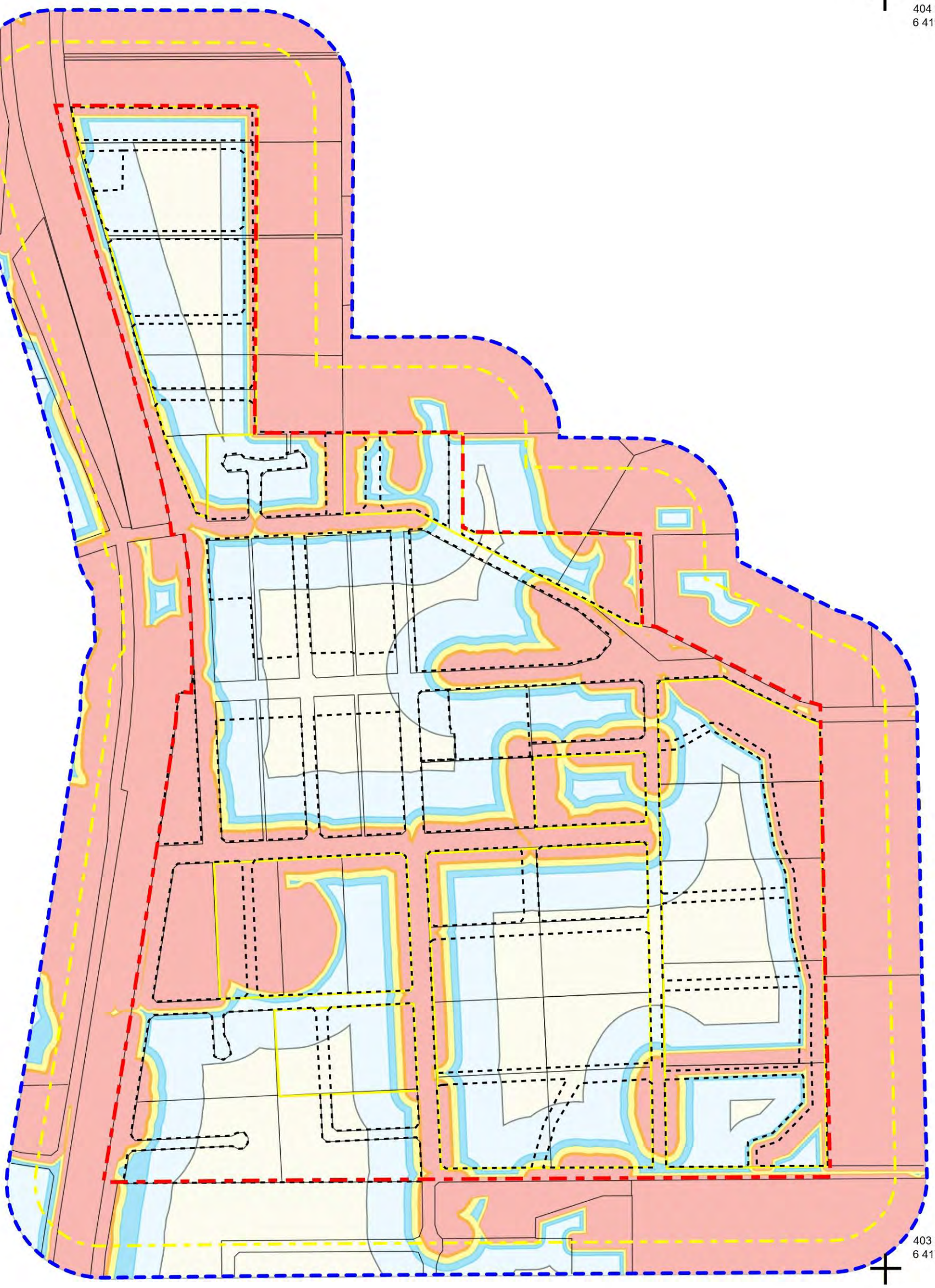
403 350mE
6 419 850mN

404 800mE
6 419 850mN



403 350mE
6 417 850mN

403 350mE
6 417 850mN

LEGEND

SUBJECT LAND

VEGETATION ASSESSMENT AREA (150m from the external boundary of the subject land)

BAL ASSESSMENT AREAS (100m from the external boundary of the subject land)

PRIMARY DEVELOPMENT CELLS

PROPOSED BOUNDARIES

VEGETATION PLOTS

NOT TO BE USED FOR INDIVIDUAL BAL ASSESSMENTS.

INDICATIVE BUSHFIRE ATTACK LEVELS

BAL - FZ
BAL - 40
BAL - 29
BAL - 19
BAL - 12.5
BAL - Low

FIGURE 13
BAL CONTOUR MAP
NO AERIAL

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4.0 Identification of Bushfire Hazard Issues

4.1 General

The relationship of the subject land to the local area is shown in Figure 14. The subject land will have rural living lots surrounding it to the east, south and part of the west. The primary vegetation hazard extends along the railway corridor to the west with a secondary corridor along the Serpentine River to the north. The Darling Escarpment starts sloping upwards east of the South Western Highway.

The relevant spatial issues are shown in Figure 15 and these are discussed in the following sections.

4.2 Non Homogenous Vegetation

The classification of the vegetation in semi urban/rural areas can be complicated as this vegetation is often not consistent or homogenous in terms of its characteristics. This can be a problem when classifying the vegetation and hence determining the bushfire hazard level and /or Bushfire Attack Level (BAL) rating.

The models used to quantify bushfire behaviour in Australian Standard AS3959 are based on fire behaviour in contiguous homogenous vegetation that is more than 1 hectares in size and over distances greater than 100m. There is potential for the BAL rating to be inflated due to the vegetation not being homogenous or with multiple areas less than 1 hectare.

In semi urban/rural areas the vegetation can have a semi bushland character, but with varied characteristics that do not comfortably sit with the classification in AS3959. Class B Woodland is defined in AS3959 as predominantly having a grassland understorey with sparse shrubs which can have a surface fuel load of up to 15 tonnes per hectare. Where the understorey is comprised of managed gardens and lawns (less than 100mm in height) there may still be reluctance to classify the vegetation as being low threat vegetation due to:

- Having more than 10% canopy coverage; and
- Not complying with the specifications for an asset protection zone within the Guidelines.

In this situation a woodland classification can potentially be used. Alternatively, a forest classification is used where there are more pronounced near surface fuel loads, woody understorey and middle storey vegetation. This also reflects a precautionary approach as advocated by SPP3.7 Planning in Bushfire Prone Areas.

4.3 Fuel Reduction

The classification of vegetation is done on the basis of observations at the time of assessment. Fire Protection Australia Association BPAD Practice Note No 2 notes that there are exceptions to this such as:

- vegetation that is impacted by fire or other natural events,
- vegetation that is not at a mature state; or
- areas of modified vegetation where there is no reasonable assurance of ongoing management.

While bushland areas within the study area may be subject to fuel reduction and especially prescribed burning, this does not alter the classification of that vegetation unless this is a permanent modification.

4.4 Grassland Management

An ongoing issue with Bushfire Attack Level (BAL) Assessments is the management of grassland areas. Open areas of rural living land are generally classified as 'grassland' unless there is evidence to justify exclusion. This requires the grass to be maintained as low threat vegetation i.e. less than 100mm in height.

In conjunction with this are issues associated with relying on Firebreak and Fuel Hazard Reduction Notice when this only applies to properties during the defined fire season. In addition, the Firebreak and Fuel Hazard Reduction Notice gives landowners the option of:

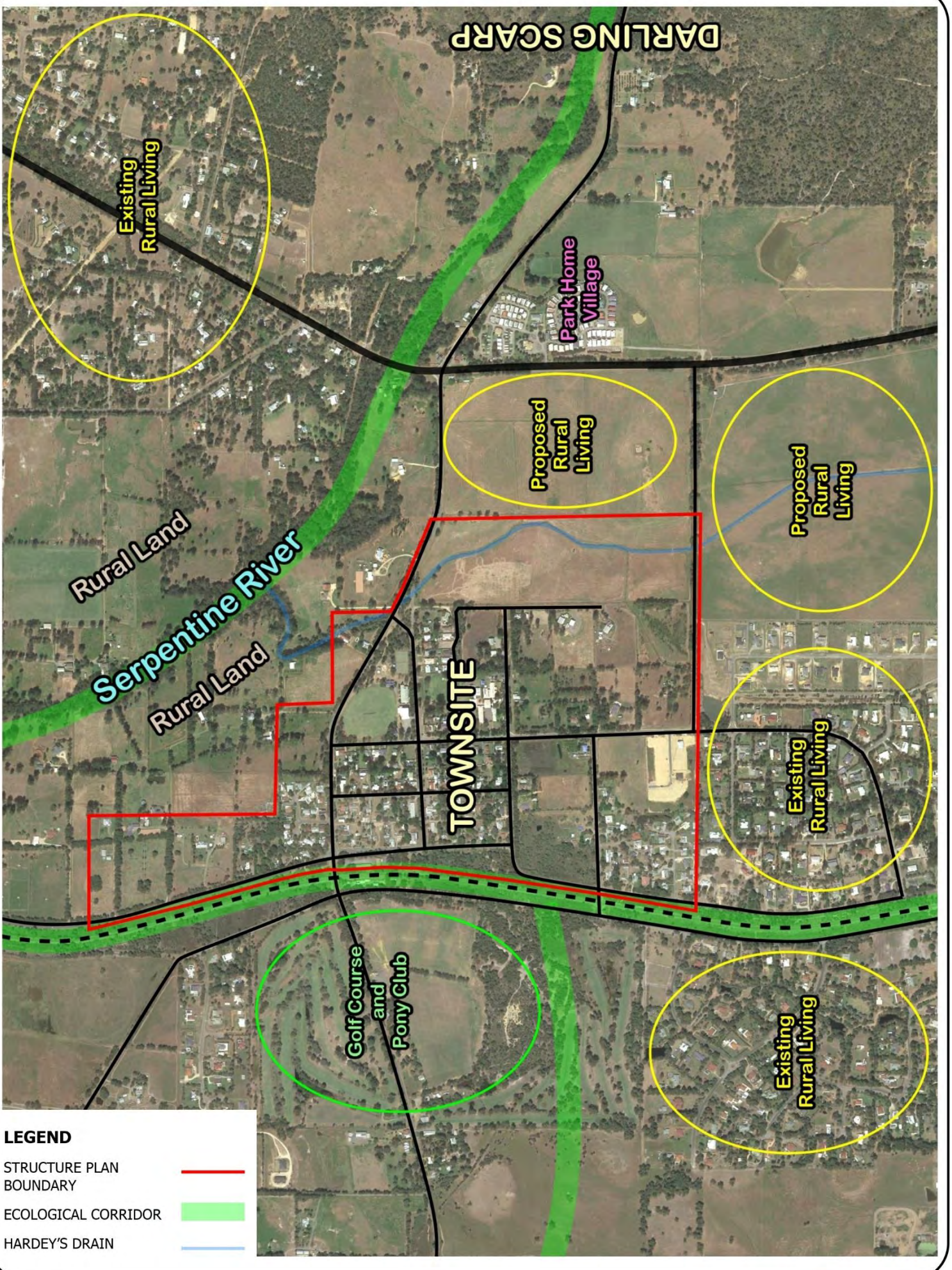

FIGURE 14
LOCAL CONTEXT

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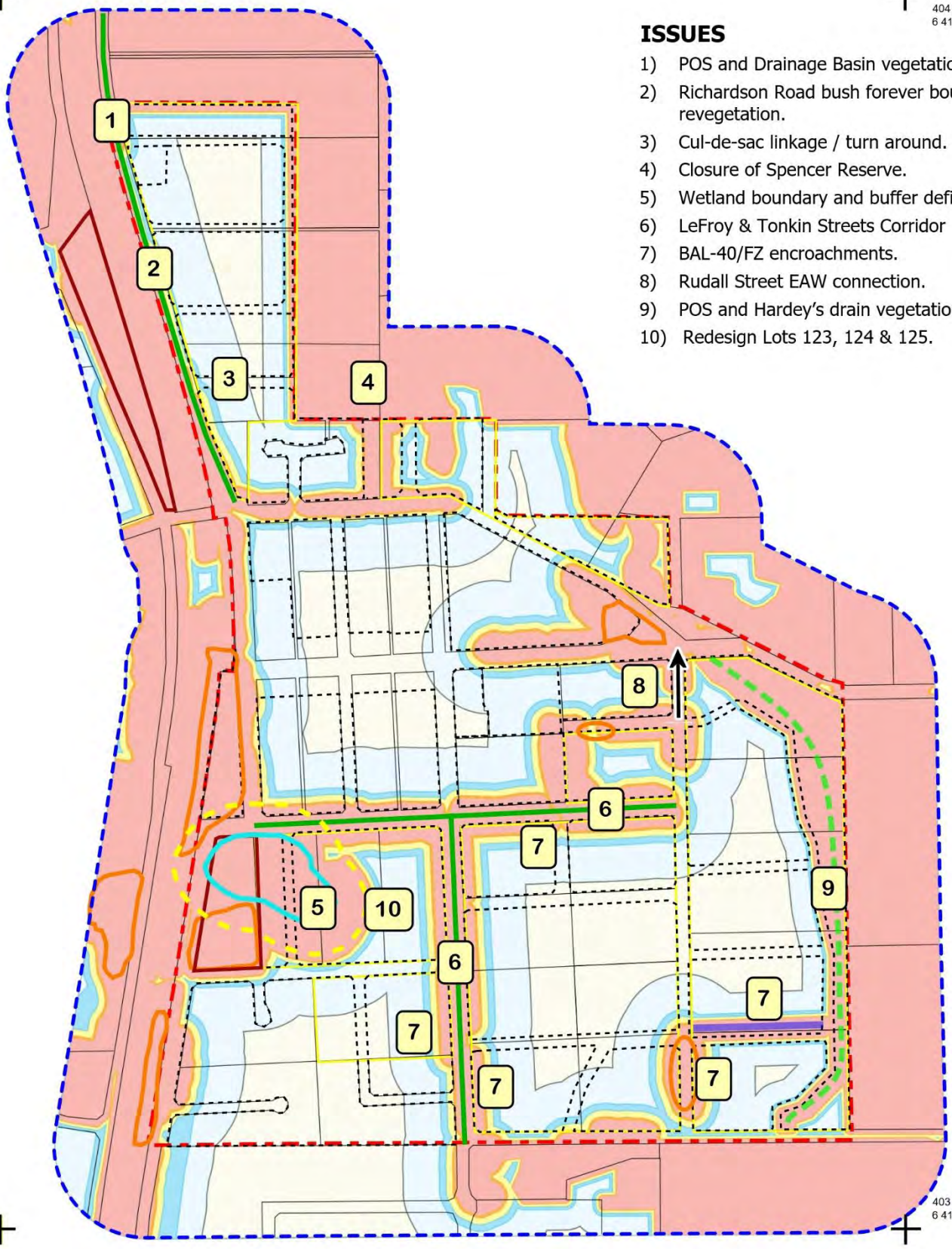
403 350mE
6 419 850mN

404 800mE
6 419 850mN

ISSUES

1) POS and Drainage Basin vegetation design.
2) Richardson Road bush forever boundary revegetation.
3) Cul-de-sac linkage / turn around.
4) Closure of Spencer Reserve.
5) Wetland boundary and buffer definition.
6) LeFroy & Tonkin Streets Corridor
7) BAL-40/FZ encroachments.
8) Rudall Street EAW connection.
9) POS and Hardey's drain vegetation design.
10) Redesign Lots 123, 124 & 125.



403 350mE
6 417 850mN

403 350mE
6 417 850mN

LEGEND

- STRUCTURE PLAN BOUNDARY
- STUDY AREA 150m Buffer
- GEO REFERENCE
- BUSH FOREVER SITE
- CONSERVATION RESERVE
- CONSERVATION WETLAND
- 50m BUFFER
- PRINCIPLE DEVELOPMENT CELLS
- DRAINAGE RESERVE
- HARDEY'S DRAIN REALIGNMENT
- ROAD CORRIDOR REVEGETATION

FIGURE 15
SPATIAL ISSUES

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- Keeping all grass to less than 25mm in height; OR
- Installing a boundary firebreak.

This becomes particularly problematic when there is adjacent vacant land which may not have been subdivided and may be used for grazing.

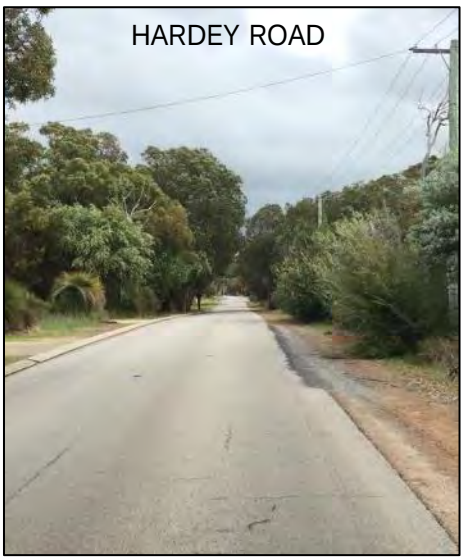
The 2019/2020 Notice now stipulates that any provisions of a Bushfire Management Plan; are to be complied with throughout the entire year including the maintenance of low threat vegetation.

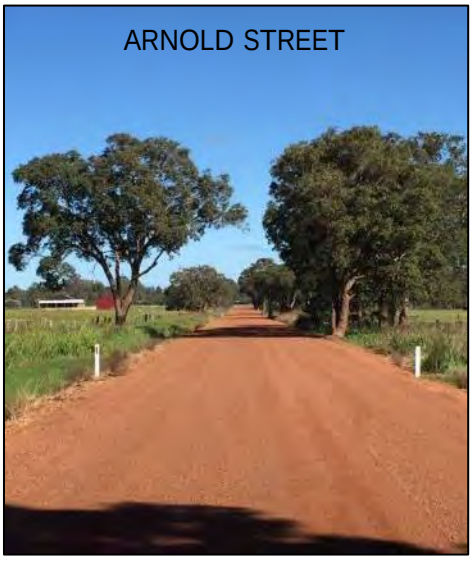
4.5 Road Corridors

It is recognised that vegetation along the road corridors has an important landscape and biodiversity function.

Wellard Road, Lefroy Street, Tonkin Street and Richardson/Hardey Roads all have 30m wide road reservations, which provides additional scope for vegetation retention. In multiple locations the vegetation canopy extends over the road carriageway improving the rural character of the area as shown in the following photographs.

The minimum width of vegetation for classification purposes is 20m provided that it is not adjacent to other classified vegetation.





4.6 BAL Setbacks

SPP3.7 Planning in Bushfire Prone Areas has a presumption against development of land with a BAL-FZ or BAL-40 rating. The BAL setbacks commence from the edge of the classified hazard vegetation. A cleared site will still have a BAL-FZ/40 rating extending into to it from vegetation on an adjoining property or road reserve.

The minimum BAL setbacks for vegetation on flat land are shown in Table 3 with the BAL-29 setback highlighted.

There has been confusion with interpreting how this applies to subdivisions as:

- SPP 3.7 refers to "land" with a BAL-FZ or BAL-40 rating and hence this can mean any land which is being subdivided.
- A 'development site' is defined in Part 10A of the Local Planning Scheme Regulations as that part of a lot on which a building that is the subject of development stands or is to be constructed. This focuses on the portion of the land where development will occur rather than the total lot.

Table 3 BAL Setbacks

Vegetation Classification	Bushfire Attack Levels (BALs) - Flat Land				
	BAL - FZ	BAL - 40	BAL - 29	BAL - 19	BAL – 12.5
	Distance (m) of the site from the vegetation class				
A Forest	< 16	16	21	31	42
B Woodland	< 10	10	14	20	29
C Shrubland	< 7	7	9	13	19
D Scrub	< 10	10	13	19	27
E Mallee/Mulga	< 6	6	8	12	17
F Rainforest	< 6	6	9	13	19
G Grassland	< 6	6	8	12	17

As indicated in Section 1.5 the Planning Commission has now released a Position Statement to clarify this issue. In relation to a structure plan. where Element 1 is satisfied, the decision-maker may consider approving lot(s) containing BAL-40 or BAL-FZ where:

a) Lot sizes provide sufficient area to accommodate a building and an asset protection zone (APZ) to achieve BAL-29 or below, or

b) There is vegetation with demonstrated biodiversity, landscape amenity and/or conservation values, that is identified for retention, or

c) The BAL-40 or BAL-FZ rating is contained within the front setback of a lot(s) with road frontage that provides for hazard separation (as prescribed in a local planning scheme or the Residential Design Codes), or

d) The BAL-40 or BAL-FZ is contained within the rear of a lot(s) that backs onto a freeway or main road reserve within the Perth metropolitan area and large regional centres.

As the lot size increases there is more opportunity to retain vegetation within the lots and to have prescribed building envelopes or setbacks to ensure that development does not occur where there is a BAL-FZ/40 rating. The areas of BAL-40 or BAL-FZ, within the study area should not create isolated pockets of developable land.

The proposed subdivision will have an R5 density coding with a minimum lot size of 2,000sqm and a minimum frontage of 30m. The R Codes provide for a minimum front setback of 12m, minimum setback to a secondary street of 6m and minimum rear setback of 6m.

These setbacks to not comply with the BAL-29 setbacks for Forest, Woodland and Scrub vegetation. This potentially becomes worse as:

- The R Codes allow for up to a 50 percent reduction in the front setback using averaging provisions;
- For side boundaries or corner lots; and
- Where any garage or carport is located within 6m of the dwelling then it is deemed to be an adjacent building under AS3959 and its BAL rating applies to the dwelling.

These setback examples are shown in Figures 17, 18 and 19. These all show the hazard vegetation being on adjoining land being the road reserve.

There are several options for dealing with this situation as documented below while noting that the Scheme or structure plan cannot normally impose more stringent measures or setbacks to those contained in the R Codes.

1 Local Development Plan

A Local Development Plan can be required to be prepared for any identified area where the BAL-29 setback might conflict with the R Code setbacks. This may simply reference the BAL setbacks or include a definition plan which becomes a de facto building envelope.

2 Subdivision Condition

Model Subdivision Condition F3 provides for the preparation of a definition plan and restrictive covenant so as to exclude development from that portion of a lot with a BAL-FZ/40 rating. It states that:

> A plan is to be provided to identify areas of the proposed lot(s) that have been assessed as BAL-40 or BAL-Flame Zone. A restrictive covenant to the benefit of the local government, pursuant to section 129BA of the Transfer of Land Act 1893, is to be placed on the certificate(s) of title of the proposed lot(s) advising of the existence of a restriction on the use of the land within areas that have been assessed as BAL-40 or BAL-Flame Zone.
>
> Notice of this restriction is to be included on the diagram or plan of survey (deposited plan). The restrictive covenant is to state as follows:
>
> *"No habitable buildings are to be built within areas identified as BAL-40 or BAL-Flame Zone". (Local Government)*

It is also noted that in accepting a request for a subdivision clearance, that the Council can seek confirmation that the conditions of any Bushfire Management Plan have been implemented. This includes confirmation of the proposed BAL ratings. This can assist in ensuring that any exclusion zones and/or setbacks are still compliant with a Local Development Plan.

3 Development Application

Clause 78D of the Local Planning Scheme Regulations requires that a development application is required for any development on a development site with a BAL-FZ/40 rating. In determining any application, the local government can require the dwelling to be setback so as to achieve a maximum of BAL-29 rating.

4 Subdivision Design

The subdivided allotment can be separated from the proposed hazard vegetation by other land management mechanisms.

The simplest means of this is to expand the land with the hazard vegetation so as to incorporate the buffer setback. The main issue with this is that it excludes that land from the development and so can dramatically reduce the lot yield especially when the hazard vegetation is on a reserve.

Options 2 above is preferred as it provides the greatest flexibility for the finalisation of any revegetation plans for adjacent areas.

FOREST

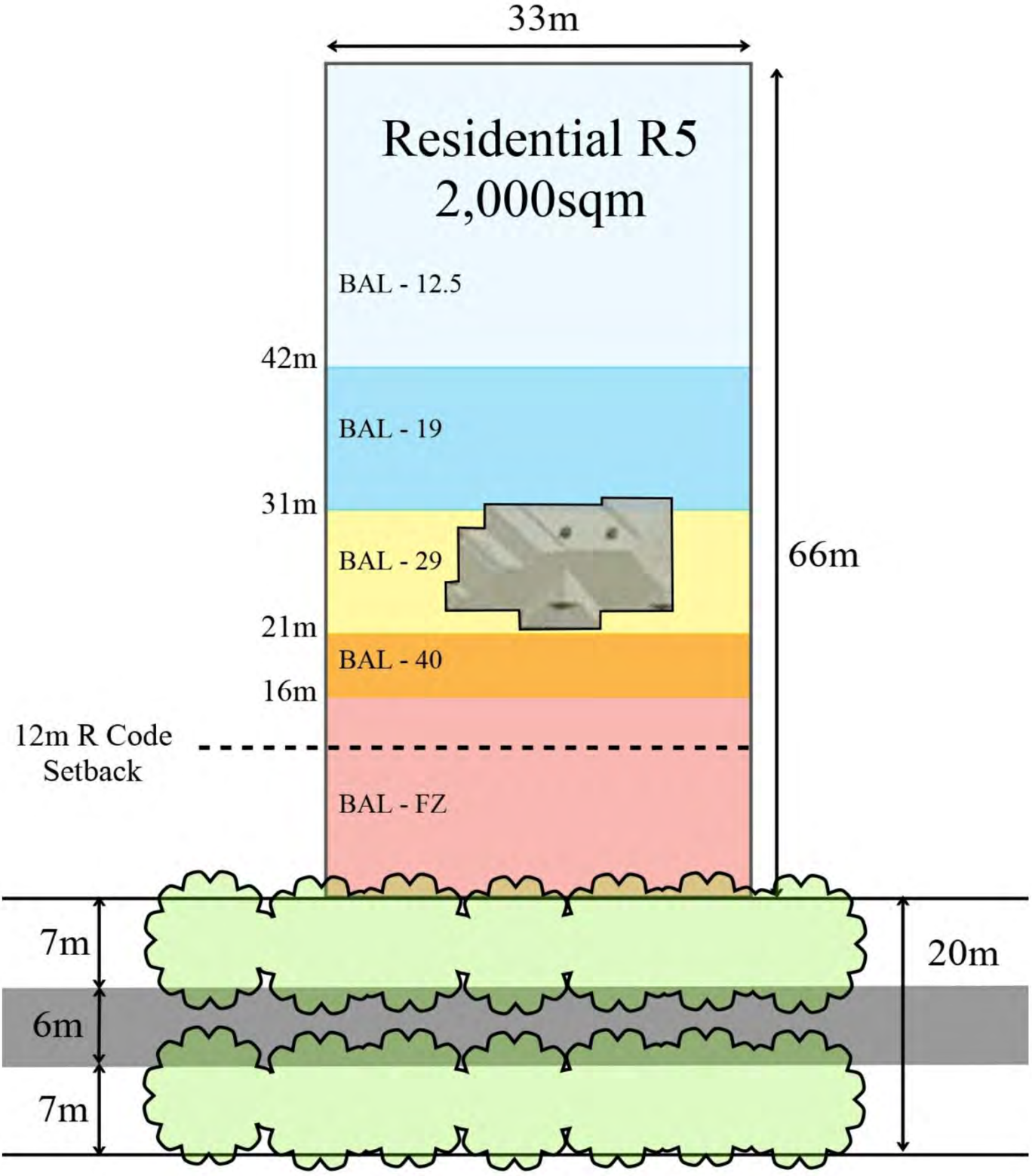


FIGURE 16
FOREST BAL SETBACK

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WOODLAND

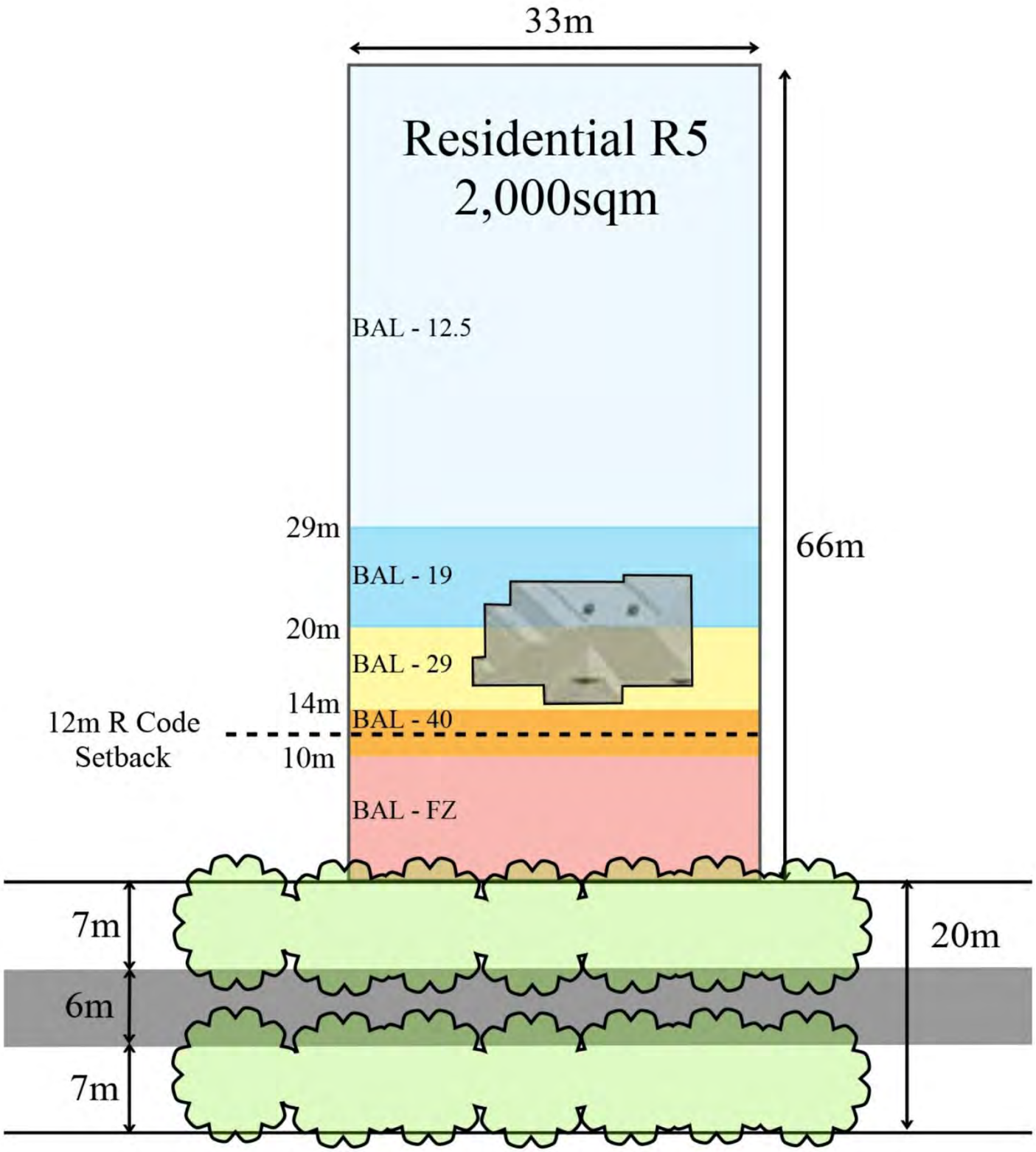

FIGURE 17
WOODLAND BAL SETBACK

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SCRUB

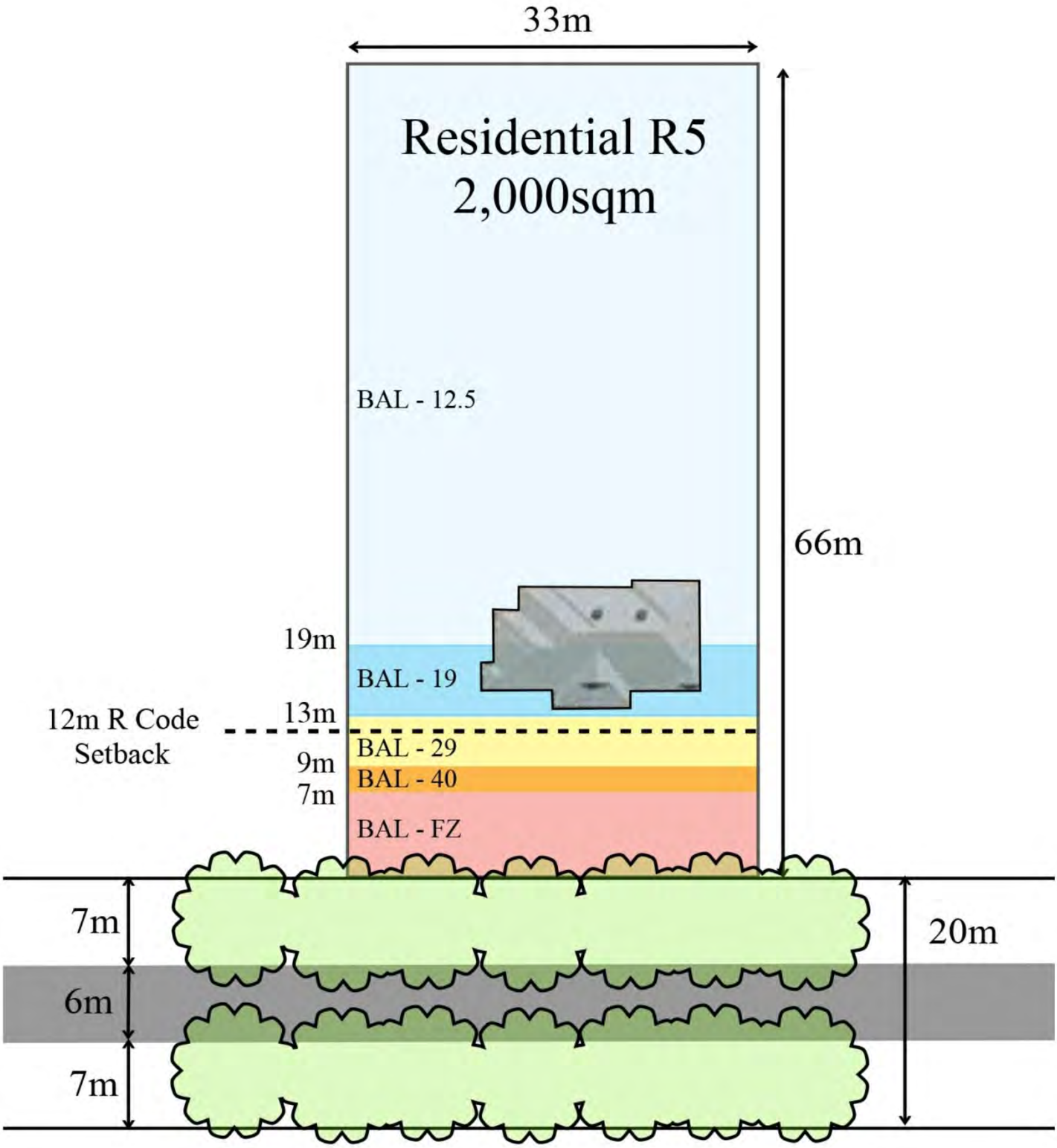

FIGURE 18
SCRUB BAL SETBACK

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4.7 Landscape Design

It is recognised that as there is a desire for people to live in closer contact with natural landscape particularly on the urban fringe, and that the provision of a wide low fuel zone area which is devoid of trees may not be acceptable. The landscaping design of public areas including road reserves is expected to enhance and protect the distinctive rural (visual) landscape character of Serpentine.

A key design issue is the relationship of the development to the vegetation areas which are classified as being a bushfire hazard. While the risk of a bushfire in an urban environment might be low, if the land is defined as being bushfire prone then the characteristics of the vegetation in public areas will affect the subsequent BAL ratings. Well managed, designed and publicly accessible landscape areas are likely to have a lower bushfire hazard and this has implications for the adjoining development and subdivision design.

The Urban and Rural Forest Strategy 2018 - 2028 notes (page 51) that areas of canopy with a maintained 'low threat' understory do not represent a significant fire risk. However, these areas may still contain classified vegetation which needs to be considered as a potential risk unless it is deemed to be low threat vegetation.

The Public Open Space areas will cater for passive use and also include drainage features. The landscaping principles for these should include:

a) Trees located closer to the central drainage areas with grassed areas on the periphery;
b) Little or no middle storey vegetation apart from drainage areas;
c) Open tree canopy to provide filtered sunlight;
d) Turfed areas will be irrigated and remain "green" and subject to regular mowing and maintenance;
e) Perimeter subdivision roads to ensure that the POS does not abut residential properties;
f) Maintaining fuel loads to less than 4 tonnes per hectare;
g) Incorporation of the Western Australian Planning Commission (2006) Designing Out Crime Guidelines and ensuring a high degree of public surveillance; and
h) Utilising plants from Council's Low Flammability Local Native Species.

The landscaping of any public open space areas is normally subject to a landscaping plan approved by Council with the landscaping established by the developer and maintained for two years as prescribed by Model subdivision condition R4 which states that:

> Arrangements being made for the proposed public open space to be developed by the landowner/ applicant to a minimum standard and maintained for two summers through the implementation of an approved landscape plan providing for the development and maintenance of the proposed public open space in accordance with the requirements of Liveable Neighbourhoods and to the specifications of the local government. (Local Government).

This is further reinforced in Section 6.3.3.2 of the Local Government Guidelines for Subdivisional Development which set out the standard requirements for the development of public open space including:

a) The preparation of a management plan;
b) A long-term maintenance agreement based on the management plan being entered into by the developer with the Local Government as part of the approval.
c) A landscape maintenance and watering period of at least two summer periods to ensure full establishment, which includes a maintenance bond.

This will also include any bioretention features incorporated in the Public Open Space thus providing a mechanism to balance environmental and bushfire management measures.

4.8 Windbreaks

A distinctive feature of the study area is the windbreak vegetation generally along property boundaries and some road reserves.

Clause 2.2.3.2 of AS3959 (2018) defines excluded vegetation and sub clause (f) refers to low threat vegetation as including grasslands managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.

It notes that a windbreak is considered as a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees.

Windbreaks both generally and also within the study area vary considerably and can comprise low scrub type vegetation, such as Callistemon (bottle brush), through to very large high trees, such as *Eucalyptus Grandis* which often exceed 30m in height. Examples of these are shown in the following photographs.

Council can elect how to consider windbreaks within the structure plan and for BAL Assessments. This could include consideration of:

- The extent of the near surface fuel loads;
- Solid screening for scrub type vegetation to 6m providing a barrier to embers; or
- Pruning of the lower tree limbs within 2m of the ground to be more consistent with the specifications for asset protection zones.

4.9 Vulnerable Land Uses

Vulnerable land uses are uses where it is considered that occupants have a lesser capacity to respond in the event of a bushfire, and which may present evacuation challenges. These are generally associated with hospitals, nursing homes and retirement villages. However, they also include any form of tourist accommodation, places of assembly, family day care centres etc.

These uses are already (D) discretionary uses in the Scheme and any development application can have regard to the provisions of SPP3.7 including the preparation of a specific bushfire management and evacuation plan.

It is also noted that the Western Australian Planning Commission has recently published (2019) a Position Statement for tourism land uses in bushfire prone areas. It has also published a simplified template for the preparation of bushfire emergency evacuation plans (BEEP) which may be suitable for townsite developments.

The general review of the bushfire framework is also considering how minor tourist uses within townsites should be considered when they are technically classified as vulnerable land uses.

4.10 Hight Risk Land Uses

High risk land uses are those uses which may lead to the potential ignition, prolonged duration and/or increased intensity of a bushfire. Such uses may also expose the community, fire fighters and the surrounding environment to dangerous, uncontrolled substances during a bushfire event. Examples of high risk land uses include service stations, landfill sites, bulk storage of hazardous materials, fuel depots.

It is not expected that there will be any additional high risk land uses within the structure plan area.

Roadside windbreak with managed understorey and few branches within 2m of the ground.

High paddock windbreak which contributes to the rural landscape quality.

Where there is significant understory vegetation, this would not be a windbreak and the understory would form the basis of any classification.

Boundary trees with minimal surface fuel. However, as they are not a single row of trees they cannot be classified as a windbreak / exempt vegetation.

4.11 Staging

It is expected that subdivision and development within the Study Area will occur progressively in stages and individual subdivision applications still have to comply with the Bushfire Protection Criteria. It is important for any subdivision to provide temporary measures for the protection of that stage of development. These may include:

- Provision of a low fuel zone so as to maintain the status of any assigned BAL rating for residential areas despite the adjoining land not being developed.
- Provision of temporary road access through an adjoining property. This should normally be protected by an easement in the event that the adjoining land is not developed. This is especially important where a proposed connecting subdivision road terminates at the property boundary effectively creating a cul-de-sac.

A BAL rating for a subdivided lot may be inflated because of the vegetation on the neighbouring land. A further issue is even if a lot is created development of that lot might only be possible at a higher BAL rating. This rating might "fall away" or be reduced when the neighbouring property is subdivided and the hazard vegetation is removed. In these situations, the initial landowner may be penalised by:

- Additional construction costs incurred by developing first; or
- Potentially preventing a subdivision if a BAL-29 or lower rating cannot be achieved.

This issue is more manageable when the adjoining vegetation is grassland rather than other classified vegetation. Requiring vacant lots to be maintained as low threat vegetation with grass less than 100mm in height for all of the year, will be create potential land management issues and likely objections from landowners.

One option would be to reference that the neighbouring property only has to do this for a 17m distance from the boundary as this would give a BAL-12.5 rating to an adjoining lot where there is no road on the common boundary. In practical terms it is more about having a means of approaching the neighbour if and or when a BAL problem arises. This would not apply where there is other classified vegetation that imposes a higher BAL rating.

5.0 Assessment Against the Bushfire Protection Criteria

5.1 Compliance Table

A summary of the compliance with the Bushfire Protection Criteria as contained in Version 1.4 (Dec 2021) of the Guidelines for Planning in Bushfire Prone Areas is documented in Table 4. This demonstrates how the Criteria are expected to be complied with at the various planning stages being:

- The amendment to the Local Planning Scheme;
- A subdivision application; and
- A development application.

Version 1.4 of the Guidelines applies the Acceptable Solutions based upon the following planning stages:

SP – Strategic planning proposal and structure plan where the lot layout is not known

Sb – Structure plan where the lot layout is known and subdivision application

Dd – Development application for a single dwelling, ancillary dwelling or minor development

Do – Development application for any other development

It is also acknowledged that the subdivision design / concept plan is likely to be refined and evolve at the subsequent planning stages.

Table 4 BPC Compliance

Development Stage / Design Requirement	Local Structure Plan	Subdivision Application	Development Application
Element 1 Location			
A1.1 Development Location	Has demonstrated that the developed land will generally have a BAL-29 or lower rating. Some minor portions may have a BAL-40/FZ rating but they will be excluded from development. Revegetation of the Conservation Category Wetland in Lambkin Reserve is to be confirmed in a buffer study. Roadsides where revegetation (classified hazard) is to occur are to be documented.	Prepare a BMP to reflect the final subdivision design. Proposed BAL ratings to be confirmed when lot layout is known. Development in portions of land with a BAL-40/FZ rating to be implemented by a Local development Plan or restrictive covenant. The BMP is to provide evidence to support the exclusion of POS areas as established and managed to low threat in accordance with AS 3959 is required.	Confirmation of the assumptions made within the BMP.
Element 2 Siting and Design			
A2.1 Asset Protection zone	The proposed lots are not large enough to contain the APZ within their own boundaries. Generally, for the "first row" of dwellings adjacent to the hazard areas the APZ will be provided within the development setback from the front boundary combined with the 18m wide road reserve and in some instance portions of the Local Open Space. This complies with the Guidelines which state on page 63 of the BPC that the APZ may include public roads, waterways, footpaths, buildings, rocky outcrops, golf courses, maintained parkland as well as cultivated gardens in an urban context.	The revised BMP will confirm the BAL-29 setback for the asset protection zone. The Firebreak and Fuel Hazard Reduction Notice stipulates that any provisions of a Bushfire Management Plan; are to be complied with throughout the entire year including the maintenance of low threat vegetation. This includes any asset protection zone.	Any development approval will implement the BMP.

Development Stage / Design Requirement	Local Structure Plan	Subdivision Application	Development Application
Element 3 Vehicular Access			
A3.1 Public Road	The subject land currently has multiple access from existing public roads constructed to the required standard.	The subdivision roads will be constructed in accordance with the Local Government Guidelines for Subdivisional Development which meet required specifications in Table 6 of the Bushfire Protection Criteria.	Is not applicable as it will be constructed for the subdivision.
A3.2a Multiple access routes (SP Sb Do)	The site has multiple access routes at both the district and local level. Multiple internal access routes provide connecting to the external road network. Suitable destinations in the event of an evacuation would be Mundijong to the north or North Dandalup to the south.	Would be in accordance with the structure plan and bushfire management plan. Any staging would require interim access measures.	Is not applicable as it will be constructed for the subdivision.
A3.2b Emergency access way (SP Sb Do)	There is an existing EAW in Rudall Street north of Turner Road. This is required to be maintained to provide access for the subdivision of Lot 102 Rudall Street until such time as Tonkin Street is extended.	The subdivision BMP is to confirm that the standard of the EAW is acceptable.	Is not applicable.
A3.3 Through-roads (SP Sb)	There are two proposed cul-de-sacs in the northern portion of the study area leading from Karnup and Richardson Roads. These are less than 200m in length and there is no viable alternative means of access.	Any Cul-de-sac's and dead-end roads would have to be justified in the BMP as they are to be avoided in bushfire prone areas because they do not provide access in different directions for residents. The BMP is to demonstrate why no alternative access exists.	Is not applicable as it will be constructed for the subdivision.
A3.4a Perimeter roads (SP Sb)	The only occurrence for this is the buffer to the wetland which will have a perimeter road separating it from the development.	The requirement for a suitable separation distance may affect the road design width as this could be more than 20m. Would be shown in the revised BMP.	Is not applicable as it will be constructed for the subdivision.

Development Stage / Design Requirement	Local Structure Plan	Subdivision Application	Development Application
A3.4b Fire service access route (SP Sb)	Is not applicable.	Is not applicable.	Is not applicable.
A3.5 Battle-axe access legs (Sb)	Is not applicable.	Any battle axe lot would have to be justified as these are to be avoided in bushfire prone areas.	Any development approval will implement the BMP.
A3.6 Private driveways (Dd Do)	The structure plan contains the framework which determines the application of A3.6 in terms of the lot, sizes, provision of reticulated water and local road speed limits.	The subdivision BMP will reflect the final subdivision design and confirm compliance with the Bushfire Protection Criteria including the application of A3.6.	Any development approval will implement the BMP.
A3.6 Emergency Access Way (EAW)	There is an existing EAW in Rudall Street north of Turner Road. This is required to be maintained to provide access for the subdivision of Lot 102 Rudall Street until such time as Tonkin Street is extended.	The subdivision BMP is to confirm that the standard of the EAW is acceptable.	Is not applicable.
A3.7 Fire Service Access Route (FSAR)	Is not applicable as none are proposed.	A FSAR may be provided where staging of a subdivision would require interim access measures.	Is not applicable.
Element 4 Water			
A4.1 Reticulated Areas	The land is serviced by reticulated water.	The subdivision will be serviced with fire hydrants in accordance with the required specification.	Is not applicable as it will be constructed for the subdivision.
A4.2 Non-reticulated Areas	Is not applicable.	Is not applicable.	Is not applicable.
A4.3 Single Lot Non-reticulated	Is not applicable.	Is not applicable.	Is not applicable.

Development Stage / Design Requirement	Local Structure Plan	Subdivision Application	Development Application
High Risk Land Uses			
Proposed high risk land uses need special consideration.	No high risk land uses are proposed within the structure plan area.	Is not applicable.	Can require a BMP and risk evaluation plan to be lodged as part of any development application.
Vulnerable Land Uses			
Proposed vulnerable land uses need special consideration.	No special provisions are required as the townsite is considered to be a suitable location for such uses.	Is not applicable.	Can require a BMP and bushfire emergency evacuation plan to be lodged as part of any development application.

6.0 Responsibilities for Implementation and Management of the Bushfire Measures

The management of the risk posed by bushfires is a shared responsibility between landowners, government and industry. These responsibilities are summarised in Table 5 shown in Figure 19.

Table 5 Implementation

No	MANAGEMENT ACTION	AGENCY
1.0 Subdivision Applications		
1.1	Identifying road reserves which will be subject to revegetation and confirmation of the specifications for this.	Council
1.2	Approval of landscape designs for public open space areas and drainage features.	Council
1.3	Preparation of a Bushfire Management Plan for individual subdivisions demonstrating compliance with the Bushfire Protection Criteria and in particular: • Evidence to support the exclusion of POS areas as established and managed to low threat in accordance with AS 3959. • The location and size of the APZs based upon a BAL-29 setback. • Justification for any proposed Cul-de-sac's or dead-end roads demonstrating why no alternative access exists. • Provide justification for any EAW as to why it is not possible to provide a public road in place of the proposed EAW's. • Provide justification for any proposed battle axe lot as these are to be avoided in bushfire prone areas. • Show any proposed subdivision staging and temporary road connections to provide multiple access; and • Document any works required on adjacent land to implement assigned BAL ratings.	Developer
1.4	Preparation of a Local Development Plan, or other appropriate measure, to document where BAL - 29 setbacks may be greater than those prescribed by the R-Codes and potentially require designated building envelopes.	Developer Council
1.5	Providing certification when applying for a subdivision clearance that the BAL ratings assigned in the Local Development Plan and/or Bushfire Management Plan are still applicable and any associated clearing and/or revegetation works have been done.	Developer
1.6	Requesting a subdivision to require a restrictive covenant to the benefit of the local government, pursuant to section 129BA of the Transfer of Land Act 1893, on the certificate(s) of title of any proposed lot(s) where a BAL-FZ/40 rating encroaches onto the lot advising of the existence of a restriction on the use of the land within areas that have been assessed as BAL- 40 or BAL-Flame Zone.	Council
1.7	Construction of subdivision roads to standards outlined in the BMP to ensure safe access and egress.	Developer
1.8	Preparation of a landscape plan for the POS areas to confirm the proposed BAL ratings.	Developer
1.9	Preparing a notification be included on the certificate of titles for the lots having a BAL-12.5 rating or higher advising that the land is subject to a Bushfire Management Plan.	Developer

No	MANAGEMENT ACTION	AGENCY
1.10	Undertaking a wetland boundary definition study for the conservation category wetland in Lambkin Reserve and the associated buffer before any subdivision of the adjacent Lots 123 and 124.	Developer
1.11	Upgrading of Rudall Street north of Turner Road to provide a secondary road connection.	Developer
1.12	Providing prospective residents with a summary of any BMP	Developer
2.0 Development of Lots		
2.1	Ensuring that any application for a building permit for a dwelling is to include an individual BAL assessment to confirm that sufficient land has been cleared to provide for BAL-29 setbacks.	Landowner
2.2	Maintaining the land within the BAL setback as an Asset Protection Zone in accordance with the following specifications: 1) Fences should be constructed from non-combustible materials (for example, iron, brick, limestone, metal post and wire, or bushfire-resisting timber referenced in Appendix F of AS 3959). 2) Fine fuel loads (combustible, dead vegetation matter <6 millimetres in thickness) should be managed and removed on a regular basis to maintain a low threat state at less than 2 tonnes per hectare (on average). Mulches should be non-combustible such as stone, gravel or crushed mineral earth or wood mulch >6 millimetres in thickness. 3) Trees (>6 m in height) should: ➢ Be a minimum distance of six metres from all elevations of the building and branches at maturity should not touch or overhang a building or powerline. ➢ Have lower branches and loose bark removed to a height of two metres above the ground and/or surface vegetation. ➢ Have a canopy cover pf less than 15 per cent of the total APZ area. ➢ Have canopies at maturity being at least five metres apart to avoid forming a continuous canopy. Stands of existing mature trees with interlocking canopies may be treated as an individual canopy provided that the total canopy cover within the APZ will not exceed 15 percent and are not connected to the tree canopy outside the APZ. 4) Shrub and scrub (0.5 m to 6m in height) should not be: ➢ Located under trees or within three metres of buildings. ➢ Planted in clumps >5 square metres in area. Clumps should be separated from each other and any exposed window or door by at least 10 metres. 5) Ground covers (<0.5 m in height) can be: ➢ Planted under trees but must be maintained to remove dead plant material, as prescribed in 'Fine fuel load' above. ➢ Located within two metres of a structure, but three metres from windows or doors if >100 millimetres in height. 6) Grass should be maintained at a height of 100 millimetres or less, at all times. Wherever possible, perennial grasses should be used and well-hydrated with regular application of wetting agents and efficient irrigation. 7) A defendable space should be provided within three metres of each wall or supporting post of a habitable building, the area is kept free from vegetation, but can include ground covers, grass and non-combustible mulches as prescribed above. 8) Any LP Gas Cylinders should:	Landowner

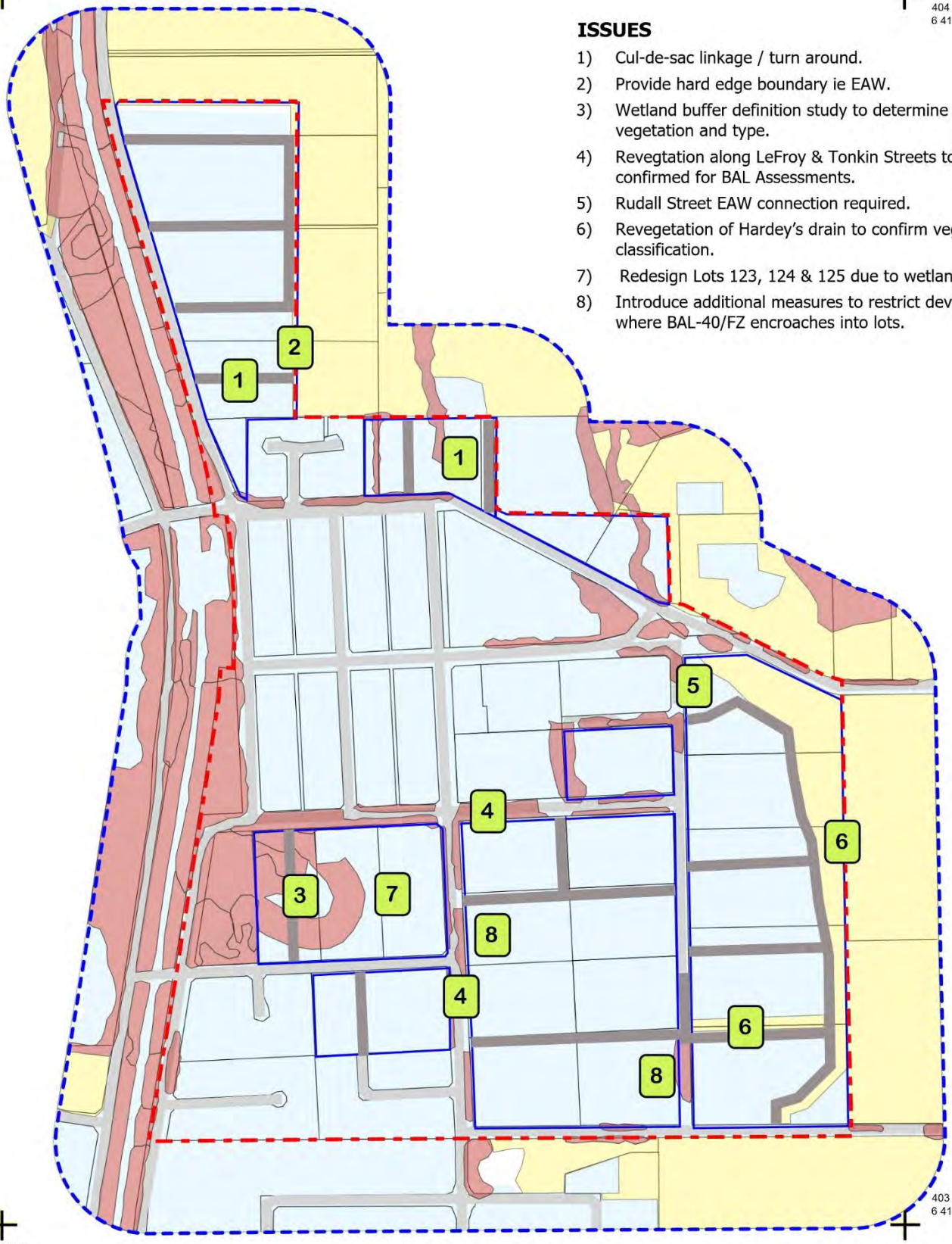
No	MANAGEMENT ACTION	AGENCY
	➢ Be located on the side of a building furthest from the likely direction of a bushfire or on the side of a building where surrounding classified vegetation is upslope, at least one metre from vulnerable parts of a building. ➢ Have the pressure relief valve pointing away from the house. ➢ Not have flammable material within six metres from the front of the valve. ➢ Sit on a firm, level and non-combustible base and be secured to a solid structure.	
2.3	Where a driveway is more than 70m in length it shall be designed and constructed as follows: • A minimum 4m trafficable surface (0.5m shoulders); • Minimum 6m horizontal clearance to vegetation; • Minimum 4.5m vertical clearance to vegetation; • Have an all-weather surface (i.e. compacted gravel, limestone or sealed); and • Provide an 18m diameter turning circle adjacent to the dwelling.	Landowner
3.0 Land Management		
3.1	Land adjoining a subdivision created under this structure plan shall maintain grass to a height of less than 100mm for a setback of 17m from the boundary all year round; so as to facilitate a BAL-12.5 rating. This does not apply where other classified vegetation imposes a higher BAL rating.	Landowner Council
3.2	Undertaking regular maintenance of property in preparation for the annual fire season.	Landowner
3.3	Implementing all fire mitigation measures prescribed in Shire's Firebreak Notice and Fuel Hazard Reduction Notice by the 1 December.	Landowner Council

403 350mE
6 419 850mN

404 800mE
6 419 850mN

ISSUES

1) Cul-de-sac linkage / turn around.
2) Provide hard edge boundary ie EAW.
3) Wetland buffer definition study to determine extent of vegetation and type.
4) Revegtation along LeFroy & Tonkin Streets to be confirmed for BAL Assessments.
5) Rudall Street EAW connection required.
6) Revegetation of Hardey's drain to confirm vegetation classification.
7) Redesign Lots 123, 124 & 125 due to wetland buffer.
8) Introduce additional measures to restrict development where BAL-40/FZ encroaches into lots.



403 350mE
6 417 850mN

403 350mE
6 417 850mN

LEGEND

- STRUCTURE PLAN BOUNDARY
- STUDY AREA 150m Buffer
- EXISTING ROAD
- PROPOSED ROAD
- GEO REFERENCE
- LOW THREAT VEGETATION
- HAZARD VEGETATION (CLASS A, B, C, D)
- HAZARD VEGETATION (CLASS G GRASSLAND)
- DEVELOPMENT CELLS
- RAILWAY LINE

FIGURE 19
SPATIAL MEASURES

BPAD Bushfire Planning & Design Accredited Practitioner Level 2

N

Job No 19-043

Rev	Description	Date
A	Preliminary	06/01/2020

LUSHfire and planning
geoffrey@lushfire.com.au
0418 954873

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Shire of Serpentine Jarrahdale

Bushfire Management Plan

Serpentine Townsite

Local Structure Plan

APPENDIX 1
VEGETATION PHOTOGRAPHS

LUSH FIRE & PLANNING
No 3 Paterson Rd
Pinjarra WA 6208
0418 954 873
ABN 74 232 678 543

BPAD Bushfire Planning & Design Accredited Practitioner Level 2

Ref 19-043
Draft 1
October 2019

Appendix 1 - Vegetation Photographs

Photograph Locations

Appendix 1 - Vegetation Photographs

Photo No 1

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Open pasture broad acre grazing land.

Photo No 2

Vegetation Classification

Class A Forest - Open forest A-03

Description

Predominantly Marri to 18m height with more than 30% canopy coverage with mixed middle and understory vegetation, shrubland. Many areas with grassland (weeds) including Watsonia. Generally continuous moderate to heavy surface fuel loads.

Photo No 3

Vegetation Classification

Class C Shrubland - Closed heath C-10

Description

Boronia generally to 1m and 60% canopy coverage with some higher plants, wet area with dense surface material.

Appendix 1 - Vegetation Photographs

Photo No 4

Vegetation Classification

Excludable - 2.2.3.2(f) Low Threat Vegetation

Description

Maintained golf course on the western boundary of the study area.

Photo No 5

Vegetation Classification

Class A Forest - Open forest A-03

Description

Predominantly Marri to 18m height with more than 30% canopy coverage with mixed middle and understory vegetation, shrubland. Many areas with grassland (weeds) including Watsonia. Generally continuous moderate to heavy surface fuel loads.

Photo No 6

Vegetation Classification

Class C Shrubland - Closed heath C-10

Description

Mixed shrubland to 1.5m and 70% canopy coverage with some occasional larger Victorian Tea Trees. Dense understory and very high fuel loads.

Appendix 1 - Vegetation Photographs

Photo No 7

Vegetation Classification

Class A Forest - Open forest A-03

Description

Predominantly Marri to 25m height with more than 30% canopy coverage with mixed middle and predominant grass tree understory vegetation. Generally continuous moderate to heavy surface fuel loads.

Photo No 8

Vegetation Classification

Class C Shrubland - Closed heath C-10

Description

Sedge and Watsonia to 1m height with more than 70% coverage.

Photo No 9

Vegetation Classification

Class D Scrub - Closed scrub D-13

Description

Mixed scrub to 6m height, 40% canopy coverage. Melaleuca, Tea Trees, some Wattles and grass trees. Variable canopy layer but dense surface layer/understory with continuous very heavy surface fuel loads.

Appendix 1 - Vegetation Photographs

Photo No 10

Vegetation Classification

Class C Shrubland - Closed heath C-10

Description

Low shrubs to 1m with grass trees and occasional Sheoak. Dense surface layer/understory with continuous very heavy surface fuel loads.

Photo No 11

Vegetation Classification

Class C Shrubland - Closed heath C-10

Description

Low shrubs to 1m with grass trees and occasional Sheoak. Dense surface layer/understory with continuous very heavy surface fuel loads.

Photo No 12

Vegetation Classification

Class D Scrub - Closed scrub D-13

Description

Melaleuca around wetland fringe to 6m height, with 80% canopy coverage.

Appendix 1 - Vegetation Photographs

Photo No 13

Vegetation Classification

Class A Forest - Open forest A-03

Description

Marri and other Eucalypts to 22m height with more than 30% canopy coverage. Grass tree and low shrub understory vegetation. Generally continuous moderate to heavy surface fuel loads.

Photo No 14

Vegetation Classification

Class B Woodland - Woodland B-05

Description

Eucalypts to 20m height with open canopy and dense Watsonia understory.

Photo No 15

Vegetation Classification

Class A Forest - Open forest A-03

Description

Marri and other Eucalypts to 22m height with more than 30% canopy coverage. Mixed middle story including Flinders Wattles. Grass and scattered shrub understory vegetation. Heavy surface fuel loads.

Appendix 1 - Vegetation Photographs

Photo No 16

Vegetation Classification

Class C Shrubland - Low shrubland C-12

Description

Low shrubs less than 1m in height with some Watsonia.

Photo No 17

Vegetation Classification

Class D Scrub - Open scrub D-14

Description

Mixture of Sheoaks and shrubs with some grass trees and higher plants. Possibly still shrubland but classified on the basis of the juvenile Sheoaks being scrub. Dense understory and continuous heavy surface and near surface fuel loads.

Photo No 18

Vegetation Classification

Class A Forest - Open forest A-03

Description

Predominantly Marri and other Eucalypts to 25m height with more than 30% canopy coverage with mixed middle and understory vegetation, shrubland with some grassland (weeds). Generally continuous moderate to heavy surface fuel loads.

Photo No 19

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Pasture used for grazing with small isolated area of Forest in the background.

Photo No 20

Vegetation Classification

Excludable - 2.2.3.2(f) Low Threat Vegetation

Description

Windbreak line of trees along Richardson Road with managed grassland underneath.

Photo No 21

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Pasture used for grazing.

Photo No 22

Vegetation Classification
Class G Grassland – Sown pasture G-26

Description
Pasture used for grazing.

Photo No 23

Vegetation Classification
Excludable - 2.2.3.2(f) Low Threat Vegetation

Description
Sports ground managed land.

Photo No 24

Vegetation Classification
Class G Grassland – Tussock grassland G-22

Description
Unmanaged grassland to 0.75m with Watsonia. Contains more grass vegetation than Photo 8 and so not classified as shrubland.

Photo No 25

Vegetation Classification

Excludable - 2.2.3.2(f) Low Threat Vegetation

Description

Small orchard which is excluded vegetation while noting that there is unmanaged grassland in the foreground.

Photo No 26

Vegetation Classification

Class A Forest - Open forest A-03

Description

Marri and other Eucalypts to 22m height with more than 30% canopy coverage. Mixed middle story including Flinders Wattles. Grass and scattered shrub understory vegetation. Heavy to very heavy surface fuel loads.

Photo No 27

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Unmanaged paddock area.

Photo No 28

Vegetation Classification
Class G Grassland – Sown pasture G-26

Description
Unmanaged paddock area.

Photo No 29

Vegetation Classification
Excludable - 2.2.3.2(f) Low Threat Vegetation

Description
Windbreak line of trees along LeFroy Street with managed grassland underneath.

Photo No 30

Vegetation Classification
Class G Grassland – Sown pasture G-26

Description
Unmanaged paddock area.

Photo No 31

Vegetation Classification
Excludable - 2.2.3.2(f) Low Threat Vegetation

Description
Fire service access way.

Photo No 32

Vegetation Classification
Class D Scrub - Closed scrub D-13

Description
Melaleuca paperbarks along Hardey's drain to 6m in height with more than 50% canopy coverage and heavy grass understorey to 0.5m. Linear vegetation approximately 20m wide.

Photo No 33

Vegetation Classification
Class A Forest - Open forest A-03

Description
High quality Marri / Jarrah to 22m height with more than 30% canopy coverage. Mixed middle storey with juvenile Eucalypts. Shrub understory vegetation, continuous heavy surface fuel loads.

Photo No 34

Vegetation Classification

Class A Forest - Open forest A-03

Description

Predominantly Marri to 25m height with more than 30% canopy coverage with mixed middle and understory shrubland with grassland weeds. Generally continuous moderate to heavy surface fuel loads.

Photo No 35

Vegetation Classification

Class A Forest - Open forest A-03

Description

Eucalypts to 25m height with more than 30% canopy coverage with mixed middle and understory shrubland with grassland weeds. Generally continuous moderate to heavy surface fuel loads.

Photo No 36

Vegetation Classification

Class A Forest - Open forest A-03

Description

Eucalypts to 25m height with more than 30% canopy coverage. No understory but has fallen dead material with moderate surface fuel loads.

Photo No 37

Vegetation Classification
Excludable - 2.2.3.2(f) Low Threat Vegetation

Description
Drainage basin.

Photo No 38

Vegetation Classification
Class G Grassland – Sown pasture G-26

Description
Open pasture broad acre grazing land.

Photo No 39

Vegetation Classification
Class G Grassland – Sown pasture G-26

Description
Pasture used for grazing.

Photo No 40

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Open pasture broad acre grazing land.

Photo No 41

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Open pasture broad acre grazing land.

Photo No 42

Vegetation Classification

Class A Forest - Open forest A-03

Description

Eucalyptus to 25m height with more than 30% canopy coverage. Located within private land used for grazing.

Photo No 43

Vegetation Classification

Class A Forest - Open forest A-03

Description

High quality Eucalyptus vegetation in Rudall Street road reserve to 25m height with 60% canopy coverage with mixed middle and understory shrubland. Generally continuous heavy surface fuel loads.

Photo No 44

Vegetation Classification

Class D Scrub - Open scrub D-14

Description

Juvenile pen Sheaoks 3m high expected to increase, canopy coverage 20% over grassland to 1m

Photo No 45

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Open pasture broad acre grazing land.

Photo No 46

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Open pasture broad acre grazing land.

Photo No 47

Vegetation Classification

Class G Grassland – Sown pasture G-26

Description

Open pasture broad acre grazing land.

Appendix 6 – Wetland Assessment

360 environmental

Serpentine Townsite Local Structure Plan

Detailed Wetland Assessment and Site Specific Buffer Study

Prepared for

Shire of Serpentine Jarrahdale

November 2019

people planet professional

Document Reference	Revision	Prepared by	Reviewed by	Admin Review	Submitted to Client	
					Copies	Date
3396AA_Rev0	Internal Draft	K. Cooper and N. Whittington	S. Walker	S. Hick	-	02/10/2019
3396AA_Rev1	Client Draft	360 Environmental			1x electronic (email)	02/10/2019
3396AA_Rev2	Client Final	360 Environmental	N.Whittington	S. Hick	1x electronic (email)	13/11/2019

Disclaimer

Executive Summary

The Shire of Serpentine Jarrahdale (the Shire) is currently amending their Serpentine Townsite Local Structure Plan (LSP) (Appendix A), which has been prepared to guide the future growth and development of the Serpentine urban area. The Western Australian Planning Commission (WAPC) have requested modifications to the LSP and re-advertising once the required modifications have been undertaken. One of the modifications required by the WAPC is the preparation of Detailed Wetland Assessment and Site-Specific Wetland Buffer Study to inform the LSP. 360 Environmental was commissioned by the Shire to undertake the of Detailed Wetland Assessment and Site-Specific Wetland Buffer Study for the following wetlands:

- Resource Enhancement Wetland (REW) (UFI 14984)
- Resource Enhancement Wetland (REW) (UFI 15204)
- Portion of Conservation Category Wetland (CCW) (UFI 15002)
- Conservation Category Wetland (CCW) (UFI 15205) and its buffer.

There is one Bush Forever Site (No. 375) being the Byford to Serpentine Rail/Road reserves and adjacent bushland within the LSP. There are two other Bush Forever Sites (No. 365 and 371) which are adjacent to the northern LSP boundary and the western and northern sections of the LSP have been identified as part of a regional ecological linkage. An Environmentally Sensitive Area (ESA) has been mapped over most of the LSP which is likely associated with the presence and boundary mapping of Bush Forever Sites, Conservation category Wetland (CCW) and associated buffers and rare flora.

A Field Survey was undertaken on 5 September 2019 by a Principal Botanist to assess the condition of the wetlands. The survey was completed as per *'A Methodology for the Evaluation of Specific Wetland Types on the Swan Coastal Plain, Western Australia'* (Department of Biodiversity Conservation and Attractions [DBCA] 2017).

Resource Enhancement Wetland (REW) (UFI 14984) no longer represents attributes, function and values associated with a REW and more accurately reflects a Multiple Use Wetland (MUW). It is recommended that this portion of REW (UFI 14984) be downgraded to a MUW. Assessment against DBCA (2017a) evaluation process confirms that the CCW's (UFI 15002 and 15205) support attributes, function and values associated with the conservation category. CCW (UFI 15002) is defined (and confined) by existing infrastructure i.e. Richardson Street and railway and urban land uses. As per Environmental Protection Authority (EPA) (2008) and DBCA policy typical buffers associated with CCW are usually 50 m from the wetland boundary. Due to the existing urban nature adjacent to the CCW (UFI 15002) application of a generic 50 m wetland buffer is not viable.

From site inspection, it can be concluded that a significant portion of REW (UFI 15204) no longer exhibits attributes and values associated with a REW. However, there is a patch of vegetation that is considered part of the wetland function area of the CCW. Modification of the REW (UFI 15204) boundary, therefore, requires only part of the REW (UFI 15204) to be downgraded to MUW. A suggested buffer (separation requirement) of up to 30 m to the revised wetland function area (in association with site management) is recommended. It is noted that

recommendation on buffers are based on vegetation type, condition and the presence of conservation significant flora and fauna habitat values. A site-specific wetland hydrological/groundwater dependent ecosystem assessment was not undertaken as part of the scope of this assessment. However, this can be subsequent completed to confirm the outcomes and recommendations of this terrestrial assessment.

Overall, the proposed LSP reflects the DBCA geomorphic wetland database (current CCWs). The LSP depicts a north-south road link between Tonkin Street and Leslie Street (near Lambkin Reserve) with residential development east of the link road which currently intersects REW (UFI 15204). As recommended in Section 5.3.1, the eastern portion of the REW (UFI 15204) reflects the attributes and values associated with a Multiple Use management category. Based on the proposed changes to the wetland reclassification of this wetland area (i.e. reclassification from REW to MUW) (Figure 9) the north-south road link between Tonkin Street and Leslie Street runs adjacent to the proposed 30 m wetland buffer.

The draft LSP proposes POS (approximately 50 m wide) adjacent to the CCW (UFI 15002) associated with Bush Forever Site 375. This 50m buffer incorporates the proposed amended buffer to the REW (subject to the recommendations in Section 5.3.1) While this area is currently Completely Degraded from clearing and grazing associated with rural activities, the use of the POS (buffer area) i.e. passive recreation, controlled access through fencing along the CCW/ Bush forever site and areas subject to rehabilitation can be confirmed through consultation between the shire and DBCA/DWER.

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1 Introduction

1.1 Background

The Shire of Serpentine Jarrahdale (the Shire) is currently amending their Serpentine Townsite Local Structure Plan (LSP) (Appendix A), which has been prepared to guide the future growth and development of the Serpentine urban area. The Western Australian Planning Commission (WAPC) have requested modifications to the LSP and re-advertising once the required modifications have been undertaken. One of the modifications required by the WAPC is the preparation of Detailed Wetland Assessment and Site-Specific Wetland Buffer Study to inform the LSP (Figure 1).

360 Environmental was commissioned by the shire to undertake the of Detailed Wetland Assessment and Site-Specific Wetland Buffer Study for the following wetlands within the LSP area:

- Resource Enhancement Wetland (REW) (UFI 14984)
- Resource Enhancement Wetland (REW) (UFI 15204)
- Portion of Conservation Category Wetland (CCW) (UFI 15002)
- Conservation Category Wetland (CCW) (UFI 15205) and its buffer (Figure 2).

Multiple Use Wetlands (MUW) (UFI 14989, UFI 1578 and UFI 16021) are mapped within the LSP, these areas are developed for urban and rural purpose (cleared grazing paddocks). Due to their current classification (Table 1) and degraded nature, these wetlands are not discussed further within this study.

1.2 Scope of Works and Objectives

In compiling of this report 360 Environmental has given due regard to the following documents:

- The Department of Biodiversity Conservation and Attractions (DBCA) 'A methodology for the evaluation of specific wetland types on the Swan Coastal Plain, Western Australia' (Department of Biodiversity Conservation and Attractions, 2017a)
- DBCA Wetland identification and delineation: information for mapping and land use planning on the Swan Coastal Plain, Department of Biodiversity, Conservation and Attractions 2017
- Western Australian Planning Commission (WAPC) Guideline for the Determination of Wetland Buffer Requirements, (Western Australian Planning Commission, 2005).

The objective of the assessment is the evaluate and assess the wetlands and associated buffers within the LSP to determine if existing classification (as per Table 1) is appropriate.

Table 1: Wetland Management Categories and Objectives Applied to the Swan Coastal Plain

Management Category	General Description	Objectives
Conservation Category Wetland (CCW)	Wetlands which support a high level of attributes and functions.	To preserve and protect their existing conservation values through various mechanisms including: • Reservation in national parks, Crown reserves and state owned land • Wetland covenanting by landowners. No development or clearing is considered appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is inappropriate.
Resource Enhancement Wetland (REW)	Wetlands which may have been modified or degraded, but still support substantial attributes and functions.	To manage, restore and protect towards improving their conservation value and hydrological/hydrogeological regime. These wetlands have the potential to be restored or rehabilitated to Conservation category focusing on wetland functions, structure and biodiversity value.
Multiple Use Wetland (MUW)	Wetlands with few remaining important attributes and functions	The use, development and management of these wetlands should be considered in the context of ecologically sustainable development and best management practice catchment planning. Their role in managing the natural hydrological and hydrogeological regime of the general area should be maintained.

2 Existing Environment

2.1 Topography and Geology

The topography within the LSP area is characterised by a relatively flat palusplain varying between approximately 30 mAHD in the north-west corner to 35 mAHD in the middle of LSP area near Karnup Road. There are no significant depressions in topography which are associated with wetland locations (Figure 3).

The LSP area is located on the Pinjarra Phase which is characterised by Poorly drained coastal plain with variable alluvial and aeolian soils (Department of Agriculture and Food WA, 2012). The subsoils located within the LSP area including the following phases (Figure 3):

- **Pinjarra P1a Phase (213Pj__P1a):** Flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity.
- **Pinjarra P1d Phase (213Pj_P1d):** Flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and moderately susceptible to salinity.
- **Pinjarra P3 Phase (213Pj_P3):** Flat to very gently undulating plain with deep, imperfect to poorly drained acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.
- **Pinjarra P4 Phase (213Pj__P4):** Poorly drained flats, sometimes with gilgai microrelief and with moderately deep to deep black, olive grey and some yellowish brown cracking clays and less commonly non-cracking friable clays with generally acidic subsoils.
- **Pinjarra B1 Phase (213Pj_B1):** Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m.
- **Pinjarra, B2 Phase (213Pj__B2):** Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
- **Pinjarra, B3 Phase (213Pj_B3):** Closed depressions and poorly defined stream channels with moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand or sandy loam (Department of Primary Industries and Regional Development, 2018).

Regional Environmental Geology mapping (Gozzard, 1986) indicates that there are three main soil units associated with the wetland areas:

- **Sand (Sb):** white to pale grey at surface, yellow at depth; fine to medium-grained, moderately sorted sub-angular to sub-rounded minor heavy minerals, of eolian origin
- **Sandy Clay (Cs):** white, grey to brown, fine to coarse, sub-angular to rounded, clay of moderate plasticity; gravel and silt layers near scarp, of alluvial origin

- **Clayey Peaty Sand (Spc):** grey to black, quartz sand with variable organic content; minor clays, of lacustrine origin (Figure 4).

2.2 Hydrology

2.2.1 Groundwater

The LSP area is outside the Department of Water and Environmental Regulation (DWER) Perth Groundwater Atlas regional groundwater contours area. GHD (2013) reports that historic maximum groundwater contours and indicates that the minimum groundwater level is 30 mAHD, approximately 0 m below the natural surface based on the existing topography. Based on site evidence, groundwater is generally perched at surface level in low lying areas during the winter months and flows in a westerly direction towards Serpentine River.

2.2.2 Surface Water and Wetlands

The LSP areas also experiences regular water logging in the low-lying area, with inundation due to a combination of persistent winter rainfall elevating the shallow water table, which rises to the surface and inundates areas of flat terrain with poor drainage (GHD, 2013). While there are Water Corporation open drains within the LSP area, none intersect the wetlands under investigation (Figure 4).

The wetland classification, landform and type for the wetlands as part of this investigation are provided in Table 2. All the wetlands are within the Bennett Brook Consanguineous Suite, which is characterised by Macroscale, irregular, subhaline poikilohaline sumplands. Microscale, meandering freshwater poikilohaline creeks. Macroscale, irregular to linear, form (Department of Biodiversity Conservation and Attractions, 2017b)

Table 2: Wetland Classification, Landform and Type

Wetland Classification	UFI	Landform and Wetland Type	Consanguineous Suite
REW	UFI 14984	Basin - Dampland	Bennett Brook
REW	UFI 15204	Basin - Sumpland	
CCW	UFI 15002	Basin - Dampland	
CCW	UFI 15205	Basin - Dampland	

2.2.3 Groundwater Dependent Ecosystems

In 2012, the Groundwater Dependent Ecosystems (GDE) Atlas was released by Bureau of Meteorology which based on remote sensing and Geographic information Systems (GIS) mapped the potential for groundwater/ecosystem interaction, which indicates the following:

- High potential for aquatic GDE: REW (UFI 14984), CCW (UFI 15002)
- Moderate potential for aquatic GDE: REW (UFI 15204), CCW (UFI 15205).

Western Australian Local Government Authority (WALGA) (2018) notes that aquatic GDE are dependent on the surface expression of groundwater, including all groundwater fed surface

water bodies such as wetlands, rivers, lakes and springs. This does not include fringing vegetation, only the aquatic component of the ecosystem.

CCW (UFI 15205) and part of REW (UFI 15204) has been mapped as moderate terrestrial GDE, which indicates that inflow-dependent ecosystems which represent the vegetation ecosystems that are likely to use groundwater in addition to rainfall (Western Australian Local Government Authority, 2018).

2.3 Vegetation and Flora

The wetland areas (Survey Area) were inspected by 360 Environmental Principal Botanist on 5 September 2019. It is noted that the mapped wetlands which extended past the LSP area were not inspected as part of this assessment. The LSP area has been subjected to extensive clearing since the early 1950s, particularly REW (UFI 14984), CCWs UFI 15002 and UFI 15205. Within CCW (UFI15205) are areas of remnant vegetation.

2.3.1 Desktop Analysis

Regional vegetation association mapping indicates that the LSP area is mapped as Pinjarra_968 which is characteristic of medium woodland of *Eucalyptus marginata* (Jarrah), *Corymbia calophylla* (Marri) and *Eucalyptus wandoo* (Wandoo) (Shepherd, Beeston, & Hopkins, 2002). (Heddle, Loneragan, & Havel, 1980) vegetation complex mapping depicts the LSP area occurring within the Guildford Complex which is characterised by a mixture of open forest to tall open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) and woodland of *Eucalyptus wandoo* (Wandoo) (with rare occurrences of *Eucalyptus lane-poolei* (Salmon White Gum). Minor components include *Eucalyptus rudis* (Flooded Gum) - *Melaleuca rhaphiophylla* (Swamp Paperbark) (Heddle et al., 1980).

The DBCA NatureMap and Department of Environment and Energy (DEE) Protected Matters Search Tool (PMST) was search with a 5km buffer, for significant species or habitats which has been recorded within or in the vicinity of the LSP area (Appendix B). These species include:

Threatened

- *Caladenia huegelii* (Grand Spider Orchid)
- *Lasiopetalum pterocarpum*
- *Synaphea sp. Fairbridge Farm* (D. Papenfus 696)
- *Synaphea sp. Pinjarra Plain* (A.S. George 17182)
- *Synaphea sp. Serpentine* (G.R. Brand 103)
- *Tetraria australiensis*
- *Verticordia plumosa var. ananeotes.*

Priority 1

- *Synaphea odocoileops*

Desktop searches has identified five Threatened Ecological Communities (TECs) as potentially occurring within 5 km radius of the Site (DEE 2019):

- Banksia Woodlands of the Swan Coastal Plain ecological community;
- Clay Pans of the Swan Coastal Plain; and
- *Corymbia calophylla – Kingia australis* woodlands on heavy soils of the Swan Coastal Plain.
- *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain
- Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological community

2.3.1.1 Lambkin Reserve

Keighery and Keighery (1996) completed a vegetation and flora survey for CCW (UFI 15002) which is part of the reserve. The vegetation types that were present within the reserve, included:

- On the sandy well drained soil a *Eucalyptus marginata-Corymbia calophylla* tall open woodland over low scrub of *Eremaea pauciflora, Xanthorrhoea preissii* and *Daviesia physodes* over low sedges of *Tetraria octandra* and *Mesomelaena* species occurs.
- Between the sandy and deep swamp there is an open to closed heath of Kunzea and Pericalymma over sedges and herbs.
- The swamp area had a *Melaleuca rhaphiophylla* low forest over tall sedges, where it has been grazed and partially cleared the canopy is open and the sedges are replaced by a layer of grass (*Eragrostis elongata*). On the boundary between this vegetation type and the Kunzea/Pericalymma heath the *Melaleuca rhaphiophylla* woodland has *Banksia littoralis* present over a diverse shrubland of *Hakea varia, Astartea fasicularis, Hakea ceratophylla, Hakea sulcata, Regelia ciliata* and *Pericalymma elliptica*.

The area of the reserve which was not disturbed was considered to be in 'Very Good' to 'Excellent' condition (Keighery and Keighery, 1996).

Bush Forever (Government of Western Australia, 2000) notes that the reserve consists of vegetation wetland and uplands structure with over half of the reserve in 'Very good' to 'Excellent' condition. A total of 136 native taxa have been recorded within the reserve including the significant flora *Tetraria australiensis, Eucalyptus marginata, Actinostrobus acuminatus, *Sphaeromorphaea australis* and *Lomandra sonderi*.

2.4 Fauna and Habitat

The DBCA NatureMap and Department of Environment and Energy (DEE) PMST was searched with a 5km buffer, for significant species or habitats which has been recorded within or in the vicinity of the LSP area (Appendix B). These species include:

- *Calyptorhynchus banksii subsp. naso* (Forest Red-tailed Black Cockatoo)
- *Calyptorhynchus baudinii* (Baudin's Cockatoo, White-tailed Long-billed Black Cockatoo)
- *Calyptorhynchus latirostris* (Carnaby's Cockatoo, White-tailed Short-billed BlackCockatoo)

- *Dasyurus geoffroii* (Chuditch, Western Quoll)
- *Euoplos inornatus* (inornate trapdoor spider)
- *Hydromys chrysogaster* (Water-rat, Rakali)
- *Isoodon fusciventer* (Quenda, southwestern brown bandicoot).

The WALGA Environmental Planning tool indicates that the LSP are is not within a known Black cockatoo roosting area (buffered) and that remnant vegetation within Lambkin Reserve may provide potential Black cockatoo foraging habitat and supports potential Quenda habitat (Western Australian Local Government Authority, 2018). These fauna habitats were not identified within REW (UFI 14984).

2.5 Environmental Significance

There is one Bush Forever Site (No. 375) Byford to Serpentine Rail/Road reserves and adjacent bushland is mapped within the LSP. There are two other Bush Forever Sites (No. 365 and 371) which are adjacent to the LSP boundary in the north (Figure 5).

Regional ecological linkages aim 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 (Del Marco et al. 2004). The western and northern sections of the LSP has been identified as part of a regional ecological linkage (Western Australian Local Government Authority, 2018) (Figure 5).

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* under Section 51B of the Environmental Protection Act 1986. ESAs 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 rare flora, TEC
- Bush Forever Site.

An ESA has been mapped over most of the LSP which is likely associated with the presence and boundary mapping of Bush Forever Sites, CCW and associated buffers and rare flora (Figure 7).

2.6 Heritage

A search of the DPLH Aboriginal Heritage Inquiry System reports one registered Aboriginal site with the LSP, Serpentine River (ID 3582), there are no other heritage sites listed within the LSP area (Appendix C).

The State Heritage Office/Heritage Council Inherit database was searched (17/09/2019) for European heritage, while there are no registered sites within the wetland areas, there are three

sites (Butcher Shop [8625], Serpentine Falls Hotel [2358] and Serpentine General Store[3866]) located within the LSP area.

2.7 Bushfire

From 2000, The NAFI Fire Frequency mapping indicates that there have been no fires within the LSP area (Western Australian Local Government Authority, 2018).

3 Resource Enhancement Wetland (REW) (UFI 14984) Assessment

The associated preliminary desktop and site assessment questions are attached as Appendix D.

3.1 Preliminary Desktop Assessment

The REW is under multiple private landowners. A significant portion of the REW is mapped as 'Rural' and part 'Residential' under the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (TPS2). Table 3 below outlines the responses to the criteria detailed in (DBCA 2017a).

Based on the background information presented in Section 2.0 and Site Survey (Section 3.2), the preliminary evaluation criterion as depicted in Table 3 has been completed. If a 'yes' can be answered to any one of the criteria then the wetland is considered to support the highest level of values, attributes and functions. Wetlands supporting a high level of values, attributes and functions are automatically assigned to Conservation management category. REW (UFI 14984) did not meet any of the preliminary evaluation criteria (Table 3). Therefore, a secondary evaluation scoring assessment was completed for the wetland (refer to Section 3.3).

Table 3: Preliminary Evaluation Criteria (REW-UFI 14984)

No.	Criteria	Y/N
1	The wetland is currently recognised as internationally or nationally significant for its natural values. Lists/registers include: • The Ramsar Convention on Wetlands • State government endorsed candidate sites for the Ramsar Convention on Wetlands • Directory of Important Wetlands in Australia • National Heritage List • Or equivalent.	N
2	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlines in Appendix B and is identified as significant for its natural values under one or more of the following: • Conservation Reserves for Western Australia Systems 1,2,3,5 • Conservation Reserves for Western Australia, The Darling System – System 6 • A Systematic Overview of Environmental Values of the Wetlands, Rivers and Estuaries of the Busselton – Walpole Region • The Environmental Significance of Wetlands in the Perth to Bunbury Region • Bush Forever, Swan Bioplan (including Peel Regionally Significant Natural Areas) or equivalent.	N
3	The wetland supports a breeding, roosting or refuge site or a critical feeding site for populations of fauna listed by the Australian Government (for example, *Environment Protection and Biodiversity Conservation Act 1999*, migratory bird agreements such as JAMBA, CAMBA and RoKAMBA) or the State (for example, threatened and specially protected fauna listed under the *Wildlife Conservation Act 1950*)	N

No.	Criteria	Y/N
4	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and supports one or more of the following: • An occurrence of a threatened ecological community • A confirmed occurrence of a priority 1 or priority 2 ecological community • A confirmed occurrence of a declared rare (threatened) flora species.	N
5	Equal or greater than 90% of the wetland supports vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B.	N
6	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and is known to support internationally, nationally or state-wide scientific values including geoheritage and geoconservation	N
7	scale outlined in Appendix B and meets one of the following: The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition • ≤10% of wetlands of the same type are assigned Conservation management category within the Swan Coastal Plain (by area) • ≤10% of all wetlands in the same consanguineous suite are assigned Conservation management category (by area) • ≤10% wetlands of the same type in its consanguineous suite are assigned Conservation management category (by area) • Best representative of its type within its consanguineous suite domain. **Note**: The site is not spatially dominated by vegetation in Good or better condition (Figure 6). • 29.3% of the same wetland type (dampland) is assigned conservation management category within the Swan Coastal Plain (DBCA 2017) • The REW (UFI 14984) belongs to the Bennett Brook consanguineous suite, of which 8.4% of its wetlands have been assigned a conservation management category (DBCA 2017) • Of the 'dampland' wetland type in the Bennett Brook consanguineous suite, 9.4% are assigned conservation management category (DBCA 2017).	N

3.2 Site Assessment

The following sections describe the flora and vegetation of wetland UFI 14984.

3.2.1 Surveyed Vegetation Associations and Condition

Majority of the site has been cleared and disturbed from previous rural land uses; however, there are some mature native trees within the boundary of the mapped wetland. The vegetation within the REW of the site has no natural structure and has been severely altered by previous rural land uses and clearing activities. The condition of the REW within the site is considered to be in Completely Degraded condition (Figure 6).

The vegetation within the Survey Area boundary of the wetland can be described as:

- Rows and /or patches of mature non-endemic trees and shrubs with scattered trees of *Corymbia calophylla, Melaleuca rhaphiophylla, Eucalyptus marginata* and *Eucalyptus rudis* over paddock weeds (Figure 7).

These have been mapped and identified on Figure 7 as follows:

- **Cc**: *Corymbia calophylla*
- **Er**: *Eucalyptus rudis*
- **Mr**: *Melaleuca rhaphiophylla*
- **Ne**: Non-endemic Trees
- **NeCc**: Non-endemic trees and *Corymbia calophylla*
- **NeMr**: Non-endemic trees and *Melaleuca rhaphiophylla*
- **G**: Garden
- **GMrCc**: Garden with scattered *Melaleuca rhaphiophylla* and *Corymbia calophylla*
- **GCc**: Garden with Scattered *Corymbia calophylla*
- **P**: Pine trees

3.2.2 Photo Monitoring Points

Thirteen photo point locations within the wetland area were used to capture the wetlands attributes. The details are outlined in Table 4 and Figure 8.

Table 4: Locations of Photo Points

Photo Point Number	Location (UTM 50J)	Direction	Photo Point Number	Location (UTM 50J)	Direction
1	403548 E 6419752 N	East	8	403599E 6419415N	South
1		South	8		West
1		West	8		North
1		North	8		East
2	403632 E 6419718 N	South	9	403625E 6419331N	East
3	403686 E 6419758 N	East	9		South
3		South	9		West
3		West	9		North
3		North	10	403640E 6419296N	East
4	403531 E 6419667 N	East	11	403642E 6419274N	East
4		South	12	403664E	East

Photo Point Number	Location (UTM 50J)	Direction	Photo Point Number	Location (UTM 50J)	Direction
4		West	12	6419206N	South
4		North	12		West
5	403549 E 6419626 N	East	12		North
6	403563 E 6419550 N	East	13	403950E 6419130N	East
6		South	13		South
6		West	13		West
6		North	13		North
7	403583 E 6419468 N	East			

3.2.3 Threatened and Priority Ecological Communities

Majority of native vegetation across wetland (UFI 14984) within the Survey Area has been cleared previously as a result of historical rural use. The remaining vegetation consists of mainly introduced weed species, planted non-endemic tree species and scattered native trees, which has no intact native understorey. As a result, it is considered unlikely that the site would contain a TEC or PEC.

3.2.4 Threatened and Priority Flora

The REW did not record any Threatened or Priority flora species within the site. Given that the vegetation across the site has been historically cleared and is in a completely degraded and disturbed condition, it is considered very unlikely that any conservation significant flora species would occur.

3.2.5 Weeds

No weeds listed as Weeds of National Significance (WONS) or Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) were found within the LSP area.

3.3 Secondary Evaluation

A secondary evaluation was undertaken that included assessing all the criteria listed under each attribute/function and value assigning an appropriate score (high, intermediate or low). These scores were tallied and are displayed in Table 5 and 6 along with the resultant applicable management category.

Table 5: Secondary Evaluation Criteria (REW UFI 14984)

Attributes /Functions / Values	General Criteria	Criteria	Score
Geomorphology			
1	*Representativeness*	≤20% of wetlands of the same type are assigned Conservation on the Swan Coastal Plain by area **Note:** 29.3% of the same wetland type (dampland) is assigned conservation management category within the Swan Coastal Plain (DBCA 2017)	-
2		≤20% of wetlands in the same consanguineous suite are assigned Conservation by area **Note:** The REW (UFI 14984) belongs to the Bennett Brook consanguineous suite, of which 8.4% of its wetlands have been assigned a conservation management category)	H
3		≤ 20% of wetlands of the same type in the same consanguineous suite are assigned Conservation by area **Note:** Of the 'dampland' wetland type in the Bennett Brook consanguineous suite, 9.4% are assigned conservation management category (DBCA 2017).	H
4		The wetland is outstanding in some geomorphic aspect, for example size, origin, height relative to sea level, depth, age. **Note:** The wetland has no apparent unique features	-
5	*Naturalness*	Alteration to the wetland's geomorphology % area: <25% altered	-
		Alteration to the wetland's geomorphology % area: 25-75% altered.	-
		Alteration to the wetland's geomorphology % area: >75% altered Note: Over75% of the REWs geomorphology has been altered due to the filling, clearing and development (urban and rural)	L
6	*Scarcity*	The wetland exhibits unusual geomorphology or unusual internal geomorphic features compared to other wetlands of the same type in the consanguineous suite.	-
7		The wetland is the best example of its type in its consanguineous suite.	-
Wetland Processes			
8	*Representativeness*	The wetland is an important component of the natural hydrological cycle providing natural functions (e.g. flood protection, recharge/discharge, hydrological storage, support for groundwater dependent ecosystems).	-
		The wetland's vegetation, geomorphology, hydrology or sediments are modified; however, the wetland is still a component of the hydrological cycle providing natural	I

Attributes /Functions / Values	General Criteria	Criteria	Score
		and artificial functions (e.g. flood remediation, recharge/discharge, hydrological storage, support for groundwater dependent ecosystems).	
		The wetland's vegetation, geomorphology, hydrology or sediments are modified to the extent that the wetlands hydrological functions are artificial such as storage, or the wetland has been disconnected from the natural hydrological cycle and no longer provides natural attributes and functions.	-
9		The wetland supports a representative process (e.g. wetland process typical of the wetland's hydrological setting, sediment accretionary process typical of the wetland's geomorphic setting or hydro-chemical process typical of the wetland's geological setting).	-
10	*Naturalness*	The wetland is not subject to altered wetland processes or, is subject to altered wetland processes and the wetland's natural attributes and functions are maintained.	-
		The wetland is subject to altered wetland processes and the wetland's natural attributes and functions have been changed; however, they have the potential to be rehabilitated.	I
		The wetland is subject to altered wetland processes to the extent that the wetland no longer supports natural attributes and functions.	-
11	*Scarcity*	The wetland exhibits unusual processes compared to other wetlands of the same type in the consanguineous suite.	-
Linkages			
12	*Representativeness*	The wetland is a hydrological link in a larger or more complex and intact system. **Note:** adjacent to the Serpentine River.	H
13	*Naturalness*	The wetland is part of continuous ecological linkage or wildlife corridor, or a regionally significant ecological linkage or wildlife corridor connecting bushland or wetland areas.	-
		The wetland is part of a fragmented ecological linkage or wildlife corridor. **Note:** The wetland does not fall within a mapped ecological linkage. Furthermore, given the mostly degraded condition of the wetland it is not considered to provide significant value as a potential ecological linkage.	I
		The wetland is disturbed and isolated, surrounded by either a built or highly disturbed environment with no nearby native vegetation or waterways to support an intact fragmented ecological linkage or wildlife corridor.	-
14	*Scarcity*	The wetland has unusual hydrological, hydrogeological, hydrochemical or ecological linkages with adjacent wetlands and bushland.	-

Attributes /Functions / Values	General Criteria	Criteria	Score
Habitats			
15	*Representativeness*	The wetland is isolated from other undisturbed wetlands or bushland and as a result, maintains important ecological or genetic fauna or flora diversity within its consanguineous suite domain.	-
16		The wetland contains evidence of surface water or groundwater expression that is vital for maintaining regionally significant populations of native aquatic or terrestrial flora or fauna.	-
		The wetland contains evidence of surface water or groundwater expression that is important for maintaining populations of native aquatic or terrestrial flora or fauna	-
17		The wetland provides a nursery for native fauna populations, or maintains fauna populations at a vulnerable stage of their life cycle	-
18	*Naturalness*	The wetland supports habitats that are unaltered, or the wetland has been altered and its natural habitats are maintained.	-
		The wetland supports habitats that are altered; however, the habitats are still identifiable and have the potential to naturally regenerate or be rehabilitated after weed control, if required.	-
		The wetland is altered and as a result is no longer supporting natural habitats which can be rehabilitated. **Note:** Approximately 95% of the wetland is in a 'Degraded' to 'Completely Degraded' condition as a result of extensive clearing and human alteration and no longer support habitats which can be rehabilitated. The site is generally dominated by weed species.	L
19	*Scarcity*	The wetland supports habitats that are unusual compared to other wetlands of the same type on the Swan Coastal Plain.	-
Flora			
20	*Representativeness*	The wetland's current diversity of native flora is similar to what would be expected in an unaltered state.	-
		The wetland supports a reduced diversity of native flora due to human induced disturbances.	-
		The wetland supports a significantly reduced diversity of native flora species due to human induced disturbances.	L
21		The wetland is identified in a vegetation complex (*Heddle et al. 1980*) which is represented by: ≤ 30% of the pre-European extent 30-50% of the pre-European extent. **Note:** The site is within the Guildford Complex that has a Pre-European extent of 5.09% remaining	H

Attributes /Functions / Values	General Criteria	Criteria	Score
		The wetland is identified in a vegetation complex (*Heddle et al. 1980*) which is represented by: 30-50% of the pre-European extent.	-
22	*Naturalness*	Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: ≥ 75% Good, Very Good, Excellent or Pristine	-
		Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: 25-75% Good, Very Good, Excellent or Pristine	-
		Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: < 25% Good, Very Good, Excellent or Pristine.	L
23		The wetland or ≥ 50% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	-
		The wetland or 10-50% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	-
		The wetland or < 10% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	L
24	*Scarcity*	The wetland supports an occurrence of declared rare, priority 1, priority 2, priority 3 or priority 4 flora, or an occurrence of three or more significant flora taxa.	-
25		The wetland is likely to support declared rare, priority 1, priority 2, priority 3 or priority 4 flora; however, the occurrence cannot be located, or its habitat has been altered and is no longer in a natural state.	-
26		The wetland supports an occurrence of a threatened ecological community, priority 1 or priority 2 ecological community	-
27		The wetland supports an occurrence of a priority 3 or priority 4 ecological community.	-
Fauna			
28	*Representativeness*	The wetland is an ecological refuge for regionally significant fauna species or fauna assemblages.	-
		The wetland has the potential to be an ecological refuge but is disturbed and its attributes and functions require rehabilitation	I
29		The wetland supports a permanent or seasonal feeding, breeding, roosting or watering site for regionally significant native fauna.	-

Attributes /Functions / Values	General Criteria	Criteria	Score
		The wetland supports a permanent or seasonal feeding, breeding, roosting or watering site for regional or local fauna but only in association with other surrounding natural areas. **Note:** As the REW is predominately 'Degraded' to 'Completely Degraded' condition and given its modified state it is unlikely to provide permanent habitat for local or regional fauna populations in isolation from the surrounding conservation areas. It is considered likely the fauna may occasionally utilise the site, particularly highly mobile species, such as birds, however, any habitat is unlikely to be necessary to support fauna populations.	-
30	*Naturalness*	The wetland's current diversity of native fauna is similar to what would be expected in an unaltered state, or the wetland supports diverse fauna compared to other wetlands of the same type.	-
		The wetland supports a reduced diversity of fauna compared to other wetlands of the same type.	-
		The wetland supports limited attributes and functions for fauna populations due to human induced disturbances. **Note:** Approximately 95% of the wetland is in a 'Degraded' to 'Completely Degraded' due to human induced disturbances and is unlikely to support fauna populations in isolation.	L
31	*Scarcity*	The wetland is likely to support a breeding, roosting, refuge or feeding site for populations of fauna listed by the Australian Government (e.g. EPBC Act 1999, JAMBA, CAMBA, RoKAMBA Agreements) or the State (e.g. threatened or specially protected fauna listed under the *Wildlife Conservation Act 1950*). **Note:** No evidence of the above species was recorded during a site visit.	-
32		The wetland supports a breeding, roosting, refuge or feeding site for priority 1, priority 2, priority 3 or priority 4 fauna. **Note:** No evidence of the above species was recorded during a site visit.	-
33		The wetland supports an occurrence of a threatened ecological community, priority 1 or priority 2 ecological community.	-
34		The wetland supports an occurrence of a priority 3 or priority 4 ecological community or a breeding, roosting, refuge or feeding site for significant fauna.	-
Cultural			
35	*Representativeness*	The wetland or its immediate surrounds is identified for its natural values on a national or State heritage list or the wetland supports other known regional heritage values.	-

Attributes /Functions / Values	General Criteria	Criteria	Score
		Note: A search of the Heritage Council Inherit search tool (2019) indicates that the Serpentine River is a registered site.	
36		The wetland or its immediate surrounds is identified for its natural values on a municipal heritage list or the wetland supports other known local heritage values.	-
37		The wetland or its immediate surrounds is identified on a national, State or local list or register for its Aboriginal cultural value. **Note**: A search of the DPLH Aboriginal Heritage Inquiry System identified the Serpentine River as a registered site which adjacent to the northern margin of the LSP area.	H
38		The wetland is important to the local community for its natural values	-
39		The wetland is or has the potential to be a site for public or private based recreation **Note:** The REW is in multiple privately owned and given its highly degraded state holds limited recreational value.	-
40		The wetland is the subject of a recognised ecological restoration / rehabilitation project by a community group, landowner or land manager that aims to improve the wetland's natural, heritage, cultural or social values.	-
		The wetland is likely to support heritage, cultural or social values; however, the values cannot be confirmed, or the values have been disturbed and are no longer as important or significant.	I
		The wetland did support heritage, cultural or social values; however, these have been significantly disturbed and are no longer important or the values have been removed.	-
Scientific and Educational			
41	*Representativeness*	The wetland supports known important teaching or research characteristics and for this reason is an existing or potential education or research site.	-
		The wetland has the potential to be used as a study or research site. **Note:** The wetland holds no unique features, is predominately 'Completely Degraded' and is located on private property; therefore the REW is unlikely to hold research value.	-
42		The wetland supports known scientific, geoheritage or geoconservation values.	-

Table 6: Results of the Secondary Evaluation Criteria (REW UFI 14984)

Attributes / Functions / Values	Scores		
	High (H)	Intermediate (I)	Low(L)
Geomorphology	2		1
Wetland processes		2	
Linkages	1	1	
Habitats			1
Flora	1		3
Fauna		1	1
Cultural	1	1	
Scientific and educational			
Total Score	5	5	6
Defining Attributes/ Functions/ Values	**Flora**		
Applicable Management Category	**Multiple Use**		

3.3.1 Conclusion

Based on the assessment, the wetland reflects the attributes, function and values and objectives (Table 1) associated with a multiple use management category (Table 6).

4 Portion of Conservation Category Wetland (CCW) (UFI 15002) and Conservation Category Wetland (CCW) (UFI 15205)

4.1 Preliminary Desktop and Site Assessment

The portion of the CCW within the LSP area is currently zoned part Residential, Urban Development and road reserve under the Shires TPS No. 2. Table 7 below outlines the responses to the criteria detailed (DBCA 2017a).

Based on the background information presented in Section 2.0 and Site Survey (Section 4.2), the preliminary evaluation criterion as depicted in Table 7 has been completed. If a 'yes' can be answered to any one of the criteria then the wetland is considered to support the highest level of values, attributes and functions. Wetlands supporting a high level of values, attributes and functions are automatically assigned to Conservation management category. Portion of CCW (UFI 15002) and CCW (UFI 15205) met five preliminary evaluation criteria (Table 7). A secondary evaluation scoring assessment was completed for the wetlands (refer to Section 4.3).

Table 7: Preliminary Evaluation Criteria

No.	Criteria	Y/N
1	The wetland is currently recognised as internationally or nationally significant for its natural values. Lists/registers include: • The Ramsar Convention on Wetlands • State government endorsed candidate sites for the Ramsar Convention on Wetlands • Directory of Important Wetlands in Australia • National Heritage List • Or equivalent.	N
2	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlines in Appendix B and is identified as significant for its natural values under one or more of the following: • Conservation Reserves for Western Australia Systems 1,2,3,5 • Conservation Reserves for Western Australia, The Darling System – System 6 • A Systematic Overview of Environmental Values of the Wetlands, Rivers and Estuaries of the Busselton – Walpole Region • The Environmental Significance of Wetlands in the Perth to Bunbury Region • Bush Forever, Swan Bioplan (including Peel Regionally Significant Natural Areas) or equivalent.	Y
3	The wetland supports a breeding, roosting or refuge site or a critical feeding site for populations of fauna listed by the Australian Government (for example, *Environment Protection and Biodiversity Conservation Act 1999*, migratory bird agreements such as JAMBA, CAMBA and RoKAMBA) or the State (for example, threatened and specially protected fauna listed under the *Wildlife Conservation Act 1950*)	Y

No.	Criteria	Y/N
4	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and supports one or more of the following: • An occurrence of a threatened ecological community • A confirmed occurrence of a priority 1 or priority 2 ecological community • A confirmed occurrence of a declared rare (threatened) flora species.	Y
5	Equal or greater than 90% of the wetland supports vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B.	Y
6	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and is known to support internationally, nationally or state-wide scientific values including geoheritage and geoconservation	Y
7	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and meets one of the following: • ≤10% of wetlands of the same type are assigned Conservation management category within the Swan Coastal Plain (by area) • ≤10% of all wetlands in the same consanguineous suite are assigned Conservation management category (by area) • ≤10% wetlands of the same type in its consanguineous suite are assigned Conservation management category (by area) • Best representative of its type within its consanguineous suite domain. **Note**: The site is not spatially dominated by vegetation in Good or better condition (Figure 6). • 29.3% of the same wetland type (dampland) is assigned conservation management category within the Swan Coastal Plain (DBCA 2017) • The CCW (UFI 15002) belongs to the Bennett Brook consanguineous suite, of which 8.4% of its wetlands have been assigned a conservation management category (DBCA 2017) • Of the 'dampland' wetland type in the Bennett Brook consanguineous suite, 9.4% are assigned conservation management category (DBCA 2017).	N

4.2 Site Assessment

The following sections describe the flora and vegetation of the site.

4.2.1 Surveyed Vegetation Associations and Condition

Majority of the wetlands consist of intact native vegetation and are considered to be in Excellent to Completely Degraded condition (Figure 6). The area mapped as Completely Degraded included the road, road verge, the parkland cleared area at the northern end as well as a patch of open water with a weed infestation of **Eragrostis curvula*. Forty percent (40%) of the two CCWs is mapped as being Excellent Condition.

It is important to note that the wetlands have a very defined edge, that is, there is a distinct boundary where the intact native vegetation ends due to existing infrastructure and land uses i.e. roads, fence lines, paddocks and the railway.

The vegetation within CCW UFI 15002 and UFI15205 has been identified as (Figure 7):

- **CcEm**: Woodland of *Corymbia calophylla, Eucalyptus marginata* and *Nuytsia floribunda* over shrubland of *Xanthorrhoea Preissii, Allocasuarina humilis, Adenanthos meisneri* and *Hakea prostrata* over grassland of *Tetraria octandra* and *Mesomelaena tetragona*
- **MrLl**: Low woodland of *Melaleuca rhaphiophylla* over *Hakea varia*, *Regelia ciliata* and *Pericalymma ellipticum* over sedgeland of *Lepidosperma longitudinale* and *Meeboldina* sp.
- **MrAs**: Low woodland of *Melaleuca rhaphiophylla* over *Acacia saligna, Acacia rostellifera* over **Eragrostis curvula* and **Ehrharta calycina*
- **Rc:** Closed shrubland of *Regelia ciliata, Pericalymma ellipticum, Hakea sulcata* and *Astartea* sp.
- **CcMr**: *Corymbia calophylla* and *Melaleuca rhaphiophylla* over mowed grass
- **Mr**: Stand of *Melaleuca rhaphiophylla*
- **Ne**: Non-endemic *Eucalyptus* sp.
- **G**: Garden

4.2.2 Photo Monitoring Points

Nineteen photo point locations within the wetland area were used to capture the wetlands attributes. The details are outlined in Table 8 and Figure 8.

Table 8: Locations of Photo Points

Photo Point Number	Location (UTM 50J)	Direction	Photo Point Number	Location (UTM 50J)	Direction
14	403675 E 6418801 N	North East	24	403750E 6418496N	Data collection point
15	403698E 6418789N	South	29	403765E 6418454N	South
16	403721E 6418747N	North	29		West
16		East	29		North
16		South	29		East
16		West	30	403761E 6418433N	South
17	403735E 6418683N	West	30		West
17		North	30		North
17		East	30		East
17		South	32	403748E 6418375N	West
18	403663E 6418670N	East	32		North
18		South	32		East
18		West	32		South

Photo Point Number	Location (UTM 50J)	Direction	Photo Point Number	Location (UTM 50J)	Direction
18		North	33	403751E 6418340N	West
19	403663E 6418637N	East	33		North
20	403741E 6418598N	West	33		East
20		North	33		South
20		East	34	403703E 6418267N	North
20		South	34		East
21	403709E 6418566N	North	34		South
21		South	34		West
22	403677E 6418506N	South	35	403640E 6418296N	east
22		North	35		South
23	403727E 6418497N	South	35		West
23		West	35		North
23		North	37	403612E 6418302N	East
23		East	37		South
			37		West
			37		North
			38	403620E 6418367N	East

4.2.3 Threatened and Priority Ecological Communities

Statistical analysis was not undertaken of the vegetation to determine if there are any TECs or PECs present. However, the desktop assessment revealed that there is a TEC present within CCW UFI:15205. The DBCA has an established monitoring plot within the wetlands boundary (xlamb01) which has been identified as Floristic Community Type SCP20b which is Eastern *Banksia attenuata* and/or *Eucalyptus marginata* Woodlands. This community is listed as Endangered by the state but is not listed under the EPBC Act. FCT SCP20b has, however, been listed as a sub-community under the EPBC Act listed Banksia woodlands of the Swan Coastal Plain, therefore has the potential to be listed and protected under the EPBC Act (DEE 2016).

4.2.4 Threatened and Priority Flora

Two Threatened species listed under the EPBC Act and gazetted as Declared Rare Flora (Threatened) pursuant to the BC Act (2016) was recorded in the Survey Area, *Synaphea* sp. Pinjarra Plain and *Synaphea* sp. Serpentine. These flora species were located with the railway

reserve and have been previously recorded by DBCA. Another Threatened species, *Tetraria australiensis* has also been previously identified within the CCW UFI15002 boundary.

4.2.5 Weeds

No weeds listed as Weeds of National Significance (WONS), or Declared under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) were found during the survey

4.3 Secondary Evaluation

A secondary evaluation was undertaken that included assessing all of the criteria listed under each attribute/function and value assigning an appropriate score (high, intermediate or low). These scores were tallied and are displayed in Table 9 and 10 along with the resultant applicable management category. Only criteria that apply to the wetlands are rated in the tables. The assessment concluded that the current conservation management category of these wetlands reflects the attributes, functions and values associated with a CCW.

Table 9: Secondary Evaluation Criteria (portion CCW UFI 15002 and CCW UFI15205)

Attributes /Functions / Values	General Criteria	Criteria	Score
Geomorphology			
1	*Representativeness*	≤20% of wetlands of the same type are assigned Conservation on the Swan Coastal Plain by area **Note:** 29.3% of the same wetland type (dampland) is assigned conservation management category within the Swan Coastal Plain (DBCA 2017)	-
2		≤20% of wetlands in the same consanguineous suite are assigned Conservation by area **Note:** The CCW (UFI 15002) belongs to the Bennett Brook consanguineous suite, of which 8.4% of its wetlands have been assigned a conservation management category)	H
3		≤ 20% of wetlands of the same type in the same consanguineous suite are assigned Conservation by area **Note:** Of the 'dampland' wetland type in the Bennett Brook consanguineous suite, 9.4% are assigned conservation management category (DBCA 2017).	H
4		The wetland is outstanding in some geomorphic aspect, for example size, origin, height relative to sea level, depth, age. **Note:** The wetland has no apparent unique features	-
5	*Naturalness*	Alteration to the wetland's geomorphology % area: <25% altered	H
		Alteration to the wetland's geomorphology % area: 25-75% altered.	-
		Alteration to the wetland's geomorphology % area: >75% altered	-

Attributes /Functions / Values	General Criteria	Criteria	Score
		Note: Over75% of the REWs geomorphology has been altered due to the filling, clearing and development (urban and rural)	
6	*Scarcity*	The wetland exhibits unusual geomorphology or unusual internal geomorphic features compared to other wetlands of the same type in the consanguineous suite.	-
7		The wetland is the best example of its type in its consanguineous suite.	-
Wetland Processes			
8	*Representativeness*	The wetland is an important component of the natural hydrological cycle providing natural functions (e.g. flood protection, recharge/discharge, hydrological storage, support for groundwater dependent ecosystems).	H
		The wetland's vegetation, geomorphology, hydrology or sediments are modified; however, the wetland is still a component of the hydrological cycle providing natural and artificial functions (e.g. flood remediation, recharge/discharge, hydrological storage, support for groundwater dependent ecosystems).	-
		The wetland's vegetation, geomorphology, hydrology or sediments are modified to the extent that the wetlands hydrological functions are artificial such as storage, or the wetland has been disconnected from the natural hydrological cycle and no longer provides natural attributes and functions.	-
9		The wetland supports a representative process (e.g. wetland process typical of the wetland's hydrological setting, sediment accretionary process typical of the wetland's geomorphic setting or hydro-chemical process typical of the wetland's geological setting).	H
10	*Naturalness*	The wetland is not subject to altered wetland processes or, is subject to altered wetland processes and the wetland's natural attributes and functions are maintained.	H
		The wetland is subject to altered wetland processes and the wetland's natural attributes and functions have been changed; however, they have the potential to be rehabilitated.	-
		The wetland is subject to altered wetland processes to the extent that the wetland no longer supports natural attributes and functions.	-
11	*Scarcity*	The wetland exhibits unusual processes compared to other wetlands of the same type in the consanguineous suite.	-

Attributes /Functions / Values	General Criteria	Criteria	Score
Linkages			
12	*Representativeness*	The wetland is a hydrological link in a larger or more complex and intact system.	-
13	*Naturalness*	The wetland is part of continuous ecological linkage or wildlife corridor, or a regionally significant ecological linkage or wildlife corridor connecting bushland or wetland areas.	-
		The wetland is part of a fragmented ecological linkage or wildlife corridor.	I
		The wetland is disturbed and isolated, surrounded by either a built or highly disturbed environment with no nearby native vegetation or waterways to support an intact fragmented ecological linkage or wildlife corridor.	-
14	*Scarcity*	The wetland has unusual hydrological, hydrogeological, hydrochemical or ecological linkages with adjacent wetlands and bushland.	-
Habitats			
15	*Representativeness*	The wetland is isolated from other undisturbed wetlands or bushland and as a result, maintains important ecological or genetic fauna or flora diversity within its consanguineous suite domain.	-
16		The wetland contains evidence of surface water or groundwater expression that is vital for maintaining regionally significant populations of native aquatic or terrestrial flora or fauna.	-
		The wetland contains evidence of surface water or groundwater expression that is important for maintaining populations of native aquatic or terrestrial flora or fauna	I
17		The wetland provides a nursery for native fauna populations, or maintains fauna populations at a vulnerable stage of their life cycle	-
18	*Naturalness*	The wetland supports habitats that are unaltered, or the wetland has been altered and its natural habitats are maintained.	H
		The wetland supports habitats that are altered; however, the habitats are still identifiable and have the potential to naturally regenerate or be rehabilitated after weed control, if required.	-
		The wetland is altered and as a result is no longer supporting natural habitats which can be rehabilitated.	-
19	*Scarcity*	The wetland supports habitats that are unusual compared to other wetlands of the same type on the Swan Coastal Plain.	-
Flora			
20	*Representativeness*	The wetland's current diversity of native flora is similar to what would be expected in an unaltered state.	H

Attributes /Functions / Values	General Criteria	Criteria	Score
		The wetland supports a reduced diversity of native flora due to human induced disturbances.	-
		The wetland supports a significantly reduced diversity of native flora species due to human induced disturbances.	-
21		The wetland is identified in a vegetation complex (*Heddle et al. 1980*) which is represented by: ≤ 30% of the pre-European extent 30-50% of the pre-European extent. **Note:** The site is within the Guildford Complex that has a Pre-European extent of 5.09% remaining	H
		The wetland is identified in a vegetation complex (*Heddle et al. 1980*) which is represented by: 30-50% of the pre-European extent.	-
22	*Naturalness*	Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: ≥ 75% Good, Very Good, Excellent or Pristine	H
		Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: 25-75% Good, Very Good, Excellent or Pristine	-
		Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: < 25% Good, Very Good, Excellent or Pristine.	-
23		The wetland or ≥ 50% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	I
		The wetland or 10-50% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	-
		The wetland or < 10% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	-
24	*Scarcity*	The wetland supports an occurrence of declared rare, priority 1, priority 2, priority 3 or priority 4 flora, or an occurrence of three or more significant flora taxa.	H
25		The wetland is likely to support declared rare, priority 1, priority 2, priority 3 or priority 4 flora; however, the occurrence cannot be located, or its habitat has been altered and is no longer in a natural state.	-
26		The wetland supports an occurrence of a threatened ecological community, priority 1 or priority 2 ecological community	-

Attributes /Functions / Values	General Criteria	Criteria	Score
27		The wetland supports an occurrence of a priority 3 or priority 4 ecological community.	-
Fauna			
28	*Representativeness*	The wetland is an ecological refuge for regionally significant fauna species or fauna assemblages.	H
		The wetland has the potential to be an ecological refuge but is disturbed and its attributes and functions require rehabilitation	-
29		The wetland supports a permanent or seasonal feeding, breeding, roosting or watering site for regionally significant native fauna.	H
		The wetland supports a permanent or seasonal feeding, breeding, roosting or watering site for regional or local fauna but only in association with other surrounding natural areas.	-
30	*Naturalness*	The wetland's current diversity of native fauna is similar to what would be expected in an unaltered state, or the wetland supports diverse fauna compared to other wetlands of the same type.	-
		The wetland supports a reduced diversity of fauna compared to other wetlands of the same type.	I
		The wetland supports limited attributes and functions for fauna populations due to human induced disturbances.	-
31	*Scarcity*	The wetland is likely to support a breeding, roosting, refuge or feeding site for populations of fauna listed by the Australian Government (e.g. EPBC Act 1999, JAMBA, CAMBA, RoKAMBA Agreements) or the State (e.g. threatened or specially protected fauna listed under the *Wildlife Conservation Act 1950*).	-
32		The wetland supports a breeding, roosting, refuge or feeding site for priority 1, priority 2, priority 3 or priority 4 fauna.	H
33		The wetland supports an occurrence of a threatened ecological community, priority 1 or priority 2 ecological community.	H
34		The wetland supports an occurrence of a priority 3 or priority 4 ecological community or a breeding, roosting, refuge or feeding site for significant fauna.	I
Cultural			
35	*Representativeness*	The wetland or its immediate surrounds is identified for its natural values on a national or State heritage list or the wetland supports other known regional heritage values.	-
36		The wetland or its immediate surrounds is identified for its natural values on a municipal heritage list or the wetland supports other known local heritage values.	-

Attributes /Functions / Values	General Criteria	Criteria	Score
37		The wetland or its immediate surrounds is identified on a national, State or local list or register for its Aboriginal cultural value.	-
38		The wetland is important to the local community for its natural values	-
39		The wetland is or has the potential to be a site for public or private based recreation	-
40		The wetland is the subject of a recognised ecological restoration / rehabilitation project by a community group, landowner or land manager that aims to improve the wetland's natural, heritage, cultural or social values.	-
		The wetland is likely to support heritage, cultural or social values; however, the values cannot be confirmed, or the values have been disturbed and are no longer as important or significant.	-
		The wetland did support heritage, cultural or social values; however, these have been significantly disturbed and are no longer important or the values have been removed.	-
Scientific and Educational			
41	*Representativeness*	The wetland supports known important teaching or research characteristics and for this reason is an existing or potential education or research site.	-
		The wetland has the potential to be used as a study or research site.	I
42		The wetland supports known scientific, geoheritage or geoconservation values.	H

Table 10: Results of the Secondary Evaluation Criteria CCWs (UFI 15002 and 15205)

Attributes / Functions / Values	Scores		
	High (H)	Intermediate (I)	Low(L)
Geomorphology	3	-	-
Wetland processes	3	-	-
Linkages	-	1	-
Habitats	1	1	-
Flora	4	1	-
Fauna	4	2	-
Cultural	-	-	-
Scientific and educational	1	1	-
Total Score	16	6	-
Defining Attributes/ Functions/ Values	**Fauna**		
Applicable Management Category	**Conservation**		

4.3.1 Conclusion

The assessment concluded that the current conservation management category of these wetlands reflects the attributes, functions and values associated with a CCW.

5 Resource Enhancement Wetland (REW) (UFI 15204)

5.1 Preliminary Desktop

Table 11 below outlines the responses to the criteria detailed in (DBCA 2017a).

Based on the background information presented in Section 2.0 and Site Survey (Section 5.2), the preliminary evaluation criterion as depicted in Table 11 has been completed. If a 'yes' can be answered to any one of the criteria then the wetland is considered to support the highest level of values, attributes and functions. Wetlands supporting a high level of values, attributes and functions are automatically assigned to Conservation management category. REW (UFI 15204) did not meet any of the preliminary evaluation criteria (Table 11). Therefore, a secondary evaluation scoring assessment was completed for the wetland (refer to Section 5.3).

Table 11: Preliminary Evaluation Criteria (REW UFI 15204)

No.	Criteria	Y/N
1	The wetland is currently recognised as internationally or nationally significant for its natural values. Lists/registers include: • The Ramsar Convention on Wetlands • State government endorsed candidate sites for the Ramsar Convention on Wetlands • Directory of Important Wetlands in Australia • National Heritage List • Or equivalent.	N
2	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlines in Appendix B and is identified as significant for its natural values under one or more of the following: • Conservation Reserves for Western Australia Systems 1,2,3,5 • Conservation Reserves for Western Australia, The Darling System – System 6 • A Systematic Overview of Environmental Values of the Wetlands, Rivers and Estuaries of the Busselton – Walpole Region • The Environmental Significance of Wetlands in the Perth to Bunbury Region • Bush Forever, Swan Bioplan (including Peel Regionally Significant Natural Areas) or equivalent.	N
3	The wetland supports a breeding, roosting or refuge site or a critical feeding site for populations of fauna listed by the Australian Government (for example, *Environment Protection and Biodiversity Conservation Act 1999*, migratory bird agreements such as JAMBA, CAMBA and RoKAMBA) or the State (for example, threatened and specially protected fauna listed under the *Wildlife Conservation Act 1950*)	N
4	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and supports one or more of the following: • An occurrence of a threatened ecological community • A confirmed occurrence of a priority 1 or priority 2 ecological community • A confirmed occurrence of a declared rare (threatened) flora species.	N

No.	Criteria	Y/N
5	Equal or greater than 90% of the wetland supports vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B.	
6	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and is known to support internationally, nationally or state-wide scientific values including geoheritage and geoconservation	N
7	The wetland is spatially dominated by vegetation in a good or better condition using the vegetation condition scale outlined in Appendix B and meets one of the following: • ≤10% of wetlands of the same type are assigned Conservation management category within the Swan Coastal Plain (by area) • ≤10% of all wetlands in the same consanguineous suite are assigned Conservation management category (by area) • ≤10% wetlands of the same type in its consanguineous suite are assigned Conservation management category (by area) • Best representative of its type within its consanguineous suite domain. **Note**: The site is not spatially dominated by vegetation in Good or better condition (Figure 6). • 29.3% of the same wetland type (dampland) is assigned conservation management category within the Swan Coastal Plain (DBCA 2017) • The CCW (UFI 15002) belongs to the Bennett Brook consanguineous suite, of which 8.4% of its wetlands have been assigned a conservation management category (DBCA 2017) • Of the 'dampland' wetland type in the Bennett Brook consanguineous suite, 9.4% are assigned conservation management category (DBCA 2017).	N

5.2 Site Assessment

The following sections describe the flora and vegetation of the wetland.

5.2.1 Surveyed Vegetation Associations and Condition

The majority of the REW has been cleared and disturbed from previous rural land uses; however, there are some mature native trees within the boundary of the mapped wetland.

The vegetation within the REW has no natural structure and has been severely altered by previous rural land uses and clearing activities.

The majority of the REW is considered to be in Completely Degraded condition with two patches in Good condition (Figure 6).

The vegetation within the Survey Area boundary of the wetland can be described as (Figure 7):

- **MrLl:** Low woodland of *Melaleuca rhaphiophylla* over *Hakea varia, Regelia ciliata* and *Pericalymma ellipticum* over sedgeland of *Lepidosperma longitudinale* and *Meeboldina* sp.
- **Mr**: *Melaleuca rhaphiophylla*

5.2.2 Photo Monitoring Points

Seven photo point locations within the wetland were used to capture the wetlands attributes. The details are outlined in Table 12 below; Locations are shown in Figure 8.

Table 12: Locations of Photo Points

Photo Point Number	Location (UTM 50J	Direction	Photo Point Number	Location (UTM 50J)	Direction
25	403788 E 6418503N	South	28	403828E 6418463N	West
25		North	28		South West
26	403794E 6418482N	South	30	403761E 6418433N	South
26		West	30		West
26		North	30		North
26		East	30		East
27	403840E 6418480N	South	31	403769 E 6418395 N	East

5.2.3 Threatened and Priority Ecological Communities

Majority of native vegetation across wetland (UFI 14984) within the Survey Area has been cleared previously as a result of historical rural use. The remaining vegetation consists of mainly introduced weed species, planted non-endemic tree species and scattered native trees, which, has no intact native understorey. As a result, it is considered unlikely that the site would contain a TEC or PEC.

5.2.4 Threatened and Priority Flora

The field surveys of the REW did not identify any Threatened or Priority flora species within the site. Given that the vegetation across the site has been historically cleared and is in a completely degraded and disturbed condition, it is considered very unlikely that any conservation significant flora species would occur.

5.2.5 Weeds

No weeds listed as Weeds of National Significance (WONS), or Declared under the Biosecurity and Agriculture Management Act 2007 (BAM Act) were found during the survey

5.3 Secondary Evaluation

A secondary evaluation was undertaken that included assessing all of the criteria listed under each attribute/function and value assigning an appropriate score (high, intermediate or low). These scores were tallied and are displayed in Table 13 and 14 along with the resultant applicable management category. Only criteria that apply to the wetlands are rated in the tables.

Table 13: Secondary Evaluation Criteria (REW UFI 15204)

Attributes /Functions / Values	General Criteria	Criteria	Score
Geomorphology			
1	*Representativeness*	≤20% of wetlands of the same type are assigned Conservation on the Swan Coastal Plain by area **Note:** 29.3% of the same wetland type (dampland) is assigned conservation management category within the Swan Coastal Plain (DBCA 2017)	-
2		≤20% of wetlands in the same consanguineous suite are assigned Conservation by area **Note:** The CCW (UFI 15002) belongs to the Bennett Brook consanguineous suite, of which 8.4% of its wetlands have been assigned a conservation management category)	H
3		≤ 20% of wetlands of the same type in the same consanguineous suite are assigned Conservation by area **Note:** Of the 'dampland' wetland type in the Bennett Brook consanguineous suite, 9.4% are assigned conservation management category (DBCA 2017).	H
4		The wetland is outstanding in some geomorphic aspect, for example size, origin, height relative to sea level, depth, age. **Note:** The wetland has no apparent unique features	-
5	*Naturalness*	Alteration to the wetland's geomorphology % area: <25% altered	-
		Alteration to the wetland's geomorphology % area: 25-75% altered.	-
		Alteration to the wetland's geomorphology % area: >75% altered Note: Over75% of the REWs geomorphology has been altered due to the filling, clearing and development (urban and rural)	L
6	*Scarcity*	The wetland exhibits unusual geomorphology or unusual internal geomorphic features compared to other wetlands of the same type in the consanguineous suite.	-
7		The wetland is the best example of its type in its consanguineous suite.	-
Wetland Processes			
8	*Representativeness*	The wetland is an important component of the natural hydrological cycle providing natural functions (e.g. flood protection, recharge/discharge, hydrological storage, support for groundwater dependent ecosystems).	-
		The wetland's vegetation, geomorphology, hydrology or sediments are modified; however, the wetland is still a component of the hydrological cycle providing natural	I

Attributes /Functions / Values	General Criteria	Criteria	Score
		and artificial functions (e.g. flood remediation, recharge/discharge, hydrological storage, support for groundwater dependent ecosystems).	
		The wetland's vegetation, geomorphology, hydrology or sediments are modified to the extent that the wetlands hydrological functions are artificial such as storage, or the wetland has been disconnected from the natural hydrological cycle and no longer provides natural attributes and functions.	-
9		The wetland supports a representative process (e.g. wetland process typical of the wetland's hydrological setting, sediment accretionary process typical of the wetland's geomorphic setting or hydro-chemical process typical of the wetland's geological setting).	-
10	*Naturalness*	The wetland is not subject to altered wetland processes or, is subject to altered wetland processes and the wetland's natural attributes and functions are maintained.	-
		The wetland is subject to altered wetland processes and the wetland's natural attributes and functions have been changed; however, they have the potential to be rehabilitated.	I
		The wetland is subject to altered wetland processes to the extent that the wetland no longer supports natural attributes and functions.	-
11	*Scarcity*	The wetland exhibits unusual processes compared to other wetlands of the same type in the consanguineous suite.	-
Linkages			
12	*Representativeness*	The wetland is a hydrological link in a larger or more complex and intact system. **Note:** adjacent to the CCW 15205	H
13	*Naturalness*	The wetland is part of continuous ecological linkage or wildlife corridor, or a regionally significant ecological linkage or wildlife corridor connecting bushland or wetland areas.	-
		The wetland is part of a fragmented ecological linkage or wildlife corridor.	I
		The wetland is disturbed and isolated, surrounded by either a built or highly disturbed environment with no nearby native vegetation or waterways to support an intact fragmented ecological linkage or wildlife corridor.	-
14	*Scarcity*	The wetland has unusual hydrological, hydrogeological, hydrochemical or ecological linkages with adjacent wetlands and bushland.	-
Habitats			
15	*Representativeness*	The wetland is isolated from other undisturbed wetlands or bushland and as a result, maintains	-

Attributes /Functions / Values	General Criteria	Criteria	Score
		important ecological or genetic fauna or flora diversity within its consanguineous suite domain.	
16		The wetland contains evidence of surface water or groundwater expression that is vital for maintaining regionally significant populations of native aquatic or terrestrial flora or fauna.	-
		The wetland contains evidence of surface water or groundwater expression that is important for maintaining populations of native aquatic or terrestrial flora or fauna	-
17		The wetland provides a nursery for native fauna populations, or maintains fauna populations at a vulnerable stage of their life cycle	-
18	*Naturalness*	The wetland supports habitats that are unaltered, or the wetland has been altered and its natural habitats are maintained.	-
		The wetland supports habitats that are altered; however, the habitats are still identifiable and have the potential to naturally regenerate or be rehabilitated after weed control, if required.	I
		The wetland is altered and as a result is no longer supporting natural habitats which can be rehabilitated.	-
19	*Scarcity*	The wetland supports habitats that are unusual compared to other wetlands of the same type on the Swan Coastal Plain.	-
Flora			
20	*Representativeness*	The wetland's current diversity of native flora is similar to what would be expected in an unaltered state.	-
		The wetland supports a reduced diversity of native flora due to human induced disturbances.	-
		The wetland supports a significantly reduced diversity of native flora species due to human induced disturbances.	L
21		The wetland is identified in a vegetation complex (*Heddle et al. 1980*) which is represented by: ≤ 30% of the pre-European extent 30-50% of the pre-European extent. **Note:** The site is within the Guildford Complex that has a Pre-European extent of 5.09% remaining	H
		The wetland is identified in a vegetation complex (*Heddle et al. 1980*) which is represented by: 30-50% of the pre-European extent.	-
22	*Naturalness*	Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: ≥ 75% Good, Very Good, Excellent or Pristine	-

Attributes /Functions / Values	General Criteria	Criteria	Score
		Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: 25-75% Good, Very Good, Excellent or Pristine	-
		Using the vegetation condition scale outlined in Appendix B, the wetland's vegetation condition by area is: < 25% Good, Very Good, Excellent or Pristine.	L
23		The wetland or ≥ 50% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	-
		The wetland or 10-50% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	I
		The wetland or < 10% of the wetland boundary is surrounded by land dominated by remnant native vegetation.	-
24	*Scarcity*	The wetland supports an occurrence of declared rare, priority 1, priority 2, priority 3 or priority 4 flora, or an occurrence of three or more significant flora taxa.	-
25		The wetland is likely to support declared rare, priority 1, priority 2, priority 3 or priority 4 flora; however, the occurrence cannot be located, or its habitat has been altered and is no longer in a natural state.	-
26		The wetland supports an occurrence of a threatened ecological community, priority 1 or priority 2 ecological community	-
27		The wetland supports an occurrence of a priority 3 or priority 4 ecological community.	-
Fauna			
28	*Representativeness*	The wetland is an ecological refuge for regionally significant fauna species or fauna assemblages.	-
		The wetland has the potential to be an ecological refuge but is disturbed and its attributes and functions require rehabilitation	I
29		The wetland supports a permanent or seasonal feeding, breeding, roosting or watering site for regionally significant native fauna.	-
		The wetland supports a permanent or seasonal feeding, breeding, roosting or watering site for regional or local fauna but only in association with other surrounding natural areas.	-
30	*Naturalness*	The wetland's current diversity of native fauna is similar to what would be expected in an unaltered state, or the wetland supports diverse fauna compared to other wetlands of the same type.	-

Attributes /Functions / Values	General Criteria	Criteria	Score
		The wetland supports a reduced diversity of fauna compared to other wetlands of the same type.	-
		The wetland supports limited attributes and functions for fauna populations due to human induced disturbances.	L
31	*Scarcity*	The wetland is likely to support a breeding, roosting, refuge or feeding site for populations of fauna listed by the Australian Government (e.g. EPBC Act 1999, JAMBA, CAMBA, RoKAMBA Agreements) or the State (e.g. threatened or specially protected fauna listed under the *Wildlife Conservation Act 1950*).	-
32		The wetland supports a breeding, roosting, refuge or feeding site for priority 1, priority 2, priority 3 or priority 4 fauna.	-
33		The wetland supports an occurrence of a threatened ecological community, priority 1 or priority 2 ecological community.	-
34		The wetland supports an occurrence of a priority 3 or priority 4 ecological community or a breeding, roosting, refuge or feeding site for significant fauna.	-
Cultural			
35	*Representativeness*	The wetland or its immediate surrounds is identified for its natural values on a national or State heritage list or the wetland supports other known regional heritage values.	-
36		The wetland or its immediate surrounds is identified for its natural values on a municipal heritage list or the wetland supports other known local heritage values.	-
37		The wetland or its immediate surrounds is identified on a national, State or local list or register for its Aboriginal cultural value.	-
38		The wetland is important to the local community for its natural values	-
39		The wetland is or has the potential to be a site for public or private based recreation.	-
40		The wetland is the subject of a recognised ecological restoration / rehabilitation project by a community group, landowner or land manager that aims to improve the wetland's natural, heritage, cultural or social values.	-
		The wetland is likely to support heritage, cultural or social values; however, the values cannot be confirmed, or the values have been disturbed and are no longer as important or significant.	-
		The wetland did support heritage, cultural or social values; however, these have been significantly disturbed and are no longer important or the values have been removed.	-

Attributes /Functions / Values	General Criteria	Criteria	Score
Scientific and Educational			
41	*Representativeness*	The wetland supports known important teaching or research characteristics and for this reason is an existing or potential education or research site.	-
		The wetland has the potential to be used as a study or research site.	-
42		The wetland supports known scientific, geoheritage or geoconservation values.	-

Table 14: Results of the Secondary Evaluation Criteria (REW UFI 15204)

Attributes / Functions / Values	Scores		
	High (H)	Intermediate (I)	Low(L)
Geomorphology	2	-	-
Wetland processes	-	2	-
Linkages	1	1	-
Habitats	-	1	-
Flora	1	1	2
Fauna	-	1	1
Cultural	-	-	-
Scientific and educational	-	-	-
Total Score	4	6	3
Defining Attributes/ Functions/ Values	**Flora**		
Applicable Management Category	**Resource Enhancement and Multiple Use**		

5.3.1 Conclusion

While the assessment in Table 13 was for the whole REW. The eastern section of REW is cleared with two isolated small areas of *Melaleuca rhaphiophylla* with no understorey (refer to Figure 7c) and in 'Completely Degraded' condition (Figure 6c). Based on attributes, function and values of this section of the wetland its more accurately reflects Multiple Use management category (Figure 9)

6 Buffer Requirements

As per EPA (2008) guidelines where wetlands and their buffers are open to the public, a surrounding road (with lots fronting the open space) is desirable to provide a physical boundary to delineate the wetland and its buffer, enable surveillance and deter vandalism and other inappropriate activities. A hard edge is a useful management tool to control the spread of weeds and grass between grassed areas and areas of native vegetation. The draft Serpentine Townsite LSP incorporates hard edges along the CCW boundaries. As per the WAPC (2005) Guideline for the Determination of Wetland Buffer Requirements, the separation requirement (buffer) effectively is the furthest extent of the separation distance required to deal with all separation issues (e.g. habitat protection, fire management, water quality management) specific to each proposed or existing adjacent land use.

The application of relevant EPA, DBCA and WAPC (2005) buffer guidelines have provided site specific recommendations about buffer and interface management:

- In accordance with EPA (2008) and DBCA policy buffers are typically not required for MUW. However, it is noted that the EPA (2008) recommends that measures are taken to retain the wetland's hydrological functions (including on-site water infiltration and flood detention) and, where possible, other wetland functions. The hydrological functions of the area are discussed within the LSP Local Water Management Strategy (GHD, 2013). In accordance with the WAPC (2008) Better Urban Water Management Guidelines, Urban Water Management Plans (UWMP) will be required to support subdivision within the LSP area, which will typically include further modelling of groundwater and surface water systems –build on previous results and specific best management practices and design of water management system, including stormwater, to meet design objectives.
- As per EPA (2008) and DBCA policy typical buffers associated with CCW are usually 50m from the wetland boundary. However, it is also noted that site specific investigations may be required (i.e. WAPC 2005 guideline) to determine an appropriate buffer. Due to the existing urban nature adjacent to the CCW (UFI 15002) application of a generic 50 m wetland buffer from the wetland function area is not viable. Should the adjacent urban area be redeveloped (change in R codes to allow for intensification in density) the management and treatment of stormwater and drainage along Richardson Street reserve interface of the wetland will need to be addressed at the next planning phase i.e. subdivision- an UWMP will need to address environmental matters particularly relating to ecological health and hydrological regime of water dependent ecosystems. Due to the areas sensitivity UWMP's will need to address drainage strategy, including avoidance and management of impacts on water dependent ecosystems and treatment of subsoil drainage water (if applicable), prior to discharge to the surface water system should overflow be permitted to occur within the CCW due to the lack of existing interface between the mapped CCW boundary and urban area. This will need to be further investigation with DBCA and the Shire.

- From site inspection, it can be concluded that a significant portion of REW (UFI 15204) no longer exhibits attributes and values associated with a REW (refer to Table 1). However, there is a section where there is a cross over in vegetation type (MrLI) and condition (refer to Figure 7c) the wetland core and function area crosses between the currently mapped CCW and REW within Lot 123 Leslie Street. Modification of the REW (UFI 15204) boundary and the other part being downgraded to MUW is depicted in Figure 9. While it is noted that generic 50 m buffer is generally applicable to CCW to protect the wetlands ecosystem, a site buffer assessment can be undertaken to determine the buffer widths (EPA 2008). The suggested buffer (separation requirement) of up to 30m to the revised wetland function area (in association with site management) is also provided in Figure 9. It is noted that most of the buffer area is cleared and degraded.
- Activities compatible with the surrounding land use and the management objective of the wetlands can be permitted in all or part of the separation area (buffer) in accordance with the respective wetland management plan. Within MUW there maybe allocation for Public Open Space (POS) and drainage requirements, subject to consultation with DWER drainage infrastructure including treatment may be permitted within REW and buffers. In general, drainage infrastructure including drainage swales/basin (particularly treatment of 1% Annual Exceedance Probability [AEP]) an POS (reticulated lawn) within a CCW and associated buffer.
- Further to the when this area is subject to WAPC subdivision applications, subdivision conditions can be applied to the approval to refine and ensure future management of the buffers i.e. Prior to the commencement of subdivisional works a wetland and buffer management plan is to be prepared in consultation with DBCA and approved to ensure the protection and management of the sites environmental assets with satisfactory arrangements being made for the implementation of the approved subdivision plan (Local Government) (WAPC, 2017).
- It is noted that recommendation on buffers (CCW UFI 15205, CCW UFI 15022 and REW UFI 15204) are based on vegetation type, condition and the presence of conservation significant flora and fauna habitat values. A site specific hydrological/groundwater dependent assessment was not undertaken as part of the scope of this assessment. However, this can be subsequent completed to confirm the outcomes and recommendations of this terrestrial assessment.

7 Management Recommendation

Other management considerations which area recommended for the wetland areas are as follows. These can be potentially address through subsequent management plans as part of WAPC subdivision condition or local government Development Application condition or incorporated within shires natural assists (Parks) management regime.

- The occurrence and spread of weeds throughout Lambkin Reserve (which includes CCW 15002 and 15205) are a major threatening process. Management of existing weeds and continued management of any encroaching weeds is essential to limiting the degradation of the conservation value of the bushland reserve. It is essential that management techniques are undertaken during optimal control periods and using recommended control methods to halt and reduce weed impact within the bushland reserve. Undertaking control of weed species at the correct stage of their lifecycle ensures that effectiveness of weed control is maximised. The optimum time to control weed species is often at the start or during the active growing period, before the species starts producing seed.
- The species of weeds in particular; **Watsonia meriana* var. *bulbillifera*, **Acacia longifolia* and **Eragrostis curvula* should be priority for weed control before they spread further. These species are widespread throughout the wetland and have become dominant in a few locations.
- Ensuring the remnant vegetation within CCW (UFI 15002 and 15205) bushland reserves remains in Excellent condition and of high conservation value is essential. Management of local residents utilising the bushland reserve is recommended to ensure their impact on the reserve is kept to a minimum. This can be undertaken by formalising the tracks through the reserve and closing off and rehabilitating the tracks that are not needed.
- Any future rehabilitation of wetland areas should be undertaken using locally endemic species and if possible, from seeds collected form the park or nearby.
- General information signs at access points to the reserve would increase public awareness of the importance of the bushland, such as, information about the flora and fauna, importance of keeping to paths, keeping dogs on leashes, not littering and information about dieback.
- Rabbits effectively degrade the vegetation, outcompete other fauna species and subsidise the occurrence of feral predators such as Red Fox and Cat. The most effective management technique for the species is likely baiting with 1080 oats alongside the fumigation of identified warrens and dens.
- Communication with the Public Transport Authority is recommended to facilitate the coordination of the railway reserve's management. Management of the railway involves chemical spraying of weeds from a moving vehicle which has the potential to drift onto native species in the reserve. The operators should be made aware of the presence of Threatened species and the impact that the pesticide can have on the reserve.

- The reserve (near CCW UFI15002) has no fence along the boundary of the railway, which, allows for easy access to the bushland. It would discourage people taking short cuts through the Reserve if the fence line was extended.
- During the survey an informal BMX track was observed in the middle of CCW (UFI 15002). The areas surrounding the BMX track and jumps were very weed infested and litter was present. It is recommended that the shire either deconstruct the track and jumps or formalise them along with added signage and bins to decrease disturbance of the bushland i.e. edge effects and fencing to protect remnant vegetation within the CCW.

8 Conclusion

A Field Survey was undertaken on 5 September 2019 by a Principal Botanist to assess the condition of the wetlands. The survey was completed as per *'A Methodology for the Evaluation of Specific Wetland Types on the Swan Coastal Plain, Western Australia'* (DBCA 2017).

REW (UFI 14984) no longer represents attributes, function and values associated with a REW and more accurately reflects a MUW. It is recommended that this portion of REW (UFI 14984) be downgraded to a MUW. Assessment against DBCA (2017a) evaluation process confirms that the CCW's (UFI 15002 and 15205) support attributes, function and values associated with the conservation category. CCW (UFI 15002) is defined (and confined) by existing infrastructure i.e. Richardson Street and railway and urban land uses. As per EPA (2008) and DBCA policy typical buffers associated with CCW are usually 50 m from the wetland boundary. Due to the existing urban (built) nature adjacent to the CCW (UFI 15002) application of a generic 50 m wetland buffer is not viable.

From site inspection, it can be concluded that a significant portion of REW (UFI 15204) no longer exhibits attributes and values associated with a REW. However, there is a patch of vegetation that is considered part of the wetland function area of the CCW. Modification of the REW (UFI 15204) boundary, therefore, requires only part of the REW (UFI 15204) to be downgraded to MUW. A suggested buffer (separation requirement) of up to 30 m to the revised wetland function area (in association with site management) is recommended. It is noted that recommendation on buffers are based on vegetation type, condition and the presence of conservation significant flora and fauna habitat values. A site-specific wetland hydrological/groundwater dependent ecosystem assessment was not undertaken as part of the scope of this assessment. However, this can be subsequent completed to confirm the outcomes and recommendations of this terrestrial assessment.

Overall, the proposed LSP reflects the DBCA geomorphic wetland database (current wetland areas). The LSP depicts a north-south road link between Tonkin Street and Leslie Street (near Lambkin Reserve) with residential development east of the link road which currently intersects REW (UFI 15204). As recommended in Section 5.3.1, the eastern portion of the REW (UFI 15204) reflects the attributes and values associated with a Multiple Use management category. Based on the proposed changes to the wetland reclassification of this wetland area (i.e. reclassification from REW to MUW) (Figure 9) the north-south road link between Tonkin Street and Leslie Street runs adjacent to the proposed 30 m wetland buffer.

The draft LSP proposes POS (approximately 50 m wide) adjacent to the CCW (UFI 15002) associated with Bush Forever Site 375. This 50m buffer incorporates the proposed amended buffer to the REW (subject to the recommendations in Section 5.3.1) While this area is currently Completely Degraded from clearing and grazing associated with rural activities, the use of the POS (buffer area) i.e. passive recreation, controlled access through fencing along the CCW/ Bush forever site and areas subject to rehabilitation can be confirmed through consultation between the shire and DBCA/DWER.

9 Limitations

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

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

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

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

10 References

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Figures

Legend

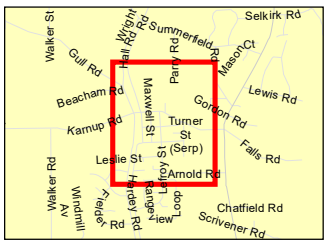
- Site Boundary
- Lot Boundaries
- Local Roads

0 90 180 270 N

Meters
1:9,000 @ A4

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

LOCALITY MAP



Powered By SLIP ENABLER

- LOCALITY MAP SOURCED FROM LANDGATE 2017
- OTHER DATA SOURCED LANDGATE 2018
- AERIAL PHOTOGRAPHY SOURCED LANDGATE 2018
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PROJECT ID	DATE
3396	17/09/2019

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

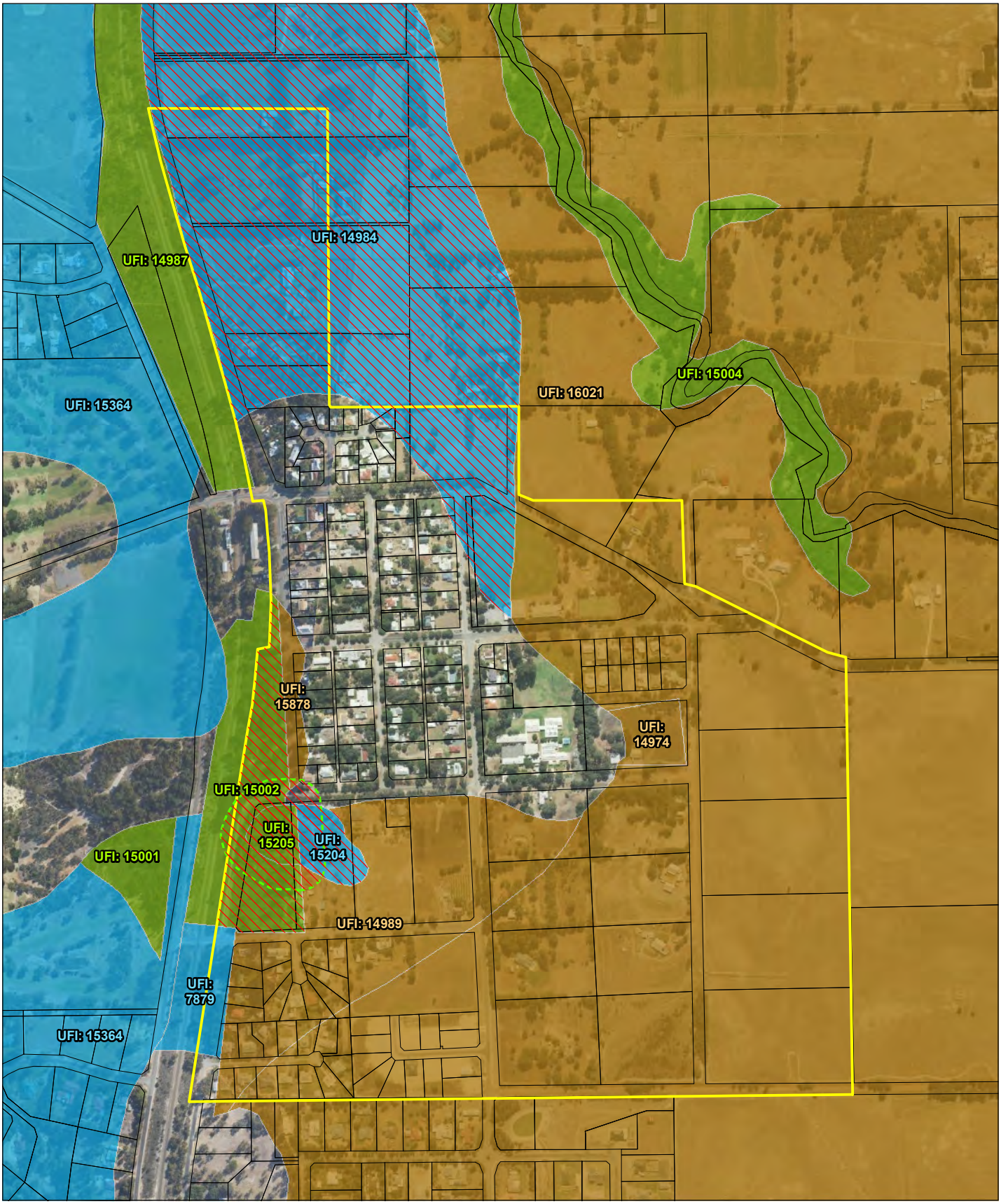
CREATED	CHECKED	APPROVED	REVISION
SL	KC	NW	0

Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan

Wetland Reclassification and Buffer Assessment

Figure 1 Site Location

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Background Figures.mxd



Legend

- Site Boundary
- Lot Boundaries
- Wetlands for Investigation

Geomorphic Wetlands

- Conservation Category
- Resource Enhancement Category
- Multiple Use Category
- 50m Buffer

Powered By SLIP ENABLER

- LOCALITY MAP SOURCED FROM LANDGATE 2017
- OTHER DATA SOURCED LANDGATE 2018
- AERIAL PHOTOGRAPHY SOURCED LANDGATE 2018
(© Western Australian Land Information Authority 2017)

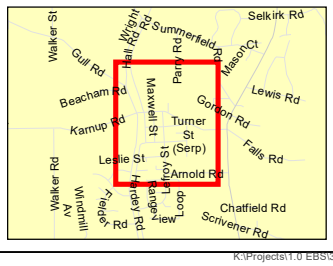
0 90 180 270 N

Meters

1:9,000 @ A4

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

LOCALITY MAP



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PROJECT ID	DATE
3396	17/09/2019

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
SL	KC	NW	0

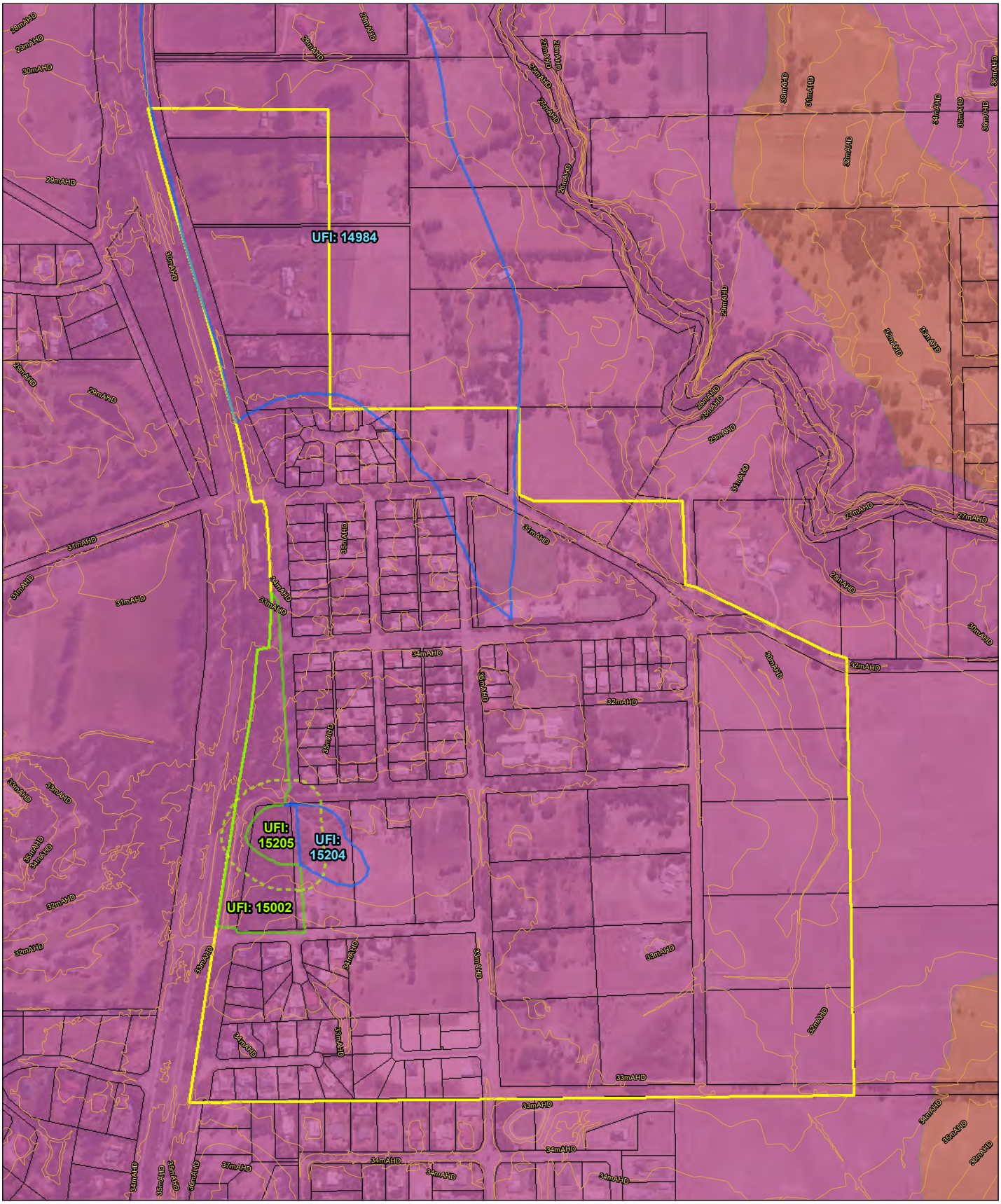
Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan

Wetland Reclassification and Buffer Assessment

Figure 2

Geomorphic Wetland Mapping

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Background Figures.mxd



Legend

- Site Boundary
- Lot Boundaries

Wetlands for Investigation

- Conservation Category
- 50 Buffer
- Resource Enhancement Category
- Contours 1m

Soil Land System

213Fo: Undulating foot slopes of the Darling and Whicher Scarps. Duplex sandy gravels, pale deep sands and grey deep sandy duplexes. Woodland of E.marginata, calophylla and wandoo and some B.grandis.

213Pj: Swan Coastal Plain from Perth to Capel. Poorly drained coastal plain with variable alluvial and aeolian soils. Variable vegetation includes Jarrah, marri, wandoo, paperbark sheoaks and rudis.

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- LOCALITY MAP SOURCED FROM LANDGATE 2017
- OTHER DATA SOURCED LANDGATE 2018
- AERIAL PHOTOGRAPHY SOURCED LANDGATE 2018

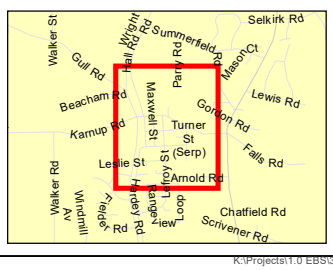
0 90 180 270 N

Meters

1:9,000 @ A4

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

LOCALITY MAP



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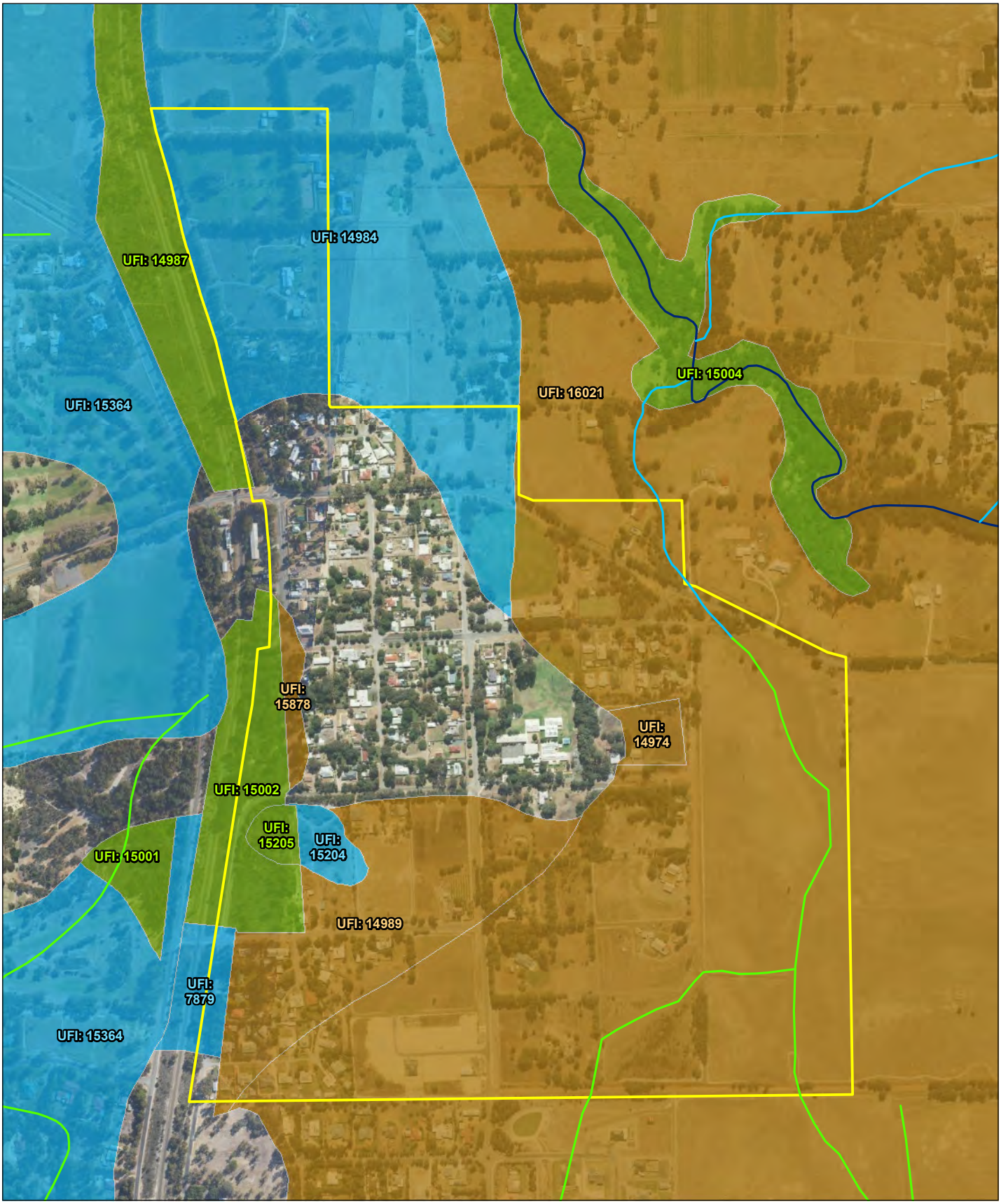
Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan

Wetland Reclassification and Buffer Assessment

Figure 3 Topography and Soils Landform Systems

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Background Figures.mxd



Legend

- Site Boundary

Hydrography

- Watercourse - major
- Watercourse - minor
- Drain - major

Geomorphic Wetlands

- Conservation Category
- Resource Enhancement Category
- Multiple Use Category

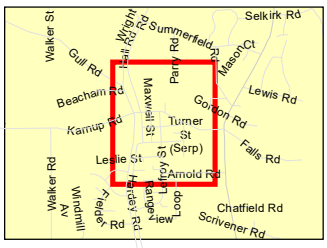
0 90 180 270 N

Meters

1:9,000 @ A4

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

LOCALITY MAP



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Shire of Serpentine Jarrahdale
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Wetland Reclassification and Buffer Assessment

Figure 4 Hydrology

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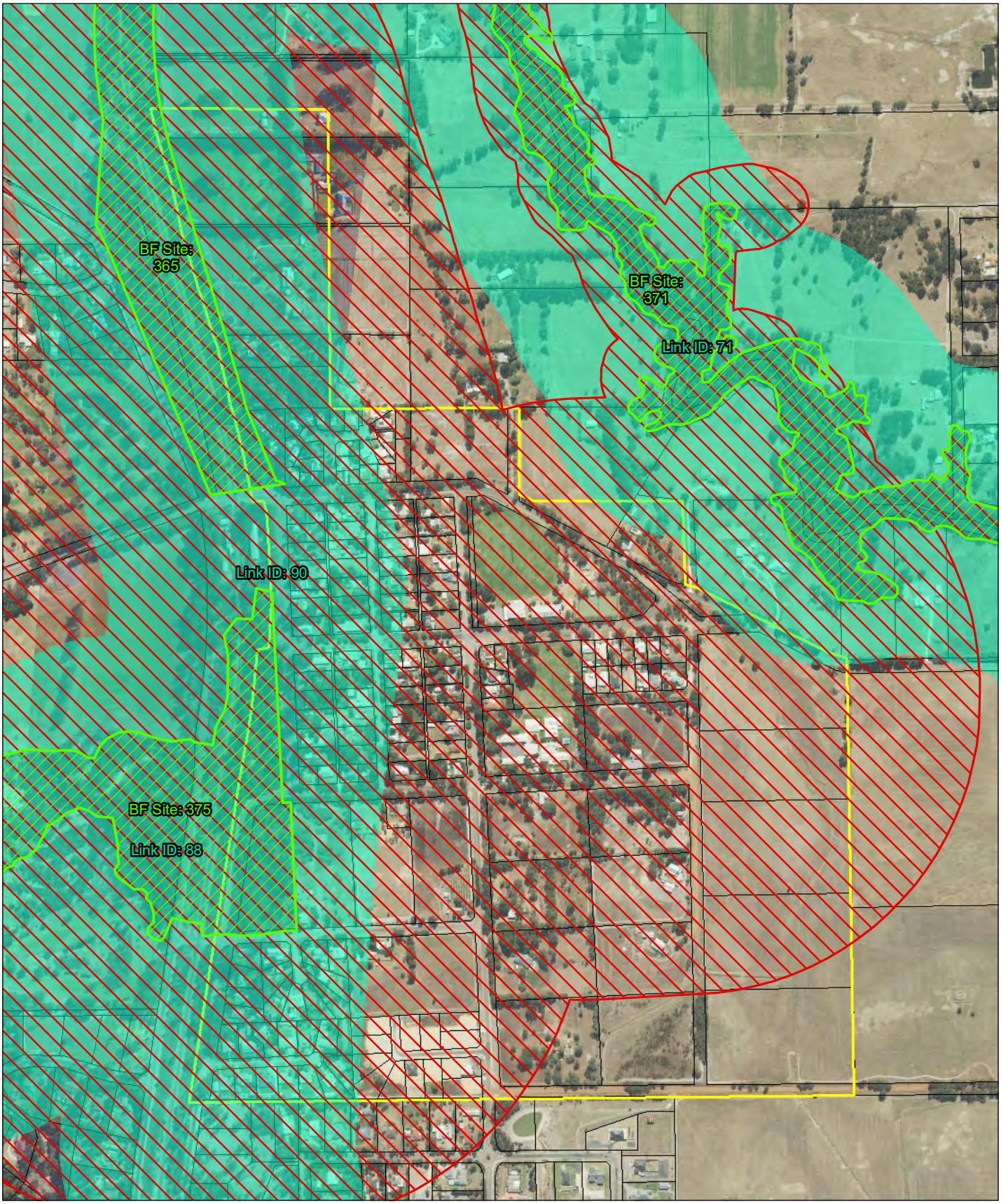


Legend

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

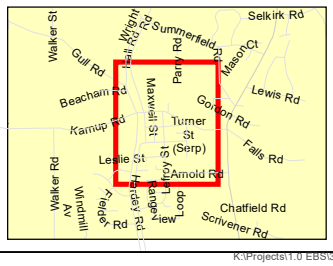
0 90 180 270 N

Meters

1:9,000 @ A4

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

LOCALITY MAP



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Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan

Wetland Reclassification and Buffer Assessment

Figure 5 Environmental Sensitive Areas and Conservation

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Background Figures.mxd

Legend

Site Boundary

Vegetation Condition

Completely Degraded

0 25 50 75

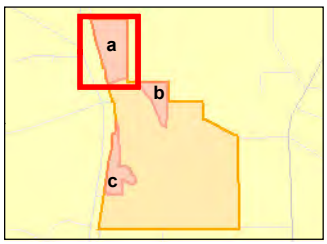
Meters

1:2,500 @ A4

N

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

LOCALITY MAP



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Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan
Wetland Reclassification and Buffer Assessment

Figure 6a Vegetation Condition

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Vegetation Figures.mxd

Legend

Site Boundary

Vegetation Condition

Completely Degraded

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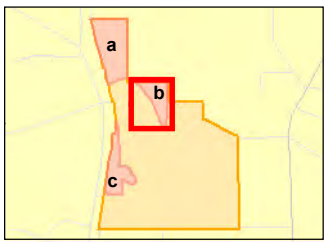
0 10 20 30
Meters
1:1,750 @ A4

N

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

LOCALITY MAP



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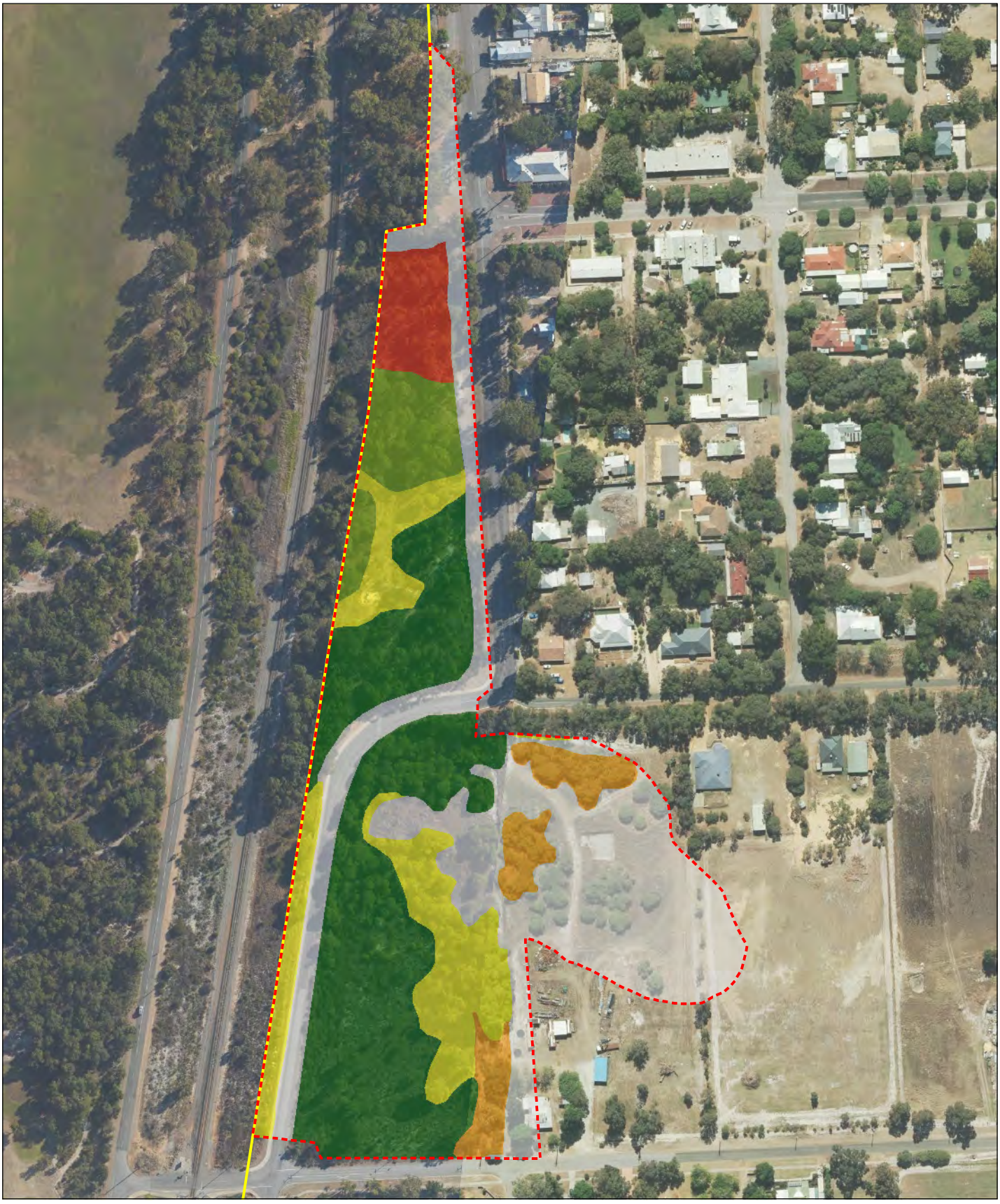
Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan
Wetland Reclassification and Buffer Assessment

Figure 6b Vegetation Condition

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Vegetation Figures.mxd



Legend

- Site Boundary

Vegetation Condition

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

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0 25 50 75

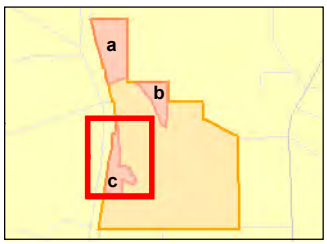
Meters

1:2,750 @ A4

N

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

LOCALITY MAP



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Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan
Wetland Reclassification and Buffer Assessment

Figure 6c Vegetation Condition

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Vegetation Figures.mxd

Legend

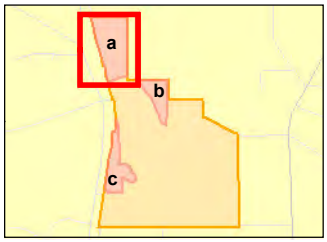
Site Boundary

0 25 50 75 Meters
1:2,500 @ A4

N

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

LOCALITY MAP



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Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan
Wetland Reclassification and Buffer Assessment

Figure 7a Vegetation Types

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Vegetation Figures.mxd

Legend

Site Boundary

0 10 20 30
Meters
1:1,750 @ A4

N

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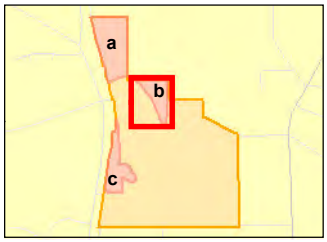
LOCALITY MAP



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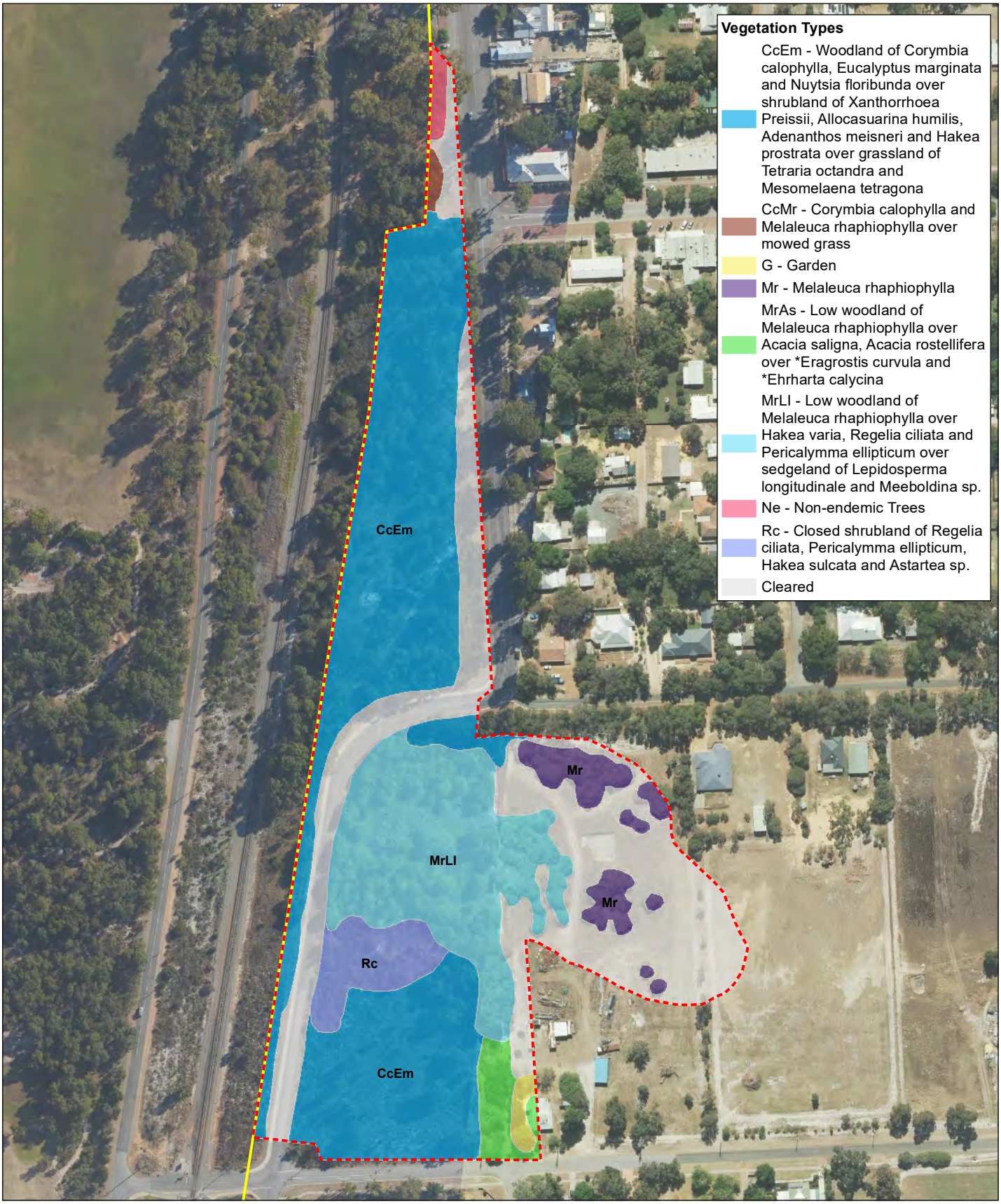
Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan
Wetland Reclassification and Buffer Assessment

Figure 7b Vegetation Types

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Vegetation Figures.mxd



Legend

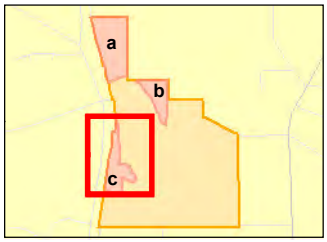
Site Boundary

0 25 50 75
Meters
1:2,750 @ A4

N

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

LOCALITY MAP



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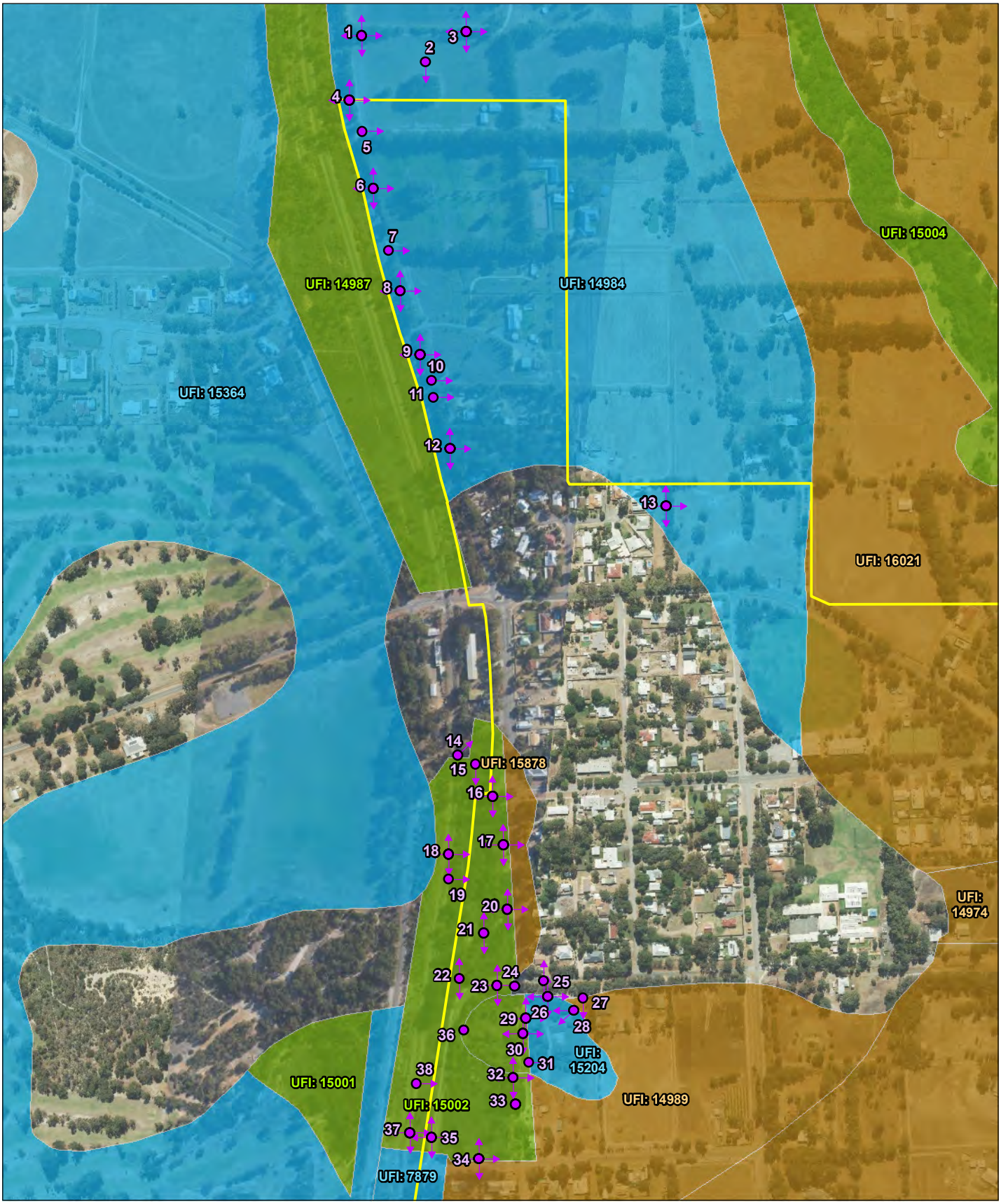
Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan
Wetland Reclassification and Buffer Assessment

Figure 7c Vegetation Types

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 Vegetation Figures.mxd



Legend

- Site Boundary
- Photo Locations

Geomorphic Wetlands

- Conservation Category
- Resource Enhancement Category
- Multiple Use Category

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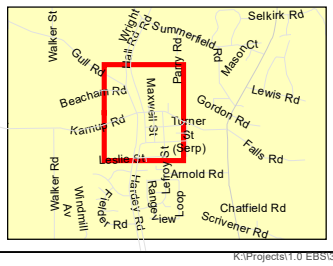
0 70 140 210 Meters
1:7,000 @ A4

N

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

LOCALITY MAP



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Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan

Wetland Reclassification and Buffer Assessment

Figure 8 Photo Locations

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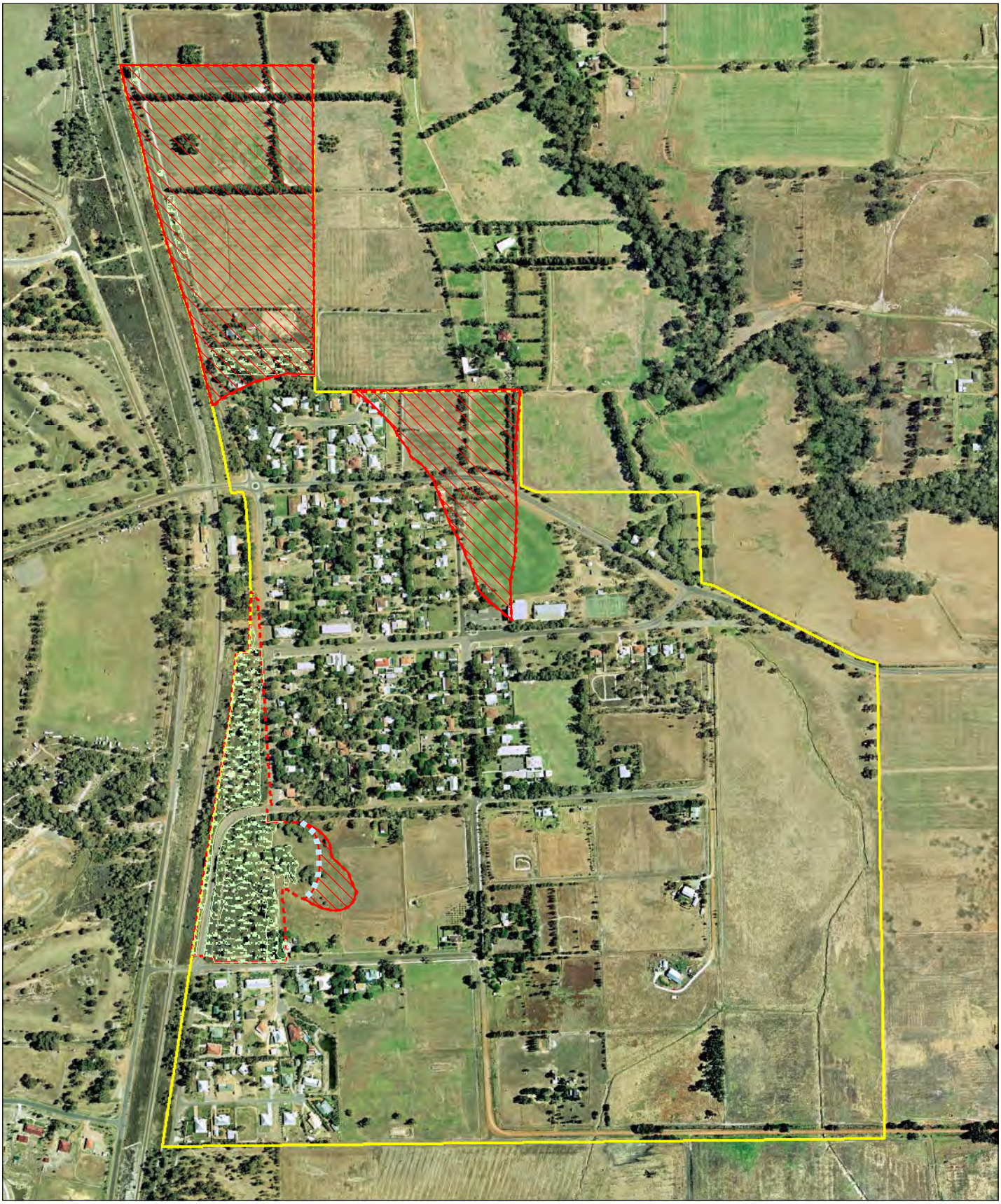

Legend

- Site Boundary
- Proposed Wetland Reclassification Areas (Resource Enhancement to Multiple Use)
- Proposed 30m Wetland Buffer
- Native Vegetation

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0 80 160 240 Meters

1:8,283 @ A4

N

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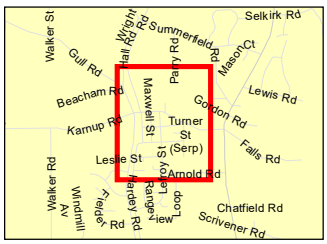
LOCALITY MAP



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Shire of Serpentine Jarrahdale
Serpentine Townsite Local Structure Plan
Wetland Reclassification and Buffer Assessment

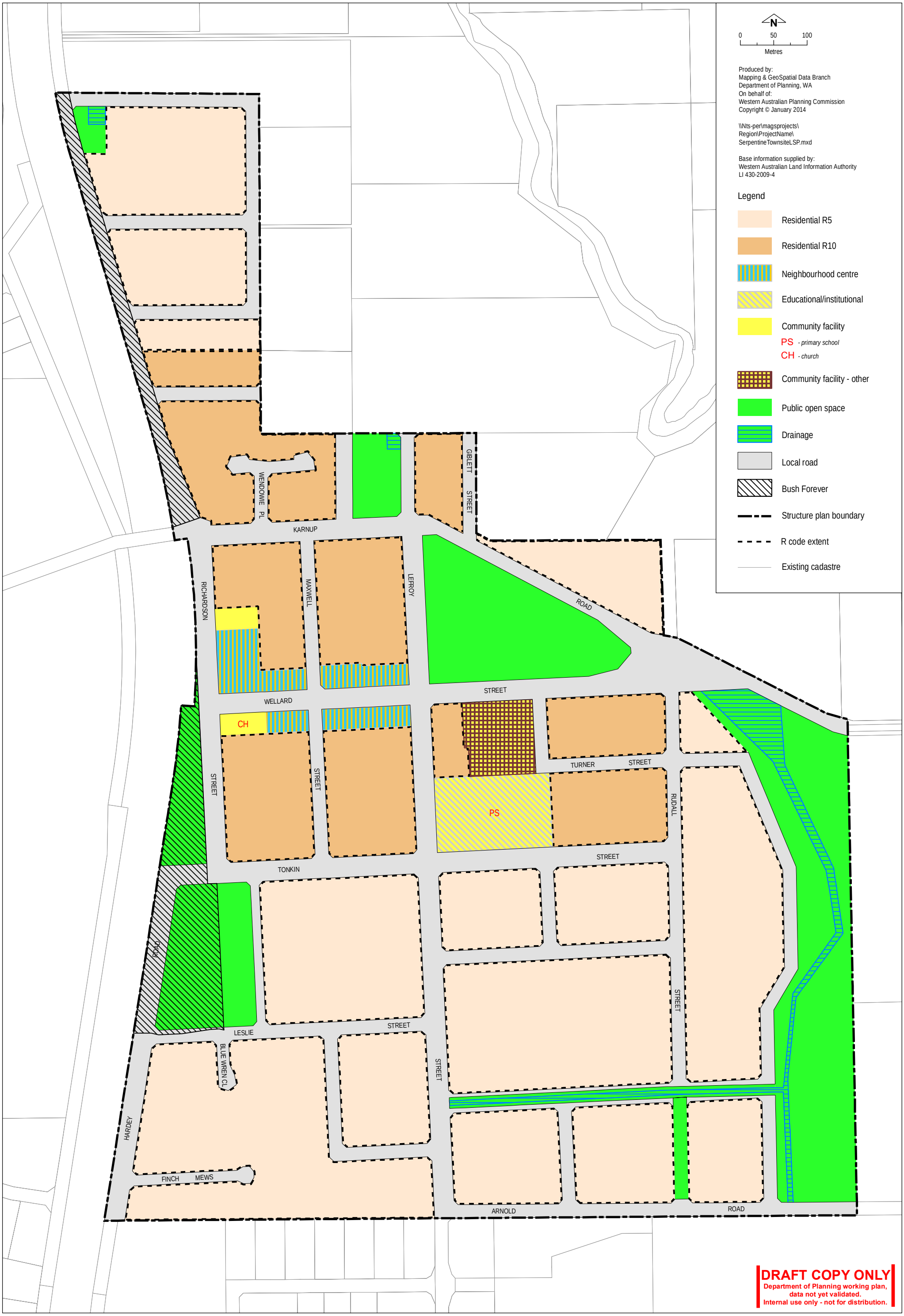
Figure 9
Proposed Wetland Reclassification

K:\Projects\1.0 EBS\3396 Tonkin St Serpentine Wetland Buffer Study\3396 F9 Reclass_Buffer.mxd

Appendices

Appendix A
Draft Local Structure Plan Area

Serpentine Townsite Local Structure Plan



Serpentine Townsite Local Structure Plan

Figure X

Appendix B
DBCA and DEE Database Searches

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 17/09/2019

Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	115° 58' 36" E,32° 22' 02" S
Buffer	5km
Group By	Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	718	4267
Other specially protected fauna	2	9
Priority 1	1	1
Priority 2	1	3
Priority 3	7	33
Priority 4	7	30
Rare or likely to become extinct	13	350
TOTAL	749	4693

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	1596	*Caladenia huegelii (Grand Spider Orchid)*		T	
2.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black Cockatoo)*		T	
3.	24733	*Calyptorhynchus baudinii (Baudin's Cockatoo, White-tailed Long-billed Black Cockatoo)*		T	
4.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo, White-tailed Short-billed Black Cockatoo)*		T	
5.	48400	*Calyptorhynchus sp. (white-tailed black cockatoo)*		T	
6.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
7.	17000	*Lasiopetalum pterocarpum*		T	
8.	18590	*Synaphea sp. Fairbridge Farm (D. Papenfus 696)*		T	
9.	30751	*Synaphea sp. Pinjarra Plain (A.S. George 17182)*		T	
10.	28354	*Synaphea sp. Serpentine (G.R. Brand 103)*		T	
11.	1033	*Tetraria australiensis*		T	
12.	12448	*Verticordia plumosa var. ananeotes*		T	
13.	34113	*Westralunio carteri (Carter's Freshwater Mussel)*		T	
Other specially protected fauna					
14.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
15.	48070	*Phascogale tapoatafa subsp. wambenger (South-western Brush-tailed Phascogale, Wambenger)*		S	
Priority 1					
16.	16865	*Synaphea odocoileops*		P1	
Priority 2					
17.	19272	*Johnsonia pubescens subsp. cygnorum*		P2	
Priority 3					
18.	3373	*Acacia horridula*		P3	
19.	14129	*Acacia oncinophylla subsp. oncinophylla*		P3	
20.	41801	*Eryngium pinnatifidum subsp. Palustre (G.J. Keighery 13459)*		P3	
21.	48579	*Euoplos inornatus (inornate trapdoor spider (northern Jarrah Forest))*		P3	
22.	34030	*Geotria australis (Pouched Lamprey)*		P3	
23.	29775	*Isopogon drummondii*		P3	
24.	45081	*Lasiopetalum glutinosum subsp. glutinosum*		P3	
Priority 4					
25.	3115	*Drosera occidentalis (Western Sundew)*		P4	
26.	24189	*Falsistrellus mackenziei (Western False Pipistrelle, Western Falsistrelle)*		P4	
27.	24215	*Hydromys chrysogaster (Water-rat, Rakali)*		P4	
28.	48588	*Isoodon fusciventer (Quenda, southwestern brown bandicoot)*		P4	
29.	6573	*Parsonsia diaphanophleba*		P4	
30.	8212	*Senecio leucoglossus*		P4	

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
31.	14714	*Verticordia lindleyi subsp. lindleyi*		P4	

Non-conservation taxon

32.		*? ?*			
33.	15429	*Acacia alata var. alata*			
34.	3294	*Acacia dentifera*			
35.	11192	*Acacia drummondii subsp. elegans*			
36.	3382	*Acacia incrassata*			
37.	3383	*Acacia incurva*			
38.	3410	*Acacia lateriticola*			
39.	3454	*Acacia nervosa (Rib Wattle)*			
40.	3464	*Acacia obovata*			
41.	3502	*Acacia pulchella (Prickly Moses)*			
42.	15483	*Acacia pulchella var. pulchella*			
43.	3527	*Acacia saligna (Orange Wattle, Kudjong)*			
44.	30032	*Acacia saligna subsp. saligna*			
45.	3541	*Acacia sessilis*			
46.	3557	*Acacia stenoptera (Narrow Winged Wattle)*			
47.	3574	*Acacia teretifolia*			
48.	3591	*Acacia urophylla*			
49.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
50.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
51.	24262	*Acanthiza inornata (Western Thornbill)*			
52.	1205	*Acanthocarpus canaliculatus*			
53.	1208	*Acanthocarpus preissii*			
54.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
55.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
56.	25536	*Accipiter fasciatus (Brown Goshawk)*			
57.		*Acritoptila margaretae*			
58.		*Acritoptila sp.*			
59.	6205	*Actinotus leucocephalus (Flannel Flower)*			
60.	14970	*Adenanthos barbiger*			
61.	1790	*Adenanthos meisneri*			
62.		*Adversaeschna brevistyla*			
63.	25544	*Aegotheles cristatus (Australian Owlet-nightjar)*			
64.	23474	*Agrostocrinum hirsutum*			
65.	1261	*Agrostocrinum scabrum (Blue Grass Lily)*			
66.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
67.	1731	*Allocasuarina huegeliana (Rock Sheoak, Kwowl)*			
68.	1732	*Allocasuarina humilis (Dwarf Sheoak)*			
69.		*Allothereua maculata*			
70.	13380	*Amphibromus nervosus*			
71.	197	*Amphipogon debilis*			
72.	20184	*Amphipogon laguroides subsp. laguroides*			
73.	199	*Amphipogon strictus (Greybeard Grass)*			
74.	200	*Amphipogon turbinatus*			
75.		*Aname mainae*			
76.	24312	*Anas gracilis (Grey Teal)*			
77.	24316	*Anas superciliosa (Pacific Black Duck)*			
78.	6300	*Andersonia aristata (Rice Flower)*			
79.	6314	*Andersonia lehmanniana*			
80.	7833	*Angianthus preissianus*			
81.	1411	*Anigozanthos manglesii (Mangles Kangaroo Paw, Kurulbrang)*			
82.	1416	*Anigozanthos viridis (Green Kangaroo Paw, Kurulbardang)*			
83.	11566	*Anigozanthos viridis subsp. viridis*			
84.	25449	*Antechinus flavipes (Yellow-footed Antechinus)*			
85.	24561	*Anthochaera carunculata (Red Wattlebird)*			
86.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
87.	12724	*Anthotium junciforme*			
88.	24285	*Aquila audax (Wedge-tailed Eagle)*			
89.		*Arachnura higginsi*			
90.		*Araneus senicaudatus*			
91.	7838	*Arctotheca calendula (Cape Weed, African Marigold)*	Y		
92.	24340	*Ardea novaehollandiae (White-faced Heron)*			
93.	24341	*Ardea pacifica (White-necked Heron)*			
94.		*Arrenuridae sp.*			
95.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
96.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
97.	20350	*Astartea affinis (West-coast Astartea)*			
98.	20249	*Astartea leptophylla (River-bank Astartea)*			
99.	6323	*Astroloma ciliatum (Candle Cranberry)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
100.	6334	*Astroloma pallidum (Kick Bush)*			
101.		*Aturidae sp.*			
102.		*Australotiphys barmutai*			
103.		*Austrogomphus collaris*			
104.	47713	*Austronomus australis (White-striped Free-tailed Bat)*			
105.	17233	*Austrostipa campylachne*			
106.	17234	*Austrostipa compressa*			
107.	233	*Avena barbata (Bearded Oat)*	Y		
108.	36441	*Babingtonia camphorosmae (Camphor Myrtle)*			
109.	1800	*Banksia attenuata (Slender Banksia, Piara)*			
110.	1852	*Banksia telmatiaea (Swamp Fox Banksia)*			
111.	32054	*Banksia undata var. undata*			
112.	32315	*Barbula calycina*			
113.		*Barnardius zonarius*			
114.	32321	*Bartramia breutelii*			
115.	32323	*Bartramia pseudostricta*			
116.	743	*Baumea juncea (Bare Twigrush)*			
117.	745	*Baumea preissii*			
118.	748	*Baumea vaginalis (Sheath Twigrush)*			
119.		*Berosus approximans*			
120.	4598	*Beyeria lechenaultii (Pale Turpentine Bush)*			
121.	25788	*Billardiera fraseri (Elegant Pronaya)*			
122.	1417	*Blancoa canescens (Winter Bell)*			
123.	11503	*Boronia crenulata subsp. crenulata var. crenulata*			
124.	4429	*Boronia molloyae (Tall Boronia)*			
125.	11564	*Boronia ramosa subsp. ramosa*			
126.	1273	*Borya sphaerocephala (Pincushions)*			
127.	48782	*Bossiaea angustifolia*			
128.	14396	*Bossiaea aquifolium subsp. aquifolium*			
129.	3710	*Bossiaea eriocarpa (Common Brown Pea)*			
130.	3714	*Bossiaea ornata (Broad Leaved Brown Pea)*			
131.	3718	*Bossiaea rufa*			
132.		*Bostockia porosa*			
133.	8661	*Brachypodium distachyon (False Brome)*	Y		
134.	7871	*Brachyscome ciliaris*			
135.	32327	*Breutelia affinis*			
136.	244	*Briza maxima (Blowfly Grass)*	Y		
137.	245	*Briza minor (Shivery Grass)*	Y		
138.	250	*Bromus hordeaceus (Soft Brome)*	Y		
139.	12770	*Burchardia congesta*			
140.	1385	*Burchardia multiflora (Dwarf Burchardia)*			
141.	25715	*Cacatua roseicapilla (Galah)*			
142.	25716	*Cacatua sanguinea (Little Corella)*			
143.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
144.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
145.	1276	*Caesia micrantha (Pale Grass Lily)*			
146.	1277	*Caesia occidentalis*			
147.	1590	*Caladenia ferruginea (Rusty Spider Orchid)*			
148.	1592	*Caladenia flava (Cowslip Orchid)*			
149.	1605	*Caladenia marginata (White Fairy Orchid)*			
150.	16365	*Calandrinia sp. Kenwick (G.J. Keighery 10905)*			
151.	1214	*Calectasia grandiflora (Blue Tinsel Lily)*			
152.	4717	*Callitriche stagnalis (Common Starwort)*	Y		
153.	36600	*Callitris pyramidalis (Swamp Cypress)*			
154.	5431	*Calothamnus torulosus*			
155.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
156.	5437	*Calytrix acutifolia*			
157.	2952	*Cassytha glabella (Tangled Dodder Laurel)*			
158.	2956	*Cassytha pomiformis (Dodder Laurel)*			
159.	2957	*Cassytha racemosa (Dodder Laurel)*			
160.		*Ceinidae sp.*			
161.	6539	*Centaurium erythraea (Common Centaury)*	Y		
162.	1121	*Centrolepis aristata (Pointed Centrolepis)*			
163.	1125	*Centrolepis drummondiana*			
164.	1134	*Centrolepis polygyna (Wiry Centrolepis)*			
165.		*Ceratopogonidae sp.*			
166.		*Cercophonius sulcatus*			
167.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
168.	1280	*Chamaescilla corymbosa (Blue Squill)*			
169.	31	*Cheilanthes austrotenuifolia*			

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170.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
171.	33939	*Cherax cainii (Marron)*			
172.		*Cherax destructor*			
173.		*Cherax quinquecarinatus*			
174.		*Cheumatopsyche sp. AV2 (SAP)*			
175.		*Chironomus aff. alternans (V24) (CB)*			
176.		*Chironomus tepperi*			
177.	8971	*Chorizema cordatum*			
178.	3753	*Chorizema dicksonii (Yellow-eyed Flame Pea)*			
179.		*Cladocera (unident.)*			
180.		*Cladopelma curtivalva*			
181.		*Cladotanytarsus sp. A (SAP)*			
182.		*Cloeon sp.*			
183.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
184.	24399	*Columba livia (Domestic Pigeon)*	Y		
185.	4550	*Comesperma calymega (Blue-spike Milkwort)*			
186.	4551	*Comesperma ciliatum*			
187.	4564	*Comesperma virgatum (Milkwort)*			
188.		*Condocerus aptus*			
189.	1875	*Conospermum huegelii (Slender Smokebush)*			
190.	1882	*Conospermum stoechadis (Common Smokebush)*			
191.	15611	*Conospermum stoechadis subsp. stoechadis (Common Smokebush)*			
192.	12109	*Conostylis aculeata subsp. preissii*			
193.	1454	*Conostylis setigera (Bristly Cottonhead)*			
194.	1455	*Conostylis setosa (White Cottonhead)*			
195.		*Conostylis sp.*			
196.		*Copepoda sp.*			
197.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
198.		*Cormocephalus aurantiipes*			
199.		*Cormocephalus turneri*			
200.	38874	*Cortinarius globuliformis*			
201.	25592	*Corvus coronoides (Australian Raven)*			
202.	17104	*Corymbia calophylla (Marri)*			
203.	7947	*Cotula turbinata (Funnel Weed)*	Y		
204.	25595	*Cracticus tibicen (Australian Magpie)*			
205.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
206.	25596	*Cracticus torquatus (Grey Butcherbird)*			
207.	13354	*Craspedia variabilis*			
208.	29054	*Crepis foetida subsp. foetida (Stinking Hawksbeard)*	Y		
209.		*Cricotopus 'brevicornis'*			
210.		*Cricotopus 'parbicinctus'*			
211.	25398	*Crinia georgiana (Quacking Frog)*			
212.	25401	*Crinia pseudinsignifera (Bleating Froglet)*			
213.	35838	*Cristonia biloba subsp. biloba*			
214.	30893	*Cryptoblepharus buchananii*			
215.		*Cryptochironomus griseidorsum*			
216.	24883	*Ctenophorus ornatus (Ornate Crevice-Dragon)*			
217.	25049	*Ctenotus labillardieri*			
218.		*Culicidae sp.*			
219.	6663	*Cuscuta epithymum (Lesser Dodder, Greater Dodder)*	Y		
220.	768	*Cyathochaeta avenacea*			
221.	815	*Cyperus tenellus (Tiny Flatsedge)*	Y		
222.	17692	*Cytogonidium leptocarpoides*			
223.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
224.	7420	*Dampiera alata (Winged-stem Dampiera)*			
225.	7454	*Dampiera linearis (Common Dampiera)*			
226.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
227.	5508	*Darwinia citriodora (Lemon-scented Darwinia)*			
228.	5531	*Darwinia thymoides*			
229.	1218	*Dasypogon bromeliifolius (Pineapple Bush)*			
230.	6960	*Datura ferox (Fierce Thornapple)*	Y		
231.	6218	*Daucus glochidiatus (Australian Carrot)*			
232.	15656	*Daviesia brachyphylla*			
233.	16579	*Daviesia decipiens*			
234.	3805	*Daviesia decurrens (Prickly Bitter-pea)*			
235.	3815	*Daviesia horrida (Prickly Bitter-pea)*			
236.	3835	*Daviesia preissii*			
237.	17663	*Desmocladus asper*			
238.	15831	*Desmocladus castaneus*			
239.	17691	*Desmocladus fasciculatus*			

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240.	11636	*Dianella revoluta var. divaricata*			
241.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
242.	306	*Dichelachne crinita (Longhair Plumegrass)*			
243.	1287	*Dichopogon capillipes*			
244.		*Dicrotendipes sp.*			
245.	17838	*Dielsia stenostachya*			
246.		*Dinocambala ingens*			
247.	1509	*Dioscorea hastifolia (Warrine, Wararn)*			
248.		*Diplacodes bipunctata*			
249.	24939	*Diplodactylus polyophthalmus*			
250.	18589	*Diplopeltis huegelii subsp. lehmannii*			
251.	12943	*Diuris brumalis*			
252.	4757	*Dodonaea ceratocarpa*			
253.		*Dolichopodidae sp.*			
254.	24470	*Dromaius novaehollandiae (Emu)*			
255.	48751	*Drosera drummondii*			
256.	3095	*Drosera erythrorhiza (Red Ink Sundew)*			
257.	3106	*Drosera macrantha (Bridal Rainbow)*			
258.	12243	*Drosera mannii*			
259.	3109	*Drosera menziesii (Pink Rainbow)*			
260.	3118	*Drosera pallida (Pale Rainbow)*			
261.	8911	*Drosera rosulata*			
262.	49090	*Drosera sp. Branched styles (S.C. Coffey 193)*			
263.	3131	*Drosera stolonifera (Leafy Sundew)*			
264.	25096	*Egernia kingii (King's Skink)*			
265.		*Egretta novaehollandiae*			
266.	349	*Ehrharta longiflora (Annual Veldt Grass)*	Y		
267.		*Elanus axillaris*			
268.	25250	*Elapognathus coronatus (Crowned Snake)*			
269.	47937	*Elseyornis melanops (Black-fronted Dotterel)*			
270.	1643	*Elythranthera brunonis (Purple Enamel Orchid)*			
271.		*Empididae sp.*			
272.		*Enchytraeidae sp.*			
273.		*Eolophus roseicapillus*			
274.	25692	*Eopsaltria australis (Yellow Robin)*			
275.	24652	*Eopsaltria georgiana (White-breasted Robin)*			
276.	379	*Eragrostis elongata (Clustered Lovegrass)*			
277.	6219	*Eryngium pinnatifidum (Blue Devils)*			
278.	15446	*Eryngium pinnatifidum subsp. pinnatifidum*			
279.	5616	*Eucalyptus decurva (Slender Mallee)*			
280.	5688	*Eucalyptus laeliae (Darling Range Ghost Gum)*			
281.	5690	*Eucalyptus lane-poolei (Salmon White Gum)*			
282.	5708	*Eucalyptus marginata (Jarrah, Djara)*			
283.	13547	*Eucalyptus marginata subsp. marginata (Jarrah)*			
284.	5763	*Eucalyptus rudis (Flooded Gum, Kulurda)*			
285.	13511	*Eucalyptus rudis subsp. rudis*			
286.	5797	*Eucalyptus wandoo (Wandoo, Wondu)*			
287.	12906	*Eucalyptus wandoo subsp. wandoo*			
288.	3872	*Euchilopsis linearis (Swamp Pea)*			
289.		*Eucyrtops latior*			
290.	4627	*Euphorbia helioscopia (Sun Spurge)*	Y		
291.	4648	*Euphorbia terracina (Geraldton Carnation Weed)*	Y		
292.	3880	*Eutaxia virgata*			
293.	25621	*Falco berigora (Brown Falcon)*			
294.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
295.	25623	*Falco longipennis (Australian Hobby)*			
296.	1747	*Ficus carica (Common Fig)*	Y		
297.	32365	*Fissidens leptocladus*			
298.	32367	*Fissidens megalotis*			
299.	32469	*Fissidens taylorii var. taylorii*			
300.	25727	*Fulica atra (Eurasian Coot)*			
301.	2969	*Fumaria capreolata (Whiteflower Fumitory)*	Y		
302.	34028	*Galaxias occidentalis (Western Minnow)*			
303.	7321	*Galium divaricatum*	Y		
304.	7323	*Galium murale (Small Goosegrass)*	Y		
305.	20513	*Gastrolobium dilatatum*			
306.	20473	*Gastrolobium ebracteolatum*			
307.	3924	*Gastrolobium spinosum (Prickly Poison)*			
308.	32383	*Gemmabryum sullivanii*			
309.	25404	*Geocrinia leai (Ticking Frog)*			

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310.	25530	*Gerygone fusca (Western Gerygone)*			
311.	1524	*Gladiolus undulatus (Wild Gladiolus)*	Y		
312.	3945	*Gompholobium aristatum*			
313.	10909	*Gompholobium confertum*			
314.	3950	*Gompholobium knightianum*			
315.	3951	*Gompholobium marginatum*			
316.	3954	*Gompholobium polymorphum*			
317.	6149	*Gonocarpus cordiger*			
318.	29362	*Goodenia coerulea*			
319.	24443	*Grallina cyanoleuca (Magpie-lark)*			
320.	1964	*Grevillea bipinnatifida (Fuchsia Grevillea)*			
321.	19628	*Grevillea bipinnatifida subsp. bipinnatifida*			
322.	13429	*Grevillea diversifolia subsp. diversifolia*			
323.	1997	*Grevillea endlicheriana (Spindly Grevillea)*			
324.	13450	*Grevillea manglesii subsp. manglesii*			
325.	2066	*Grevillea pilulifera (Woolly-flowered Grevillea)*			
326.	2122	*Grevillea wilsonii (Native Fuchsia)*			
327.	32473	*Grimmia pulvinata var. africana*			
328.		*Gripopterygidae sp.*			
329.		*Gyrinidae sp.*			
330.	1465	*Haemodorum discolor*			
331.	1468	*Haemodorum laxum*			
332.	1472	*Haemodorum simplex*			
333.	1474	*Haemodorum sparsiflorum*			
334.	2128	*Hakea amplexicaulis (Prickly Hakea)*			
335.	2137	*Hakea ceratophylla (Horned Leaf Hakea)*			
336.	2152	*Hakea cyclocarpa (Ramshorn)*			
337.	2166	*Hakea incrassata (Marble Hakea)*			
338.	2175	*Hakea lissocarpha (Honey Bush)*			
339.	2203	*Hakea ruscifolia (Candle Hakea)*			
340.	2206	*Hakea stenocarpa (Narrow-fruited Hakea)*			
341.	2212	*Hakea sulcata (Furrowed Hakea)*			
342.	2214	*Hakea trifurcata (Two-leaf Hakea)*			
343.	2215	*Hakea undulata (Wavy-leaved Hakea)*			
344.		*Haliplus fuscatus*			
345.		*Haliplus sp.*			
346.		*Harrisius sp. A (SAP)*			
347.	32392	*Hedwigidium integrifolium*			
348.		*Hellyethira litua*			
349.		*Helochares tenuistriatus*			
350.	439	*Hemarthria uncinata (Matgrass)*			
351.		*Hemicordulia tau*			
352.	25115	*Hemiergis initialis subsp. initialis*			
353.	6856	*Hemigenia incana (Silky Hemigenia)*			
354.		*Henicops dentatus*			
355.	1293	*Hensmania turbinata*			
356.	5108	*Hibbertia acerosa (Needle Leaved Guinea Flower)*			
357.	5114	*Hibbertia commutata*			
358.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
359.	5148	*Hibbertia mylnei*			
360.	5150	*Hibbertia nymphaea*			
361.	5155	*Hibbertia pilosa (Hairy Guinea Flower)*			
362.	5169	*Hibbertia serrata (Serrate Leaved Guinea Flower)*			
363.	11481	*Hibbertia spicata subsp. spicata*			
364.	5173	*Hibbertia subvaginata*			
365.	47965	*Hieraaetus morphnoides (Little Eagle)*			
366.		*Hirudinea sp.*			
367.	24491	*Hirundo neoxena (Welcome Swallow)*			
368.	6222	*Homalosciadium homalocarpum*			
369.	3964	*Hovea chorizemifolia (Holly-leaved Hovea)*			
370.	3966	*Hovea pungens (Devil's Pins, Puyenak)*			
371.	3968	*Hovea trisperma (Common Hovea)*			
372.	12741	*Hyalosperma cotula*			
373.	12007	*Hybanthus floribundus subsp. floribundus*			
374.	6226	*Hydrocotyle callicarpa (Small Pennywort)*			
375.		*Hydrodromidae sp.*			
376.		*Hyphydrus elegans*			
377.	5817	*Hypocalymma angustifolium (White Myrtle, Kudjid)*			
378.	5825	*Hypocalymma robustum (Swan River Myrtle)*			
379.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		

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380.	9352	*Hypochaeris radicata (Flat Weed, Cats-ear)*	Y		
381.	1070	*Hypolaena exsulca*			
382.		*Idiommata blackwalli*			
383.	20200	*Isolepis cernua var. setiformis*			
384.	917	*Isolepis marginata (Coarse Club-rush)*			
385.	919	*Isolepis oldfieldiana*			
386.		*Isometroides vescus*			
387.		*Isopeda leishmanni*			
388.	2221	*Isopogon asper*			
389.	7396	*Isotoma hypocrateriformis (Woodbridge Poison)*			
390.	4018	*Jacksonia lehmannii*			
391.	4025	*Jacksonia restioides*			
392.	1180	*Juncus capitatus (Capitate Rush)*	Y		
393.	11922	*Juncus kraussii subsp. australiensis*			
394.	1196	*Juncus usitatus (Common Rush)*	Y		
395.		*Karaops ellenae*			
396.	4037	*Kennedia coccinea (Coral Vine)*			
397.	4045	*Kennedia stirlingii (Bushy Kennedia)*			
398.	1221	*Kingia australis (Kingia, Pulonok)*			
399.	5835	*Kunzea micrantha*			
400.	17461	*Kunzea micrantha subsp. micrantha*			
401.	17785	*Kunzea micrantha subsp. petiolata*			
402.	3667	*Labichea lanceolata (Tall Labichea)*			
403.	11289	*Labichea lanceolata subsp. lanceolata*			
404.	3669	*Labichea punctata (Lance-leaved Cassia)*			
405.	18585	*Lagenophora huegelii*			
406.	14083	*Lambertia multiflora var. darlingensis*			
407.		*Lancetes lanceolatus*			
408.		*Latrodectus hasseltii*			
409.	11911	*Laxmannia ramosa subsp. ramosa*			
410.	1309	*Laxmannia squarrosa*			
411.	7568	*Lechenaultia biloba (Blue Leschenaultia)*			
412.		*Lectrides parilis*			
413.	41620	*Lepidosperma asperatum*			
414.	936	*Lepidosperma leptostachyum*			
415.	940	*Lepidosperma pubisquameum*			
416.	29141	*Lepidosperma sp. Gosnells (A. Markey 1145)*			
417.	29150	*Lepidosperma sp. Margaret River (B.J. Lepschi 1841)*			
418.	948	*Lepidosperma tetraquetrum*			
419.	949	*Lepidosperma tuberculatum*			
420.	46375	*Leptocarpus decipiens*			
421.		*Leptoceridae sp.*			
422.	2342	*Leptomeria cunninghamii*			
423.		*Leptoperla australica*			
424.	1085	*Lepyrodia glauca*			
425.	25131	*Lerista distinguenda*			
426.	6367	*Leucopogon capitellatus*			
427.	6400	*Leucopogon gracillimus*			
428.	6436	*Leucopogon propinquus*			
429.	6439	*Leucopogon pulchellus (Beard-heath)*			
430.	6447	*Leucopogon strictus*			
431.	7676	*Levenhookia pusilla (Midget Stylewort)*			
432.	7677	*Levenhookia stipitata (Common Stylewort)*			
433.	25661	*Lichmera indistincta (Brown Honeyeater)*			
434.		*Limnesiidae sp.*			
435.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
436.		*Limnoxenus zelandicus*			
437.	4363	*Linum trigynum (French Flax)*	Y		
438.	9289	*Lobelia anceps (Angled Lobelia)*			
439.	7402	*Lobelia gibbosa (Tall Lobelia)*			
440.	7403	*Lobelia heterophylla (Wing-seeded Lobelia)*			
441.	478	*Lolium rigidum (Wimmera Ryegrass)*	Y		
442.	1222	*Lomandra brittanii*			
443.	1223	*Lomandra caespitosa (Tufted Mat Rush)*			
444.	1228	*Lomandra hermaphrodita*			
445.	1229	*Lomandra integra*			
446.	1232	*Lomandra micrantha (Small-flower Mat-rush)*			
447.	14542	*Lomandra micrantha subsp. micrantha*			
448.	1234	*Lomandra nigricans*			
449.	1236	*Lomandra odora (Tiered Matrush)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
450.	1239	*Lomandra preissii*			
451.	1240	*Lomandra purpurea (Purple Mat Rush)*			
452.	1243	*Lomandra sericea (Silky Mat Rush)*			
453.	1244	*Lomandra sonderi*			
454.	1245	*Lomandra spartea*			
455.		*Lophoictinia isura*			
456.	4059	*Lotus angustissimus (Narrowleaf Trefoil)*	Y		
457.	8564	*Lotus subbiflorus*	Y		
458.		*Macrogyrus angustatus*			
459.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
460.	85	*Macrozamia riedlei (Zamia, Djiridji)*			
461.	25650	*Malurus elegans (Red-winged Fairy-wren)*			
462.	25654	*Malurus splendens (Splendid Fairy-wren)*			
463.	17630	*Marianthus tenuis*			
464.		*Maydenoptila baynesi*			
465.	18394	*Melaleuca parviceps*			
466.	5958	*Melaleuca radula (Graceful Honeymyrtle)*			
467.	5959	*Melaleuca rhaphiophylla (Swamp Paperbark)*			
468.	5964	*Melaleuca seriata*			
469.	5983	*Melaleuca trichophylla*			
470.	13280	*Melaleuca viminea subsp. viminea*			
471.	25663	*Melithreptus brevirostris (Brown-headed Honeyeater)*			
472.	24598	*Merops ornatus (Rainbow Bee-eater)*			
473.	953	*Mesomelaena graciliceps*			
474.	955	*Mesomelaena pseudostygia*			
475.	11473	*Mesomelaena stygia subsp. stygia*			
476.	957	*Mesomelaena tetragona (Semaphore Sedge)*			
477.		*Microcarbo melanoleucos*			
478.	485	*Microlaena stipoides (Weeping Grass)*			
479.	11747	*Microlaena stipoides var. stipoides*			
480.		*Micronecta gracilis*			
481.		*Micronecta robusta*			
482.	15419	*Microtis media subsp. media*			
483.	14344	*Millotia tenuifolia var. tenuifolia (Soft Millotia)*			
484.	4090	*Mirbelia dilatata (Holly-leaved Mirbelia)*			
485.	4091	*Mirbelia floribunda (Purple Mirbelia)*			
486.	4100	*Mirbelia spinosa*			
487.	37440	*Monopsis debilis var. depressa*	Y		
488.		*Naididae sp.*			
489.	49026	*Nandina domestica*	Y		Y
490.		*Nannoperca vittata*			
491.		*Necterosoma darwini*			
492.		*Necterosoma sp.*			
493.		*Nematoda sp.*			
494.		*Nemertini sp.*			
495.	24738	*Neophema elegans (Elegant Parrot)*			
496.		*Neosilurus hyrtlii*			
497.	492	*Neurachne alopecuroidea (Foxtail Mulga Grass)*			
498.		*Newmanoperla exigua*			
499.		*Notalina nr. sp. AV14*			
500.	25252	*Notechis scutatus (Tiger Snake)*			
501.		*Nousia sp. AV16*			
502.		*Nunciella aspera*			
503.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
504.		*Occiperipatoides gilesii*			
505.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
506.		*Oecetis sp.*			
507.		*Offadens soror (ex genus 1 WA sp. 1)*			
508.	2365	*Olax benthamiana*			
509.	8143	*Olearia paucidentata (Autumn Scrub Daisy)*			
510.	18254	*Opercularia apiciflora*			
511.	7346	*Opercularia echinocephala (Bristly Headed Stink Weed)*			
512.	18255	*Opercularia vaginata (Dog Weed)*			
513.		*Opisthopora sp.*			
514.		*Oribatida sp.*			
515.	11749	*Orthrosanthus laxus var. laxus (Morning Iris)*			
516.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
517.		*Ostracoda (unident.)*			
518.	4349	*Oxalis corniculata (Yellow Wood Sorrel)*	Y		
519.	4355	*Oxalis perennans*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
520.		*Oxyethira sp.*			
521.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
522.		*Paracladopelma M1 [SFM)*			
523.		*Paralimnophyes pullulus (V42)*			
524.		*Paramelitidae sp.*			
525.		*Paramerina levidensis*			
526.	25253	*Parasuta gouldii*			
527.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
528.	25682	*Pardalotus striatus (Striated Pardalote)*			
529.	7089	*Parentucellia latifolia (Common Bartsia)*	Y		
530.	27922	*Parmotrema chinense*			
531.	527	*Paspalum dilatatum*	Y		
532.	1542	*Patersonia babianoides*			
533.	1550	*Patersonia occidentalis (Purple Flag, Koma)*			
534.	1551	*Patersonia pygmaea (Pygmy Patersonia)*			
535.	11550	*Patersonia umbrosa var. xanthina (Yellow Flags)*			
536.		*Pentaneurini genus V20*			
537.	6245	*Pentapeltis peltigera*			
538.	39058	*Perichaena depressa*			
539.	2267	*Persoonia longifolia (Snottygobble)*			
540.	2273	*Persoonia saccata (Snottygobble)*			
541.		*Perthiidae sp.*			
542.	48061	*Petrochelidon nigricans (Tree Martin)*			
543.	48066	*Petroica boodang (Scarlet Robin)*			
544.	2284	*Petrophile biloba (Granite Petrophile)*			
545.	2312	*Petrophile striata*			
546.	24409	*Phaps chalcoptera (Common Bronzewing)*			
547.	25587	*Phaps elegans (Brush Bronzewing)*			
548.	32409	*Philonotis australiensis*			
549.	18529	*Philotheca spicata (Pepper and Salt)*			
550.	1173	*Philydrella pygmaea (Butterfly Flowers)*			
551.		*Phreodrilidae sp.*			
552.	48071	*Phylidonyris niger (White-cheeked Honeyeater)*			
553.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
554.	16177	*Phyllangium paradoxum*			
555.	4675	*Phyllanthus calycinus (False Boronia)*			
556.		*Phytophthora cinnamomi*			
557.	11667	*Pimelea brevistyla subsp. brevistyla*			
558.	5251	*Pimelea imbricata*			
559.	11402	*Pimelea imbricata var. piligera*			
560.	5259	*Pimelea preissii*			
561.	12041	*Pimelea suaveolens subsp. suaveolens*			
562.	8165	*Pithocarpa pulchella (Beautiful Pithocarpa)*			
563.		*Planorbidae sp.*			
564.	25720	*Platycercus icterotis (Western Rosella)*			
565.	24747	*Platycercus spurius (Red-capped Parrot)*			
566.	25721	*Platycercus zonarius (Australian Ringneck, Ring-necked Parrot)*			
567.		*Platynectes sp.*			
568.	6253	*Platysace filiformis*			
569.	32413	*Pleuridium ecklonii*			
570.	573	*Poa drummondiana (Knotted Poa)*			
571.	8175	*Podolepis gracilis (Slender Podolepis)*			
572.		*Poecilipta smaragdinea*			
573.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
574.	2419	*Polygonum aviculare (Wireweed)*	Y		
575.		*Polypedilum nr. convexum (SAP)*			
576.		*Polypedilum nubifer*			
577.		*Polypedilum watsoni*			
578.	25722	*Polytelis anthopeplus (Regent Parrot)*			
579.	4691	*Poranthera microphylla (Small Poranthera)*			
580.	1677	*Prasophyllum macrostachyum (Laughing Leek Orchid)*			
581.	10853	*Prasophyllum plumiforme*			
582.		*Procladius paludicola*			
583.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
584.	25433	*Pseudophryne guentheri (Crawling Toadlet)*			
585.	13255	*Pterochaeta paniculata*			
586.	24173	*Pteropus scapulatus (Little Red Flying-fox)*			
587.	2742	*Ptilotus manglesii (Pom Poms, Mulamula)*			
588.		*Purpureicephalus spurius*			
589.	32480	*Racopilum cuspidigerum var. convolutaceum*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
590.		*Raveniella cirrata*			
591.	6012	*Regelia ciliata*			
592.		*Rheotanytarsus trivittatus*			
593.		*Rheotanytarsus underwoodi*			
594.	48096	*Rhipidura albiscapa (Grey Fantail)*			
595.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
596.	15035	*Rhodanthe corymbosa*			
597.	13234	*Rhodanthe manglesii*			
598.		*Riethia v4*			
599.		*Riethia v5*			
600.	1556	*Romulea rosea (Guildford Grass)*	Y		
601.	20506	*Rubus anglocandicans*	Y		
602.	23990	*Rubus ulmifolius var. ulmifolius*	Y		
603.	2433	*Rumex crispus (Curled Dock)*	Y		
604.	40427	*Rytidosperma setaceum*			
605.	7602	*Scaevola calliptera*			
606.	7613	*Scaevola glandulifera (Viscid Hand-flower)*			
607.	7635	*Scaevola pilosa (Hairy Fan-flower)*			
608.	6263	*Schoenolaena juncea*			
609.	975	*Schoenus bifidus*			
610.	978	*Schoenus brevisetis*			
611.	979	*Schoenus caespititius*			
612.	991	*Schoenus grammatophyllus*			
613.	1002	*Schoenus nanus (Tiny Bog Rush)*			
614.	17614	*Schoenus plumosus*			
615.	1013	*Schoenus sculptus (Gimlet Bog-rush)*			
616.	18164	*Schoenus sp. smooth culms (K.R. Newbey 7823)*			
617.	1023	*Schoenus tenellus*			
618.	1026	*Schoenus unispiculatus*			
619.	17409	*Schoenus variicellae*			
620.		*Scirtidae sp.*			
621.		*Scolopendra laeta*			
622.	32433	*Sematophyllum homomallum*			
623.	8203	*Senecio diaschides*			
624.	20663	*Senecio multicaulis subsp. multicaulis*			
625.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
626.	8225	*Siloxerus humifusus (Procumbent Siloxerus)*			
627.		*Simuliidae sp.*			
628.	30948	*Smicrornis brevirostris (Weebill)*			
629.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
630.	617	*Sorghum halepense (Johnson Grass)*	Y		
631.	1312	*Sowerbaea laxiflora (Purple Tassels)*			
632.	4207	*Sphaerolobium medium*			
633.	41623	*Sphaeromorphaea australis*	Y		
634.	4716	*Stachystemon vermicularis*			
635.	4733	*Stackhousia monogyna*			
636.	24645	*Stagonopleura oculata (Red-eared Firetail)*			
637.	39083	*Stemonitis fusca*			
638.		*Sternopriscus browni*			
639.		*Sternopriscus marginatus*			
640.		*Sternopriscus minimus*			
641.		*Sternopriscus sp.*			
642.	2316	*Stirlingia latifolia (Blueboy)*			
643.		*Stratiomyidae sp.*			
644.	25597	*Strepera versicolor (Grey Currawong)*			
645.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
646.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
647.	7693	*Stylidium brunonianum (Pink Fountain Triggerplant)*			
648.	7694	*Stylidium bulbiferum (Circus Triggerplant)*			
649.	7696	*Stylidium calcaratum (Book Triggerplant)*			
650.	7699	*Stylidium carnosum (Fleshy-leaved Triggerplant)*			
651.	7719	*Stylidium ecorne (Foot Triggerplant)*			
652.	7721	*Stylidium emarginatum (Biddy-four-legs)*			
653.	7736	*Stylidium hispidum (White Butterfly Triggerplant)*			
654.	7745	*Stylidium junceum (Reed Triggerplant)*			
655.	7783	*Stylidium pycnostachyum (Downy Triggerplant)*			
656.	33106	*Stylidium recurvum*			
657.	7790	*Stylidium roseoalatum (Pink-wing Triggerplant)*			
658.	25806	*Stylidium scariosum*			
659.		*Stylidium sp.*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
660.	45594	*Stylidium tenue subsp. majusculum (Showy Fountain Triggerplant)*			
661.	23511	*Stylidium thesioides (Delicate Triggerplant)*			
662.	7806	*Stylidium utricularioides (Pink Fan Triggerplant)*			
663.	1260	*Stypandra glauca (Blind Grass)*			
664.	6476	*Styphelia tenuiflora (Common Pinheath)*			
665.	2323	*Synaphea gracillima*			
666.	2324	*Synaphea petiolaris (Synaphea)*			
667.		*Synsphyronus mimulus*			
668.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
669.	24207	*Tachyglossus aculeatus (Short-beaked Echidna)*			
670.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
671.		*Tandanus bostocki*			
672.		*Tanytarsus fuscithorax/semibarbitarsus*			
673.		*Tanytarsus nr K5*			
674.		*Tanytarsus palmatus*			
675.		*Tanytarsus sp. I (SAP)*			
676.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
677.		*Taschorema pallescens*			
678.		*Tasmanocoenis tillyardi*			
679.	20135	*Taxandria linearifolia*			
680.		*Tetragnatha maeandrata*			Y
681.	1034	*Tetraria capillaris (Hair Sedge)*			
682.	1036	*Tetraria octandra*			
683.	667	*Tetrarrhena laevis (Forest Ricegrass)*			
684.	48342	*Tetratheca hirsuta subsp. hirsuta*			
685.	48341	*Tetratheca hirsuta subsp. viminea*			
686.	4536	*Tetratheca hispidissima*			
687.	4537	*Tetratheca nuda*			
688.	1705	*Thelymitra crinita (Blue Lady Orchid)*			
689.	1707	*Thelymitra flexuosa (Twisted Sun Orchid)*			
690.	11053	*Thelymitra macrophylla*			
691.	1715	*Thelymitra spiralis (Curlylocks)*			
692.		*Thienemanniella sp. (V19) (SAP)*			
693.	5080	*Thomasia foliosa*			
694.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
695.	32486	*Thuidium sparsum var. hastatum*			
696.	1328	*Thysanotus dichotomus (Branching Fringe Lily)*			
697.	1338	*Thysanotus manglesianus (Fringed Lily)*			
698.	1351	*Thysanotus sparteus*			
699.	1354	*Thysanotus tenellus*			
700.	1357	*Thysanotus thyrsoideus*			
701.	1358	*Thysanotus triandrus*			
702.	25207	*Tiliqua rugosa subsp. rugosa*			
703.		*Tipulidae sp.*			
704.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
705.	8248	*Tolpis barbata (Yellow Hawkweed)*	Y		
706.	19041	*Trachymene coerulea subsp. coerulea*			
707.	6280	*Trachymene pilosa (Native Parsnip)*			
708.	1482	*Tribonanthes brachypetala (Nodding Tiurndin)*			
709.	39098	*Trichia favoginea*			
710.	8251	*Trichocline spathulata (Native Gerbera)*			
711.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
712.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
713.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
714.	4292	*Trifolium campestre (Hop Clover)*	Y		
715.	4293	*Trifolium cernuum (Drooping Flower Clover)*	Y		
716.	4304	*Trifolium ornithopodioides (Birdsfoot Fenugreek)*	Y		
717.		*Triplectides australis*			
718.	4737	*Tripterococcus brunonis (Winged Stackhousia)*			
719.	13479	*Trymalium ledifolium var. rosmarinifolium*			
720.	33418	*Trymalium odoratissimum subsp. odoratissimum*			
721.	48147	*Turnix varius (Painted Button-quail)*			
722.	24983	*Underwoodisaurus milii (Barking Gecko)*			
723.		*Urodacus novaehollandiae*			
724.		*Urodacus planimanus*			
725.		*Uromycladium tepperianum*			
726.	8255	*Ursinia anthemoides (Ursinia)*	Y		
727.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
728.	12411	*Verticordia densiflora var. cespitosa*			
729.	6107	*Verticordia pennigera*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
730.	12449	*Verticordia plumosa var. brachyphylla*			
731.	24206	*Vespadelus regulus (Southern Forest Bat)*			
732.	4325	*Viminaria juncea (Swishbush, Koweda)*			
733.	24040	*Vulpes vulpes (Red Fox)*	Y		
734.	722	*Vulpia bromoides (Squirrel Tail Fescue)*	Y		
735.	724	*Vulpia myuros (Rat's Tail Fescue)*	Y		
736.	7389	*Wahlenbergia preissii*			
737.	1567	*Watsonia meriana (Bulbil Watsonia)*	Y		
738.	18108	*Watsonia meriana var. bulbillifera*	Y		
739.	32456	*Weissia rutilans*			
740.		*Wheenyoides cooki*			
741.	1394	*Wurmbea dioica (Early Nancy)*			
742.	12072	*Wurmbea dioica subsp. alba*			
743.		*Xanthagrion erythroneurum*			
744.	1249	*Xanthorrhoea acanthostachya*			
745.	1253	*Xanthorrhoea gracilis (Graceful Grass Tree, Mimidi)*			
746.	1256	*Xanthorrhoea preissii (Grass tree, Palga)*			
747.	6284	*Xanthosia candida*			
748.	6289	*Xanthosia huegelii*			
749.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

Australian Government
Department of the Environment and Energy

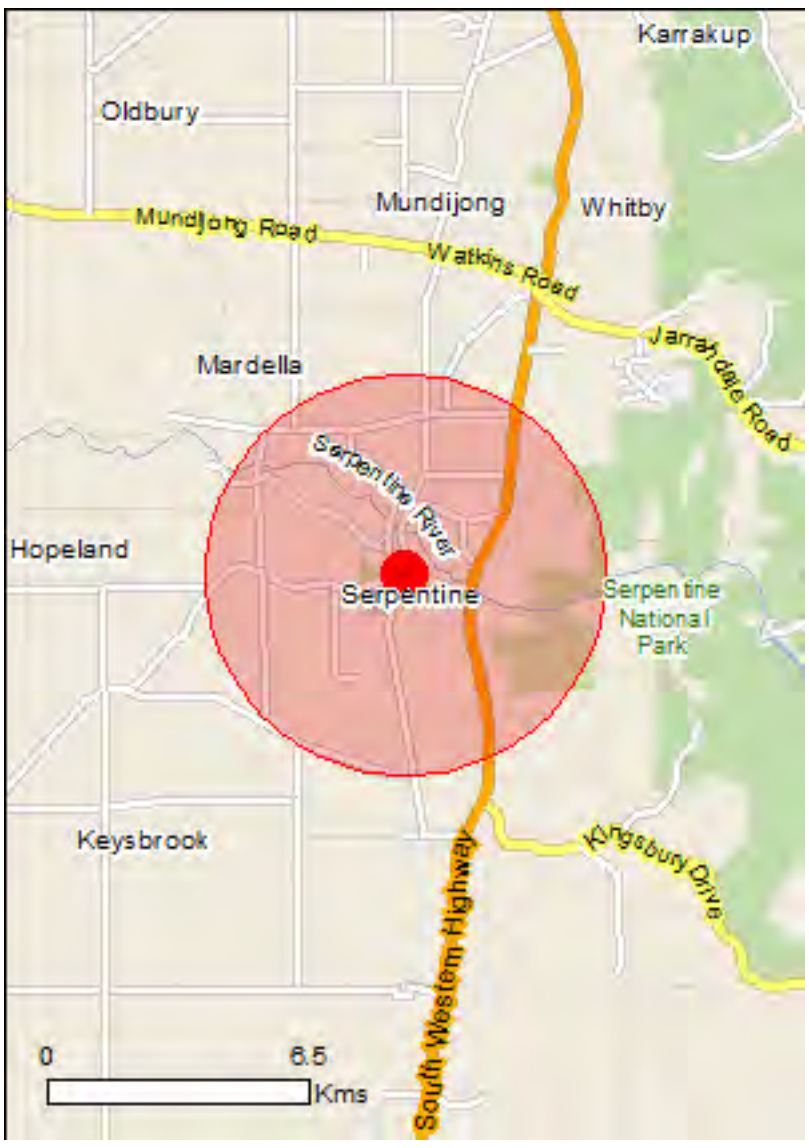
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 01/10/19 13:43:27



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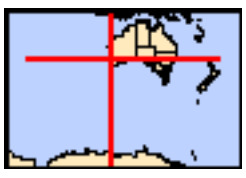
Coordinates

Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	29
Listed Migratory Species:	8

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	13
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	1
Invasive Species:	38
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Peel-yalgorup system	20 - 30km upstream

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Clay Pans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area
Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan Coastal Plain	Endangered	Community known to occur within area
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Endangered	Community known to occur within area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Roosting known to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Mammals		
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat may occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat likely to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat likely to occur within area
Other		
Westralunio carteri Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat known to occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Anthocercis gracilis Slender Tailflower [11103]	Vulnerable	Species or species habitat may occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Eucalyptus x balanites Cadda Road Mallee, Cadda Mallee [87816]	Endangered	Species or species habitat likely to occur within area
Lasiopetalum pterocarpum Wing-fruited Lasiopetalum [64922]	Endangered	Species or species habitat known to occur within area
Synaphea sp. Fairbridge Farm (D. Papenfus 696) Selena's Synaphea [82881]	Critically Endangered	Species or species habitat known to occur within area
Synaphea sp. Serpentine (G.R. Brand 103) [86879]	Critically Endangered	Species or species habitat known to occur within area
Tetraria australiensis Southern Tetraria [10137]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Thelymitra dedmaniarum Cinnamon Sun Orchid [65105]	Endangered	Species or species habitat may occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat may occur within area
Verticordia plumosa var. ananeotes Tufted Plumed Featherflower [23871]	Endangered	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		

Name	Threatened	Type of Presence
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Karnet	WA
Lambkin	WA
NTWA Bushland covenant (0076)	WA
Serpentine	WA
Unnamed WA46587	WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur

Name	Status	Type of Presence within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-32.36131 115.97687

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix C
DPLH Aboriginal Site Database

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

Search Criteria

1 Registered Aboriginal Sites in Custom search area - Polygon - 115.972413360036°E, 32.3717067095714°S (GDA94) : 115.972413360036°E, 32.3513301892629°S (GDA94) : 115.988901865389°E, 32.3513301892629°S (GDA94) : 115.988901865389°E, 32.3717067095714°S (GDA94) : 115.972413360036°E, 32.3717067095714°S (GDA94)

Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at heritageenquiries@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

South West Settlement ILUA Disclaimer

Your heritage enquiry is on land within or adjacent to the following Indigenous Land Use Agreement(s): Gnaala Karla Booja People ILUA.

On 8 June 2015, six identical Indigenous Land Use Agreements (ILUAs) were executed across the South West by the Western Australian Government and, respectively, the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip & Southern Noongar groups, and the South West Aboriginal Land and Sea Council (SWALSC).

The ILUAs bind the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Noongar Standard Heritage Agreement (NSHA) when conducting Aboriginal Heritage Surveys in the ILUA areas, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the NSHA when conducting Aboriginal Heritage Surveys in the ILUA areas. It is recommended a NSHA is entered into, and an 'Activity Notice' issued under the NSHA, if there is a risk that an activity will 'impact' (i.e. by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the NSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

Likewise, from 8 June 2015 the Department of Mines, Industry Regulation and Safety (DMIRS) in granting Mineral, Petroleum and related Access Authority tenures within the South West Settlement ILUA areas, will place a condition on these tenures requiring a heritage agreement or a NSHA before any rights can be exercised.

If you are a State Government Department, Agency or Instrumentality, or have a heritage condition placed on your mineral or petroleum title by DMIRS, you should seek advice as to the requirement to use the NSHA for your proposed activity. The full ILUA documents, maps of the ILUA areas and the NSHA template can be found at https://www.dpc.wa.gov.au/swnts/South-West-Native-Title-Settlement/Pages/default.aspx.

Further advice can also be sought from the Department of Planning, Lands and Heritage at heritageenquiries@dplh.wa.gov.au.

Coordinate Accuracy

Coordinates (Easting/Northing metres) are based on the GDA 94 Datum. Accuracy is shown as a code in brackets following the coordinates.

Terminology (NB that some terminology has varied over the life of the legislation)

Place ID/Site ID: This a unique ID assigned by the Department of Planning, Lands and Heritage to the place.

Status:

- Registered Site : The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972.*
- Other Heritage Place which includes:
  - Stored Data / Not a Site: The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972.*
  - Lodged: Information has been received in relation to the place, but an assessment has not been completed at this *stage* to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972.*

Access and Restrictions:

- File Restricted = No: Availability of information that the Department of Planning, Lands and Heritage holds in relation to the place is not restricted in any way.
- File Restricted = Yes: Some of the information that the Department of Planning, Lands and Heritage holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Planning, Lands and Heritage receives written approval from the informants who provided the information. To request access please contact heritageenquiries@dplh.wa.gov.au.
- Boundary Restricted = No: Place location is shown as accurately as the information lodged with the Registrar allows.
- Boundary Restricted = Yes: 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. If you are a landowner and wish to find out more about the exact location of the place, please contact the Department of Planning, Lands and Heritage.
- Restrictions:
  - No Restrictions: *Anyone* can view the information.
  - Male Access Only: Only *males* can view restricted information.
  - Female Access Only: *Only* females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

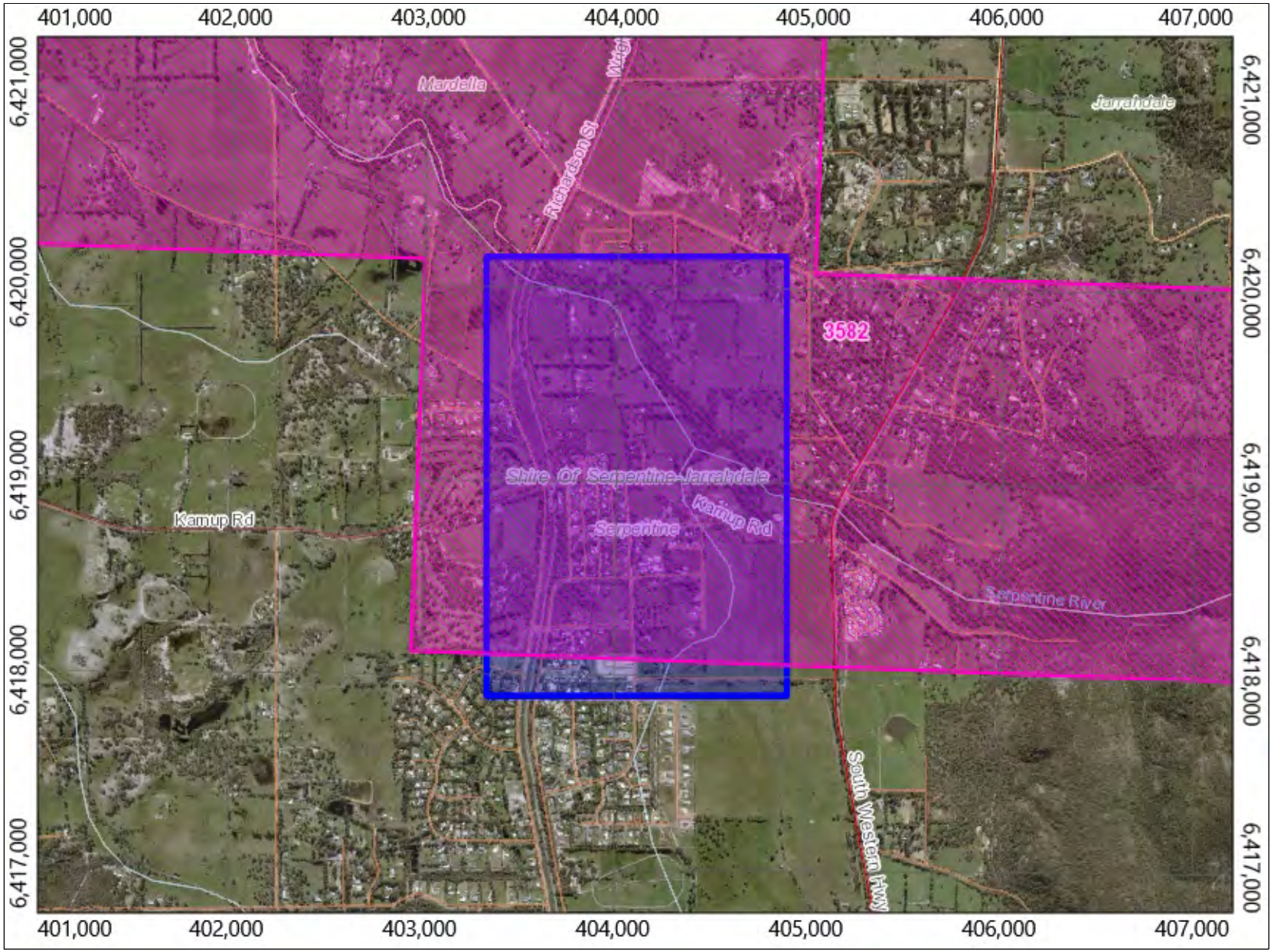
ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
3582	SERPENTINE RIVER	Yes	Yes	No Gender Restrictions	Registered Site	Ceremonial, Mythological	*Registered Knowledge Holder names available from DAA	Not available when location is restricted	S02407

Department of Planning, Lands and Heritage

Aboriginal Heritage Inquiry System

Map of Registered Aboriginal Sites

For further important information on using this information please see the Department of Planning, Lands and Heritage's Disclaimer statement at https://www.dplh.wa.gov.au/about-this-website



Legend

- Registered Aboriginal Site
- Search Area
- Town
- Road
- River
- Local Government Authority

1.17 kilometres

Map Scale 1 : 35,400

MGA Zone 50 (GDA94)

Aboriginal Heritage Inquiry System

List of Other Heritage Places

Search Criteria

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Coordinate Accuracy

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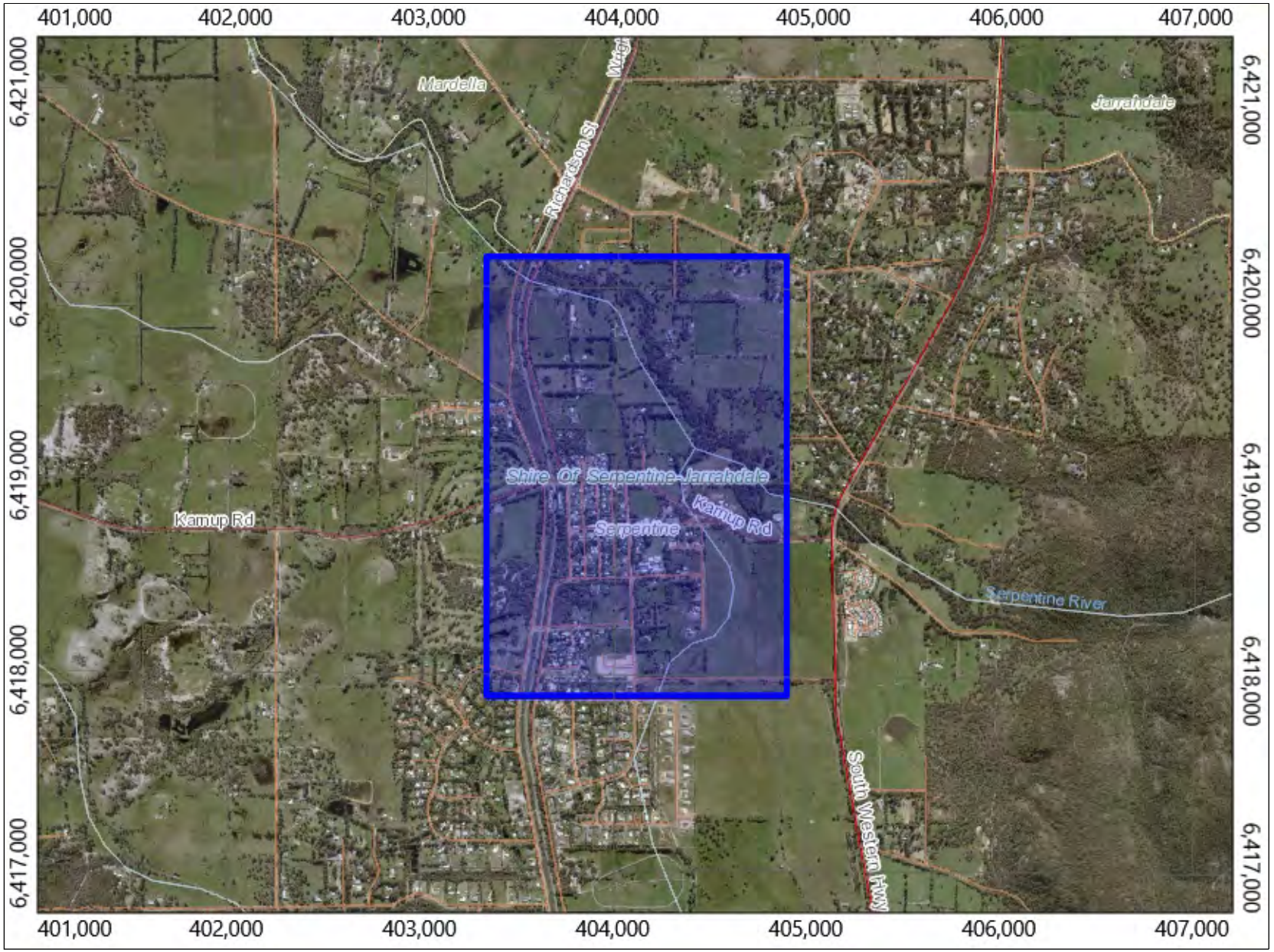
Department of Planning, Lands and Heritage

Aboriginal Heritage Inquiry System

Map of Other Heritage Places



Legend

- Other Heritage Place
- Search Area
- Town
- Road
- River
- Local Government Authority

1.17 kilometres

Map Scale 1 : 35,400

MGA Zone 50 (GDA94)

360 environmental

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