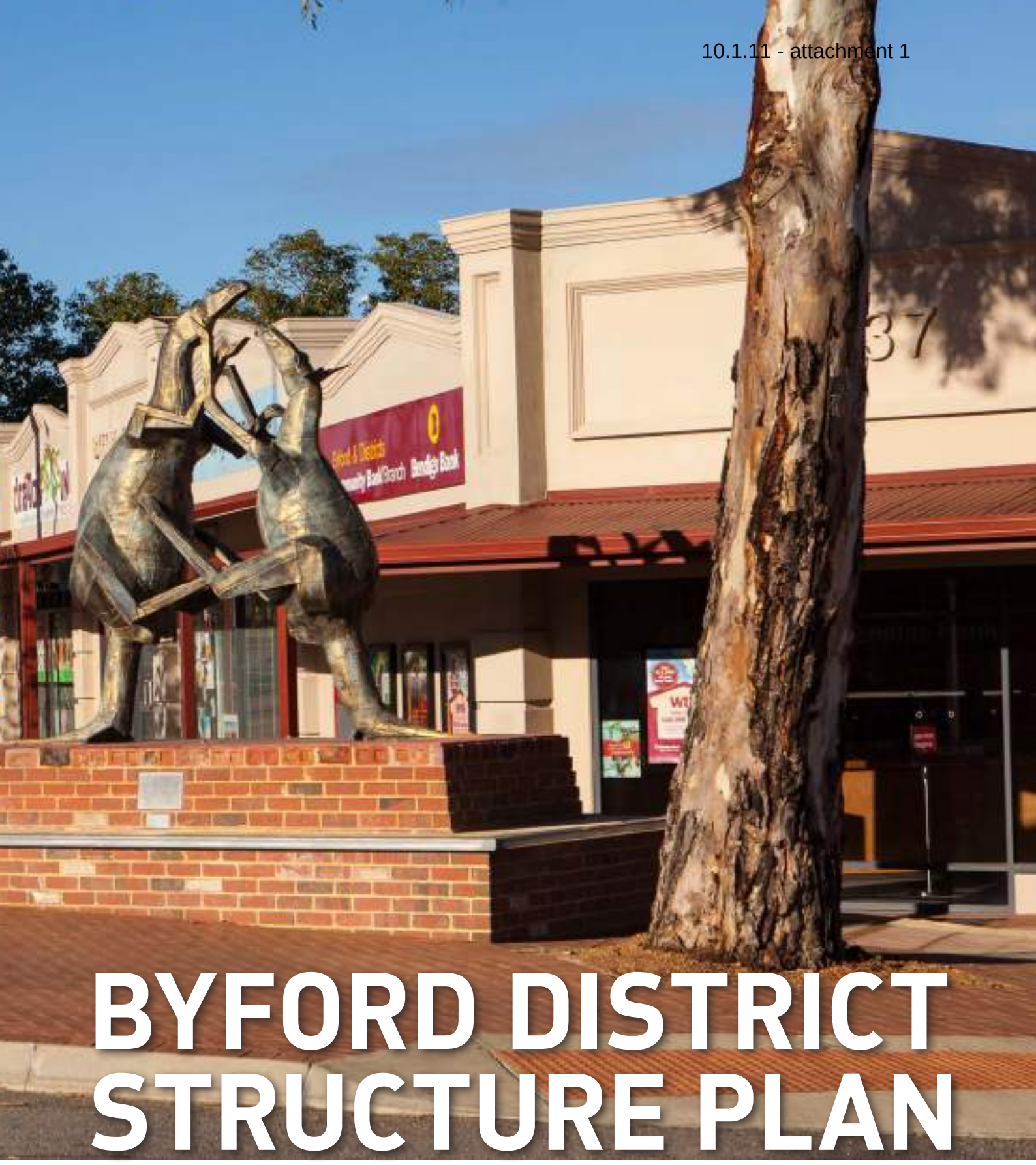

# BYFORD DISTRICT STRUCTURE PLAN

Hames Sharley
www.hamessharley.com.au

Shire of Serpentine Jarrahdale

DECEMBER 2018

Prepared for:

Shire of Serpentine Jarrahdale

DECEMBER 2018

Prepared by Hames Sharley:

Hames Sharley

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In collaboration with Cardno and SPP Consulting

| Revision Letter | Date | Reason for Issue | Issued By |
|---|---|---|---|
| A | 19-04-2018 | Draft Report | SOS |
| B | 26-04-2018 | Shire revisions | SOS |
| C | 16-05-2018 | Draft for Informal Public Advertising | SOS |
| D | 31-07-2018 | Draft Review | SOS |
| E | 16-10-2018 | Final Draft Review | NS |
| F | 31-10-2018 | Final Draft Review | SOS |
| G | 20-11-2018 | Final Draft for Public Advertising | SOS |
| **H** | **04-12-2018** | **Final Draft for Public Advertising** | **SOS** |

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Project Ref. 43874

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| | |
|---|---|
| **ACP** | Activity Centre Plan |
| **BAL** | Bushfire Attack Level |
| **BMP** | Bushfire Management Plan |
| **BRT** | Bus Rapid Transit |
| **CIDCP** | Community Infrastructure Development Contributions Plan |
| **CPTED** | Crime Prevention Through Environmental Design |
| **DCP** | Development Contribution Plan |
| **DIA** | Development Investigation Area |
| **DPLH** | Department of Planning, Land and Heritage |
| **DWMS** | District Water Management Strategy |
| **DWER** | Department of Water and Environmental Regulation |
| **HFTC** | High Frequency Transit Corridor |
| **LPS** | Local Planning Strategy |
| **LPS3** | Shire of Serpentine Jarrahdale Local Planning Scheme 3 |
| **LSP** | Local Structure Plan |
| **MRS** | Metropolitan Region Scheme |
| **MRWA** | Main Roads Western Australia |
| **POS** | Public Open Space |
| **PTA** | Public Transport Authority |
| **SPP** | State Planning Policy |
| **SPS** | State Planning Strategy |
| **TOD** | Transit Oriented Development |
| **TPS2** | Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 |
| **WAPC** | Western Australian Planning Commission |
| **WSUD** | Water Sensitive Urban Design |

# ENDORSEMENT PAGE

This District Structure Plan is prepared under the provisions of the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2.

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

DATE

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

_____

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

_____Witness

_____Date

_____Date of Expiry

## TABLE OF AMENDMENTS

| AMENDMENT NO. | SUMMARY OF THE AMENDMENT | AMENDMENT TYPE | DATE APPROVED BY WAPC |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

## TABLE OF DENSITY PLANS

| DENSITY PLAN NO. | AREA OF DENSITY PLAN APPLICATION | DATE ENDORSED BY WAPC |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

# EXECUTIVE SUMMARY

The original Byford District Structure Plan was prepared in 2005 and updated in 2009 to provide high-level strategic guidance on future planning and development in the Byford locality. Since the preparation of this document, the Shire has undergone a significant amount of change due to exponential population growth, most of which has occurred in Byford. A number of new Local Structure Plans have been submitted and the State strategic and policy frameworks have changed.

The reason for the revision to the Byford District Structure Plan is therefore to consider the significant population growth. This revision also better reflects a number of State and local policy changes and to incorporate a significant number of strategic documents that have been produced by the Shire of Serpentine Jarrahdale since the Byford Structure Plan was first adopted in 2005. The following list of documents provide reference to strategic decisions that will have an impact on the future development of Byford. Although this list is not exhaustive, it provides a good indication of the high-level decision making that has guided the Byford District Structure Plan.

**State Planning Framework**

- Planning and Development (Local Planning Schemes) Regulations 2015
- Perth and Peel @ 3.5 million - The South Metropolitan Peel Sub-regional Planning Framework
- Perth Transport Plan @ 3.5 million
- State strategic infrastructure decisions
- METRONET and related studies
- Westport and related studies
- Various State Planning Policies and Guidelines

**Local Planning Framework**

- Draft Local Planning Strategy
- Draft Local Planning Scheme No.3
- Rural Strategy Review 2013
- Community Infrastructure and Public Open Space Strategy
- Community Infrastructure Implementation Plan
- Local Structure Plans for Byford
- Infrastructure provisioning and changes in staging
- Council decisions regarding planning matters in the Town Planning Scheme No. 2 (TPS2) area
- Various Local Planning Policies

The Byford District Structure Plan has been informed by the following strategic plans and documents. A full list of the documents is included in the reference section of this document.

- Byford District Water Management Strategy (2018)
- Traffic Assessment (2018)
- Previous District Structure Plan for Byford (2009) and supporting technical plans
- Previous Local Structure Plans for the Byford District Structure Plan area (including the Byford Town Centre Local Structure Plan and Local Planning Policies), with supporting studies
- Previous strategies including the Activity Centres Strategy, Byford Town Centre Access and Parking Strategy, with the supporting technical studies
- Development Contribution Plans for Byford, and Local Planning Policy 3.7 – George Street Design Guidelines
- Unofficial documents such as the Byford Progress Association Byford Public Art Master Plan and the Byford Townscape Project

The Byford District Structure Plan consolidates the above mentioned technical studies to provide an updated framework to guide planning and development within the district of Byford.

## STRUCTURE PLAN CONTENT

This structure plan comprises:

- **Part One – Implementation**

  Includes the Byford District Structure Plan map and planning provisions.

- **Part Two – Explanatory Section**

  Provides an overview of how the Byford District Structure Plan responds to the existing planning framework and local context. It identifies the layers that informed the preparation of the Byford District Structure Plan.

## SUMMARY TABLE

| Item | Data | Structure Plan Reference |
|---|---|---|
| Total area covered by the structure plan | 5,530 hectares | Section 2.2.2 'Area and Land Use' |
| Area of each land use proposed:<br>+ Residential<br>+ Commercial<br>+ Industrial<br>+ Rural Residential | <br>710 hectares<br>40 hectares<br>211 hectares<br>1662 hectares | Section 3.2.2 'Land Use' |
| Estimated number of dwellings | 20,780 dwellings | Section 3.2.1 'Population and Density' |
| Estimated residential site density | 25 dwellings per hectare | Section 3.2.1 'Population and Density' |
| Estimated population | 60,054 people (at 2.89 people per household) | Section 3.2.1 'Population and Density' |
| Number of high schools | 3 | Section 3.5.1 'Education Facilities' |
| Number of primary schools | 9 | Section 3.5.1 'Education Facilities' |
| Estimated commercial floor space | 32,900m$^2$ net lettable area | Section 3.3.1 'Economy' |
| Estimated area and percentage of public open space given over to:<br>+ District Open Space<br>+ Local Parks and Multiple Use Corridors | <br>30 hectares (0.5% coverage)<br>262 hectares (4.7% coverage) | Section 3.5.2 'Public Open Space'<br>Section 3.6 'Environment and Landscape' |
| + Estimated percentage of natural area | 377 hectares (6.8% coverage) | Section 3.6 'Environment and Landscape' |

# PART ONE
# IMPLEMENTATION


coles
Bryford
Village

# 1.0 IMPLEMENTATION

# 1.1 Structure Plan Area

The Byford District Structure Plan Byford District Structure Plan shall apply to the land contained within the inner edge of the line denoting the structure plan boundary as shown on **Figure 1**.

# 1.2 Operation

The Byford District Structure Plan shall come into operation on the day it is approved by the Western Australian Planning Commission (WAPC) and will replace the 2009 Byford District Structure Plan. The Byford District Structure Plan is a strategic planning document intended to guide and coordinate more detailed planning in the form of Local Structure Plans (LSPs) and/or Local Development Plans for individual sites within the Byford District Structure Plan area.

# 1.3 Staging

Staging of the Byford District Structure Plan will be dependent on population-based triggers, which will determine the need for essential infrastructure such as:

- Provision of services infrastructure;
- Provision of community infrastructure (e.g. schools); and
- Construction/upgrading of roads.

As staging is dependent on population based triggers, timing for the Byford District Structure Plan has not been identified.

# 1.4 Subdivision and Development Requirements

The land use arrangements, district level infrastructure and movement network illustrated in the Byford District Structure Plan will inform the Shire's response to requests for rezoning and more detailed LSPs where these do not exist within the Byford District Structure Plan area.

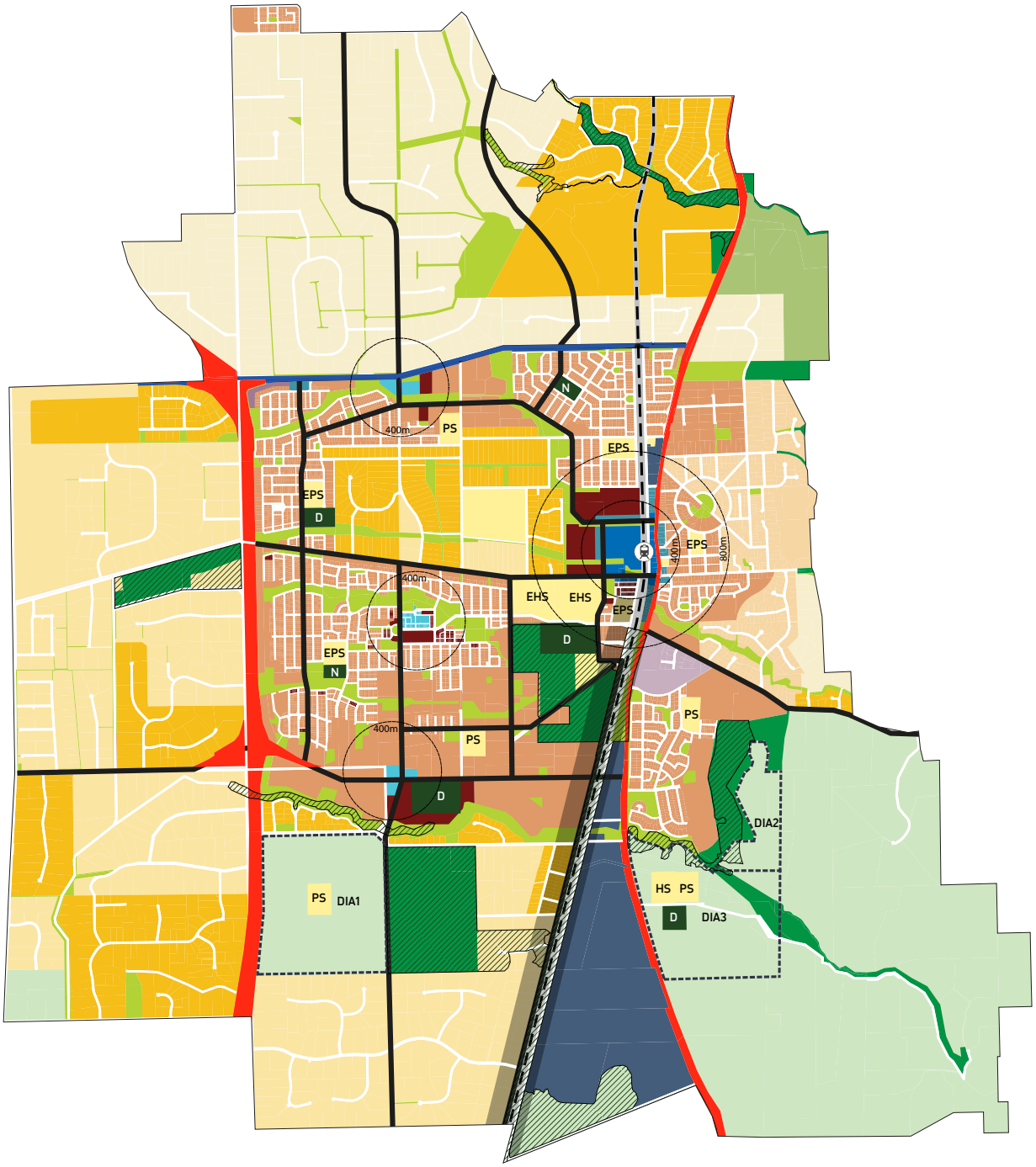
The layout illustrated within Figure 1 represents a high-level structural response to key issues which may be subject to refinement at more detailed stages of planning, at the discretion of the local government. Subdivision and development will be determined in accordance with the applicable zoning, planning scheme provisions, the Byford District Structure Plan and, where applicable, an approved LSP.

The Byford District Structure Plan identifies areas where LSPs shall be required. In these instances, LSPs shall be prepared for that area and approved in accordance with the Deemed Provisions. Subdivision and development shall generally not be supported prior to the preparation and approval of a LSP. The local government may grant planning approval for a development or land use, or make recommendation to the WAPC regarding a subdivision in the absence of a LSP where the local government considers the proposed development, land use or subdivision to be of a minor nature, which would not prejudice the preparation of a LSP. Where land has not been identified within a structure plan area under the Byford District Structure Plan, subdivision and development must be in accordance with Part One and Part Two of the Byford District Structure Plan, including any specific requirements outlined under section 1.7 of Part One of the Byford District Structure Plan.

For the purposes of development within the 'Urban Settlement' category under the Byford District Structure Plan, where no approved local structure plan applies, residential development shall be in accordance with the following density codes under the Residential Design Codes:

- R20 for lots less than 1,000 $m^2$ in area;
- R10 for lots between 1,000 $m^2$ – 2,000 $m^2$ in area;
- R5 for lots greater than 2,000 $m^2$ in area.

*Figure 1: Byford District Structure Plan*




Byford District Structure Plan

Status : Preliminary (not to be used for feasibility purposes)
Path : P:\43874 Development Strategies for Serpentine-Jarrahdale

Scale: 1:15,000 @ A1
0 100 200 300 400
© Hames Sharley

North:

Project Number: 43874
Drawing Number: A101
Revision: A
Date: 29/11/18

## LEGEND

- BYFORD DSP BOUNDARY
- DISTRICT CENTRE
- NEIGHBOURHOOD CENTRE
- MIXED USE
- COMMUNITY AND PUBLIC PURPOSE
- LIGHT INDUSTRIAL
- SERVICE COMMERCIAL
- BUSH FOREVER
- DISTRICT/ NEIGHBOURHOOD OPEN SPACE
- RESERVE
- MULTIPLE USE CORRIDOR/LOCAL OPEN SPACE
- MEDIUM - HIGH: R40-100
- LOW (SUBURBAN): R20-35
- LOW (TRANSITIONAL): R2-10
- SPECIAL RESIDENTIAL
- RR-1
- RR-2
- RURAL SMALL HOLDINGS
- RURAL
- PRIMARY DISTRIBUTOR
- SECONDARY DISTRIBUTOR
- DISTRICT DISTRIBUTOR
- RAILWAY RESERVE
- HIGH FREQUENCY TRANSIT CORRIDOR
- PASSENGER RAIL LINE
- RAIL STATION
- DIA BOUNDARY
- DIA DEVELOPMENT INVESTIGATION AREA
- EHS EXISTING HIGH SCHOOL
- EPS EXISTING PRIMARY SCHOOL
- HS HIGH SCHOOL
- PS PRIMARY SCHOOL
- D DISTRICT OPEN SPACE
- N NEIGHBOURHOOD OPEN SPACE

The above density codes only apply for the purposes of residential development, which is not considered by the local government to prejudice the preparation of a local structure plan. The density codes do not apply for the purposes of subdivision.

# 1.5 General Provisions

The following provisions shall apply to all LSPs across the whole Byford District Structure Plan area:

- LSPs prepared within the Byford District Structure Plan area should generally conform with the layout illustrated within the Byford District Structure Plan and be accompanied by:
  - A Local Water Management Strategy consistent with any approved District Water Management Strategy;
  - An Environmental Assessment Report that addresses: Threatened species and communities; Conservation Category and Resource Enhancement wetlands; Interface with Bush Forever Sites; Buffers; and Detailed flora and fauna surveys where necessary;
  - A Bushfire Hazard Assessment and/or Bushfire Management Plan;
  - A Transport Impact Assessment;
  - Servicing Report;
  - Landscape design guidelines that address measures to be adopted to implement both public and private landscaping that reflects the historic landscape character of Byford; and
  - Other submission requirements consistent with the Planning and Development (Local Planning Schemes) 2015 Schedule 2 – Deemed provisions.
- LSPs should establish objectives for built form and any design guidelines that are required to be established, typically as Local Planning Policies or Centre Plans that are required prior to applications for developments and/or subdivision.

The following provisions shall apply to all LSP, local development plans, subdivisions and developments across the whole Byford District Structure Plan area where relevant:

- Maximise connectivity for vehicular, pedestrian and cycling transport networks both internally and to the surrounding street network.
- Provide public spaces, community facilities and meeting points to create an active, vibrant and engaging place to live and work.
- Acknowledge and allow for appropriate interface with Bush Forever sites and other sites of environmental significance.
- Protect and enhance significant areas and their buffers, including those with ecological linkage values along railroads, roads and scenic highways.
- Maximise the efficient use and reuse of water by conserving water through efficiency and facilitating water reuse and fit-for-purpose use.
- Reduce consumption of non-renewable resources via climate responsive design, efficient use of energy and water and increased use of renewable energy.
- Identify and protect multiple use corridors and ensure water sensitive urban design elements are incorporated in stormwater management.
- Such other information as may reasonably be required by the local government or the WAPC.

# 1.6 Local Structure Plans

A number of existing LSPs have been prepared within the Byford District Structure Plan area to provide more detailed planning and development guidance (refer to **Figure 2** Byford Local Structure Plan Areas). These LSPs should be considered in conjunction with the Byford District Structure Plan.

The LSPs that currently operate within the Byford District Structure Plan area from the time which the Byford District Structure Plan was drafted are listed in **Table 1**:

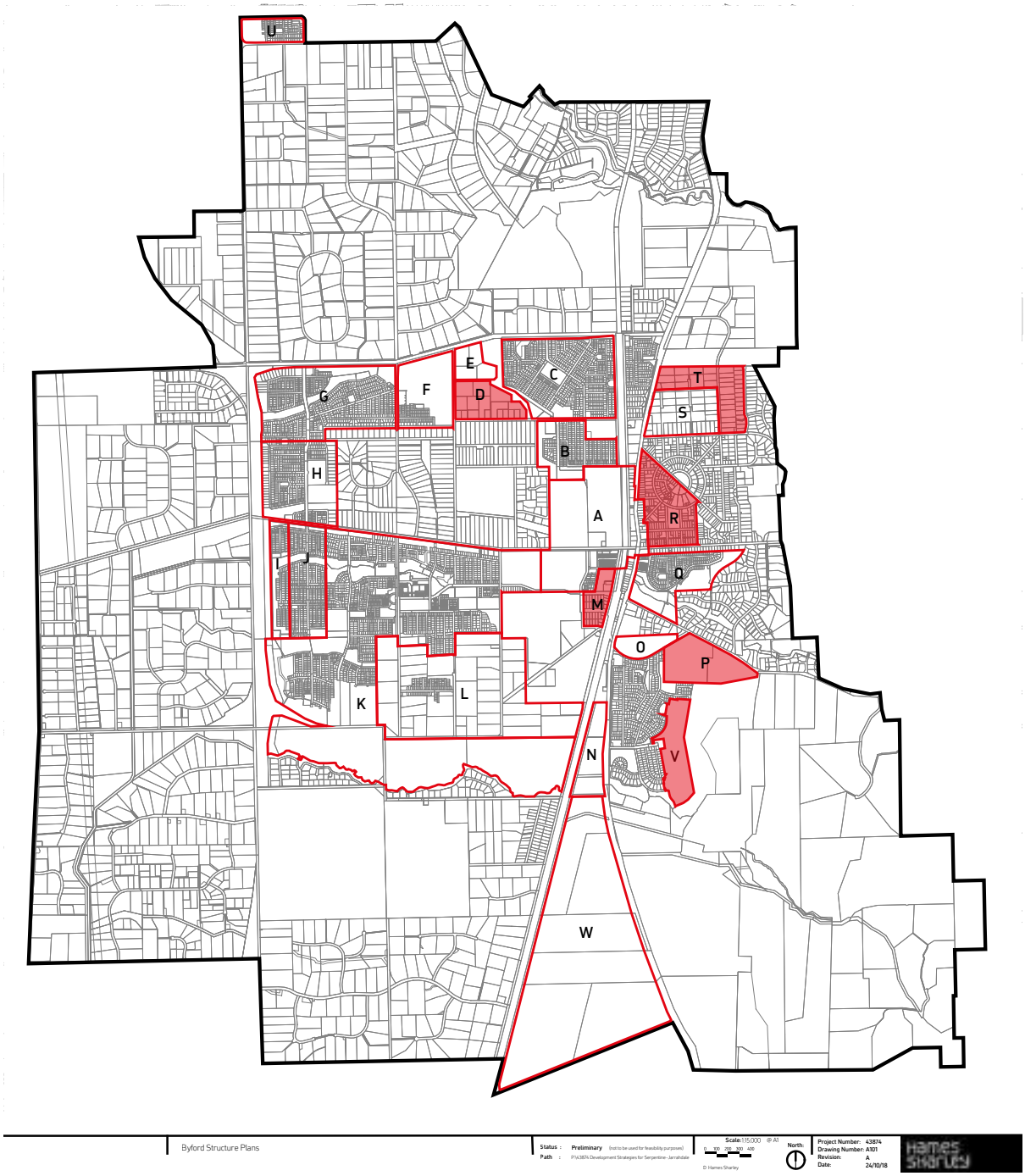
*Table 1: Byford Local Structure Plan Areas*

| LPS AREA | OPERATIONAL | STATUS |
|---|---|---|
| Area A | Byford Town Centre | Approved |
| Area B | Marri Park Estate - Lot 3 Larsen Rd and Lot 3 Alexander Road, Byford | Approved |
| Area C | Byford Central | Approved |
| Area D | Briggs Road / Larsen Road Precinct | No LSP exists |
| Area E | Lots 59-62 Briggs Road Byford | Approved |
| Area F | Byford Meadows Estate, Lot 9500 Thomas Road, Briggs Road | Approved |
| Area G | Redgum Brook Estate | Approved |
| Area H | Kalimna Estate | Approved |
| Area I | Grange Meadows, Lot 6 and Lot 27 Abernethy Road, Byford | Approved |
| Area J | Byford West | Approved |
| Area K | The Glades | Approved |
| Area L | Doley Road Precinct | Approved |
| Area M | Mead Street Precinct | No LSP exists |
| Area N | Lots 1, 3 and 128 South Western Highway, Byford | Approved |
| Area O | Lot 806 South Western Highway, Byford | Approved |
| Area P | Nettleton Road South | No LSP exists |
| Area Q | Lot 2 Nettleton Road, Byford (The Brook) | Approved |
| Area R | Byford Old Quarter West | No LSP exists |
| Area S | Stanley Road Precinct | Approved |
| Area T | Stanley Road North East | No LSP exists |
| Area U | Lots 1 and 2 Rowley Road, Darling Downs | Approved |
| Area V | Byford by the Scarp East | No LSP exists |
| Area W | Cardup Business Park (subject to modifications) | Draft |

Development of detailed LSP's must be in accordance with the relevant LSP Areas identified in Figure 2. For areas where a LSP does not exist or is yet to be approved or where a LSP is considered to potentially require significant modification, the Byford District Structure Plan outlines specific matters required to be addressed in the preparation and/or modification of a LSP for that particular LSP Area.

The following sub-sections outline the matters to be addressed for LSP Areas where a LSP does not exist, is yet to be approved or may require significant modification.

*Figure 2: Byford Local Structure Plan Areas*



## 1.6.1 LSP AREA A – BYFORD TOWN CENTRE

+ LSP Area A is bounded by South Western Highway in the east, Evans Way to the north, Warburton Court to the west and Mead Street to the south.
+ The Byford Town Centre LSP has been approved by the Shire of Serpentine Jarrahdale.

**Key Matters to be addressed:**

+ Subject to outcomes of METRONET investigations for extension of the Armadale rail line to Byford, address the integration of a transit-oriented development to service a new railway station within the town centre.
+ Provide for a diversity of land uses, lot sizes and housing types at a greater density to support activation of the Byford centre.
+ Design buildings and dwellings with a high level of adaptability to suit different lifecycle stages/changing demographic needs.
+ Maximise connectivity for vehicular, pedestrian and cycling transport networks both internally and to the surrounding street network.
+ Demonstrate the retail and commercial demand for the Byford Town Centre as a district level activity centre.
+ Sensitively address the interface between the Byford Town Centre and the Byford Trotting Complex Precinct.
+ Protect a connected network of multiple use corridors.

## 1.6.2 LSP AREA D – BRIGGS ROAD / LARSEN ROAD PRECINCT

+ LSP Area D fronts onto Larsen Road to the south and is surrounded by residential development predominantly to the north-east.
+ A LSP shall be prepared for the entire precinct.

**Key Matters to be addressed:**

+ Create a distinctive and responsive built form that enhances the sense of place, community identity and character of Byford.
+ Allow for a new east-west district roads through the precinct.
+ Preserve the existing rural, "leafy green" character of the structure plan area including its scenic values, viewscapes and landscapes.
+ Enhance the green network through the creation of multiple green linkages integrating pedestrian and cycle connections.
+ Protect and enhance wetlands, waterways and catchments through appropriate management of water quality and maintenance of hydrology as part of land use change and development.
+ Preserve fringing vegetation along roads, waterways and rail corridors.
+ Sensitively address the interface between LSP Area D and the Byford Trotting Complex Precinct.
+ Orientation of lots to ensure passive surveillance over the multiple use corridor to the east.

## 1.6.3 LSP AREA M – MEAD STREET PRECINCT

+ LSP Area M is bounded by Soldiers Road in the east, Granfell Way to the north, Gordin Way to the west and south.
+ A LSP shall be prepared for the entire precinct.

**Key Matters to be addressed:**

+ Create a distinctive and responsive built form that enhances the sense of place, community identity and character of Byford.
+ Provide for a diversity of land uses, lot sizes and housing types.

- Design buildings and dwellings with a high level of adaptability to suit different lifecycle stages/changing demographic needs.
- Preserve the existing rural, "leafy green" character of the structure plan area including its scenic values, viewscapes and landscapes.
- Enhance the green network through the creation of multiple green linkages integrating pedestrian and cycle connections.
- Preserve fringing vegetation along roads, waterways and rail corridors.
- Preserve existing tree canopy coverage within the precinct.
- Produce a bushfire risk management plan for the precinct.
- Protect Brickwood Reserve and ensure the interface between Brickwood Reserve and LSP Area M is sensitively managed.
- Sensitive interface with the adjoining Conservation Category Wetland and Bush Forever Sites.
- Integration between LSP Area M and the Briggs Park Precinct.
- Preservation of the environmental values and biodiversity.

## 1.6.4 LSP AREA P - NETTLETON ROAD SOUTH

- LSP Area N fronts onto Nettleton Road in the north and is surrounded by residential development predominantly to the west and south.
- A LSP shall be prepared for the entire precinct.

**Key Matters to be addressed:**

- Create a distinctive and responsive built form that enhances the sense of place, community identity and character of Byford.
- Provide for a diversity of land uses, lot sizes and housing types.
- Design buildings and dwellings with a high level of adaptability to suit different lifecycle stages/changing demographic needs.
- Preserve the existing rural, "leafy green" character of the structure plan area including its scenic values, viewscapes and landscapes.
- Enhance the green network through the creation of multiple green linkages integrating pedestrian and cycle connections.
- Preserve fringing vegetation along roads, waterways and rail corridors.
- Produce a bushfire risk management plan for the precinct.
- Preserve existing tree canopy coverage within the precinct.
- Integration of the primary school that is partially located within LSP Area P to the south-west.
- Integration with the existing wildlife park at the site, if this is proposed to be retained.
- Appropriate road reserves to ensure on-street parking, street trees, water sensitive design and adequate separation to vegetated areas where necessary.

## 1.6.5 LSP AREA R - BYFORD OLD QUARTER WEST

- LSP Area R is bounded by South Western Highway in the west, Park Road to the north east and Beenyup Road to the south.
- A LSP shall be prepared for the entire precinct.

**Key Matters to be addressed:**

- Subject to outcomes of METRONET investigations for extension of the Armadale rail line to Byford, address the integration of a transit-oriented development to service a new railway station within the town centre.
- Integration of medium/higher density residential development with the Town Centre development along South Western Highway.
- Create a distinctive and responsive built form that enhances the sense of place, community identity and character of Byford.
- Design buildings and dwellings with a high level of adaptability to suit different lifecycle stages/changing demographic needs.
- Preserve the existing rural, "leafy green" character of the structure plan area including its scenic values, viewscapes and landscapes.
- Reduce reliance on vehicles by creating a pedestrian-oriented community and providing for alternative modes of transport.
- Enhance the green network through the creation of multiple green linkages integrating pedestrian and cycle connections.
- Preserve existing tree canopy coverage within the precinct.
- Incorporation of water sensitive urban design principles and measures.
- Legible movement network and lot configurations.
- Identification of local public open space.
- Incorporation of the primary school.
- Retention of wide road reserves to ensure on-street parking, street trees, water sensitive design and adequate separation to vegetated areas where necessary.

## 1.6.6 LSP AREA T - STANLEY ROAD NORTH EAST

- LSP Area T is bounded by Dalley Street in the east, Walters Road to the south, Linton Street to the west and Stanley Road linking through to South Western Highway in the north west.
- A LSP shall be prepared for the entire precinct.

**Key Matters to be addressed:**

- Create a distinctive and responsive built form that enhances the sense of place, community identity and character of Byford.
- Design buildings and dwellings with a high level of adaptability to suit different lifecycle stages/changing demographic needs.
- Preserve the existing rural, "leafy green" character of the structure plan area including its scenic values, viewscapes and landscapes.
- Reduce reliance on vehicles by creating a pedestrian-oriented community and providing for alternative modes of transport.
- Enhance the green network through the creation of multiple green linkages integrating pedestrian and cycle connections.
- Incorporation of water sensitive urban design principles and measures.
- Preserve existing tree canopy coverage within the precinct.
- Produce a bushfire risk management plan for the precinct.

## 1.6.7 LSP AREA V - BYFORD BY THE SCARP EAST

+ LSP Area V is connected by Clondyke Drive from the west and is surrounded by bush reserve to the south and east.
+ A LSP may be required to be prepared for the entire precinct. Where a LSP is not required, subdivision stages shall address the following matters to be addressed.

**Key Matters to be addressed:**

+ Create a distinctive and responsive built form that enhances the sense of place, community identity and character of Byford.
+ Provide for a diversity of land uses, lot sizes and housing types.
+ Design buildings and dwellings with a high level of adaptability to suit different lifecycle stages/changing demographic needs.
+ Preserve the existing rural, "leafy green" character of the structure plan area including its scenic values, viewscapes and landscapes.
+ Enhance the green network through the creation of multiple green linkages integrating pedestrian and cycle connections.
+ Protect and enhance wetlands, waterways and catchments through appropriate management of water quality and maintenance of hydrology as part of land use change and development.
+ Preserve fringing vegetation along roads, waterways and rail corridors.
+ Produce a bushfire risk management plan for the precinct.
+ Preserve existing tree canopy coverage within the precinct.
+ Ensure the interface and separation distance with Bush Forever Site #271 to the east is sensitively managed.
+ Appropriate road reserves to ensure on-street parking, street trees, water sensitive design and adequate separation to vegetated areas where necessary.
+ Appropriate separation distances to extractive industries.
+ Water management.

## 1.6.8 LSP AREA W - CARDUP BUSINESS PARK

+ LSP Area W is bounded by Cardup Siding Road in the north, South Western Highway to the east, Soldiers Road to the west and Norman Road to the south.
+ The Cardup Business Park LSP has been approved by the Shire of Serpentine-Jarrahdale, subject to modifications.

**Key Matters to be addressed:**

+ Create a strong local employment base which provides for locally available infrastructure and services.
+ Enhance the employment of the area with service commercial development.
+ Create a north/south road connection linking Norman Road to Cardup Siding Road.
+ Protect and enhance wetlands, waterways and catchments through appropriate management of water quality and maintenance of hydrology as part of land use change and development.
+ Undertake detailed floristic surveys around TECs and for protected flora and fauna where any clearing of remnant vegetation is proposed.
+ Retain and protect Bush Forever sites and rehabilitate nearby areas to establish fauna linkages.
+ Preserve fringing vegetation along roads, waterways and rail corridors.
+ Produce a bushfire risk management plan for the precinct.

# 1.7 Other Requirements

All urban development within the Byford District Structure Plan area is / will be subject to:

- The Byford Development Contribution Plan (current revision)
- The Community Infrastructure Development Contribution Plan (current revision)

Some precincts and sites require specific additional provisions to guide subdivision, development and local development plans. Such precincts or sites may include but are not limited to undeveloped sites that are too small to be a local structure plan area, strategic nodes at prominent intersections, sites where particular constraints apply and precincts where it is desirable for a specific character to be retained.

## 1.7.1 LSP AREA K – THE GLADES

LSP Area K – The Glades covers a large portion of land within the Byford area, with much of the land within this area already having been developed. As a large area within Byford, The Glades contains district distributor roads which connect to other precincts. This requires additional provisions to coordinate the strategic planning and development staging of such infrastructure. The Glades has also been developed with a specific character throughout the precinct which has resulted in a distinct built form and streetscape outcome. Other requirements relating to potential development standards to maintain consistency with the established built form and streetscape have been included within this section of the Byford District Structure Plan to provide some certainty in regards to the development character of The Glades. The local government may consider the following built form provisions within local development plans for all development within LSP Area K – The Glades:

- Reduced setback requirements, subject to landscaping provisions and/or public open space interface
- Reduced open space requirements, subject to landscaping provisions, public open space interface, provision of functional outdoor space and/or specific location of outdoor living areas

All local development plans are subject to the approval of the local government.

## 1.7.2 LOT 2 (NO. 640) SOUTH WESTERN HIGHWAY, BYFORD

Other development requirements apply to Lot 2 (No.640) South Western Highway, Byford as the site is too small to be designated as a local structure plan area and it is surrounded by existing residential development. Additionally, the strategic location of this site at the intersection of South Western Highway and Thomas Road and the potential of this site to provide an entry statement to Byford requires other provisions to be included within the Byford District Structure Plan."

The following land uses shall be discretionary for Lot 2 (No. 640) South Western Highway, Byford under TPS2:

- Aged and dependent persons' dwelling
- Civic buildings
- Child minding centre
- Club premises
- Consulting rooms
- Dry cleaning premises
- Health studio
- Holiday accommodation
- Home business
- Home occupation
- Industry – cottage
- Market
- Medical Centre
- Office
- Private recreation
- Public utility
- Place of worship
- Residential
- Shop
- Veterinary Establishment

All development applications for Lot 2 (No. 640) South Western Highway, Byford shall be accompanied by the following:

- Transport Impact Assessment
- Urban Water Management Plan
- Servicing Report
- Other submission requirements consistent with the Planning and Development (Local Planning Schemes) 2015 as required by the local government and/or the WAPC.

## 1.7.3 DEVELOPMENT INVESTIGATION AREAS

The Byford District Structure Plan identifies three development investigation areas (DIA). Future planning and development in these areas shall address the key considerations listed in **Table 2**.

*Table 2: Development Investigation Areas*

| Site | Key Considerations |
|---|---|
| **DIA1** | + Geotechnical analysis/land capability.<br>+ Connections to reticulated water and wastewater services.<br>+ Interface with Bush Forever Site No. 352 and the Conservation Category Wetland.<br>+ Existence of Resource Enhancement Wetlands at the site.<br>+ Existence of Threatened Ecological Communities at the site.<br>+ Local Heritage Place No. 24405 and 9625 – Fremnells Dairy.<br>+ Aboriginal Heritage Sites.<br>+ Tonkin Highway Extension.<br>+ Access and Movement.<br>+ Interface with surrounding Rural Living development.<br>+ Provision of a new primary school. |
| **DIA2** | + Geotechnical analysis/land capability.<br>+ Connections to reticulated water and wastewater services.<br>+ Rehabilitation of extractive industries.<br>+ Interface with Bush Forever Site No. 271.<br>+ Aboriginal Heritage Sites.<br>+ Native Vegetation.<br>+ Bushfire Risk.<br>+ Access and Movement. |
| **DIA3** | + Geotechnical analysis/land capability.<br>+ Proximity to Brickworks, buffer considerations.<br>+ Connections to reticulated water and wastewater services.<br>+ Waterways Management.<br>+ Interface with Bush Forever Site No. 271 and the Conservation Category Wetland.<br>+ Aboriginal Heritage Sites.<br>+ Bushfire Risk.<br>+ Access to/from South Western Highway and movement.<br>+ Interface with the existing Brickworks facility.<br>+ Consideration of the character and heritage of the Brickworks facility .<br>+ Interface with Cardup Business Park.<br>+ Investigation of the provision of key community facilities/services requiring a large area of land.<br>+ Provision of a new high school, primary school and district open space. |

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# PART TWO
# EXPLANATORY SECTION


coles
Bryford
Village


# 1.0 PLANNING BACKGROUND

# 1.1 Introduction and Purpose

## 1.1.1 INTRODUCTION

The original Byford District Structure Plan was prepared in 2005 and updated in 2009 to provide high-level strategic guidance on future planning and development in the Byford locality. Since the preparation of this document, the Shire has undergone a significant amount of change due to exponential population growth, most of which has occurred in Byford. According to the Australian Bureau of Statistics Byford had a population of 3,335 people in 2001. In 2016, the ABS estimated population for the Byford District Structure Plan area was 18,123 people representing an increase of over 440%. This growth has put pressure on existing services, facilities and infrastructure, providing the impetus for a review of the Byford District Structure Plan.

In addition, in 2018 the Department of Planning, Lands and Heritage released the Perth and Peel@3.5 million strategic planning framework and more specifically the South Metropolitan and Peel Sub-regional Framework. This strategy identified that the Shire can expected to accommodate an additional 90,000 people (113,000 in total). SJ2050, the Shire's high-level strategic vision explored how best to distribute this significant increase in population and came to the conclusion that approximately 60,000 people would call the Byford District Structure Plan area home when most of the development concludes. This would be approximately three times the current population. This is the challenge that structure planning for the future presents in the area.

## 1.1.2 STRUCTURE PLAN PURPOSE

The Byford District Structure Plan has been prepared in collaboration with key stakeholders including relevant government agencies, major landholders and the community. As a broad district level planning instrument, its primary aim is to guide future planning and development in the Byford area. This will include the broad disposition of land use, major roads, rail and other community infrastructure for a population of 50,000 people. It is intended that the Byford District Structure Plan will form the general basis for subsequent preparation of Local Structure Plans on a precinct-basis.

The coordination of planning for the Byford District Structure Plan area presents a valuable opportunity for the State to achieve many of its planning and land use objectives identified for Perth, and consolidation of urban development in the southern metropolitan corridor. As illustrated in **Figure 3** this has provided the framework for implementing change within the Byford District Structure Plan area. The Byford District Structure Plan does not intend to make significant modification to the approved Byford "District" structure plan but does incorporate the local structure plans that have been approved. It also addresses some of the planning policy changes and some of the challenges that the previous plan did not and could not have anticipated.

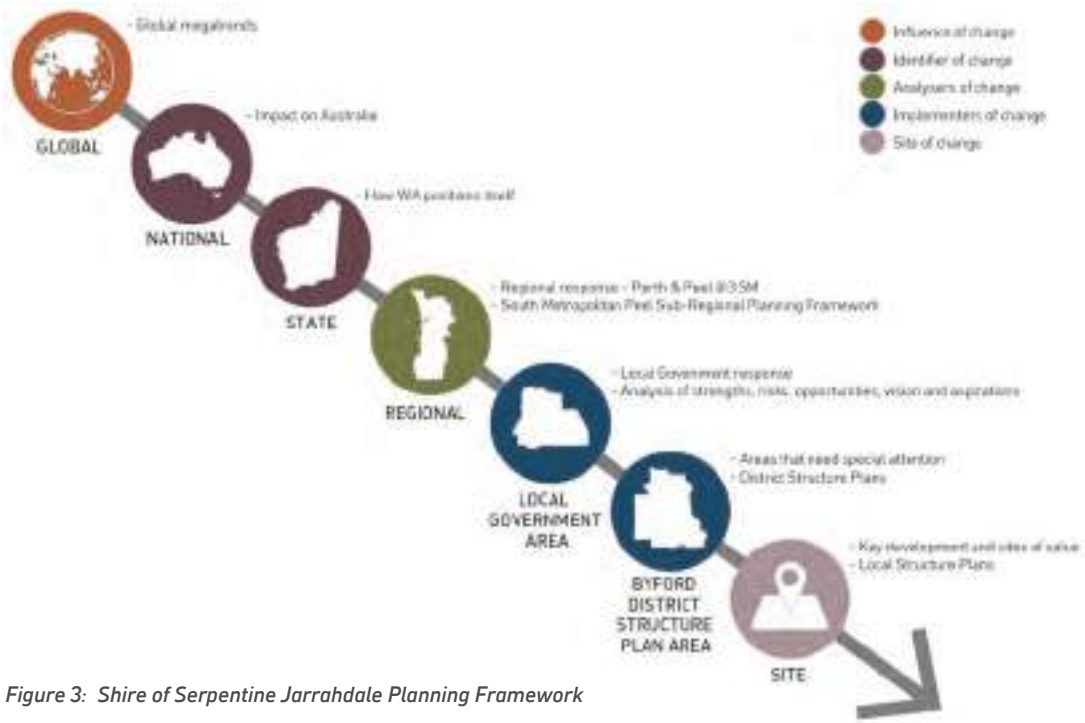



*Figure 3: Shire of Serpentine Jarrahdale Planning Framework*

## 1.1.3 VISION AND OBJECTIVES

The vision and objectives for the Byford District Structure Plan area have been framed by previous planning studies to accommodate future urban growth while maintaining the areas unique lifestyle and sense of identity. These have been considered in concert with the outcomes of a comprehensive stakeholder engagement process undertaken as part of the preamble review of the existing Byford District Structure Plan.

Development within the Byford District Structure Plan area will be guided by the following vision and objectives which identify elements of importance to the community:

**A Lifestyle Area of Choice**

- A contemporary and connected place that is growing significantly but sustainably as an area of choice
- A progressive model Centre of activity emerging respectfully from a long history as a unique rural setting at the foot of the Darling Scarp
- A thriving district hub for business, education and community life which respects its historical and natural context and the lifestyle aspirations of the surrounding community
- A built character that responds to the landscape and lifestyle of Byford

**A Vibrant and Integrated District Centre**

- A vibrant town centre containing a mix of retail, commercial, civic, recreation, residential uses consistent with its role as a District Centre
- The existing and expansion areas of the town centre are seamlessly integrated and connected, and demonstrate historical and contemporary reflections of the local rural character
- The location of major store anchors, high quality shop front environments and car parking areas contribute to an active main street environment
- An Identifiable Character and Distinct Sense of Place
- Natural, cultural and heritage features, landmarks and public art within the public realm, contribute to sense of place
- A network of public space and open space corridors contribute to the rural and bushland feel of the area

**A Safe Pedestrian and Transit Oriented Centre**

- More options for getting around providing an expanded and connected network of bike and pedestrian facilities
- New forms of transit, coordinated with Metro's transit system improvements already underway
- A new intensity of development integrated around a town square, the community library, retail centre within the walkable catchment of the new Byford train station bringing community life, vibrancy and housing choice to the centre
- The street network and urban environment provides high levels of connectivity and legibility

**A Place that Capitalises on its Environmental Assets**

- Existing natural assets such as mature and remnant vegetation and streams are central to public realm theming
- The main street environment is sheltered from strong easterly winds
- Existing views and vistas to and from the centre are maintained
- A network of open spaces and green linkages connect the centre

**A Water Integrated Place**

- Bio-retention tree pits, living streams and swales are a feature of the town centre and contribute to its sense of place

**A Smart City Hub**

- Reduce consumption of non-renewable resources via climate responsive design, efficient use of energy and water and increased use of renewable energy
- Ensure that existing road, highway and transit systems are properly maintained, improved, and implemented in a fair and equitable manner

# 1.2 Land Description

## 1.2.1 LOCATION

The Byford District Structure Plan will apply to the area delineated on **Figure 4**. It can broadly be defined as the area approximately 8km north- south between Rowley Road and Gossage Road, and 15km east-west between the Darling Ranges foothills and Kargotich Road within the Shire of Serpentine Jarrahdale. The Byford District Structure Plan area includes the suburbs of Byford and Darling Downs, and parts of Cardup, Oakford and Karrakup.

## 1.2.2 AREA AND LAND USE

The Byford District Structure Plan covers an area of approximately 5,530 hectares. Existing land within the Byford District Structure Plan area is comprised primarily of urban and rural residential land. Urban development is currently concentrated within Byford. This includes the emerging Byford Town Centre which is a District Activity Centre and the primary retail and commercial hub in the region.

Key land uses within the Byford District Structure Plan can be summarised as follows:

+ Retail and commercial is concentrated within the Byford Town Centre which is located at the corner of Abernethy Road and South Western Highway;
+ Residential land (typically in the form of low-density R20) is provided in Byford, typically within close proximity to the various local centres and Byford Town Centre;
+ Larger rural residential lots are located on the periphery of the Byford District Structure Plan in Darling Downs, Oakford and Cardup; and
+ Other residential character areas include the Byford Trotting Complex (and surrounds), and the Byford Old Quarter which is located east of South Western Highway.

## 1.2.3 LEGAL DESCRIPTION AND OWNERSHIP

The Byford District Structure Plan applies to land under the jurisdiction of the Shire of Serpentine Jarrahdale. It includes a combination of State and local reserves, conservation areas and significant private landholdings (of varying sizes).

# 1.3 Planning Framework

## 1.3.1 ZONING AND RESERVATION

### METROPOLITAN REGION SCHEME

**Figure 5** indicates that the Byford District Structure Plan area incorporates various zones and reservations under the Metropolitan Region Scheme (MRS) including: 'Parks and Recreation', 'Railways', 'State Forests', 'Public Purpose', 'Primary Regional Roads', ' Urban', 'Urban Deferred', 'Rural', 'Bush Forever Area'.

No changes to the MRS are proposed within the Byford District Structure Plan.

### SHIRE OF SERPENTINE JARRAHDALE DRAFT LOCAL PLANNING SCHEME 3

Following Council's 2016 resolution to prepare a new Local Planning Strategy, officers have prepared draft Local Planning Scheme No. 3 (draft LPS 3) in accordance with the model provisions contained within Schedule 1 of the Local Planning Scheme Regulations. Draft LPS 3 seeks to rationalise the zoning and provisions contained within the existing TPS 2 and reflect the strategic objectives of the Draft Local Planning Strategy. At its December Meeting, Council resolved to advertise Draft LPS 3 and submit copies to the EPA for consent to advertise and the WAPC.

The local scheme zoning applicable to the Byford District Structure Plan area is illustrated on **Figure 6**. As draft LPS 3 will supersede TPS 2, the zones proposed in the Byford District Structure Plan align with the zonings proposed in draft LPS 3.


*Figure 4: Byford District Structure Plan Area*

Note: Not to scale

*Figure 5: MRS Map Extract*

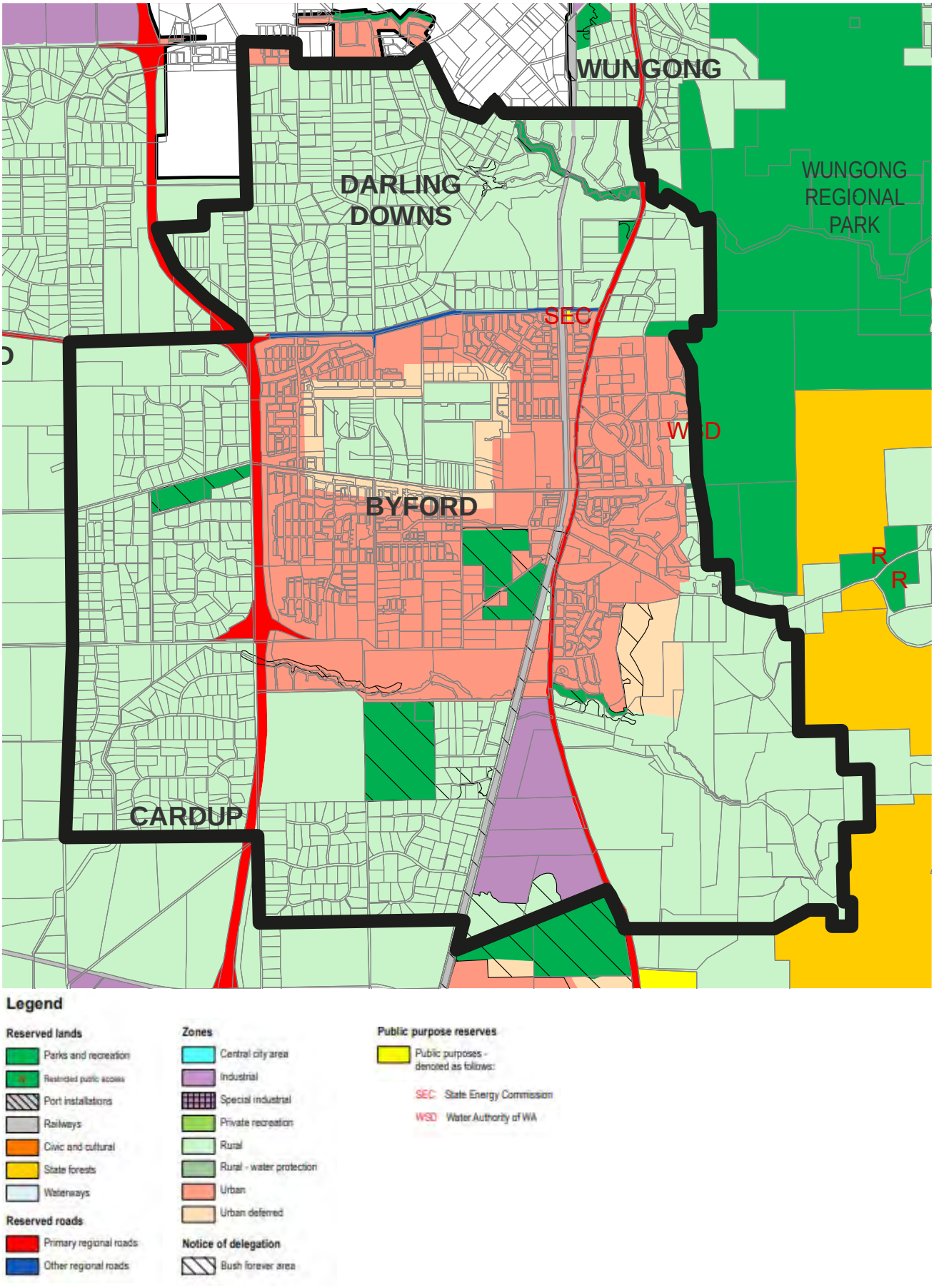
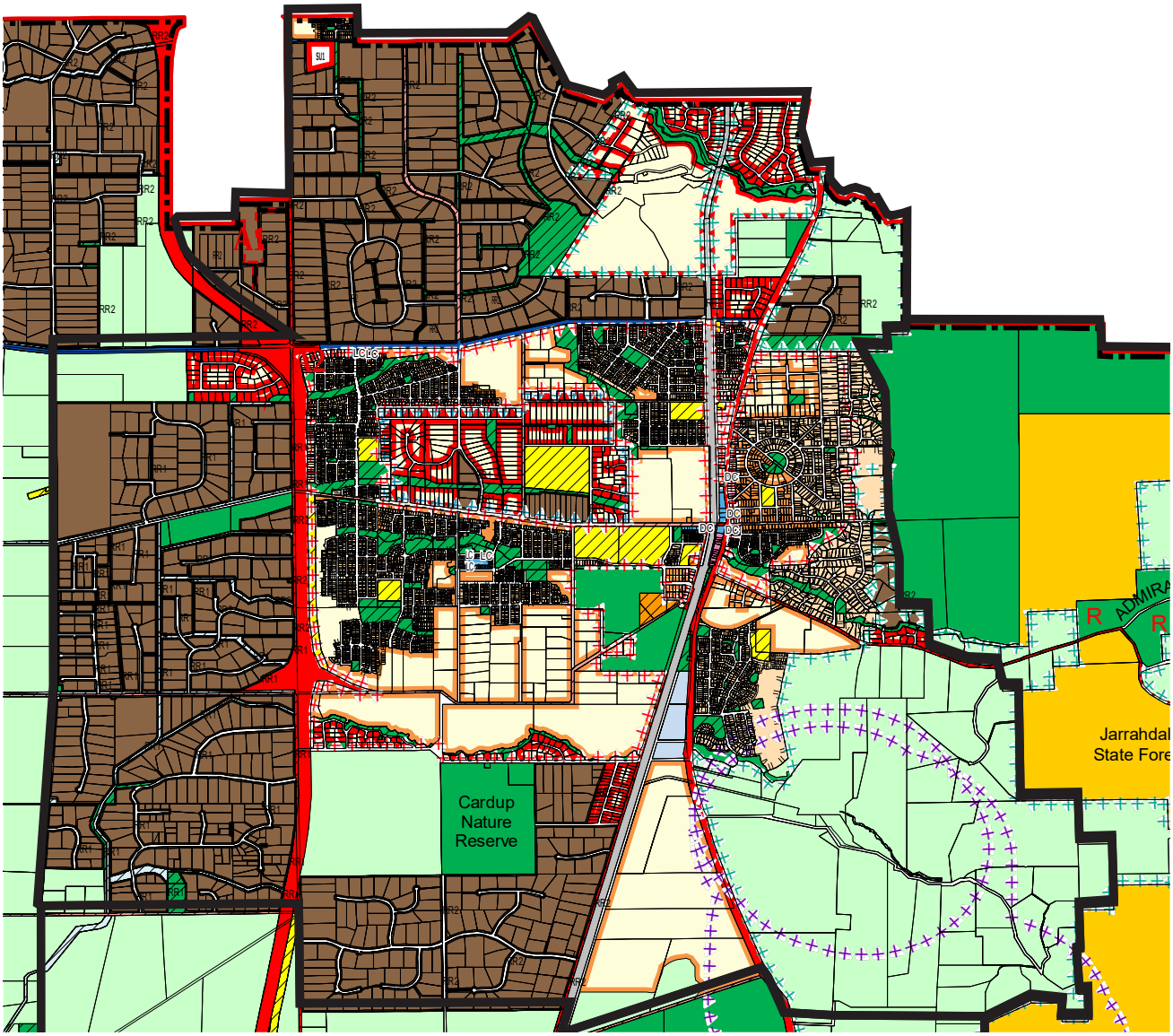


*Figure 6: Draft Local Planning Scheme 3 Map Extract*




Note: Not to scale

## LEGEND

### REGION SCHEME RESERVES (MRS)

- Civic and Cultural
- Other Regional Roads
- Parks and Recreation
- R Parks and Recreation - restricted
- Port Installations
- Primary Regional Roads
- Railways
- State Forests
- Waterways
- Water Catchments

Public Purposes
- CP Public Purposes - Car Park
- CG Public Purposes - Commonwealth Government
- HS Public Purposes - High School
- H Public Purposes - Hospital
- P Public Purposes - Prison
- SU Public Purposes - Special Uses
- SEC Public Purposes - State Energy Commission
- TS Public Purposes - Technical school
- U Public Purposes - University
- WSD Public Purposes - Water Authority of WA

### LOCAL SCHEME RESERVES

(see scheme text for additional information)

- Civic and Community
- C Cultural Facilities
- SC Social Care Facilities
- District Distributor Road
- Drainage/Waterway
- Environmental Conservation
- Local Distributor Road
- Local Road
- Primary Distributor Road
- Public Open Space
- Public Purposes
- CE Cemetery
- E Education
- GS Government Services
- IS Infrastructure Services
- R Recreational
- Railways

### LOCAL SCHEME ZONES

(see scheme text for additional information)

- DC District Centre
- Environmental Conservation
- Industrial Development
- LC Local Centre
- Mixed Use
- Residential
- Rural
- Rural Enterprise
- Rural Residential
- Rural Smallholdings
- Rural Townsite
- Service Commercial
- Special Residential
- Special Use
- Urban Development

### OTHER CATEGORIES

(see scheme text for additional information)

- Scheme Area Boundary
- Local Government Boundary
- R20 R Codes
- A1 Additional Uses
- RR1 Rural Residential Area
- SU1 Special Use Area
- SCA1 Special Control Area - Heritage
- SCA2 Special Control Area - Environment
- SCA3 Special Control Area - Environment
- SCA4 Special Control Area - Develo
- SCA5 Special Control Area - Develo
- SCA6 Special Control Area - Develo
- SCA7 Special Control Area - Enviror
- SCA8 Special Control Area - Heritag
- SCA9 Special Control Area - Genera
- SCA10 Special Control Area - Genera

## 1.3.2 STATE AND REGIONAL PLANNING FRAMEWORK

### STATE PLANNING STRATEGY 2050 (2014)

The State Planning Strategy (SPS) is the lead strategic planning document within the Western Australian Government. It acts as a guide and highlights principles, strategic goals and strategic directions that are important to future land-use planning and development in WA.

The Byford District Structure Plan aligns with the SPS by addressing the priorities of Strategic Goal 2 - strong and resilient regions, Strategic Goal 3 - Sustainable Communities, Strategic Goal 4 - Infrastructure Planning and Coordination, and Strategic Goal 5 - Conservation. These include:

+ **Diversity**
  - Embracing diverse economic and social opportunities.
  - Community-specific development, responsive to diverse needs, places and contexts
  - Supporting economic diversity, innovation and resilience
  - Understanding, maintaining and conserving biodiversity, landscapes and natural environments
+ **Liveability**
  - Creating places where people want to live and work
  - Communities with attractive, liveable environments
  - Providing contemporary, effective, resource-efficient services
  - Securing our natural environments and resources
+ **Connectedness**
  - Building strong relationships and accessibility
  - Providing natural and built connections within and between communities
  - Linking regional economic opportunities to the movement of people, goods and services across the State
  - Connecting ecosystems, people and natural resources
+ **Collaboration**
  - Enabling collaborative advantages across and within regions
  - Collaborative and inclusive planning
  - Sharing new ideas and creating new business and lifestyle opportunities
  - Realising opportunities through collaboration for environmental conservation and sustainable resource use

### PERTH AND PEEL @3.5 MILLION

The Perth and Peel@3.5 million suite of strategic land use planning documents provide a framework for future growth in the Perth and Peel regions. The strategy recognises the benefits of a consolidated and connected city utilising the region's previous historic patterns of urban growth. This strategy promotes more efficient use of land and infrastructure and maintains a target of 47% of new development in the form of urban infill. The strategy is divided into four sub-regional frameworks, which provide more detailed guidance on future land use and development for a city of 3.5 million people. The frameworks provide for different lifestyle choices, vibrant nodes for economic and social activity and a more sustainable urban transport network.

The Shire of Serpentine Jarrahdale is guided by the South Metropolitan Peel Sub-Regional Framework. The framework outlines that the Shire has a population target of 113,060 by 2050, including a need for 1,370 infill dwellings. This significant population growth requires careful coordination to ensure quality and sustainable development in the Shire is achieved. Byford is identified in the sub regional framework as a district level activity centre (**Figure 7**), highlighting the importance of its role as a place for people to live, work and play.

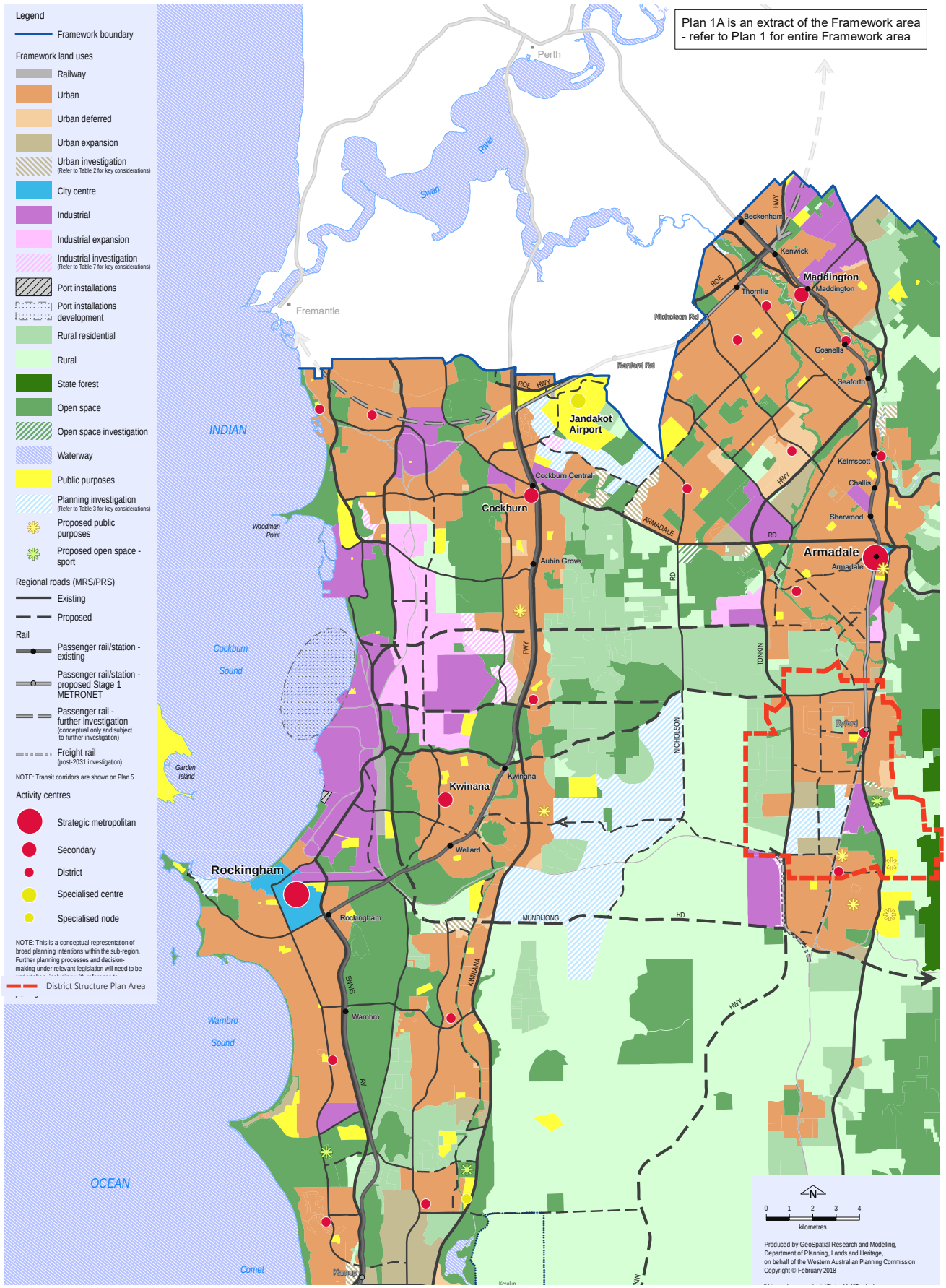



*Figure 7: South Metropolitan Peel Sub-Regional Planning Framework*

## EPA GUIDELINES

The Environmental Protection Authority (EPA) Guidelines fall under the provisions of the Environmental Protection Act 1986 and help guide the Shire in how to undertake assessments of applications. The Byford District Structure Plan has been prepared taking into consideration the following applicable EPA guidelines:

- EPB 20 – Protection of Naturally Vegetated Areas Through Planning and Development;
- GS 3 – Separation Distances Between Industrial and Sensitive Land Uses; and
- GS 33 – Environmental Guidance for Planning and Development.

## STATE PLANNING POLICIES (SPP)

### SPP 2.1 - Peel Harvey Coastal Plain Management

SPP 2.1 applies to all residential, commercial, industrial, rural and recreation land uses, and public sector undertakings within that portion of the Catchment of the Peel-Harvey Estuarine System that lies on the Swan Coastal Plain of Western Australia and within which part of the Shire is situated. The objectives of the policy are to improve the social, economic, ecological, aesthetic, and recreational potential of the Peel-Harvey Coastal Plain Catchment and to ensure that changes to land use within it are controlled so as to avoid and minimise environmental damage to the Peel-Harvey Estuarine system.

The policy area includes the Byford District Structure Plan area west of the Darling Scarp. When considering proposed development, including subdivision, the Shire must take into account land capability and suitability and specific management practices (such as effluent treatment, red mud amendment, revegetation, and stocking rates). Land used for intensive agriculture that is likely to drain towards the Peel-Harvey Estuarine System must be managed to reduce or eliminate nutrient export from the land. The retention and rehabilitation of existing remnant vegetation is also encouraged.

### SPP 2.4 - Basic Raw Materials

SPP 2.4 Basic Raw Materials sets out the matters which are to be taken into account and given effect to by the Local Government and WAPC in considering zoning, subdivision and development applications for extractive industries. The key objectives of the policy are as follows:

- Identify the location and extent of known basic raw material resources;
- Protect priority resource locations, key extraction areas and extraction areas from being developed for incompatible land uses which could limit future exploitation;
- Ensure that the use and development of land for the extraction of basic raw materials does not adversely affect the environment or amenity in the locality of the operation during or after extraction; and
- Provide a consistent planning approval process for extractive industry proposals including the early consideration of sequential land uses.

### SPP 2.5 - Land Use Planning in Rural Areas

SPP 2.5 Rural Planning seeks to protect and preserve Western Australia's rural land assets due to the importance of their economic, natural resource, food production, environmental and landscape values. Ensuring broad compatibility between land uses is essential to delivering this outcome. The Byford District Structure Plan contains numerous lots which are currently zoned Rural. Provisions to retain many of these rural lots have be implemented in the Byford District Structure Plan to ensure consistency with this policy.

### SPP 2.8 - Bushland Policy for the Perth Metropolitan Region

SPP 2.8 Bushland Policy for the Perth Metropolitan Region aims to ensure the bushland protection and management issues in the Perth Metropolitan Region are appropriately addressed and integrated with broader land use planning and decision making. Within the Byford District Structure Plan there large amounts of area classed as Bush Forever, State Forest or native vegetation. Due to this, consideration has been given to the impact development within the Byford District Structure Plan may have on these bushland areas, especially Bush Forever areas. More detailed negotiation on any areas to be retained or removed will occur during the rezoning and local structure planning stages.

**SPP 3 - Urban Growth and Settlement**

SPP 3 Urban Growth and Settlement sets out the principles and considerations which apply to planning for urban growth and settlement in Western Australia. The Byford District Structure Plan has given consideration to the key objectives outlined in this policy including;

- Creating sustainable communities;
- Managing urban growth and settlements across Western Australia;
- Managing urban growth in Metropolitan Perth;
- Planning for liveable neighbourhoods;
- Coordination of services and infrastructure; and
- Managing rural residential growth.

**SPP - 3.1 Residential Design Codes**

SPP 3.1 Residential Design Codes (R-Codes) seeks to control the design of most residential development throughout Western Australia. The R-Codes aim to address emerging design trends, promote sustainability, improve clarity and highlight assessment pathways to facilitate better outcomes for residents. They are also used for the assessment of residential subdivision proposals. Whilst the R-Codes will be suitable for certain types of development within the Byford District Structure Plan area, there will be other locations that will require specific guidance under the provisions of Local Development Plans in order to promote site responsive design outcomes.

**SPP 3.4 - Natural Hazards and Disasters**

SPP 3.4 Natural Hazards and Disasters aims to mitigate the adverse effects of natural hazards and disasters. There are two main hazards which the Byford District Structure Plan needs to address to respond to this policy. Flood risk needs to be assessed due to the presence of inland waterbodies in the form of rivers and streams running though the Byford District Structure Plan. Local structure plans should where necessary be accompanied with a flood risk assessment report. Bush fires are the other significant hazard present in the Byford District Structure Plan as some area contain large amounts of remnant vegetation. LSPs will need to be accompanied with approved Bushfire Management Plans to mitigate the risk of bushfire within the Byford District Structure Plan.

**SPP 3.5 - Historic Heritage Conservation**

SPP 3.5 Historic Heritage Conservation sets out the principles for the conservation and protection of Western Australia's historic heritage. The Byford District Structure Plan contains a number of heritage listed places which are planned to be maintained, upgraded or re-purposed to enable their continued use. The areas around these heritage places are to be developed in a sensitive manner that does not adversely affect the significance of the heritage place.

**SPP 3.6 - Development Contributions for Infrastructure**

SPP 3.6 Developer Contributions for Infrastructure aims to help guide local governments in establishing Development Contribution Plans (DCPs). DCPs will be needed to help fund and deliver many of the community facilities and infrastructure specified within the Byford District Structure Plan. Including but not limited to; upgrading of roads and intersections due to the increased traffic volume expected from an increased population, the construction of district open space to support the rapid growth in local sporting memberships and need for new facilities. These infrastructure items will be delivered through two separate DCPs, with a focus on infrastructure, and community facilities respectively.

**SPP 3.7 - Planning in Bushfire Prone Areas**

SPP 3.7 Planning in Bushfire Prone Areas intends to implement effective, risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure. Under the bushfire guidelines the Byford District Structure Plan is considered a strategic planning proposal, therefore a high level bushfire hazard level assessment should be undertaken. Detailed bushfire attack level (BAL) assessments and bushfire management plans will need to be conducted for future local structure plans, subdivisions and development applications.

**SPP 4.1 - State Industrial Buffer Policy**

The purpose of SPP 4.1 is to provide a consistent state-wide approach for the protection and long-term security of industrial zones. The objectives of SPP 4.1 are:

- To provide a consistent state-wide approach for the definition and securing of buffer areas around industry, infrastructure and some special uses;
- To protect industry, infrastructure and special uses from the encroachment of incompatible land uses;
- To provide for the safety and amenity of land uses surrounding industry, infrastructure and special uses; and
- To recognise the interests of existing landowners within buffer areas who may be affected by residual emissions and risks, as well as the interests, needs and economic benefits of existing industry and infrastructure which may be affected by encroaching incompatible land uses.

The Byford District Structure Plan contains some industrial zoned land on Nettleton Road, as such consideration should be given to the delineation of buffer areas within these areas.

**SPP 4.2 - Activity Centres for Perth and Peel**

SPP 4.2 Activity Centres for Perth and Peel identifies the broad requirements for the planning and development of new and renewal of existing activity centres in the Perth and Peel regions. A primary objective of the policy is to increase the diversity and density of housing within and around activity centres to help improve land use efficiency, residential amenity, access to services, housing variety and centre vitality.

The Byford District Structure Plan contains a district level activity centre (Byford Town Centre) and a number of neighbourhood centres (existing and future). The Byford Town Centre is of particular importance as it is projected to service a catchment of approximately 50,000 people. Through appropriate land use planning and transport integration the Byford District Structure Plan must enable the Byford Town Centre to provide a range of employment opportunities, access to retail and entertainment, housing diversity, and sufficient access to public transport.

**SPP 5.4 - Road and Rail Transport Noise and Freight Consideration in Land Use Planning**

SPP 5.4 seeks to promote a system where sustainable land use and transport are mutually compatible. Specifically it sets out how amenity impacts such as transport noise, associated with high volume roads, rail lines and freight routes should be addressed through the planning system.

The objectives of this policy are to:

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

The policy is applicable to the Byford District Structure Plan area due to the presence of major arterial roads such as Tonkin Highway, Thomas Road and South Western Highway. The Byford District Structure Plan will have consideration for how best to minimise conflicts between freight and other modes of transport, particularly in the Byford Town Centre.

**Draft SPP 7 - Design of the Built Environment (2016)**

Draft SPP 7 addresses the design quality of the built environment across all planning and development types, to deliver broad economic, environmental, social and cultural benefit. It also seeks to improve the consistency and rigour of design review and assessment processes across the State. The policy sets out the principles, processes and considerations

which apply to the design of the built environment in Western Australia. It provides the overarching framework for those State Planning Policies that deal with design related issues, to be used in conjunction on specific development types relating to the design matters of a proposal.

As the Byford Town Centre evolves, becoming an increasingly multifunctional mixed use environment, new development will need to respond to this policy to address the design quality of both the built environment and its public realm.

## DEVELOPMENT CONTROL POLICIES

### Development Control Policy 2.3 - Public Open Space in Residential Areas

This policy is to ensure that the provision of public open space allows for a reasonable distribution of land for active and passive recreation in each locality. The WAPC accepts that this may be secured by providing larger areas for active recreation and smaller areas for passive recreation within residential cells but treats each case on its merits. This policy sets out the WAPC objectives for public open space and the provision of land for community facilities in residential areas as follows:

- Ensure that all residential development in the State is complemented by adequate, well-located areas of public open space that will enhance the amenity of the development and provide for the recreational needs of local residents. In appropriate cases, facilitate the provision of land for community facilities - such as community centres, branch libraries and day-care centres - in conjunction with land ceded for public open space.
- Protect and conserve the margins of wetlands, water-courses and the foreshores adjacent to residential development.

### Development Control Policy 2.4 - School Sites

This policy contains the WAPC's general requirements for school and TAFE college sites in residential areas and recognises the need to consider any requirements for higher education facilities. It should be used during the preparation of designs for the subdivision of residential land at both the structure planning (district and local structure planning) and subdivision design stages. The objectives of the policy are to:

- To make provision for school sites and other education facilities related to community needs.
- To indicate school site requirements, specify criteria for selecting new sites, and
- To establish guidelines for their design and location in new subdivisions.

The Byford District Structure Plan is an emerging area therefore a range of education facilities will be required to help provide equitable access to education for Shire residents. The provisions of this policy will inform preparation of the Byford District Structure Plan map which will identify the location for new schools. in accordance with the following standards:

- Primary Schools - one site for between 1,500 and 1,800 housing units for government schools;
- Secondary Schools - one site for every four or five primary schools for government schools. While the basis for providing non-government schools will be different from government schools, their provision at the average ratio of one non-government to three government primary schools and one to two for secondary schools may be an appropriate basis for planning; and
- For technical colleges there is a general correlation between population and the need for college sites. The general requirement is one site for every 60,000 to 70,000 population. This may vary in densely populated urban areas, where the viable population for a TAFE college can be as high as 250,000 because of the particular demographic characteristics of the area.

### Development Control Policy 2.5 – Special Residential Zones

Development Control Policy 5.4 sets out the requirements of the WAPC for the creation of special residential zones in terms of location, internal design and servicing, and statutory provisions. The objectives of the Policy are:

- To provide for the creation of lots of between 2,000 square metres and one hectare in suitable locations.

- To ensure that the use and development of such lots are subject to appropriate standards and controls.
- To protect the character and amenity of adjacent rural areas.

Within the Byford District Structure Plan a number of Special Rural Residential areas exist west of Hopkinson Road, north of Thomas Road, south Orton Road, east along Nettleton Road, and central, within the Byford Trotting Centre. These areas are synonymous with Byford, known for their unique character and equine focus. The Byford District Structure Plan has been prepared taking into account the requirements of the policy, particularly the stated exemptions to the requirement to connect to reticulated sewerage which may have relevance in some instances.

**Development Control Policy 3.4 - Subdivision of rural land**

This policy sets out the principles that will be used by the WAPC in determining applications for the subdivision of rural land. The policy is consistent with the objectives of State Planning Policy 2.5: Rural Planning, which establishes the state wide policy framework for rural land use planning in Western Australia.

This operational policy guides the subdivision of rural land to achieve the key objectives of State Planning Policy 2.5: Rural Planning. A number of rural zoned lots are located on the fringe of the Byford District Structure Plan area. Special consideration is required to determine how best to preserve these areas to ensure that the objectives of the policy are not compromised.

**Development Control Policy 4.1 - Industrial Subdivision**

This policy provides guidance on the matters considered by the WAPC when determining applications for industrial subdivision throughout the state. These include such matters as the design and shape of industrial lots, road layout, servicing and open space requirements. More detailed development control requirements - such as car parking, landscape and the design and siting of industrial buildings will be found in the Town Planning Scheme and local policies.

Policy objectives include to:

- Encourage the development of well-designed industrial areas serving the full range of general and special industrial needs throughout the State.
- Provide for the safe and efficient movement of traffic to and from each site within the industrial area.
- Provide for infrastructure services and public open space consistent with the operational needs of industrial users and the workforce.
- Protect the amenity of adjacent land uses, where necessary, from the effects of industrial development.

Within the Byford District Structure Plan area, future development within the Cardup Business Park will need to preserve a landscape buffer along Soldiers Road to reduce impacts on adjacent residential dwellings. Future development will also need to address safe and efficient connections on to South Western Highway and linkages through to the Tonkin Highway extension.

**Draft Government Sewerage Policy**

The Draft Government Sewerage Policy 2016 promotes reticulated sewerage as the best disposal method for sewerage. It requires all new subdivision and development to be connected to reticulated sewerage where available or considered necessary on health, environment or planning grounds. The Byford District Structure Plan has been prepared taking into account the requirements of the draft Policy, particularly the stated exemptions to the requirement to connect to reticulated sewerage which may have relevance in some instances.

**Liveable Neighbourhoods**

Liveable Neighbourhoods is a Western Australian Planning Commission (WAPC, 2015) operational policy that guides the structure planning and subdivision for greenfield and large brownfield (urban infill) sites. Liveable Neighbourhoods is an integral component of the state planning framework, delivering the objectives of the Perth and Peel@3.5million sub-regional frameworks and future sub-regional structure plans. It plays a key role within the state planning framework and in relation to the local planning framework including local planning strategies, local planning schemes and policies. The Byford District Structure Plan must meet the criteria of the Liveable Neighbourhoods unless there is an approved local planning policy that varies some of the provisions.

## 1.3.3 LOCAL PLANNING FRAMEWORK

### SJ 2050 VISION

The Serpentine Jarrahdale 2050 Vision (SJ2050) process commenced in April 2016, in response to the draft 'Perth and Peel@3.5 million' strategic plan released by the State Government in 2015. As mentioned above, the strategy estimated a population increase of approximately 100,000 in the Shire by 2050.

SJ2050 was developed through extensive consultation and engagement with the local community and key stakeholders. The document identifies the core values and guiding aspirations of the Shire's community. SJ 2050 sets out a strategic growth framework that aims to accommodate rapid growth, without compromising the community's values and aspirations.

The SJ2050 spatial framework (**Figure 8**) identifies that Byford will accommodate approximately 50,000 people, this significant growth resulted in the need to review and update the existing Byford District Structure Plan.

### SHIRE OF SERPENTINE JARRAHDALE RURAL STRATEGY REVIEW (2013)

The Shire of Serpentine Jarrahdale Local Rural Strategy (2013) is a strategic document that seeks to preserve and enhance the Shire's rural character and its role as an important economic contributor to the Shire and broader region. The Strategy has been developed based on the following key themes:

- Protection of Natural Assets;
- Protection of Rural Character; and
- Facilitate Productive Rural Areas.

The Rural Strategy specifically excludes the Byford urban centre.

### SHIRE OF SERPENTINE JARRAHDALE DRAFT LOCAL PLANNING STRATEGY

The Shire of Serpentine Jarrahdale Draft Local Planning Strategy sets out long term planning direction and provides the rationale for the zones and other provisions of the draft Shire of Serpentine Jarrahdale Local Planning Scheme No.3. The Local Planning Strategy outlines the general aims and intentions for future long-term growth and change within the Shire of Serpentine Jarrahdale. A key component of the Strategy is the Strategic Plan, which includes land use categories that have been guided by the overall vision, principles and objectives of the Strategy.

The draft Local Planning Strategy aligns with SJ2050 by planning for a future urban population in Byford of 55,000 (incuding DIAs) people, to facilitate this growth the following objectives were developed (and have been considered in preparing the Byford District Structure Plan):

- Achieve a diversity of housing types to provide choice, adaptability and to accommodate a range of incomes, households, life stages and the changing demographics of Byford.
- Achieve greater housing densities in proximity to the Byford Town Centre, neighbourhood activity centres, schools, community facilities, public open space and transport nodes and corridors to improve accessibility and enhance community connections.
- Integrate new housing and urban development with nearby rural land types and natural areas as well as older urban development patterns and housing in a sensitive manner.
- Encourage urban development and housing to be environmentally sustainable and resource efficient.

These objectives are supported by a number of strategies and actions, some of which include:

- Review the Byford District Structure Plan; and
- Review the development contribution scheme and plan for Byford.

*Figure 8: SJ 2050 Spatial Framework*

## BYFORD DEVELOPMENT CONTRIBUTION PLAN NO.4

The Byford Traditional Infrastructure Development Contribution Plan (DCP) – Report No. 4 was updated in February 2017 and has been prepared to set out the infrastructure, land and other items for which development contributions are to be collected, as well as cost estimates, how land values are to be calculated and the methodology that will be used to calculate contributions. The Byford DCP is required to be reviewed annually, and DCP 5 is currently under preparation.

## BYFORD DISTRICT STRUCTURE PLAN

The original Byford District Structure Plan was approved in 2005 and sought to guide development and subdivision of the Byford District Structure Plan area, setting the foundation for the initial growth and expansion of the town centre and surrounds. The revised Byford District Structure Plan reflects and builds upon the key objectives and principles of the original District Structure Plan in order to consolidate the work undertaken to date and to sustainably guide the future growth of Byford.

## LOCAL PLANNING POLICIES

In addition to the above, the Shire of Serpentine Jarrahdale administers a number of Local Planning Policies that have been taken into consideration in the preparation of the Byford District Structure Plan. These are included in **Table 3.**

*Table 3: Shire of Serpentine Jarrahdale Local Planning Policies*

| OPERATIONAL | STATUS |
|---|---|
| + LPP 1.1 - Development Assessment Unit | Approved |
| + LPP 1.2 - Development Applications Information | Approved |
| + LPP 1.3 - Amendments and Extensions to Existing Approvals | Approved |
| + LPP 1.4 - Public Consultation for Planning Matters | Approved |
| + LPP 1.5 - Other Exempt Developments | Approved |
| + LPP 1.6 - Public Art for Major Developments | Approved |
| + LPP 1.7 - Road Naming | Approved |
| + LPP 1.8 - Cash-in-lieu for Parking | Approved |
| + LPP 1.9 - Bonds and Bank Guarantees | Approved |
| + LPP 24 – Designing Out Crime | Approved |
| + LPP 40 – Local Development Plans | Approved |
| **PLANNING FRAMEWORKS** | **STATUS** |
| + LPP 2.1 - Structure Plan and Subdivision Standards | Draft |
| + LPP 2.2 - Local Development Plan Guidelines | Draft |
| + LPP 2.3 - Development Standards for Development Applications | Approved |
| + LPP 2.4 - Water Sensitive Design | Approved |
| + LPP 2.5 - Activity Centres | Approved |
| + LPP 2.6 - Stanley Road Precinct Planning Framework | Approved |
| + LPP 2.7 - Biodiversity Planning | Approved |
| + LPP 2.8 - Public Open Space | Approved |
| + LPP 3.5 - Byford Town Centre Public Realm Guidelines | Approved |
| + LPP 3.6 - The Glades Village Centre Guidelines | Approved |
| + LPP 3.7 - George Street Design Guidelines | Approved |
| + LPP 3.8 - Byford Town Centre Built Form Guidelines | Approved |
| + LPP 51 - Oakford Rural Economic Living Area Planning Framework | Approved |
| **DESIGN GUIDELINES** | **STATUS** |

| | |
|---|---|
| + LPP 3.1 - McNeil Grove Design Guidelines | Approved |
| + LPP 3.2 - Woodlot Subdivision Jarrahdale Design Guidelines | Approved |
| + LPP 3.3 - Wellard and Richardson Street Serpentine Design Guidelines | Approved |
| **LAND USE** | **STATUS** |
| + LPP 4.1 - Ancillary Dwelling | Approved |
| + LPP 4.2 - Sea Containers | Approved |
| + LPP 4.3 - Landscape Protection | Approved |
| + LPP 4.4 - Dams and Lakes | Approved |
| + LPP 4.5 - Temporary Accommodation | Approved |
| + LPP 4.6 - Telecommunications Infrastructure | Approved |
| + LPP 4.7 - Placement of Fill in Non-Urban Areas | Approved |
| + LPP 4.8 - Land Sales Offices | Approved |
| + LPP 4.9 - Fast Food Premises | Approved |
| + LPP 4.10 - Extractive Industries | Approved |
| + LPP 4.11 - Advertising | Approved |
| + LPP 4.12 - Horticulture | Approved |
| + LPP 4.13 - Revegetation | Approved |
| + LPP 4.14 - Rural Worker's Dwellings | Approved |
| + LPP 4.15 - Bicycle Facilities | Approved |
| + LPP 4.16 - Landscape and Vegetation | Approved |
| + LPP 4.17 - Multiple Use Trails | Approved |
| + LPP 4.18 - Street Trees | Approved |

The above policies do not pose a conflict with the Byford District Structure Plan but will require consideration in the more detailed design and implementation planning processes to follow.

## 1.3.4 OTHER APPROVALS AND DECISIONS

Local Structure Plans (LSPs) provide a much greater level of detail than District Structure Plans, and are generally required prior to future subdivision and development. Existing LSPs for current consideration are outlined in **Table 4**.

*Table 4: Approved Byford Local Structure Plans*

| LPS AREA | OPERATIONAL | STATUS |
|---|---|---|
| Area A | Byford Town Centre | Approved |
| Area B | Marri Park Estate - Lot 3 Larsen Rd and Lot 3 Alexander Road, Byford | Approved |
| Area C | Byford Central | Approved |
| Area E | Lots 59-62 Briggs Road Byford | Approved |
| Area F | Byford Meadows Estate, Lot 9500 Thomas Road, Briggs Road | Approved |
| Area G | Redgum Brook Estate | Approved |
| Area H | Kalimna Estate | Approved |
| Area I | Grange Meadows, Lot 6 and Lot 27 Abernethy Road, Byford | Approved |
| Area J | Byford West | Approved |
| Area K | The Glades | Approved |
| Area L | Doley Road Precinct | Approved |
| Area N | Lots 1, 3 and 128 South Western Highway, Byford | Approved |

| | | |
|---|---|---|
| Area O | Lot 806 South Western Highway, Byford | Approved |
| Area Q | Lot 2 Nettleton Road, Byford (The Brook) | Approved |
| Area S | Stanley Road Precinct | Approved |
| Area U | Lots 1 and 2 Rowley Road, Darling Downs | Approved |

## 1.3.5 PRE-LODGEMENT CONSULTATION

Significant community and stakeholder engagement was undertaken to inform development of concept options and subsequently the development of the Byford District Structure Plan. Key stakeholders are defined as those with significant holdings or influence in the way that the Byford District Structure Plan area will develop.

In addition, there was a significant on-line presence asking for input through nine surveys. The engagement surveys included Activities and events, Equine, Community facilities, Dogs, Transport, Sport and recreation, Environment, Employment, and Education and training. This engagement was open for more than two months starting on 15 December 2017 and concluding on 8 March 2018.

A summary of community and stakeholder engagement is provided in **Table 5**.

*Table 5: Pre-Lodgement Engagement Summary*

| AGENCY / GROUP | DATE | CONSULTED BY | METHOD OF ENGAGEMENT | SUMMARY OF OUTCOME |
|---|---|---|---|---|
| Shire of Serpentine Jarrahdale Internal Stakeholder – Local Development Strategy Champions | 16/11/17 + 22/03/18 | Hames Sharley | Internal Workshops Emails | Input into concept plan, precinct plans and District Structure Plan |
| Shire Councillor's | 4/12/2017 + 4/4/2018 | Hames Sharley | Councillor Workshops | Input into concept plan and precinct plans |
| Salvado Catholic College | 30/01/18 | Shire Project Team Hames Sharley | Meetings | Input into concept plan and precinct plans |
| Woolworths | 30/01/18 | Shire Project Team Hames Sharley | Meetings | Input into concept plan and precinct plans |
| Public Transport Authority / METRONET | 1/02/18 - Ongoing | Shire Project Team Hames Sharley | Meetings | Input into Transport Assessment and concept plan |
| Department of Planning Lands and Heritage / Public Transport Authority | 1/02/18 - Ongoing | Shire Project Team Hames Sharley | Meetings Phone / Emails | Input into Transport Assessment, District Structure Plan and Development Contribution Plan |
| Byford Industrial Reference Group | 7/02/18 | Shire Project Team Hames Sharley SPP Consulting | Meetings | Input into Development Contribution Plan |
| Byford Progress Association | 19/02/18 | Shire Project Team Hames Sharley | Meeting Survey Emails | Input into concept plan and precinct plans |
| YMCA Byford Recreation Centre | 19/02/18 | Shire Project Team Hames Sharley | Meeting | Input into concept plan and precinct plans |
| Byford IGA | 19/02/18 | Shire Project Team Hames Sharley | Meeting | Input into concept plan and precinct plans |

| AGENCY / GROUP | DATE | CONSULTED BY | METHOD OF ENGAGEMENT | SUMMARY OF OUTCOME |
|---|---|---|---|---|
| Racing and Wagering WA | 19/02/18 | Shire Project Team<br>Hames Sharley | Meeting | Input into concept plan and precinct plans |
| Coles | 20/02/18 | Shire Project Team<br>Hames Sharley | Meeting | Input into concept plan and precinct plans |
| Mainroads WA | 20/02/18 | Shire Project Team<br>Hames Sharley | Meetings<br>Emails | Input into Transport Assessment |
| Consolidate UT Pty Ltd | 21/02/18 | Shire Project Team<br>Hames Sharley | Meeting | Input into concept plan and District Structure plan |
| Byford Secondary College | 21/02/18 | Shire Project Team<br>Hames Sharley | Workshop | Input into concept plan and precinct plans |
| LWP Property | 21/02/18 | Shire Project Team<br>Hames Sharley | Meeting | Input into concept plan and precinct plans |
| Byford Community Workshop | 24/02/18 | Hames Sharley | Workshop<br>Survey | Input into concept plan and precinct plans |
| Department of Water and Environmental Regulation | 8/03/18 | Shire Project Team<br>Hames Sharley | Meeting<br>Emails | Input into District Structure Plan |
| Byford Secondary College, Student Councillors | 8/03/18 | Shire Project Team<br>Hames Sharley | Workshop<br>Survey | Input into concept plan and precinct plans |
| Department of Education | 9/03/18 | Shire Project Team<br>Hames Sharley | Meeting<br>Emails | Input into concept plan and District Structure Plan |
| Harley Drykstra Planning | 9/03/18 | Shire Project Team<br>Hames Sharley | Meeting | Input into concept plan and precinct plans |

Outcomes of the Byford community and stakeholder engagement process identified above are further summarised in Technical Appendix 1.

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# 2.0 CONTEXT ANALYSIS

# 2.1 Regional Context

The Byford District Structure Plan is located in the south-eastern corridor of the Perth Metropolitan region in the Shire of Serpentine Jarrahdale. It is located in the northern portion of the Shire and is generally bound by Thomas Road to the north, the existing Byford Townsite to the east, South Western Highway to the southeast, Cardup Siding Road to the south and Hopkinson Road to the west.

As illustrated on **Figure 9** the Byford Town Centre is located approximately 7km south of Armadale, 18km east of Kwinana and 35km southeast of the Perth CBD. It has good access to the arterial road network with north-south connections via Tonkin Highway and South Western Highway connecting to major employment areas such as Perth Airport, Welshpool, and Armadale in the north. South Western Highway also provides links to major tourism centres in the Southwest Region such as Bunbury. The Perth CBD can be accessed via Thomas Road and Kwinana Freeway.

The freight network within the Byord District Structure Plan area currently links the South Western Highway as the major north-south corridor and Thomas Road as the major east-west connection to the Kwinana Industrial Area. Combined with local vehicle traffic, significant movements are increasing along these routes on a daily basis. The future extension of Tonkin Highway from Thomas Road through to South Western Highway is set to become the primary north-south freight link driving development of the West Mundijong Industrial Area. This also provides the opportunity to mitigate the effects of freight movement within the Byford centre and local residential areas.

Current land uses are dominated by residential development or rural-residential/equine pursuits. The Darling Scarp and State Forest to the east provide an alternative landscape background to the subject area and offer potential for tourism and alternative lifestyle experiences.

Within the Perth and Peel activity centre's network Byford is classified as a District Centre. It is therefore earmarked to be the primary location for retail and entertainment in the Byford District Structure Plan area. The highest order activity centre in the surrounding region is the Armadale Strategic Metropolitan Centre. Due to its proximity, Byford currently leverages off Armadale for access to higher order services such as health and employment, however, future planning should look to increase the provision of these services locally.

A number of major strategic initiatives such as the Tonkin Highway Extension and passenger rail extension (METRONET) are already planned or being considered. These projects will have a significant influences on the regional context within which the Byford District Structure Plan must be considered.

*Figure 9: Regional Context*

# 2.2 Local Context

## 2.2.1 EXISTING AREA CHARACTERISTICS

The Byford District Structure Plan area has undergone rapid change over the last decade with the population increasing significantly over the last decade. **Figure 10** illustrates that majority of this growth has occurred west of South Western Highway and south of Thomas Road.

It has changed the urban structure of Byford significantly, including the Byford Town Centre. Historically, the Byford Town Centre has been located on the eastern side of the railway corridor and was comprised of small-scale established premises which were dispersed in a north-south strip along South Western Highway. There was no defined focal point or town square for the community to engage and interact. However, as the population within the Byford District Structure Plan area has grown so to has its needs. Due to spatial constraints the Byford Town Centre has shifted from South Western Highway to Pioneer Street on the western side of the railway corridor. This relocation will enable the town centre to grow organically, and better service the majority of the population.

As a result of the change that has occurred, the Byford District Structure Plan area possesses a number of distinct character areas, which can be described as follows:

+ The area north of Thomas Road in Darling Downs, west of Hopkinson Road and around the Byford Trotting Complex are rural-residential areas which contain a number of large lifestyle lots which support the local equine industry;
+ The area east of South Western Highway and north of Beenyup Road is referred to as the Byford 'Old Quarter' or Blytheswook Park, being the original estate concept for Byford influenced by the garden city movement. The area includes traditional larger lots and is contained by a green belt. The spatial development pattern is still relevant as this presents a desirable alternative to urban sprawl. This area is also the historical development approach for Byford that should be celebrated as a part of the Shire's heritage;
+ The area west of South Western Highway (with the exception of the Trotting Complex and surrounds) is where majority of new development has occurred. As evidenced by **Figure 10** this is where majority of urban growth has occurred; and
+ New low density residential areas as a result of urban sprawl are placing increasing pressure on equine activities within the Byford District Structure Plan area.

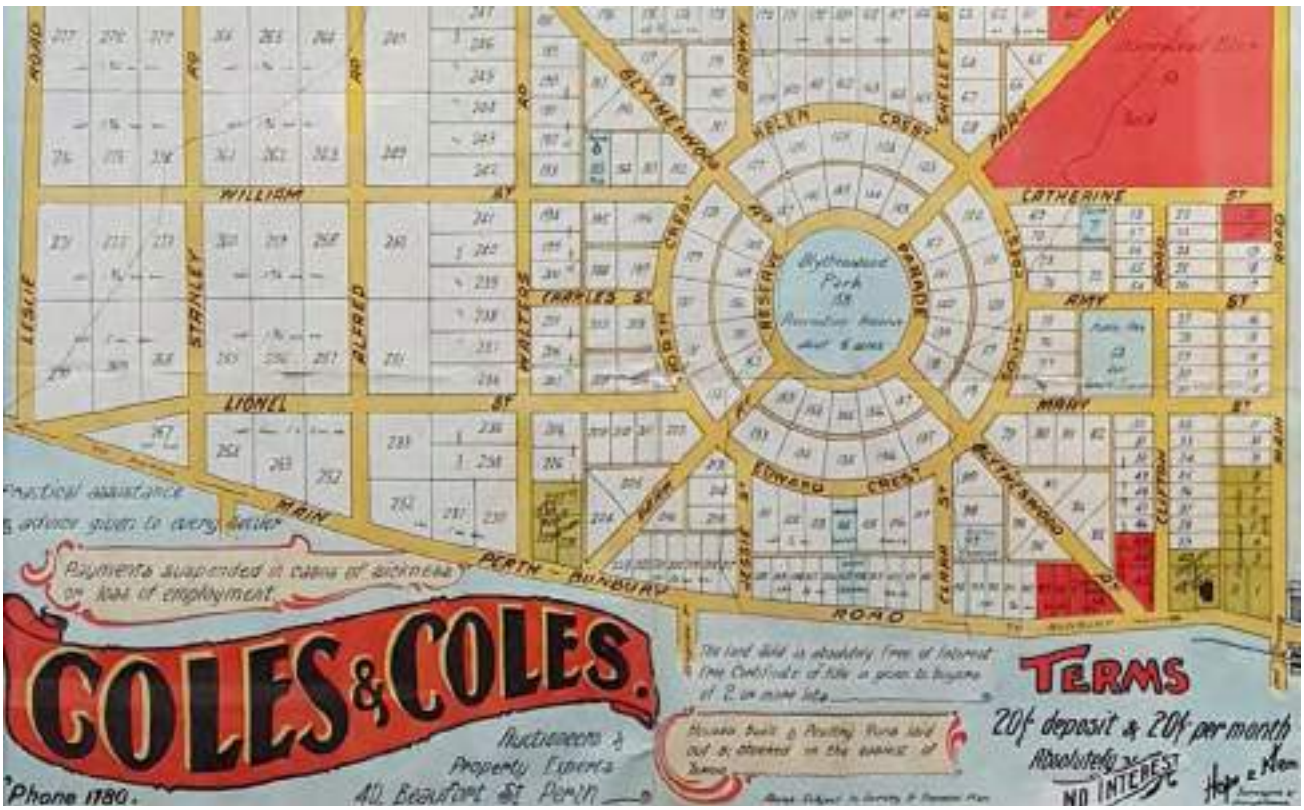



*Photo: Old Estate Plan Blystheswood Park, Byford*

2008


2018


*Figure 10: Byford Change Overtime 2008-2018*
*Source: Nearmap*

## 2.2.2 LAND USE

### RESIDENTIAL

The existing Byford District Structure Plan identifies medium residential densities (R30 – R60) in the immediate vicinity of the town centre and local centres, with remaining residential land designated as R20. The built form being realised in the Byford District Structure Plan area is almost exclusively single detached housing, demonstrating that there is currently a lack of housing diversity. To meet the future needs of the Shire's population greater housing diversity will be important. With the vast majority of new dwellings providing detached single houses aimed at first-home buyers, there are risks in creating a town for a socially and economically vulnerable population.

The potential for higher densities exists primarily in the Byford Town Centre, in close proximity to amenity and public transport. Housing types ranging from single bedroom dwellings to family households, in detached, grouped and multiple housing forms should be considered. The adaptability of housing to accommodate 'ageing-in-place' will also cater for a wider variety of lifestyle preferences and price points. Future development, will be largely dependent on the proposed Byford Metronet project which will determine the location of a potential future train station.

Achieving both housing diversity and increased net density in the Byford District Structure Plan area will require careful consideration of the:

- Range of lot sizes provided in any given development area with a view to both immediate housing provision and future infill opportunities;
- Shape of lots to accommodate different housing typologies in the short term and over time (irregular shaped lots being more difficult to develop and redevelop;
- Dwelling size and mix provided within any given development area; and
- Ability of dwellings to be adapted/converted to suit different household types without the need for demolition or extensive and expensive renovation.

### RURAL RESIDENTIAL

The amenity and character within Rural Residential areas is recognised as an important aspect of housing choice within the Shire. Existing Rural Residential living (**Figure 11**) is contained within the fringe transitional areas of the Byford District Structure Plan. Residential development in this context provides for residential lot sizes generally ranging between 4000m$^2$ and 4ha depending on the location. These areas should be retained and enhanced to ensure a high amenity living environment with strong connections to nature is maintained.

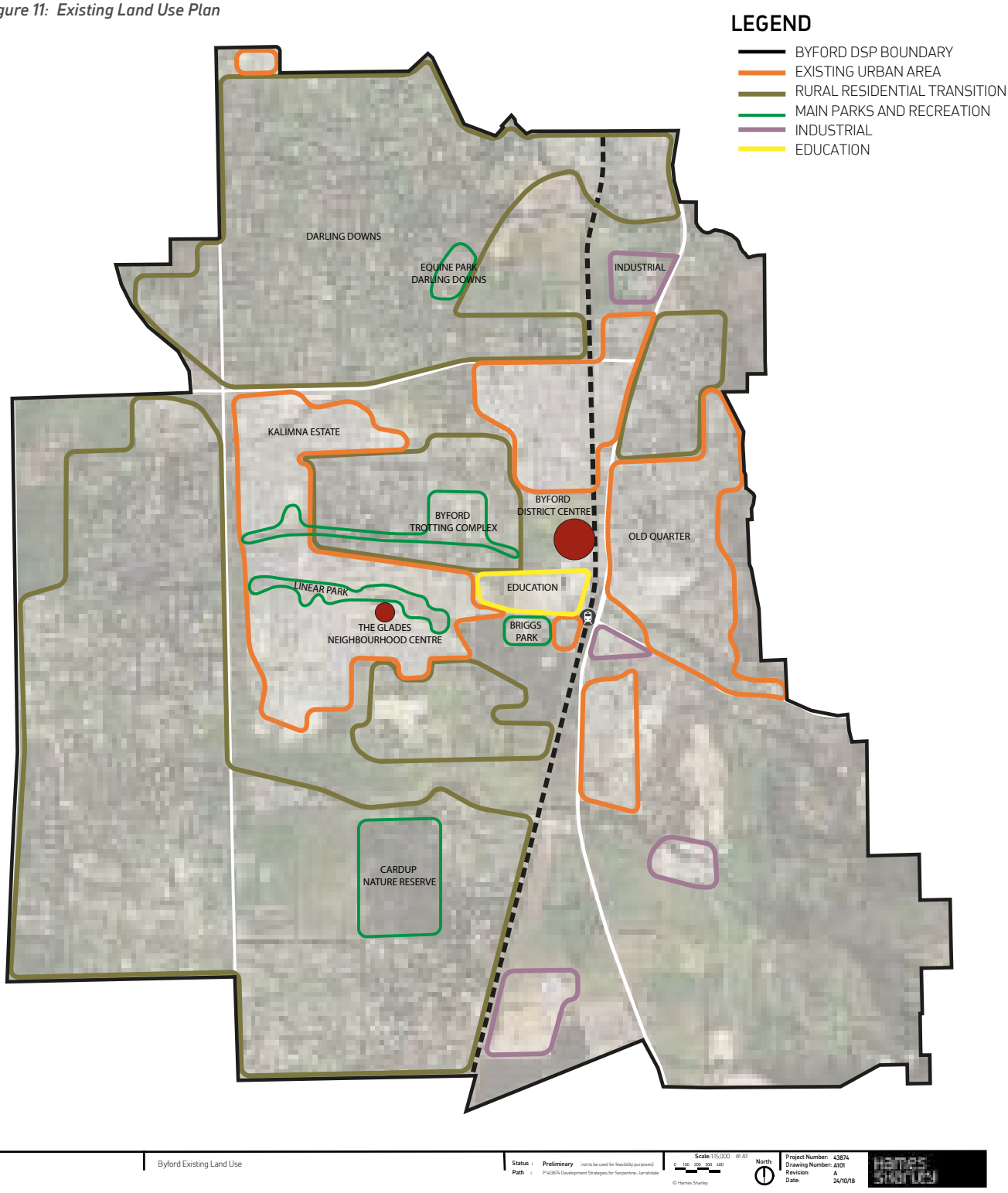
### EQUINE FACILITIES

The Shire has a well-established equine industry, as such a number of equestrian activities operate within the Byford District Structure Plan area. These activities provide lifestyle opportunities, and contribute to local character and the local economy. Within the Byford District Structure Plan area the Byford Trotting Complex and the Darling Downs Equestrian Reserve provide specific lots for equestrian purposes under the Rural Smallholdings land use category. These areas are also complemented by a network of existing bridle trails which are managed by the Shire. Equine activities in the Byford District Structure Plan area are under pressure from ongoing urban development, however, future growth should support the retention of existing equine activities within Rural Smallholdings.

### INDUSTRIAL

Industrial development is fundamental to sustaining and strengthening the local economy and creating local employment opportunities. Existing industrial zoned land in the Byford District Structure Plan area is based around Nettleton Road and the future Cardup Business Park. The latter area is well located on South Western Highway between the Byford and Mundijong urban areas and is identified in the South Metropolitan Peel framework as a future industrial area. A local structure plan for the area has not yet been finalised, however, the intention for the Cardup Business Park is to provide for a wide variety of lot sizes to accommodate various types of mixed business and service commercial uses. Sizes are expected to range from two to five hectares and include warehousing, transport and logistics businesses, and showroom/bulky goods type commercial facilities.

*Figure 11: Existing Land Use Plan*




## RURAL LAND

The rural land use category provides for a full range of rural land uses, tourism opportunities and the preservation of the natural landscape. The Shire considers it important to maintain rural land in close proximity to Perth to accommodate various rural industries and food production activities for the growing population. Due to ongoing development, productive rural land within the Byford District Structure Plan area is limited, majority of former rural land has been developed as either residential or rural residential.

## 2.2.3 ECONOMY AND EMPLOYMENT

### EXISTING EMPLOYMENT AREAS

**Activity centres**

The Byford District Structure Plan contains a network of activity centres which provide consolidated access to goods and services. The hierarchy includes the Byford District Centre and a number of supporting neighbourhood / local centres. Higher order services can be accessed from the Armadale Strategic Metropolitan Centre which is approximately 7km north of the Byford District Structure Plan area.

The Byford Town Centre is nominated as a District Activity Centre under SPP4.2. Historically retail and commercial activity has been focused within the 'old' Byford town centre, along South Western Highway between Larsen Road and Abernethy Road. This area continues to accommodate a range of small businesses with a focus on retail and food and beverage. As discussed in **Section 2.2.1** population growth in Byford has changed the function and location of the Byford Town Centre. New retail development has been provided on the western side of the railway corridor to create a 'new' town centre. The new town centre is anchored by Coles and Woolworths supermarkets and will support an additional mix of retail, cafes and restaurants, as well as medical facilities and services to reinforcing the new town centre. As the Byford Town Centre continues to expand, a greater diversity of uses will be provided.

Neighbourhood and local centres in the Byford District Structure Plan area are emerging in the west Byford growth areas. The most established centre is The Glades which is located at the corner of Doley Road and Mead Street. The Glades provides a range of local services including an IGA Supermarket, food and beverage tenancies and personal care (e.g. hair and beauty).

There is current neighbourhood centres located at The Glades and at the intersection of Thomas Road and Kardan Road provide for daily and weekly retail and service needs including smaller scale supermarkets, convenience stores and local services to support the surrounding new residential development. As residential development expands further south within the Byford District Structure Plan area, new neighbourhood centres will be required. These should be strategically located along major distributor network to enable direct access to local services and conveniences.

**Commercial**

Existing commercial provision is limited in the Byford District Structure Plan area. It is primarily consolidated along South Western Highway between Larsen and Abernethy Roads. Larger scale tenancies such as hardware and vehicle services are provided in the north and small-medium scale tenancies are provided in or near the Old Byford Town Centre. There is also a small local commercial area being established at the corner of Thomas Road and Kardan Boulevard, this provides a service station, fast food tenancy, and gym.

**Industrial**

There is an existing light industrial area provided in Byford along Nettleton Road (near South Western Highway). This area includes a number of localised businesses.

### EMPLOYMENT SELF-SUFFICIENCY AND SELF CONTAINMENT

Employment self-sufficiency measures the proportion of local jobs that are filled by local residents. It indicates the level at which local residents meet the needs of local industries and businesses. The economy in the Byford District Structure Plan area is an emerging market, therefore due to the lack of available data and low number of jobs currently available employment self-sufficiency has not been measured.

Employment self-containment measures the proportion of local residents who also work in the Byford District Structure Plan area. It indicates the level at which local jobs meet the needs of local residents and determined how many of the Byford District Structure Plan residents have to leave the area for their work. **Table 6** demonstrates that employment self-containment within the Byford District Structure Plan area is very low at 14.2%. This suggests that 85% of the working population leave the area everyday to access their places of employment, it means that currently the Byford District Structure Plan area does not provide enough jobs, or the right jobs.

In 2016, the most popular industries in the Byford District Structure Plan were:

1. Construction
2. Health Care and Social Assistance
3. Retail Trade
4. Manufacturing
5. Transport, Postal and Warehousing

In 2016, the industries with the highest employment self-containment in the Byford District Structure Plan were:

1. Arts and Recreation Services (43.9%)
2. Agriculture (38.3%)
3. Education and Training (28.8%)
4. Accommodation and Food Services (27.8%)
5. Construction (19.3%)

*Table 6: Byford District Structure Plan Employment Self-Containment*

| INDUSTRY OF EMPLOYMENT | TOTAL LOCAL WORKERS Byford District Structure Plan* | LOCAL WORKERS RESIDING IN Byford District Structure Plan* | EMPLOYMENT SELF CONTAINMENT % |
|---|---|---|---|
| Agriculture, Forestry and Fishing | 47 | 18 | 38.3% |
| Mining | 528 | 19 | 3.6% |
| **Manufacturing** | **639** | **40** | **6.3%** |
| Electricity, Gas, Water and Waste Services | 100 | 0 | 0.00% |
| **Construction** | **1074** | **207** | **19.3%** |
| Wholesale Trade | 304 | 10 | 3.3% |
| **Retail Trade** | **880** | **80** | **9.1%** |
| Accommodation and Food Services | 392 | 109 | 27.8% |
| **Transport, Postal and Warehousing** | **612** | **86** | **14.1%** |
| Information Media and Telecommunications | 58 | 10 | 17.2% |
| Financial and Insurance Services | 147 | 13 | 8.8% |
| Rental, Hiring and Real Estate Services | 151 | 26 | 17.2% |
| Professional, and Technical Services | 324 | 62 | 19.1% |
| Administrative and Support Services | 232 | 44 | 19.0% |
| Public Administration and Safety | 495 | 46 | 9.3% |
| Education and Training | 539 | 155 | 28.8% |
| **Health Care and Social Assistance** | **946** | **100** | **10.6%** |
| Arts and Recreation Services | 98 | 43 | 43.9% |
| Other Services | 436 | 63 | 14.5% |
| Inadequately described | 328 | 47 | 14.3% |
| Not stated | 92 | 19 | 20.7% |
| **Total** | **8422** | **1,197** | **14.21%** |

* Calculated using ABS 2016 Census Table Builder tool, data was sourced from Byford, Cardup, and Darling Downs suburb datasets.

In summary, the findings of **Table 6** suggests there is a need to strategically target local jobs growth to improve employment self-containment. The Shire's Economic Development Strategy identifies a need for more local employment opportunities with a target for 45,000 new jobs by 2050. As one of the major growth centres in the Shire, it is important the Byford District Structure Plan contributes to this target because without additional local jobs, Byford risks becoming a dormitory suburb which would create future issues around traffic congestion and numerous negative economic and community impacts. It is important that the Byford District Structure Plan facilitates employment growth by capitalising on the Shire's competitive advantages which include:

+ Significantly growing population and large surrounding workforce catchment;
+ Affordability of land and access to key transport links; and
+ Ability to capitalise on existing agricultural and equine industries which currently account for approximately 20% of the Shire's Gross Regional Product.

## 2.2.4 COMMUNITY AND SOCIAL INFRASTRUCTURE

### COMMUNITY INFRASTRUCTURE

Community infrastructure is the term used to describe facilities which accommodate services that support, contribute and respond to the needs of people living, working and studying in an area. A recent audit of existing community infrastructure identified that whilst some facilities in the Byford District Structure Plan area provide a high quality service others are underutilised. The Shire's Community Infrastructure Implementation Plan (CIIP), 2017 outlines key facilities of priority within the Byford District Structure Plan area as well as responsibility for future provision to form part of the Developer Contribution Plan and the Shire's long term financial plan.

The Byford District Structure Plan area is characterised by a relatively young population with a high presence of families, therefore children and youth activities will be important. In the Byford District Structure Plan area there are a range of existing community infrastructure facilities which cater for local residents, these are provided in **Table 7** and on **Figure 12**.

*Table 7: Summary Existing Community Infrastructure*

| | EXISTING COMMUNITY INFRASTRUCTURE | | |
|---|---|---|---|
| 1 | Darling Downs Equestrian Facility | 14 | Byford Hall |
| 2 | Byford Scout Hall/ Old Rifle Range | 15 | Byford John Calvin Primary School |
| 3 | Byford and Districts Country Club | 16 | Byford Cricket Nets and Change Rooms |
| 4 | Bill Hicks Facility | 17 | Briggs Park Pavilion |
| 5 | Mary Gove Primary School | 18 | BMX Track |
| 6 | West Byford Primary School | 19 | Lower Briggs Park Storage Facilities |
| 7 | Byford Community Kindergarden and Child Health Clinic | 20 | Byford Secondary College Oval |
| 8 | Kalimna Reserve | 21 | Serpentine Jarrahdale Community Recreation Centre |
| 9 | Kalimna Club Rooms | 22 | Byford Community Garden |
| 10 | Byford Fire Station | 23 | Woodland Grove Primary School |
| 11 | Byford Tennis Courts | 24 | Woodland Grove Reserve |
| 12 | Byford Primary School | 25 | Byford Trotting Complex |
| 13 | Byford Secondary College | 26 | Brickwood Reserve Facility |

### SPORT AND RECREATION

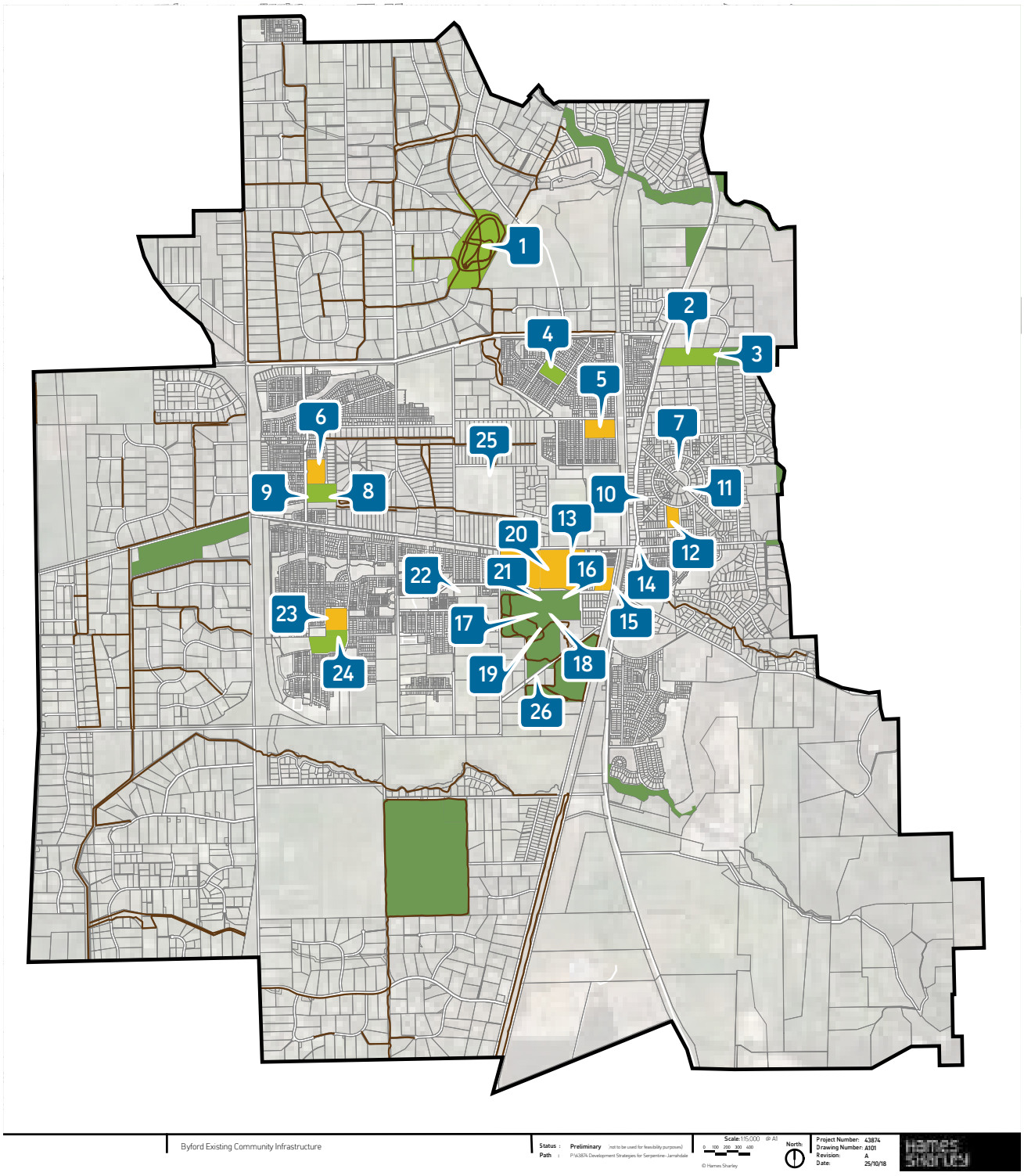
The Byford District Structure Plan area provides a range of existing sport and recreation facilities which cater for passive and active recreation. Numerous parks, nature reserves and sports fields provide opportunity for residents to engage in physical activity. Currently, Briggs Parks Recreation Precinct is the primary focal point due to the clustering of facilities, however, increased demand is creating pressure on the site. As the Byford District Structure Plan area comes under greater pressure to accommodate a growing population (approximately 60,000 people by 2050) planning for additional facilities is required. The Byford District Structure Plan will identify the requirement for and location of proposed facilities

### EDUCATION AND TRAINING

As identified in **Table 7** and on **Figure 12** the Byford District Structure Plan area currently accommodates five primary and two secondary schools (1 public and 1 private). Rapid urban development in the area in recent years has required continued provision of new schools to meet demand. This is likely to continue in the future as additional growth occurs.

The level of education achieved by any population is linked to its economic prosperity, at present the population in the Byford District Structure Plan area has lower levels of tertiary qualification than both the Shire and Greater Perth. This is due in large part to the fact that there are currently no tertiary facilities provided within the Byford District Structure Plan area. The closest facility is the Murdoch University development proposed at Whitby, which is intended to be an innovations centre for teaching and research in veterinary and agricultural sciences, environmental science and conservation and a drone research facility. It will be important for the population to have access to tertiary education to ensure that current levels of economic and social disadvantage are not exacerbated (AECgroup, 2016). Therefore in the short-medium term it is important that Byford maintains good public transport connectivity to tertiary education opportunities in areas outside of the Shire.

*Figure 12: Existing Community Infrastructure*



## 2.2.5 MOVEMENT AND ACCESS

Providing accessible transportation is essential in facilitating an efficient and connected movement network within the Byford District Structure Plan ensuring that community, businesses and industry are well-connected to the greater Perth and Peel Regions.

### ROAD NETWORK

**Primary Distributors**

Form the regional and inter-regional grid of MRWA 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. Within the Byford District Structure Plan area, there are two existing major distributor roads (**Figure 13)**, these are:

- South Western Highway South is a primary north-south distributor road. It provides a connection between Bunbury and Armadale, however, its prominence has been reduced in recent years due to the construction of Forrest Highway.
- Tonkin Highway is the other key north-south road. Tonkin Highway is planned to be extended southward to connect through to Mundijong Road and further onto the Forrest Highway southwest of Pinjarra. The plan is to enable freight movement to bypass South Western Highway. The Tonkin Highway extension would require intersection connection treatments at Thomas Road and Orton Road, while Abernethy Road is proposed to terminate at this point. Recognising current upgrades underway for Abernethy Road providing a central east-west distributor role within the Byford District Structure Plan area, the desired outcome indicated by the Shire is to enable the continuation of Abernethy Road under Tonkin Highway, enabling greater permeability within the local road network.

Within the South Metropolitan Peel Sub-Regional Framework (WAPC, 2018), the future regional road network indicates a number of new and upgraded primary distributor and integrator arterial roads. This includes the upgrade of Thomas Road and Orton Road providing vital east–west freight linkages between the future Outer Harbour and freight logistics centres in the region, other major road linkages, and strategic industrial locations.

**Regional Distributors**

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. Regional distributors in the Byford District Structure Plan area include:

- Nettleton Road which provides connections to Jarrahdale; and
- Soldiers Road and Hopkinson Road (north-south) which provide connections to Cardup and Mundijong. As the population grows within the southern portion of the Byford District Structure Plan area, Soldiers Road will increasingly be under pressure to provide additional capacity to link activities within the Mundijong district. However, this is impacted by the Threatened Ecological Communities (TECs) present along this corridor.

**Distributor A**

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. Thomas Road is the only Distributor A road and main east-west connector in the Byford District Structure Plan area. It provides connections between the Kwinana Freeway, Tonkin Highway and South Western Highway linking all key north-south distributor roads.

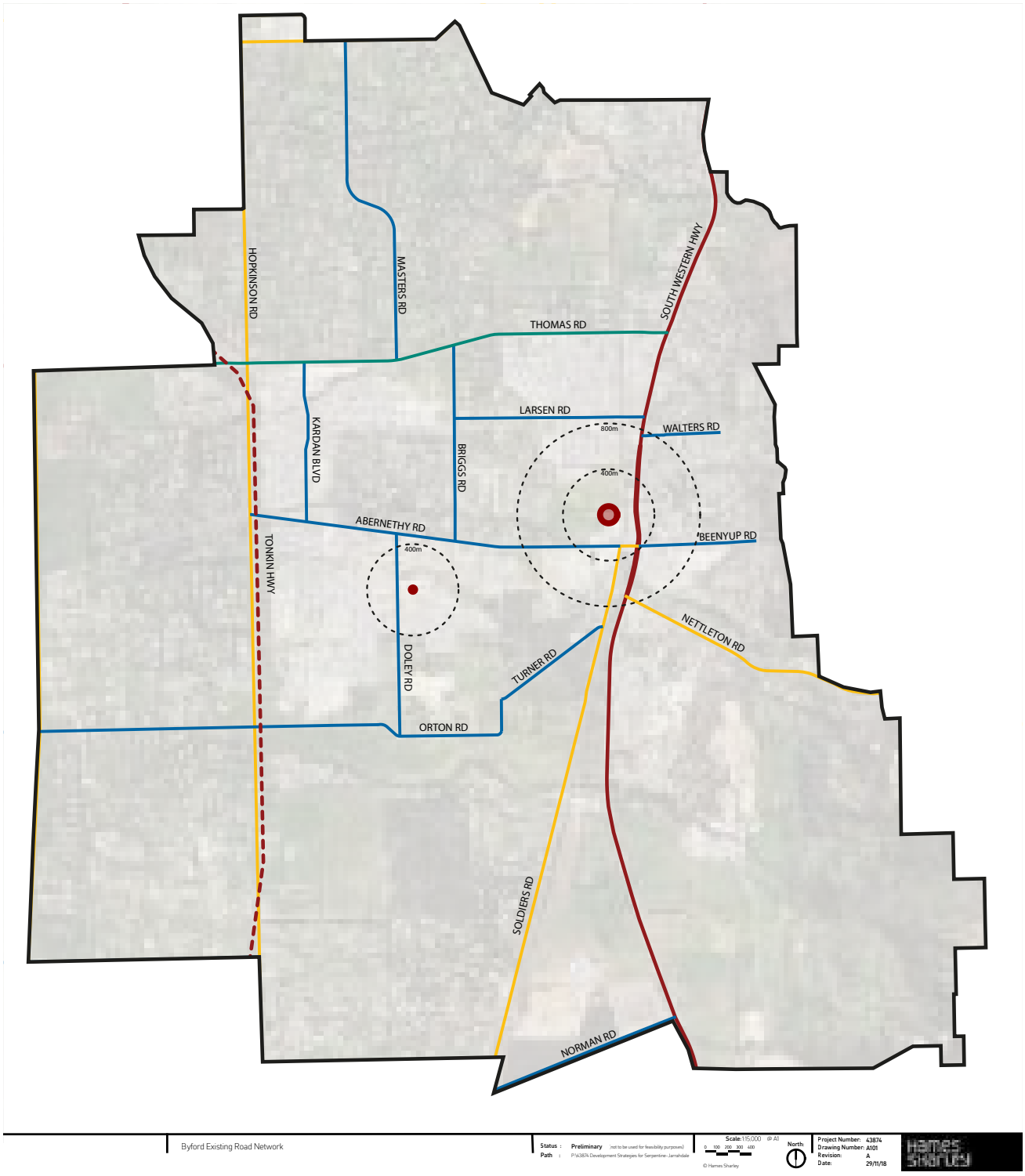
**Local Distributors**

The Byford District Structure Plan area includes a number of key roads which comprise the local movement network. Orton Road and Abernethy Road (east-west) are the main local distributor roads providing connectivity between residential areas to the Byford Town Centre.

To reinforce the Byford–Cardup–Mundijong road network, the South Metropolitan Peel Sub-Regional Framework identifies a number of upgrades, these are considered in the preparation of the Byford District Structure Plan and include:

- Extension of Norman Road westward to connect with Bishop Road, future investigations along this network will need to consider the impacts on Bush Forever sites located in adjacent;

*Figure 13: Existing Vehicle Movement Network*




## LEGEND

- BYFORD DSP BOUNDARY
- PRIMARY DISTRIBUTOR
- REGIONAL DISTRIBUTOR
- DISTRICT CENTRE
- DISTRIBUTOR A
- NEIGHBOURHOOD CENTRE
- LOCAL DISTRIBUTOR
- FUTURE PRIMARY DISTRIBUTOR

+ Additional north-south local distributor roads including the extension and upgrading of Wungong South Road to Wungong Road and the Eleventh Road,
+ Extension of Doley Road southward linking through to the Mundijong District Structure Plan area. Connecting Doley Road within the internal north-south network would require realignment of the southern portion of Malarkey Road with Doley Road. However, current conflicts of increased traffic movement along Malarkey Road, central to the Byford Trotting Precinct has triggered the review and potential modification of road alignments by the Shire in order to reduce through traffic and preserve the function of equine activity within the precinct.

## FREIGHT

The efficient movement of freight in the Shire is required to satisfy the needs of local business and industry and encourage economic growth. Global trends as well as the general growth occurring throughout the Greater Perth Region is placing additional pressure on the freight system. In addition, the impact that freight movement imposes on local communities including noise pollution and severance along freight routes is a source of concern. While the metropolitan-wide nature of freight movement restricts the Shire's ability to determine freight network locations, it does allow the Shire capacity to work with State Government to negotiate the location of industrial areas and mitigate the effects of freight on local areas.

The freight network in the Shire consists of major roads plus the existing Kwinana Freight Rail Line. While separation of freight from activity areas in accordance with *SPP 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* is required, current road freight traffic is still required to access businesses within centres and travel through local residential areas where pedestrians and cyclists commute. The volume of freight movement on the regional road within the Byford District Structure Plan area will increase substantially by 2050. This increase will be centred on interstate road and rail routes, particularly those servicing port facilities and connecting with existing and proposed intermodal terminals located Mundijong. The freight network is critically important to the Western Australian economy. Where practicable, these transport corridors will be protected from the encroachment of sensitive and incompatible land uses. This is an important consideration when identifying locations for infill housing development within the Byford District Structure Plan area. Similarly, the design, construction, upgrade and operation of this infrastructure within these corridors should seek to minimise impacts on surrounding land uses.

## PUBLIC TRANSPORT

A key component of providing effective transport connections within the Byford District Structure Plan area will involve improvements to the provision and frequency of public transport. Primarily, an improved public transport will be required to align with the needs of a growing population in the Byford District Structure Plan area, and to meet the need of connecting people to key employment nodes. Secondly, good public transport will be necessary to reduce congestion in the shorter term and increase road capacity for transport functions reliant on the regional road system, especially freight movement.

### Rail

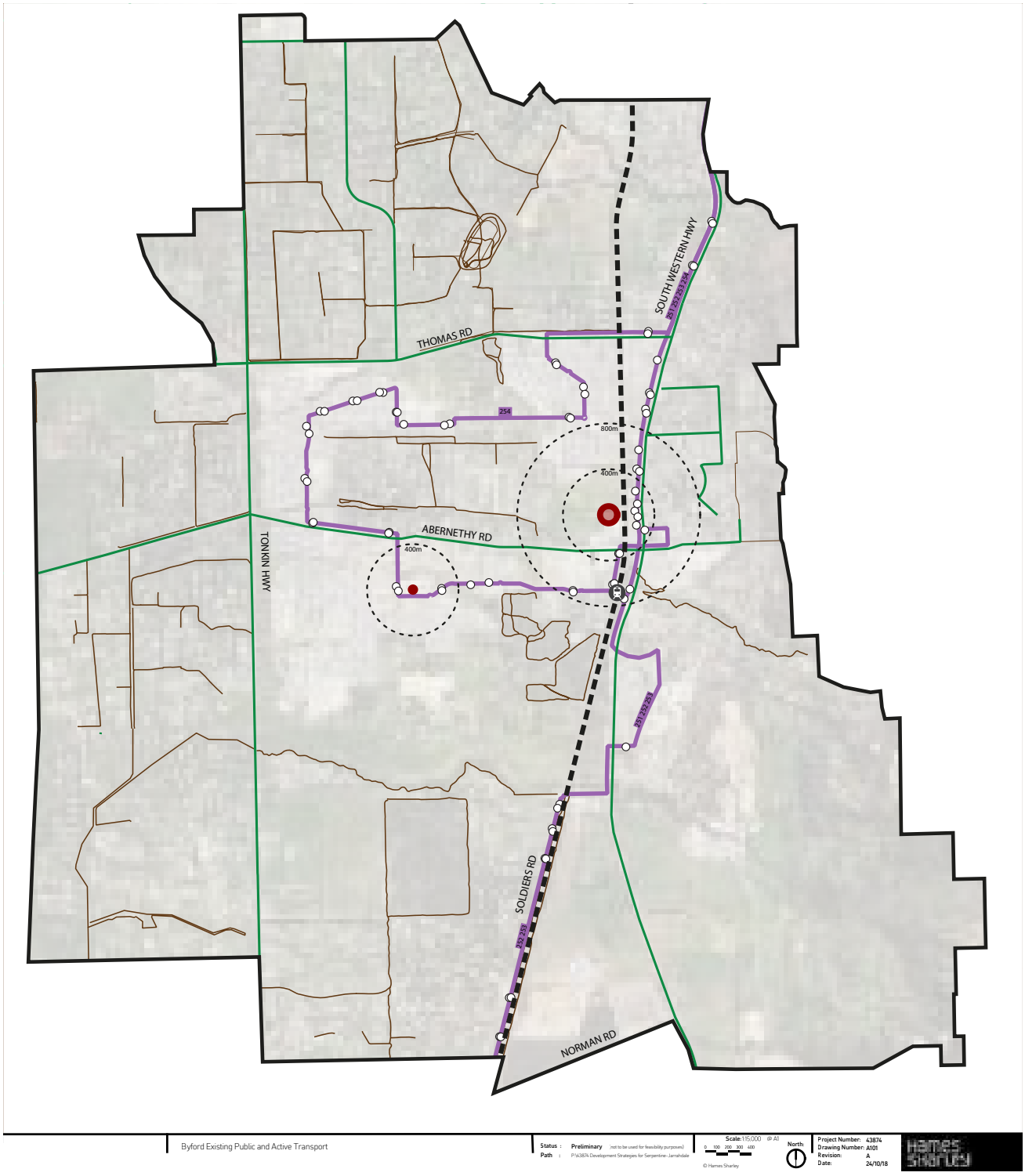
TransWA currently provides rail access to the Byford District Structure Plan area via the Australind rail service (Perth-Bunbury). The train station is located south of the existing Byford Town Centre on Soldiers Road (**Figure 14**). A limited service is provided which includes a morning and evening service everyday in both directions (four services total). Transperth commuter rail services currently terminate at Armadale. The proposed public transport network outlined within the South Metropolitan Peel Sub-Regional Framework includes an integrated network of passenger rail lines and transit corridors. Stage 1 METRONET passenger rail infrastructure within the Byford District Structure Plan area includes the proposal to extend the Armadale rail line to Byford. The ultimate location of the train station will be determined as part of this process.

### Bus

Bus services within the Byford District Structure Plan area are currently limited to four north-south services which connect to Armadale Train Station via South Western Highway. There are currently no east-west services that service major employment centres of Mandurah, Rockingham, or Kwinana. The existing bus routes include:

+ Bus route 254 which provides connections to majority of residential areas in Byford;
+ Bus route 251 terminates in south Byford; and
+ Bus routes 252 and 253 provide connections to Mundijong and Jarrahdale respectively.

*Figure 14: Existing Public / Active Transport Network*



The greatest transport challenge in the Byford District Structure Plan area is the lack of adequate public transport services to enable residents to access employment and education opportunities. The nearest commuter train station is in Armadale. This forces a dependence on private vehicles that is unsustainable and inequitable. As the population grows to the south and north of Byford Town Centre improved connectivity, particularly to the west would be required.

### ACTIVE TRANSPORT

Existing pedestrian and cycle network is very limited due to the rural nature of the area. Active modes of transport such as walking and cycling are currently available for short distance journeys within the urban areas. There are several opportunities for network improvements to address existing issues of disconnected streets, lack of footpaths, unsafe routes and long distances. Between the 2006 and 2016 Censuses, the proportion of people walking to work in the Byford area dropped from 2.7% to 0.6%. Low walking levels are largely due to the disconnected street systems, lack of footpaths, unsafe routes and long distances to most destinations. While there is a strong network base of bridle trails illustrated on **Figure 14**, the local network of paths are largely disconnected to major destinations. This highlights the need for pedestrian infrastructure to include built and planted features that provide amenities or affect pedestrian mobility, safety and comfort – these include the basic street pattern and road classification, as well as the provision of footpaths, pedestrian crossings, street trees, aesthetics and furniture.

## 2.2.6 SERVICE INFRASTRUCTURE

### WATER SUPPLY

The Water Corporation's existing water supply infrastructure that serves the South Metropolitan Peel Sub-Regional Framework includes several key water sources including surface water, groundwater and desalinated seawater. Water is transferred from sources to treatment and storage facilities by trunk mains that traverse the Shire. A reticulated water supply is available to all urban areas within the Byford District Structure Plan area and some rural residential areas. The Byford District Structure Plan area is currently supplied by a storage reservoir located in the northeast. As development has increased it has been necessary to increase the size of the existing storage reservoir. The South Metropolitan Peel Sub-Regional Framework identifies future conceptual water supply planning for the eastern Serpentine Jarrahdale sector where major water storage reservoirs will be necessary in the escarpment near Byford Tank (Byford) and Mundijong Reservoir (Jarrahdale) to serve long-term urban development in these areas (WAPC, 2018).

The Water Corporation undertakes water services planning and allocates funds for infrastructure upgrades on the basis of land use planning information. Where a development proposal requires drinking water headworks infrastructure, for which the Water Corporation has not allocated funds to suit the developer's schedule, prefunding of the works may be necessary (Urbaqua, 2018).

Where connection to a reticulated scheme water supply is not always possible for rural residential areas, the State Planning Policy 2.5; Rural Planning Policy (2016) recognises that there may be alternative service delivery models proposed and provides the following guidance for water supply as follows: :

- where lots with an individual area of four hectares or less are proposed and a reticulated water supply of sufficient capacity is available in the locality, the precinct will be required to be serviced with reticulated potable water by a licensed service provider, including water for firefighting. Should an alternative to a licensed supply be proposed it must be demonstrated that a licensed supply is not available; or
- where a reticulated supply is demonstrated to not be available, or the individual lots are greater than four hectares, the WAPC may consider a fit-for purpose domestic potable water supply, which includes water for firefighting. The supply must be demonstrated, sustainable and consistent with the standards for water and health; or
- the development cannot proceed if an acceptable supply of potable water cannot be demonstrated.

All rural areas are serviced by rain water tanks or groundwater bores or a combination of the two. SPP 2.7 Public Drinking Water Source Policy is critical because of the significant water demands that rural land uses require. A reticulated water supply is required for all new residential lots and special rural zoned lots of one hectare in size.

Due to the current availability of groundwater in the Byford District Structure Plan area, water recycling and reuse to provide fit-for-purpose sources of water may not be considered cost effective. However, the Shire is currently undertaking an Integrated Water Management Strategy where consideration of alternative methods for optimising (re) use of the total water cycle should be considered in any future development. This will also address the opportunity for alternative water service providers to facilitate where appropriate for current and future water assets within the wider area

### WASTEWATER

The Byford District Structure Plan area is currently served by the wastewater treatment plant in Kwinana. Urban areas in Byford are either sewered or have access to a reticulated sewer system. No sewer system is available to the rural or semi-rural areas.

Byford has a Special Developer Contribution area managed by the Shire referred to as the Byford Contribution Arrangement (BCA). Home owners in the remainder of the Shire operate on-site effluent disposal systems. A proposed Byford Pressure Main to East Rockingham Wastewater Treatment Plant is also proposed in the medium term.

The draft State Sewerage Policy (Department of Planning, 2016) will introduce more specific requirements for disposal of wastewater through off-site (reticulated) and on-site systems. All proposed lots must be capable of the treatment and disposal of all sewage within a designated land application area within the property boundary of each individual green title lot or survey strata, outside of any applicable public health and environmental setbacks. Where lots are less than 2,000m$^2$ secondary treatment systems with nutrient removal may be required. The opportunity for alternative wastewater service providers facilitated where appropriate within the Shire is currently under review with the Shire as part of an Integrated Water Management Strategy.

The Water Corporation has planned water and wastewater services for all land currently zoned Urban and Urban Deferred in the sub-region. Urban Expansion and Investigation areas are capable of being serviced within the timeframe of the framework, subject to the staged provision of new and/or upgraded infrastructure. However, these will require detailed investigation prior to zoning to ensure the orderly and financially sustainable provision of water and wastewater services. Further investigations are required to confirm servicing capabilities for Planning Investigation areas (WAPC, 2018).

## 2.2.7 ENVIRONMENT AND LANDSCAPE

### FLORA AND FAUNA

#### Conservation Significant Flora

The Shire is located within the Kwongan ecoregion of the South West Australian Floristic Region, which is one of only twenty-five biodiversity hotspots in the world. The Shire is part of two of Western Australia's bioregions - the Northern Jarrah Forest subregion, which includes the plateau and Darling Scarp in the east of the Shire, and the flat low lying Swan Coastal Plain subregion in the west of the Shire. The Swan Coastal Plain Bioregion, which makes up most of the Byford District Structure Plan area, is dominated by woodlands of Banksia and tuart on sandy soils, she-oak on outwash plains and paperbark in swampy areas.

Thirty-five species of threatened flora (including seven Declared Rare Flora (DRF) are recorded in Environmentally Sensitive Areas identified within the Byford District Structure Plan area. These are mostly found on verges, drains, private land and railway reserves. The Salmon White Gum (Eucalyptus lane-poolei), a conservation significant flora species, has been identified within the Byford District Structure Plan under 'Native Vegetation'. The Salmon White Gum is uncommon in the metropolitan region and is found only in a few places in the Foothills around Keysbrook, Mundijong and Byford.

Threatened Ecological Communities (TECs) and their associated threat category are assessed by the Department of Environment and Conservation. TECs are identified by the floristic community type (FCT) classification which has been identified and classified based on species composition across the Swan Coastal Plain. TECs are included with a number of other Biodiversity Features and their buffers in areas designated as "environmentally sensitive areas" (**Figure 15)** and protected under the Environmental Protection Act, 1986 (WA). Scheduled TECs are also further protected at the

Commonwealth level under the EPBC Act. Where the TEC is a wetland, the buffer distance incorporates the minimum area to protect the wetland from developments with potential to impact hydrology.

**Bush Forever**

While much of the Byford District Structure Plan area has been cleared as a result of previous land use and mining activities, the majority of vegetation and TECs remaining falls within Bush Forever sites 354, 350, 365, 362, 360 and 71. (**Figure 15**). The vegetation condition for these sites is mostly good to excellent condition. Descriptions are provided below:

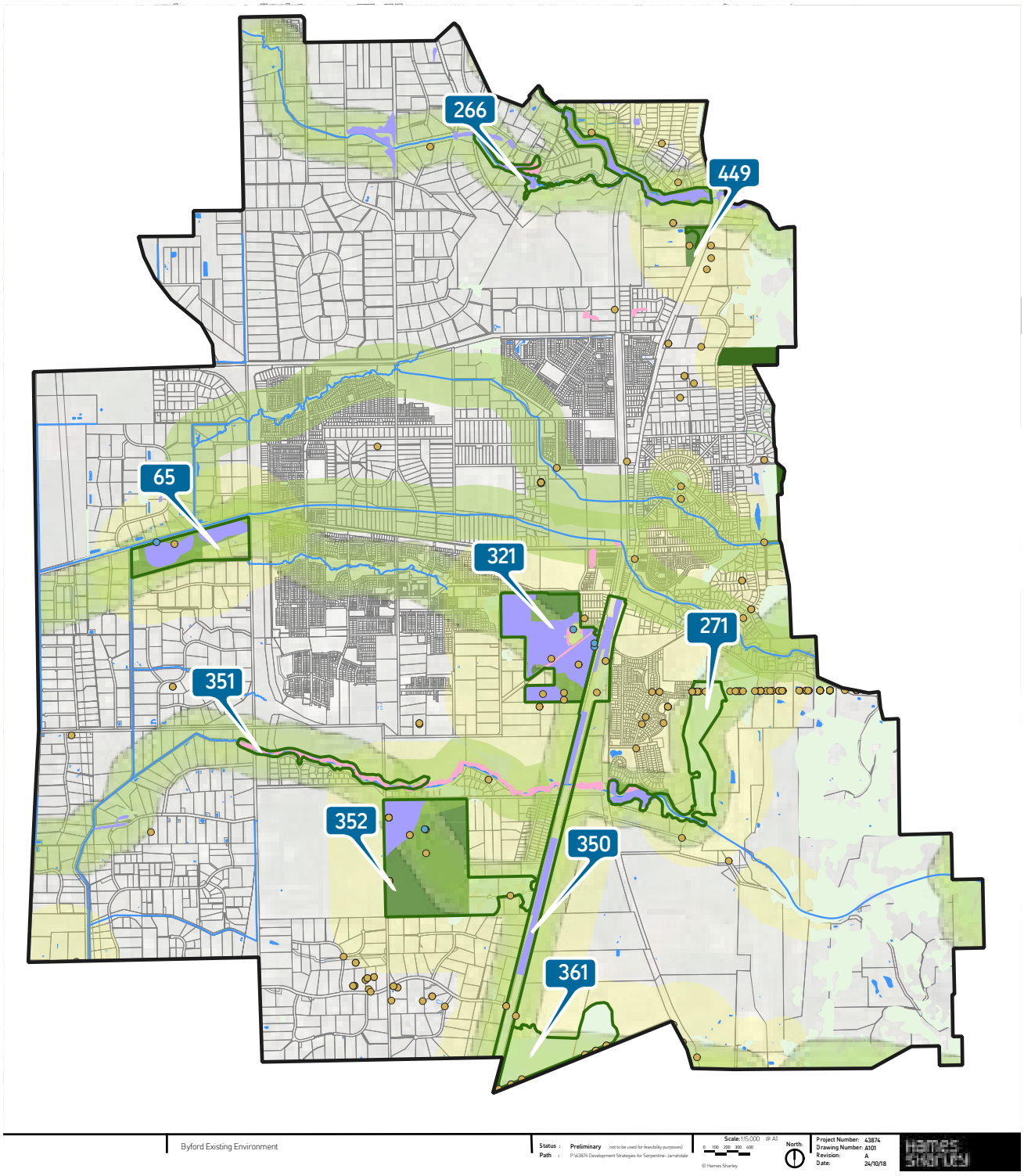
- **Bush Forever Site 350** is representative of significant areas of remnant vegetation, recognised by the Shire as the Soldiers Road Flora Road (Shire of Serpentine-Jarrahdale 1992, Keighery 1996c cited from WAPC, 2000). With Bella Cumming Reserve this Flora Road forms Bush Forever Site 350. The Flora Road is a significant vegetation asset as it contains a north-south transect of plant communities, which is representative of the eastern side of the Swan Coastal Plain (WAPC, 2000). Bush Forever Site 350 also contains three TECs. The vegetation condition along Soldiers Road is considered to be 50% excellent to very good and 50% good to completely degraded, with areas of localised disturbance. The vegetation for the Bella Cumming Reserve is considered to be excellent to very good.
- **Bush Forever Site 352** contains two TECs. The condition of the vegetation was found to be 90% excellent to very good and 10% good. The boundary of Bush Forever Site 354 has been successfully renegotiated with the WAPC by Urban Pacific.
- **Bush Forever Site 351** contains plant communities representative of the eastern side of the Swan Coastal Plain (WAPC, 2000), and two TEC's. The condition of the vegetation has been found to be 75% very good to good and 25% good to degraded, with areas of severe localised disturbance.
- **Bush Forever Site 361** contains plant communities representative of the eastern side of the Swan Coastal Plain and is linked to the adjacent bushland/canopy along Site 350; part of Greenway 106; and part of regionally significant fragmented bushland/wetland linkage (WAPC, 2000).
- **Bush Forever Site 321** contains plant communities representative of the eastern side of the Swan Coastal Plain (WAPC, 2000), two TEC's and a significant cluster of native fauna. The condition of the vegetation has been found to be 80% very good to good and 20% good to degraded, with areas of severe localised disturbance.
- **Bush Forever Site 271** containing plant communities representative of the eastern side of the Swan Coastal Plain (WAPC, 2000). The condition of the vegetation has been found to be have less than 70% good to very good to good with degraded patches and areas of severe localised disturbance.
- **Bush Forever Site 266** linked to the adjacent bushland/canopy to the west adjacent creekline canopy to the east; part of Greenways 70, 106, 119 ; and part of a regionally significant fragmented bushland/wetland linage. The vegetation condition varies from patches in Excellent Condition to Completely Degraded (WAPC, 2000).
- **Bush Forever Site 65** contains plant communities representative of the eastern side of the Swan Coastal Plain (WAPC, 2000), two TEC's. The condition of the vegetation has been found to be 50% good and 50% degraded, with areas of severe localised disturbance.
- **Bush Forever Site 449** forming part of the adjacent Greenways 62 and 114, contains plant communities representative of the eastern side of the Swan Coastal Plain (WAPC, 2000), one TEC. The condition of the vegetation has been found to be 50% good and 50% degraded, with areas of severe localised disturbance.

For any future detailed local structure planning within the Byford District Structure Plan area, consideration should be given to contemporary mechanisms to retain and protect existing DRF, TECs, Conservation Category Wetlands and other environmental assets to the area, as well as achieving appropriate tree coverage. This will include the integration of mechanisms proposed within the Urban Forest Strategy currently being prepared by the Shire. This may considers the incorporation of trees into the Shires asset register through appropriate valuation.

**Darling Scarp – Landscape Protection**

One of the most outstanding landscape elements of the Shire and one which lends much to the character of both the rural and urban areas within the Byford District Structure Plan area, is the backdrop provided by the Darling Scarp. As encapsulated in the text of LPP 8 Landscape Protection Policy, every landscape has a different capacity to successfully

*Figure 15: Existing Environment*



absorb change such as new development including subdivision, infrastructure works and extractive industry, and some landscapes are more valued by the community and more sensitive to change than others.

LPP 8 targets areas of high landscape value and aims to maintain the integrity of significant landscape areas and features. In particular, such areas occur all along the escarpment between the railway line and the top of the escarpment in a line of sight (viewshed) from the South Western Highway and along some major watercourses. Preservation of these viewsheds will need to be considered for any future development within the Byford District Structure Plan area.

**Areas of Natural Beauty**

The Scheme contains provisions relating to Places of Natural Beauty, Historic Buildings, and Objects of Historical or Scientific Interest, where clearing of land or removal of trees is not permitted without the approval of Council. Within the Byford District Structure Plan two areas are identified. The Red Gum Patch, on the corner of Alice and Redcliffe Road, Cardup and another located along Kiln Road within the south eastern boundary (**Figure 15**). Any future planning in or around these sites will need to take into consideration these provisions.

**Ecological (Green) Links**

The Byford District Structure Plan area includes a system of green linkages which connect isolated natural areas, including a number of major waterways. As illustrated on **Figure 15**, Ecological (Green) Linkages running east-west align themselves with natural drainage areas. The Regional Ecological Linkages have been previously designated by the State Government as part of Bush Forever, Perth's Greenways and the System Six Study, and are now reflected in the South Metropolitan Peel Sub-Regional Framework, although it is noted that only those designated as Bush Forever have some protection for conservation purposes.

The Ecological Linkages should not be confused with Multiple Use Corridors (MUC's) and Trails, which were not developed on ecological criteria and are not expected to achieve significant biodiversity conservation. However MUC's do form an important part of the ecology and environmental connections across the Shire.

Identification of Ecological Linkages is designed to protect existing natural areas that occur along the linkages, improve their resilience through management and re-vegetation of their buffers, and allow safe movement and growth of fauna and flora. It is noted, however, that many ecological linkages are associated with infrastructure corridors for roads, rail and drainage as illustrated in **Figure 15**, and are generally reserved for purposes other than conservation. Accordingly, many ecological corridors are often subject to disturbance (Essential Environmental, 2016).

Ecological links are important to facilitate fauna movement and species adaptation to changing climate and conditions. Where these linkages are associated with infrastructure corridors, consideration should be given to the achievement of multiple objectives including biodiversity conservation through, for example, modification to the reserve purpose. Multiple Use Corridors can also provide important linkages where native vegetation and habitat is created.

**Conservation Significant Fauna**

The Swan Coastal Plain was once home to a great abundance and diversity of fauna, but habitat loss and alteration have severely reduced most populations. Around 140 species of birds occur here and the populations of almost half have declined significantly. Thirty-three mammals were once recorded on the Swan Coastal Plain. Recent surveys often record only three mammals (western grey kangaroo, common brushtail possum and southern brown bandicoot).

One of the key species of focus of the Perth and Peel Green Growth Plan for 3.5 million is Carnaby's Black Cockatoo (Calyptorhynchus latirostris), a species of Specially Protected Fauna known to feed, breed and roost throughout the Byford District Structure Plan area. They are a partially migratory species that breed in the wheatbelt in winter to mid-spring and wander in flocks to coastal areas for foraging in the non-breeding season.

This bird species is listed as Critically Endangered under the Commonwealth EPBC Act and is now reliant on parkland areas in the Shire for feeding habitat. The main threats to the long-term survival of the species are loss of nesting hollows and food resources due to land clearing. Within the Byford District Structure Plan area, a number of hollows have been identified within Bush Forever zones south of Abernethy Road. Retention of the majority of existing remnant vegetation within the Byford District Structure Plan area will limit the impact on these species.

## BUSHFIRE HAZARD

In accordance with the Map of Bush Fire Prone Areas gazetted by the Department of Fire and Emergency Services, the large majority of the Shire is classified as a bushfire prone area, with the exception of areas cleared for urban development, large water bodies, and areas affected by mining.

Areas within the Byford District Structure Plan have been identified as bushfire prone so will require detailed Bushfire Hazard Assessment and application of Bushfire Management Plans to address bushfire risk in order as is the requirements of SPP 3.7: Planning in Bushfire Prone Areas and the Guidelines for Planning in Bushfire Prone Areas.

Likely measures for future planning and development include the provision of hazard separation through the placement of roads and/or managed local open space abutting areas of retained vegetation, and application of BAL construction standard requirements to lots in close proximity to areas of retained vegetation. Detailed assessments will be required as a routine component of the preparation of local structure plans.

## LANDFORM AND SOILS

### Land Form

The topography of the Byford District Structure Plan area, as shown in **Figure 16** at 5m contours, captures the unique topography and landform typical of the Shire with two distinct halves. To the west of the South Western Highway, the terrain is relatively low flat palusplain (seasonally waterlogged land), typical of the Swan Coastal Plain, whilst the eastern portion is characterised by undulating ridge peaks and troughs of the landform of the Darling Plateau. At the junction of the two landforms, known as the Darling Scarp, the topography is steep, with an average gradient of five percent.

The topographic features of the Darling Plateau and Darling Scarp allow for substantial water bodies to form, such as the Serpentine and Wungong Dam, and are an important catchment for surface water runoff.

The Swan Coastal Plain has changed significantly, most importantly by draining of the extensive wetlands that once covered it for much of the year. Many of the drains intersect the groundwater, causing drawdown and reducing soil moisture content. The plain soils within the Byford area have been extensively cleared for agricultural and residential uses.

### Soils

The soils of the Byford District Structure Plan are reflective of the topography. The eastern Darling Scarp typically has a geology of gneiss, granite and shale with colluvium soils of gravel, clay-silt-sand, whilst the Swan Coastal Plain having the Guildford Formation of shallow sands over a basal conglomerate (typically clay). The three primary soil types across the Byford District Structure Plan area are:

- Ridge Hill colluvium from the Yogannup formation (S12) – highly variable layers of gravelly to sandy clay with lenses of silt and gravel
- Guildford clay (Csg) – lenses of sandy clay, clayey sand, iron-rich cemented sand and sand. Low horizontal conductivity and very low vertical conductivity
- Bassendean sand (Cs) – bleached grey to pale yellow sand with little ability to retain moisture or nutrients

Ridge Hill colluvium is found to the east of the study area, in the region of the Darling Scarp. To the west of the study area Guildford clay can be found interlaced with Ridge Hill colluvium. Overlaying the Guildford clay is Bassendean sand, which occurs in thin layers across the majority of the site.

Development in areas of seasonally waterlogged soils must be constructed to withstand these conditions. This has traditionally required the use of fill; however, declining access to said fill is likely to lead to the use of alternative construction techniques and footings (Essential Environmental, 2016). Local structure planning for development areas remaining in the Byford District Structure Plan area should give consideration for alternative methods of constructions.

**Acid Sulphate Soils**

Acid sulphate soils (ASS) are soils and sediments that contain iron sulphides. They are harmless when left in a waterlogged, undisturbed environment. However, when exposed to air, through drainage or excavation, the iron sulphides in the soil react with oxygen and water to produce iron compounds and sulphuric acid.

ASS in the Byford District Structure Plan, are located to the west of the South Western Highway (**Figure 16**) consist of moderate to low risk of actual ASS or potential ASS occurring generally at greater than 3 m depth. Low to no risk of actual ASS or potential ASS occurring generally at greater than 3 m depth can be found to the east of the South Western Highway in the Byford District Structure Plan area. While the risk of ASS being exposed to oxidation due to development in the Byford District Structure Plan area is considered low, as part of development requirements, new developments within the area will need to introduce fill to a depth that is acceptable for residential construction as well as provide suitable flood clearance and adequate subsoil drainage (Urbaqua, 2018).

## 2.2.8 NATURAL RESOURCES

### WATER RESOURCES

Environmental impacts within the Shire affect significant water resources in the region with parts of the Peel Harvey Catchment and Jandakot Groundwater Mound located within the Shire. It is therefore crucial that the Shire's environmental values are preserved and that natural areas, areas of significant vegetation, wetlands and waterways are protected, preserved and enhanced as a central element of liveability and a defining characteristic of the Shire.

**Ground Water**

The most significant groundwater resources underlie the Swan Coastal Plain portion of the Shire. This includes the superficial aquifer, which is unconfined and recharged by rainfall, and the deeper, confined aquifers of the Leederville and Yarragadee. Groundwater is generally within 3 metres of the surface in areas of sand. For areas where groundwater is at the surface this is reflective of the palusplain soil type that occurs on the Swan Coastal Plain. Groundwater quality is generally good but information on groundwater quality is limited (Essential Environmental, 2016).

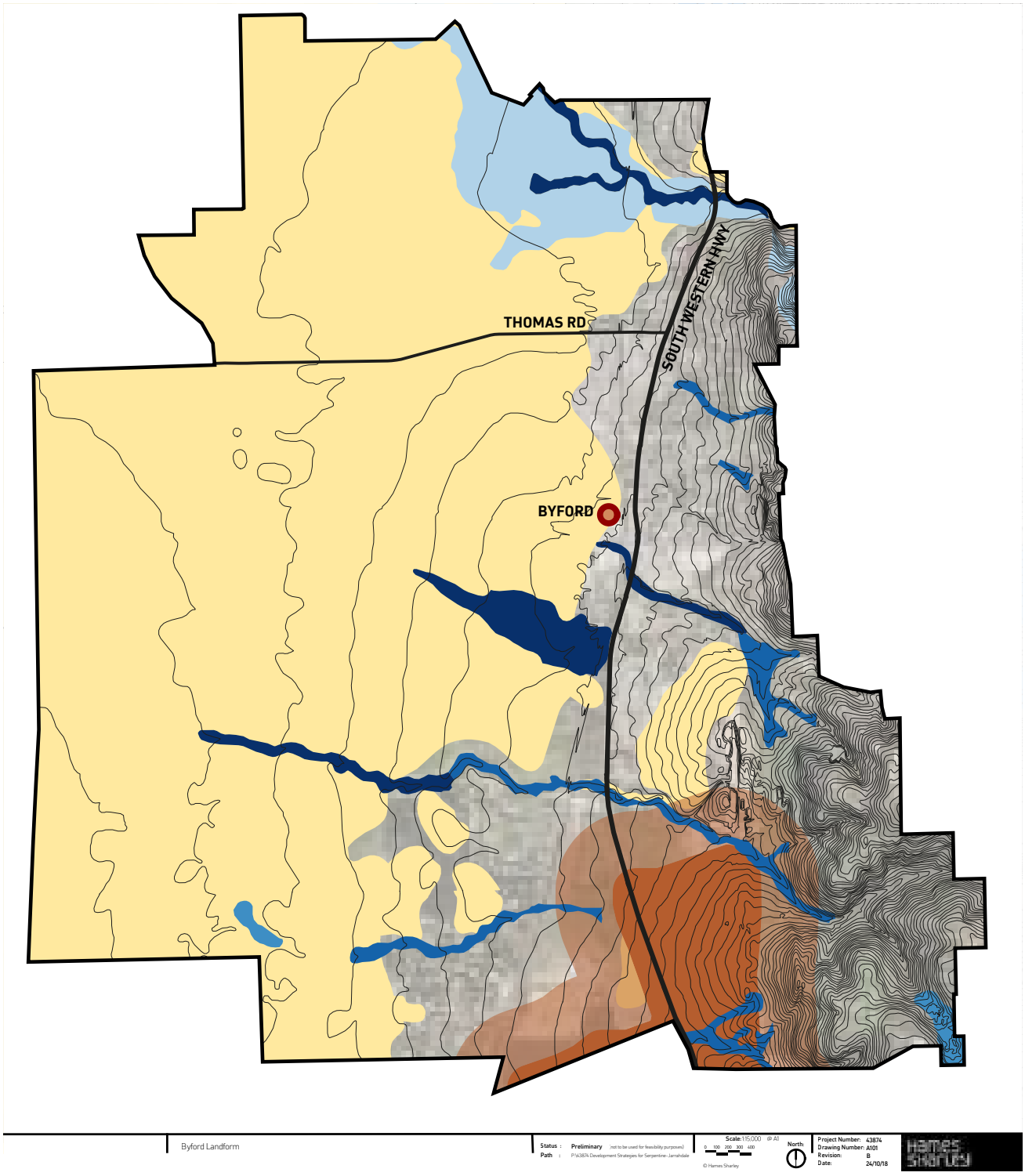
There are approximately 150 private groundwater bores in the Byford District Structure Plan area, the majority of which target groundwater in sand lenses at the base of the Guildford clay at 17.5 – 25 m below natural surface level (Urbaqua, 2018). Because of the local geology, groundwater in the Byford District Structure Plan area is often perched during the winter months. The installation of improved surface and subsurface drainage systems is likely to quickly export this perched water into the drainage system, rather than allowing it to sit and gradually subside. This is likely to result in reduced deep aquifer recharge and increased drain baseflows (Urbaqua, 2018).

Based on current allocation limits and availability, it is evident that there is sufficient groundwater allocation available to provide for future public open space irrigation demands. However, it is important to note that allocation limits may be reduced in response to climate change impacts and other groundwater management issues. At the same time, sustainable yield from the superficial aquifer in the Byford District Structure Plan area is significantly restricted due to clay soils. Developments affected by this issue may require numerous shallow, low-yielding bores and/or require a supplementary irrigation source. It is likely that 'fit-for-purpose' water could be provided to industrial areas to reduce the use of potable (Scheme) water (Urbaqua, 2018).

The Shire is currently undertaking an Integrated Water Management Plan to investigate water recycling and reuse, such as the reuse of fit-for-purpose water for irrigation of public open spaces, as a means to reduce demand and improve efficiency. These principles should be adopted for any future development within the Byford District Structure Plan area.

Clearing of land for agriculture and/or development may result in threats to water quality, including exposure of ASS, sediment and nutrient export and chemical pollutants. While the risk of ASS being exposed to oxidation due to development is considered low in the Byford District Structure Plan area, new developments will need to introduce fill or alternative building practices including appropriate footing methods to a depth that is acceptable for residential construction as well as provide suitable flood clearance and adequate subsoil drainage.

*Figure 16: Existing Landform, Soils and Flood Risk*



**Surface Water**

The most notable waterway within the Shire is the Serpentine River, which forms part of the Serpentine Dams (Serpentine Reservoir and Serpentine Pipehead Dam), traverses the Shire southeast flowing through the western boundary of the Shire. As a result, several waterways traverse the Byford District Structure Plan area in a generally westerly direction from the scarp as shown in **Figure 16**. The most ecologically significant of these watercourses include Wungong River, Cardup Brook and Beenyup Brook, and less so the Birrega Main Drain and Oaklands Drain. Each of these watercourses are highly incised and their beds are usually a few metres below the surrounding land surface (Urbaqua, 2018).

The Byford District Structure Plan area is known to experience regular water logging in the low-lying areas to the west of the area. As outlined within the Byford District Water Management Strategy, 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, as well as poor drainage due to palusplain soils, with insufficient capacity that does not allow runoff to leave the area. There is also potential for wetlands within the Byford District Structure Plan area to receive additional flood water from outside their natural catchment by overtopping of drains and watercourses. There are several local depressions east and west of the South Western Highway, which result in local perching of surface water after a large rainfall event. These areas will require recontouring and / or management as part of any redevelopment.

As intensive and residential land use grows, Peel Harvey catchment ecosystem is increasingly under pressure from eutrophication due to increasing nutrient export. Filling of the land has resulted in a loss of wetlands and the installation of drains has significantly altered the hydrology of the landscape. This results in a loss of environmental values. Consideration must be given to the natural water cycle as part of any future development in the Byford District Structure Plan area in order to re-establish lost values and design systems to cope with soil waterlogging and minimise nutrient and sediment export.

The Shire currently stipulates a high standard of water sensitive urban design in areas of new development, with particular focus on treatment of sub-soil drainage. This practice should be maintained through all new development. The Shire also has a policy requiring re-vegetation, including streamlining, as a condition of subdivision approvals. The potential to ameliorate export will depend on planting quality and compliance. Landfill sites are a potential source of pollutants to ground and surface waters, and must be carefully designed, managed and monitored to avoid impacts.

**Flood Risk**

The Serpentine catchment provides around 15% of the annual surface inflow to the Peel-Harvey system. As illustrated in **Figure 16**, many brooks pass through the Byford District Structure Plan area, flowing down from the Darling Scarp across the Swan Coastal Plain. These waterways are a key natural attribute attracting residents to the area. However there is an associated flood risk to development near any waterway. Flood levels illustrated on **Figure 16** indicate large areas of the Byford District Structure Plan are susceptible to flooding under an ARI 100yr rainfall event. The central spine of the Byford District Structure Plan area is most at risk to widespread flooding, particularly along major roads. The eastern side of the Byford District Structure Plan area is categorized by long thin flooded areas protruding from the main body of flood water.

The Shire currently reviewed its floodplain management strategy within the Byford District Water Management Strategy (Urbaqua 2018) for the Byford area with indicative flood levels and provisions for minimum habitable building floor heights. In accordance with both SPP 2.9: Water Resources and LPP 6 Water Sensitive Design, a similar approach will be required to support any further development within the Shire in proximity to waterways to minimise risk of flooding.

## BASIC RAW MATERIALS

Basic raw material resources occur within the Shire providing an important natural resource in close proximity to developing urban areas. It is important to identify the location of basic raw materials to ensure that these resources are protected and remain in non-urban zones. It is important for land use planning to consider environmental assets and natural resources at a strategic level to ensure that more detailed planning and development does not compromise the integrity of environmental systems and the accessibility of natural resources.

The Byford District Structure Plan area has significant resources in the south eastern portion of the site (**Figure 16**). Clearing of the land for resource extraction can result in a loss of biodiversity and can lead to erosion. Mining activities also impact on the visual landscape of the Shire and can result in off-site impacts on nearby land uses including dust, noise and light. For industries operating within these areas, strong guidance should be provided for future rehabilitation and mine closure planning.

## 2.2.9 HERITAGE AND CULTURE

Heritage places, including places of natural heritage value, are important contributors to the visual character and cultural identity of the Byford District Structure Plan area. The area has a rich history, and contains many places of cultural heritage value to both Aboriginal and non-Aboriginal people. Recognising, respecting and celebrating heritage is a way of adding meaning to place, helping people to connect to and value the places they occupy, and to learn from the past.

### ABORIGINAL HERITAGE

The original inhabitants of the Serpentine-Jarrahdale area are the Gnaala Karla Boodja Aboriginal people of the Noongar group of south-west Western Australia. The Department of Aboriginal Affairs maintains a register of known Aboriginal Heritage Sites, which records the places and objects of significance under the *Aboriginal Heritage Act 1972 (WA)*. Under this Act, obligations exist precluding the interference with registered sites without prior clearance, and disturbance of any artefacts discovered. This will need to be observed by any development within the Byford District Structure Plan.

A number of Aboriginal Heritage Sites and one other Aboriginal Heritage Place have been registered in the Byford District Structure Plan area which are mapped on **Figure 17**. These sites are concentrated in the southern portion of the Byford District Structure Plan area close to Cardup Brook and Cardup Reserve. Prior to future subdivision and development in the Byford District Structure Plan area, it is recommended an assessment be undertaken by a qualified consultant to determine where more thorough Aboriginal heritage investigations are required.

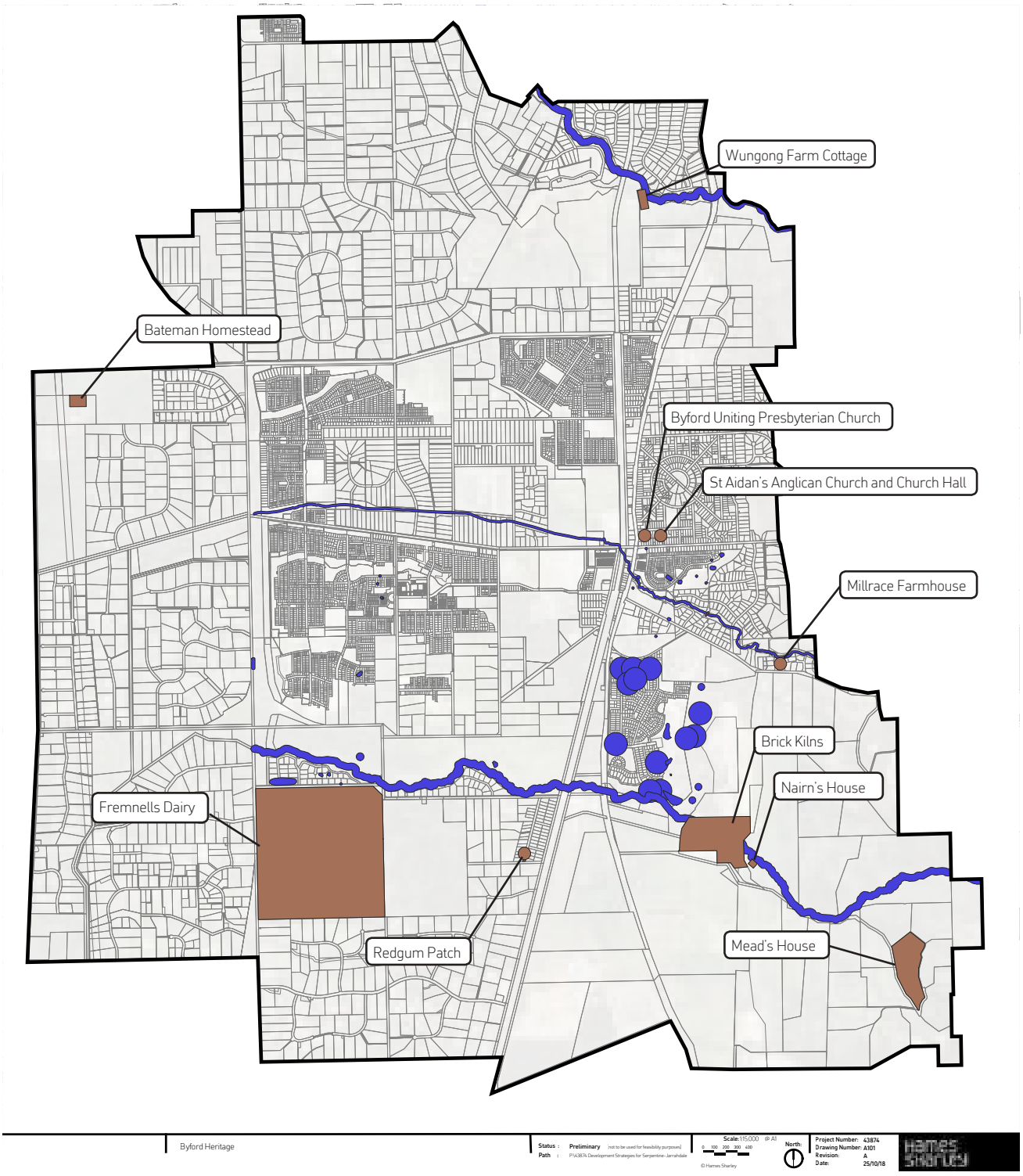
### NON-ABORIGINAL HERITAGE

European settlement in the Shire of Serpentine-Jarrahdale dates from the 1830s, with land cleared and used primarily for farming and obtaining timber. The population was minimal until the late 1800s when many townships were established (including Byford, Cardup, Jarrahdale, Mundijong, and Serpentine), aided by the opening of timber mills in the 1870s and the construction of the South Western Railway from Perth to Bunbury in 1893, originally for timber transportation. Brickmaking was also a significant industry which contributed to the development of Byford and surrounding townships during this time, after the discovery of shale in Cardup in the 1850s. The Cardup brickworks did not close until 2012.

A number of historic heritage sites within the Byford District Structure Plan area (**Figure 17**) are located and registered with both the Heritage Council of WA State Register and the Shire of Serpentine-Jarrahdale Municipal Inventory. In total, ten sites within the Byford District Structure Plan area are listed on the Shire of Serpentine Jarrahdale's Municipal Heritage Inventory. Places entered in a Municipal Inventory do not have legal protection unless they are listed in a separate Heritage List linked to the local Town Planning Scheme, or are already entered in the State Register of Heritage Places.

Adaptive reuse of heritage buildings is an important aspect of heritage conservation as defined by the Australia ICOMOS Charter for Places of Cultural Significance (Burra Charter, 2013) If owners of heritage cannot continue to use places for contemporary purposes, there is a risk that those places will become neglected and could be lost. The challenge within the Byford District Structure Plan is to encourage adaptive reuse whilst retaining the significant elements of the place, not possible without an assessment of those values. While heritage is primarily managed through State and Commonwealth legislation, opportunities exist to protect and promote both Aboriginal and European cultural heritage through joint management arrangements with traditional owners and optimise opportunities for Indigenous training, employment and businesses.

*Figure 17: Existing Heritage Places*



# 2.3 Opportunities and Challenges

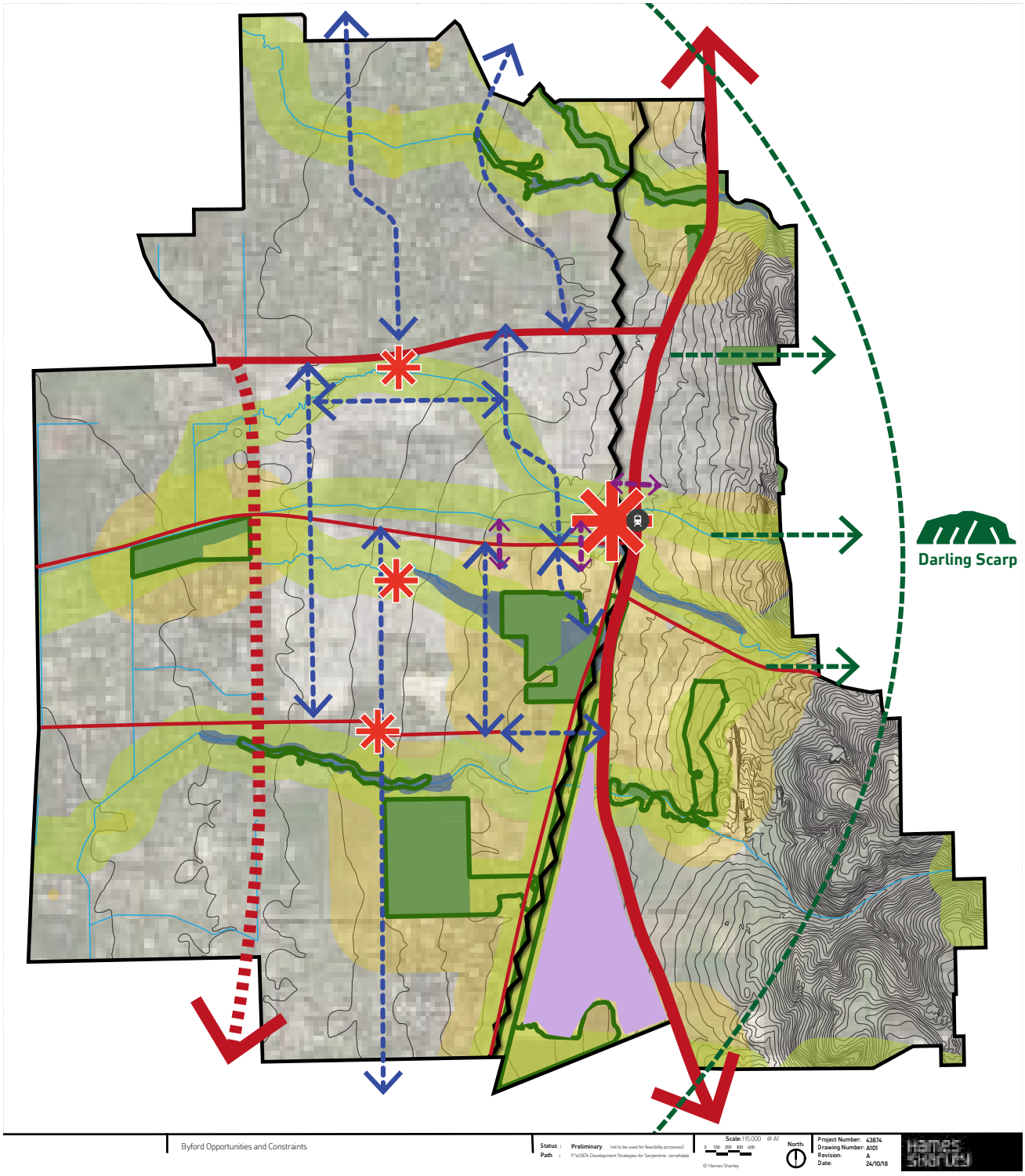
The analysis above has determined a number of opportunities and challenges for the Byford District Structure Plan area. These are summarised in **Table 8** and on **Figure 18**, they will assist in shaping the framework for a revised Byford District Structure Plan.

*Table 8: Opportunities and Challenges in Byford District Structure Plan Area*

| BYFORD | OPPORTUNITIES | CHALLENGES |
|---|---|---|
| Land Use | + Byford Town Centre to consolidate as an urban centre with a distinctive character that builds on its unique sense of place and community.<br>+ Byford Town Centre established as an exemplar TOD with grade separated rail resulting in improved access and integrated transport and development outcomes.<br>+ Improve residential density and diversity in the Byford Town Centre to provide greater choice. | + Overcoming perceptions that Byford is losing its character by merging with metropolitan suburban development.<br>+ Lack of distinctive public spaces for community gathering.<br>+ Fragmented ownership will impact timing of development. |
| Economy and Employment | + Byford consolidated as a contemporary district town centre with a range of activities and employment opportunities including retail, civic and commercial.<br>+ Recognition of the value of Byford Trotting Complex and associated equine activity to the local economy.<br>+ Educational and training opportunities associated with practical and on-ground equine and environmental learning. | + Limited employment and training opportunities for young people.<br>+ Commercial and light industrial demands of a rapidly growing population. |
| Community and Social Infrastructure | + Strategic planning framework in place for delivery of community infrastructure.<br>+ Celebrate Byford's role as a family friendly place.<br>+ Enhance sport and recreation provision at Briggs Park through exploration of collocation opportunities with schools. | + Increasing population requires more funding, planning and development of new communities and associated infrastructure.<br>+ Limited provision of facilities for specific groups such as ageing population, and youth and young families. |
| Movement and Access | + Access to employment opportunities, retail and services, improved via improved public transport access through:<br>- Delivery of a rail extension to Byford via METRONET.<br>- Improved and potential rapid bus service along Soldiers Road and freight rail alignment linking centres within the Shire to other destinations.<br>+ Coordination of grade separated east-west links from South Western Highway across rail line to improve permeability across Byford District Structure Plan area.<br>+ Walking and cycling catchments to the Byford Town Centre, proposed railway station and neighbourhood centres – present opportunities to link to a wider cycle and pedestrian network and promote active and healthy communities.<br>+ Improved connectivity along streets and greenways for walking and cycling. | + Reducing physical barriers provided by the rail line and South Western Highway to improve east-west connectivity and therefore better integration and vibrancy in the town centre.<br>+ Lack of public transport between activity centres and regional destinations.<br>+ Long term planning and delivery of METRONET is unknown at this stage and will require land for park and ride facilities.<br>+ Traffic issues and road environments that do not provide safe and convenient active transport.<br>+ Safe pedestrian access to schools.<br>+ Access to Development Investigation Area to south of Cardup Brook identified in Perth and Peel @3.5 requires bridge and appropriate structure planning of area to north.<br>+ The widening of transport corridors are constrained by environmentally sensitive flora. |

| BYFORD | OPPORTUNITIES | CHALLENGES |
|---|---|---|
| Service infrastructure | + Consideration for precinct-wide sustainability including provision of services enabling disconnection of communities from centralised systems. This includes power, water, wastewater and non-drinking water.<br>+ Decentralised waste-management strategies which optimise reuse and recycling of waste materials. | + Groundwater in the Leederville aquifer is mostly allocated, with some remaining capacity within the superficial aquifer to supply groundwater for NDW (eg. public open space irrigation, aquifer recharge, agriculture and industrial use where quality is fit-for-purpose.<br>+ Lack of waste water provision.<br>+ Funding constraints for infrastructure provision. |
| Environment and Landscape | + The community's desire for a sustainable, connected and thriving community into the future supports many opportunities for environmental innovations.<br>+ Reserves, areas of natural beauty and Bush Forever sites reinforce the area's distinctive visual character.<br>+ Significant view corridors to the Darling Scarp reinforce the areas unique backdrop of natural beauty and its location in proximity to the region's national park and state forests.<br>+ Consideration should be given to the prioritisation of protection of Local Natural Areas for incorporation into LPS 3.<br>+ Natural drainage corridors provide for multi-use corridors to conserve existing vegetation, promote indigenous re-vegetation, providing recreational and active transport opportunities and surface drainage function. | + Declining rainfall and rising temperatures have the potential to impact on the health of the environment and the community, as well as the maintenance of public lands and capacity of infrastructure systems including those managed by the Shire;<br>+ Bush Forever sites, particularly along and east of rail line impacting on METRONET outcomes and consolidation of townsites.<br>+ Flood risk associated with drains running across the Swan Coastal Plain portion, which are managed to rural or urban drainage standards..<br>+ Less than 10% of vegetation complexes across the Swan Coastal Plain portion of the Shire are currently contained in secure conservation reserves, with only 12% remaining uncleared. Continued development in Byford District Structure Plan area may adversely affect local biodiversity if not managed.<br>+ The majority of the area is located within a Bush Fire Prone Area of WA as designated by the Fire and Emergency Services (FES) Commissioner. |
| Natural Resources | + Re-purpose former extractive industry sites and implement measures to ensure their rehabilitation upon closure.<br>+ Protecting more of the vegetation types in the Shire (i.e. Banksia Woodlands) | + Any further extraction of minerals and raw materials has the potential to impact on the health of the community and the environment through loss of vegetation, erosion, noise, dust and light.<br>+ Visual impacts of extraction industries could impact on tourism potential. |
| Heritage and Character | + Preserve character in areas that celebrate Byford's uniqueness such as the Old Quarter and Trotting Complex / Darling Downs.<br>+ Ensure built form solutions are site responsive, having consideration for land form, ground water and local climate.<br>+ Sound strategic planning framework that acknowledges local heritage and culture and recognises the value of history as well as innovation and looking to the future.<br>+ Aboriginal Heritage Places, State Registered and Municipal Inventory Places and areas under an Assessment Program provide the opportunity to celebrate the areas natural heritage value, its cultural identity and build the local economy through unique tourism opportunities. | + Heritage and culture is shifting from a rural and country town atmosphere to an urban settlement pattern which requires a different look and feel.<br>+ Subdivision of larger lots and removal of existing mature trees within the Old Quarter threatening the existing character. |

*Figure 18: Opportunities and Challenges*



# 3.0 THE STRUCTURE PLAN

# 3.1 Strategic Intent

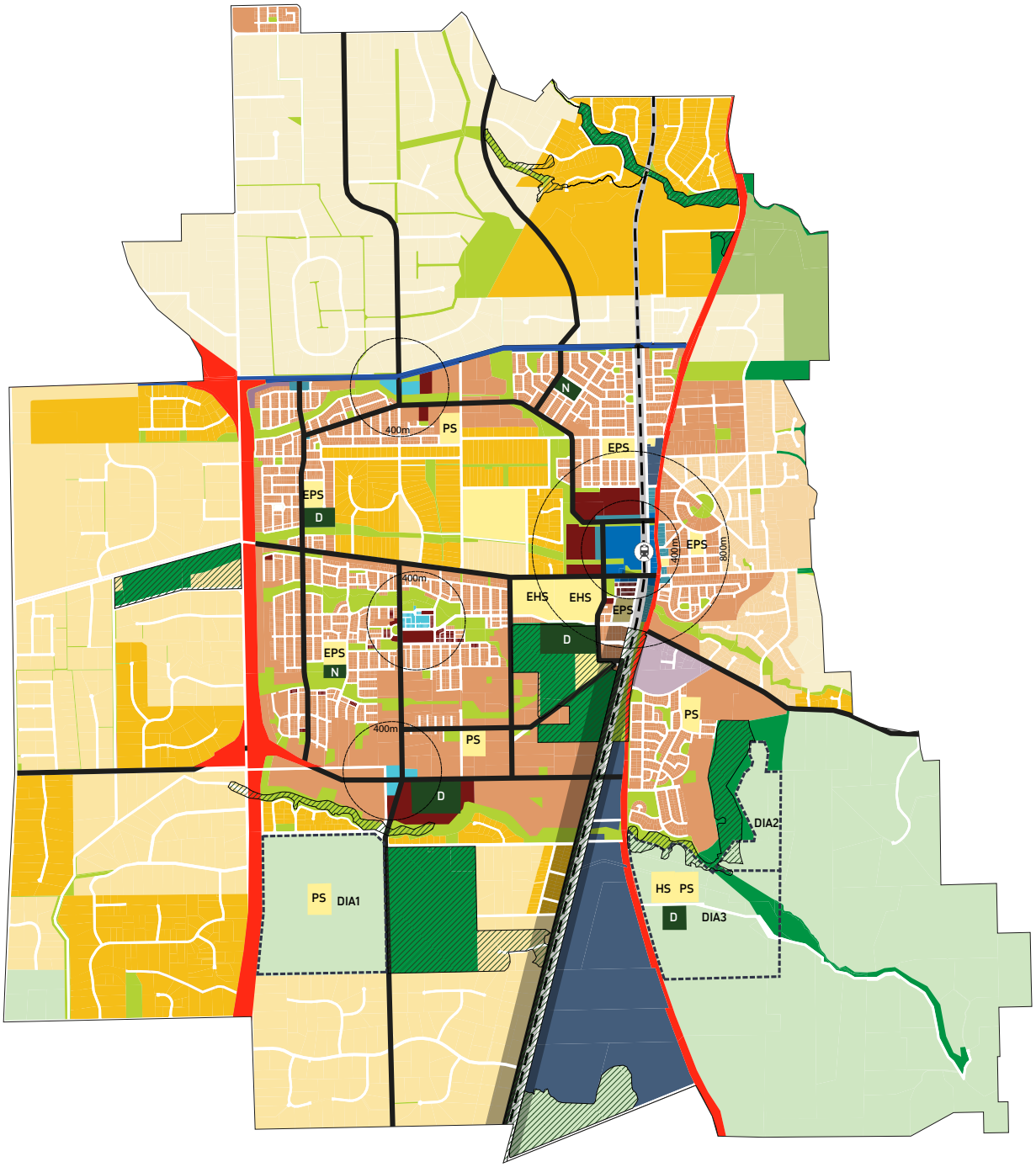
The Byford District Structure Plan (**Figure 19**) has been prepared in response to the South Metropolitan Peel Sub-Regional Framework, the draft Local Planning Strategy vision and objectives, and the key opportunities and challenges identified in **Section 2.3**. It seeks to consolidate all previous plans developed for the area to provide a revised Byford District Structure Plan.

This will be achieved through the following key changes (from the 2009 Byford District Structure Plan):

1. Redefined urban growth boundary which delineates a core and rural-residential fringe. This will accommodate future growth in a defined area and protect existing rural-residential areas.
2. Increased residential density in the Byford Town Centre and establishment of it as an exemplar example of a TOD based around the proposed Byford Railway Station.
3. 3. Identification of development investigation areas DIA1 (description as per 1.5.11), DIA2 (description as per 1.5.11) and (DIA3 (description as per 1.5.11).
4. Increased area of the Byford Town Centre.
5. Identification of neighbourhood centres to provide local services in close proximity to urban growth areas, in accordance with the relevant approved local structure plans.
6. Identification of the Cardup Business Park within the Byford District Structure Plan area.
7. Provision of a new high school and district open space in the southern portion of the Byford District Structure Plan area.
8. Extension of internal north-south road linkages to the west of Soldiers Road to provide for through connection between San Simeon Road and Turner Road;
9. Extension of Orton Road through to South Western Highway to reduce traffic congestion on Soldiers Road;
10. Extension of internal east-west linkage at Clara Street to facilitate internal movements around the Town Centre providing ease of access to parking and Kiss and Ride drop off zones;
11. Extension of the Tonkin Highway providing a major freight route to Mundijong;
12. Identification of character protection areas;
13. Identification of LSP areas and the matters to be considered within each LSP area; and
14. Cardup Business Park changed from Industrial to Service Commercial.

The following section provides additional detail and justification for the changes proposed above.

*Figure 19: Byford District Structure Plan Map*




## LEGEND

- BYFORD DSP BOUNDARY
- DISTRICT CENTRE
- NEIGHBOURHOOD CENTRE
- MIXED USE
- COMMUNITY AND PUBLIC PURPOSE
- LIGHT INDUSTRIAL
- SERVICE COMMERCIAL
- BUSH FOREVER
- DISTRICT/ NEIGHBOURHOOD OPEN SPACE
- RESERVE
- MULTIPLE USE CORRIDOR/LOCAL OPEN SPACE
- MEDIUM - HIGH: R40-100
- LOW (SUBURBAN): R20-35
- LOW (TRANSITIONAL): R2-10
- SPECIAL RESIDENTIAL
- RR-1
- RR-2
- RURAL SMALL HOLDINGS
- RURAL
- PRIMARY DISTRIBUTOR
- SECONDARY DISTRIBUTOR
- DISTRICT DISTRIBUTOR
- RAILWAY RESERVE
- HIGH FREQUENCY TRANSIT CORRIDOR
- PASSENGER RAIL LINE
- RAIL STATION
- DIA BOUNDARY
- DIA DEVELOPMENT INVESTIGATION AREA
- EHS EXISTING HIGH SCHOOL
- EPS EXISTING PRIMARY SCHOOL
- HS HIGH SCHOOL
- PS PRIMARY SCHOOL
- D DISTRICT OPEN SPACE
- N NEIGHBOURHOOD OPEN SPACE

# 3.2 Land Use and Activity

It is critical that planning for the predicted population growth of the Byford District Structure Plan area aligns with Perth and Peel@3.5million by promoting urban consolidation. This will be achieved through focussing development around existing activity centres providing efficient use of existing transport networks, service infrastructure, employment and key community/social infrastructure facilities. The Byford District Structure Plan seeks to optimise the use of land in close proximity to key public transport infrastructure to establish new nodes of activities, underpinned by high-quality built form and public spaces linked together by a network of 'multiple use corridors'.

## 3.2.1 POPULATION AND DENSITY

SJ2050 and the Shire's Local Planning Strategy identify that the Byford District Structure Plan area will need to accommodate a population of approximately 50,000 people by 2050 to meet the Shire's long term growth targets. This growth is planned to be provided primarily in the residential zoned areas and designated future investigation areas identified on the Byford Urban Growth Capacity Map (**Figure 20**). These areas delineate a defined urban growth boundary which seek to limit expansion, enabling the preservation of the existing rural-residential character in the Byford District Structure Plan fringe.

Based on the Shire's average of 2.89 people per household approximately 17,300 dwellings would be required to achieve a population of 50,000. In calculating the estimated population the following methodology was applied to calculate the estimated dwelling/lot targets for each precinct:

- A review of LSPs and spatial data has been undertaken to identify the estimated total lot/dwelling yield for each area covered by an LSP or approved subdivision application;
- The lot/dwelling estimates for greenfield areas not yet subject to LSPs have been determined through identifying their total land area, deducting 40 percent of this land area (accounting for land required for public purposes such as roads, public open space and drainage), and then determining the subdivision/development potential of the remaining land area based on its residential density coding;
- The lot/dwelling estimates for infill sites (i.e. existing urban) not yet subject to LSPs were determined through manual calculations of the development potential of each landholding based on the relevant residential density; and
- The lot/dwelling estimates for existing developed areas were calculated manually.

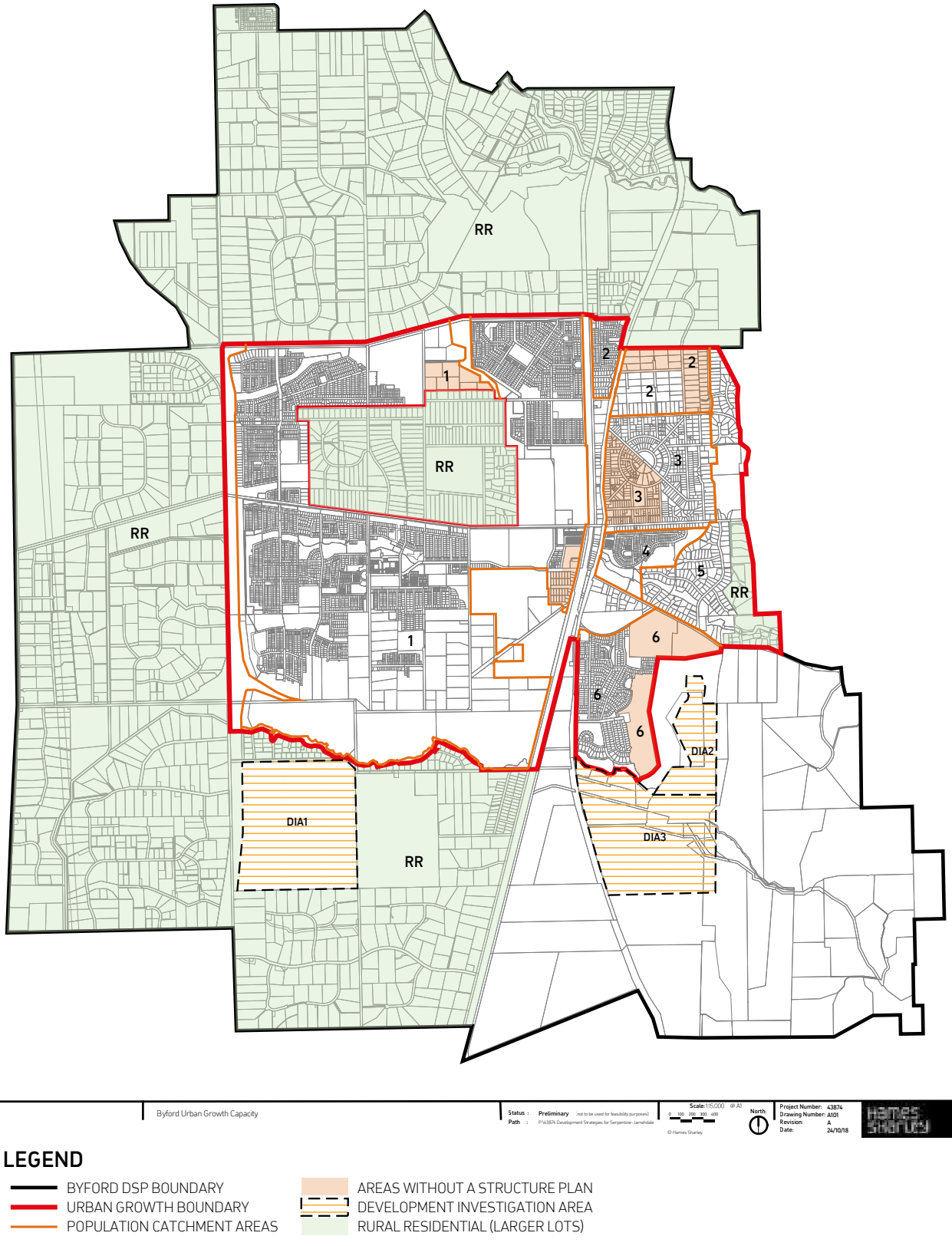
*Table 9: Approximate Population and Dwellings Target*

| AREA | CURRENT DWELLINGS | FUTURE DWELLINGS | ESTIMATED DWELLINGS* | ESTIMATED POPULATION |
|---|---|---|---|---|
| Urban Areas | 6,116 | 9,455 | 15,571 | 45,000 |
| Trotting Complex / Rural Residential | 1,577 | 371 | 1,948 | 5,630 |
| **SUB TOTAL** | **7,693** | **9,826** | **17,519** | **50,630** |
| DIA1 Area | | 1,610 | 1,610 | 4,653 |
| DIA2 Area | | 419 | 419 | 1,211 |
| DIA3 Area | | 1,232 | 1,232 | 3,560 |
| **TOTAL** | **7,693** | **13,087** | **20,780** | **60,054** |

* Calculated based on existing dwellings and dwellings proposed by approved structure plans. DIA areas applied a conservative estimate of R25. It is expected that more detailed estimates will be provided in the LSP stage which include a distribution of densities.

**Table 9** provides a summary of the estimated dwellings and population the Byford District Structure Plan area can accommodate. It demonstrates that the current framework (which includes all approved local structure plans) can accommodate 20,780 dwellings or 60,054 people (based on the Shire's average of 2.89 people per household).

*Figure 20: Byford Urban Growth Capacity*



## 3.2.2 LAND USE

The Byford District Structure Plan identifies the broad land use zones to guide future development in the surrounding area. The proposed intent of the various zones/land uses is described below.

### ACTIVITY CENTRES

The Byford District Structure Plan identifies a total of four activity centres which are evenly distributed throughout the structure plan area. The activity centre's are based around a clear hierarchy which is explained below. Activity centre's are expected to be the primary activity nodes and locations for medium-high density housing.

**District Centre**

The Byford District Structure Plan aligns with the State planning framework by identifying the existing Byford Town Centre as a District Centre. The Byford District Centre will accommodate a finer grain urban form, it will be the primary location for retail activity, commercial uses, employment, and medium-high density housing.

Development will be consolidated in the relocated Byford Town Centre (west of the railway) and based around the Byford Train Station which will provide enhanced public transport access and enable the centre to embody TOD principles. The final station location will be dependent on the outcomes of METRONET aimed at providing a high level of connectivity and legibility leading to the transit hub.

**Neighbourhood Centre**

Three neighbourhood centres are identified in the Byford District Structure Plan, these are distributed throughout the major urban growth areas in the western portion of the Byford District Structure Plan area. The primary role of the neighbourhood centre's is to support the district centre by providing localised services. Walkability and cycling access are key drivers for neighbourhood centres therefore they will require minimum dwelling densities to be achieved to be viable from the walkable catchment. It recommended that LSPs achieve a minimum density of 15-20 dwellings per hectare within the 800m radius.

### URBAN SETTLEMENT

As discussed in **Section 3.2.1** the Byford District Structure Plan is expected to accommodate an urban population of up to 45,000 people (excluding DIAs). The Byford District Structure Plan map identifies an urban growth boundary which determines where residential development will be permitted. The purpose of the growth boundary is to ensure further encroachment into existing rural residential and rural land is prohibited to ensure that the existing rural character is preserved. However, the potential for realisation of higher densities should be explored in urban areas to ensure that a range of housing types are provided. The adaptability of housing to accommodate ageing-in-place and universal access will also need to be addressed.

Residential development in the Byford District Structure Plan area can be broadly classified into the following categories:

**Medium/High Density (Urban)**

Medium/high densities will be based on density codes which range from R40-R100. Housing typologies in these areas should include dwelling types such as terraces (grouped dwelling) and apartments (multiple dwelling) provided in close proximity to amenity and public transport. This will give residents with additional choice and diversity, promoting opportunities for ageing in place.

Medium/high density development will be limited to specific areas within the Byford Town Centre and around the various neighbourhood centres. The final density range and distribution shall be determined through preparation of an Activity Centre Plan for Byford and LSPs for neighbourhood centres (where they do not already exist).

**Low Density (Suburban)**

Low density suburban development will be the most common type of development within the Byford District Structure Plan. Density will range from R20-R35 and single detached housing is likely to be the most common type of dwelling in the suburban setting.

LSPs should ensure equitable access to public open space, linear parks, community facilities, local centres and public transport routes. Residential development based upon the upper end of the density range should be provided around the proposed neighbourhood centres. The final density range and distribution shall be determined as part of Local Structure Planning.

**Low Density (Transitional)**
Larger lots (800m$^2$-5,000m$^2$) are encouraged on the peripheries of the urban settlement zone where possible to contribute to the rural character of Byford, providing a gradual transition from high-density to rural residential. Density will range from R2-10 and single detached housing is likely to be the most common type of dwelling in the suburban setting.

**Rural Residential**
The rural residential living zones will facilitate a gradual transition in development intensity from the urban areas to the rural surrounds. They will also provide opportunities to provide buffers around sensitive areas. Rural residential lot sizes generally range between 4000m$^2$ and 4ha depending on the location within the Byford District Structure Plan area. The final densities and distribution shall be determined as part of Local Structure Planning.

Rural Residential development in the Byford District Structure Plan area is classified into the following categories:

**Special Residential**
Special Residential areas provide for existing precincts of lots that have been subdivided between a minimum of 4000m$^2$ up to 1ha. Located in defined areas, Special Residential lots provide a buffer to rural land uses and define the urban edge.

**Rural Residential 1**
Rural Residential 1 provides for a lot size minimum of 1ha. Located in well defined areas, rural residential lots are contained within existing precincts in close proximity to existing urban centres.

**Rural Residential 2**
Rural Residential 2 provides for a minimum lot size of 2ha up to 4ha. While no more than one single house is permitted, rural residential lots accommodate a range of lifestyles and preserve the rural character.

It is expected that a total of approcimately 5,600 people will live in these areas.

## INDUSTRIAL

A new general industrial area is identified in Cardup (to be referred to as Cardup Business Park). It is expected to generate a significant amount of employment boosting the local economy. The nature of land uses proposed include:

- Furniture, appliances and electronics sales
- Motor vehicle, boat or caravan sales
- Bulky goods showrooms
- Hardware stores
- Home improvement stores
- Offices
- Storage facilities and warehouses
- Exhibition centres
- Motor vehicle repair and wash
- Trade display and supplies
- Industry
- Industry - light

## DEVELOPMENT INVESTIGATION AREAS

The Byford District Structure Plan identifies three DIAs. The intent of these DIAs is to provide future opportunities for urban expansion to increase the number dwellings the Byford District Structure Plan can accommodate. Development within the DIAs will need to be in accordance with endorsed LSPs. These are to be prepared with regard for the specific considerations identified in **Table 2**.

The DIAs provide the potential to accommodate approximately an additional 10,000 people.

# 3.3 Economy and Employment

## 3.3.1 ECONOMY

### ACTIVITY CENTRES

As discussed in **Section 3.2.2** the Byford District Structure Plan proposes a network of activity centre's which are earmarked as strategic locations for employment growth (**Figure 21**). The Shire's activity centre strategy determines that approximately 20-25% of the Byford District Structure Plans jobs should be located within the defined activity centres. It is expected that this growth would accommodate industries such as retail, professional services, and financial services, however, it should also provide opportunities for start-ups and small businesses to cluster and grow. Retail demand is expected to be a major driver of economic growth. The Activity Centre's Strategy identifies that the Byford District Structure Plan could accommodate 32,900m$^2$ of retail floor space. This would be distributed as follows:

- Approximately 14,700 m$^2$ NLA in the Byford District Centre (Byford Town Centre LSP estimates between 8,952 m$^2$ - 15,538 m$^2$ NLA);
- Approximately 5,000 m$^2$ NLA in each Neighbourhood Centre (15,000 m$^2$ total); and
- Approximately 3,200 m$^2$ NLA in various local nodes.

Based on approximately 25 m$^2$ NLA per employee activity centres in Byford are expected to provide approximately 1,300 local jobs.

### INDUSTRIAL

Future employment in industrial, light industrial and service commercial will be concentrated in the existing light industrial area at the corner of Nettleton Road and South Western Highway and within the Cardup Business Park which is the triangular piece of land between Soldiers Road and South Western Highway.

### EQUINE

The Byford District Structure Plan has a rich equine history centred around the Byford Trotting Complex and Darling Downs area. Future investigations are required to determine how best to expand upon the existing equine industry to promote localised employment opportunities.

### EDUCATION AND HEALTH

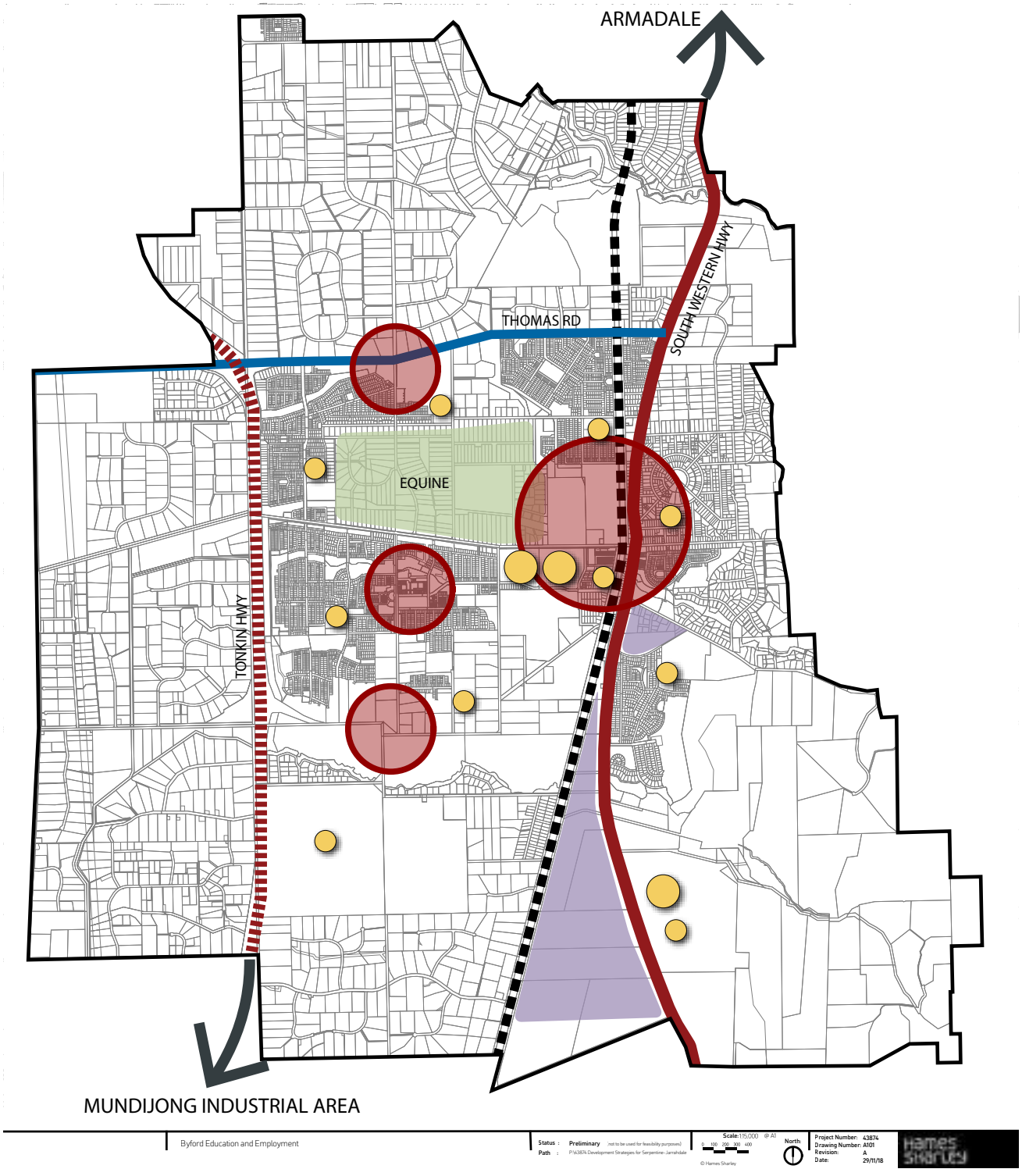
As the local population continues to grow and evolve, providing access to a range of education and health related facilities locally in the Byford District Structure Plan area will become more important. The Byford District Structure Plan includes a number of education facilities including six primary and three secondary schools. In addition, an ageing population will require investment into a range of aged care and retirement living villages to cater for people in all stages of life. It is recommended that these facilities be located in high amenity areas such as the Byford Town Centre.

## 3.3.2 EMPLOYMENT

Currently, the estimated resident labourforce in the Byford District Structure Plan area is 8,422. With a proposed population of up to 60,000 people the resident labourforce is expected to grow exponentially, increasing pressure on the need to provide a large amount of new jobs. It is estimated that 60% of Byford District Structure Plan residents will be involved in the workforce. Based on an estimated population of 60,000 this would equate to a resident labourforce of approximately 36,000.

The South Metropolitan Peel Sub-Regional Framework identifies an employment self-sufficiency target of 61% for the eastern sector of the South-Metropolitan Peel Sub-Region. Based on an estimated 36,000 resident jobs, the Byford District Structure Plan area would need to provide approximately 21,960 jobs to achieve a self-sufficiency rating of 61%. Whilst the industries mentioned above have the potential to provide some of these jobs a self-sufficiency rating of 61% in Byford is unlikely. The Byford District Structure Plan has taken a sub-regional focus to employment. Acknowledging that not all jobs can be provided in the local area the focus is to strengthen transport links. This would enable residents in the Byford District Structure Plan area to access major regional employment areas such as Armadale, Rockingham, and Kwinana, as well as localised opportunities in Mundijong and Jarrahdale.

*Figure 21: Employment Opportunities*



# 3.4 Movement and Access

To accommodate the anticipated population growth for Byford and to ensure efficiency of the movement system is not compromised, the Byford District Structure Plan recognises the need to integrate urban development and employment nodes with transport infrastructure and services. A challenge for the Byford District Structure Plan area is to ensure key roads are appropriately managed and upgraded over time to facilitate future transport efficiency. An effective and adaptable public transport network will be a key mechanism for achieving greater sustainability. This will be achieved through an integrated network of passenger rail lines and transit corridors.

## 3.4.1 PUBLIC TRANSPORT

The key to improving regional accessibility in the Byford District Structure Plan is the extension of the passenger rail service to Byford. Passenger rail infrastructure proposed under the South Metropolitan Peel Sub-Regional Framework includes the Stage 1 METRONET proposal to extend the Armadale Train Line to Byford. The station is proposed to be centrally located in the Byford Town Centre providing opportunities for TOD. The passenger rail will be supported by a network of feeder bus services to reduce the amount of car parking required. Key local distributor roads have been identified as the preferred locations for bus routes to ensure a high degree of accessibility is provided for residents. It is recommended that any 'park n ride' facilities are located off-site so as not to compromise the development potential immediately surrounding the station.

In the short/medium-term the existing rail corridor has been identified with the potential to accommodate Bus Rapid Transit (BRT). This is subject to further investigations and planning for METRONET with the Department of Transport and the Public Transport Authority.

## 3.4.2 ACTIVE TRANSPORT

Active modes of transport such as walking and cycling are supported for short distance journeys within urban areas. Providing safe, accessible and interconnected pedestrian and cycle links between residential areas and destinations such as schools, shops, public transport stops and parks is essential in encouraging greater pedestrian and cycling activity. Such modes of transport have many benefits including improved physical and mental health, activated streetscapes with a higher level of passive surveillance, reduced dependency on the automobile leading to less traffic congestion and greenhouse gas emissions and increased engagement within communities. Facilitating active modes of transport is also important for recreational purposes offering opportunities for jogging, dog walking, horse riding, bushwalking and off-road cycling.

**Figure 22** identifies the primary cyclist connections in the Byford District Structure Plan area. These routes will include dedicated cycle infrastructure that is integrated with the existing Perth Bicycle Network. Active transport should also be given priority in activity centres. Medium-high density housing combined with safe and attractive streets will make walking and cycling viable transport options for short, local trips.

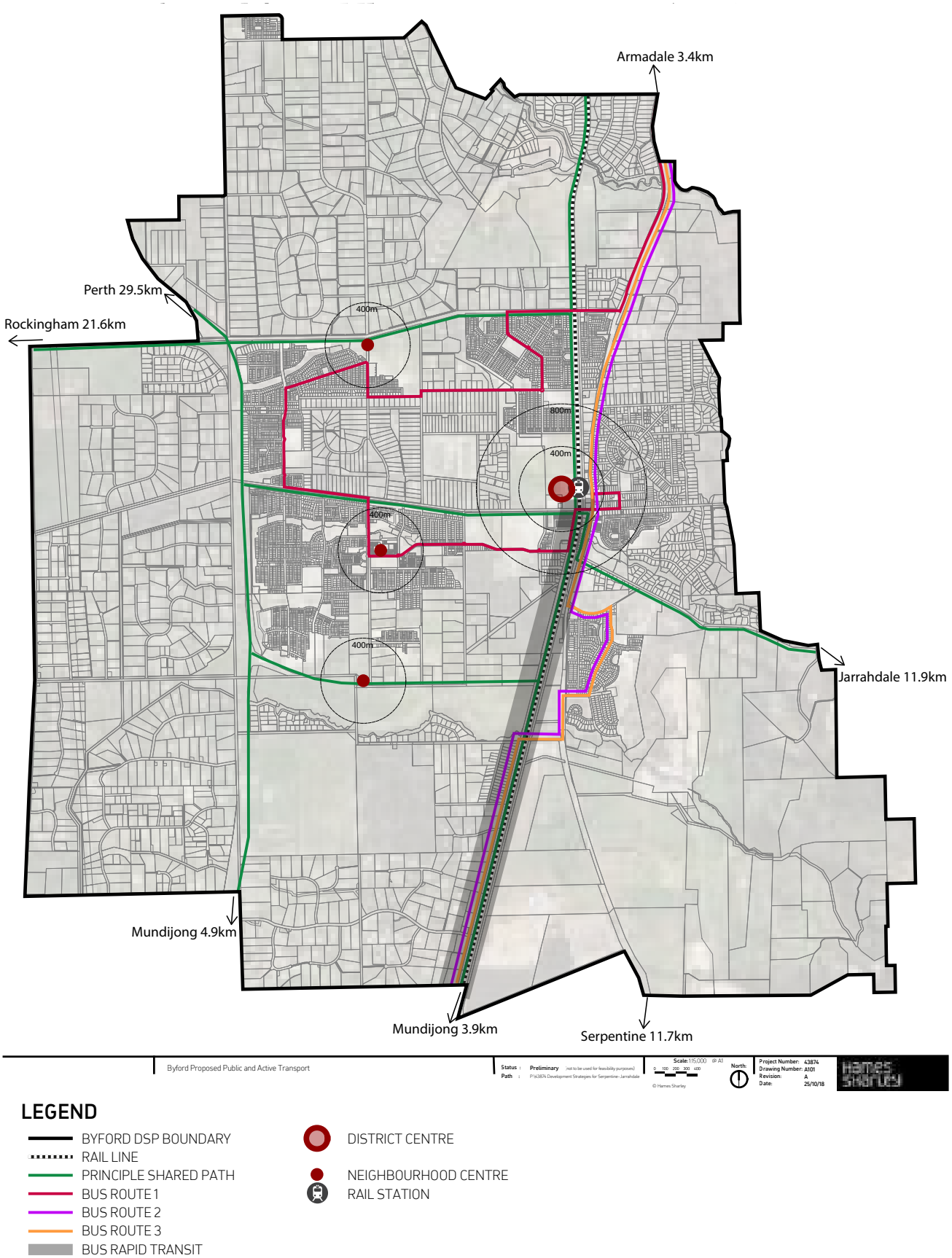
## 3.4.3 ROAD NETWORK

The Byford District Structure Plan seeks to align with the South Metropolitan Peel Sub-Regional Framework which identifies a number of upgrades to the future regional road network including new and upgraded primary distributor and integrator arterial roads, this includes the extension of Tonkin Highway (**Figure 23**). Good access to and from key distributor roads is a key focus of the Byford District Structure Plan and a major consideration for people moving to and within the Byford District Structure Plan. New or improved local connections throughout existing and future development areas are essential in providing an efficient movement network.

### PRIMARY DISTRIBUTORS

Tonkin Highway and South Western Highway are identified as primary distributors in the Byford District Structure Plan. Both roads are currently key north-south connectors providing access to the wider Perth Metropolitan Region. It is expected that the Tonkin Highway extension will take pressure off South Western Highway by redirecting heavy vehicles to Tonkin Highway. This will mitigate existing conflicts in the Byford Town Centre and contribute to a more pedestrian oriented environment. An on-ramp will be provided at Orton Road.

*Figure 22: Proposed Public and Active Transport Network*



Ultimately, Tonkin Highway will connect to South Western Highway south of Mundijong Road. This will enable freight movement to access the proposed Intermodal Hub in West Mundijong and bypass both the Byford and Mundijong Town Centre's.

## REGIONAL DISTRIBUTORS

Regional distributor roads in the Byford District Structure Plan are typically located on the periphery of the urban area and provide enhanced connectivity to primary distributor roads or surrounding urban areas. Regional distributors can be summarised as follows:

- **Thomas Road and Orton Road** - primary east-west connectors between Tonkin Highway and South Western Highway. Both roads provide access to Tonkin Highway. Thomas Road is the most important east-west connector as it also connect to Kwinana Freeway providing access to the Perth CBD and Rockingham. Grade separation is required on both roads where they intersect the railway reserve.
- **Soldiers Road** - primary north-south distributor road which provides a direct connection between the Byford District Structure Plan are and the Mundijong and Whitby District Centres.
- **Nettleton Road** - east-west distributor road that provides a connection to the Jarrahdale Townsite and tourism opportunities.

## LOCAL DISTRIBUTORS

The Byford District Structure Plan includes a network of local distributor roads which provide localised connections and interconnectivity to both regional and primary distributors. Key connections summarised below:

- **Doley Road** - proposed to be extended to the Mundijong District Structure Plan area providing a secondary north-south connection with Soldiers Road.
- **Abernethey Road** - primary east-west connector between Tonkin Highway and South Western Highway. Provides connections to the Byford Town Centre. An underpass is proposed at Tonkin Highway to ensure east-west vehicle permeability via Abernethy Road is maintained.
- **Wungong Road South** - north-south distributor that provides a connection to growth areas south of the Armdale SMC.
- **East-West Connector** - provides a new link between Ballawarra Avenue and San Simeon Boulevard to improve connectivity to the northern side of the Byford Town Centre.

## BYFORD TOWN CENTRE

Connectivity to and within the Byford Town Centre is essential. As the primary retail and activity hub in the Byford District Structure Plan access via all transport modes is required. Central to improving connectivity from a vehicle movement perspective is removing the physical barrier currently provided by the railway. Grade separation of the railway is proposed between Clara Street and Abernethy Road, this would significantly improve access for residents in the Byford Old Quarter. In addition, car parking areas should be located on the periphery of the town centre to ensure the activity centre core gives priority to pedestrians and public transport.

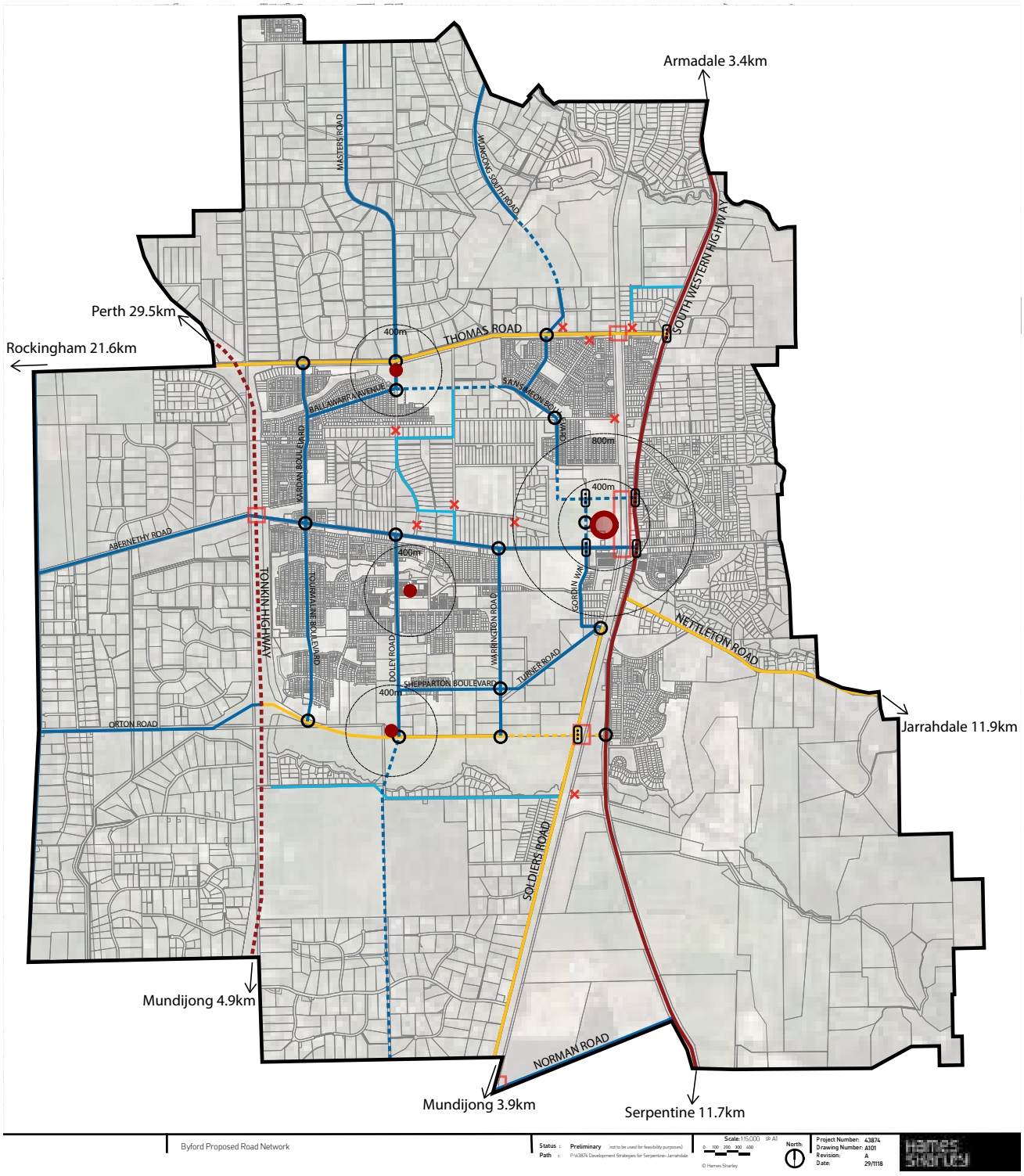
All new connections and upgrades to the road network in the Byford District Structure Plan will be funded through the Byford Development Contribution Plan.

## TRAFFIC IMPACT ASSESSMENT

Cardno prepared a Traffic Impact Assessment (**Appendix 2**) to test the efficiency and performance of the proposed Byford District Structure Plan road network.

A mesoscopic traffic model was developed to model the current traffic situation and provide a base to determine the likely future traffic impacts. A number of data sources were used in the formulation of the mesoscopic model which included traffic, surveys, census data and information provided by local authorities. The future-year models are based on the traffic growth scenario derived from information provided by the Shire of Serpentine-Jarrahdale and Main Roads (ROM24 outputs) for the 2031 scenario years.

*Figure 23: Proposed Vehicle Movement Network*



Based on the results provided by the mesoscopic model, the network in the area of Byford is operating at an acceptable level of service with sufficient capacity to accommodate traffic for the 2018 scenario. With respect to the 2031 scenario, the mesoscopic model identified a number of intersections which exhibited capacity or delay issues. These intersections have been assessed in SIDRA to determine the minimum extent of upgrades required to ensure that they are operating at an acceptable level of service in 2031.

## Operational Performance

**Figure 24** identifies the results of intersection evaluation across the Byford area. Intersections have been classified into 3 groups as described below:

1. Existing Intersection Sufficient: the existing (2018) geometry has been evaluated through the Aimsun mesoscopic model and shown to be sufficient to accommodate future traffic growth.
2. Modified Intersection Sufficient: the Shire's proposed modifications have been evaluated through the Aimsun mesoscopic model and shown to be sufficient to accommodate future traffic growth.
3. Additional Reconfiguration Required: The existing and/or proposed intersection form has been evaluated through the Aimsun mesoscopic model and found to experience excessive congestion or delay. These intersections have been re-evaluated in SIDRA and changes identified to improve operation.


*Figure 24: Intersection Sufficiency*
*Source: Cardno, 2018*

The traffic impacts from the Byford District Structure Plan were evaluated in a mesoscopic modelling framework. Key intersections within the road network were classified in three categories based on operational performance:

1. The existing intersection forms are considered sufficient to accommodate future growth. These include:
   - Kardan Boulevard/Ballawarra Avenue
   - South West Highway/Thomas Road
   - Abernethy Road/Briggs Road
   - Warrington Road/Turner Road
   - Doley Road/Shepparton Boulevard
2. The proposed intersection forms are considered sufficient to accommodate future growth. These include:
   - Thomas Road/Kardan Boulevard
   - Thomas Road/Masters Road
   - Thomas Road/Plaistowe Boulevard
   - Thomas Road/Alexander Road
   - Thomas Road/George Street
   - Ballawarra Avenue/Malarkey Street
   - Ballawarra Avenue/Briggs Road
   - Ballawarra Avenue/Plaistowe Boulevard
   - Ballawarra Avenue/Larsen Road/Sansimeon Boulevard
   - Abernethy Road/Tonkin Highway
   - Abernethy Road/Kardan Boulevard/Tourmaline Boulevard
   - Abernethy Road/Doley Road
   - Abernethy Road/Warrington Road
   - Soldiers Road/Turner Road
   - Turner Road/Warrington Road
   - Orton Road/Warrington Road
   - Orton Road/Doley Road
   - Doley Road/Cardup Siding Road
   - Orton Road/Tourmaline Boulevard
3. For a number of key intersections, alternative intersection forms were considered necessary to accommodate future growth. These include:
   - Tonkin Highway/Thomas Road
   - Abernethy Road/Sansimeon Boulevard
   - Sansimeon Boulevard/Clara Street
   - South Western Highway/Abernethy Road
   - Soldiers Road/Orton Road
   - South Western Highway/Orton Road

Overall, with the reconfigured intersection the Traffic Impact Assessment has determined that the Byford District Structure Plan road network is considered to operate satisfactorily in the 2031 future scenario.

Further details on the intersection performance assessment are provided in **Appendix 2**.

# 3.5 Community and Social Infrastructure

Community facilities within the Byford District Structure Plan area will have an important role in creating activated community hubs bringing together different groups and individuals. Community and social infrastructure required for the provision of health, education, sport and recreation services in the Byford District Structure Plan will also need to accommodate a growing and ageing population. The focus for the Byford District Structure Plan area will be the co-location of key community and social infrastructure to promote better use of existing infrastructure and facilities, reduce traffic movements and establish a sense of social cohesion by creating key focal points for activity and the delivery of services to nearby residents.

## 3.5.1 EDUCATION FACILITIES

New education facilities are proposed to address the needs of the growing population. Education requirements in the Byford District Structure Plan area have been guided by relevant policy and the requirements of the Department for Education (DoE). The DoE has identified the provision for nine public primary school sites and two public high school, in addition to the existing private high school, as necessary for the Byford District Structure Plan area.

The Byford District Structure Plan area has five existing primary schools, which are to be included within the nine required, and one existing high schools (public). The additional primary schools and the new high school are conceptually shown on the Byford District Structure Plan to provide an indication of the expected distribution of school sites to meet catchment requirements across the whole Byford District Structure Plan area (**Figure 25).** However, final locations, the size, shape and dimensions of school sites will be confirmed as part of Local Structure Plans and should be determined in accordance with Liveable Neighbourhoods Element 8, and in liaison with the Department of Education.

During preparation of LSP's proponents are encouraged to consider innovative approaches to integrate school sites and school activities with surrounding residential areas. Shared use of school facilities and/or provision of uses compatible with adjoining residential activities to encourage greater community use of school facilities either as part of educational facilities or an adjoining local node is encouraged.

## 3.5.2 PUBLIC OPEN SPACE

The Byford District Structure Plan area incorporates a network of well-distributed and connected Public Open Space areas which include a combination of natural reserves, multiple use corridors, dedicated sport and recreation facilities and local parks providing opportunities for both informal and formal recreation activities.

Equitable provision of sport and recreation facilities and services across the Byford District Structure Plan area is important to community vitality. A network of both active/formal open space and passive/informal open space areas are necessary in maximising participation in physical activity within any community.

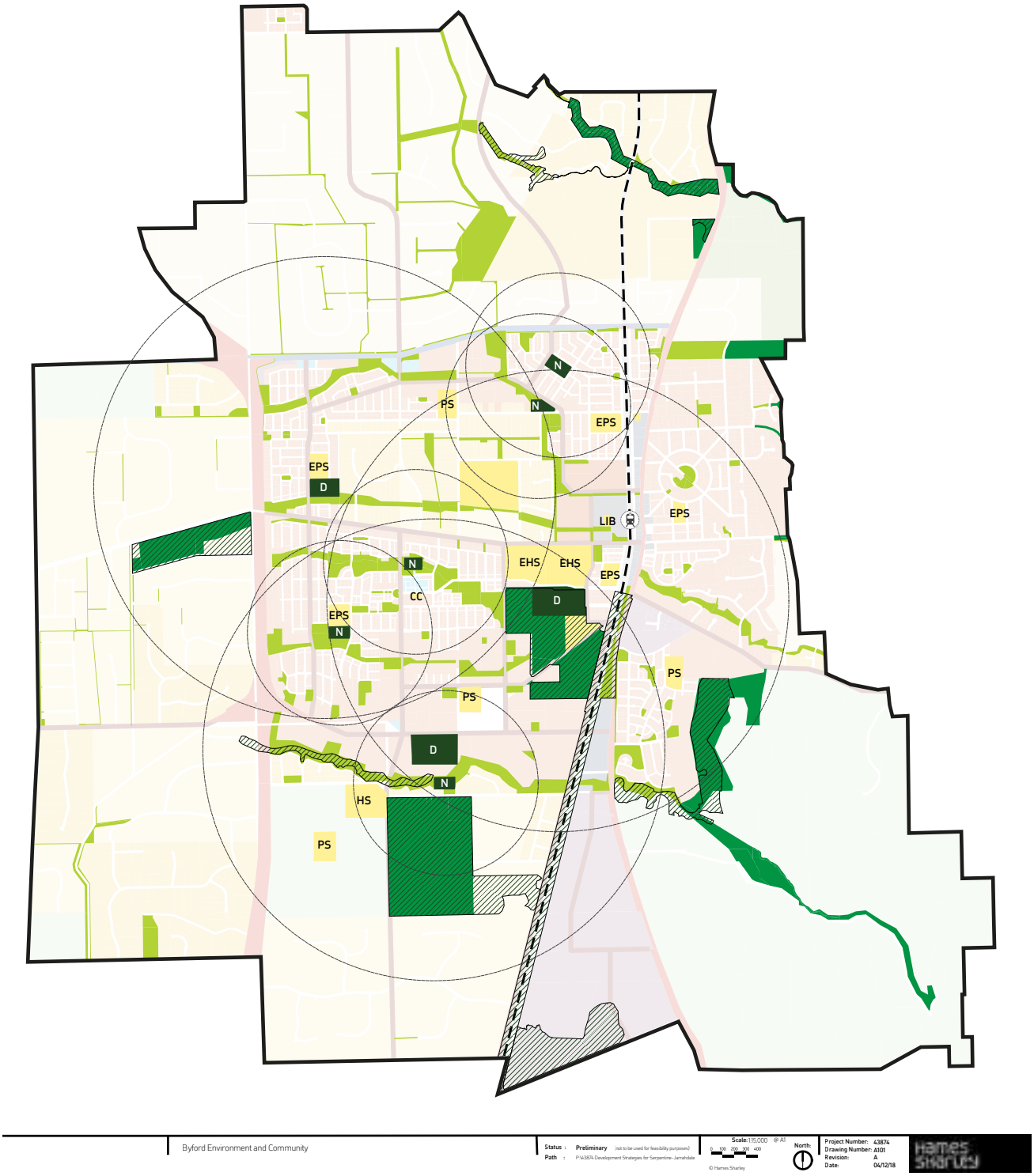
### SIZE AND DISTRIBUTION OF PUBLIC OPEN SPACE

**Figure 25** illustrates the location and distribution of open space throughout the Byford District Structure Plan area. To make the most efficient use of land, the Byford District Structure Plan proposes to collocate district open space areas with education facilities (where possible). New facilities are proposed in Woodland Grove and on Orton Road where district level open space is integrated with school sites. The same is proposed at Briggs Park where integration of existing recreation facilities with Salvado Catholic College and Byford Secondary School are being explored. This would allow the space to function more effectively for the community and provide significantly more space.

In total five district open space areas are proposed, these are all located in newer development areas between Tonkin Highway and South Western Highway. The respective sizes are in accordance with Liveable Neighbourhoods which is >5ha for a district level facility. No neighbourhood level parks are proposed, however, urban areas are services by a number of smaller local parks and multiple use corridors.

For future development a 10% Public Open Space contribution will be required. This is to be calculated on the basis of 10% of purely residential designated land use only. Deductions from the total site area to determine the gross subdivisible area

*Figure 25: Proposed Community Infrastructure and Open Space Network*




## LEGEND

- BYFORD DSP BOUNDARY
- BUSH FOREVER
- MULTIPLE USE CORRIDOR/LOCAL OPEN SPACE
- RESERVE
- DISTRICT/NEIGHBOURHOOD OPEN SPACE
- COMMUNITY PURPOSE
- RAIL LINE
- TRANSIT NODE
- EHS EXISTING HIGH SCHOOL
- EPS EXISTING PRIMARY SCHOOL
- HS HIGH SCHOOL
- PS PRIMARY SCHOOL
- D DISTRICT OPEN SPACE
- N NEIGHBOURHOOD OPEN SPACE
- CC COMMUNITY CENTRE
- LIB LIBRARY
- 2KM CATCHMENT
- 800M CATCHMENT

include all non-residential land uses that do not generate the need for a contribution to Public Open Space, and for which a Public Open Space allowance has not been sought.

The 10 per cent Public Open Space requirement allows for the provision of a maximum of 2 per cent of restricted use Public Open Space as outlined within Liveable Neighbourhoods. Resource enhancement wetlands and buffers to environmentally sensitive areas are not deemed Public Open Space for 'recreation' purposes, however, in some cases it is acceptable for the land to be utilised and accessed by the community and therefore deemed to be 'restricted use'. These areas must have an approved management plan to manage impact and enhance the environmental values of the area. Areas of remnant vegetation are to be protected from subdivision and development and therefore may also be included within the 10% Public Open Space contribution.

**Variations to 10 per cent public open space contribution**

A contribution of more or less than 10 per cent of the gross subdivisible area may be considered, or is needed where the area is subject to particular circumstances or when it is more appropriate to apply an alternate cash-in-lieu contribution instead of provision as outlined within the Liveable Neighbourhoods Element 5 Public Open Space.

In some instances, additional land over and above the standard 10% public open space requirement, may be required to be provided at the time of subdivision and/or development to accommodate drainage, recreational, environmental or other similar functions. Such land may be required to be provided free of cost at the time of subdivision and/or development.

An indicative schedule of deductions for the purposes of calculating Public Open Space is provided in the following section.

### INDICATIVE PUBLIC OPEN SPACE SCHEDULE

In residential areas 10 per cent of the gross subdivisible area must be provided free of cost by the subdivider and vested in the Crown under the provisions of Section 152 of the Planning and Development Act 2005 for Public Open Space and foreshore management purposes.

For the purposes of calculating the 10% Public Open Space requirement at LSP stage, the following indicative Public Open Space schedule is recommended;

**Calculation of Required Public Open Space Provision:**

a. The total site area, less deduction resulting in the Gross Subdivisible Area (GSA):

   **Less:** Non residential land uses (including Commercial, Mixed Use, School Sites, Utility and infrastructure facilities); and Multiple Use Corridor (including Urban Water Management and vegetation protection components as determined under District and Local Water Management Strategies)

   **Leaves:** Net residential development area

b. The GSA (total site minus deductions) - divided by 10% equals the required Public Open Space provision requirement

**Breakdown of Public Open Space Provided within LSP areas:**

a. The total restricted Public Open Space – to a maximum of 20%

b. Added to the total unrestricted Public Open Space: by function – identified as a percentage of the Gross Subdivisible Area

In accordance with WAPC requirements, residential components of mixed use developments will be included within the net residential development area for the purposes of calculating the Public Open Space requirement.

## 3.5.3 EQUINE DISTRICT FACILITIES

Subdivision in rural residential areas is to contribute 10% of land value (monetary value) for the Shire to use on equine facilities. This will include upgrade of the existing reserve in Darling Downs and upgrade / provision of new bridle trails.

# 3.6 Environment and Landscape

The natural areas and environmental quality of Byford enhances amenity and creates character within both urban and rural areas. It is important for this purpose to ensure that the natural environment is preserved and enhanced as a central element of liveability and a defining characteristic of the Shire. The challenge for the Byford District Structure Plan area will be to retain or create a 'sense of place' by maintaining key individual landscape characteristics and vistas in areas that may be subject to large-scale landscape change. This can be achieved through strong guidance, local structure plans and local planning policy to protect and preserve important natural features.

## 3.6.1 MULTIPLE USE CORRIDORS

Retaining and enhancing vegetation in the Byford District Structure Plan is supported as it is critical to maintaining the desirability, amenity and sustainability of the district. Multiple Use Corridors (identified on **Figure 25**) are a defining element of the Byford area. They incorporate water sensitive urban design, ecological linkages, vegetation retention, recreation and amenity. Multiple-use corridors should be protected at all stages of planning. Living streams will be strengthened to emphasise Byford's rural character and close connection to the landscape. These corridors will help to protect flora and allow fauna movement. Ecological linkages also provide attractive routes for pedestrian, cyclists and horse riders. Commercial and community centres are strategically located to optimise walkable catchment and also promote use of living streams, which encourages community interaction, ownership and relationship to nature.

## 3.6.2 CONSERVATION OF SIGNIFICANT FLORA AND FAUNA

The Byford District Structure Plan identifies locally significant natural areas that may be retained as part of local open space and dealt with through the LSP process. Throughout the Byford District Structure Plan area, there are several avenues of trees established along rural roads and driveways. Where possible, the LSPs should retain this vegetation and take the opportunity to do this in open space or within new road reserve verges. Where LSPs are affected by Bush Forever, conservation corridors or multiple use corridors, management plans will need to be prepared and implemented in order to provide for ongoing health and viability. The design of LSPs should demonstrate the preservation of as much vegetation within the urban fabric as possible.

In addition to several declared rare and priority flora species within the there are also several species of Specially Protected Fauna reliant on parkland areas for feeding habitat located in the Byford District Structure Plan area, Detailed flora and fauna assessments will be required to be undertaken as part of more detailed levels of planning to ensure that development and subdivision is cognisant of and sensitive to the protection of native flora and fauna.

# 3.7 Service Infrastructure

## 3.7.1 WATER SUPPLY

The Sub-regional Planning Framework identifies future conceptual water supply planning for the the eastern sub-regional sector where major water storage reservoirs will be necessary in the escarpment near Byford Tank (Byford) and Mundijong Reservoir (Jarrahdale) to serve long-term urban development in these areas (WAPC, 2018).

The Shire is also committed to considering alternative sources of water management and exploring options beyond business as usual. The approach to integrated water cycle management will entail the conceptualisation and assessment of alternate schemes supplying water of appropriate quality for various Non-Drinking Water (NDW) purposes to ensure equitable outcomes for new development within the Byford District Structure Plan area.

## 3.7.2 WATER MANAGEMENT

The Byford District Structure Plan has been updated to reflect the recommendations of the Byford District Water Management Strategy (BDWMS) prepared by Urbaqua, 2018. It will be necessary for all land owners to comply with the strategy when preparing Detailed Local Structure Plans and Plans for Subdivision. Proposals should address groundwater and surface water management, water conservation and efficiency; and water reuse and recycling in an

integrated manner, focussing on key issues identified in the strategy. It is, therefore, recommended that all land owners review the entire documentation of the BDWMS for compliance.

The following provides a brief overview of the steps for implementation. In accordance with Better Urban Water Management (WAPC 2008) the implementation of this strategy will be through the land use planning process with proponents of development required to develop water management strategies and plans at each planning stage to support and inform their planning proposals, environmental investigations, engineering, landscaping and urban designs as follows.

1. A District Water Management Strategy is required to support a region scheme amendment for future urban or industrial development not proposed by the Byford District Structure Plan (2018), consistent with Better Urban Water Management (WAPC, 2008).
2. A local water management strategy is required to support a local scheme amendment or the preparation of any local structure plan, whichever is the earlier consistent with Better Urban Water Management (WAPC, 2008), Interim: Developing a Local Water Management Strategy (DWER, 2008) and the Byford District Water Management Strategy.
3. Where no approved local water management strategy exists, any application for subdivision in greenfield areas, or where more than 30 lots are proposed in infill or brownfield areas, must be accompanied by a draft urban water management plan, consistent with the Department of Water and Environmental Regulation's Urban Water Management Plans: Guidelines for preparing plans and for complying with subdivision conditions (DWER, 2008) and the Byford District Water Management Strategy, and developed in consultation with the local government, with advice as necessary from DWER.
4. Where an approved local water management strategy exists, the preparation and implementation of an urban water management plan will be required as conditions of urban or industrial subdivision. In this case, the subdivision application should be supported by a brief document which outlines a broad strategy for water management that has been previously agreed with the Shire. The urban water management plan is to be consistent with the Department of Water and Environmental Regulation's Urban Water Management Plans: Guidelines for preparing plans and for complying with subdivision conditions (DWER, 2008) and the Byford District Water Management Strategy, and developed in consultation with the Shire of Serpentine-Jarrahdale with advice as necessary from DWER.
5. 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.

Proponents of development should demonstrate that their proposals and designs are consistent with the strategies and design criteria presented in the BDWMS, as well as satisfying other requirements of other relevant agencies.

# 3.8 Heritage and Culture

The character of a place is closely linked to its heritage and it is therefore crucial that elements of heritage, such as the built form, mature trees and local landscape are preserved and incorporated into any new development.

## 3.8.1 NON-ABORIGINAL HERITAGE

The Byford District Structure Plan area contains a number of non-aboriginal heritage places and landscapes that need to be preserved for future generations. Opportunities exist for the adaptive reuse of these heritage places, as well as the inclusion of underutilised spaces which can add to and benefit from existing heritage value and character within areas of new development.

In addition to designated heritage sites identified in "**Figure 17**: Existing Heritage Places" on page 76, the character of unique areas such as the Byford Trotting Complex and Byford Old Quarter will need to be preserved as these areas reflect the rural character of the Byford District Structure Plan area. Preparation of local planning policies or design guidelines which provide statutory guidance are recommended.

## 3.8.2 ABORIGINAL HERITAGE

As discussed in section 2.2.9 of this report, the Department of Planning, Lands and Heritage (DPLH) has identified Aboriginal Heritage Places in the Byford District Structure Plan area. Prior to construction of individual developments, assessment should be undertaken by a qualified consultant to determine whether a more thorough Aboriginal Heritage investigation of the area needs to be undertaken for any specific location to identify unregistered sites


# 4.0 APPENDICES

# 4.1 References

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Western Australian Planning Commission (WAPC), 2015 (Draft). Liveable neighbourhoods, WAPC, Perth.

### State Planning Policies

A full current list of State Planning Policies can be accessed via the Shire of Serpentine Jarrahdale website << https://www.planning.wa.gov.au/state-planning-framework.aspx#State-Planning-Policies>> (accessed 18 March 2018)

### Local Structure Plans

A full current list of local structure plans can be accessed via the Shire of Serpentine Jarrahdale website << http://www.sjshire.wa.gov.au/what-we-do/planning-and-building/structure-plans/>> (accessed 15 November 2017)

## 4.2 Technical Appendices

The Byford District Structure Plan was prepared with reference to the following technical appendices (provided in separate attachments).

- Appendix 1 - Byford Engagement Report, 2018
- Appendix 2 - Byford Traffic Study, 2018
- Appendix 3 - Byford District Water Management Strategy, 2018


GEORGE ST
POST OFFICE
PARKING
BYFORD
NEWSAGENCY
Giftware & Toys
Cheap Ink Cartridges
Stationery & Magazines
Lotto & Cards
CHEMIST

# Transport Impact Assessment

## Byford Structure Plan

CW1039600

Prepared for
Shire of Serpentine Jarrahdale

5 December 2018

Cardno

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# 1 Introduction

## 1.1 Background

Cardno was commissioned by the Shire of Serpentine to prepare a Transport Impact Assessment for the proposed Byford District Structure Plan (BDSP) ('the Site' or 'the Structure Plan').

This report has been prepared in accordance with the Western Australian Planning Commission (WAPC) *Transport Impact Assessment Guidelines Volume 2 – Planning Schemes, Structure Plans & Activity Centre Plans (2016).* This report will support the detailed structure planning for the locality by evaluating the sufficiency of existing and proposed intersection treatments across the Structure Plan Area.

## 1.2 Site Location and Description

The suburbs in the Shire of Serpentine Jarrahdale include Byford, Mundijong, Serpentine, Jarrahdale and Keysbrook. The Site covers in Byford, in the Shire of Serpentine Jarrahdale on the south-eastern edge of Perth with a population of 16,871 as of 2017 and with a density of 9.44 persons per hectare. The land area of Byford is 1,787 hectares, most of which is recent and developing with an industrial area and some commercial use of land.

**Figure 1-1** depicts the location of the site and the study area within the structure plan.

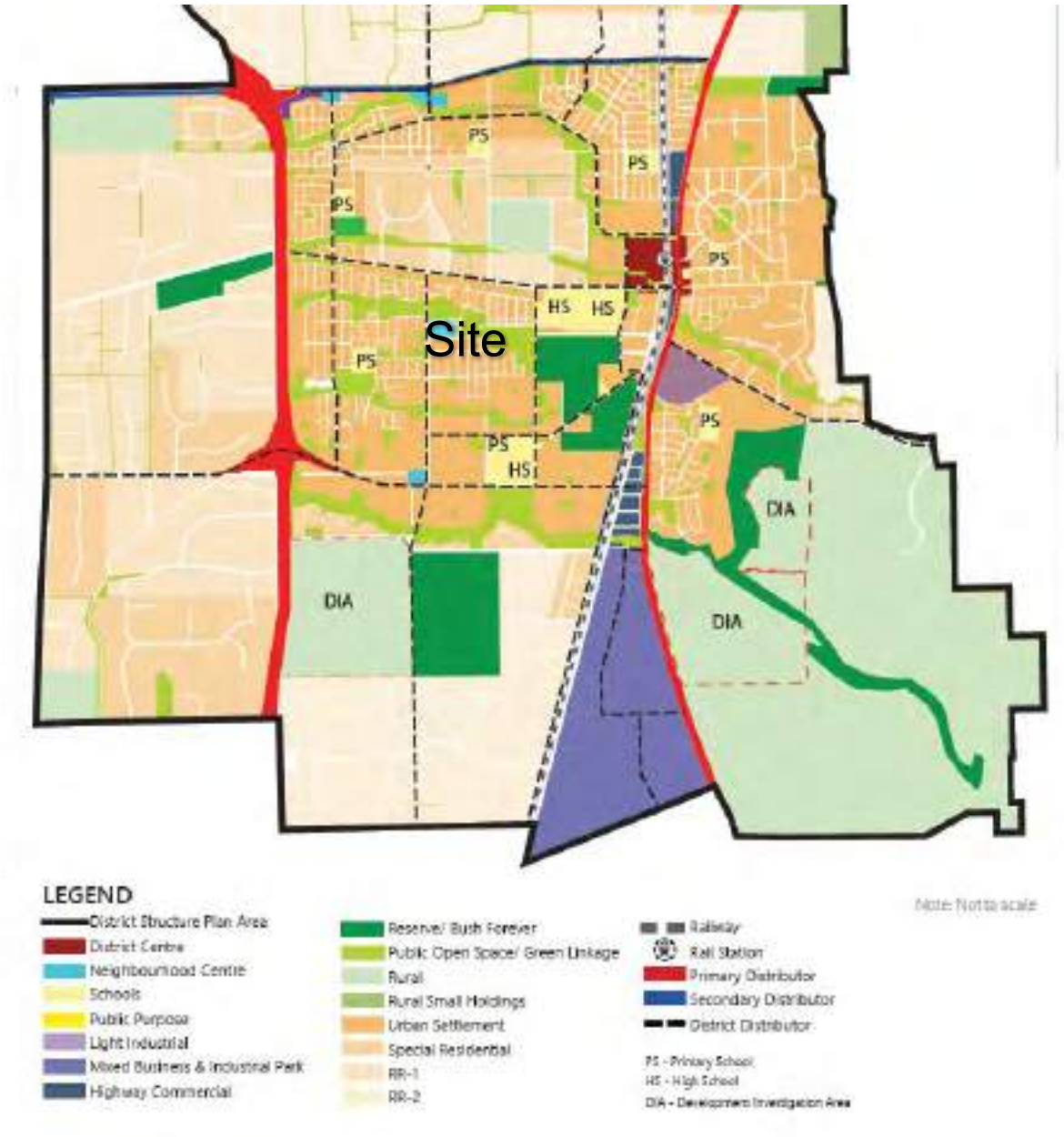
Figure 1-1 Study Area

*Source: Nearmap*

**Figure 1-2** shows the Byford structure plan area with the different types of developments including residential, commercial and urban areas.

The structure plan covers an area of 5,530 hectares of which predominant areas are urban or remnant rural residential zoned for future development. The main features in the structure plan area comprise the Byford Town Centre Precinct, Byford Trotting Complex Precinct and Briggs Park Sport and Education Precinct.

Figure 1-2 Structure Plan Location

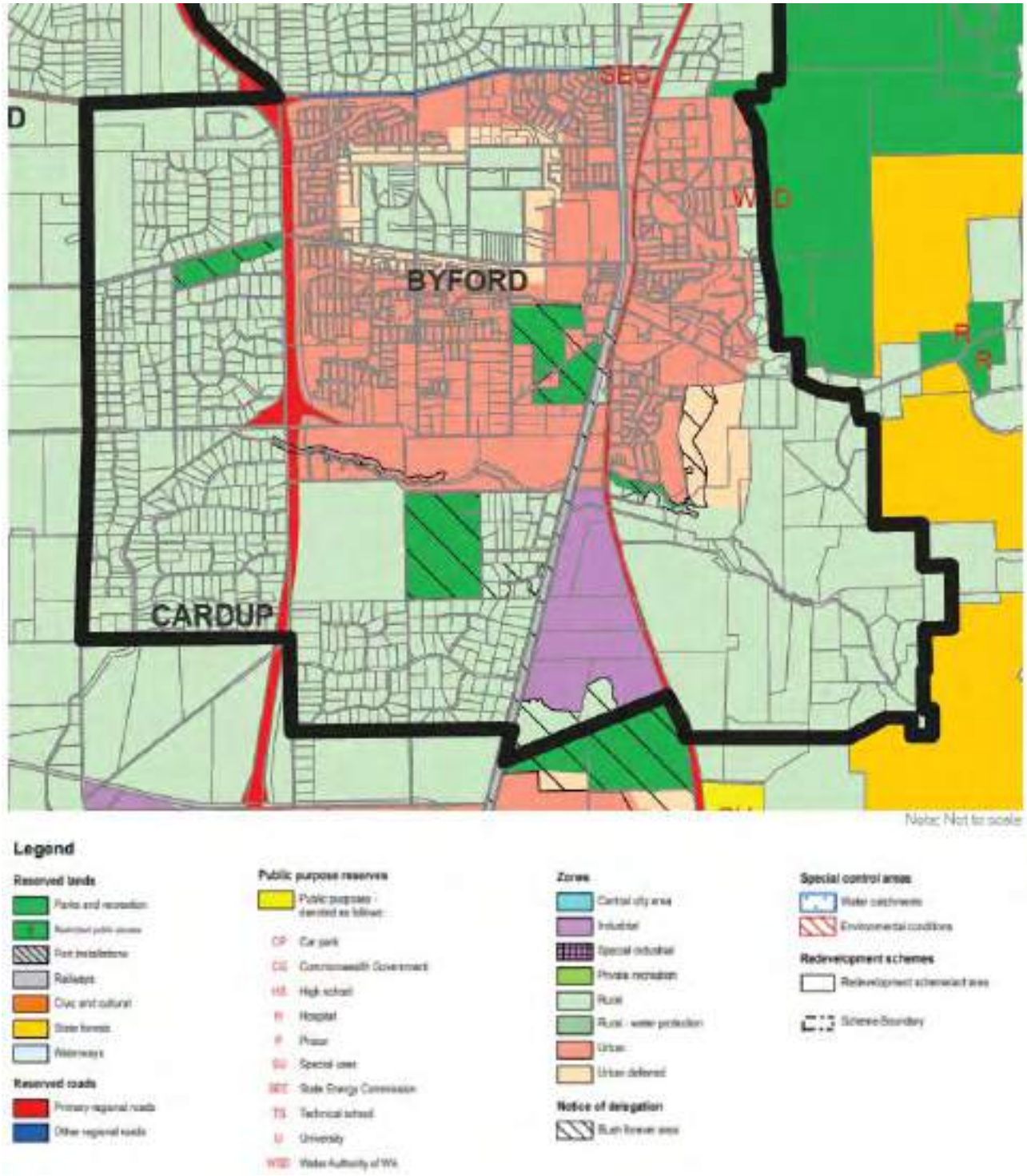



*Source: Shire of Serpentine Jarrahdale*

## 1.3 Land Use Proposal

The main areas within the structure plan area are retail and commercial, residential development and rural pursuits with a significant amount of changes proposed for the future. The proposed structure plan comprises mostly of rural and urban areas and some industrial. The Cardup Business Park to the south of the District structure plan area is recognised as a future industrial area in the South Metropolitan Peel Framework. The rural land will be maintained and preserved as existing for various rural industries and food production activities.

Figure 1-3 Existing Situation




*Source: Shire of Serpentine Jarrahdale*

### 1.3.2 Key Issues Identified

Some of the main issues and constraints identified are as follows:

- Lack of facilities and connectivity for pedestrians and cyclists.
- Lack of public transport between activity centres and regional destinations.
- Traffic issues that do not assist active transport modes.
- Limited connectivity through rail line

# 2 Existing Situation

## 2.1 Existing Land Uses

Current land use consists of medium residential densities R30-R60 within the immediate vicinity of the town centre and local centres.

As evident from **Figure 2-1 and Figure 2-2,** the land within the structure plan is predominantly zoned as urban development, rural living and rural under the local scheme zone as a significant portion of the Shire consists of rural areas.

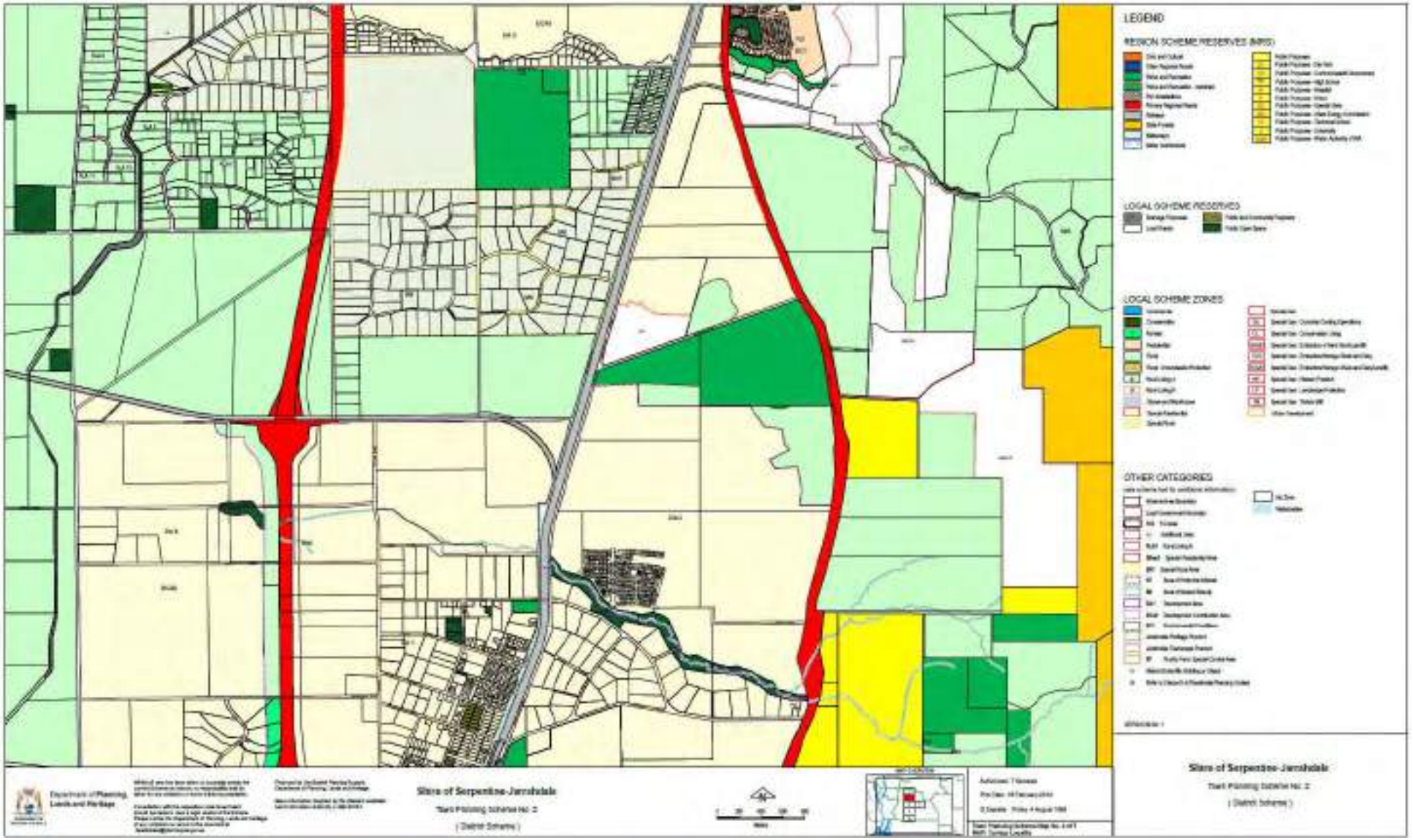
Retail and commercial activity has been concentrated within the 'old' Byford town centre between Larsen Road and Abernethy Road.

Also existing is an industrial area at the intersection of South Western Highway and Nettleton Road and some commercial land use.

The BDSP covers 5,530 hectares of area of which the land is predominantly urban or remnant rural residential zoned for future urban development.

Figure 2-1 Existing Zoning

Figure 2-2 Existing Zoning



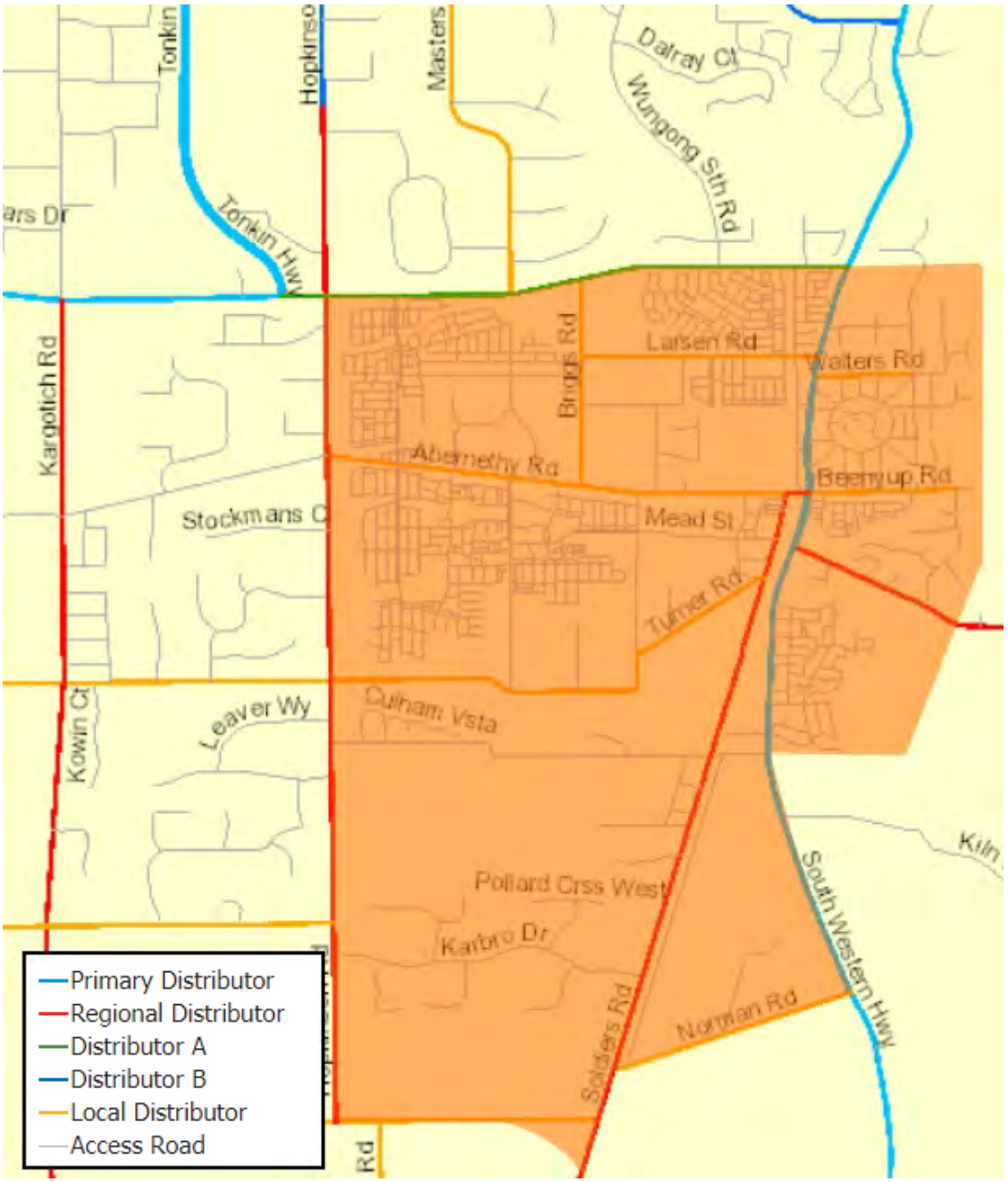

*Source: Local Planning Scheme*

## 2.2 Existing Road Network

The existing road network surrounding and within the LSP is shown in **Figure 2-3**. Road classifications are defined in the Main Roads Functional Hierarchy as follows:

- **Primary Distributors (light blue):** Form the regional and inter-regional grid of MRWA 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.

Figure 2-3 Existing Road Network




*Source: Main Roads WA*

The following discusses the characteristics of the road network surrounding the Structure Plan:

- **Tonkin Highway** is classified as *Primary Distributor* with a posted speed of 100 km/h. It forms a part of RAV 7 network (north of Welshpool Road East).
- **South Western Highway** lies to the east of the structure plan area and is classified as *Primary Distributor* with a posted speed limit that varies from 70 km/h from Hobbs Dr to Rails Crescent, to 90 km/h from Mitchell Street to Thomas Rd then to 60 km/h from Thomas Road to Abernethy Road.
- **Thomas Road** is an undivided two lane road classified as *Distributor A*, with a posted speed limit of 70 km/h.
- **Hopkinson Road** is classified as *Regional Distributor* with a posted speed limit of 60 km/h from Gloaming way which is a built up area, the speed then increases to
- **Orton Road** is classified as a Local Distributor with a posted speed limit of 50 km/h.

## 2.3 Existing Traffic Volumes

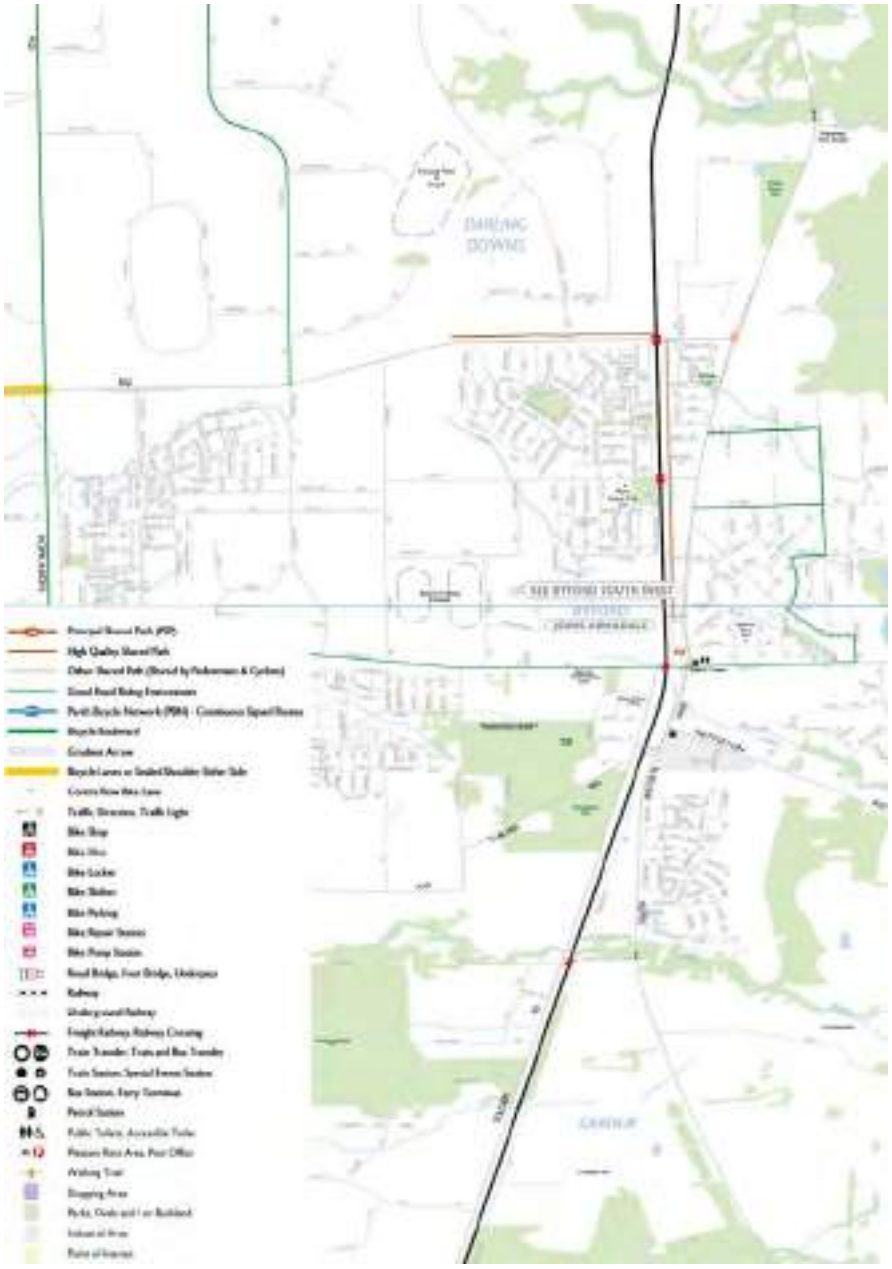
Traffic surveys were conducted on numerous locations within the Byford area. The results of these traffic counts are provided in **Appendix B**.

## 2.4 Existing Pedestrian/ Cycle Network

Existing pedestrian and cycle network is very limited due to the rural nature of the area. Active modes of transport such as walking and cycling are currently available for short distance journeys within the urban areas. There are several opportunities for network improvements to address existing issues of disconnected streets, lack of footpaths, unsafe routes and long distances.

**Figure 2-4** shows the existing pedestrian and cycle facilities within the Study Area.

Figure 2-4 Pedetrian/Cycling Network



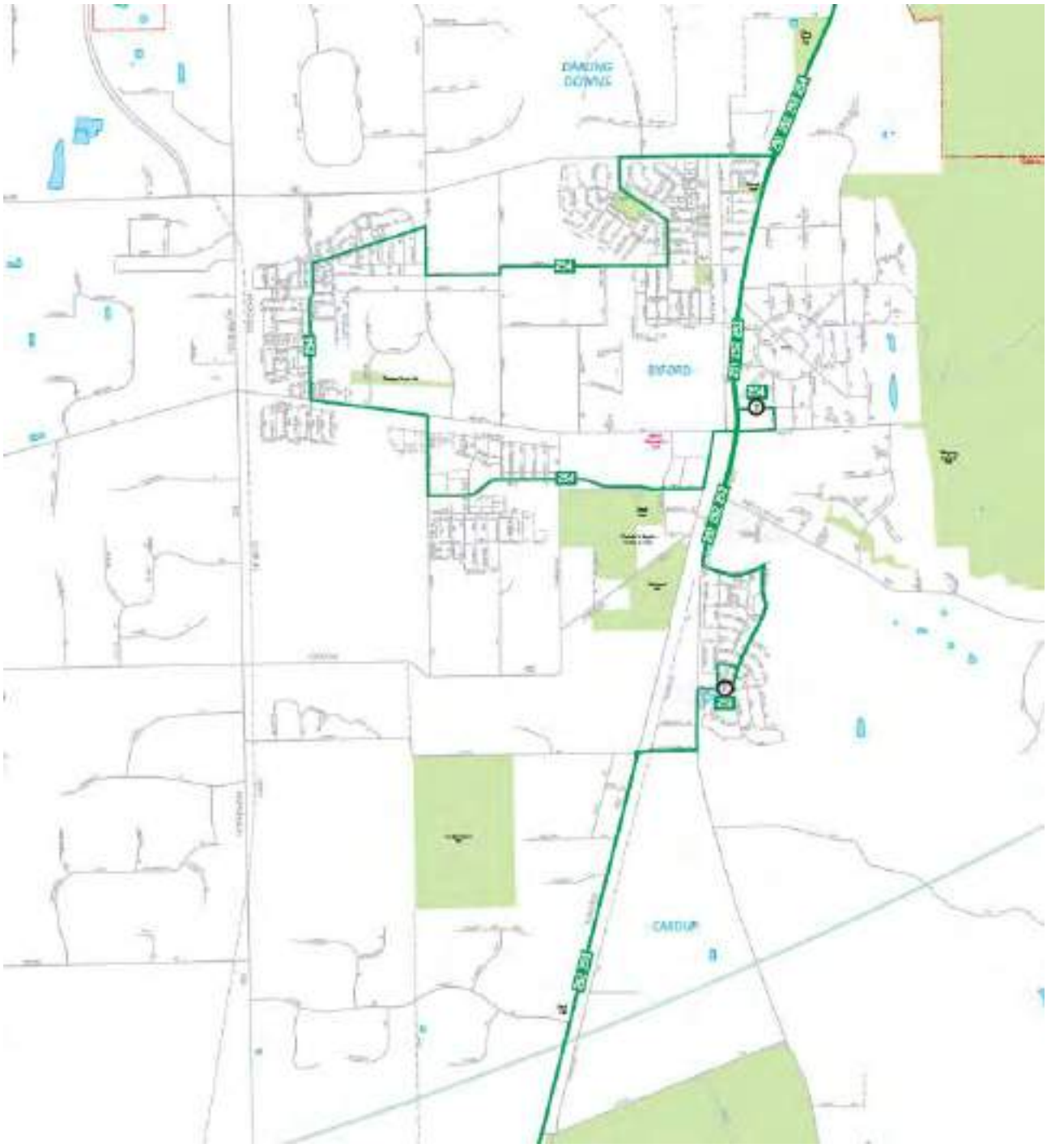
*Source: Department of Transport (2016)*

## 2.5 Existing Public Transport Services

The existing public transport services are shown below in **Figure 2-5**. A railway line runs alongside the South Western Highway; however, standard commuter rail services currently terminate at Armadale.

The rail line south of Armadale is used primarily for freight, with a regional rail service provided by the Australind to Perth and Bunbury twice daily.

Figure 2-5 Existing Public Transport Routes




*Source: Transperth*

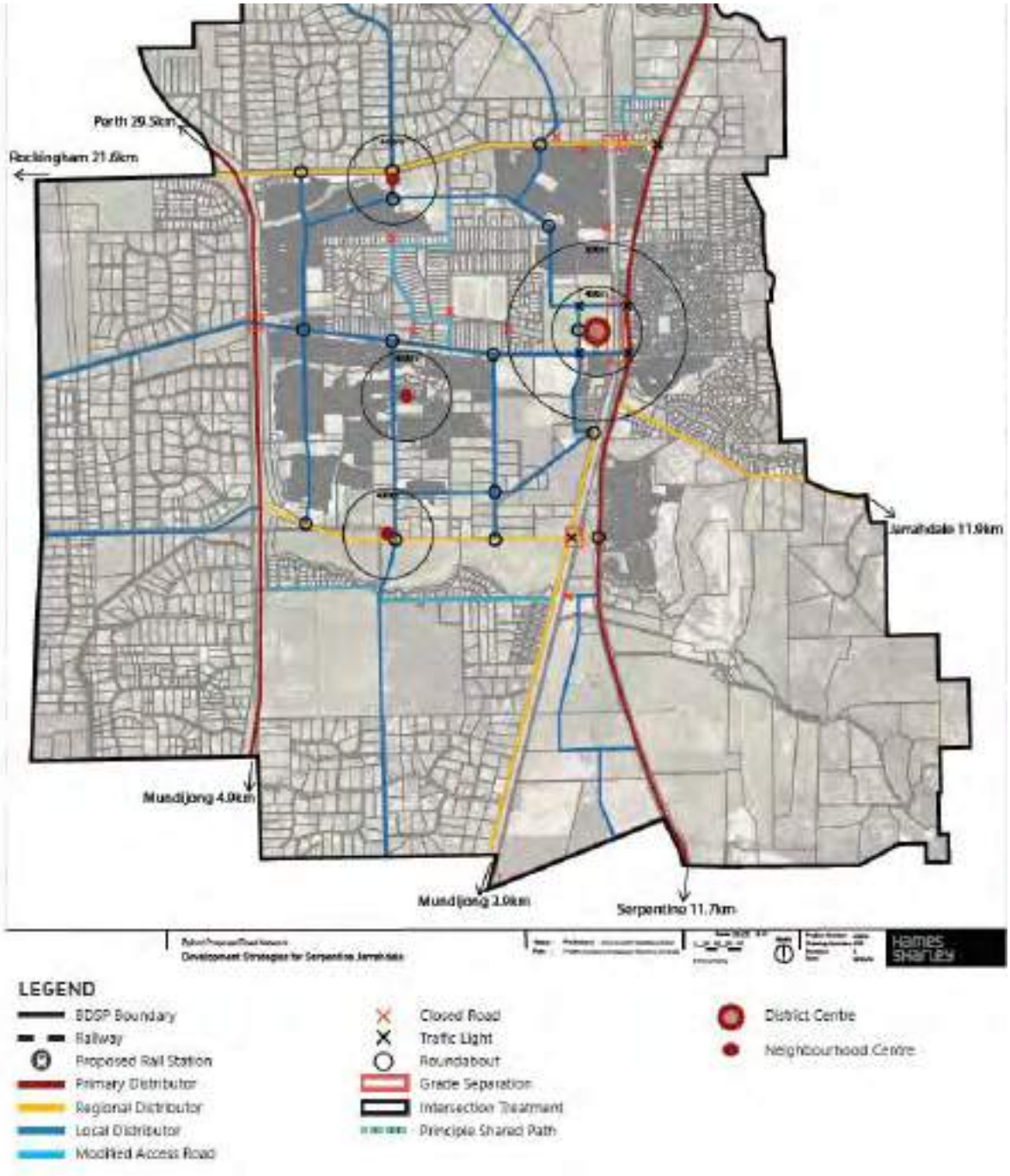
Transperth bus Routes 251,252 and 253 connect Kingsbury Drive/Jacaranda Avenue to Armadale Station, while Route 254 connects Clifton Street/South Western Highway to Armadale Station.

# 3 Proposed Changes to Transport Networks

## 3.1 Road Network Changes

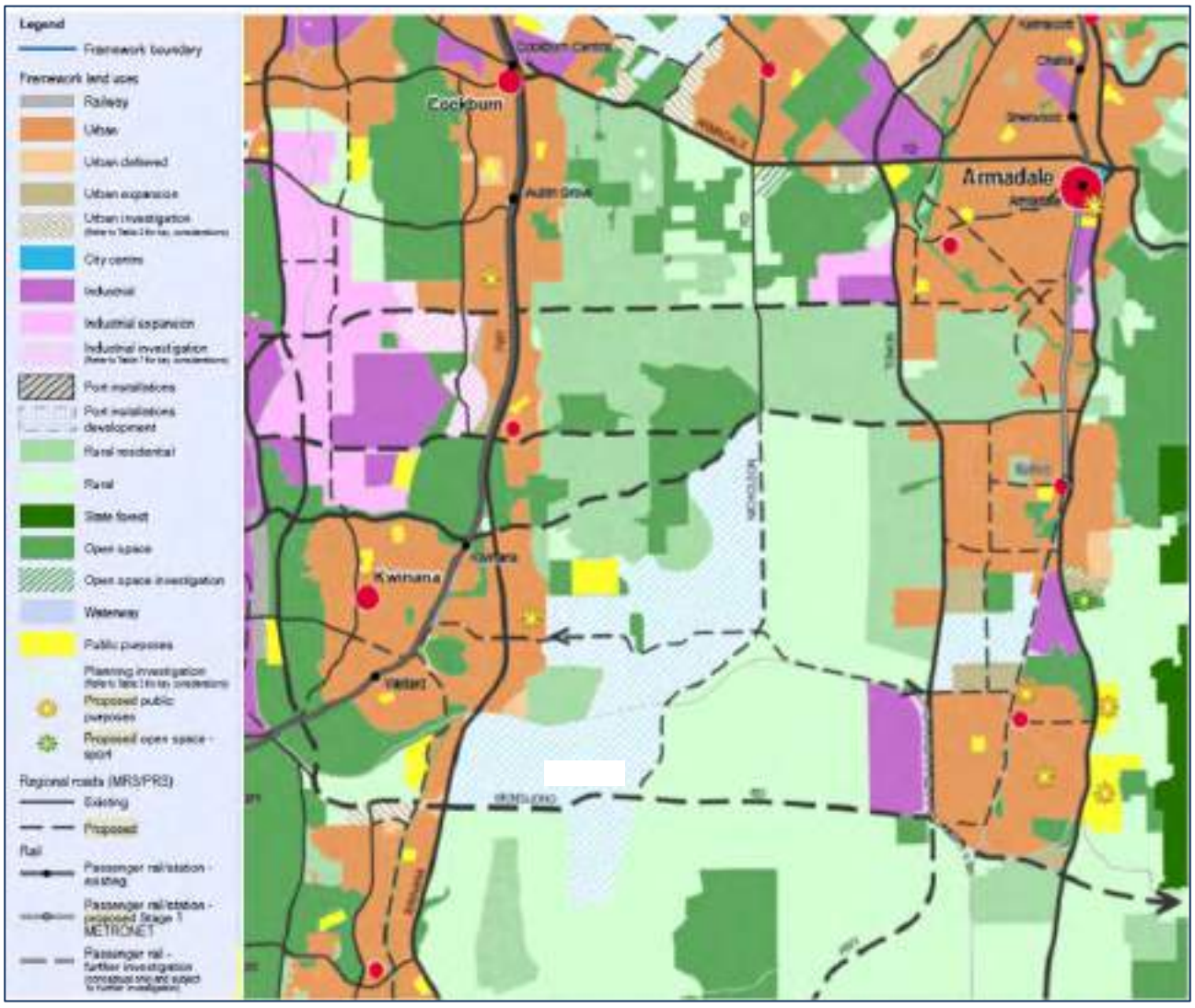
The current structure plan provides a list of changes that are proposed for the existing roads as per **Figure 3-1** and **Figure 3-2**. These upgrades have been evaluated through Aimsun mesoscopic modelling and SIDRA analysis.

Figure 3-1 Road Network Changes




*Source: Shire of Serpentine Jarrahdale*

Figure 3-2 Existing and Proposed Roads




*Source: Shire of Serpentine Jarrahdale*

The following changes are proposed to the existing road network along with the proposed new roads:

- Extension of Tonkin Highway southward to connect through to Mundijong Road.
- Intersection connection treatments onto Tonkin Highway at Thomas Road and Orton Road.
- Abernethy Road continuation under Tonkin Highway.
- New and upgraded primary distributors and integrator arterial roads.
- Upgrade of Thomas Road and Orton Road.
- Orton Road extension to link South Western Highway.
- Additional north to south distributor roads included in extension/upgrade of Wungong South Road to Wungong Road.

## 3.2 Pedestrian and Cycle Network Changes

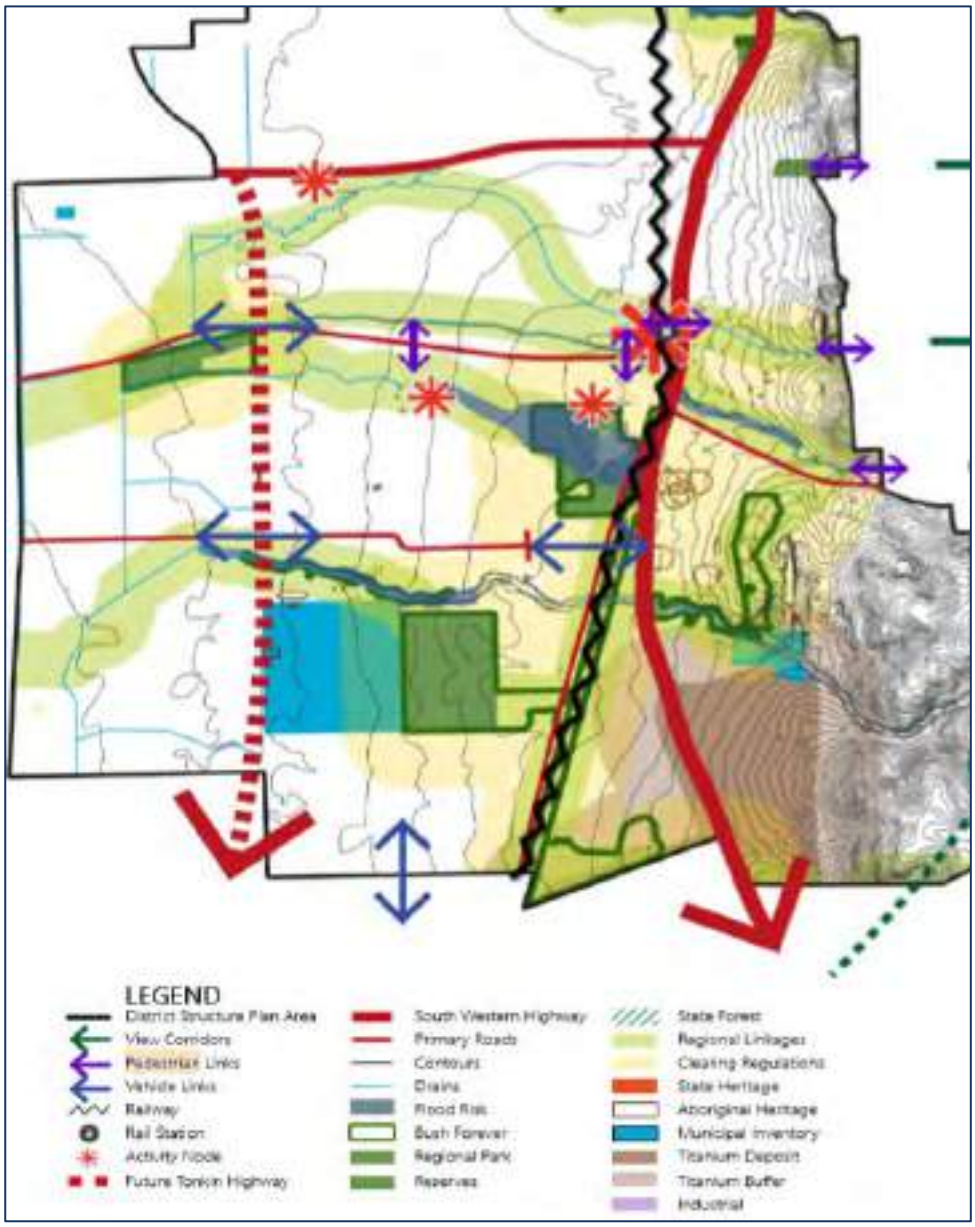
The strategies and opportunities to improve the pedestrian and cycle network include:

- Provision of pedestrian, bridle trail, cycling linkages internally and to the scarp.
- Complete various trails that have not been ceded yet.
- Improved connectivity and greenways for cycling and walking.

> Walking and cycling catchments to the Byford Town Centre Railway Station and neighbourhood centres present opportunities to link to a wider cycle and pedestrian network.

As such, the opportunities and constraints map is explained on **Figure 3-3**.

Figure 3-3 Opportunities and Constraints Map




*Source: Shire of Serpentine Jarrahdale*

## 3.3 Public Transport Network Changes

Within the Sub-regional Planning Framework, the proposed public transport includes a network of passenger rail lines and transit corridors. A proposal for the extension of the Armadale line to Byford exists within the BDSP area. This railway facility is also proposed to have a High Frequency Transit Corridors (HFTC) providing public transport connections between activity centres, population catchments, train stations and local bus services.

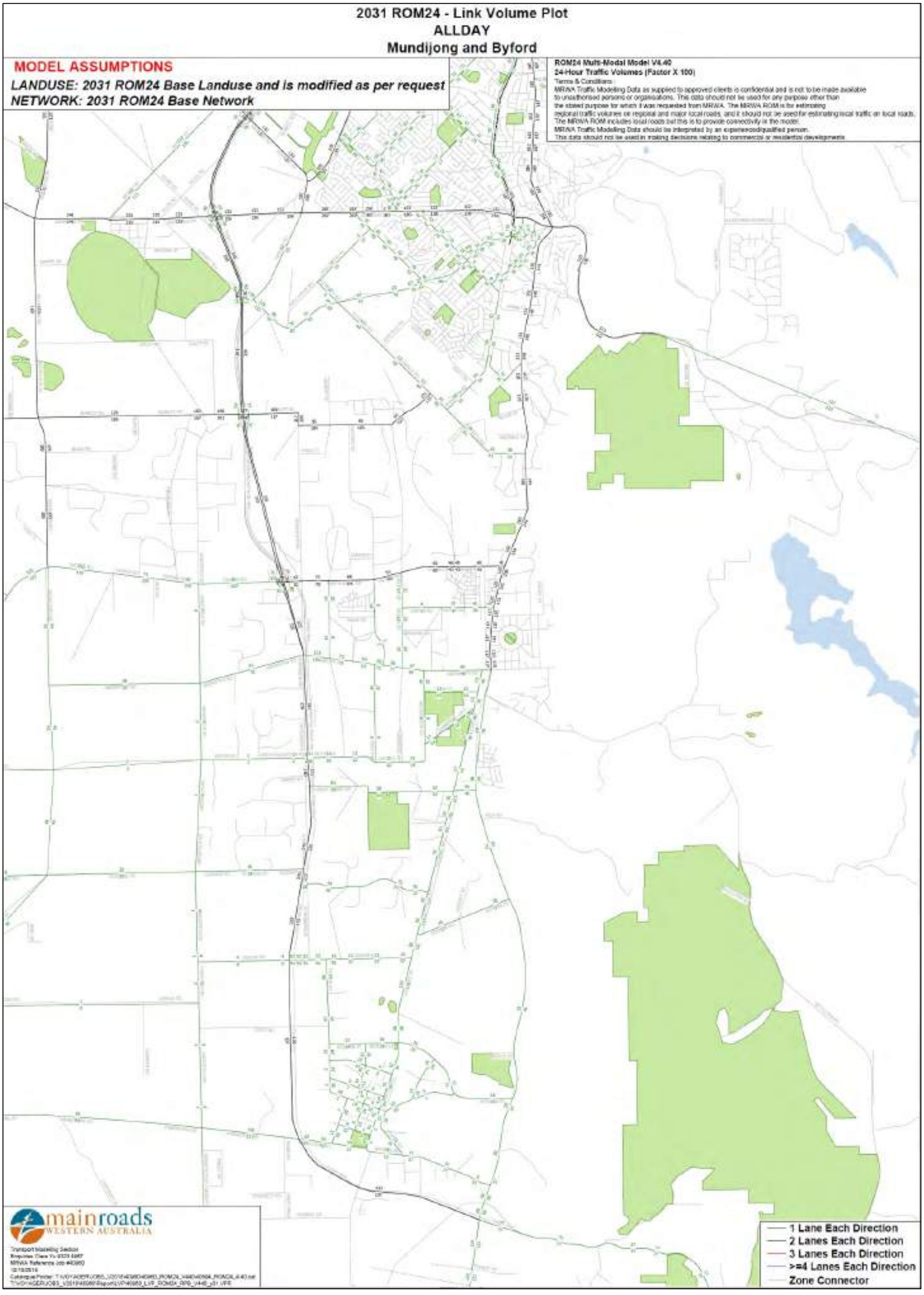
## 3.4 Projected Daily Traffic Volumes

Assessment of the impacts of development growth both within and beyond the Byford Structure Plan area has been facilitated through Main Roads' ROM24 strategic model. This model relies on land use projections provided by Local and State Government agencies to generate vehicle trips across the network. Cardno has endeavoured to ensure that the land uses defined in ROM24 within the Study Area are consistent with the Shire's anticipated development horizon.

It is acknowledged that full build-out of this land area may not be achieved within the 2031 horizon, which is the only ROM24 time scale currently supplied by Main Roads WA. As such, the ROM24 outputs used as the basis of this TIA have been used to establish an anticipated development and traffic scenario at the point when build-out of the Shire's development planning has been achieved.

**Figure 3-4** shows the 2031 daily vehicle volume output from ROM24 model as provided by Main Roads WA.

Figure 3-4 ROM24 Daily Traffic Volumes (2031 horizon)




*Source: Main Roads WA*

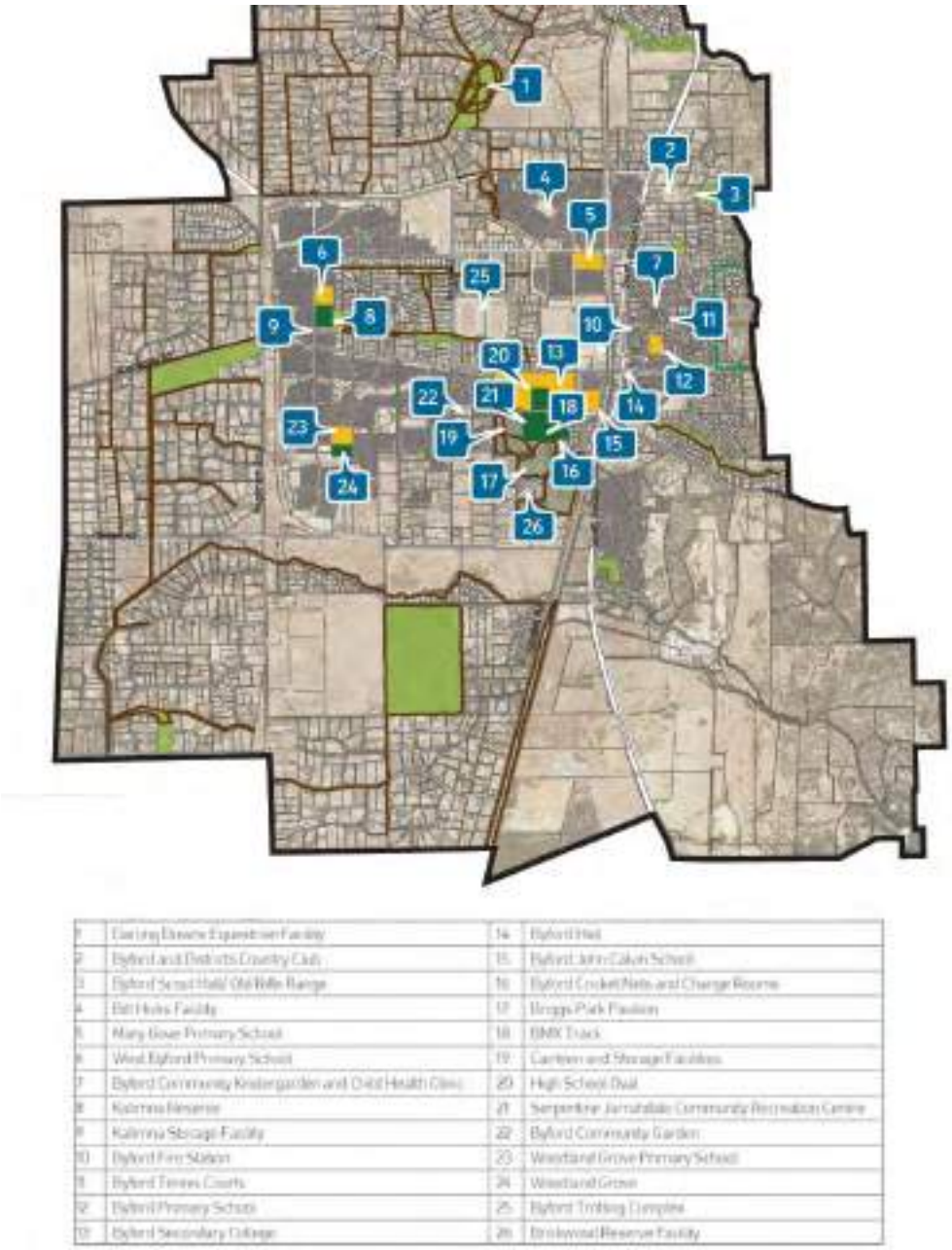
# 4 Integration with Surrounding Area

## 4.1 Surrounding Attractors/Generators

The major attractors for people from within the structure plan area include the Darling Downs Equestrian Facility, Byford and Districts Country Club, Serpentine Jarrahdale Community Recreation Centre and other surrounding areas as per **Figure 4-1.**

Major generators within the structure plan include the Mary Grove Primary School, West Byford Primary School, Byford Trotting Complex and other existing infrastructure as per **Figure 4-1.** The Shire also has a well-established focus on equestrian activities, these areas along with the trails act as a major generator.

Figure 4-1 Generators and Attractors




*Source: Shire of Serpentine Jarrahdale*

## 4.2 Proposed Changes to Surrounding Land uses

The structure plan identifies the requirement for development of areas in close proximity of key public transport networks and new nodes of activities. The surrounding area is to remain as rural and urban development whilst increasing the density codes around the town centre.

## 4.3 Level of Accessibility

The main access to the structure plan area from external attractors is through the connectivity of internal road networks to South Western Highway and Thomas Road, which are classified as Primary Distributor and Distributor A. Access through internal road intersections include:

- Thomas Road and Hopkinson Road
- Orton Road and Hopkinson Road
- Abernethy Road and South Western Highway
- South Western Highway and Cardup Siding Road
- Hopkinson Road and Abernethy Road
- Larsen Road and South Western Highway

For access by public transport, there are bus Routes 251, 252 and 253 run along South Western Highway and through the internal road network to Armadale Station.

Current provision of alternative transport modes such as cycling and walking include a good riding environment and a shared path along South Western Highway.

The proposed Train Station in Byford Town Centre and the associated walking and cycling catchment will further improve accessibility and match the desire lines.

It is expected that the existing road network will be able to cater for the travel desire lines between the structure plan area and the surrounding land uses.

# 5 Analysis of Transport Network

## 5.1 Assessment Years and Time Periods

The assessment period is based on the future mesoscopic modelling results which was conducted for 2031.

## 5.2 Background and Future Traffic Generation Estimation

A mesoscopic traffic model was developed to model the current traffic situation and provide a base to determine the likely future traffic impacts.

A number of data sources were used in the formulation of the mesoscopic model which included traffic, surveys, census data and information provided by local authorities.

The future-year models are based on the traffic growth scenario derived from information provided by the Shire of Serpentine-Jarrahdale and Main Roads (ROM24 outputs) for the 2031 scenario years.

## 5.3 Intersection Assessment

Based on the results provided by the mesoscopic model, the network in the area of Byford is operating at an acceptable level of service with sufficient capacity to accommodate traffic for the 2018 scenario.

With respect to the 2031 scenario, the mesoscopic model identified a number of intersections which exhibited capacity or delay issues. These intersections have been assessed in SIDRA to determine the minimum extent of upgrades required to ensure that they are operating at an acceptable level of service in 2031.

**Table 5-1** provides a summary of the intersections which experienced excessive delays or overcapacity issues as identified by the mesoscopic model in the 2031 scenario.

Table 5-1 Intersections to be Assessed

| Number | Intersections | Time Period |
|---|---|---|
| 1 | Tonkin Hwy & Thomas Rd | 2031 AM & PM |
| 2 | Abernethy Rd & S Western Hwy | 2031 PM |
| 3 | Abernethy Rd & New Road 4 & Gordin Way | 2031 PM |
| 4 | Soldiers Rd & New Road 6 | 2031 AM & PM |
| 5 | New Road 5 & Tonkin Hwy | 2031 AM & PM |

All other intersections assessed through the mesoscopic model were considered to operate at an acceptable level of service for the 2031 scenario.

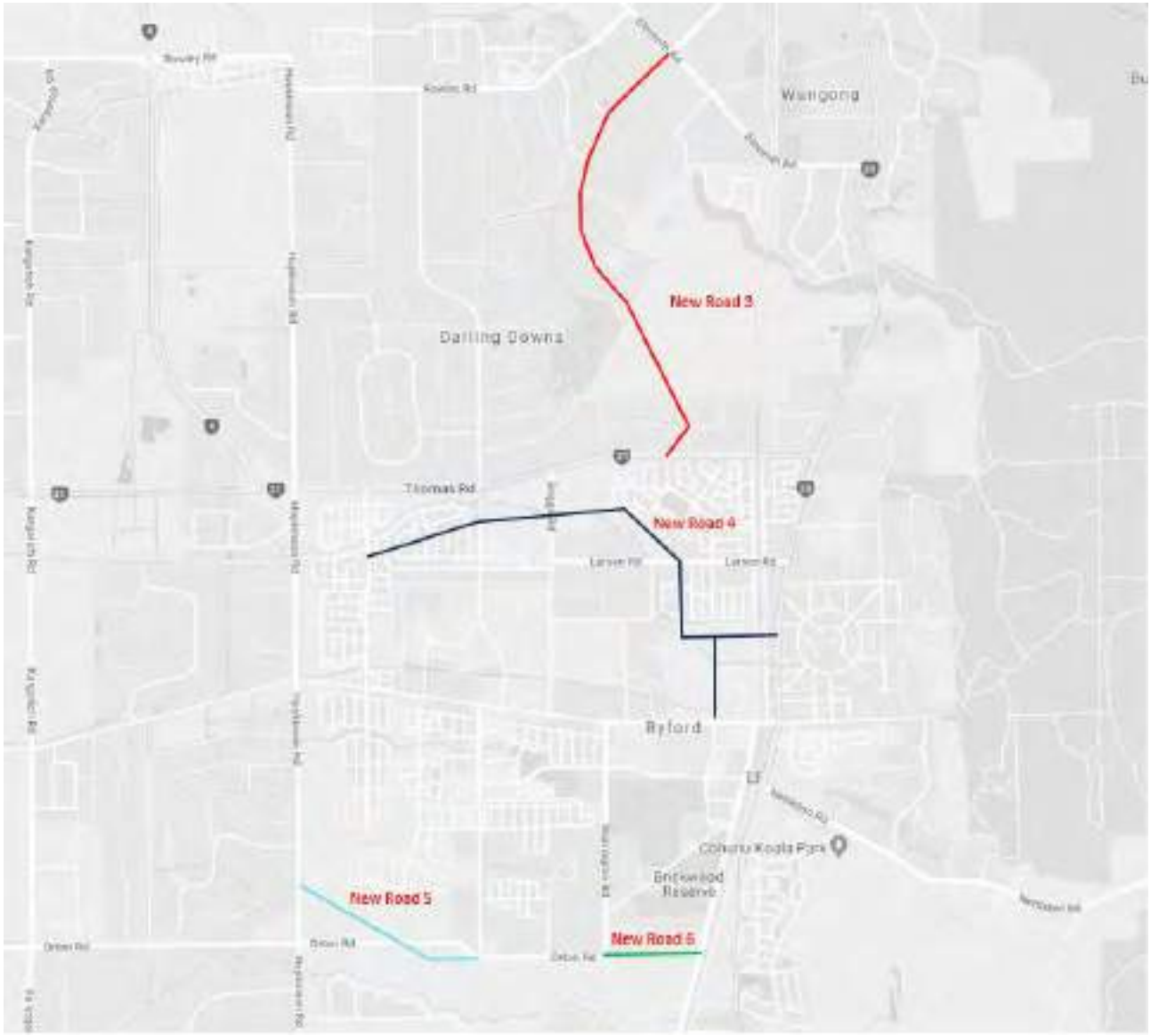
The following density maps identify locations where peak period demand may create localised capacity constraints, and where upgrades to the network may be required. These locations have been assessed further through SIDRA assessment to ascertain whether further upgrades are required.

Figure 5-1 Simulated 2031 Density Map (AM Peak)

Figure 5-2 Simulated 2031 Density Map (PM Peak)

**Figure 5-3** indicates the new road locations and the locations of the assessed intersections within the Byford Area.

Figure 5-3 Location of New Links



## 5.4 Summary of Results

The following map identifies the results of intersection evaluation across the Byford area. Intersections have been classified into 3 groups and shown in **Figure 5-4 and Figure 5-5** below:

1. **Existing Intersection Sufficient:** the existing (2018) geometry has been evaluated through the Aimsun mesoscopic model and shown to be sufficient to accommodate future traffic growth.
2. **Modified Intersection Sufficient:** the Shire's proposed modifications have been evaluated through the Aimsun mesoscopic model and shown to be sufficient to accommodate future traffic growth.
3. **Additional Reconfiguration Required:** The existing and/or proposed intersection form has been evaluated through the Aimsun mesoscopic model and found to experience excessive congestion or delay. These intersections have been re-evaluated in SIDRA and changes identified to improve operation.

Figure 5-4 Intersection Sufficiency Map

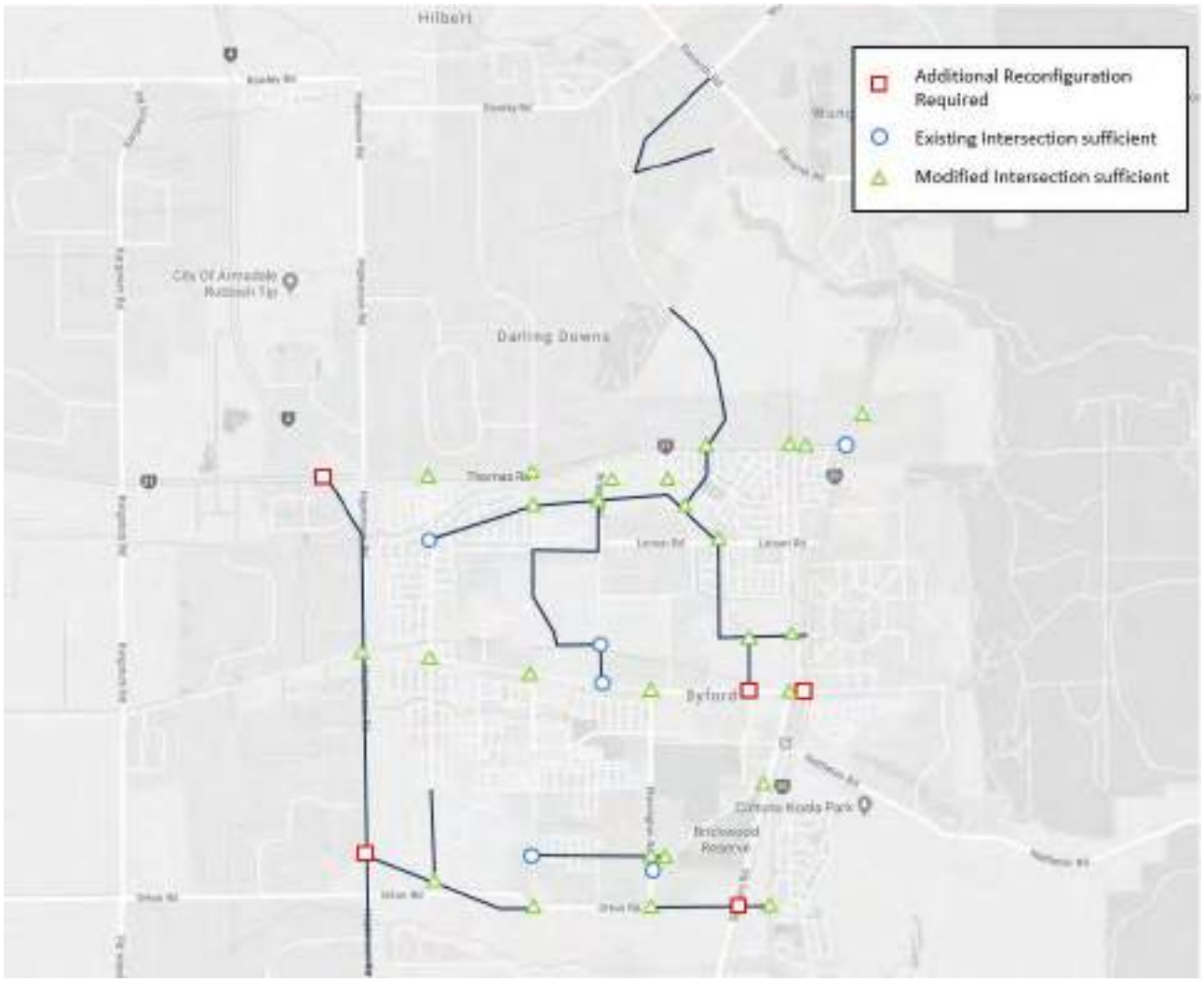


Figure 5-5 Intersection Sufficiency Map

## 5.5 Intersection Performance

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 characteristics 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 time delays for vehicles through the intersection. An unsignalised intersection can be considered to be operated 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 stream and the perception by motorists and/or passengers. The different levels of service can generally be described as shown in **Table 5-2.**

Table 5-2 Level of Service (LOS) Performance Criteria

| LOS | Description | Signalised Intersection | Unsignalised Intersection |
|---|---|---|---|
| A | Free-flow operations (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 | 5-35 sec |
| E | Operations at capacity | 55-80 sec | 35-50 sec |
| F | A breakdown in vehicular flow (worst condition) | ≥80 sec | ≥50 sec |

### 5.5.2 Evaluation Process

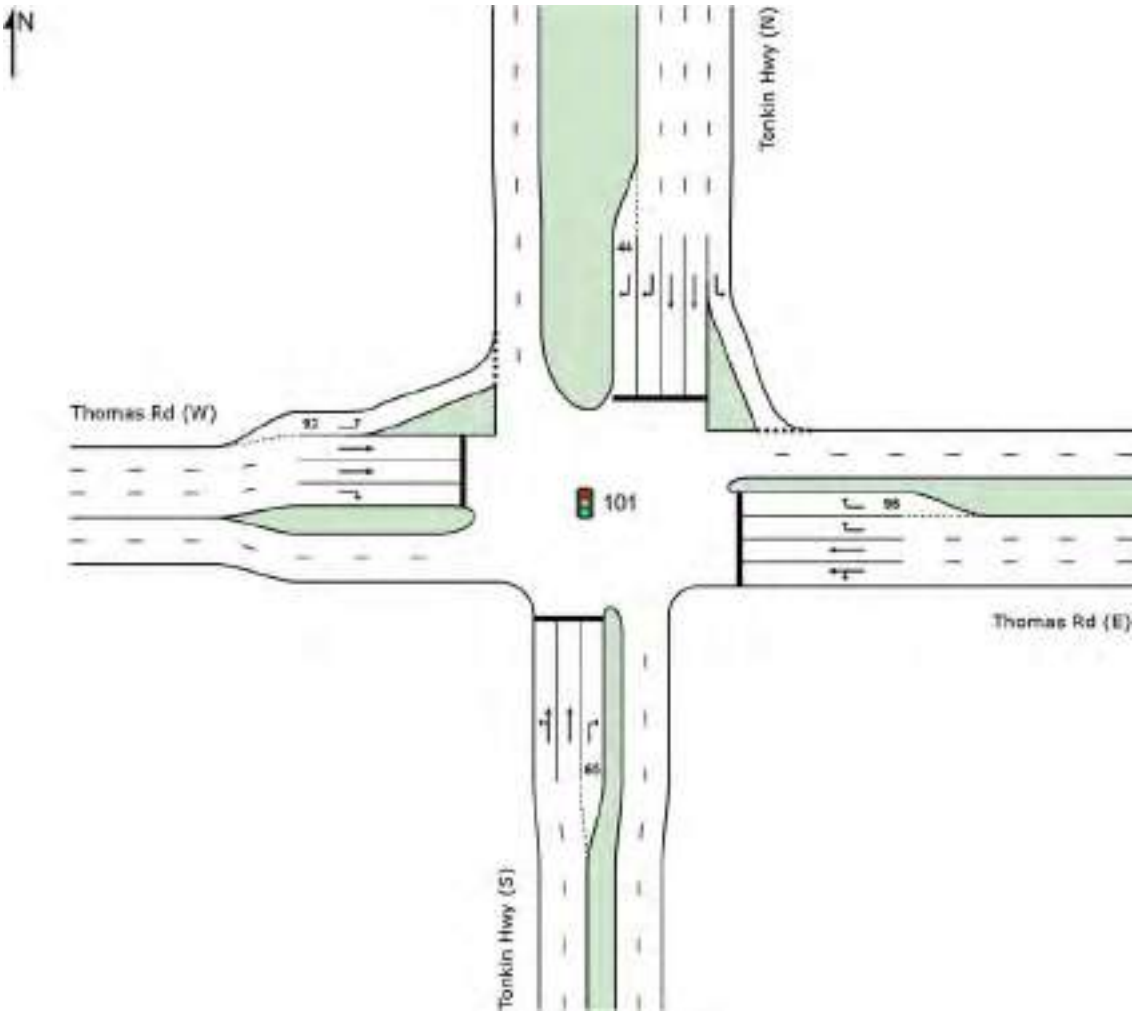
The following process has been used to inform the SIDRA assessment:

- Intersections have been modelled as per their proposed configuration, or where no changes have previously been identified, the existing road form.
- Intersections where Aimsun modelling shows simulated traffic density or approach projected delays are high are considered to be ‘at risk’, and have been reviewed using SIDRA analysis.
- For the purposed of the SIDRA assessment, turning movements with extremely low turning volumes (<5 vph) have been tripled to provide a robust assessment. It is acknowledged that these low volumes are likely an artefact of the coarse road network and zoning structure. However, it can be expected that these turning movement values will not dominate the intersection function.
- SIDRA intersection modelling has been used ***only*** to identify the minimum necessary intervention required from an operational standpoint. Additional measures may be required to ensure intersection geometry meets Austroads guidelines for safety and function.

### 5.5.3 No. 1 – Tonkin Highway and Thomas Road

The following presents the results of the analysis of the Tonkin Highway/Thomas Road intersection**. Figure 5-6** is a SIDRA layout representation of the intersection which is based on the indicative layouts used in the mesoscopic model.

Figure 5-6 SIDRA Layout for Tonkin Highway/Thomas Road Intersection




The results from the SIDRA analysis are summarised in **Table 5-3** and **Table 5-4**.

Table 5-3 Tonkin Highway/Thomas Road Intersection AM Results 2031

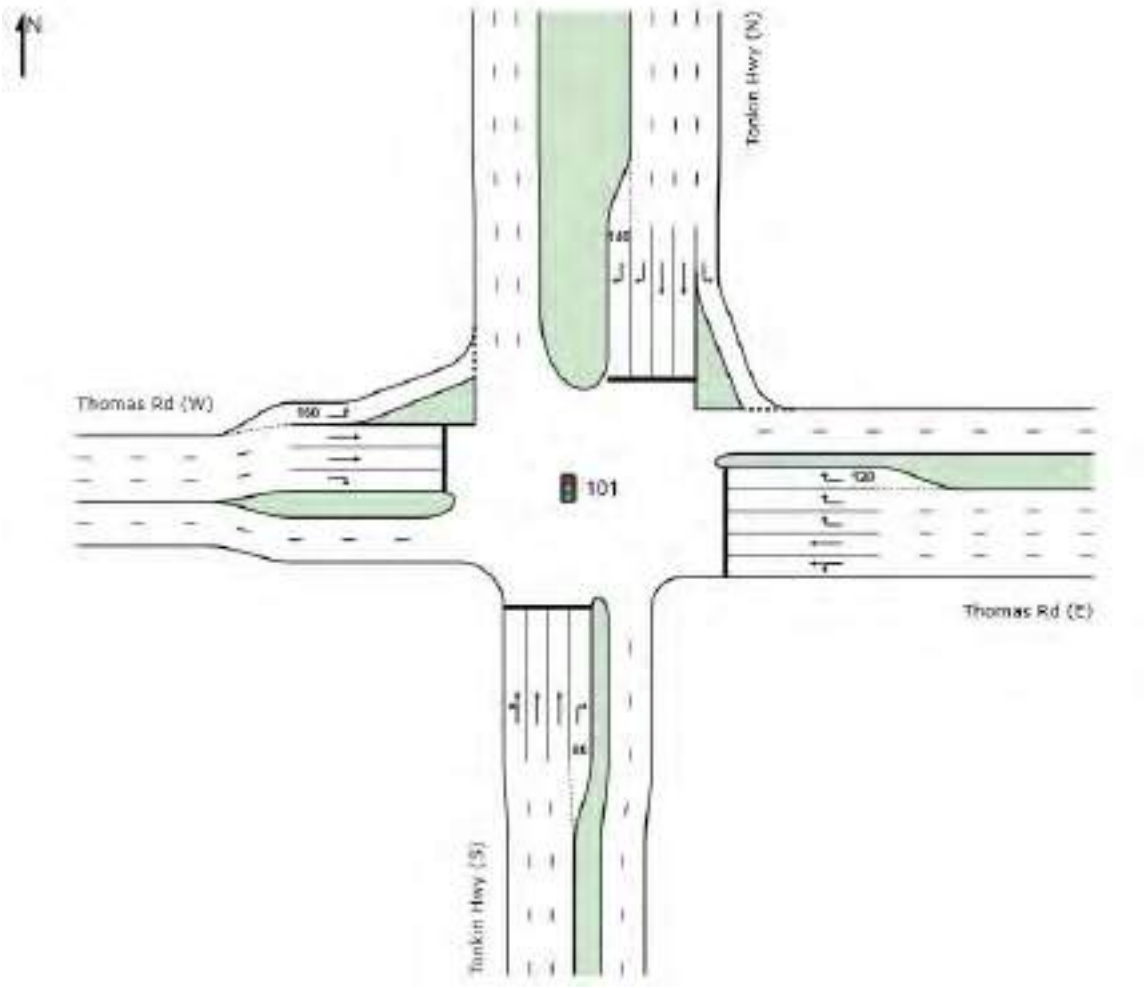
| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Tonkin Hwy | | | | | | | | | | | | |
| 1 | L2 | 394 | 7.4 | 0.918 | 57.6 | LOS E | 37.2 | 276.6 | 1.00 | 1.08 | 1.33 | 30.8 |
| 2 | T1 | 670 | 7.2 | 0.918 | 55.2 | LOS E | 37.2 | 276.6 | 1.00 | 1.13 | 1.38 | 31.1 |
| 3 | R2 | 17 | 0.0 | 0.918 | 62.2 | LOS E | 28.7 | 213.0 | 1.00 | 1.16 | 1.40 | 30.4 |
| Approach | | 1081 | 7.1 | 0.918 | 56.1 | LOS E | 37.2 | 276.6 | 1.00 | 1.11 | 1.36 | 31.0 |
| East: New Road 5 | | | | | | | | | | | | |
| 4 | L2 | 16 | 0.0 | 1.116 | 279.6 | LOS F | 93.7 | 698.9 | 1.00 | 1.97 | 3.31 | 10.6 |
| 5 | T1 | 109 | 5.5 | 1.116 | 274.0 | LOS F | 93.7 | 698.9 | 1.00 | 1.97 | 3.31 | 10.6 |
| 6 | R2 | 490 | 8.4 | 1.116 | 279.6 | LOS F | 93.7 | 698.9 | 1.00 | 1.97 | 3.31 | 10.6 |
| Approach | | 615 | 7.6 | 1.116 | 278.6 | LOS F | 93.7 | 698.9 | 1.00 | 1.97 | 3.31 | 10.6 |
| North: Tonkin Hwy | | | | | | | | | | | | |
| 7 | L2 | 299 | 6.0 | 1.025 | 139.2 | LOS F | 70.2 | 519.2 | 1.00 | 1.63 | 2.14 | 18.3 |
| 8 | T1 | 394 | 7.1 | 1.025 | 133.6 | LOS F | 70.2 | 519.2 | 1.00 | 1.63 | 2.14 | 18.5 |
| 9 | R2 | 107 | 7.5 | 1.297 | 592.3 | LOS F | 26.1 | 194.7 | 1.00 | 2.32 | 5.60 | 5.5 |
| Approach | | 800 | 6.8 | 1.297 | 197.0 | LOS F | 70.2 | 519.2 | 1.00 | 1.72 | 2.61 | 14.0 |
| West: New Road 5 | | | | | | | | | | | | |
| 10 | L2 | 58 | 19.0 | 1.093 | 241.3 | LOS F | 36.0 | 270.4 | 1.00 | 1.84 | 3.19 | 11.9 |
| 11 | T1 | 43 | 7.0 | 1.093 | 235.6 | LOS F | 36.0 | 270.4 | 1.00 | 1.84 | 3.19 | 12.0 |
| 12 | R2 | 169 | 5.3 | 1.093 | 241.2 | LOS F | 36.0 | 270.4 | 1.00 | 1.84 | 3.19 | 11.9 |
| Approach | | 270 | 8.5 | 1.093 | 240.3 | LOS F | 36.0 | 270.4 | 1.00 | 1.84 | 3.19 | 11.9 |
| All Vehicles | | 2766 | 7.3 | 1.297 | 164.3 | LOS F | 93.7 | 698.9 | 1.00 | 1.55 | 2.33 | 16.0 |

Table 5-4 Tonkin Highway/Thomas Road Intersection PM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Tonkin Hwy (S) | | | | | | | | | | | | |
| 1 | L2 | 50 | 4.0 | 0.858 | 70.4 | LOS E | 8.7 | 63.5 | 1.00 | 0.92 | 1.40 | 32.4 |
| 2 | T1 | 243 | 4.5 | 0.858 | 62.4 | LOS E | 8.9 | 64.6 | 1.00 | 0.92 | 1.40 | 36.7 |
| 3 | R2 | 11 | 0.0 | 0.072 | 60.0 | LOS E | 0.6 | 3.9 | 0.95 | 0.68 | 0.95 | 34.5 |
| Approach | | 304 | 4.3 | 0.858 | 63.7 | LOS E | 8.9 | 64.6 | 1.00 | 0.92 | 1.38 | 35.8 |
| East: Thomas Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 10 | 10.0 | 0.777 | 57.4 | LOS E | 13.9 | 101.6 | 1.00 | 0.91 | 1.13 | 35.7 |
| 5 | T1 | 496 | 5.0 | 0.777 | 50.9 | LOS D | 13.9 | 101.8 | 1.00 | 0.91 | 1.13 | 35.6 |
| 6 | R2 | 863 | 0.6 | 0.855 | 55.7 | LOS E | 24.9 | 175.0 | 1.00 | 0.95 | 1.19 | 35.1 |
| Approach | | 1369 | 2.3 | 0.855 | 54.0 | LOS D | 24.9 | 175.0 | 1.00 | 0.93 | 1.17 | 35.3 |
| North: Tonkin Hwy (N) | | | | | | | | | | | | |
| 7 | L2 | 541 | 11.8 | 0.463 | 12.3 | LOS B | 8.8 | 67.7 | 0.41 | 0.75 | 0.41 | 59.4 |
| 8 | T1 | 798 | 10.0 | 0.856 | 50.7 | LOS D | 23.2 | 176.3 | 1.00 | 0.97 | 1.20 | 42.1 |
| 9 | R2 | 571 | 6.5 | 0.842 | 40.0 | LOS D | 9.9 | 73.0 | 1.00 | 0.90 | 1.23 | 41.7 |
| Approach | | 1910 | 9.5 | 0.856 | 36.6 | LOS D | 23.2 | 176.3 | 0.83 | 0.89 | 0.99 | 45.7 |
| West: Thomas Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 380 | 4.5 | 0.369 | 16.2 | LOS B | 9.3 | 67.8 | 0.56 | 0.74 | 0.56 | 55.3 |
| 11 | T1 | 542 | 6.1 | 0.836 | 54.6 | LOS D | 15.7 | 115.4 | 1.00 | 0.96 | 1.23 | 34.4 |
| 12 | R2 | 57 | 1.8 | 0.114 | 38.7 | LOS D | 2.3 | 16.3 | 0.79 | 0.74 | 0.79 | 41.5 |
| Approach | | 979 | 5.2 | 0.836 | 38.8 | LOS D | 15.7 | 115.4 | 0.82 | 0.86 | 0.94 | 40.8 |
| All Vehicles | | 4562 | 6.0 | 0.858 | 44.1 | LOS D | 24.9 | 176.3 | 0.89 | 0.90 | 1.06 | 40.3 |

The SIDRA results show that the intersection will operate at an unacceptable level of service with long delays and queues. Significant modifications to the geometry and the signal timing are required to ensure that the intersection operates within an acceptable level of service. **Figure 5-7** shows the reconfigured do-minimum intersection layout.

Figure 5-7 Reconfigured SIDRA Layout for Tonkin Highway/Thomas Road Intersection




The SIDRA results based on this reconfigured intersection layout and signal phasing analysis are summarised in **Table 5-5** and **Table 5-6**. The results show that there will be some slight delays for right turning movements, particularly on the western and northern legs of the intersection. However, these delays are considered to be acceptable as they do not considerably exceed the LOS threshold for unacceptable delays.

For the PM peak period, the intersection is approaching capacity and grade separation could be considered to improve capacity.

Table 5-5 Reconfigured Tonkin Highway/Thomas Road Intersection AM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | Distance | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | | | km/h |
| South: Tonkin Hwy (S) | | | | | | | | | | | | |
| 1 | L2 | 103 | 6.8 | 0.892 | 61.6 | LOS E | 21.5 | 160.3 | 1.00 | 1.01 | 1.35 | 35.1 |
| 2 | T1 | 1021 | 7.8 | 0.892 | 53.4 | LOS D | 21.8 | 162.5 | 1.00 | 1.01 | 1.35 | 40.6 |
| 3 | R2 | 45 | 24.4 | 0.158 | 47.0 | LOS D | 1.9 | 16.0 | 0.88 | 0.74 | 0.88 | 36.9 |
| Approach | | 1169 | 8.4 | 0.892 | 53.9 | LOS D | 21.8 | 162.5 | 1.00 | 1.00 | 1.33 | 39.9 |
| East: Thomas Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 9 | 0.0 | 0.600 | 31.3 | LOS C | 9.0 | 66.9 | 0.94 | 0.78 | 0.94 | 49.3 |
| 5 | T1 | 506 | 6.9 | 0.600 | 25.0 | LOS C | 9.0 | 67.0 | 0.94 | 0.78 | 0.94 | 47.5 |
| 6 | R2 | 888 | 3.4 | 0.680 | 44.8 | LOS D | 13.4 | 96.9 | 0.97 | 0.85 | 0.98 | 38.9 |
| Approach | | 1403 | 4.6 | 0.680 | 37.6 | LOS D | 13.4 | 96.9 | 0.96 | 0.82 | 0.97 | 41.7 |
| North: Tonkin Hwy (N) | | | | | | | | | | | | |
| 7 | L2 | 520 | 8.3 | 0.397 | 11.2 | LOS B | 6.6 | 49.6 | 0.36 | 0.73 | 0.36 | 61.4 |
| 8 | T1 | 769 | 6.6 | 0.894 | 53.8 | LOS D | 22.1 | 163.4 | 1.00 | 1.02 | 1.35 | 40.7 |
| 9 | R2 | 578 | 7.6 | 0.911 | 69.0 | LOS E | 17.3 | 129.4 | 1.00 | 1.00 | 1.50 | 31.4 |
| Approach | | 1867 | 7.4 | 0.911 | 46.7 | LOS D | 22.1 | 163.4 | 0.82 | 0.93 | 1.12 | 40.8 |
| West: Thomas Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 653 | 8.4 | 0.747 | 25.6 | LOS C | 19.9 | 149.2 | 0.86 | 0.93 | 1.05 | 48.0 |
| 11 | T1 | 359 | 7.2 | 0.876 | 57.9 | LOS E | 10.1 | 74.8 | 1.00 | 1.01 | 1.45 | 33.4 |
| 12 | R2 | 36 | 5.6 | 0.336 | 58.8 | LOS E | 1.8 | 13.3 | 0.99 | 0.73 | 0.99 | 33.6 |
| Approach | | 1048 | 7.9 | 0.876 | 37.8 | LOS D | 19.9 | 149.2 | 0.91 | 0.95 | 1.19 | 41.2 |
| All Vehicles | | 5487 | 7.0 | 0.911 | 44.2 | LOS D | 22.1 | 163.4 | 0.91 | 0.92 | 1.14 | 40.9 |

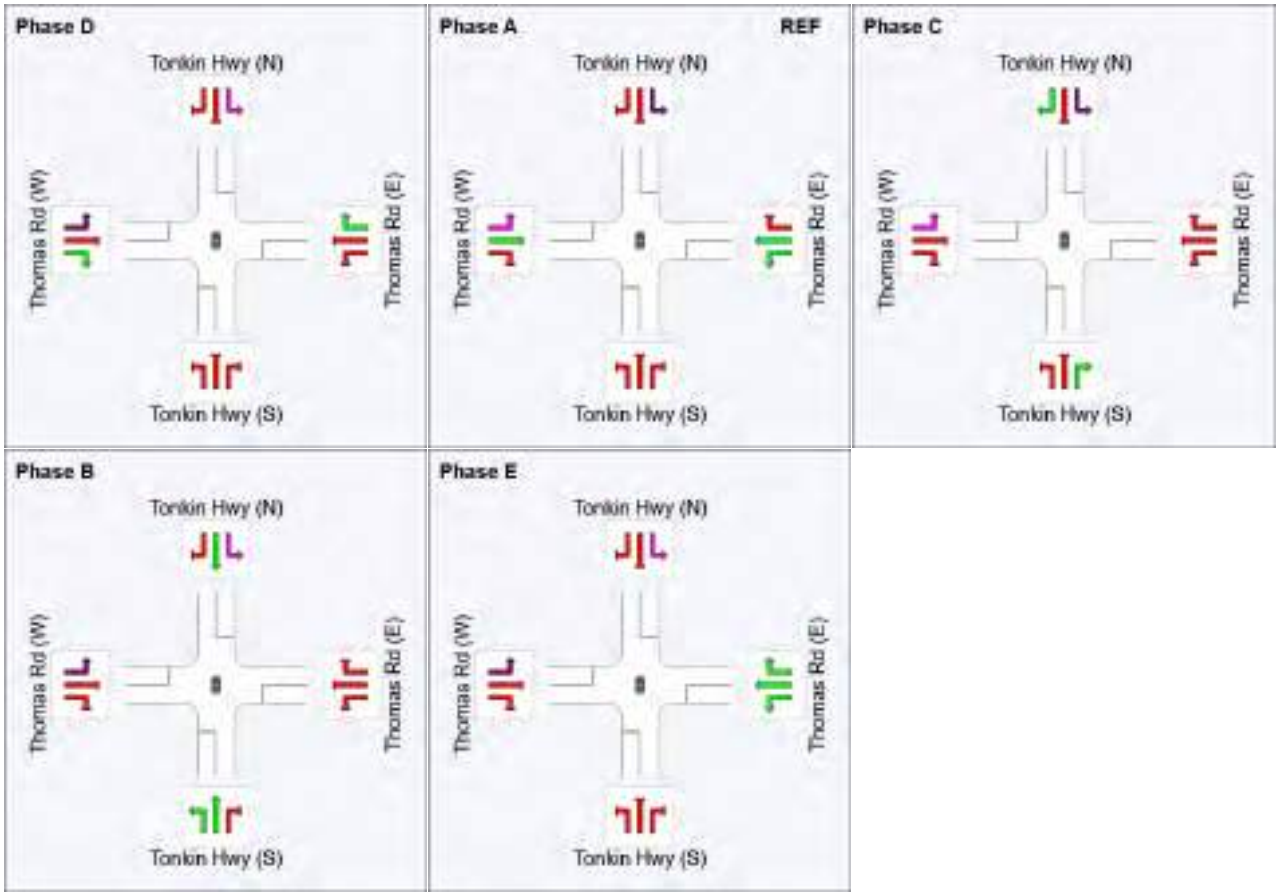
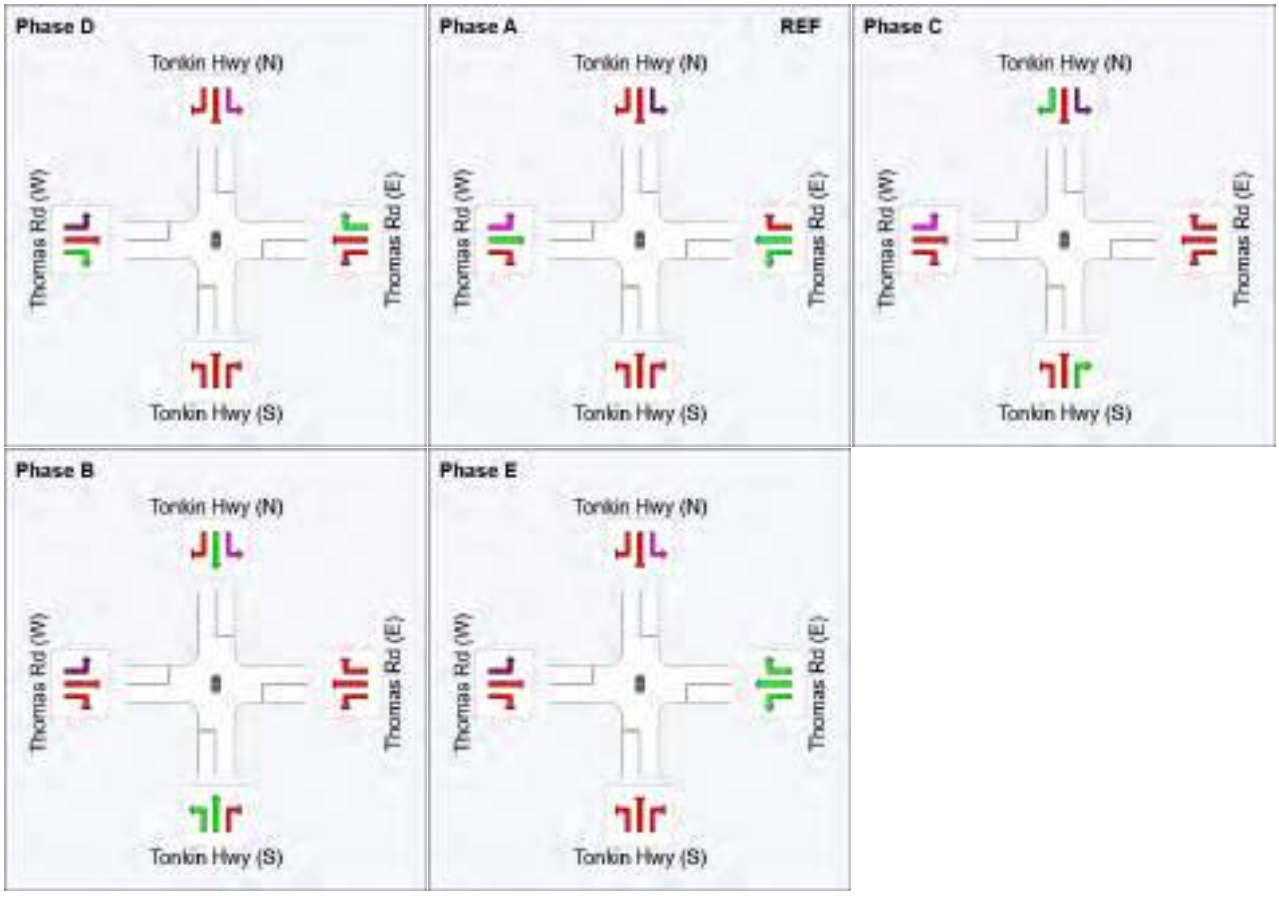


Table 5-6 Reconfigured Tonkin Highway/Thomas Road Intersection PM Results 2031

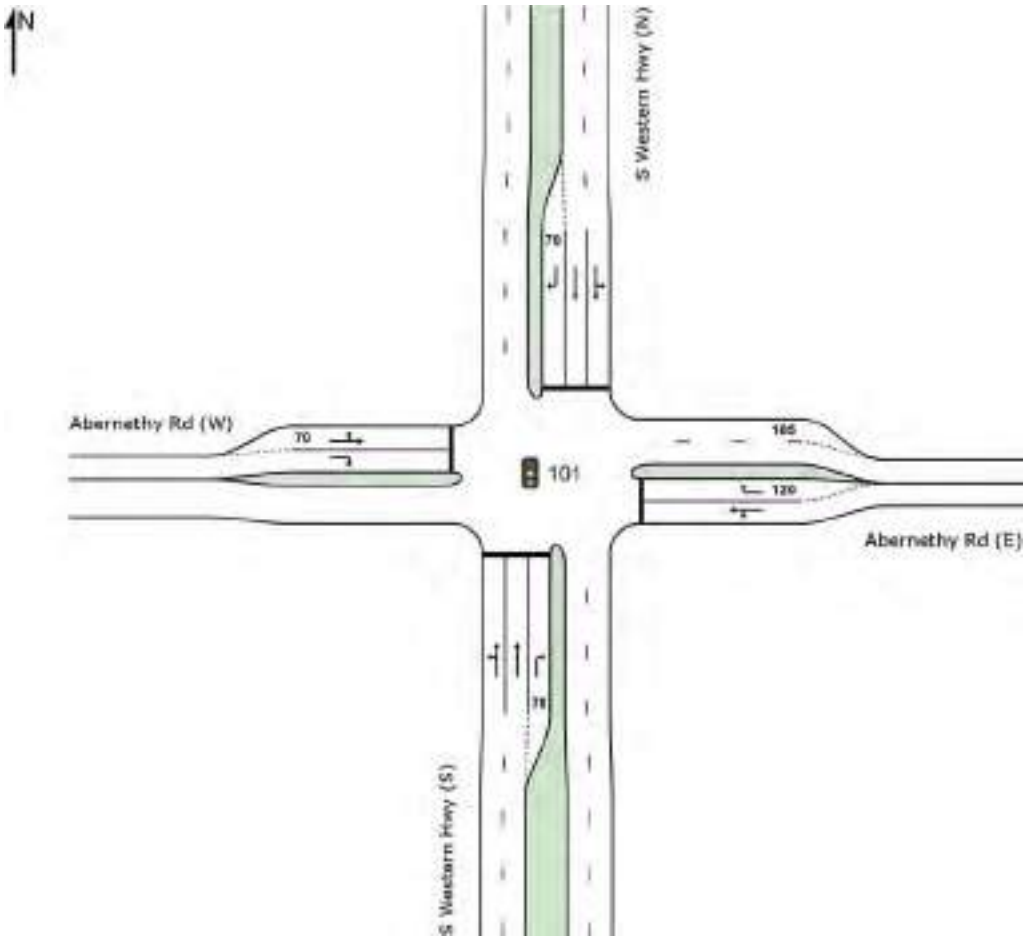
| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Tonkin Hwy (S) | | | | | | | | | | | | |
| 1 | L2 | 50 | 4.0 | 0.208 | 40.1 | LOS D | 3.7 | 27.1 | 0.83 | 0.72 | 0.83 | 43.5 |
| 2 | T1 | 243 | 4.5 | 0.208 | 32.1 | LOS C | 3.8 | 27.8 | 0.83 | 0.67 | 0.83 | 52.9 |
| 3 | R2 | 11 | 0.0 | 0.035 | 45.8 | LOS D | 0.5 | 3.2 | 0.86 | 0.68 | 0.86 | 40.0 |
| Approach | | 304 | 4.3 | 0.208 | 33.9 | LOS C | 3.8 | 27.8 | 0.83 | 0.68 | 0.83 | 50.5 |
| East: Thomas Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 10 | 10.0 | 0.610 | 36.4 | LOS D | 9.0 | 65.7 | 0.95 | 0.84 | 1.10 | 44.9 |
| 5 | T1 | 496 | 5.0 | 0.610 | 29.9 | LOS C | 9.0 | 65.8 | 0.95 | 0.84 | 1.10 | 44.7 |
| 6 | R2 | 863 | 0.6 | 0.819 | 54.5 | LOS D | 14.9 | 105.1 | 1.00 | 0.93 | 1.20 | 35.5 |
| Approach | | 1369 | 2.3 | 0.819 | 45.4 | LOS D | 14.9 | 105.1 | 0.98 | 0.89 | 1.16 | 38.4 |
| North: Tonkin Hwy (N) | | | | | | | | | | | | |
| 7 | L2 | 541 | 11.8 | 0.436 | 12.3 | LOS B | 8.2 | 63.4 | 0.42 | 0.74 | 0.42 | 59.4 |
| 8 | T1 | 798 | 10.0 | 0.872 | 49.2 | LOS D | 21.9 | 166.8 | 1.00 | 0.99 | 1.27 | 42.9 |
| 9 | R2 | 571 | 6.5 | 0.946 | 79.8 | LOS E | 18.8 | 138.9 | 1.00 | 1.06 | 1.69 | 28.8 |
| Approach | | 1910 | 9.5 | 0.946 | 47.9 | LOS D | 21.9 | 166.8 | 0.84 | 0.94 | 1.16 | 40.2 |
| West: Thomas Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 380 | 4.5 | 0.324 | 11.4 | LOS B | 6.2 | 45.2 | 0.43 | 0.71 | 0.43 | 59.6 |
| 11 | T1 | 542 | 6.1 | 0.963 | 78.7 | LOS E | 18.7 | 137.7 | 1.00 | 1.24 | 1.83 | 28.2 |
| 12 | R2 | 57 | 1.8 | 0.518 | 59.6 | LOS E | 2.9 | 20.7 | 1.00 | 0.75 | 1.01 | 33.7 |
| Approach | | 979 | 5.2 | 0.963 | 51.4 | LOS D | 18.7 | 137.7 | 0.78 | 1.01 | 1.24 | 35.8 |
| All Vehicles | | 4562 | 6.0 | 0.963 | 47.0 | LOS D | 21.9 | 166.8 | 0.87 | 0.92 | 1.15 | 39.1 |



### 5.5.4 No. 2 – Abernethy Road and South Western Highway

The following presents the results of the analysis of the Abernethy Road/South Western Highway intersection**. Figure 5-8** is a SIDRA layout representation of the intersection which is based on the indicative layouts used in the mesoscopic model.

Figure 5-8 SIDRA Layout for Abernethy Road/South Western Highway Intersection




The SIDRA results based on this intersection layout and signal phasing analysis are summarised in **Table 5-7** and **Table 5-8**.

Table 5-7 Abernethy Road/South Western Highway Intersection AM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: S Western Hwy (S) | | | | | | | | | | | | |
| 1 | L2 | 129 | 10.1 | 0.803 | 56.7 | LOS E | 30.8 | 228.6 | 0.96 | 0.85 | 0.96 | 31.6 |
| 2 | T1 | 784 | 6.1 | 0.803 | 50.2 | LOS D | 30.8 | 228.6 | 0.94 | 0.83 | 0.94 | 32.7 |
| 3 | R2 | 65 | 4.6 | 0.266 | 69.8 | LOS E | 4.2 | 30.8 | 0.91 | 0.75 | 0.91 | 27.6 |
| Approach | | 978 | 6.5 | 0.803 | 52.3 | LOS D | 30.8 | 228.6 | 0.94 | 0.83 | 0.94 | 32.2 |
| East: Abernethy Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 74 | 5.4 | 0.298 | 55.9 | LOS E | 7.7 | 57.0 | 0.84 | 0.73 | 0.84 | 31.5 |
| 5 | T1 | 59 | 6.8 | 0.298 | 50.2 | LOS D | 7.7 | 57.0 | 0.84 | 0.73 | 0.84 | 32.0 |
| 6 | R2 | 137 | 10.2 | 0.362 | 54.4 | LOS D | 8.2 | 62.7 | 0.86 | 0.78 | 0.86 | 31.2 |
| Approach | | 270 | 8.1 | 0.362 | 53.9 | LOS D | 8.2 | 62.7 | 0.85 | 0.76 | 0.85 | 31.5 |
| North: S Western Hwy (N) | | | | | | | | | | | | |
| 7 | L2 | 35 | 14.3 | 0.627 | 53.0 | LOS D | 22.5 | 167.4 | 0.89 | 0.78 | 0.89 | 32.9 |
| 8 | T1 | 665 | 6.8 | 0.627 | 46.6 | LOS D | 22.5 | 167.4 | 0.87 | 0.76 | 0.87 | 33.9 |
| 9 | R2 | 123 | 3.3 | 0.498 | 72.5 | LOS E | 8.3 | 59.9 | 0.95 | 0.79 | 0.95 | 27.1 |
| Approach | | 823 | 6.6 | 0.627 | 50.7 | LOS D | 22.5 | 167.4 | 0.89 | 0.77 | 0.89 | 32.7 |
| West: Abernethy Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 209 | 9.1 | 0.625 | 60.9 | LOS E | 16.9 | 126.8 | 0.92 | 0.82 | 0.92 | 29.8 |
| 11 | T1 | 56 | 5.4 | 0.625 | 55.2 | LOS E | 16.9 | 126.8 | 0.92 | 0.82 | 0.92 | 30.4 |
| 12 | R2 | 116 | 7.8 | 0.484 | 72.5 | LOS E | 7.8 | 58.6 | 0.95 | 0.79 | 0.95 | 27.1 |
| Approach | | 381 | 8.1 | 0.625 | 63.6 | LOS E | 16.9 | 126.8 | 0.93 | 0.81 | 0.93 | 29.0 |
| All Vehicles | | 2452 | 7.0 | 0.803 | 53.7 | LOS D | 30.8 | 228.6 | 0.91 | 0.80 | 0.91 | 31.7 |

Table 5-8 Abernethy Road/South Western Highway Intersection PM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: S Western Hwy (S) | | | | | | | | | | | | |
| 1 | L2 | 134 | 6.0 | 0.578 | 47.4 | LOS D | 18.5 | 136.1 | 0.87 | 0.78 | 0.87 | 34.2 |
| 2 | T1 | 546 | 6.2 | 0.578 | 41.5 | LOS D | 18.5 | 136.1 | 0.86 | 0.76 | 0.86 | 35.4 |
| 3 | R2 | 71 | 4.2 | 0.262 | 62.0 | LOS E | 4.1 | 30.0 | 0.90 | 0.76 | 0.90 | 29.3 |
| Approach | | 751 | 6.0 | 0.578 | 44.5 | LOS D | 18.5 | 136.1 | 0.87 | 0.76 | 0.87 | 34.5 |
| East: Abernethy Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 94 | 6.4 | 0.459 | 58.9 | LOS E | 9.4 | 69.5 | 0.91 | 0.78 | 0.91 | 30.6 |
| 5 | T1 | 69 | 5.8 | 0.459 | 53.3 | LOS D | 9.4 | 69.5 | 0.91 | 0.78 | 0.91 | 31.2 |
| 6 | R2 | 96 | 6.3 | 0.228 | 36.6 | LOS D | 4.1 | 30.1 | 0.80 | 0.75 | 0.80 | 36.9 |
| Approach | | 259 | 6.2 | 0.459 | 49.1 | LOS D | 9.4 | 69.5 | 0.87 | 0.76 | 0.87 | 32.8 |
| North: S Western Hwy (N) | | | | | | | | | | | | |
| 7 | L2 | 68 | 5.9 | 0.773 | 51.0 | LOS D | 27.1 | 200.6 | 0.95 | 0.84 | 0.95 | 33.5 |
| 8 | T1 | 765 | 7.1 | 0.773 | 43.9 | LOS D | 27.1 | 200.6 | 0.91 | 0.80 | 0.91 | 34.7 |
| 9 | R2 | 236 | 2.5 | 0.860 | 69.2 | LOS E | 15.4 | 110.3 | 1.00 | 0.84 | 1.02 | 27.8 |
| Approach | | 1069 | 6.0 | 0.860 | 50.0 | LOS D | 27.1 | 200.6 | 0.93 | 0.81 | 0.94 | 32.8 |
| West: Abernethy Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 116 | 10.3 | 0.503 | 59.6 | LOS E | 10.2 | 77.0 | 0.92 | 0.79 | 0.92 | 30.3 |
| 11 | T1 | 59 | 5.1 | 0.503 | 53.9 | LOS D | 10.2 | 77.0 | 0.92 | 0.79 | 0.92 | 30.9 |
| 12 | R2 | 312 | 2.9 | 1.155 | 349.0 | LOS F | 56.7 | 406.9 | 1.00 | 1.71 | 2.97 | 8.7 |
| Approach | | 487 | 4.9 | 1.155 | 244.3 | LOS F | 56.7 | 406.9 | 0.97 | 1.38 | 2.24 | 11.7 |
| All Vehicles | | 2566 | 5.8 | 1.155 | 85.2 | LOS F | 56.7 | 406.9 | 0.91 | 0.90 | 1.16 | 24.7 |

The SIDRA results shows that the western leg of the intersection will experience delays in the PM peak. However, reconfiguring the turning movement arrangement and intersection layout would likely improve the operation of the intersection. **Figure 5-9** shows the updated layout and **Table 5-10** and **Table 5-10** show the results with the modified signal phasing for the PM peak.

Figure 5-9 Reconfigured SIDRA Layout for Abernethy Road/South Western Highway Intersection

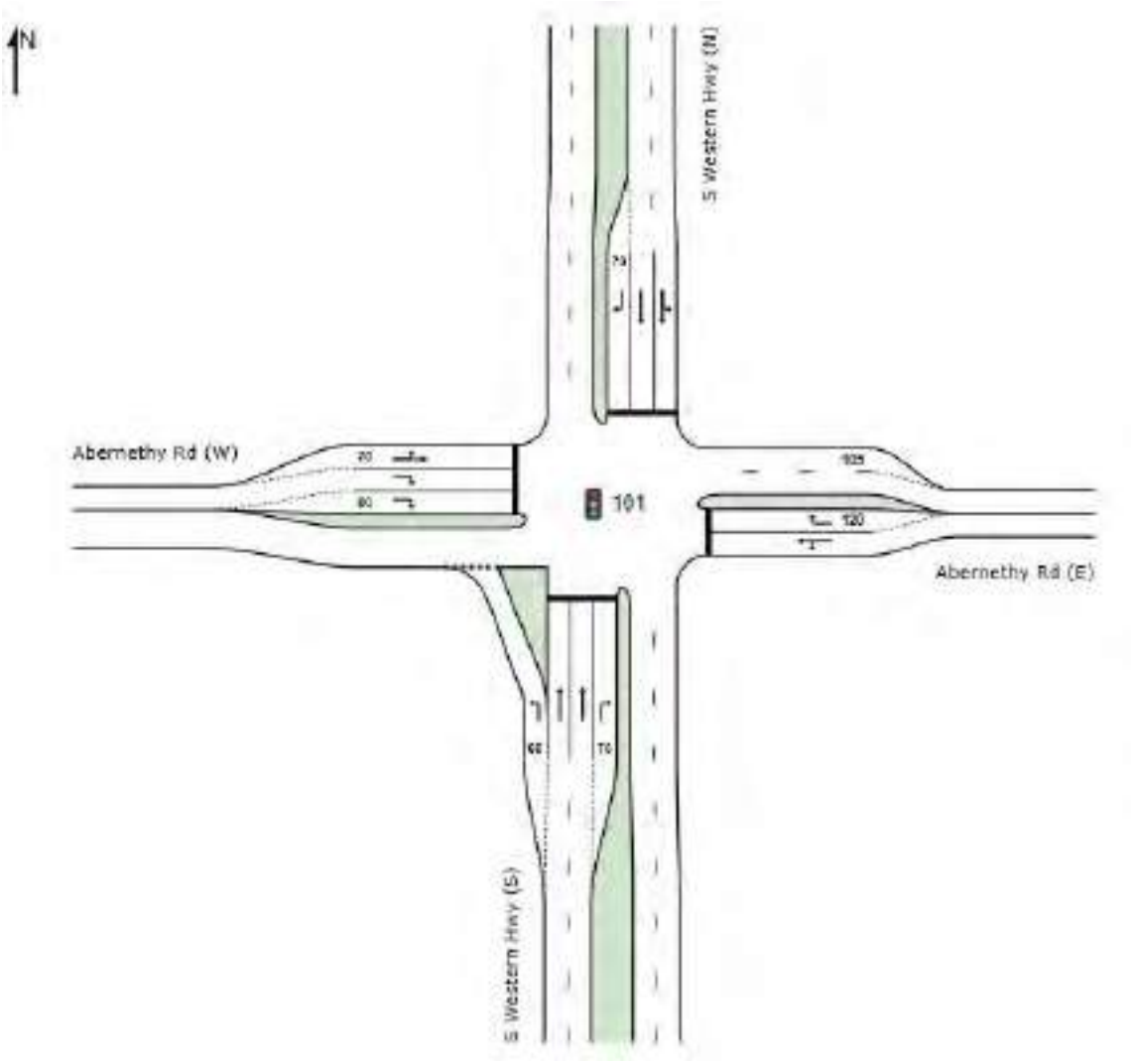


Table 5-9 Abernethy Road/South Western Highway Intersection AM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | Distance | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | | | km/h |
| South: S Western Hwy (S) | | | | | | | | | | | | |
| 1 | L2 | 129 | 10.1 | 0.100 | 7.2 | LOS A | 1.2 | 9.3 | 0.19 | 0.60 | 0.19 | 52.7 |
| 2 | T1 | 784 | 6.1 | 0.754 | 47.6 | LOS D | 24.3 | 179.4 | 0.91 | 0.79 | 0.91 | 33.7 |
| 3 | R2 | 65 | 4.6 | 0.257 | 66.9 | LOS E | 4.1 | 29.6 | 0.91 | 0.75 | 0.91 | 28.2 |
| Approach | | 978 | 6.5 | 0.754 | 43.6 | LOS D | 24.3 | 179.4 | 0.82 | 0.76 | 0.82 | 34.9 |
| East: Abernethy Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 74 | 5.4 | 0.305 | 54.9 | LOS D | 7.5 | 55.5 | 0.84 | 0.74 | 0.84 | 31.7 |
| 5 | T1 | 59 | 6.8 | 0.305 | 49.3 | LOS D | 7.5 | 55.5 | 0.84 | 0.74 | 0.84 | 32.3 |
| 6 | R2 | 137 | 10.2 | 0.360 | 52.6 | LOS D | 8.0 | 60.6 | 0.86 | 0.78 | 0.86 | 31.7 |
| Approach | | 270 | 8.1 | 0.360 | 52.5 | LOS D | 8.0 | 60.6 | 0.85 | 0.76 | 0.85 | 31.9 |
| North: S Western Hwy (N) | | | | | | | | | | | | |
| 7 | L2 | 35 | 14.3 | 0.643 | 52.8 | LOS D | 21.9 | 163.0 | 0.90 | 0.79 | 0.90 | 33.0 |
| 8 | T1 | 665 | 6.8 | 0.643 | 46.4 | LOS D | 21.9 | 163.0 | 0.89 | 0.77 | 0.89 | 34.0 |
| 9 | R2 | 123 | 3.3 | 0.481 | 69.5 | LOS E | 8.0 | 57.6 | 0.94 | 0.79 | 0.94 | 27.8 |
| Approach | | 823 | 6.6 | 0.643 | 50.1 | LOS D | 21.9 | 163.0 | 0.89 | 0.77 | 0.89 | 32.9 |
| West: Abernethy Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 209 | 9.1 | 0.625 | 59.9 | LOS E | 16.5 | 123.6 | 0.93 | 0.82 | 0.93 | 30.1 |
| 11 | T1 | 56 | 5.4 | 0.625 | 54.3 | LOS D | 16.5 | 123.6 | 0.93 | 0.82 | 0.93 | 30.6 |
| 12 | R2 | 116 | 7.8 | 0.234 | 66.8 | LOS E | 3.6 | 27.0 | 0.90 | 0.75 | 0.90 | 28.4 |
| Approach | | 381 | 8.1 | 0.625 | 61.2 | LOS E | 16.5 | 123.6 | 0.92 | 0.80 | 0.92 | 29.6 |
| All Vehicles | | 2452 | 7.0 | 0.754 | 49.5 | LOS D | 24.3 | 179.4 | 0.86 | 0.77 | 0.86 | 33.0 |

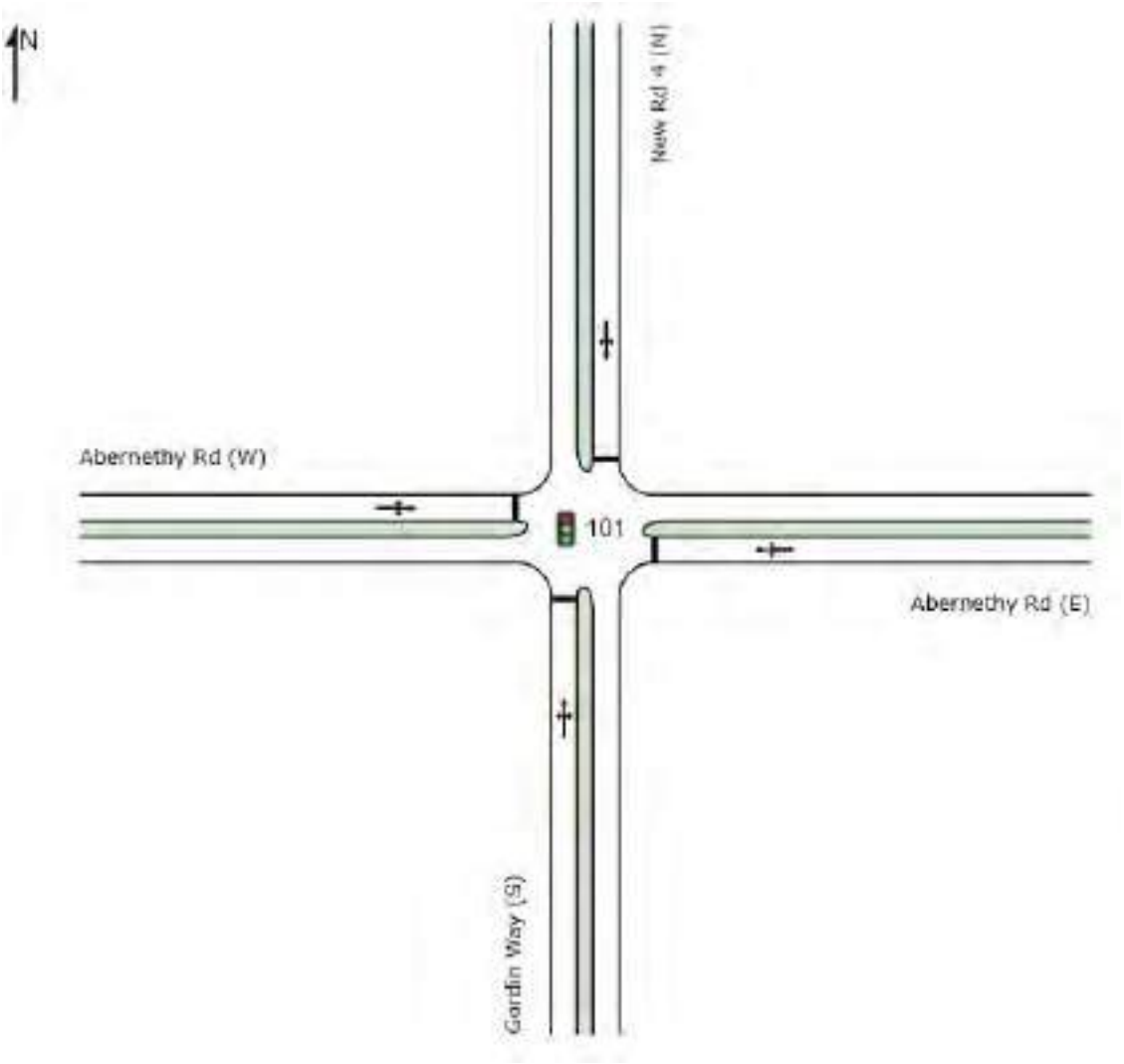
Table 5-10 Abernethy Road/South Western Highway Intersection PM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | Distance | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | | | km/h |
| South: S Western Hwy (S) | | | | | | | | | | | | |
| 1 | L2 | 134 | 6.0 | 0.104 | 9.1 | LOS A | 1.9 | 13.9 | 0.28 | 0.62 | 0.28 | 51.4 |
| 2 | T1 | 546 | 6.2 | 0.451 | 39.6 | LOS D | 13.9 | 102.8 | 0.82 | 0.70 | 0.82 | 36.4 |
| 3 | R2 | 71 | 4.2 | 0.262 | 62.0 | LOS E | 4.1 | 30.0 | 0.90 | 0.76 | 0.90 | 29.3 |
| Approach | | 751 | 6.0 | 0.451 | 36.3 | LOS D | 13.9 | 102.8 | 0.73 | 0.69 | 0.73 | 37.5 |
| East: Abernethy Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 94 | 6.4 | 0.459 | 58.9 | LOS E | 9.4 | 69.5 | 0.91 | 0.78 | 0.91 | 30.6 |
| 5 | T1 | 69 | 5.8 | 0.459 | 53.3 | LOS D | 9.4 | 69.5 | 0.91 | 0.78 | 0.91 | 31.2 |
| 6 | R2 | 96 | 6.3 | 0.228 | 36.6 | LOS D | 4.1 | 30.1 | 0.80 | 0.75 | 0.80 | 36.9 |
| Approach | | 259 | 6.2 | 0.459 | 49.1 | LOS D | 9.4 | 69.5 | 0.87 | 0.76 | 0.87 | 32.9 |
| North: S Western Hwy (N) | | | | | | | | | | | | |
| 7 | L2 | 68 | 5.9 | 0.775 | 51.0 | LOS D | 27.1 | 201.1 | 0.95 | 0.84 | 0.95 | 33.5 |
| 8 | T1 | 765 | 7.1 | 0.775 | 43.9 | LOS D | 27.1 | 201.1 | 0.91 | 0.80 | 0.91 | 34.8 |
| 9 | R2 | 236 | 2.5 | 0.860 | 69.2 | LOS E | 15.4 | 110.3 | 1.00 | 0.84 | 1.02 | 27.9 |
| Approach | | 1069 | 6.0 | 0.860 | 50.0 | LOS D | 27.1 | 201.1 | 0.93 | 0.81 | 0.94 | 32.9 |
| West: Abernethy Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 116 | 10.3 | 0.503 | 59.6 | LOS E | 10.2 | 77.0 | 0.92 | 0.79 | 0.92 | 30.3 |
| 11 | T1 | 59 | 5.1 | 0.503 | 53.9 | LOS D | 10.2 | 77.0 | 0.92 | 0.79 | 0.92 | 30.9 |
| 12 | R2 | 312 | 2.9 | 0.570 | 65.4 | LOS E | 9.6 | 68.9 | 0.95 | 0.80 | 0.95 | 28.8 |
| Approach | | 487 | 4.9 | 0.570 | 62.7 | LOS E | 10.2 | 77.0 | 0.94 | 0.80 | 0.94 | 29.4 |
| All Vehicles | | 2566 | 5.8 | 0.860 | 48.3 | LOS D | 27.1 | 201.1 | 0.87 | 0.77 | 0.87 | 33.3 |

### 5.5.5 No. 3 – Abernethy Rd/New Road 4/Gordin Way

The following presents the results of the analysis of the Abernethy Rd/New Road 4/Gordin Way intersection**.** **Figure 5-10** is a SIDRA layout representation of the intersection which is based on the indicative layouts used in the mesoscopic model.

Figure 5-10 SIDRA Layout for Abernethy Rd/New Road 4/Gordin Way Intersection




The SIDRA results based on this intersection layout and signal phasing are summarised in **Table 5-11** and **Table 5-12**.

Table 5-11 Abernethy Rd/New Road 4/Gordin Way Intersection AM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Gordin Way (S) | | | | | | | | | | | | |
| 1 | L2 | 29 | 6.9 | 0.519 | 50.2 | LOS D | 10.3 | 74.1 | 0.91 | 0.77 | 0.91 | 33.6 |
| 2 | T1 | 168 | 3.0 | 0.519 | 44.6 | LOS D | 10.3 | 74.1 | 0.91 | 0.77 | 0.91 | 34.2 |
| 3 | R2 | 11 | 0.0 | 0.519 | 50.0 | LOS D | 10.3 | 74.1 | 0.91 | 0.77 | 0.91 | 33.5 |
| Approach | | 208 | 3.4 | 0.519 | 45.7 | LOS D | 10.3 | 74.1 | 0.91 | 0.77 | 0.91 | 34.1 |
| East: Abernethy Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 7 | 14.3 | 0.569 | 48.6 | LOS D | 11.9 | 91.0 | 0.91 | 0.79 | 0.91 | 33.7 |
| 5 | T1 | 156 | 7.1 | 0.569 | 42.9 | LOS D | 11.9 | 91.0 | 0.91 | 0.79 | 0.91 | 34.5 |
| 6 | R2 | 80 | 16.3 | 0.569 | 48.5 | LOS D | 11.9 | 91.0 | 0.91 | 0.79 | 0.91 | 33.5 |
| Approach | | 243 | 10.3 | 0.569 | 44.9 | LOS D | 11.9 | 91.0 | 0.91 | 0.79 | 0.91 | 34.2 |
| North: New Rd 4 (N) | | | | | | | | | | | | |
| 7 | L2 | 13 | 0.0 | 0.384 | 60.8 | LOS E | 3.8 | 26.7 | 0.95 | 0.74 | 0.95 | 30.2 |
| 8 | T1 | 32 | 0.0 | 0.384 | 55.3 | LOS E | 3.8 | 26.7 | 0.95 | 0.74 | 0.95 | 30.6 |
| 9 | R2 | 26 | 0.0 | 0.384 | 60.7 | LOS E | 3.8 | 26.7 | 0.95 | 0.74 | 0.95 | 30.0 |
| Approach | | 71 | 0.0 | 0.384 | 58.3 | LOS E | 3.8 | 26.7 | 0.95 | 0.74 | 0.95 | 30.3 |
| West: Abernethy Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 54 | 7.4 | 0.568 | 48.4 | LOS D | 12.4 | 90.1 | 0.91 | 0.78 | 0.91 | 33.9 |
| 11 | T1 | 166 | 4.2 | 0.568 | 42.8 | LOS D | 12.4 | 90.1 | 0.91 | 0.78 | 0.91 | 34.6 |
| 12 | R2 | 32 | 3.1 | 0.568 | 48.3 | LOS D | 12.4 | 90.1 | 0.91 | 0.78 | 0.91 | 33.7 |
| Approach | | 252 | 4.8 | 0.568 | 44.7 | LOS D | 12.4 | 90.1 | 0.91 | 0.78 | 0.91 | 34.3 |
| All Vehicles | | 774 | 5.7 | 0.569 | 46.3 | LOS D | 12.4 | 91.0 | 0.91 | 0.78 | 0.91 | 33.8 |

Table 5-12 Abernethy Rd/New Road 4/Gordin Way Intersection PM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Gordin Way (S) | | | | | | | | | | | | |
| 1 | L2 | 54 | 1.9 | 0.596 | 67.6 | LOS E | 14.6 | 104.0 | 0.94 | 0.80 | 0.94 | 28.8 |
| 2 | T1 | 139 | 1.4 | 0.596 | 62.0 | LOS E | 14.6 | 104.0 | 0.94 | 0.80 | 0.94 | 29.2 |
| 3 | R2 | 25 | 4.0 | 0.596 | 67.5 | LOS E | 14.6 | 104.0 | 0.94 | 0.80 | 0.94 | 28.6 |
| Approach | | 218 | 1.8 | 0.596 | 64.0 | LOS E | 14.6 | 104.0 | 0.94 | 0.80 | 0.94 | 29.0 |
| East: Abernethy Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 36 | 0.0 | 0.637 | 65.9 | LOS E | 16.6 | 123.5 | 0.94 | 0.81 | 0.94 | 29.2 |
| 5 | T1 | 159 | 5.0 | 0.637 | 60.4 | LOS E | 16.6 | 123.5 | 0.94 | 0.81 | 0.94 | 29.6 |
| 6 | R2 | 53 | 18.9 | 0.637 | 66.0 | LOS E | 16.6 | 123.5 | 0.94 | 0.81 | 0.94 | 28.8 |
| Approach | | 248 | 7.3 | 0.637 | 62.4 | LOS E | 16.6 | 123.5 | 0.94 | 0.81 | 0.94 | 29.4 |
| North: New Rd 4 (N) | | | | | | | | | | | | |
| 7 | L2 | 40 | 0.0 | 0.589 | 68.3 | LOS E | 13.9 | 99.2 | 0.94 | 0.80 | 0.94 | 28.5 |
| 8 | T1 | 114 | 1.8 | 0.589 | 62.7 | LOS E | 13.9 | 99.2 | 0.94 | 0.80 | 0.94 | 28.9 |
| 9 | R2 | 53 | 3.8 | 0.589 | 68.2 | LOS E | 13.9 | 99.2 | 0.94 | 0.80 | 0.94 | 28.3 |
| Approach | | 207 | 1.9 | 0.589 | 65.2 | LOS E | 13.9 | 99.2 | 0.94 | 0.80 | 0.94 | 28.7 |
| West: Abernethy Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 118 | 11.0 | 0.734 | 63.9 | LOS E | 22.4 | 164.4 | 0.96 | 0.83 | 0.96 | 29.5 |
| 11 | T1 | 194 | 2.6 | 0.734 | 58.2 | LOS E | 22.4 | 164.4 | 0.96 | 0.83 | 0.96 | 30.1 |
| 12 | R2 | 21 | 0.0 | 0.734 | 63.7 | LOS E | 22.4 | 164.4 | 0.96 | 0.83 | 0.96 | 29.5 |
| Approach | | 333 | 5.4 | 0.734 | 60.6 | LOS E | 22.4 | 164.4 | 0.96 | 0.83 | 0.96 | 29.8 |
| All Vehicles | | 1006 | 4.4 | 0.734 | 62.7 | LOS E | 22.4 | 164.4 | 0.95 | 0.81 | 0.95 | 29.3 |

The SIDRA results shows that the intersection will operate at an unacceptable level of service with long delays and queues in the PM peak. However, reconfiguring the intersection layout and signal phasing for the PM period will likely improve the operation of the intersection. **Figure 5-11** shows the updated layout. **Table 5-13** and **Table 5-14** shows the results with the modified signal phasing

Figure 5-11 Reconfigured SIDRA Layout for Abernethy Rd/New Road 4/Gordin Way Intersection

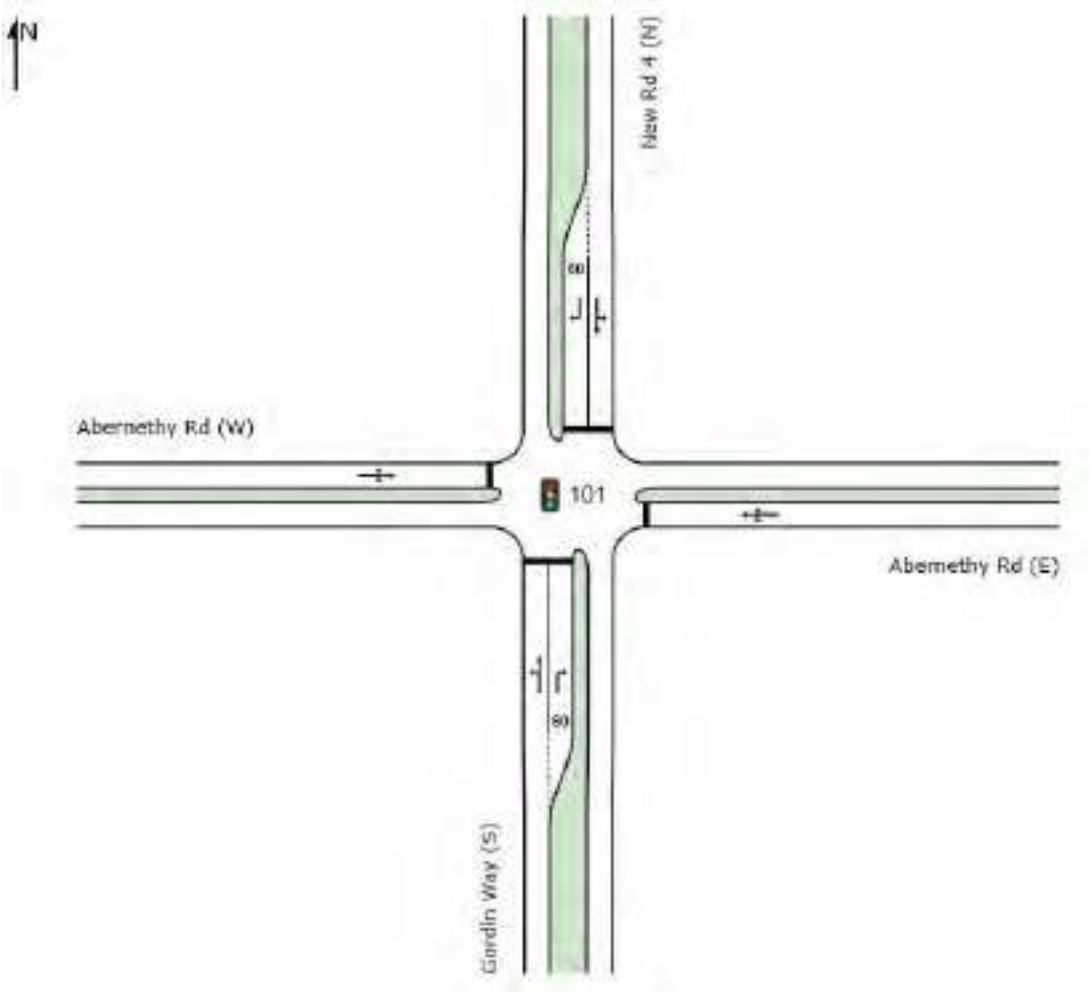



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Table 5-13 Reconfigured Abernethy Rd/New Road 4/Gordin Way Intersection AM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | Distance | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | | | km/h |
| South: Gordin Way (S) | | | | | | | | | | | | |
| 1 | L2 | 29 | 6.9 | 0.501 | 45.9 | LOS D | 8.7 | 63.1 | 0.91 | 0.76 | 0.91 | 35.1 |
| 2 | T1 | 168 | 3.0 | 0.501 | 40.2 | LOS D | 8.7 | 63.1 | 0.91 | 0.76 | 0.91 | 35.8 |
| 3 | R2 | 11 | 0.0 | 0.100 | 57.6 | LOS E | 0.5 | 3.8 | 0.95 | 0.67 | 0.95 | 30.2 |
| Approach | | 208 | 3.4 | 0.501 | 41.9 | LOS D | 8.7 | 63.1 | 0.91 | 0.75 | 0.91 | 35.3 |
| East: Abernethy Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 7 | 14.3 | 0.549 | 43.3 | LOS D | 10.6 | 80.7 | 0.90 | 0.78 | 0.90 | 35.5 |
| 5 | T1 | 156 | 7.1 | 0.549 | 37.6 | LOS D | 10.6 | 80.7 | 0.90 | 0.78 | 0.90 | 36.4 |
| 6 | R2 | 80 | 16.3 | 0.549 | 43.3 | LOS D | 10.6 | 80.7 | 0.90 | 0.78 | 0.90 | 35.4 |
| Approach | | 243 | 10.3 | 0.549 | 39.6 | LOS D | 10.6 | 80.7 | 0.90 | 0.78 | 0.90 | 36.0 |
| North: New Rd 4 (N) | | | | | | | | | | | | |
| 7 | L2 | 13 | 0.0 | 0.113 | 41.8 | LOS D | 1.8 | 12.7 | 0.82 | 0.65 | 0.82 | 36.3 |
| 8 | T1 | 32 | 0.0 | 0.113 | 36.3 | LOS D | 1.8 | 12.7 | 0.82 | 0.65 | 0.82 | 36.9 |
| 9 | R2 | 26 | 0.0 | 0.236 | 58.7 | LOS E | 1.3 | 9.1 | 0.96 | 0.71 | 0.96 | 29.9 |
| Approach | | 71 | 0.0 | 0.236 | 45.5 | LOS D | 1.8 | 12.7 | 0.87 | 0.67 | 0.87 | 33.9 |
| West: Abernethy Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 54 | 7.4 | 0.548 | 43.1 | LOS D | 11.0 | 79.9 | 0.90 | 0.78 | 0.90 | 35.7 |
| 11 | T1 | 166 | 4.2 | 0.548 | 37.5 | LOS D | 11.0 | 79.9 | 0.90 | 0.78 | 0.90 | 36.4 |
| 12 | R2 | 32 | 3.1 | 0.548 | 43.1 | LOS D | 11.0 | 79.9 | 0.90 | 0.78 | 0.90 | 35.6 |
| Approach | | 252 | 4.8 | 0.548 | 39.4 | LOS D | 11.0 | 79.9 | 0.90 | 0.78 | 0.90 | 36.2 |
| All Vehicles | | 774 | 5.7 | 0.549 | 40.7 | LOS D | 11.0 | 80.7 | 0.90 | 0.76 | 0.90 | 35.7 |

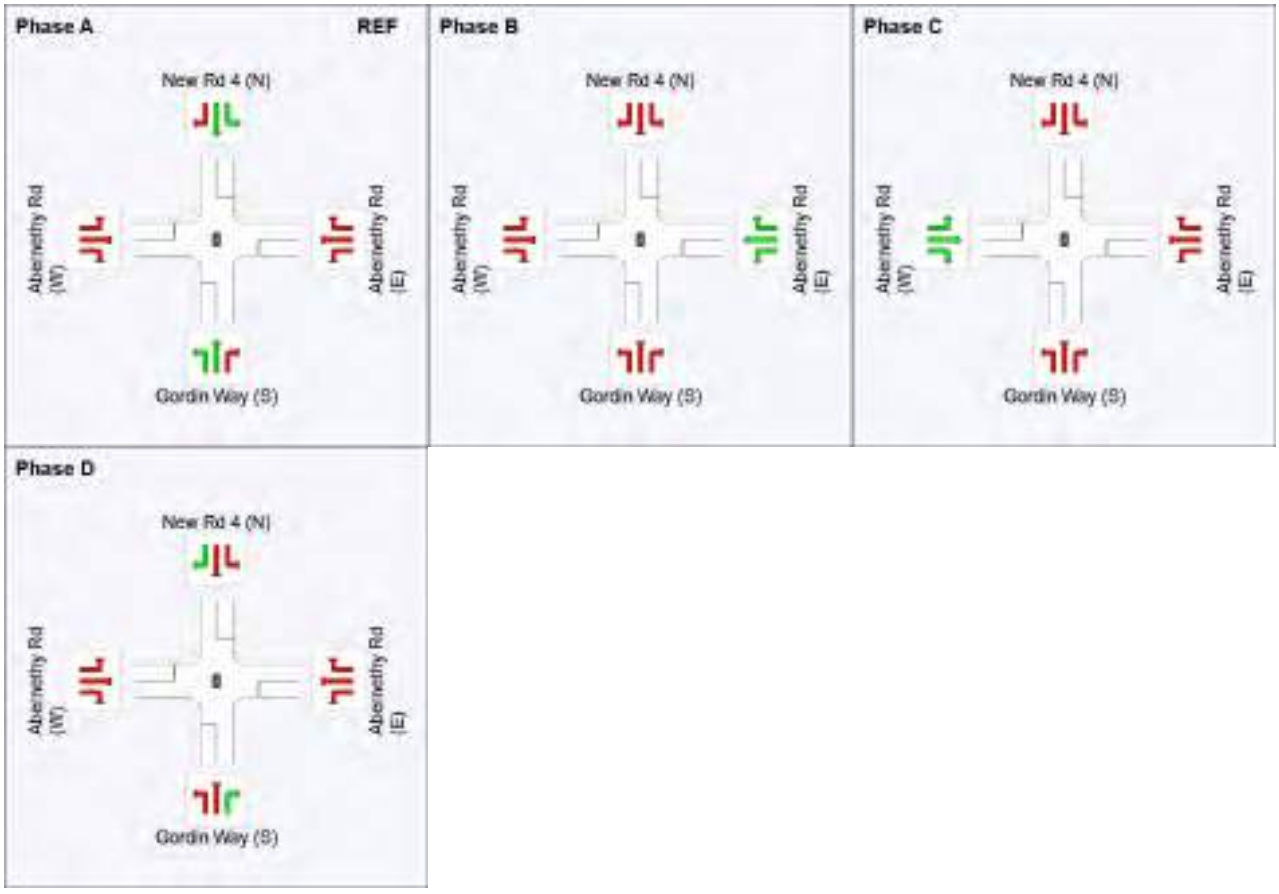
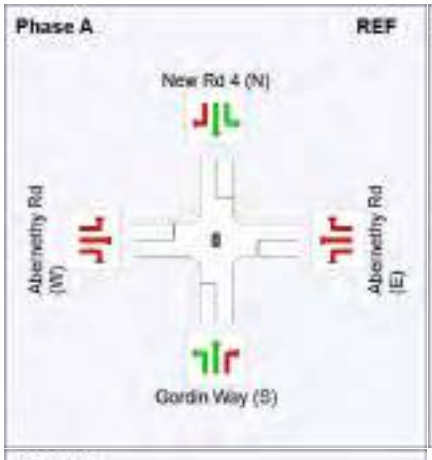
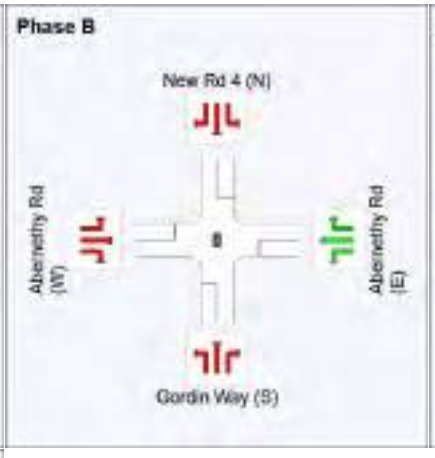
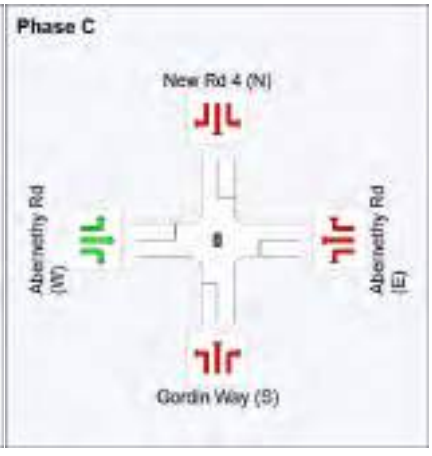


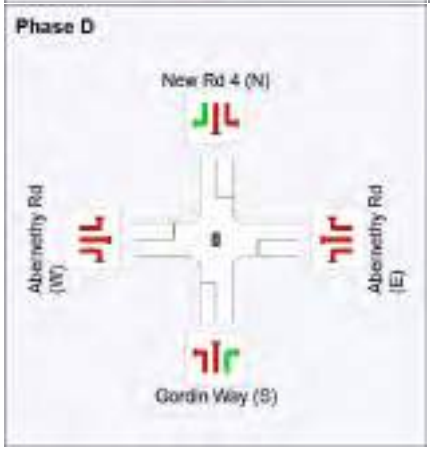
Table 5-14 Reconfigured Abernethy Rd/New Road 4/Gordin Way Intersection PM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | Distance | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | | | km/h |
| South: Gordin Way (S) | | | | | | | | | | | | |
| 1 | L2 | 54 | 1.9 | 0.490 | 51.5 | LOS D | 9.8 | 69.2 | 0.91 | 0.76 | 0.91 | 33.1 |
| 2 | T1 | 139 | 1.4 | 0.490 | 45.9 | LOS D | 9.8 | 69.2 | 0.91 | 0.76 | 0.91 | 33.7 |
| 3 | R2 | 25 | 4.0 | 0.178 | 63.2 | LOS E | 1.4 | 10.0 | 0.94 | 0.71 | 0.94 | 28.8 |
| Approach | | 218 | 1.8 | 0.490 | 49.3 | LOS D | 9.8 | 69.2 | 0.91 | 0.76 | 0.91 | 32.9 |
| East: Abernethy Rd (E) | | | | | | | | | | | | |
| 4 | L2 | 36 | 0.0 | 0.563 | 49.2 | LOS D | 12.4 | 92.5 | 0.91 | 0.78 | 0.91 | 33.8 |
| 5 | T1 | 159 | 5.0 | 0.563 | 43.6 | LOS D | 12.4 | 92.5 | 0.91 | 0.78 | 0.91 | 34.3 |
| 6 | R2 | 53 | 18.9 | 0.563 | 49.4 | LOS D | 12.4 | 92.5 | 0.91 | 0.78 | 0.91 | 33.3 |
| Approach | | 248 | 7.3 | 0.563 | 45.7 | LOS D | 12.4 | 92.5 | 0.91 | 0.78 | 0.91 | 34.0 |
| North: New Rd 4 (N) | | | | | | | | | | | | |
| 7 | L2 | 40 | 0.0 | 0.390 | 50.3 | LOS D | 7.6 | 53.8 | 0.88 | 0.74 | 0.88 | 33.5 |
| 8 | T1 | 114 | 1.8 | 0.390 | 44.8 | LOS D | 7.6 | 53.8 | 0.88 | 0.74 | 0.88 | 34.1 |
| 9 | R2 | 53 | 3.8 | 0.378 | 64.8 | LOS E | 3.0 | 21.7 | 0.96 | 0.75 | 0.96 | 28.4 |
| Approach | | 207 | 1.9 | 0.390 | 50.9 | LOS D | 7.6 | 53.8 | 0.90 | 0.74 | 0.90 | 32.3 |
| West: Abernethy Rd (W) | | | | | | | | | | | | |
| 10 | L2 | 118 | 11.0 | 0.677 | 48.6 | LOS D | 17.0 | 124.5 | 0.93 | 0.82 | 0.93 | 33.7 |
| 11 | T1 | 194 | 2.6 | 0.677 | 42.9 | LOS D | 17.0 | 124.5 | 0.93 | 0.82 | 0.93 | 34.5 |
| 12 | R2 | 21 | 0.0 | 0.677 | 48.4 | LOS D | 17.0 | 124.5 | 0.93 | 0.82 | 0.93 | 33.8 |
| Approach | | 333 | 5.4 | 0.677 | 45.3 | LOS D | 17.0 | 124.5 | 0.93 | 0.82 | 0.93 | 34.1 |
| All Vehicles | | 1006 | 4.4 | 0.677 | 47.4 | LOS D | 17.0 | 124.5 | 0.92 | 0.78 | 0.92 | 33.5 |



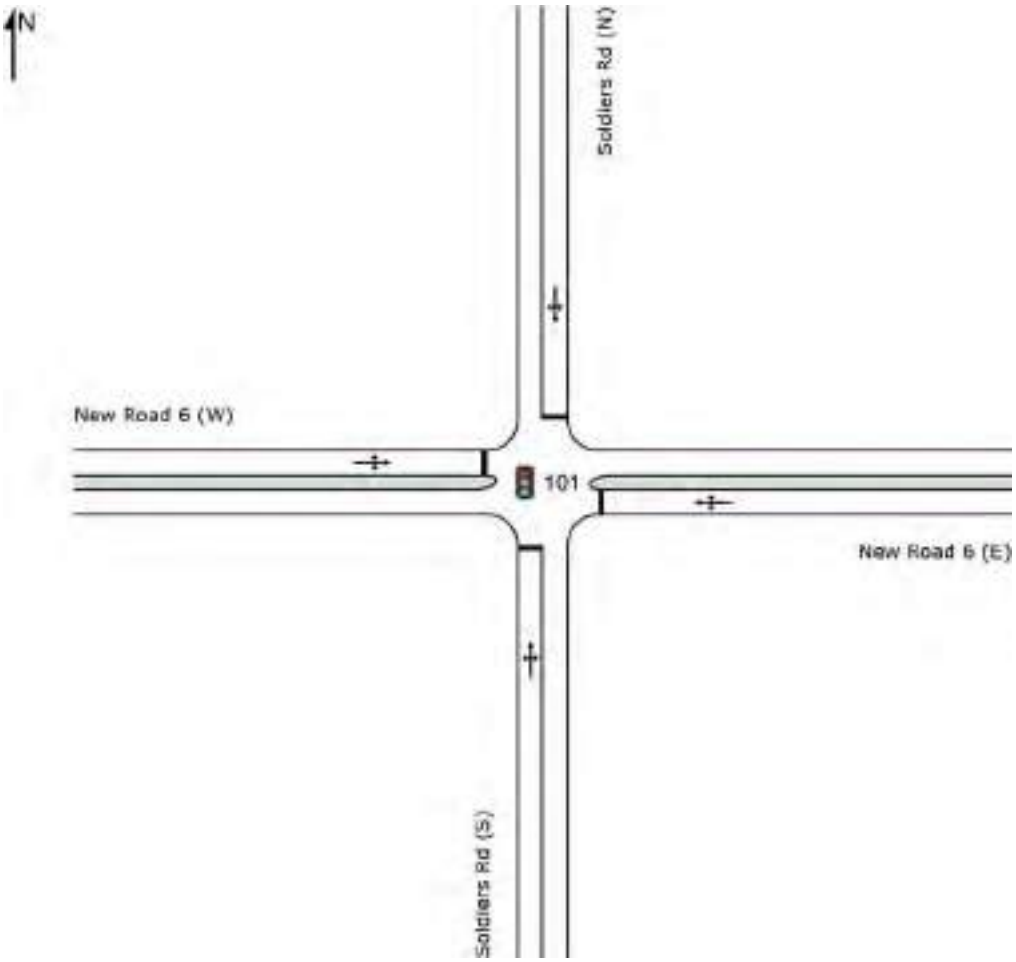



### 5.5.6 No. 4 – Soldiers Road and New Road 6 (Orton Road)

The following presents the results of the analysis of the Soldiers Road/New Road 6 intersection**. Figure 5-12** is a SIDRA layout representation of the intersection which is based on the indicative layouts used in the mesoscopic model.

Figure 5-12 SIDRA Layout for Soldiers Road/New Road 6 Intersection




The SIDRA results based on this reconfigured intersection layout and signal phasing analysis are summarised in **Table 5-15** and **Table 5-16**.

Table 5-15 Soldiers Road/New Road 6 Intersection AM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | 95% Back of Queue Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Soldiers Rd (S) | | | | | | | | | | | | |
| 1 | L2 | 171 | 4.1 | 1.063 | 221.9 | LOS F | 43.2 | 309.1 | 1.00 | 1.42 | 2.25 | 13.1 |
| 2 | T1 | 81 | 1.2 | 1.063 | 214.9 | LOS F | 43.2 | 309.1 | 1.00 | 1.42 | 2.25 | 13.5 |
| 3 | R2 | 49 | 0.0 | 1.063 | 221.5 | LOS F | 43.2 | 309.1 | 1.00 | 1.42 | 2.25 | 13.1 |
| Approach | | 301 | 2.7 | 1.063 | 219.9 | LOS F | 43.2 | 309.1 | 1.00 | 1.42 | 2.25 | 13.2 |
| East: New Road 6 (E) | | | | | | | | | | | | |
| 4 | L2 | 80 | 1.3 | 1.089 | 254.1 | LOS F | 108.3 | 793.5 | 1.00 | 1.84 | 2.32 | 11.7 |
| 5 | T1 | 520 | 6.5 | 1.089 | 248.5 | LOS F | 108.3 | 793.5 | 1.00 | 1.84 | 2.32 | 11.6 |
| 6 | R2 | 63 | 1.6 | 1.089 | 254.0 | LOS F | 108.3 | 793.5 | 1.00 | 1.84 | 2.32 | 11.7 |
| Approach | | 663 | 5.4 | 1.089 | 249.7 | LOS F | 108.3 | 793.5 | 1.00 | 1.84 | 2.32 | 11.6 |
| North: Soldiers Rd (N) | | | | | | | | | | | | |
| 7 | L2 | 166 | 4.8 | 1.090 | 262.6 | LOS F | 58.4 | 421.5 | 1.00 | 1.67 | 2.43 | 11.4 |
| 8 | T1 | 198 | 2.5 | 1.090 | 255.5 | LOS F | 58.4 | 421.5 | 1.00 | 1.67 | 2.43 | 11.8 |
| 9 | R2 | 1 | 0.0 | 1.090 | 262.2 | LOS F | 58.4 | 421.5 | 1.00 | 1.67 | 2.43 | 11.4 |
| Approach | | 365 | 3.6 | 1.090 | 258.8 | LOS F | 58.4 | 421.5 | 1.00 | 1.67 | 2.43 | 11.6 |
| West: New Road 6 (W) | | | | | | | | | | | | |
| 10 | L2 | 1 | 0.0 | 1.069 | 227.8 | LOS F | 52.8 | 385.5 | 1.00 | 1.71 | 2.26 | 12.8 |
| 11 | T1 | 255 | 6.3 | 1.069 | 222.3 | LOS F | 52.8 | 385.5 | 1.00 | 1.71 | 2.26 | 12.6 |
| 12 | R2 | 102 | 2.0 | 1.069 | 227.7 | LOS F | 52.8 | 385.5 | 1.00 | 1.71 | 2.26 | 12.7 |
| Approach | | 358 | 5.0 | 1.069 | 223.8 | LOS F | 52.8 | 385.5 | 1.00 | 1.71 | 2.26 | 12.6 |
| All Vehicles | | 1687 | 4.4 | 1.090 | 240.9 | LOS F | 108.3 | 793.5 | 1.00 | 1.70 | 2.32 | 12.1 |

Table 5-16 Soldiers Road/New Road 6 Intersection PM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | 95% Back of Queue Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Soldiers Rd (S) | | | | | | | | | | | | |
| 1 | L2 | 160 | 1.3 | 1.010 | 151.0 | LOS F | 42.3 | 298.3 | 1.00 | 1.20 | 1.81 | 17.8 |
| 2 | T1 | 71 | 0.0 | 1.010 | 144.0 | LOS F | 42.3 | 298.3 | 1.00 | 1.20 | 1.81 | 18.6 |
| 3 | R2 | 133 | 0.8 | 1.010 | 150.6 | LOS F | 42.3 | 298.3 | 1.00 | 1.20 | 1.81 | 17.7 |
| Approach | | 364 | 0.8 | 1.010 | 149.5 | LOS F | 42.3 | 298.3 | 1.00 | 1.20 | 1.81 | 17.9 |
| East: New Road 6 (E) | | | | | | | | | | | | |
| 4 | L2 | 109 | 0.0 | 0.998 | 133.7 | LOS F | 53.5 | 381.4 | 1.00 | 1.31 | 1.66 | 19.5 |
| 5 | T1 | 307 | 2.9 | 0.998 | 128.1 | LOS F | 53.5 | 381.4 | 1.00 | 1.31 | 1.66 | 19.1 |
| 6 | R2 | 62 | 1.6 | 0.998 | 133.6 | LOS F | 53.5 | 381.4 | 1.00 | 1.31 | 1.66 | 19.4 |
| Approach | | 478 | 2.1 | 0.998 | 130.1 | LOS F | 53.5 | 381.4 | 1.00 | 1.31 | 1.66 | 19.2 |
| North: Soldiers Rd (N) | | | | | | | | | | | | |
| 7 | L2 | 125 | 4.8 | 1.020 | 163.2 | LOS F | 33.3 | 239.3 | 1.00 | 1.33 | 1.94 | 16.9 |
| 8 | T1 | 153 | 2.0 | 1.020 | 156.2 | LOS F | 33.3 | 239.3 | 1.00 | 1.33 | 1.94 | 17.7 |
| 9 | R2 | 1 | 0.0 | 1.020 | 162.8 | LOS F | 33.3 | 239.3 | 1.00 | 1.33 | 1.94 | 16.9 |
| Approach | | 279 | 3.2 | 1.020 | 159.3 | LOS F | 33.3 | 239.3 | 1.00 | 1.33 | 1.94 | 17.3 |
| West: New Road 6 (W) | | | | | | | | | | | | |
| 10 | L2 | 132 | 0.0 | 0.995 | 131.2 | LOS F | 51.0 | 363.3 | 1.00 | 1.27 | 1.65 | 19.7 |
| 11 | T1 | 238 | 3.8 | 0.995 | 125.6 | LOS F | 51.0 | 363.3 | 1.00 | 1.27 | 1.65 | 19.3 |
| 12 | R2 | 91 | 1.1 | 0.995 | 131.1 | LOS F | 51.0 | 363.3 | 1.00 | 1.27 | 1.65 | 19.6 |
| Approach | | 461 | 2.2 | 0.995 | 128.3 | LOS F | 51.0 | 363.3 | 1.00 | 1.27 | 1.65 | 19.5 |
| All Vehicles | | 1582 | 2.0 | 1.020 | 139.2 | LOS F | 53.5 | 381.4 | 1.00 | 1.28 | 1.74 | 18.6 |

The SIDRA results shows that the intersection will operate at an unacceptable level of service with long delays and queues. Modifications to the geometry and the signal timing are required to ensure that the intersection operates within an acceptable level of service. **Figure 5-13** shows the reconfigured intersection layout and **Table 5-17** and **Table 5-18** shows the results for the modified signal phasing.

Figure 5-13 Reconfigured SIDRA Layout for Soldiers Road/New Road 6 Intersection

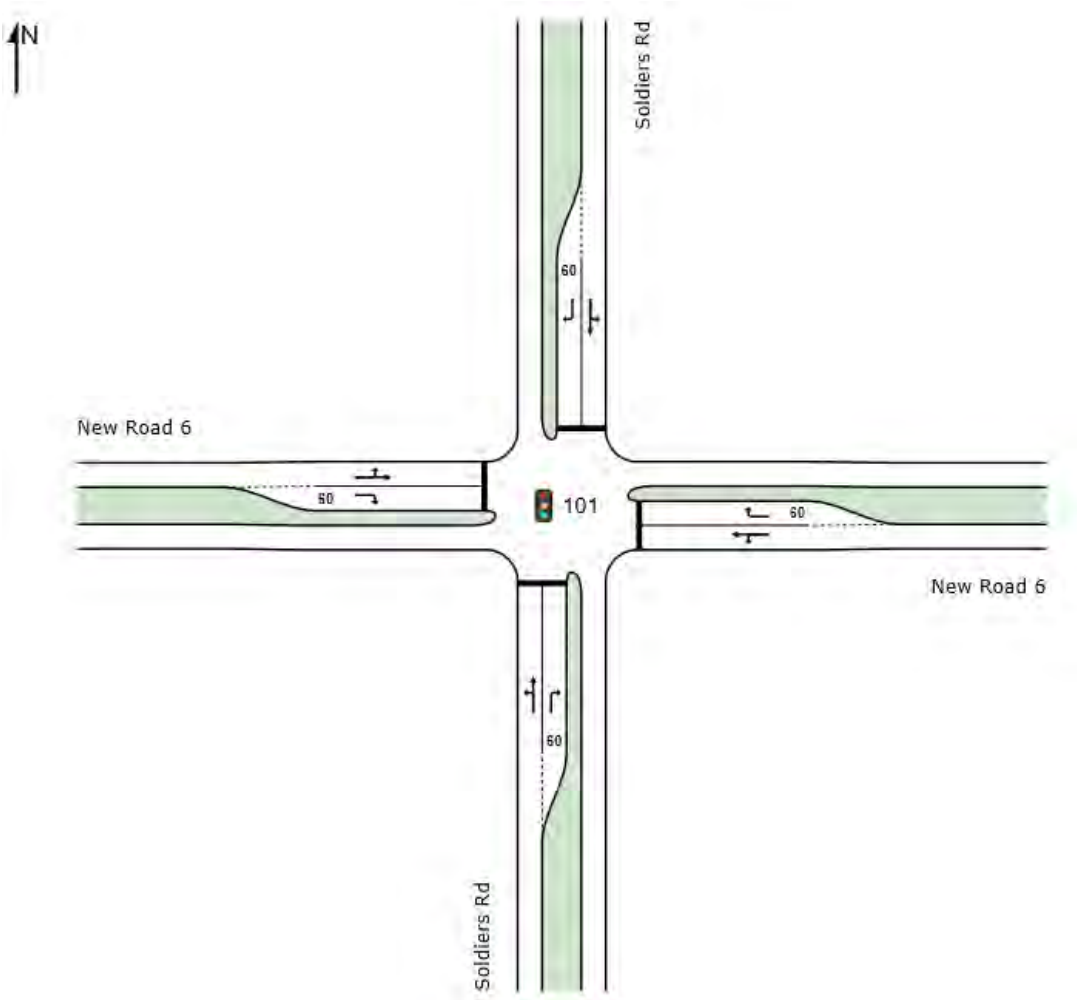
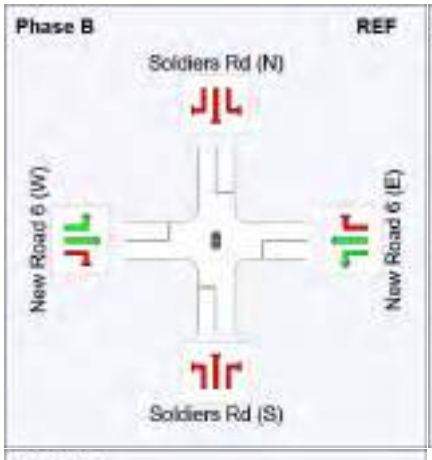
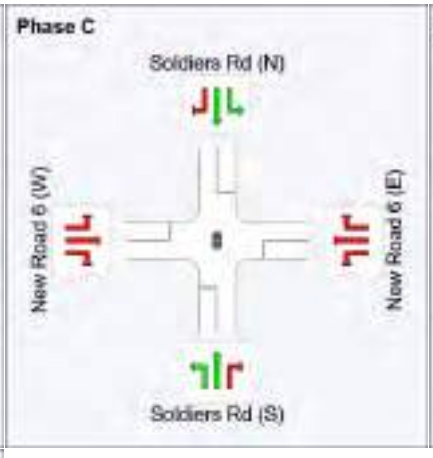
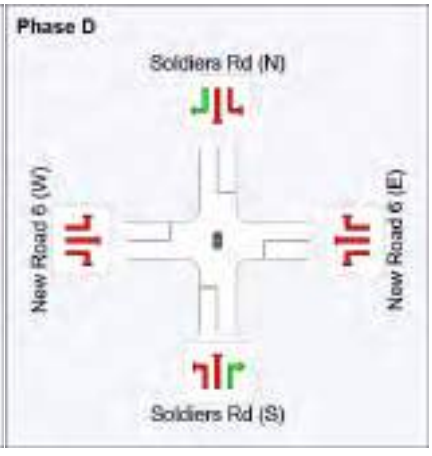


Table 5-17 Reconfigured Soldiers Road/New Road 6 Intersection AM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Soldiers Rd | | | | | | | | | | | | |
| 1 | L2 | 171 | 4.1 | 0.574 | 44.1 | LOS D | 11.6 | 83.1 | 0.94 | 0.81 | 0.94 | 34.8 |
| 2 | T1 | 81 | 1.2 | 0.574 | 38.5 | LOS D | 11.6 | 83.1 | 0.94 | 0.81 | 0.94 | 35.4 |
| 3 | R2 | 49 | 0.0 | 0.462 | 61.0 | LOS E | 2.6 | 18.3 | 1.00 | 0.74 | 1.00 | 29.5 |
| Approach | | 301 | 2.7 | 0.574 | 45.4 | LOS D | 11.6 | 83.1 | 0.95 | 0.80 | 0.95 | 33.9 |
| East: New Road 6 | | | | | | | | | | | | |
| 4 | L2 | 80 | 1.3 | 0.836 | 40.2 | LOS D | 29.6 | 217.4 | 0.94 | 0.92 | 1.04 | 37.2 |
| 5 | T1 | 520 | 6.5 | 0.836 | 34.6 | LOS C | 29.6 | 217.4 | 0.94 | 0.92 | 1.04 | 37.9 |
| 6 | R2 | 63 | 1.6 | 0.515 | 60.0 | LOS E | 3.3 | 23.7 | 1.00 | 0.75 | 1.00 | 29.7 |
| Approach | | 663 | 5.4 | 0.836 | 37.7 | LOS D | 29.6 | 217.4 | 0.94 | 0.90 | 1.04 | 36.9 |
| North: Soldiers Rd | | | | | | | | | | | | |
| 7 | L2 | 166 | 4.8 | 0.823 | 52.2 | LOS D | 19.5 | 140.4 | 1.00 | 0.96 | 1.16 | 32.6 |
| 8 | T1 | 198 | 2.5 | 0.823 | 46.6 | LOS D | 19.5 | 140.4 | 1.00 | 0.96 | 1.16 | 33.2 |
| 9 | R2 | 1 | 0.0 | 0.009 | 57.2 | LOS E | 0.0 | 0.3 | 0.96 | 0.59 | 0.96 | 30.4 |
| Approach | | 365 | 3.6 | 0.823 | 49.2 | LOS D | 19.5 | 140.4 | 1.00 | 0.96 | 1.16 | 32.9 |
| West: New Road 6 | | | | | | | | | | | | |
| 10 | L2 | 49 | 0.0 | 0.397 | 28.9 | LOS C | 10.9 | 79.9 | 0.75 | 0.67 | 0.75 | 42.0 |
| 11 | T1 | 255 | 6.3 | 0.397 | 23.4 | LOS C | 10.9 | 79.9 | 0.75 | 0.67 | 0.75 | 42.9 |
| 12 | R2 | 102 | 2.0 | 0.835 | 66.1 | LOS E | 5.9 | 41.7 | 1.00 | 0.94 | 1.42 | 28.3 |
| Approach | | 406 | 4.4 | 0.835 | 34.8 | LOS C | 10.9 | 79.9 | 0.81 | 0.74 | 0.92 | 37.9 |
| All Vehicles | | 1735 | 4.3 | 0.836 | 40.8 | LOS D | 29.6 | 217.4 | 0.93 | 0.86 | 1.02 | 35.7 |



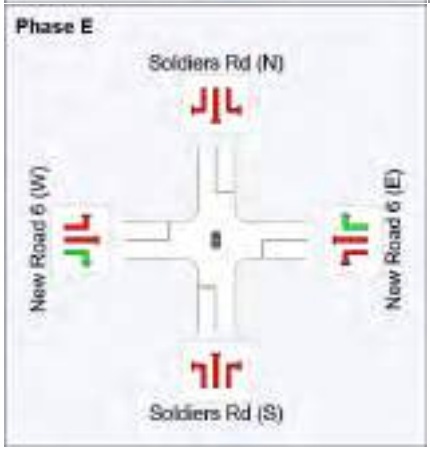
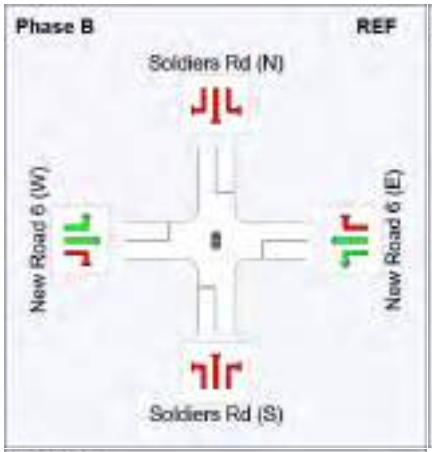
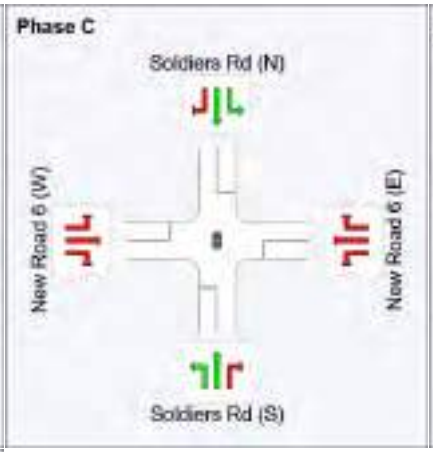
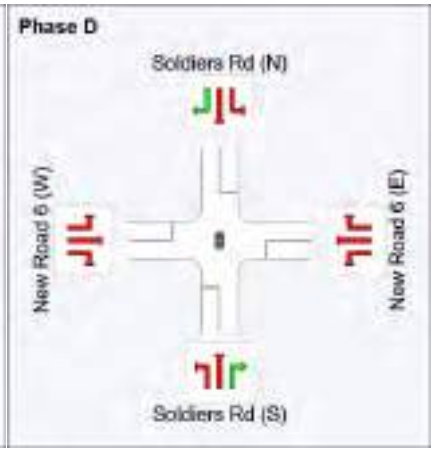



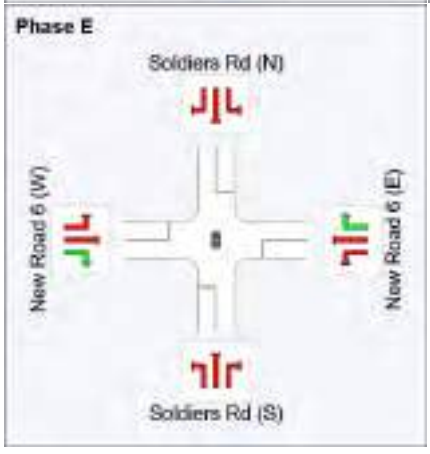
Table 5-18 Reconfigured Soldiers Road/New Road 6 Intersection PM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | Distance | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | | | km/h |
| South: RoadName | | | | | | | | | | | | |
| 1 | L2 | 160 | 1.3 | 0.664 | 36.0 | LOS D | 7.8 | 55.0 | 0.98 | 0.85 | 1.04 | 37.7 |
| 2 | T1 | 71 | 0.0 | 0.664 | 30.5 | LOS C | 7.8 | 55.0 | 0.98 | 0.85 | 1.04 | 38.4 |
| 3 | R2 | 133 | 0.8 | 0.720 | 42.5 | LOS D | 4.9 | 34.6 | 1.00 | 0.87 | 1.21 | 34.6 |
| Approach | | 364 | 0.8 | 0.720 | 37.3 | LOS D | 7.8 | 55.0 | 0.99 | 0.86 | 1.10 | 36.6 |
| East: New Road 6 | | | | | | | | | | | | |
| 4 | L2 | 110 | 0.9 | 0.785 | 34.2 | LOS C | 14.8 | 106.4 | 0.98 | 0.94 | 1.13 | 39.3 |
| 5 | T1 | 312 | 4.5 | 0.785 | 28.7 | LOS C | 14.8 | 106.4 | 0.98 | 0.94 | 1.13 | 40.1 |
| 6 | R2 | 62 | 1.6 | 0.394 | 40.7 | LOS D | 2.2 | 15.4 | 0.98 | 0.75 | 0.98 | 35.2 |
| Approach | | 484 | 3.3 | 0.785 | 31.5 | LOS C | 14.8 | 106.4 | 0.98 | 0.92 | 1.11 | 39.2 |
| North: RoadName | | | | | | | | | | | | |
| 7 | L2 | 125 | 4.8 | 0.803 | 40.2 | LOS D | 10.3 | 74.3 | 1.00 | 0.97 | 1.25 | 36.6 |
| 8 | T1 | 153 | 2.0 | 0.803 | 34.6 | LOS C | 10.3 | 74.3 | 1.00 | 0.97 | 1.25 | 37.3 |
| 9 | R2 | 1 | 0.0 | 0.005 | 36.7 | LOS D | 0.0 | 0.2 | 0.92 | 0.59 | 0.92 | 36.7 |
| Approach | | 279 | 3.2 | 0.803 | 37.1 | LOS D | 10.3 | 74.3 | 1.00 | 0.96 | 1.25 | 37.0 |
| West: New Road 6 | | | | | | | | | | | | |
| 10 | L2 | 133 | 0.8 | 0.690 | 30.8 | LOS C | 11.8 | 84.6 | 0.95 | 0.85 | 0.99 | 40.6 |
| 11 | T1 | 238 | 3.8 | 0.690 | 25.3 | LOS C | 11.8 | 84.6 | 0.95 | 0.85 | 0.99 | 41.4 |
| 12 | R2 | 91 | 1.1 | 0.576 | 41.7 | LOS D | 3.3 | 23.1 | 1.00 | 0.79 | 1.06 | 34.9 |
| Approach | | 462 | 2.4 | 0.690 | 30.1 | LOS C | 11.8 | 84.6 | 0.96 | 0.84 | 1.00 | 39.7 |
| All Vehicles | | 1589 | 2.5 | 0.803 | 33.4 | LOS C | 14.8 | 106.4 | 0.98 | 0.89 | 1.10 | 38.3 |



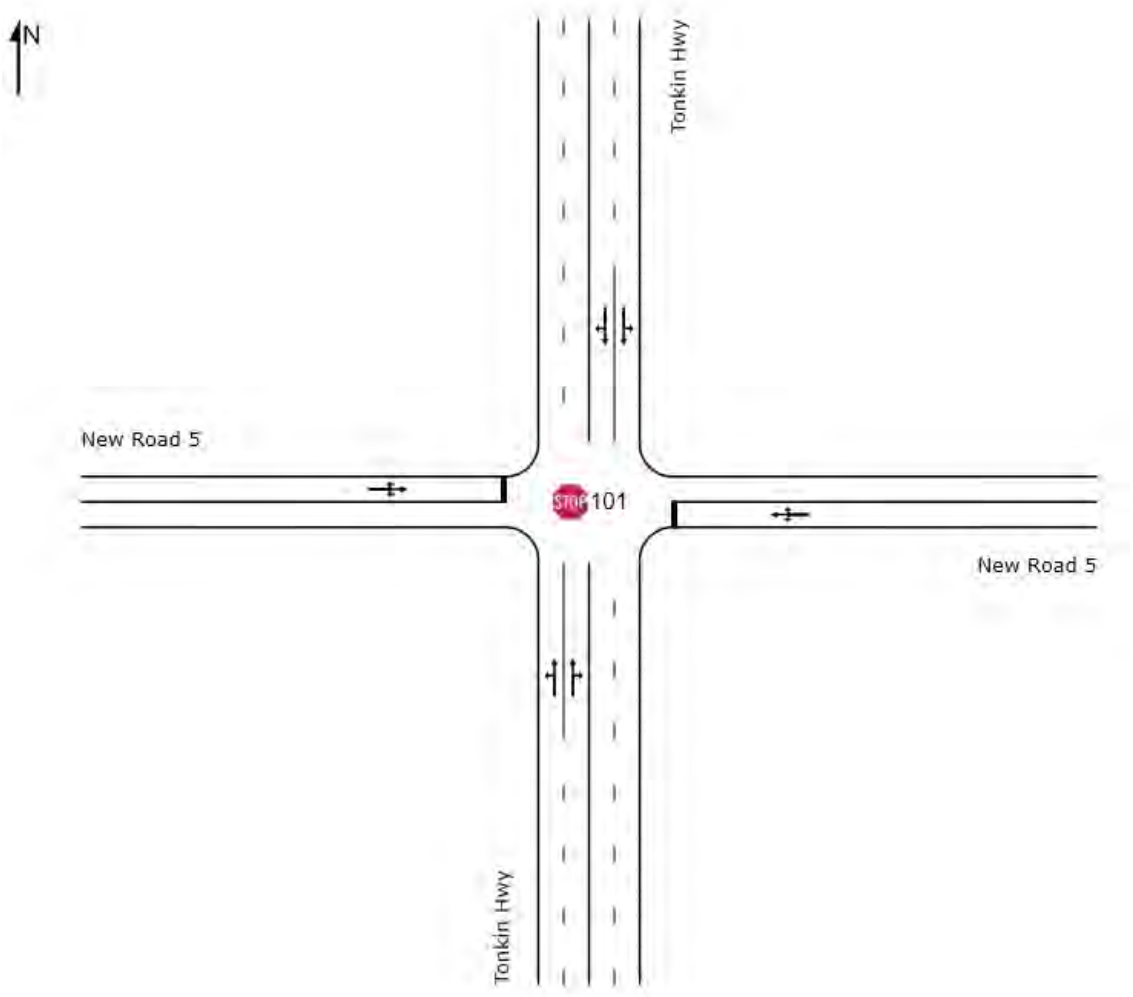



### 5.5.7 No. 5 – New Road 5 and Tonkin Highway

The following presents the results of the analysis of the New Road 5 and Tonkin Highway intersection**.** **Figure 5-14** is a SIDRA layout representation of the intersection which is based on the indicative layouts used in the mesoscopic model.

Figure 5-14 SIDRA Layout for New Road 6/South Western Highway Intersection




The SIDRA results based on this intersection layout and signal phasing analysis are summarised in **Table 5-19** and **Table 5-20**.

Table 5-19 New Road 5 and Tonkin Highway Intersection AM Results 2031

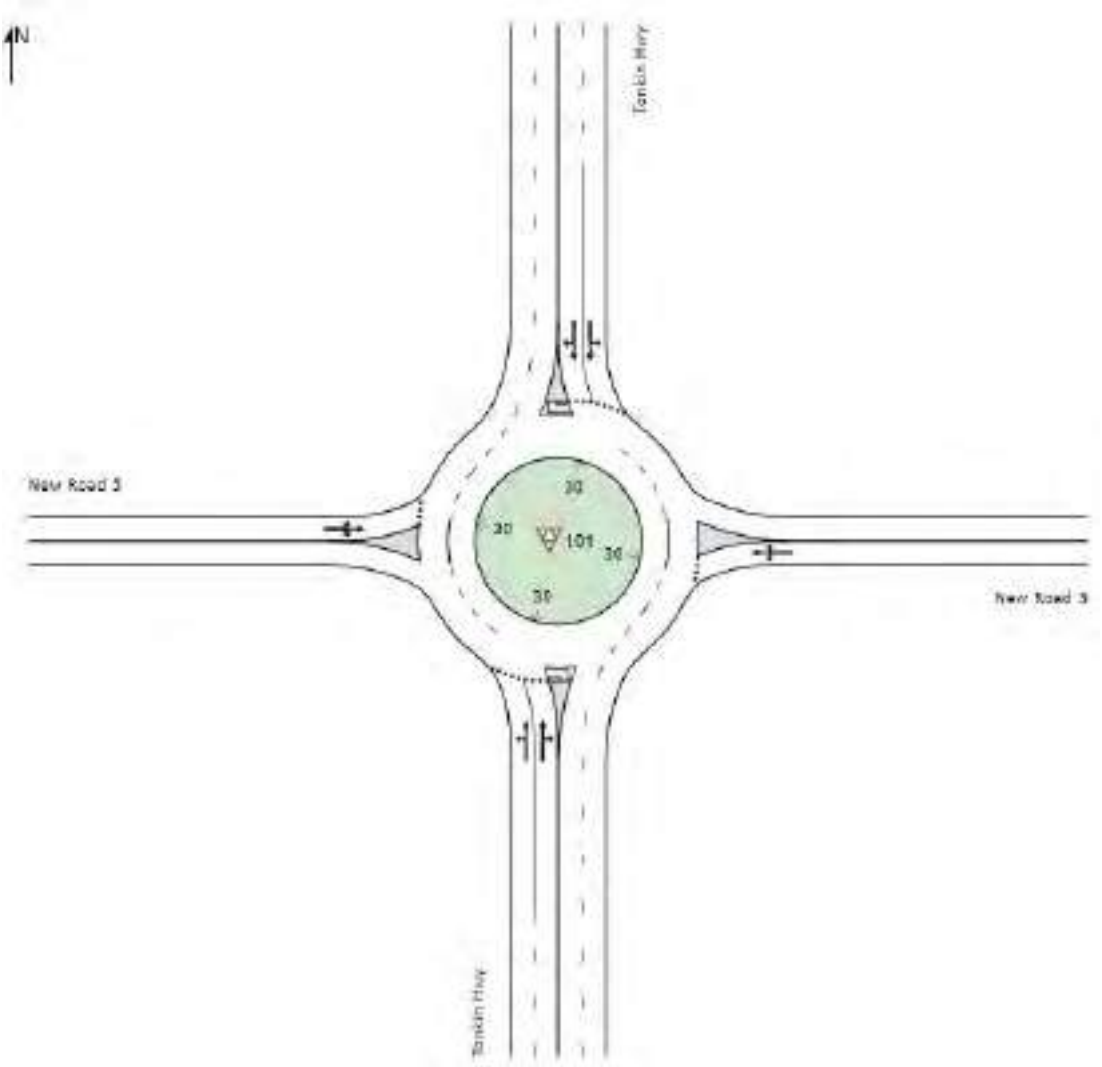
| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | 95% Back of Queue Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Tonkin Hwy | | | | | | | | | | | | |
| 1 | L2 | 394 | 7.4 | 0.305 | 6.6 | LOS A | 0.0 | 0.0 | 0.00 | 0.45 | 0.00 | 59.9 |
| 2 | T1 | 670 | 7.2 | 0.305 | 0.7 | LOS A | 0.5 | 3.4 | 0.06 | 0.17 | 0.08 | 90.2 |
| 3 | R2 | 17 | 0.0 | 0.305 | 14.0 | LOS B | 0.5 | 3.4 | 0.08 | 0.09 | 0.10 | 70.1 |
| Approach | | 1081 | 7.1 | 0.305 | 3.1 | NA | 0.5 | 3.4 | 0.04 | 0.27 | 0.05 | 75.8 |
| East: New Road 5 | | | | | | | | | | | | |
| 4 | L2 | 16 | 0.0 | 16.529 | 27975.3 | LOS F | 765.4 | 5708.7 | 1.00 | 5.29 | 19.46 | 0.1 |
| 5 | T1 | 109 | 5.5 | 16.529 | 27983.0 | LOS F | 765.4 | 5708.7 | 1.00 | 5.29 | 19.46 | 0.1 |
| 6 | R2 | 490 | 8.4 | 16.529 | 27981.3 | LOS F | 765.4 | 5708.7 | 1.00 | 5.29 | 19.46 | 0.1 |
| Approach | | 615 | 7.6 | 16.529 | 27981.4 | LOS F | 765.4 | 5708.7 | 1.00 | 5.29 | 19.46 | 0.1 |
| North: Tonkin Hwy | | | | | | | | | | | | |
| 7 | L2 | 299 | 6.0 | 0.337 | 7.1 | LOS A | 0.0 | 0.0 | 0.00 | 0.32 | 0.00 | 67.7 |
| 8 | T1 | 394 | 7.1 | 0.337 | 4.6 | LOS A | 2.3 | 16.8 | 0.17 | 0.40 | 0.21 | 77.1 |
| 9 | R2 | 107 | 7.5 | 0.337 | 19.5 | LOS C | 2.3 | 16.8 | 0.84 | 0.72 | 1.06 | 49.7 |
| Approach | | 800 | 6.8 | 0.337 | 7.6 | NA | 2.3 | 16.8 | 0.20 | 0.41 | 0.25 | 68.5 |
| West: New Road 5 | | | | | | | | | | | | |
| 10 | L2 | 58 | 19.0 | 6.380 | 9719.6 | LOS F | 302.6 | 2272.5 | 1.00 | 5.67 | 19.09 | 0.4 |
| 11 | T1 | 43 | 7.0 | 6.380 | 9739.6 | LOS F | 302.6 | 2272.5 | 1.00 | 5.67 | 19.09 | 0.4 |
| 12 | R2 | 169 | 5.3 | 6.380 | 9736.3 | LOS F | 302.6 | 2272.5 | 1.00 | 5.67 | 19.09 | 0.4 |
| Approach | | 270 | 8.5 | 6.380 | 9733.2 | LOS F | 302.6 | 2272.5 | 1.00 | 5.67 | 19.09 | 0.4 |
| All Vehicles | | 2766 | 7.3 | 16.529 | 7175.0 | NA | 765.4 | 5708.7 | 0.39 | 1.95 | 6.28 | 0.5 |

Table 5-20 New Road 5 and Tonkin Highway Intersection PM Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | 95% Back of Queue Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Tonkin Hwy | | | | | | | | | | | | |
| 1 | L2 | 131 | 5.3 | 0.124 | 6.9 | LOS A | 0.0 | 0.0 | 0.00 | 0.37 | 0.00 | 65.0 |
| 2 | T1 | 95 | 5.3 | 0.124 | 0.0 | LOS A | 0.0 | 0.0 | 0.00 | 0.37 | 0.00 | 70.9 |
| 3 | R2 | 37 | 0.0 | 0.143 | 19.5 | LOS C | 0.5 | 3.3 | 0.85 | 0.94 | 0.85 | 44.3 |
| Approach | | 263 | 4.6 | 0.143 | 6.2 | NA | 0.5 | 3.3 | 0.12 | 0.45 | 0.12 | 62.8 |
| East: New Road 5 | | | | | | | | | | | | |
| 4 | L2 | 36 | 0.0 | 6.501 | 9929.8 | LOS F | 346.7 | 2533.9 | 1.00 | 6.11 | 21.75 | 0.4 |
| 5 | T1 | 64 | 14.1 | 6.501 | 9944.4 | LOS F | 346.7 | 2533.9 | 1.00 | 6.11 | 21.75 | 0.4 |
| 6 | R2 | 211 | 3.3 | 6.501 | 9943.1 | LOS F | 346.7 | 2533.9 | 1.00 | 6.11 | 21.75 | 0.4 |
| Approach | | 311 | 5.1 | 6.501 | 9941.8 | LOS F | 346.7 | 2533.9 | 1.00 | 6.11 | 21.75 | 0.4 |
| North: Tonkin Hwy | | | | | | | | | | | | |
| 7 | L2 | 361 | 6.4 | 0.410 | 7.2 | LOS A | 0.0 | 0.0 | 0.00 | 0.31 | 0.00 | 67.8 |
| 8 | T1 | 893 | 6.2 | 0.410 | 3.1 | LOS A | 1.9 | 14.2 | 0.14 | 0.51 | 0.15 | 83.0 |
| 9 | R2 | 153 | 5.2 | 0.410 | 9.1 | LOS A | 1.9 | 14.2 | 0.25 | 0.67 | 0.26 | 62.9 |
| Approach | | 1407 | 6.1 | 0.410 | 4.8 | NA | 1.9 | 14.2 | 0.12 | 0.48 | 0.12 | 76.0 |
| West: New Road 5 | | | | | | | | | | | | |
| 10 | L2 | 5 | 20.0 | 8.568 | 13647.0 | LOS F | 481.3 | 3480.6 | 1.00 | 6.01 | 22.80 | 0.3 |
| 11 | T1 | 50 | 0.0 | 8.568 | 13658.0 | LOS F | 481.3 | 3480.6 | 1.00 | 6.01 | 22.80 | 0.3 |
| 12 | R2 | 360 | 4.2 | 8.568 | 13655.1 | LOS F | 481.3 | 3480.6 | 1.00 | 6.01 | 22.80 | 0.3 |
| Approach | | 415 | 3.9 | 8.568 | 13655.3 | LOS F | 481.3 | 3480.6 | 1.00 | 6.01 | 22.80 | 0.3 |
| All Vehicles | | 2396 | 5.4 | 8.568 | 3659.1 | NA | 481.3 | 3480.6 | 0.38 | 2.16 | 6.86 | 1.0 |

The SIDRA results shows that the intersection will operate at an unacceptable level of service with long queues and delays on the eastern and western leg of the intersection. Modifications to the geometry are required to ensure that the intersection operates within an acceptable level of service. **Figure 5-15** shows the reconfigured intersection layout Option 1.

Figure 5-15 Reconfigured SIDRA Layout for New Road 5 and Tonkin Highway Intersection Option 1




The SIDRA results based on this reconfigured intersection layout Option 1 – Roundabout are summarised in **Table 5-21** and **Table 5-22**. The results show that the intersection will operate at an acceptable level of service with these upgrade.

Table 5-21 Reconfigured New Road 5 and Tonkin Highway Intersection AM Option 1 Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Tonkin Hwy | | | | | | | | | | | | |
| 1 | L2 | 394 | 7.4 | 0.662 | 11.8 | LOS B | 8.6 | 63.6 | 1.00 | 1.03 | 1.29 | 50.2 |
| 2 | T1 | 670 | 7.2 | 0.662 | 13.3 | LOS B | 8.6 | 63.6 | 1.00 | 1.09 | 1.33 | 50.7 |
| 3 | R2 | 17 | 0.0 | 0.662 | 19.4 | LOS B | 7.5 | 55.8 | 1.00 | 1.12 | 1.35 | 50.5 |
| Approach | | 1081 | 7.1 | 0.662 | 12.8 | LOS B | 8.6 | 63.6 | 1.00 | 1.07 | 1.32 | 50.5 |
| East: New Road 5 | | | | | | | | | | | | |
| 4 | L2 | 16 | 0.0 | 0.767 | 11.6 | LOS B | 7.8 | 57.8 | 0.87 | 1.12 | 1.31 | 47.7 |
| 5 | T1 | 109 | 5.5 | 0.767 | 12.0 | LOS B | 7.8 | 57.8 | 0.87 | 1.12 | 1.31 | 48.9 |
| 6 | R2 | 490 | 8.4 | 0.767 | 17.8 | LOS B | 7.8 | 57.8 | 0.87 | 1.12 | 1.31 | 49.0 |
| Approach | | 615 | 7.6 | 0.767 | 16.6 | LOS B | 7.8 | 57.8 | 0.87 | 1.12 | 1.31 | 48.9 |
| North: Tonkin Hwy | | | | | | | | | | | | |
| 7 | L2 | 299 | 6.0 | 0.307 | 4.6 | LOS A | 2.3 | 16.8 | 0.50 | 0.50 | 0.50 | 54.2 |
| 8 | T1 | 394 | 7.1 | 0.307 | 4.7 | LOS A | 2.3 | 16.8 | 0.51 | 0.53 | 0.51 | 55.1 |
| 9 | R2 | 107 | 7.5 | 0.307 | 10.5 | LOS B | 2.1 | 15.9 | 0.52 | 0.54 | 0.52 | 54.8 |
| Approach | | 800 | 6.8 | 0.307 | 5.5 | LOS A | 2.3 | 16.8 | 0.51 | 0.52 | 0.51 | 54.7 |
| West: New Road 5 | | | | | | | | | | | | |
| 10 | L2 | 58 | 19.0 | 0.524 | 12.8 | LOS B | 3.5 | 26.5 | 0.87 | 1.03 | 1.11 | 47.6 |
| 11 | T1 | 43 | 7.0 | 0.524 | 12.3 | LOS B | 3.5 | 26.5 | 0.87 | 1.03 | 1.11 | 49.1 |
| 12 | R2 | 169 | 5.3 | 0.524 | 17.9 | LOS B | 3.5 | 26.5 | 0.87 | 1.03 | 1.11 | 49.3 |
| Approach | | 270 | 8.5 | 0.524 | 15.9 | LOS B | 3.5 | 26.5 | 0.87 | 1.03 | 1.11 | 48.9 |
| All Vehicles | | 2766 | 7.3 | 0.767 | 11.8 | LOS B | 8.6 | 63.6 | 0.82 | 0.92 | 1.06 | 51.1 |

Table 5-22 Reconfigured New Road 5 and Tonkin Highway Intersection PM Option 1 Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: RoadName | | | | | | | | | | | | |
| 1 | L2 | 131 | 5.3 | 0.116 | 5.2 | LOS A | 0.7 | 5.4 | 0.57 | 0.56 | 0.57 | 54.0 |
| 2 | T1 | 95 | 5.3 | 0.116 | 5.5 | LOS A | 0.7 | 5.4 | 0.58 | 0.60 | 0.58 | 54.5 |
| 3 | R2 | 37 | 0.0 | 0.116 | 11.2 | LOS B | 0.7 | 5.0 | 0.58 | 0.61 | 0.58 | 54.7 |
| Approach | | 263 | 4.6 | 0.116 | 6.2 | LOS A | 0.7 | 5.4 | 0.57 | 0.58 | 0.57 | 54.3 |
| East: RoadName | | | | | | | | | | | | |
| 4 | L2 | 36 | 0.0 | 0.652 | 15.2 | LOS B | 4.8 | 34.9 | 0.91 | 1.10 | 1.33 | 45.9 |
| 5 | T1 | 64 | 14.1 | 0.652 | 16.1 | LOS B | 4.8 | 34.9 | 0.91 | 1.10 | 1.33 | 46.9 |
| 6 | R2 | 211 | 3.3 | 0.652 | 21.2 | LOS C | 4.8 | 34.9 | 0.91 | 1.10 | 1.33 | 47.3 |
| Approach | | 311 | 5.1 | 0.652 | 19.4 | LOS B | 4.8 | 34.9 | 0.91 | 1.10 | 1.33 | 47.0 |
| North: RoadName | | | | | | | | | | | | |
| 7 | L2 | 361 | 6.4 | 0.628 | 7.3 | LOS A | 6.7 | 49.6 | 0.81 | 0.76 | 0.90 | 52.7 |
| 8 | T1 | 893 | 6.2 | 0.628 | 7.9 | LOS A | 6.7 | 49.6 | 0.82 | 0.82 | 0.94 | 53.6 |
| 9 | R2 | 153 | 5.2 | 0.628 | 14.3 | LOS B | 6.5 | 47.7 | 0.83 | 0.86 | 0.98 | 53.2 |
| Approach | | 1407 | 6.1 | 0.628 | 8.5 | LOS A | 6.7 | 49.6 | 0.82 | 0.81 | 0.93 | 53.3 |
| West: RoadName | | | | | | | | | | | | |
| 10 | L2 | 5 | 20.0 | 0.423 | 5.7 | LOS A | 2.5 | 18.0 | 0.57 | 0.73 | 0.57 | 50.7 |
| 11 | T1 | 50 | 0.0 | 0.423 | 5.3 | LOS A | 2.5 | 18.0 | 0.57 | 0.73 | 0.57 | 52.6 |
| 12 | R2 | 360 | 4.2 | 0.423 | 11.1 | LOS B | 2.5 | 18.0 | 0.57 | 0.73 | 0.57 | 52.7 |
| Approach | | 415 | 3.9 | 0.423 | 10.4 | LOS B | 2.5 | 18.0 | 0.57 | 0.73 | 0.57 | 52.7 |
| All Vehicles | | 2396 | 5.4 | 0.652 | 10.0 | LOS A | 6.7 | 49.6 | 0.76 | 0.81 | 0.88 | 52.4 |

The SIDRA results based on this reconfigured intersection layout Option 2 – Signal Intersection are summarised in **Table 5-23 and Table 5-24**. The results show that the intersection will operate at an acceptable level of service with these upgrade. **Figure 5-16** shows the reconfigured intersection layout Option 2.

Figure 5-16 Reconfigured intersection layout Option 2

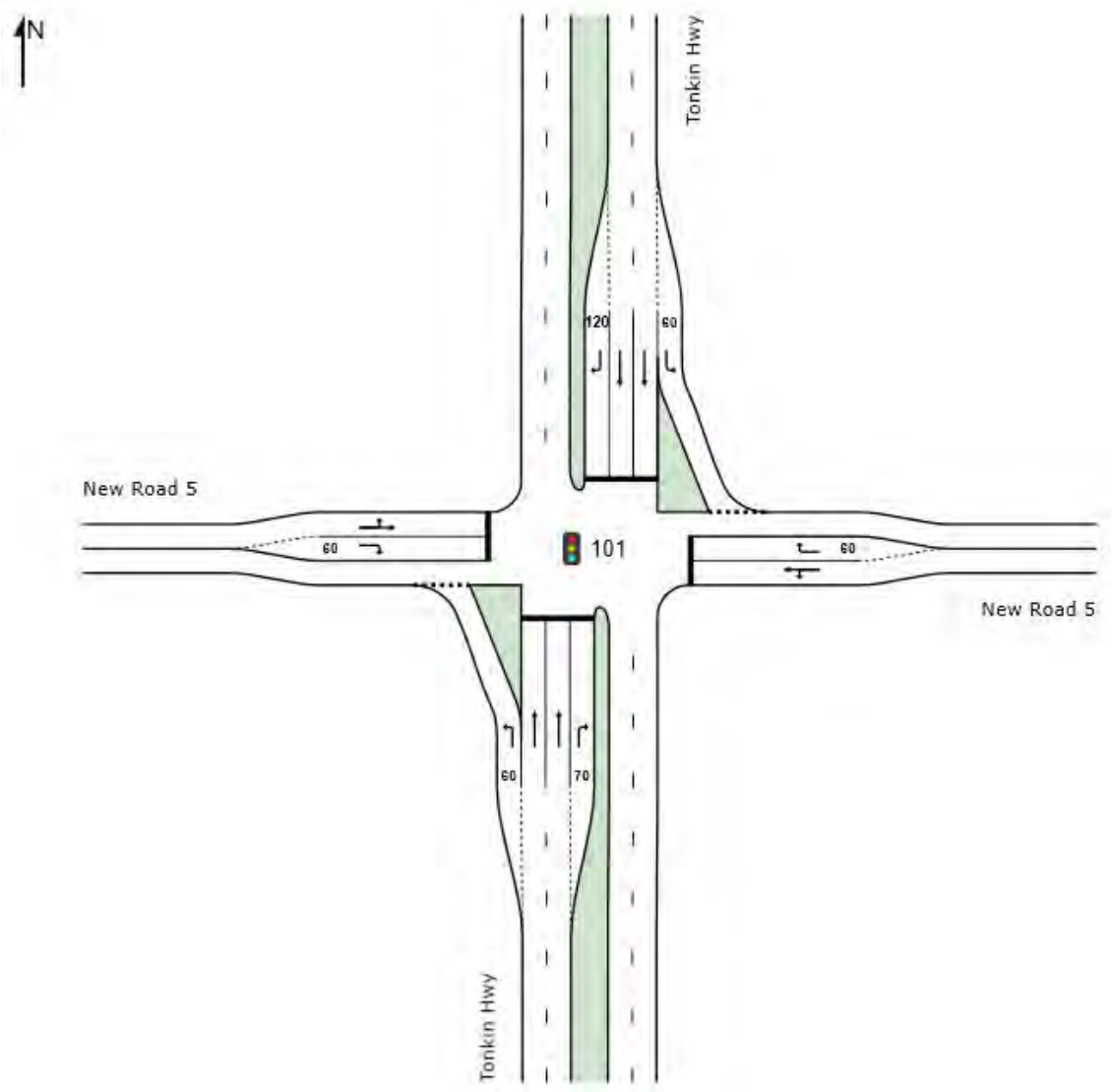
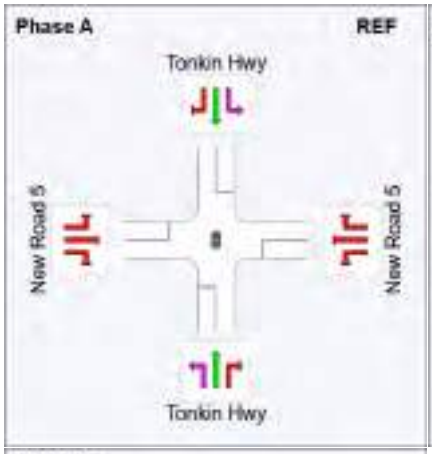
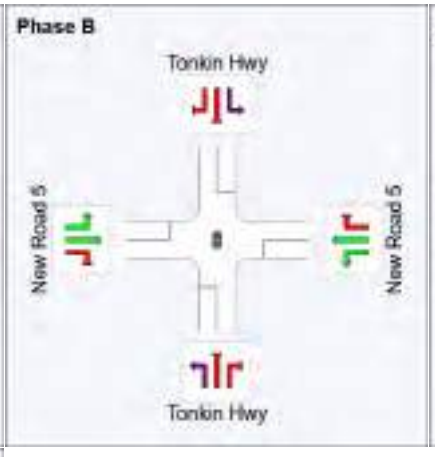
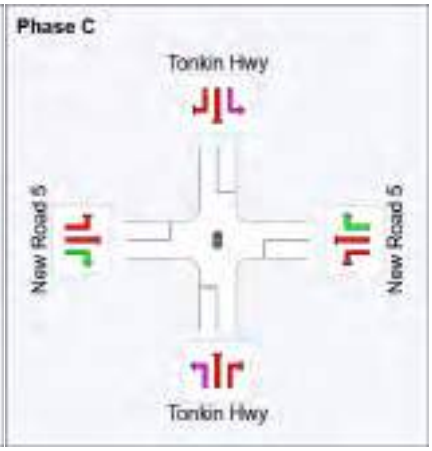


Table 5-23 Reconfigured New Road 5 and Tonkin Highway Intersection PM Option 2 Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total | HV | Deg. Satn | Average Delay | Level of Service | 95% Back of Queue Vehicles | Distance | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed |
| | | veh/h | % | v/c | sec | | veh | m | | | | km/h |
| South: Tonkin Hwy | | | | | | | | | | | | |
| 1 | L2 | 394 | 7.4 | 0.297 | 7.9 | LOS A | 3.7 | 27.3 | 0.36 | 0.66 | 0.36 | 52.2 |
| 2 | T1 | 670 | 7.2 | 0.899 | 47.3 | LOS D | 16.1 | 119.4 | 1.00 | 1.13 | 1.49 | 33.7 |
| 3 | R2 | 17 | 0.0 | 0.122 | 45.0 | LOS D | 0.7 | 4.6 | 0.96 | 0.69 | 0.96 | 34.0 |
| Approach | | 1081 | 7.1 | 0.899 | 32.9 | LOS C | 16.1 | 119.4 | 0.77 | 0.95 | 1.07 | 38.8 |
| East: New Road 5 | | | | | | | | | | | | |
| 4 | L2 | 16 | 0.0 | 0.887 | 55.7 | LOS E | 5.8 | 42.3 | 1.00 | 1.04 | 1.68 | 32.3 |
| 5 | T1 | 109 | 5.5 | 0.887 | 50.2 | LOS D | 5.8 | 42.3 | 1.00 | 1.04 | 1.68 | 32.8 |
| 6 | R2 | 490 | 8.4 | 0.868 | 41.9 | LOS D | 21.4 | 160.7 | 0.97 | 0.99 | 1.25 | 35.1 |
| Approach | | 615 | 7.6 | 0.887 | 43.7 | LOS D | 21.4 | 160.7 | 0.97 | 1.00 | 1.34 | 34.6 |
| North: Tonkin Hwy | | | | | | | | | | | | |
| 7 | L2 | 299 | 6.0 | 0.204 | 6.5 | LOS A | 1.4 | 10.2 | 0.22 | 0.62 | 0.22 | 53.3 |
| 8 | T1 | 394 | 7.1 | 0.528 | 31.8 | LOS C | 7.1 | 52.7 | 0.94 | 0.77 | 0.94 | 39.4 |
| 9 | R2 | 107 | 7.5 | 0.809 | 51.8 | LOS D | 4.7 | 35.2 | 1.00 | 0.93 | 1.42 | 31.9 |
| Approach | | 800 | 6.8 | 0.809 | 25.0 | LOS C | 7.1 | 52.7 | 0.68 | 0.74 | 0.74 | 42.2 |
| West: New Road 5 | | | | | | | | | | | | |
| 10 | L2 | 58 | 19.0 | 0.780 | 51.1 | LOS D | 4.4 | 34.6 | 1.00 | 0.91 | 1.35 | 32.7 |
| 11 | T1 | 43 | 7.0 | 0.780 | 45.4 | LOS D | 4.4 | 34.6 | 1.00 | 0.91 | 1.35 | 33.5 |
| 12 | R2 | 169 | 5.3 | 0.270 | 25.9 | LOS C | 4.8 | 34.9 | 0.76 | 0.76 | 0.76 | 41.5 |
| Approach | | 270 | 8.5 | 0.780 | 34.4 | LOS C | 4.8 | 34.9 | 0.85 | 0.82 | 0.98 | 37.9 |
| All Vehicles | | 2766 | 7.3 | 0.899 | 33.2 | LOS C | 21.4 | 160.7 | 0.80 | 0.89 | 1.02 | 38.5 |



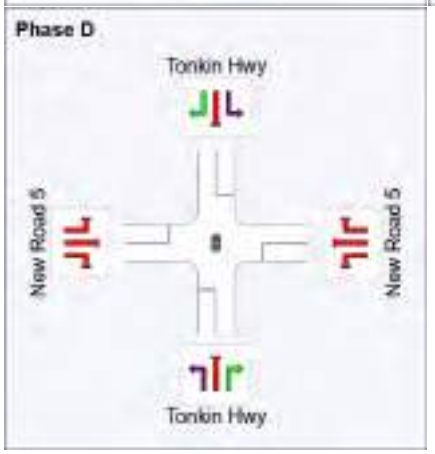
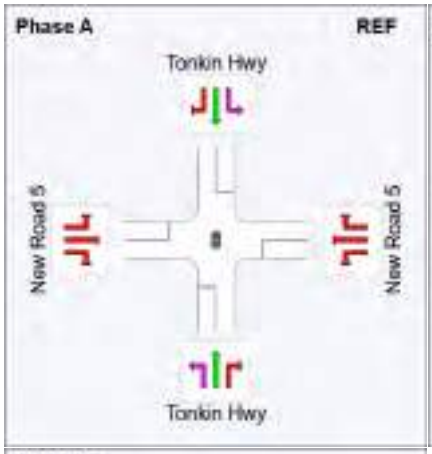
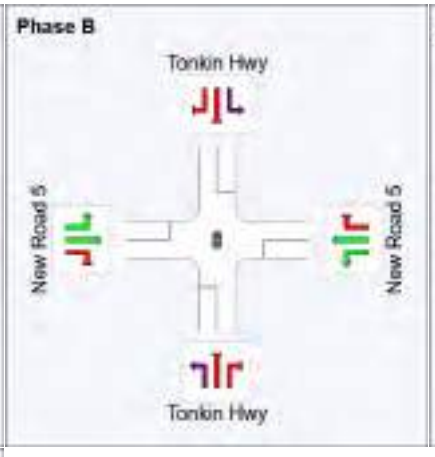
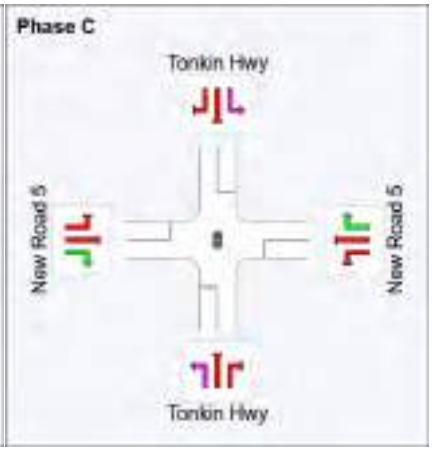



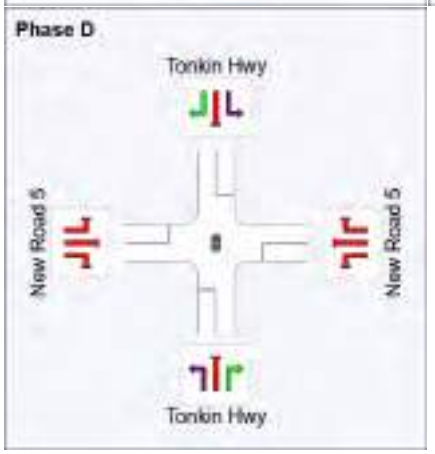
Table 5-24 Reconfigured New Road 5 and Tonkin Highway Intersection PM Option 2 Results 2031

| Movement Performance - Vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mov ID | Turn | Demand Flows Total veh/h | HV % | Deg. Satn v/c | Average Delay sec | Level of Service | 95% Back of Queue Vehicles veh | Distance m | Prop. Queued | Effective Stop Rate | Aver. No. Cycles | Average Speed km/h |
| South: Tonkin Hwy | | | | | | | | | | | | |
| 1 | L2 | 131 | 5.3 | 0.098 | 7.6 | LOS A | 1.0 | 7.5 | 0.30 | 0.63 | 0.30 | 52.5 |
| 2 | T1 | 95 | 5.3 | 0.088 | 22.5 | LOS C | 1.4 | 9.9 | 0.76 | 0.58 | 0.76 | 43.8 |
| 3 | R2 | 37 | 0.0 | 0.199 | 43.0 | LOS D | 1.4 | 9.8 | 0.95 | 0.72 | 0.95 | 34.6 |
| Approach | | 263 | 4.6 | 0.199 | 17.9 | LOS B | 1.4 | 9.9 | 0.56 | 0.62 | 0.56 | 45.9 |
| East: New Road 5 | | | | | | | | | | | | |
| 4 | L2 | 36 | 0.0 | 0.736 | 49.7 | LOS D | 4.3 | 32.3 | 1.00 | 0.87 | 1.26 | 33.6 |
| 5 | T1 | 64 | 14.1 | 0.736 | 44.1 | LOS D | 4.3 | 32.3 | 1.00 | 0.87 | 1.26 | 34.2 |
| 6 | R2 | 211 | 3.3 | 0.490 | 34.7 | LOS C | 7.3 | 52.5 | 0.91 | 0.80 | 0.91 | 37.8 |
| Approach | | 311 | 5.1 | 0.736 | 38.4 | LOS D | 7.3 | 52.5 | 0.94 | 0.83 | 1.02 | 36.4 |
| North: Tonkin Hwy | | | | | | | | | | | | |
| 7 | L2 | 361 | 6.4 | 0.252 | 6.7 | LOS A | 2.0 | 14.7 | 0.25 | 0.63 | 0.25 | 53.1 |
| 8 | T1 | 893 | 6.2 | 0.862 | 38.0 | LOS D | 20.5 | 151.0 | 0.99 | 1.04 | 1.27 | 36.9 |
| 9 | R2 | 153 | 5.2 | 0.855 | 52.4 | LOS D | 6.9 | 50.5 | 1.00 | 1.00 | 1.49 | 31.7 |
| Approach | | 1407 | 6.1 | 0.862 | 31.5 | LOS C | 20.5 | 151.0 | 0.80 | 0.93 | 1.03 | 39.3 |
| West: New Road 5 | | | | | | | | | | | | |
| 10 | L2 | 5 | 20.0 | 0.383 | 46.5 | LOS D | 2.2 | 15.6 | 0.99 | 0.74 | 0.99 | 34.9 |
| 11 | T1 | 50 | 0.0 | 0.383 | 40.8 | LOS D | 2.2 | 15.6 | 0.99 | 0.74 | 0.99 | 35.9 |
| 12 | R2 | 360 | 4.2 | 0.840 | 44.4 | LOS D | 15.6 | 112.9 | 1.00 | 0.97 | 1.26 | 34.3 |
| Approach | | 415 | 3.9 | 0.840 | 44.0 | LOS D | 15.6 | 112.9 | 1.00 | 0.94 | 1.23 | 34.5 |
| All Vehicles | | 2396 | 5.4 | 0.862 | 33.1 | LOS C | 20.5 | 151.0 | 0.83 | 0.89 | 1.01 | 38.6 |



### 5.5.8 Soldiers Road / Gordin Way / Turner Road

Cardno understands that there is a strong desireline for trips between Mundijong residential cells and the Byford Town Centre. This trip is currently supported by Soldiers Road and Abernethy Road.

However, the close spacing of South Western Highway, George Street, the rail line, Soldiers Road and the Byford Village access road means that this heavy traffic demand puts significant stress on the local road infrastructure.

The following modification to the road network has been considered in this context, and is intended to support a preferred route between the Byford Town Centre and Mundijong along the Gordin Way alignment. In addition, regional traffic would be partially redirected onto South Western Highway through to Abernethy Road.


It is noted that the location of Turner Way imposes a geometric impediment on the types of intersection treatment that may be considered. In this instance, a 'peanut' roundabout provides full turning movement capability and a reasonably high capacity intersection.

Traffic from Soldiers Road south is incentivised to undertake the new 'through' movement to Gordin Way, rather than the wide deviation to stay on Soldiers Road. Traffic from Soldiers Road north is only slightly inconvenienced by the roundabout. This intersection geometry could be designed to support some small truck movements, but any larger vehicles should use South Western Highway.

This geometry can be expected to result the following changes to traffic flow:

- Diversion to **Gordin Way**
  - the majority of traffic headed to the Byford Town Centre,
  - the majority of traffic travelling to and from Soldiers Road (south) to Abernethy Road (west).
- Diversion to **South Western Highway**
  - A small proportion of traffic heading from Soldiers Road (south) to Abernethy Road (east)
  - A minor component of traffic heading from Abernethy Road (east) to Soldiers Road (south)

The extent of this impact is determined by the origin-destination profile of traffic using Soldiers Road across the day. OD modelling and turn count data has been used to provide an indication of the existing directional splits (Table 5-25) for traffic:

Table 5-1 Existing Local Traffic Distribution – Soldiers Road

| Direction (from/to) | Soldiers Road Northbound | | Soldiers Road Southbound | |
|---|---|---|---|---|
| | AM Peak | PM Peak | AM Peak | PM Peak |
| Gordin Way | 5% | 4% | 9% | 6% |
| Soldiers Road | 95% | 96% | 91% | 94% |
| *to/from Byford Town Centre* | *35%* | *30%* | *35%* | *30%* |
| *to/from Abernethy Road East* | *39%* | *41%* | *38%* | *36%* |
| *to/from Abernethy Road West* | *21%* | *25%* | *18%* | *28%* |

With the potential for the above modifications to redirect traffic, a possible future distribution is described below (Table 5-26). These results are largely consistent with the modelled network scenario, with some minor amendments to reflect the additional turn penalties imposed by the modified intersection form.

Table 5-2 Potential Modified Local Traffic Distribution (Future Network) – Soldiers Road

| Direction (from/to) | Soldiers Road Northbound | | Soldiers Road Southbound | |
|---|---|---|---|---|
| | AM Peak | PM Peak | AM Peak | PM Peak |
| Gordin Way | 47% | 59% | 73% | 74% |
| *to/from Byford Town Centre* | *22%* | *10%* | *4%* | *8%* |
| *to/from Abernethy Road/Mead Street West* | *21%* | *31%* | *63%* | *31%* |
| *to/from San Simeon Boulevard* | *4%* | *18%* | *6%* | *35%* |
| Soldiers Road | 23% | 21% | 23% | 23% |
| *to/from Byford Town Centre* | *12%* | *8%* | *4%* | *12%* |
| *to/from Abernethy Road East* | *10%* | *12%* | *16%* | *10%* |
| *to/from Abernethy Road West* | *1%* | *1%* | *3%* | *1%* |
| South Western Highway | 30% | 10% | 4% | 3% |

This distribution would result in a significant decrease in traffic on Soldiers Road north of Turner Road, from a projected 5,000vpd (ROM24 for 2031), to less than 2,000vpd. Of this traffic a sizeable portion would be relocated to Gordin Way. However, this would primarily be local traffic accessing the Byford Town Centre.

### 5.5.9 Byford Town Centre Signalisation

The *Byford Structure Plan* shows a series of new signal-controlled intersections around the Byford District Centre. These intersections have been evaluated as part of this TIA and are shown to be effective at

controlling traffic movements. More importantly, the signalised intersections support pedestrian and cycling movements in this key activated area, creating a safer and more attractive environment for visitors to the Centre.

An alternative arrangement consisting of roundabout intersections would perform a similar function with respect to allowing vehicle turning movements, but without the intrinsic benefits for active transport modes.

As such, the traffic controls identified in the *Byford Structure Plan* are recommended to be retained as part of future development works.

# 6 Conclusions

Cardno was commissioned by the Shire of Serpentine to prepare a Transport Impact Assessment for the proposed Byford Town Centre Structure Plan ('the Site' or 'the Structure Plan').

The traffic impacts from this Structure Plan have been evaluated in a mesoscopic modelling framework, which classified the network into three categories based on operational performance:

1. The existing intersection forms are considered sufficient to accommodate future growth. These include:
    - Kardan Boulevard/Ballawarra Avenue
    - South West Highway/Thomas Road
    - Abernethy Road/Briggs Road
    - Warrington Road/Turner Road
    - Doley Road/Shepparton Boulevard
2. The proposed intersection forms are considered sufficient to accommodate future growth. These include:
    - Thomas Road/Kardan Boulevard
    - Thomas Road/Masters Road
    - Thomas Road/Plaistowe Boulevard
    - Thomas Road/Alexander Road
    - Thomas Road/George Street
    - Ballawarra Avenue/Malarkey Street
    - Ballawarra Avenue/Briggs Road
    - Ballawarra Avenue/Plaistowe Boulevard
    - Ballawarra Avenue/Larsen Road/Sansimeon Boulevard
    - Abernethy Road/Tonkin Highway
    - Abernethy Road/Kardan Boulevard/Tourmaline Boulevard
    - Abernethy Road/Doley Road
    - Abernethy Road/Warrington Road
    - Turner Road/Warrington Road
    - Orton Road/Warrington Road
    - Orton Road/Doley Road
    - Doley Road/Cardup Siding Road
    - Orton Road/Tourmaline Boulevard

- South Western Highway/Sansimeon Boulevard
- Sansimeon Boulevard Intersection

3. For a number of key intersections, alternative intersection forms were considered necessary to accommodate future growth. These include:
   - Tonkin Highway/Thomas Road
   - Abernethy Road/Sansimeon Boulevard/Gordin Way
   - Soldiers Road/Orton Road
   - Tonkin Highway/Orton Road
   - South Western Highway/Abernethy Rd

   The minimum intersection form required to accommodate future traffic growth is shown in **Section 5.5**. It is anticipated that additional works will be required to ensure intersection geometry meets Austroads and Main Roads WA guidelines.

Overall, with the reconfigured intersection forms, the SP network is considered to operate satisfactorily in the 2031/future scenario.

Byford Structure Plan

# APPENDIX A

## WAPC CHECKLIST

| Item | Provided | Comments/Proposals |
|---|---|---|
| **Summary** | | |
| **Introduction/Background** | Included in Section 1 | |
| **Structure plan proposal** | Included in Section 1 | |
| ▪ regional context | Included in Section 1 | |
| ▪ proposed land uses | Included in Section 1 | |
| ▪ table of land uses and quantities | Included in Section 1 | |
| ▪ major attractors/generators | Included in Section 4 | |
| ▪ specific issues | N/A | |
| **Existing situation** | | |
| ▪ existing land uses within structure plan | Included in Section 2 | |
| ▪ existing land uses within 800 metres of structure plan area | Included in Section 2 | |
| ▪ existing road network within structure plan area | Included in Section 2 | |
| ▪ existing pedestrian/cycle networks within structure plan area | Included in Section 2 | |
| ▪ existing public transport services within structure plan area | Included in Section 2 | |
| ▪ existing road network within 2 (or 5) km of structure plan area | Included in Section 2 | |
| ▪ traffic flows on roads within structure plan area (PM and/or AM peak hours) | N/A | |
| ▪ traffic flows on roads within 2 (or 5) km of structure plan area (AM and/or PM peak hours) | Included in Section 2 | |
| ▪ existing pedestrian/cycle networks within 800m of structure plan area | Included in Section 2 | |
| ▪ existing public transport services within 800m of structure plan area | Included in Section 2 | |
| **Proposed internal transport networks** | | |
| ▪ changes/additions to existing road network or proposed new road network | Included in Section 3 | |
| ▪ road reservation widths | N/A | |
| ▪ road cross-sections & speed limits | N/A | |
| ▪ intersection controls | Included in Section 3 | |
| ▪ pedestrian/cycle networks and crossing facilities | Included in Section 3 | |
| ▪ public transport routes | Included in Section 3 | |
| **Changes to external transport networks** | | |
| ▪ road network | Included in Section 3 | |
| ▪ intersection controls | Included in Section 3 | |
| ▪ pedestrian/cycle networks and crossing facilities | Included in Section 3 | |
| ▪ public transport services | Included in Section 3 | |
| **Integration with surrounding area** | | |
| ▪ trip attractors/generators within 800 metres | Included in Section 4 | |
| ▪ proposed changes to land uses within 800 metres | Included in Section 4 | |
| ▪ travel desire lines from structure plan to these attractors/generators | N/A | |
| ▪ adequacy of external transport networks | N/A | |
| ▪ deficiencies in external transport networks | N/A | |

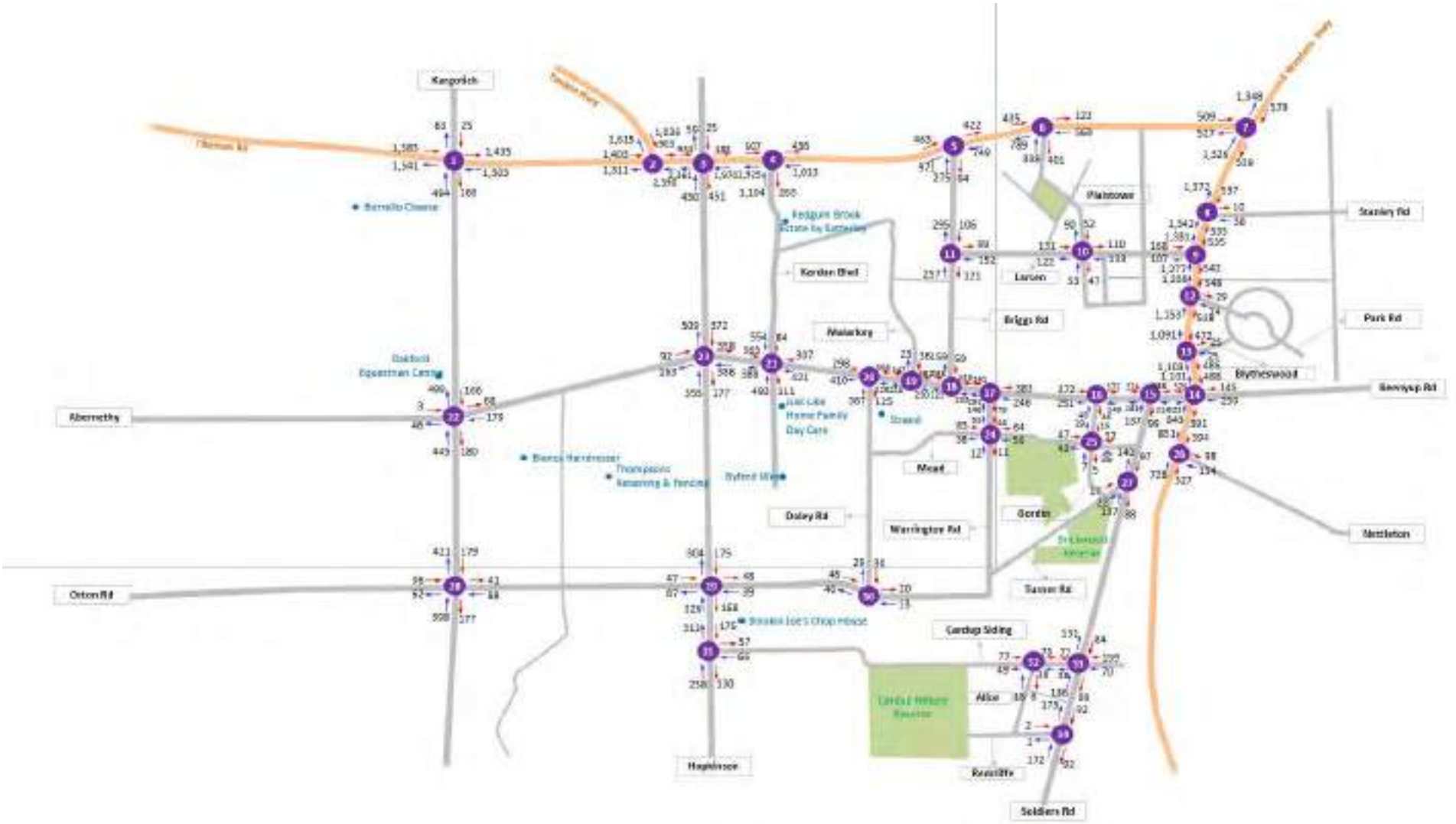
| | | |
|---|---|---|
| ▪ remedial measures to address deficiencies | N/A | |
| **Analysis of internal transport networks** | | |
| ▪ assessment year(s) and time period(s) | Included in Section 5 | |
| ▪ structure plan generated traffic | Included in Section 5 | |
| ▪ extraneous (through) traffic | Included in Section 5 | |
| ▪ design traffic flows (ie. total traffic) | Included in Section 5 | |
| ▪ road cross-sections | N/A | |
| ▪ intersection controls | Included in Section 5 | |
| ▪ access strategy | N/A | |
| ▪ pedestrian / cycle networks | Included in Section 3 | |
| ▪ safe routes to schools | N/A | |
| ▪ pedestrian permeability & efficiency | Included in Section 3 | |
| ▪ access to public transport | Included in Section 3 | |
| **Analysis of external transport networks** | | |
| ▪ extent of analysis | Included in Section 5 | |
| ▪ base flows for assessment year(s) | Included in Section 5 | |
| ▪ total traffic flows | Included in Section 5 | |
| ▪ road cross-sections | N/A | |
| ▪ intersection layouts & controls | Included in Section 5 | |
| ▪ pedestrian/cycle networks | Included in Section 3 | |
| **Conclusions** | Included in Section 6 | |

Byford Structure Plan

# APPENDIX B

## EXISTING TRAFFIC VOLUMES

Cardno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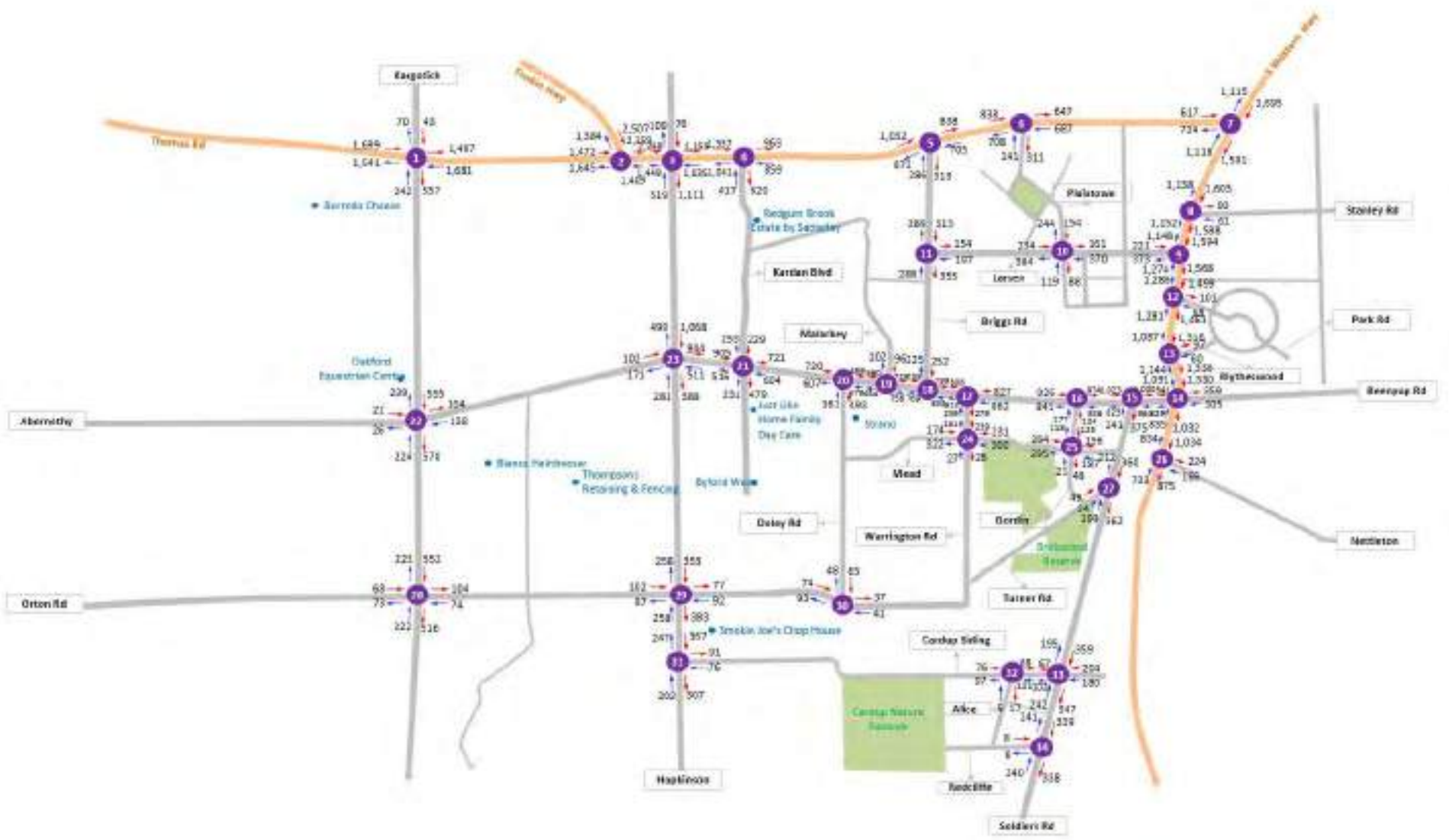
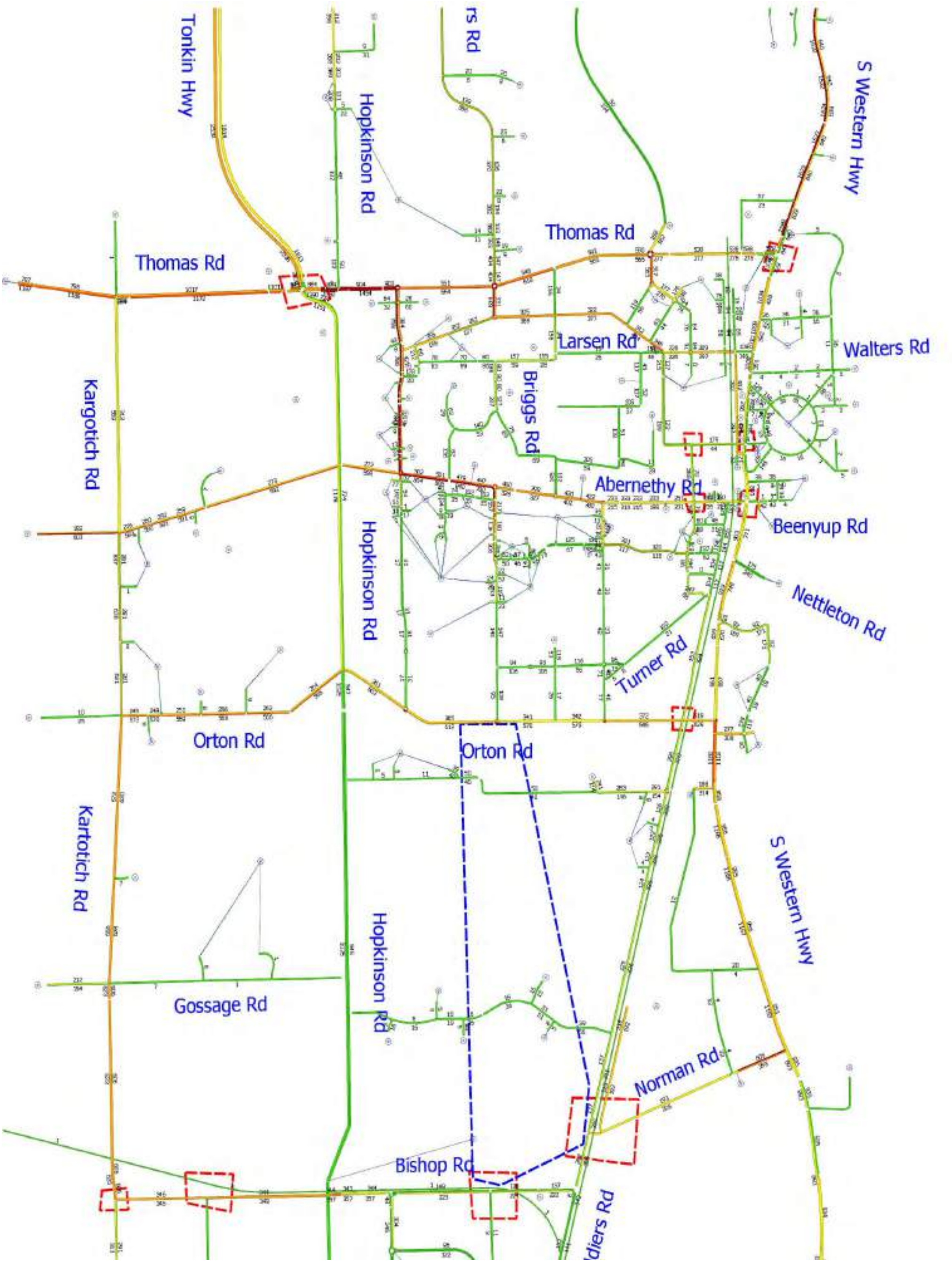
Abernethy
Orton Rd
Oakford Equestrian Centre
Bellatto Cheese
Redgum Brook
Kardan Blvd
Malarkey
Briggs Rd
Larsen
Plainsman
Stanley Rd
Park Rd
Brymesswood
Bennyup Rd
Nettleton
Mead
Daley Rd
Warrington Rd
Gordon
Sussex Rd
Cardup Siding
Alice
Hopkinson
Soldiers Rd
Just Like Home Family Day Care
Thompsons Retaining & Fencing
Byford Wines
Broken Joe's Chop House


Kargotich
Thomas Rd
Barrels Chasin
Redgum Brook Estate by Satterley
Kardan Blvd
Briggs Rd
Matarkey
Oxford Equestrian Centre
Abernethy
Mead
Darley Rd
Warrington Rd
Orton Rd
Hopkinson
Cardup Siding
Alice
Redcliffe
Soldiers Rd
Tarcoola Rd
Dorothy
Nettleton
Beenyup Rd
Park Rd
Stanley Rd
Blythewood
Platinum
Larsen

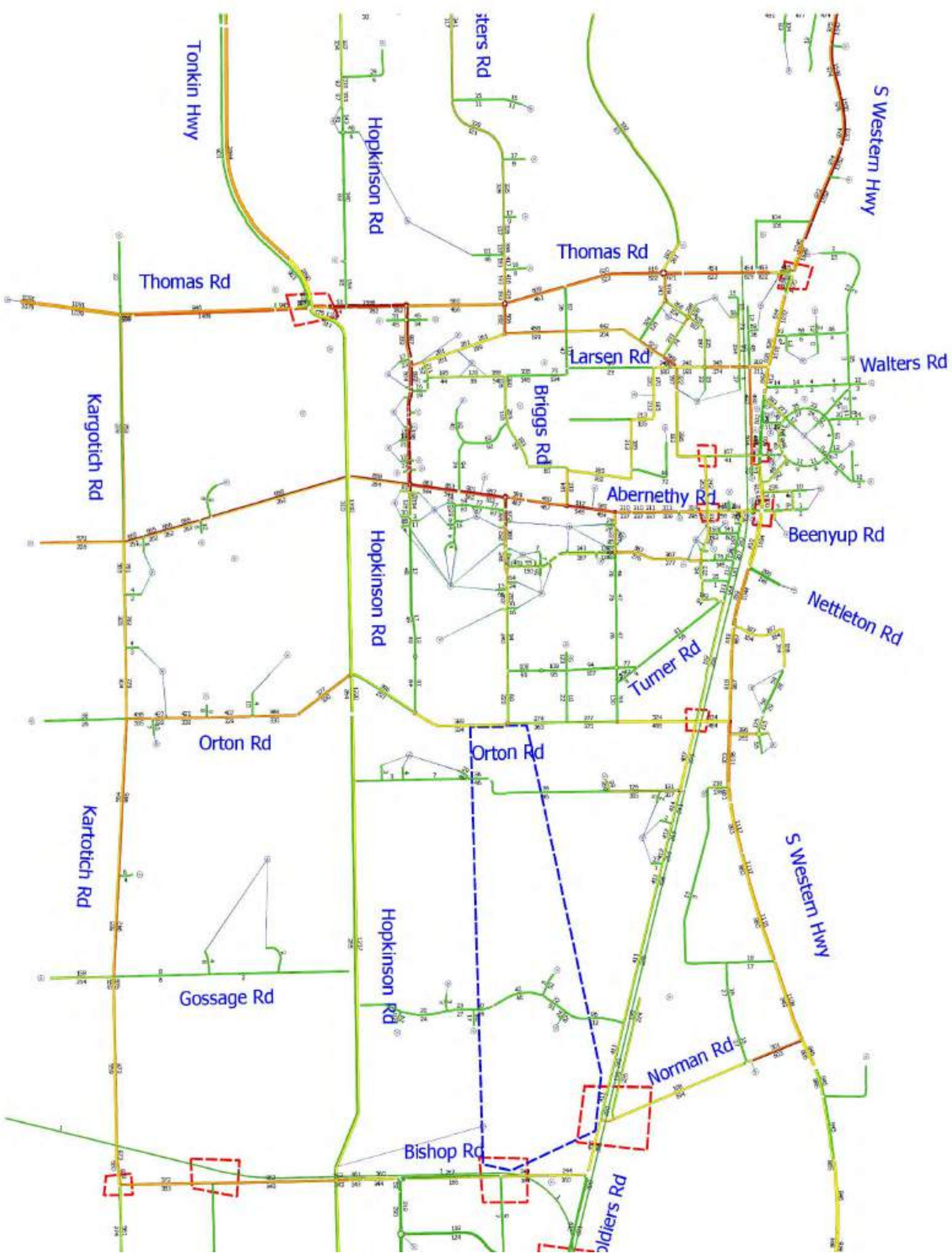
# APPENDIX C

## FUTURE MODELLED TRAFFIC

2031 AM Peak – Byford Area



2031 PM Peak – Byford Area



# Byford

## District Water Management Strategy

Prepared for:

Shire of Serpentine-Jarrahdale

By Urbaqua

June 2018

urbaqua
land and water solutions

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# Tables

# Figures

# 1 INTRODUCTION

This District Water Management Strategy (DWMS) has been prepared for Serpentine-Jarrahdale Shire (SJ Shire) to supersede and update *Byford Townsite Drainage and Water Management Plan* (DWMP) (DWER, 2008) and to support a review of the *Byford Townsite District Structure Plan* currently underway.

This DWMS considers a larger study area than both the preceding DWMP and the DSP, presents an updated summary of the existing environment and builds upon each of the strategies first presented in the DWMP with reference to updated state and local government policies where relevant. The document also provides a detailed review and update to the Arterial Drainage Scheme (ADS) for the Byford townsite that was proposed in the DWMP in accordance with the responsibilities for drainage planning assigned to the Department of Water by the state government.

The scope of the DWMS is to cover all aspects of total water cycle management, including:

- protection of significant environmental assets within the structure plan area, including meeting water requirements and managing potential impacts from development
- water demands, supply options, opportunities for conservation and demand management measures and wastewater management
- surface runoff, including peak event (flood) management and the application of water-sensitive urban design principles to frequent events
- groundwater, including the impact of urbanisation, variation in climate, installation of drainage to reduce groundwater levels, potential impacts on the environment and the potential to use groundwater as a resource
- water quality management, which includes source control of pollution inputs by catchment management, acid sulfate soil management, control of contaminated discharges from industrial areas and management of nutrient exports from surface runoff and groundwater through structural measures

The position of the DWMS within the state government planning framework is defined in *Better Urban Water Management* (WAPC, 2008) and outlined in Figure 1 below.

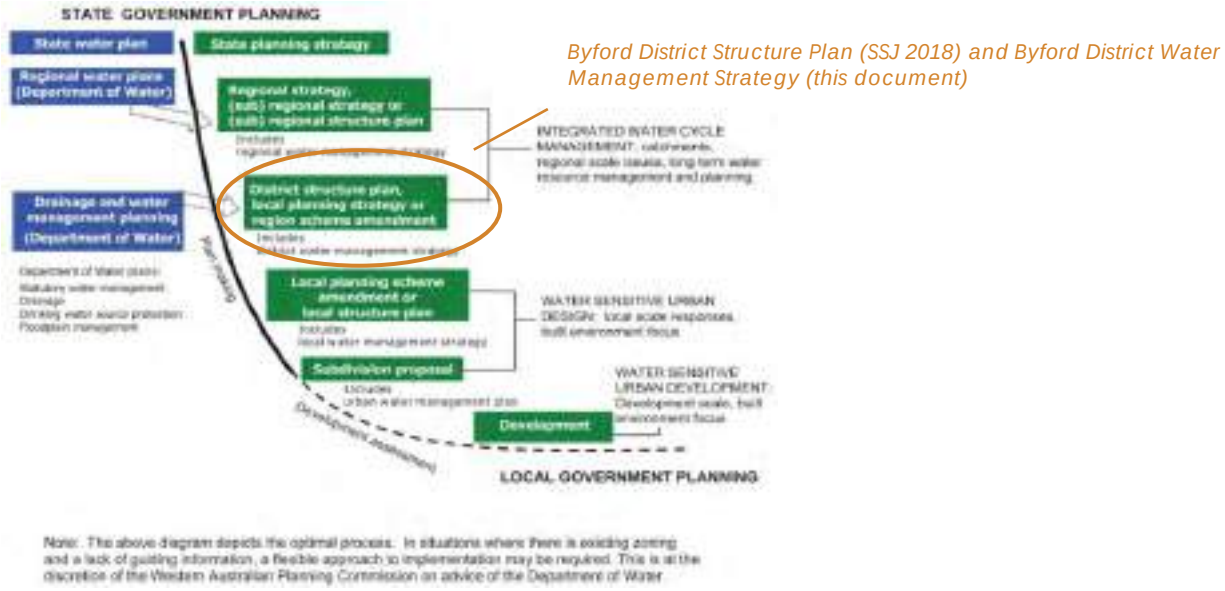



Figure 1: Planning framework integrating drainage planning with land planning processes

## 1.1 Planning background

### *1.1.1 District structure planning*

The *Byford District Structure Plan* (TBB, 2005) provides high level guidance for land use change and development in the Byford Townsite, excluding the Byford Trotting Complex Precinct (see Figure 2).

The study area is the subject of a District Structure Plan review currently being undertaken by Hames Sharley. This review will ultimately deliver a revised District Structure Plan for the whole study area which will supersede the *Byford District Structure Plan* (TBB, 2005).

### *1.1.2 Local structure plans*

There are numerous local structure plans in the study area which provide more detailed guidance for the development of specific areas. Current local structure plans within the study area include:

- Byford Town Centre Local Structure Plan
- Byford Central Local Structure Plan
- Byford West Local Structure Plan
- Byford Main Precinct - The Glades Local Structure Plan
- Kalimna Estate Local Structure Plan
- Redgum Brook Estate - North Local Structure Plan
- Redgum Brook Estate - South Local Structure Plan
- Marri Park Estate - Lot 3 Larsen Rd & Lot 3 Alexander Road, Byford Local Structure Plan
- Lot 6 and Lot 27 Abernethy Road, Byford - Grange Meadows Local Structure Plan
- L1, L3 & L128 South Western Highway, Byford - Map Local Structure Plan
- Lot 806 South Western Highway, Byford Local Structure Plan
- Lots 59-62 Briggs Road, Byford Local Structure Plan
- Lot 2 Nettleton Road, Byford Local Structure Plan
- Byford Meadows Estate Local Structure Plan
- Lot 9500 Thomas Road, Briggs Road, Byford Local Structure Plan
- Doley Road Precinct Local Structure Plan

## 1.2 Previous studies

A number of key investigations have been previously undertaken in the Byford locality. These include:

- Byford urban stormwater management strategy (Parsons Brinkerhoff, 2003)
- Byford urban stormwater management strategy – Developer guidelines (Parsons Brinkerhoff, 2005)
- Local scale groundwater modelling to assess effects of climatic variations and planned development (CyMod Systems, 2007)
- Serpentine River floodplain management study – flood modelling report (SKM, 2007)
- Serpentine River floodplain management study – floodplain management strategy (SKM, 2007)
- Byford drainage and water management plan (DWER, 2008)
- Lower Serpentine hydrological studies: conceptual model report (Hall et al, 2012)
- Lower Serpentine hydrological studies: model construction and calibration report (Hall et al, 2012)

- Lower Serpentine hydrological studies: Land development, drainage and climate scenario report (Hall et al, 2012)
- Birrega Oaklands flood modelling and drainage study (Hall et al, 2015)
- Birrega Oaklands drainage and water management plan (Unpub.)

### 1.2.1 Byford district structure plan supporting studies

The Byford urban stormwater management strategy was completed by Parsons Brinkerhoff in 2003. It presented stormwater management strategies for the study area and many of the proposed strategies have been incorporated into this study. The drainage hydraulic modelling carried out within this study has incorporated key hydraulic features of the strategy's XP-Storm model. The Byford urban stormwater management strategy was later simplified and issued as developer guidelines in 2005.

### 1.2.2 Byford DWMP and supporting studies

Byford Townsite Drainage and Water Management Plan was published by the Department of Water and Environmental Regulation in 2008. The document aimed to incorporate information from all previous studies and present design criteria and management strategies to guide development in the Byford Townsite District Structure Plan area.

Local-scale groundwater modelling was completed by CyMod Systems (2007) in support of the Byford DWMP to assess any impacts from variations in climate or planned development in the study area.

A floodplain management study including two-dimensional flood modelling has been completed by SKM (2007). A high resolution digital elevation model, created to assist flood modelling, has been made available as part of the surface water modelling outputs to supplement Landgate information.

### 1.2.3 Recent studies

The Department of Water and Environmental Regulation has recently undertaken a number of hydrological studies for the Lower Serpentine River catchments including the Birrega Oaklands drainage catchments with the intent to develop *Birrega Oaklands Drainage and Water Management Plan* (DWMP). The DWMP has not yet been published.

Groundwater modelling has been completed in the study area by the Department of Water and Environmental Regulation (DWER) and presented in a series of three *Lower Serpentine Hydrological Studies* reports (Hall et al 2015).

Flood modelling has also been completed in the study area by the Department of Water and Environmental Regulation (DWER) and presented in *Birrega Oaklands flood study* (DWER, 2015)

### 1.2.4 Local water management strategies and Urban water management plans

A large number of Local Water Management Strategies (LWMS) and Urban Water Management Plans (UWMP) have been prepared to support local structure planning and subdivisions within the study area. The following list is not exhaustive but provides a summary of most of the reports that have been previously approved in the study area:

- Byford Town Centre Local Water Management Strategy (GHD, 2014)
    - Lot 1 Abernethy Road, Byford UWMP (Wave International, 2016)

  - Lot 2 Abernethy Rd, Byford UWMP (JDA, 2015)
  - Lot 4 Abernethy Road, Byford - UWMP (True Civil Consulting, 2018)
  - Lot 5 Abernethy Road, Byford UWMP (GHD, 2017)
  - Lot 15 Abernethy Road, Byford UWMP (RPS, 2016)
- Lots 1,2 & 63 Thomas Road, Larsen Road, Byford (Byford Central) DNMP (Cardno, 2006)
- Lots 4&5 Abernethy Road, Byford (Byford West) DNMP (Cardno, 2007)
- Byford Main Precinct Local Structure Plan (The Glades): LWMS (JDA, 2005)
  - The Glades at Byford: Stages 6, 7 & 8a UWMP (JDA 2011)
  - The Glades at Byford: Woodland Grove North UWMP (JDA 2013)
  - The Glades at Byford: Icaria Stages 1 to 4 UWMP (JDA, 2014)
  - The Glades at Byford: Icaria Stages 5 to 10 UWMP (JDA, 2014)
  - The Glades at Byford: Woodland Grove South UWMP (JDA 2013)
  - The Glades at Byford: Stage 2 UWMP (JDA, 2009)
  - The Glades at Byford: Stage 9 & High School Precinct UWMP (JDA, 2011)
  - The Glades at Byford: Stage 8 UWMP (JDA, 2012)
  - The Glades Cardup Brook, East and West Precinct, UWMP (JDA, 2016)
- Lot 9 Abernethy Road (Kalimna Estate) LWMS (DEC, 2009)
  - Lot 9 Abernethy Rd, Byford, UWMP (DEC, 2010)
- Redgum Brook Estate DNMP (GHD, 2008)
  - Redgum Brook Estate (Northern Section) LWMS (GHD, 2014)
  - Redgum Brook Estate Stages 9-12, UWMP (GHD, 2015)
  - Redgum Brook – East of Kardan Boulevard, UWMP (GHD, ???)
  - Redgum Brook Stage 10A, 10B and Stage 13 UWMP (GHD, 2014)
- Larsen Road Estate (Marri Park), Byford UWMP (Cardno 2008)
- Grange Meadows, Byford UWMP (BPA Engineering, 2013)
- Lot 9500 Thomas Road, Byford (Byford Meadows) LWMS (HyD2o, 2014)
  - Lot 9500 Thomas Road, (Byford Meadows), Stage 1 UWMP (Hyd2o, 2014)
  - Lot 9500 Thomas Road, (Byford Meadows), Stage 2(a&b) UWMP (Hyd2o, 2015)
  - Lot 9500 Thomas Road, (Byford Meadows), Stage 2c UWMP (Hyd2o, 2016)
  - Byford Meadows (Remaining Stages), UWMP (Hyd2o, 2017)
- Byford, Doley Road Precinct Local Water Management Strategy (EE, 2016)
  - Parcel Property Landholding, Byford (Doley Precinct) UWMP (Urbaqua, 2017)
  - Lot 8, 9 & 23 Warrington Road, Byford (Doley Precinct) UWMP (Cardno 2017)
- Lot 2 Nettleton Road, Byford (Brook @ Byford) LWMS (JDA, 2009)
  - Lot 2 Nettleton Road, Byford (Brook @ Byford) LWMS Addendum (Hyd2o, 2012)
  - Lot 2 Nettleton Road, Byford (Brook @ Byford) Stage 1 UWMP (Hyd2o, 2013)
  - The Brook @ Byford Stages 1-3 UWMP (EE, 2016)
- L1, L3 & L128 South Western Highway, Byford - LWMS (GHD, 2012)
- Town Planning Scheme 2 Amendment 77 (Byford on the Scarp) DNMP (Gilbert Rose Consulting, 1999)
  - Byford on the Scarp – Stages 4, 5 & 6 UWMP (JDA, 2008)
  - Byford on the Scarp – Stage 7 UWMP (EE, 2014)
  - Byford on the Scarp – Stage 8a UWMP (EE, 2016)

## 1.3 Requirements for future stages of planning and development

In accordance with *Better Urban Water Management* (WAPC 2008) the implementation of this strategy will be through the land use planning process with proponents of development required to develop water management strategies and plans at each planning stage to support and inform their planning proposals, environmental investigations, engineering, landscaping and urban designs as follows.

1. A *local water management strategy* shall be prepared to support a local scheme amendment or the preparation of any local structure plan, whichever is the earlier consistent with *Better Urban Water Management* (WAPC, 2008), *Interim: Developing a Local Water Management Strategy* (DWER, 2008) and the *Byford District Water Management Strategy* (this document).

2. Where no approved local water management strategy exists, any application for subdivision in greenfield areas, or where more than 30 lots are proposed in infill or brownfield areas, shall be accompanied by a draft *urban water management plan*, consistent with *Urban Water Management Plans: Guidelines for preparing plans and for complying with subdivision conditions* (DWER, 2008) and the *Byford District Water Management Strategy* (this document), and developed in consultation with the Shire of Serpentine-Jarrahdale, with advice as necessary from DWER.

3. Where an approved local water management strategy exists, the preparation and implementation of an *urban water management plan* will be required as conditions of urban or industrial subdivision. The urban water management plan shall be consistent with *Urban Water Management Plans: Guidelines for preparing plans and for complying with subdivision conditions* (DWER, 2008) and the *Byford District Water Management Strategy* (this document) and developed in consultation with the Shire of Serpentine-Jarrahdale, with advice as necessary from DWER.

4. In exceptional circumstances, subject to consultation with the Shire of Serpentine-Jarrahdale and DWER, where a development consists of a small area and/or has limited water management requirements, an urban water management plan may not be required. In this case, subsequent subdivision application(s) would only need to be accompanied by a simplified *drainage design scoping summary* developed in consultation with the Shire of Serpentine-Jarrahdale, with advice as necessary from DWER.

5. Where an urban water management plan has been prepared and approved at the time of subdivision, or to accompany the initial stage(s) of a multi-stage development it is recognised that the document may contain limited drainage design detail for all or part of the subdivision area. In this case it will be necessary for design submissions relating to future stages to be accompanied by a *drainage design compliance summary*.

Proposals should address groundwater and surface water management, water conservation and efficiency; and water reuse and recycling in an integrated manner, focussing on key issues identified below.

### *1.3.1 Scale, complexity and timing – applying a risk-based approach*

Different levels of detail in water management documents are expected dependent on the scale and complexity of the site as well as the timing of lodgement.

Urban water management plans lodged early in the design process are likely to contain less detail and may be informed by assumptions based on surrounding development and/or designers prior experience. However, the document must still contain critical elements of design that address key risks associated with public safety and the functionality of the water management system. These critical elements include but may not be limited to:

- Invert levels, bank slopes, top water levels and volumes of major flood storage areas.

- Invert levels, staged cross-sections, top water levels and general landscape design characteristics of living streams.
- Critical invert levels, outlet arrangements, general layout and design characteristics for any proposed groundwater management system (including supporting modelling).
- Lot-scale stormwater management arrangements (location and general design characteristics of lot-based infrastructure including infiltration systems and/or raingardens where used).
- Street-scale stormwater management arrangements (location and general design characteristics of street-based infrastructure including infiltration systems, raingardens and/or tree-pits where used).

Each of the critical element listed above must also be addressed in any subsequent drainage design compliance summary which should either state that the element remains unchanged from the preceding UWMP or provide details of, and justification for, any changes.

Urban water management plans lodged to accompany detailed designs are expected to contain a greater level of detail and should be informed by accumulated knowledge of the site and any previous development stages with limited assumptions.

### *1.3.2 Staging and levels of detail – learning by doing*

Staged developments can sometimes occur over long timeframes. Because building styles and methodologies evolve, it is important that urban water management plans and drainage designs recognise and adapt to these changes. Specifically, the following potential changes should be considered in preparation of each progressive document and/or design:

- Changes to built form/lot ratios – it is expected that runoff parameters used for design purposes are continually reviewed in relation to current practice.
- Innovations in best practice water management – it is expected that consideration is given to ways to progressively incorporate new or different approaches to water management into each stage of development.
- Changes to drainage configuration/storage provision – it acknowledged that there may be opportunities to rationalise previously approved storage volumes through optimised drainage system designs including using online storage within multiple use corridors. Any proposals to reduce previously approved storage volume provision must demonstrate, in an urban water management plan lodged with or prior to subdivision, that peak discharges can be managed within the arterial drainage system, to the satisfaction of the Shire of Serpentine Jarrahdale in consultation with Department of Water and Environmental Regulation.

### *1.3.3 Adoption of Australian Rainfall and Runoff 2016 procedures*

It is expected that all future local water management strategies and urban water management plans include consideration of the revised rainfall patters and modelling procedures presented in the latest edition of Australian Rainfall and Runoff (AR&R 2016).

Where there is no previously approved local water management strategy or urban water management plan, full adoption of AR&R 2016 procedures is expected.

Where there is a previously approved local water management strategy or urban water management plan based on other modelling methodologies the consequences of adopting AR&R 2016 and the risks associated with retaining the previous methodology should be presented in subsequent documentation for consideration by the Shire of Serpentine-Jarrahdale in consultation with DWER as necessary.

# 2 PRE-DEVELOPMENT ENVIRONMENT

## 2.1 Study area

The *Byford District Water Management Strategy* (DWMS) study area is presented in Figure 2 and located approximately 35 km south-east of the Perth CBD, within the Serpentine Jarrahdale Shire. The area is approximately 4,500 hectares and includes the *Byford Townsite Drainage and Water Management Plan* study area (Byford Townsite) which is superseded by this document.

Byford Townsite is approximately 1,500 hectares and is bounded by Thomas Road to the north, Hopkinson Road and the future Tonkin Highway to the west, Cardup Siding Road to the south and the Byford townsite and Darling Range foothills to the east. Land within the townsite is predominantly urban or remnant rural residential which is zoned for future urban development. Key features of the townsite include:

- Byford Town Centre Precinct
- Byford Trotting Complex Precinct
- Briggs Park Sport and Education Precinct

Areas of the study area outside Byford Townsite are predominantly rural with some areas of urban and industrial land.

## 2.2 Topography

The topography of the DWMS study area, as shown in Figure 3, is characterised by steep slopes in the foothills of the Darling Range, with an elevation of 120 m AHD falling rapidly to 80 m AHD at Linton Street and then gradually to 55 to 60 m AHD at the South Western Highway. To the west of the South Western Highway, the terrain is relatively flat palusplain (seasonally waterlogged land).

## 2.3 Soils

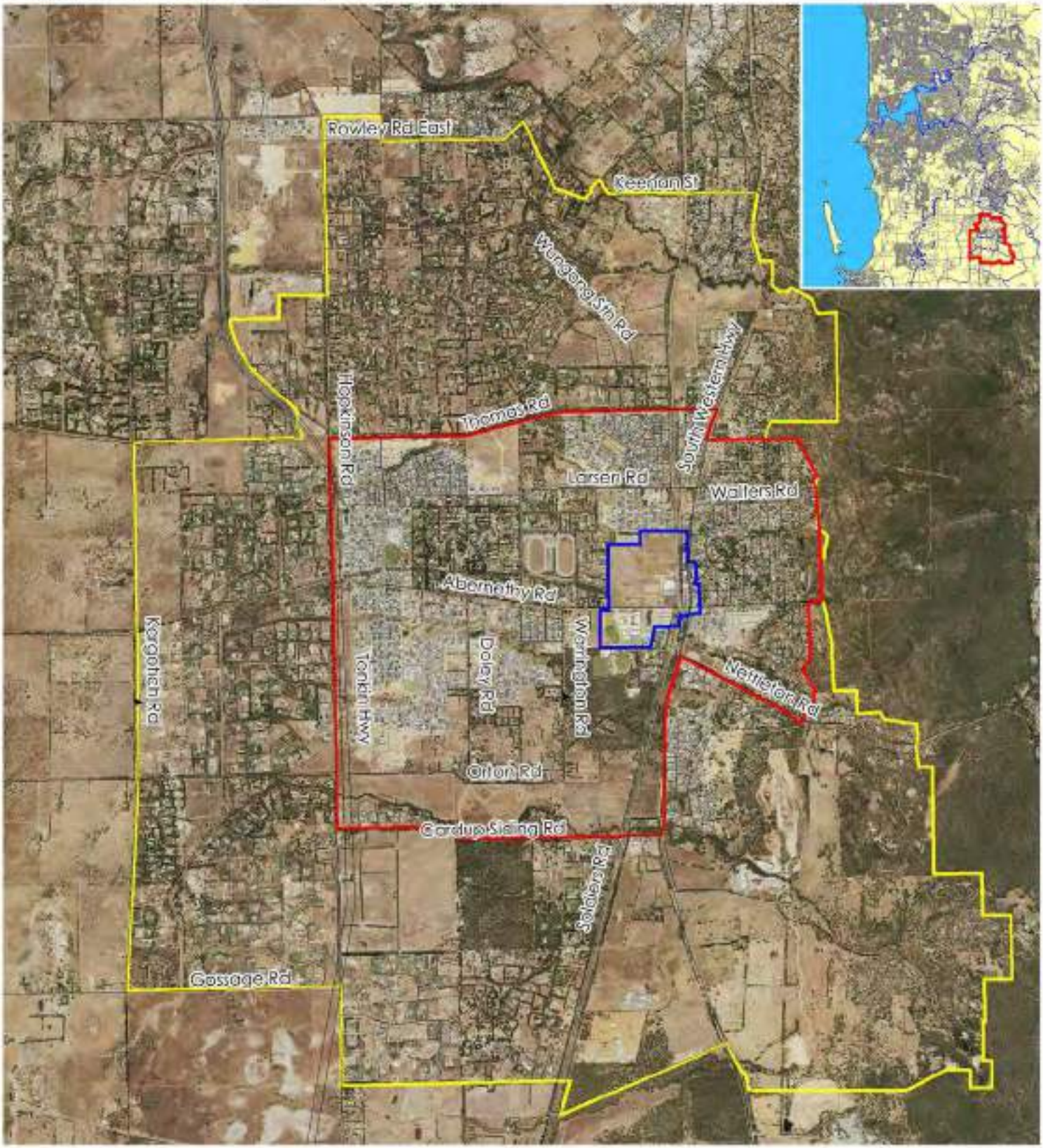
There are three primary soil types across the study area, as shown in Figure 3. The soil types are:

- Ridge Hill colluvium from the Yogannup formation (S12) – highly variable layers of gravelly to sandy clay with lenses of silt and gravel
- Guildford clay (Csg) – lenses of sandy clay, clayey sand, iron-rich cemented sand and sand. Low horizontal conductivity and very low vertical conductivity
- Bassendean sand (Cs) – bleached grey to pale yellow sand with little ability to retain moisture or nutrients

Ridge Hill colluvium is found to the east of the study area, in the region of the Darling Scarp. To the west of the study area Guildford clay can be found interlaced with Ridge Hill colluvium. Overlaying the Guildford clay is Bassendean sand, which occurs in thin layers across the majority of the site.

The on-site soils are highly variable in phosphorous retention capacity, with grey brown sands having a low capacity to retain phosphorous.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure 2 - Study Area




Legend

- DWMS Study Area
- Byford Townsite
- Byford Town Centre

Scale 1: 50,000 at A4

0 2km

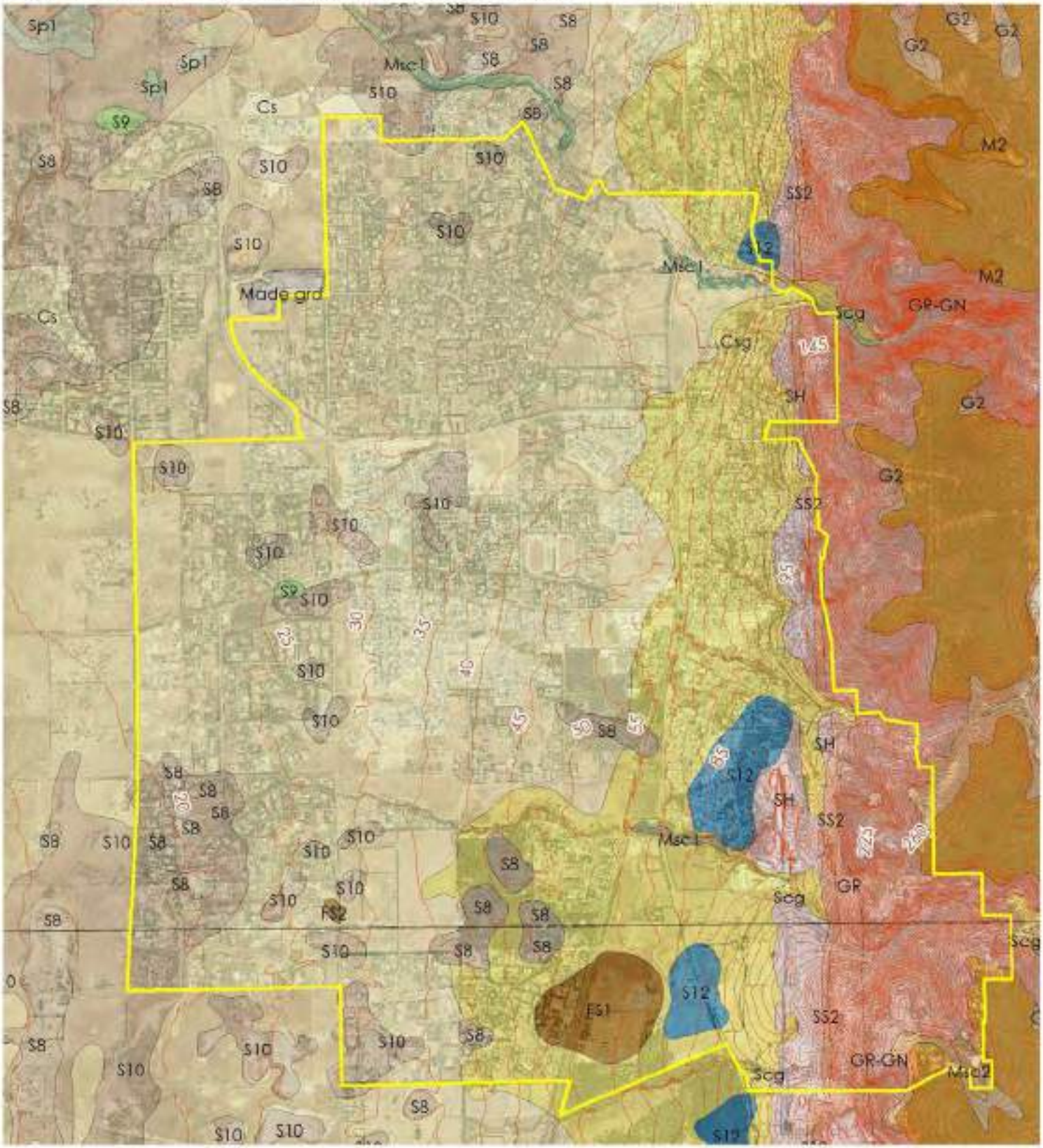
N

urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER, Created by: HB Projection: MGA: zone 50.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure 3 - Topography and Soils




Legend

DWMS Study Area

Elevation contours (mAHD)

Surface Geology:

| | | | |
|---|---|---|---|
| S8/S10 | SH | GR-GN | SS2 |
| Cs | Csg | G2 | LA1 |
| FS1 | S12 | Msc1 | S9 |

Scale 1: 50,000 at A4

0 2km

N

urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB. Projection: MGA: zone 50.

## 2.4 Acid sulfate soils

The Department of Water and Environmental Regulation (DWER) maintains mapping of Acid Sulfate Soil Risk on the Swan Coastal Plan which was developed for the Western Australian Planning Commission's Planning Bulletin No. 64 (2003) and is presented for the DWMS study area in Figure 4. The mapping is based upon a review of geomorphological, geological and hydrological information, and indicates that the soils in the DWMS study area to the west of the South Western Highway consist of moderate to low risk of actual acid sulfate soils or potential acid sulfate soils occurring generally at greater than 3 m depth.

Low to no risk of actual acid sulfate soils or potential acid sulfate soils occurring generally at greater than 3 m depth can be found to the east of the South Western Highway in the DWMS study area.

The risk of acid sulfate soils being exposed to oxidation due to development in the study area is considered low. As part of development requirements, new developments will need to introduce fill to a depth that is acceptable for residential construction as well as provide suitable flood clearance and adequate subsoil drainage.

## 2.5 Wetlands and Environmental Assets

Wetlands and environmental assets present in the study area are presented in Figure 5.

The Department of Biodiversity, Conservation and Attractions maintains a database of high value wetlands on the Swan Coastal Plain. Current mapping indicates there are high value wetlands (conservation category and resource enhancement) present within the study area including at:

- Brickwood Reserve in the south-eastern section of the study area;
- Cardup Reserve on the southern boundary of the study area;
- Abernethy Road bushland in the western part of the study area;
- Land between the South Western Highway and rail line north of Cardup Brook;
- Along the course of Cardup Brook in the southern part of the study area
- Along the course of Wungong River in the north eastern corner of the study area
- Along the course of Birrega Main Drain in the northern part of the study area

Brickwood Reserve is a Bush Forever Site (No: 321) and noted as containing "one of the largest and most intact examples of a critically endangered threatened ecological community, protected under Federal and State policies, on the Swan Coastal Plain" (SSJ, 2009).

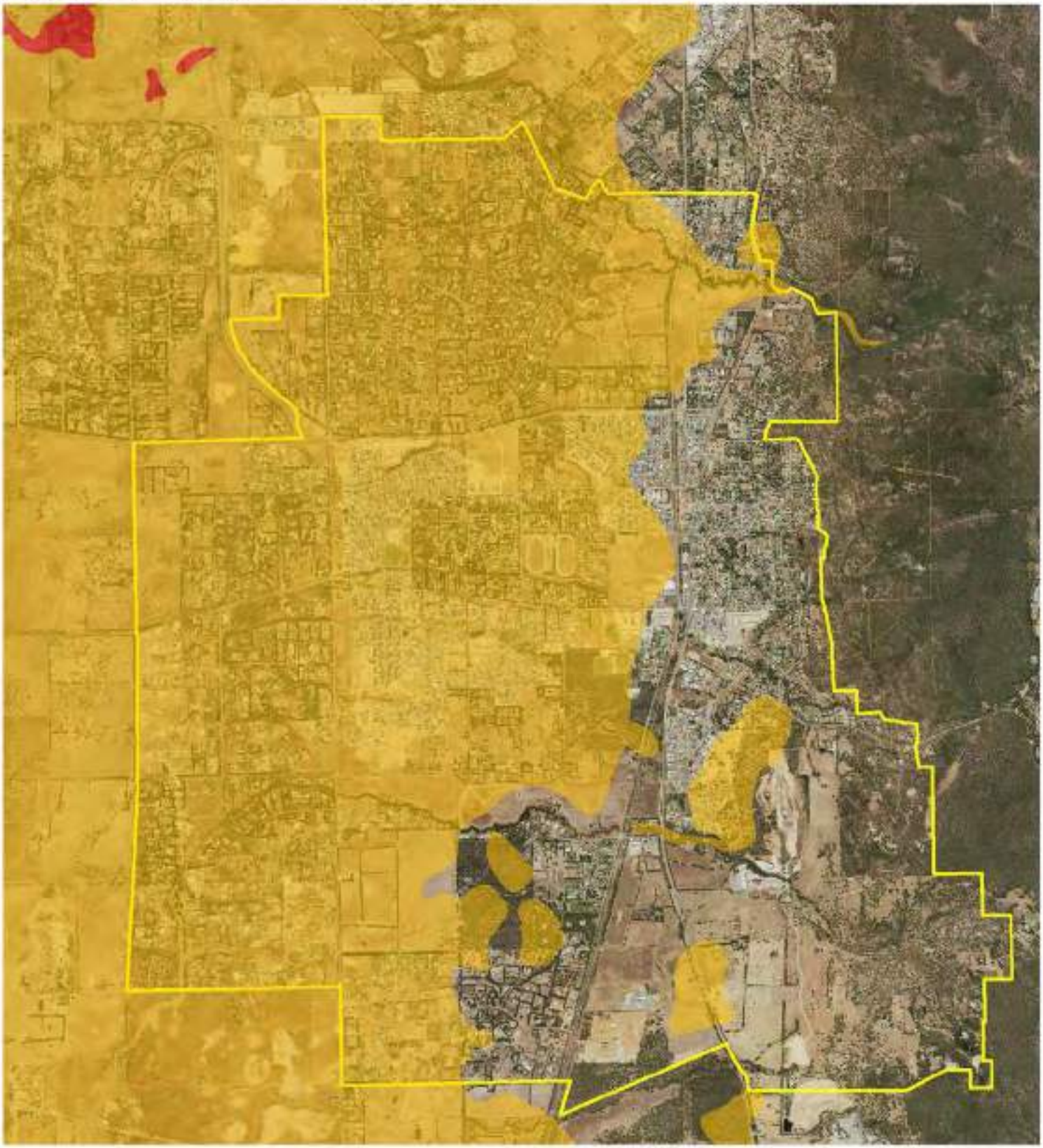
*Brickwood Reserve and Briggs Park Management Plan* (SJ Shire) was prepared in 2009 to guide and prioritise the use and management of the reserve, recognising the likely pressures associated with the surrounding urban expansion of Byford. The protection of the important environmental values of this reserve is a key objective of this DWMS.

Cardup Nature Reserve, which lies on the southern boundary of the study area, is classified as Bush Forever Site 352 and contains at least four priority taxa. A section of the Cardup Brook to the north of Cardup Nature Reserve is listed as Bush Forever Site 351.

Abernethy Road bushland which is south of Abernethy Road and west of Hopkinson Road is listed as Bush Forever Site 65.

Remnant vegetation between the rail line and South Western Highway north of Cardup Brook is listed as Bush Forever Site 350.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure 4 - Acid Sulfate Soil Risk



Legend

DWMS Study Area

Acid Sulfate Soil Risk:

High to moderate risk

Moderate to low risk

Scale 1: 50,000 at A4

0 2km

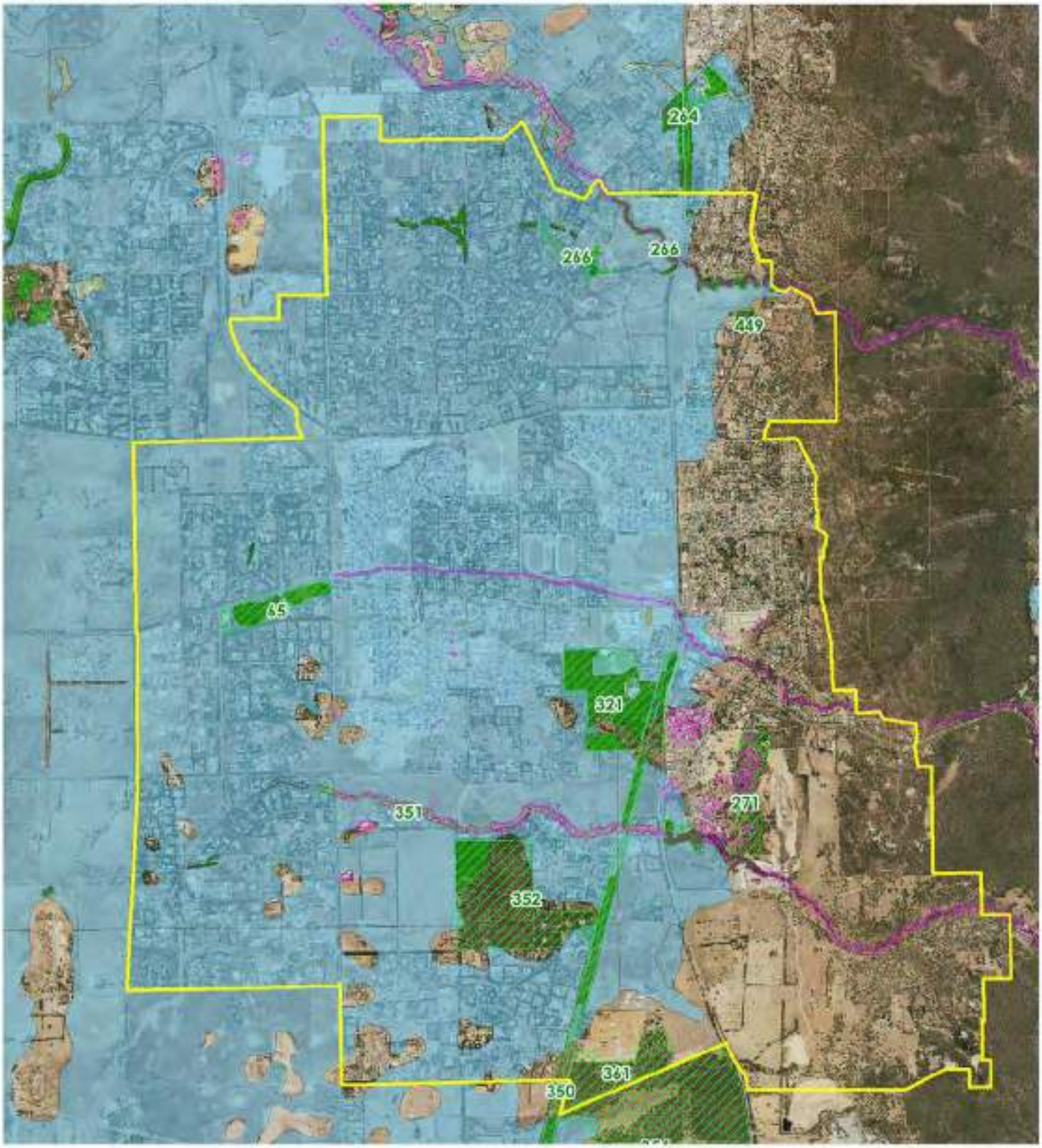
N

urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER, Created by: HB Projection: MGA: zone 50.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure 5 - Wetlands and Environmental & Social Assets




Legend

DWMS Study Area

Bush Forever Sites

Aboriginal Heritage Places

Geomorphic Wetlands:

Conservation

Multiple Use

Resource Enhancement

Scale 1: 50,000 at A4

0 2km

N

urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB. Projection: MGA: zone 50.

Two old shale quarries at the base of the scarp in the south eastern portion of the study area carry permanent water and have some conservation value but are not listed as high value wetlands. The area west of these quarries and along Cardup Brook to South Western Highway are listed as Bush Forever Site 271.

Reserves along the Wungong River and Birrega Main Drain in the north eastern corner of the study area are listed as Bush Forever Site 266.

Remnant vegetation in Oscar Bruns Reserve, in the north eastern corner of the site adjacent to South Western Highway is listed as Bush Forever Site 449.

## 2.6 Social considerations

The Department of Planning, Lands and Heritage have registered two Aboriginal Heritage Sites and one other Aboriginal Heritage Place in the study area which are mapped in Figure 5. These sites are in the southern portion of the site close to Cardup Brook and Cardup Reserve. However, it is noted that there may be other sites located in the study area that have not been registered. Prior to construction of individual developments, assessment should be undertaken by a qualified consultant to determine whether a more thorough Aboriginal heritage investigation of the area needs to be undertaken for any specific location to identify unregistered sites.

## 2.7 Surface water

Several watercourses traverse the site in a generally westerly direction from the scarp as shown in Figure 6. These watercourses include Wungong River, Birrega Main Drain Oaklands Drain, Beenyup Brook and Cardup Brook. Of these, Wungong River, Cardup Brook and Beenyup Brook are the most ecologically significant. Each of these watercourses is highly incised and their beds are usually a few metres below the surrounding land surface.

Most of the site, drains via Oaklands Drain, Beenyup Brook and Cardup Brook which ultimately discharge to the Birrega Main Drain. These watercourses eventually discharge to the Serpentine River system, which links to the Peel Harvey Estuary. A small portion of the site directly drains to the upper catchment of the Birrega Main Drain and an even smaller portion drains to the Wungong River which ultimately discharges to the Southern River and on into the Swan Canning River system.

To the west of Hopkinson Road, surface drainage consists of rural open drains. Some of these drains are declared and managed by the Water Corporation. They were originally designed to carry specified flows that would comply with the Department of Agriculture and Food's requirement that inundation of rural land should last no longer than three days. More recent monitoring and modelling, carried out by the Water Corporation, have indicated that this design criterion is approximately equivalent to the two-year average recurrence interval for main drains and the six-month interval for sub-drains.

The surface water drainage system comprises numerous small catchments draining from east to west. The upper catchments of the Darling Range foothills are well defined with steep catchment slopes, whereas the lower catchments are less defined.

The Byford 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,

as well as poor drainage, with insufficient capacity that does not allow runoff to leave the area. There is also potential for wetlands within the study area to receive additional flood water from outside their natural catchment by overtopping of drains and watercourses.

There are several local depressions east and west of the South Western Highway, which result in local perching of surface water after a large rainfall event.

The Department of Water and Environmental Regulation's *Birrega and Oaklands flood modelling and drainage study* (Hall et al, 2015) indicates that large areas of the Study Area are susceptible to flooding under an ARI 100yr rainfall event. The central spine of the Study Area is most at risk to widespread flooding, particularly along major roads. The western edge of the Study Area was not shown to flood under ARI 100yr conditions; however confined areas of ponded water were modelled throughout the area. The eastern side of the Study Area was categorized by long thin flooded areas protruding from the main body of flood water. The flooded areas were most prominent over roads traversing in an east west direction and rural properties.

### *2.7.1 Surface water quality*

Limited surface water quality data is available within the study area. The Snapshot survey of the Serpentine, Murray and Harvey catchments of the Peel-Harvey Estuary (Wilson & Paling, 2002) included 10 sites within the Byford catchment. Samples were recorded for October 2001 and September 2002 but were only reported for 2002.

Four sites were in Oaklands drain, one at Hopkinson Road and one on each of the three upstream branches. There were two sites on the Cardup Brook, one at Hopkinson Road and one close to the railway. Beenyup Brook was also served by two sites, again at Hopkinson Road, and close to the railway. The two remaining sites were at the Hopkinson Road end of two of the minor drains between Beenyup Brook and Cardup Brook.

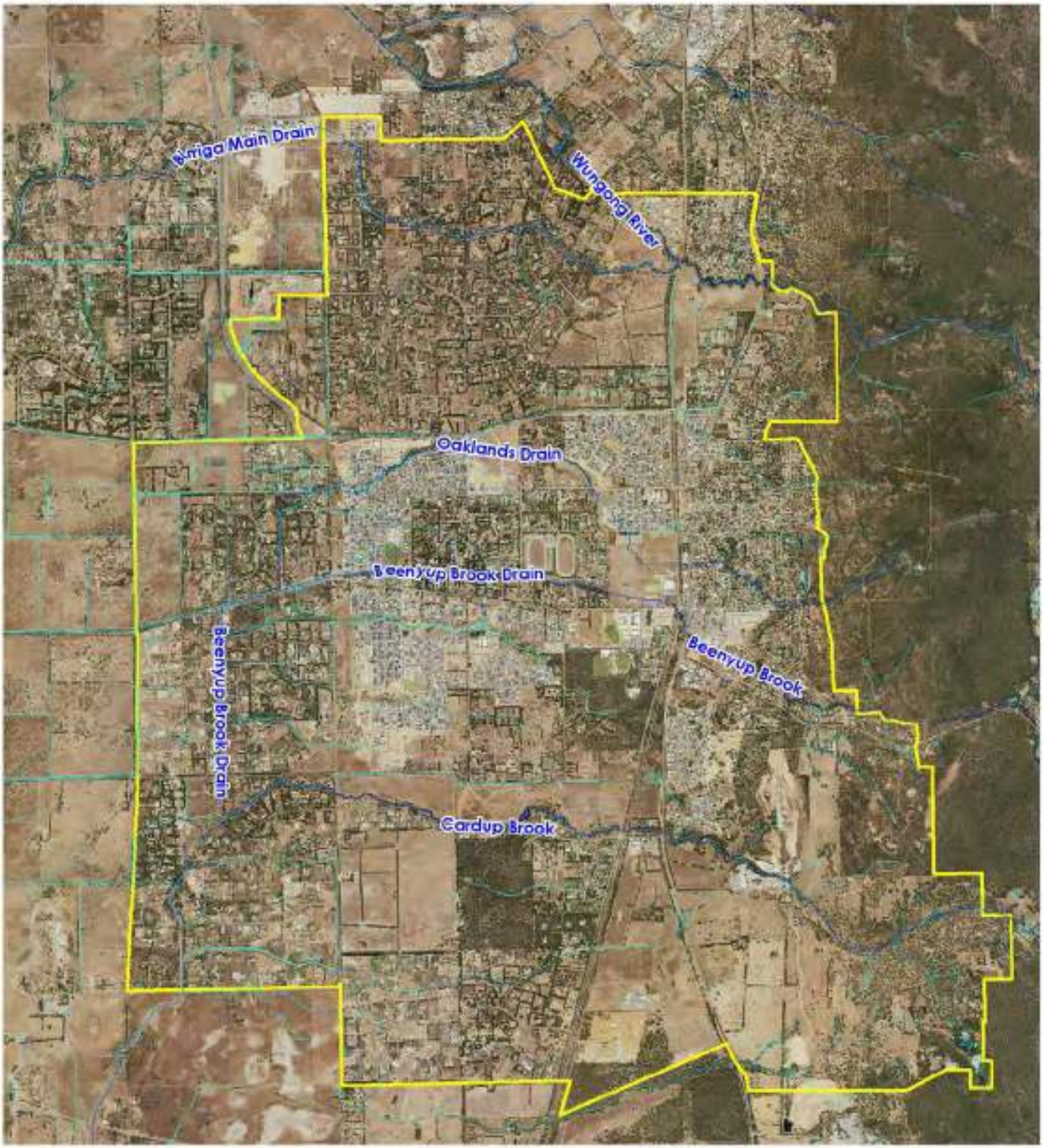
Total phosphorous concentrations recorded at most of the sites in the Byford catchment were below 0.065 mg/L. This was the target concentration suggested by the Byford urban stormwater management strategy (PB 2003), although the downstream end of Beenyup Brook recorded total phosphorus concentrations in the range 0.065-0.20 mg/L and the downstream ends of both minor drains recorded total phosphorus concentrations greater than 0.20 mg/L.

Total nitrogen concentrations recorded in two of the upstream branches of Oaklands drain were below 1.2 mg/L, which was the target concentration suggested by the *Byford urban stormwater management strategy* (PB 2003). Total nitrogen concentrations in the third branch and the downstream end were in the range 1.2-3.0 mg/L. Beenyup Brook was also below 1.2 mg/L upstream but was greater than 3.0 mg/L at its downstream location. In Cardup Brook, this trend was reversed with total nitrogen concentrations greater than 3.0 mg/L recorded upstream and less than 1.2 mg/L downstream. One of the minor drains was in the range 1.2-3.0 mg/L and the other was greater than 3.0 mg/L.

Water quality in Beenyup Brook in Byford Town Centre was tested on an opportunistic basis in 2009 and 2010 (by BGE and Emerson Stewart). Total nitrogen concentrations ranged from 0.8 to 5mg/L with a median of 1.1 mg/L reported in the *Lot 1 Abernethy Road LWMS* (ES, 2011). Total phosphorous concentrations ranged from 0.01 to 0.05 mg/L with a median of 0.01 mg/L.

Surface water quality in the Byford Townsite area was also measured at two sites for *The Glades at Byford LWMS* (JDA, 2009). Results presented indicate average total nitrogen concentration of 1.02 mg/L and average total phosphorous concentrations of 0.07 mg/L and 0.09 mg/L.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure 6 - Surface Water




Legend

- DWMS Study Area
- Major Watercourses
- Other Watercourses and Waterbodies

Scale 1:50,000 at A4

0 2km

N

urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER, Created by: HB. Projection: MGA: zone 50.

## 2.8 Groundwater

Geotechnical and groundwater investigations have been undertaken several parties in the study area. Results from field measurements typically indicate that groundwater levels are shallow across the study area, varying between 0 – 6 m below natural surface level. Near Beenyup Brook for example, Department of Water data indicate groundwater varies between 1 – 5.4 m below natural surface level.

There are approximately 150 private groundwater bores in the study area, the majority of which target groundwater in sand lenses at the base of the Guildford clay at 17.5 – 25 m below natural surface level. For details of current groundwater allocations in Byford townsite, the Department of Water should be contacted directly.

Because of the local geology, groundwater in the study area is often perched during the winter months. The installation of improved surface and subsurface drainage systems is likely to quickly export this perched water into the drainage system, rather than allowing it to sit and gradually subside. This is likely to result in reduced deep aquifer recharge and increased drain baseflows.

Groundwater modelling has been recently completed in the study area by the Department of Water and Environmental Regulation (DWER) and presented in a series of three *Lower Serpentine Hydrological Studies* reports (Hall et al 2015). Maximum and Minimum groundwater levels predicted by this modelling study for the base (S0) scenario are presented in Figure 7.

### *2.8.1 Groundwater quality*

There is limited groundwater quality data readily available for the study area although data has been collected in support of several water management strategies and plans.

The Byford urban stormwater management strategy stated that shallow groundwater quality monitoring shows low levels of total phosphorous and very small concentrations of ortho-phosphorous in the groundwater. Total nitrogen concentrations were moderate, with moderate concentrations of nitrate and nitrite.

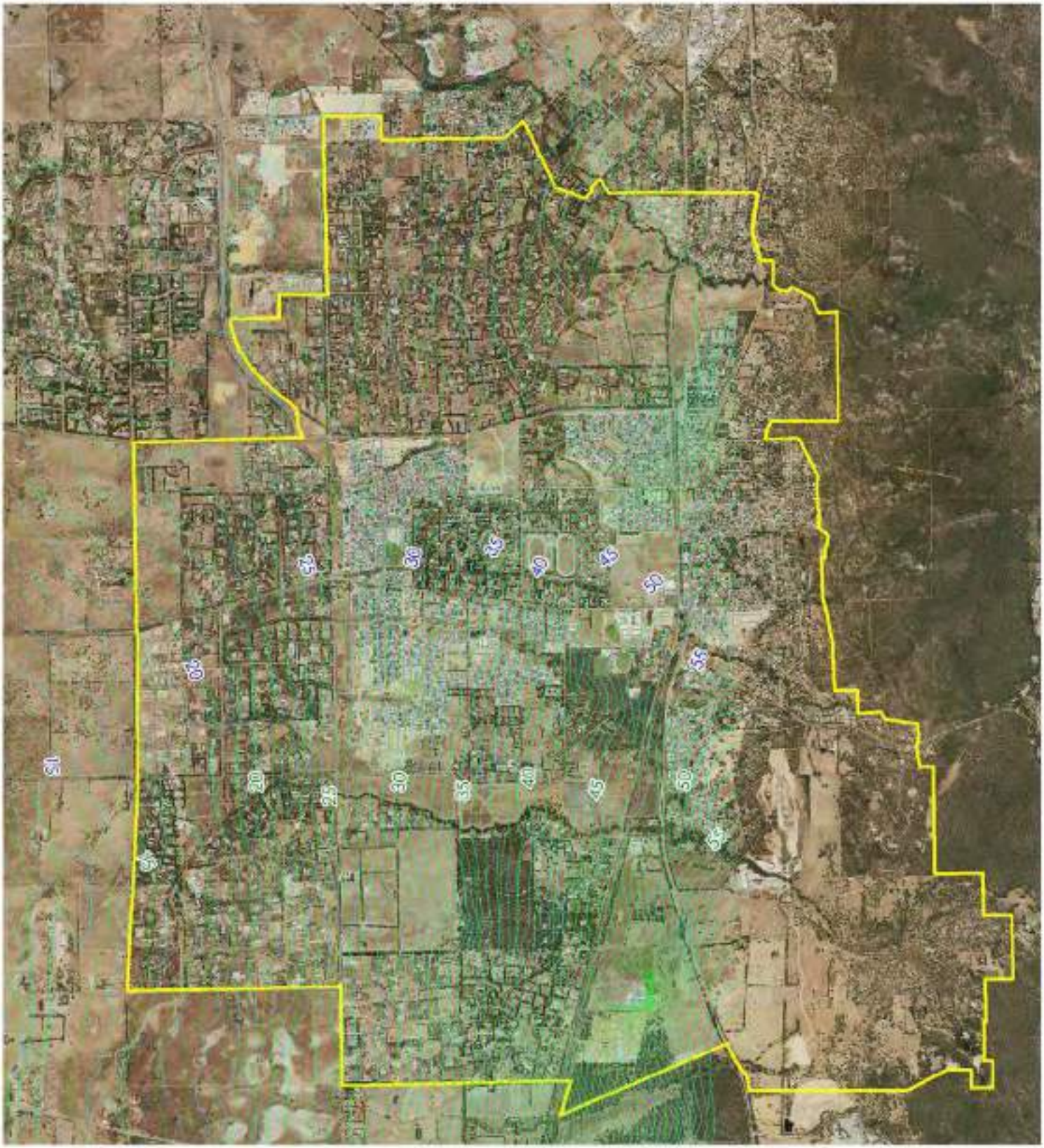
The report states that although these concentrations exceed relevant water quality guidelines, these concentrations are relatively low compared to other typical sites on the Swan Coastal Plain with historically pastoral or horticultural land uses.

Regarding salinity of groundwater within the study area, CyMod Systems (2007) found that the surface superficial groundwater is generally fresh or slightly brackish, whilst the groundwater of the Leederville aquifer is generally fresh (<1000 mg/L TDS).

Groundwater quality in Byford Town Centre was tested in 2009 (by BGE and Emerson Stewart). Total nitrogen concentrations ranged from 0.2 to 6.9mg/L with a median of 1.5 mg/L reported in the *Lot 1 Abernethy Road LWMS* (ES, 2011). Total phosphorous concentrations ranged from 0.01 to 0.88 mg/L with a median of 0.11 mg/L.

Groundwater quality in the Byford Townsite area was also measured at several sites for *The Glades at Byford LWMS* (JDA, 2009). Results presented indicate average total nitrogen concentrations ranging from 0.93 mg/L to 6.4 mg/L and average total phosphorous concentrations from 0.04 mg/L to 0.40 mg/L.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure 7 - Groundwater




Legend

- DWMS Study Area
- Groundwater Minimum (mAHD)
- Groundwater Maximum (mAHD)

Scale 1:50,000 at A4

0 2km

N

urbaqua
land and water solutions


Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER, Created by: HB. Projection: MGA: zone 50.

# 3 PROPOSED DEVELOPMENT

## 3.1 Key elements of the structure plan

The proposed Byford District Structure Plan, as shown in Figure 8, has a larger area study area than the previous Byford Townsite Structure Plan including the Byford trotting complex area and rural residential and special rural areas surrounding the townsite. Largely, land uses are consistent with previous local planning with the following key changes noted:

- Creation of a new Mixed Business & Industrial Park south of Cardup Brook
- Creation of three new Development Investigation Areas

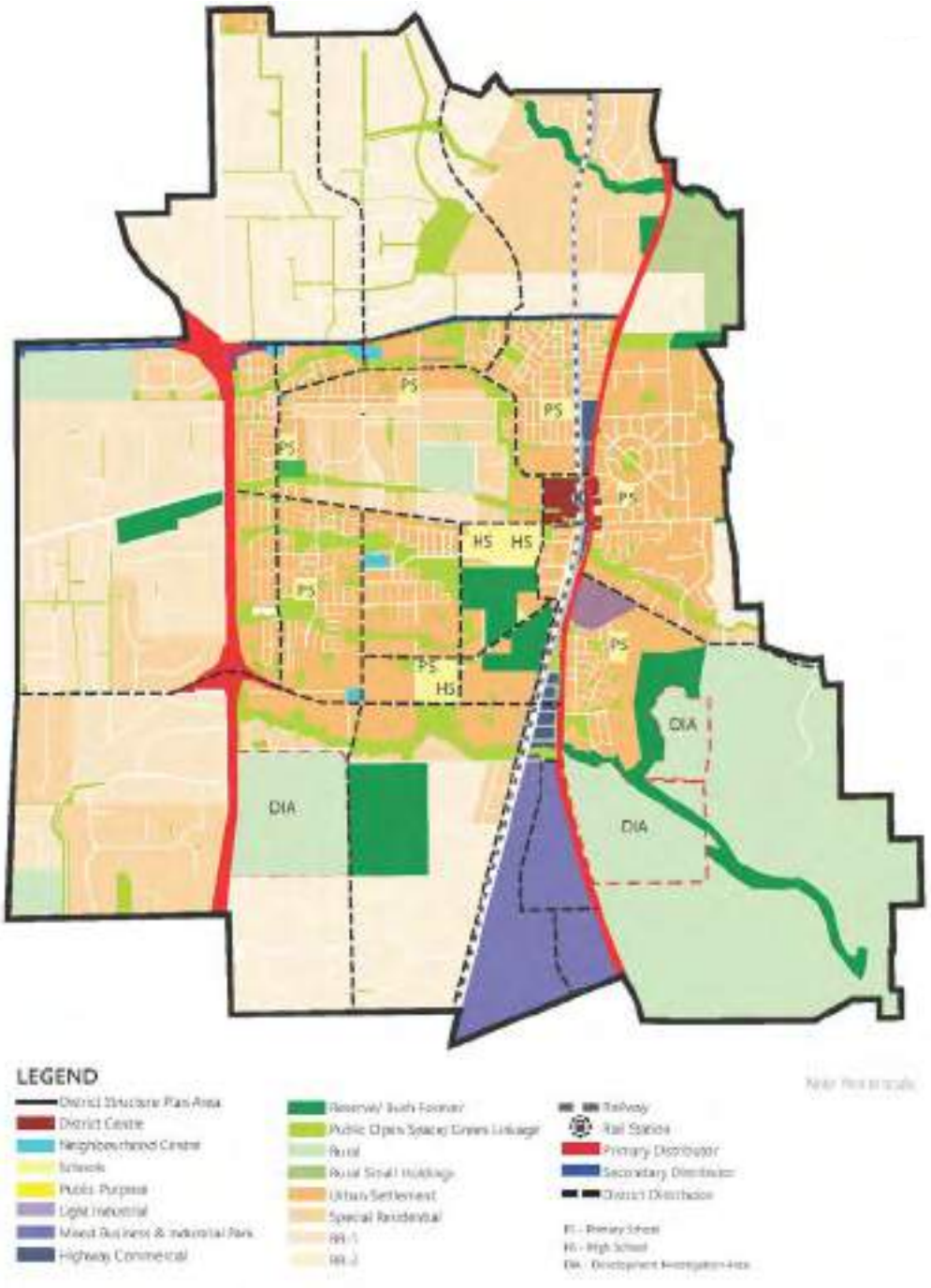



Figure 8: Byford District Structure Plan (SSJ, 2018)

# 4 PROTECTION OF ENVIRONMENTAL ASSETS

The following strategies have been developed to protect and enhance the value of environmental assets in the Byford structure plan area.

- Minimise changes to hydrology to prevent impacts on watercourses and wetlands
- Manage and restore watercourses and wetlands
- Assess and manage impacts on native flora and fauna
- Assess and manage impacts on Aboriginal Heritage Sites
- Investigate opportunities to mitigate for the potential impacts of climate change

## 4.1 Minimise changes to hydrology to prevent impacts on watercourses and wetlands

Changes in land use from rural to urban may lead to local increases in peak flows and volumes of runoff due to increases in impervious area (Figure 9a). Large increases in peak flows and volumes have the potential to adversely impact on receiving environments by causing erosion and increasing the period of inundation of vegetation.

Surface water management must ensure that urban development does not increase the peak flows discharging to receiving environments although there may be increases in total runoff volumes (Figure 9b). Development must also ensure that watercourses and wetlands do not dry out due to over abstraction of water resources or lowering of groundwater levels



Figure 9a and b: Typical pre- and post-development runoff hydrograph comparison showing a: uncompensated and b: compensated post-development flows (Source: DWER, 2008)

As discussed in sections 2.5 and 2.7 there are several high value wetlands and significant watercourses in the study area. The preservation of pre-development flow rates and hydraulic grade lines along the main watercourses in developing areas is expected to ensure that the potential for development impacts to these systems will be minimised.

The addition of imported fill and subsurface drainage as a part of development will control groundwater levels and soil wetness and therefore reduce the extent of inundated areas throughout the study area. In addition, improvements to surface water drainage will result in less extensive surface inundation, which will be confined to predetermined locations within public open space areas and multiple use corridors. The location of subsoil drainage inverts at or above the locally determined average annual maximum groundwater level is expected to prevent impacts to high value wetlands and watercourses caused by local groundwater control.

## 4.2 Manage and restore watercourses and wetlands

There are high value wetlands and significant watercourses in the study area. All high value (conservation and resource enhancement) wetlands and significant watercourses are expected to be retained, protected and managed for conservation purposes. This should include restoration, revegetation and reservation of appropriate buffers and corridor widths. Various guidelines are available for all aspects of wetland and watercourse protection and restoration and are published by the Department of Water and Environmental Regulation (DWER) and Department of Biodiversity, Conservation and Attractions (DBCA).

## 4.3 Assess and manage impacts on native flora and fauna

There are several declared rare and priority flora species within the study area. Detailed flora and fauna assessments are required to be undertaken as part of more detailed levels of planning to ensure that development and subdivision is cognisant of and sensitive to the protection of native flora and fauna.

## 4.4 Assess and manage impacts on Aboriginal Heritage Sites

As discussed in section 2.5 of this report, the Department of Planning, Lands and Heritage (DPLH) has identified Aboriginal Heritage Places in the study area (Figure A-4). Prior to construction of individual developments, assessment should be undertaken by a qualified consultant to determine whether a more thorough Aboriginal Heritage investigation of the area needs to be undertaken for any specific location to identify unregistered sites.

## 4.5 Investigate opportunities to mitigate for the potential impacts of climate change

Development could help to mitigate the potential impacts of climate change by careful design of drainage infrastructure.

For example, discharge of drainage flows from surrounding developed areas into treatment areas or naturalised constructed wetlands (not constructed lakes) could provide valuable recharge to groundwater stores surrounding the wetland. Additionally, when combined with overland flow paths, this arrangement may help to maintain periodic inundation cycles and even allow for future redirection of additional flow into the wetland should the need arise.

# 5 URBAN WATER USE

The key objectives for urban water use are to:

- Achieve highest-value use of fit-for-purpose water, considering all available forms of water for their potential as a resource
- Maintain opportunities for future generations by using water more efficiently. This is best achieved by combining several approaches such as raising community awareness, regulation, market mechanisms to facilitate recognition of the true value of water and financial incentives/assistance to facilitate change

## 5.1 Potable water use

Reticulated potable water supply systems are present in Byford Townsite and other urban areas in the study area. Many of the rural areas are, however, in locations where there is no existing reticulated water supply system. The Water Corporation undertakes water services planning and allocates funds for infrastructure upgrades on the basis of land use planning information. Where a development proposal requires drinking water headworks infrastructure, for which the Water Corporation has not allocated funds to suit the developer's schedule, prefunding of the works may be necessary.

Connection to a reticulated scheme water supply is not always possible for rural residential areas. State planning policy 2.5; rural planning policy (2016) recognises that there may be alternative service delivery models proposed and provides the following guidance:

*water supply shall be as follows:*

- *where lots with an individual area of four hectares or less are proposed and a reticulated water supply of sufficient capacity is available in the locality, the precinct will be required to be serviced with reticulated potable water by a licenced service provider, including water for firefighting. Should an alternative to a licenced supply be proposed it must be demonstrated that a licenced supply is not available; or*
- *where a reticulated supply is demonstrated to not be available, or the individual lots are greater than four hectares, the WAPC may consider a fit-for purpose domestic potable water supply, which includes water for firefighting. The supply must be demonstrated, sustainable and consistent with the standards for water and health; or*
- *the development cannot proceed if an acceptable supply of potable water cannot be demonstrated;*

## 5.2 Fit for purpose water

An appropriate fit-for-purpose water source for irrigation of public open spaces and schools must be confirmed and secured at the local structure plan/local water management strategy stage of planning.

Groundwater is used extensively in the study area as a fit for purpose water supply for public open space irrigation, agriculture and commercial/industrial purposes as well as for private uses (garden and stock watering) which are exempt from licensing.

Groundwater availability reporting and licensing is based on groundwater management areas and subareas proclaimed under the *Rights in Water and Irrigation Act 1914* which have been defined by the Department of Water and Environmental Regulation based on natural

catchment boundaries in some cases and administrative boundaries in others. Land to the east of the South Western Highway and north of Beenyup Road is within the unproclaimed Karri groundwater management area whilst the remainder of the site is split between the Perth and Serpentine groundwater management areas. To the north of Thomas Road, the study area falls within the Perth groundwater management area, and to the south the Serpentine groundwater management area.

An allocation limit is the annual volume of water set aside for consumptive use from a water resource. This includes water available for licensing and water for uses exempt from licensing (including stock and domestic 'backyard' bores). Exempted groundwater use within the study area is expected to be significant but there is little reliable consumption information available.

Allocation limits have been set for all aquifers present in the Perth and Serpentine groundwater management areas and water remains available for allocation in all aquifers except the Perth Leederville Confined.

Based on current allocation limits and availability, it appears that there is sufficient groundwater allocation available to provide for future public open space irrigation demands. However, it is important to note that allocation limits may be reduced in response to climate change impacts and other groundwater management issues. At the same time, sustainable yield from the superficial aquifer in the study area is significantly restricted due to clay soils. Developments affected by this issue may require numerous shallow, low-yielding bores and/or require a supplementary irrigation source.

### Design Criteria

- avoid the use of imported scheme water for irrigation of public open space or domestic gardens
- prioritise all available on-site water resources for use and/or re-use without discounting them on a water quality or seasonal availability basis, but rather identifying fit-for-purpose options and developing strategies for water quality improvement
- investigate the beneficial use of all water resources before considering draining surface and/or groundwater
- maximise opportunities for stormwater harvesting and re use
- investigate opportunities for groundwater use and re-use schemes including aquifer storage and recovery and managed aquifer recharge
- investigate opportunities for wastewater re-use
- raise community awareness of water management issues to ensure recognition of the true value of water

# 6 STORMWATER MANAGEMENT STRATEGY

The key objectives for surface water management are:

- protection of receiving environments from the impacts of urban runoff
- protection of infrastructure and assets from flooding and inundation

## 6.1 Floodplain management

In Western Australia, the State Government is responsible for the development of appropriate standards and strategic approaches for floodplain management and to ensure that they are applied in a coordinated and integrated fashion. The role involves the provision of expert technical advice by the Department of Water and Environmental Regulation (DWER), land-use planning through the Department of Planning, Lands and Heritage (DPLH) and the provision of effective flood emergency response management and planning though the Department of Fire and Emergency Services (DFES).

DWER is the State Government's lead agency in floodplain mapping and providing floodplain development advice. In accordance with the Water Agencies Act 1984, its function is to 'develop plans for and provide advice on flood management'. The department provides advice on development on floodplains with the objective of promoting the wise use of floodplains while minimising the flood risk and damage. It provides advice to the Department of Planning on land-use planning, to local government on development conditions and to other agencies to ensure appropriate development on floodplains.

DWER has undertaken floodplain modelling and mapping for the study area which is presented in the *Birrega Oaklands Flood Modelling and Drainage Study* (Hall et al, 2015). Model results are presented in several forms, which include:

- Flood extent mapping: Simulated maximum levels and flood extent for the 1% AEP and other events.
- Detailed floodplain mapping based on the 1% AEP event is provided on request by the Department of Water and Environmental Regulation.
- Main drain long-sections illustrating peak flood levels and discharge for the Oaklands Main Drain and sections of the Birrega Main Drain.

Results are reported for the entire hydraulic model domain, which is larger than the study area of this report. Note that locations within the Byford region have been developed and drainage works undertaken since the model's topographic LiDAR dataset was flown, and as such any flooding reported in this area should be disregarded.

An overview of the floodplain mapping for the 1% AEP event is shown in Figure 10, and detailed floodplain mapping is provided by DWER on request.

Modelling indicates that widespread shallow inundation would occur over much of the study area in a 1% AEP event and is particularly significant in areas outside the Byford Townsite area west of Hopkinson Road. Within the Byford Townsite area, the most significant flooding is predicted to occur in the Town Centre Precinct.

Key findings of the *Birrega Oaklands Flood Modelling and Drainage Study* which are particularly relevant to the study area include:

The capacity of Birrega and Oaklands Main Drains to convey drainage water without influencing downstream landholders: The regular breaks and lateral culverts in the drains mean that additional discharge to the drain upstream could result in increased downstream flooding.

The importance of floodplain storage: The study area contains large areas of floodplain storage which help mitigate peak flood flows and total flood volumes. Consideration of the floodplain storage should be taken into account in the development process – as reducing or eliminating these storage areas will probably result in additional discharge to the main drains, which in turn could result in more extensive downstream flooding or levee bank overtopping.

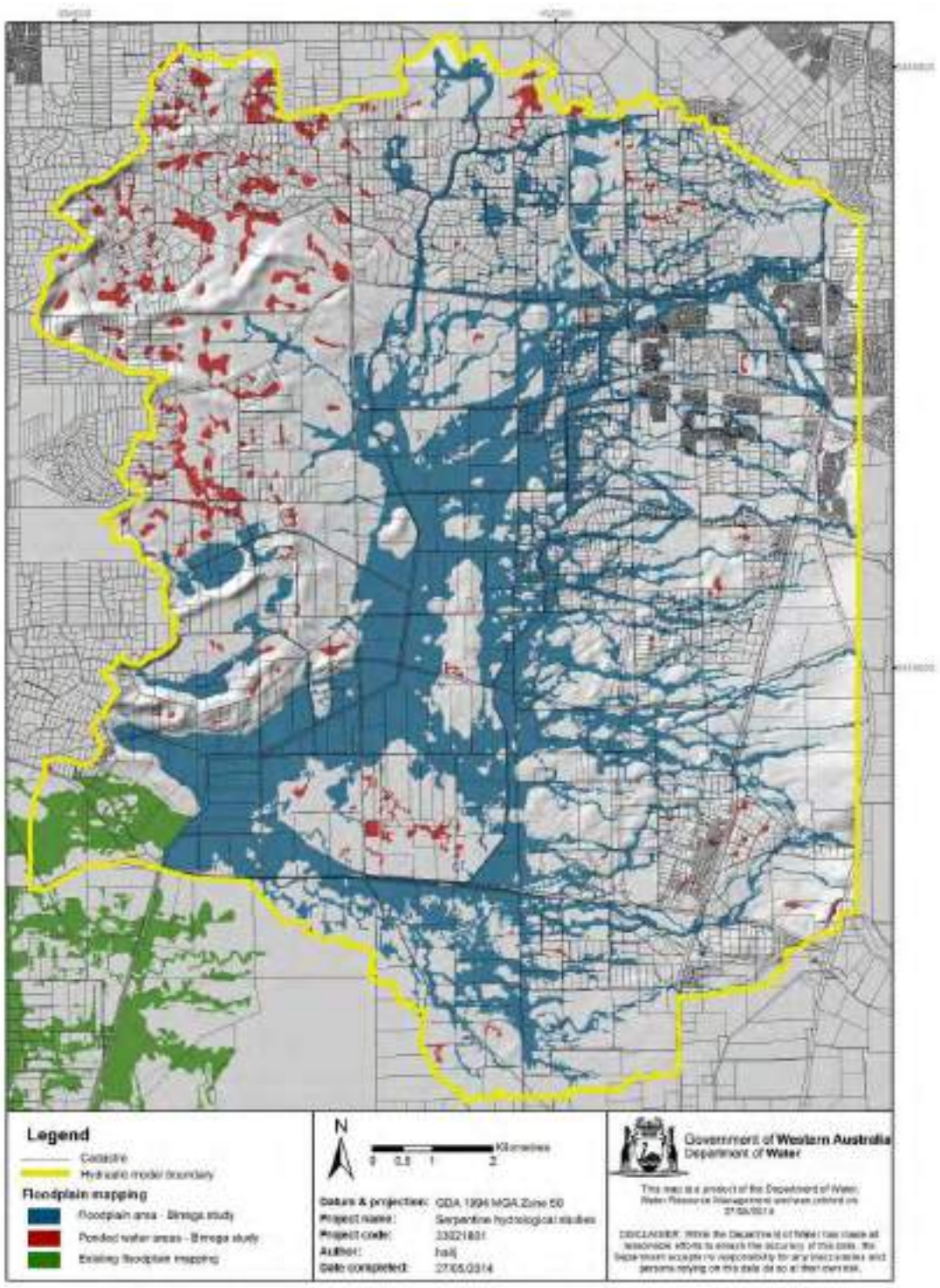



Figure 10: Detailed 1%AEP floodplain mapping and ponded areas (Source: Hall et al, 2015)

## 6.2 Surface water quality management

The environmental values of downstream waterways within and surrounding the study area must be upheld.

Maintaining pre-development discharge rates and volumes from developed catchments is expected to prevent the majority of contaminants from reaching the waterways by ensuring that the majority of flows from high-frequency events are detained or infiltrated on site.

Provided that the initial flow of more significant events is subject to the same detention and treatment received by high-frequency events, surface runoff that occurs during more significant events represents a lower risk to downstream water quality. This is because nutrients and other contaminants that represent a threat to downstream water quality are typically transported within the 'first flush' of an event.

### Design Criteria

- Manage — retain and/or detain and treat (if required) — stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.
    - At-source means that lot runoff is managed within lots and road runoff is managed within road reserves and the stormwater has not entered a piped or lined channel conveyance system.
    - Where site conditions do not allow for the full runoff to be managed at-source, manage as much as practical at-source, subject to the pre-development hydrology. Convey the remaining runoff from the lot or road reserve via overland flow wherever practical.
    - At-source treatment using a stormwater quality treatment system may be required depending on the pre-development environment and the post-development land uses. Determine if at-source stormwater quality treatment is required based on the:
        - quality of pre-development surface water and groundwater
        - quality of post-development stormwater and groundwater (mobilised or discharged)
        - potential pathways towards receiving environments, by considering factors such as soil types, depth to groundwater and horizontal distance to receiving environments
        - requirements of receiving environments.
- Install off-line stormwater quality treatment systems at the outlet of pipes or lined channels that directly convey small rainfall event runoff from constructed impervious surfaces.
- Ensure the emptying time of stormwater management systems is based on the type of system, requirements for prevention of disease vector and breeding of nuisance insects, and requirements for useability of systems post-rainfall. Table 1provides emptying times adapted from recommendations from the *Stormwater Management Manual for WA* (DWER, 2004-07) and *Australia Runoff Quality* (Engineers Australia, 2006).

Table 1: Criteria for emptying time of a stormwater storage system for different AEP

| Annual Exceedance Probability | 63.2% (1 Exceedance per Year) | 50% | 20% | 10% | 5% | 2% | 1% |
|---|---|---|---|---|---|---|---|
| Maximum emptying time in days | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 |

Section 8 provides additional information on the Shire's preferred approach to provision of water quality treatment systems and strategies.

## 6.3 Surface water quantity management

### *6.3.1 Minimise changes in hydrology to prevent impacts on receiving environments*

Urbanisation results in 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. Surface water quantity management is not only restricted to preventing runoff from increasing due to development but must also manage the maintenance or even restoration of desirable environmental flows and/or hydrological cycles where potential impacts on significant ecosystems such as wetlands are identified.

Design criteria

- Maintain pre-development peak flow rates and total volume runoff from the outlets of the development area for the critical 1 exceedance per year (EY) event.

### *6.3.2 Manage surface water flows to protect infrastructure and assets*

Design criteria

- Design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.
- Maintain the 1%AEP pre-development flood regime (flood level, peak flow rates and storage volumes) at identified critical locations.
- Implement the Byford Town Centre Precinct flood management strategy presented in Figure 13.
- Detailed flood modelling, including definition of floodways is provided in Appendix A, section A.8.
- Floodways may not be developed or obstructed in any way and are entirely separate from subcatchment scale detention volumes required to manage surface water flows resulting from future land use change which are presented in Appendix A.
- Developments adjacent to floodways should ensure finished floor levels at a minimum of 0.5 m above the 1% AEP flood level.
- The existing cross-sectional area of waterways must be maintained, and restoration of waterways is essential. In some cases, channel realignments and channel profile modifications may be carried out provided it is demonstrated that the pre-development cross-sectional area has been preserved. A permit may be required to alter beds and banks of waterways under the *Rights in Water and Irrigation Act 1914.*
- Flood retention and/or detention systems, where required, must be designed to avoid impacting on functionality of public open spaces.
- Defined major arterial roads should remain passable in the 1% AEP event. This requirement applies to but is not confined to Abernethy Road, Kardan Boulevard, Thomas Road and South Western Highway. The local authority should be contacted to identify other roads where this requirement applies.
- Minor roads should remain passable in the 20% AEP event.

Hydrologic and hydraulic modelling of the study area using InfoWorks Integrated Catchment Model (ICM) has been undertaken and is presented in Appendix A. This modelling builds upon modelling previously undertaken for the Byford Townsite area incorporating several significant updates:

- Expanded study area to include development outside of the Byford Townsite;
- Hydrological parameters (catchment loss rates) adjusted consistent with those adopted for the *Birrega Oaklands flood modelling and drainage study* (DoW, 2015);
- Hydraulic system elements and structures modified to reflect changes to the system that have been constructed or approved in UWMPs or engineering design plans; and
- Hydraulic system elements and structures modified to reflect any survey information that could be obtained within the timeframes of the project.

Key outputs from this modelling are provided in Appendix A at critical locations as a guide to developers and should be refined and located during local structure planning via the local water management strategy and finalised during subdivision scale planning via the urban water management plan. Outputs include:

*For areas which are not subject to currently approved LWMS and/or UWMP documents:*

- Subcatchment scale peak discharge flows, volumes and times of concentration for critical 1EY, 20% AEP and 1% AEP events.
- Subcatchment scale detention volumes required to manage surface water flows for critical 20% AEP and 1% AEP events based on land use change in accordance with the Byford District Structure Plan.

*For the entire study area:*

- Mapping of predicted 20% and 1% AEP flood inundation extents including peak levels and flows at critical locations.
- Critical 1EY, 20% AEP and 1% AEP event longitudinal sections for significant watercourses are provided to assist with the design of subdivisional drainage and may be used to accurately determine flows and levels.

It is important to note that modelling assumes that the first 15mm of rainfall (from allotments and also from the road network) is retained at source, so this volume is not included in indicative flood detention volumes.

Subcatchment scale discharge flows presented are not within main waterways and do not include flows generated by upstream subcatchments. Discharge criteria are set for whole subcatchments at the point at which they connect to main waterways as shown in Figure 11.

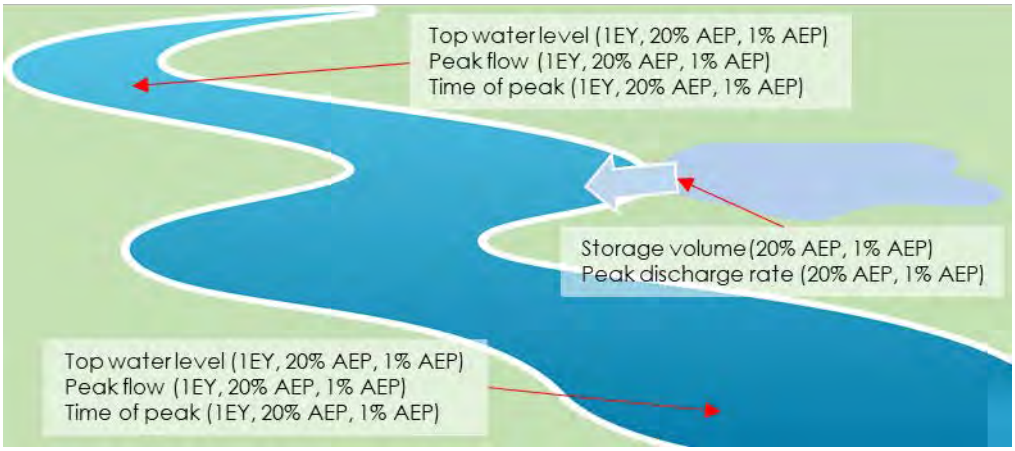



Figure 11: Schematic presentation of information for subcatchments and main waterways

Overview mapping of the Byford district stormwater management strategy is presented in Figure 12. Detailed flood maps and longitudinal sections of significant watercourses for critical duration 1EY, 20% AEP and 1% AEP flood events are provided in Appendix C.

A flood management strategy has been specifically developed to address flood risk in the Town Centre precinct. This strategy is presented in Figure 13. Key elements of the proposed Byford Town Centre strategy include:

- Re-alignment of the drainage corridor connecting Beenyup Brook to Oaklands drain.
- Upgrades to culverts on Oaklands drain at Thatcher Road and Larsen Road to prevent flooding of Larsen Road

Otherwise the drainage system remains as constructed and/or previously designed and approved through relevant LWMS's and UWMP's. Table 2 provides top water levels, peak flows and the approximate time of the peak flow at several locations throughout the study area.

This strategy has reviewed, and incorporated drainage designs presented in a previously approved Local Water Management Strategies and Urban Water Management Plans including specified stormwater storage volumes. It is acknowledged that there may be opportunities to rationalise previously approved storage volumes through optimised drainage system designs including using online storage within multiple use corridors. Any proposals to reduce previously approved storage volume provision must demonstrate that peak discharges can be managed within the arterial drainage system, to the satisfaction of the Shire of Serpentine Jarrahdale in consultation with Department of Water and Environmental Regulation. Table 2 provides peak flow timing information at key locations within the arterial system to assist with this process.

There are several areas within the study area that are proposed for future development but are not yet the subject of any approved local water management strategy or urban water management plan. Table 3 provides storage volumes by subcatchment to guide potential future development in these areas as well as in areas not currently proposed for development which include:

- Land reserved for the future Tonkin Highway – there is substantial natural storage provided in land that has been reserved for the future Tonkin Highway. In future, when the highway is constructed, it will be necessary to provide equivalent storage to prevent downstream flooding.
- Rural and rural residential land outside the Byford townsite – there are several areas of rural and rural residential that are subject to flooding and therefore provide natural flood storage. Any future development of these areas will be required to provide equivalent storage to prevent downstream flooding.

Table 2: Top water levels, peak flows and timing of peaks at critical locations

| Location | 1EY (63.2% AEP, S10-3h)) | | | 20% AEP (S7-3h) | | | 1% AEP (S2-3hr) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) |
| 1. Oaklands drain d/s George Road (north) | 49.4 | 2.8 | 2:30:00 | 49.4 | 4.0 | 2:55:00 | 49.5 | 8.9 | 3:10:00 |
| 2. Oaklands drain d/s George Road (south) | 51.3 | 1.2 | 2:50:00 | 51.3 | 1.4 | 3:00:00 | 51.4 | 2.0 | 3:00:00 |
| 3. Oaklands drain d/s Evans Road | 42.3 | 6.8 | 2:50:00 | 42.3 | 10.0 | 3:05:00 | 42.4 | 15.5 | 3:15:00 |
| 4. Oaklands drain u/s Malarkey Road | 30.7 | 6.9 | 2:20:00 | 30.7 | 9.9 | 1:45:00 | 30.7 | 19.0 | 0:55:00 |
| 5. Thomas Road drain u/s Malarkey Road | 30.3 | 2.4 | 3:50:00 | 30.6 | 4.3 | 4:15:00 | 31.2 | 9.2 | 4:00:00 |
| 6. Oaklands drain d/s Malarkey Road | 29.9 | 9.2 | 3:40:00 | 30.0 | 13.8 | 2:50:00 | 30.2 | 28.6 | 1:40:00 |
| 7. Oaklands drain at Hopkinson Road | 25.6 | 6.5 | 4:35:00 | 25.8 | 12.5 | 3:40:00 | 26.0 | 31.2 | 3:00:00 |
| 8. Beenyup Brook d/s South Western Hwy | 59.0 | 6.6 | 2:35:00 | 59.1 | 10.4 | 2:50:00 | 59.3 | 18.8 | 3:00:00 |
| 9. Beenyup Brook d/s Town Centre | 47.7 | 3.4 | 2:45:00 | 47.9 | 3.6 | 3:05:00 | 48.1 | 3.5 | 3:15:00 |
| 10. Beenyup Brook to Oaklands drain link | 48.4 | 3.2 | 2:45:00 | 48.8 | 5.4 | 3:05:00 | 49.5 | 9.2 | 3:15:00 |
| 11. Beenyup Brook at Hopkinson Road | 25.8 | 2.6 | 3:10:00 | 26.1 | 3.9 | 3:15:00 | 26.5 | 7.0 | 3:15:00 |
| 12. Brickwood drain u/s Doley Road | 35.2 | 1.2 | 3:00:00 | 35.4 | 2.9 | 3:25:00 | 36.1 | 6.2 | 3:30:00 |
| 13. Brickwood drain at Hopkinson Road | 27.0 | 1.4 | 3:25:00 | 27.4 | 3.6 | 3:45:00 | 27.9 | 7.4 | 4:20:00 |
| 14. Doley Drain at Hopkinson Road | 26.6 | 2.2 | 3:15:00 | 26.8 | 4.0 | 3:15:00 | 27.4 | 9.4 | 3:20:00 |
| 15. Cardup Brook d/s South Western Hwy | 55.7 | 3.4 | 2:10:00 | 55.8 | 4.0 | 1:15:00 | 55.9 | 20.7 | 0:40:00 |
| 16. Cardup Brook at Hopkinson Road | 27.1 | 2.6 | 3:25:00 | 27.5 | 3.9 | 3:15:00 | 28.3 | 10.6 | 3:20:00 |
| 17. Birrega Main Drain at Wungong South (N) | 35.3 | 0.1 | 3:00:00 | 35.4 | 0.7 | 3:05:00 | 35.7 | 3.0 | 3:15:00 |
| 18. Birrega Main Drain at Wungong South (S) | 34.1 | 0.0 | 3:40:00 | 34.2 | 0.2 | 3:50:00 | 34.3 | 0.2 | 3:05:00 |
| 19. Birrega Main Drain at Masters Road | 29.6 | 0.1 | 2:55:00 | 30.0 | 0.3 | 3:45:00 | 30.6 | 3.4 | 3:45:00 |
| 20. Birrega Main Drain at Hopkinson Road | 25.8 | 0.4 | 2:45:00 | 26.3 | 1.1 | 4:20:00 | 26.8 | 1.8 | 3:05:00 |
| 21. Birrega Branch Drain at Hopkinson Road | 26.8 | 0.5 | 2:50:00 | 27.1 | 0.8 | 3:00:00 | 27.9 | 0.9 | 3:00:00 |

| Location | 1EY (63.2% AEP, S10-3h)) | | | 20% AEP (S7-3h) | | | 1% AEP (S2-3hr) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) |
| 22. Birrega Branch Drain 2 at Kargotich Road | 21.6 | 1.3 | 3:00:00 | 21.7 | 2.2 | 3:20:00 | 21.9 | 5.0 | 3:20:00 |
| 23. Birrega Branch Drain 3 at Kargotich Road | 18.7 | 5.2 | 5:40:00 | 18.9 | 7.7 | 3:40:00 | 19.5 | 15.0 | 3:45:00 |
| 24. Birrega Branch Drain 4 at Kargotich Road | 16.8 | 0.7 | 2:30:00 | 16.9 | 1.9 | 2:45:00 | 17.3 | 7.7 | 3:00:00 |
| 25. Birrega Branch Drain 5 at Kargotich Road | 15.5 | 0.0 | 0:00:00 | 15.6 | 0.4 | 3:30:00 | 15.9 | 2.1 | 3:35:00 |
| 26. Orton Road Drain at South Western Hwy | 59.2 | 0.3 | 2:50:00 | 59.6 | 0.5 | 2:55:00 | 59.9 | 1.0 | 3:15:00 |
| 27. Brickwood Drain at South Western Hwy | 56.9 | 0.7 | 3:35:00 | 57.2 | 0.9 | 3:10:00 | 57.4 | 1.0 | 3:00:00 |
| 28. Brickwood Drain at Glades Confluence | 41.2 | 1.1 | 2:45:00 | 41.3 | 2.0 | 3:00:00 | 41.3 | 2.7 | 3:00:00 |
| 29. Beenyup Brook d/s Abernethy Road | 56.4 | 6.5 | 2:40:00 | 56.5 | 9.9 | 2:55:00 | 56.6 | 16.0 | 3:10:00 |
| 30. Doley Drain at Warrington Road | 43.9 | 0.3 | 2:45:00 | 44.1 | 0.3 | 3:10:00 | 44.6 | 0.9 | 3:20:00 |
| 31. Doley Drain at Doley Road | 37.0 | 0.8 | 2:50:00 | 37.1 | 0.9 | 3:00:00 | 37.3 | 1.2 | 3:05:00 |
| 32. Norman Drain at South Western Hwy | 77.6 | 0.5 | 2:30:00 | 77.7 | 2.0 | 3:00:00 | 78.0 | 8.5 | 3:00:00 |
| 33. Norman Drain at Railway | 47.3 | 4.2 | 2:30:00 | 47.6 | 6.3 | 2:45:00 | 48.2 | 10.6 | 3:00:00 |
| 34. Norman Drain at Hopkinson Road | 27.9 | 0.9 | 3:05:00 | 28.6 | 1.3 | 3:00:00 | 29.4 | 4.6 | 3:05:00 |
| 35. Oaklands Drain at Kargotich Road | 17.1 | 8.7 | 4:40:00 | 17.8 | 12.9 | 4:10:00 | 18.4 | 16.8 | 3:10:00 |
| 36. Oaklands Drain d/s Norman Drain | 16.6 | 10.2 | 4:30:00 | 16.8 | 15.0 | 4:50:00 | 16.9 | 19.0 | 4:45:00 |
| 37. Cardup Drain at Railway | 51.7 | 2.9 | 2:30:00 | 51.9 | 3.9 | 2:45:00 | 52.1 | 5.7 | 3:00:00 |
| 38. Cardup Drain at Hopkinson Road | 25.9 | 0.4 | 4:05:00 | 26.3 | 0.6 | 3:35:00 | 27.2 | -5.1 | 5:10:00 |
| 39. Oaklands Drain d/s bifurcation | 21.3 | 3.4 | 5:40:00 | 21.5 | 3.6 | 3:15:00 | 22.2 | 4.4 | 3:20:00 |
| 40. Oaklands Drain d/s Cardup Brook | 19.5 | 8.0 | 3:50:00 | 19.8 | 12.1 | 3:25:00 | 21.1 | 16.4 | 3:05:00 |
| 41. Orton Road Drain at Warrington Road | 47.4 | 0.5 | 3:05:00 | 47.5 | 0.9 | 3:10:00 | 47.6 | 1.3 | 3:45:00 |
| 42. Orton Road Drain at Doley Road | 38.6 | 0.6 | 3:15:00 | 38.7 | 1.1 | 3:25:00 | 38.8 | 1.6 | 3:20:00 |
| 43. Thomas Road Drain North at Railway | 40.7 | 1.6 | 3:05:00 | 40.7 | 1.6 | 3:20:00 | 40.7 | 1.7 | 3:15:00 |

| Location | 1EY (63.2% AEP, S10-3h)) | | | 20% AEP (S7-3h) | | | 1% AEP (S2-3hr) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) | Top water level (mAHD) | Peak flow (m3/s) | Time of peak (H:M:S) |
| 44. Thomas Road Drain at Railway | 42.0 | 0.3 | 3:05:00 | 42.1 | 0.4 | 3:25:00 | 42.1 | 0.4 | 3:20:00 |
| 45. Wungong River at South Western Hwy | 42.9 | 0.9 | 3:00:00 | 43.0 | 1.6 | 3:10:00 | 43.2 | 4.6 | 3:10:00 |
| 46. Wungong River nr Keenan Street | 35.4 | 2.3 | 2:40:00 | 35.6 | 4.8 | 2:55:00 | 36.1 | 11.9 | 3:05:00 |
| 47. Wungong River at Rowley Road | 29.8 | 2.3 | 3:00:00 | 30.0 | 5.6 | 3:10:00 | 30.3 | 15.9 | 3:20:00 |

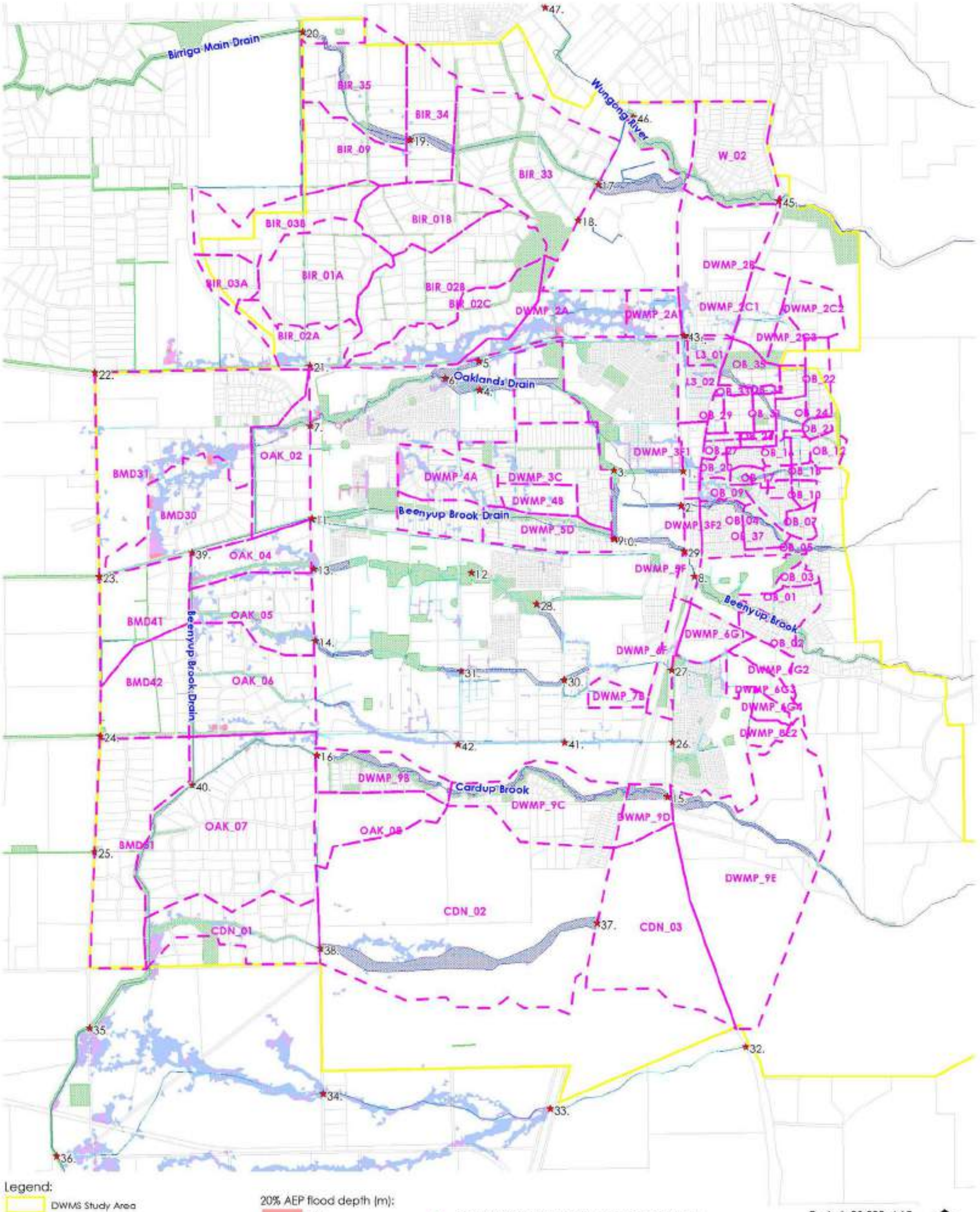
Table 3: Subcatchment details for undeveloped areas

| Subcatchment id | 20% AEP | | 1% AEP | |
|---|---|---|---|---|
| | Storage volume ($m^3$) | Peak discharge rate ($m^3/s$) | Storage volume ($m^3$) | Peak discharge rate ($m^3/s$) |
| OB_22 | 17 | 0.117 | 33 | 0.126 |
| OB_21 | 6 | 0.177 | 20 | 0.174 |
| OB_24 | 37 | 0.410 | 213 | 1.246 |
| OB_34 | 480 | 0.293 | 868 | 0.372 |
| OB_26 | 69 | 0.116 | 197 | 0.295 |
| OB_25 | 256 | 0.244 | 661 | 0.536 |
| OB_27 | 122 | 0.341 | 547 | 0.266 |
| OB_28 | 65 | 0.172 | 311 | 0.306 |
| OB_19 | 48 | 0.277 | 201 | 0.292 |
| OB_13 | 336 | 0.265 | 487 | 0.213 |
| OB_12 | 0 | 0.389 | 0 | 1.180 |
| OB_10 | 0 | 0.463 | 0 | 0.969 |
| OB_11 | 32 | 0.182 | 80 | 0.186 |
| OB_08 | 281 | 0.258 | 583 | 0.264 |
| OB_07 | 145 | 0.443 | 304 | 0.306 |
| OB_16 | 127 | 0.260 | 482 | 0.233 |
| BIR_33 | 0 | 0.500 | 811 | 2.782 |
| BIR_34 | 290 | 0.346 | 1,316 | 1.809 |
| BIR_35 | 1,912 | 0.144 | 14,144 | 0.840 |
| BIR_09 | 250 | 0.503 | 7,046 | 2.149 |
| BIR_02C | 10,184 | 0.720 | 39,396 | 2.995 |
| BIR_02B | 194 | 0.145 | 2,479 | 0.934 |
| BIR_02A | 4,246 | 0.286 | 48,288 | 1.631 |
| BIR_01A | 0 | 1.208 | 3,101 | 4.502 |
| BIR_01B | 0 | 1.208 | 0 | 4.502 |
| BIR_03A | 0 | 1.053 | 41,275 | 4.535 |
| BIR_03B | 0 | 1.053 | 25,773 | 4.535 |
| BMD30 | 20,940 | 0.367 | 61,031 | 1.843 |
| BMD31 | 14,865 | 1.466 | 94,079 | 4.762 |
| BMD41 | 17 | 0.602 | 10,653 | 1.999 |
| BMD42 | 0 | 1.417 | 11,507 | 5.942 |
| BMD51 | 0 | 0.702 | 18,834 | 3.031 |

| Subcatchment id | 20% AEP | | 1% AEP | |
|---|---|---|---|---|
| | Storage volume ($m^3$) | Peak discharge rate ($m^3/s$) | Storage volume ($m^3$) | Peak discharge rate ($m^3/s$) |
| OB_15 | 28 | 0.332 | 169 | 0.777 |
| DWMP_6F | 1,150 | 1.240 | 2,534 | 3.311 |
| GL_82 | 0 | 0.412 | 0 | 1.329 |
| OB_01 | 0 | 1.388 | 0 | 3.200 |
| OB_02 | 0 | 0.911 | 0 | 2.031 |
| DWMP_5F | 34 | 0.710 | 670 | 1.550 |
| DWMP_5D | 3,723 | 1.251 | 7,813 | 2.412 |
| DWMP_5C | 1,495 | 0.736 | 3,408 | 3.086 |
| DWMP_9E | 37,233 | 3.702 | 82,280 | 9.612 |
| DWMP_9D | 28,190 | 0.865 | 51,760 | 1.959 |
| DWMP_9C | 125 | 1.180 | 23,263 | 6.370 |
| DWMP_9B | 0 | 0.013 | 18,058 | 0.045 |
| DWMP_8E2 | 0 | 0.006 | 0 | 0.014 |
| DWMP_6G4 | 0 | 0.558 | 0 | 1.270 |
| DWMP_6G3 | 42 | 0.519 | 113 | 1.989 |
| DWMP_6G2 | 0 | 1.202 | 16 | 2.078 |
| OB_03 | 0 | 0.535 | 0 | 1.165 |
| DWMP_7B | 0 | 0.302 | 582 | 0.624 |
| OB_32 | 408 | 0.075 | 705 | 0.090 |
| DWMP_6G1 | 965 | 0.094 | 1,882 | 0.427 |
| OB_35 | 2,315 | 0.566 | 4,497 | 1.876 |
| DWMP_2C3 | 105 | 0.311 | 222 | 1.070 |
| L3_01 | 1,973 | 0.638 | 4,298 | 1.575 |
| DWMP_2C1 | 589 | 0.909 | 1,553 | 3.388 |
| OB_30 | 30 | 0.457 | 149 | 1.298 |
| OB_29 | 36 | 0.393 | 247 | 0.887 |
| OAK_08 | 0 | 1.468 | 146 | 4.434 |
| CDN_03 | 349 | 1.848 | 3,118 | 2.908 |
| CDN_02 | 22,143 | 4.299 | 31,844 | 9.642 |
| OB_05 | 518 | 0.289 | 923 | 0.791 |
| OB_37 | 2,442 | 0.508 | 4,203 | 1.600 |
| OB_04 | 1,386 | 0.660 | 2,693 | 2.379 |
| DWMP_3F2 | 473 | 0.391 | 808 | 0.523 |

| Subcatchment id | 20% AEP | | 1% AEP | |
|---|---|---|---|---|
| | Storage volume ($m^3$) | Peak discharge rate ($m^3/s$) | Storage volume ($m^3$) | Peak discharge rate ($m^3/s$) |
| BM_02 | 3,700 | 2.437 | 9,789 | 6.189 |
| OAK_02 | 14,678 | 0.914 | 62,548 | 1.757 |
| OAK_04 | 9,495 | 0.579 | 15,274 | 2.236 |
| OAK_05 | 17,490 | 0.762 | 30,532 | 2.468 |
| OAK_06 | 14,059 | 1.379 | 70,552 | 2.779 |
| OAK_07 | 6,293 | 1.631 | 74,118 | 3.211 |
| CDN_01 | 20,425 | 1.108 | 68,140 | 3.158 |
| OB_09 | 2,105 | 0.225 | 4,267 | 0.229 |
| OB_31 | 138 | 0.541 | 609 | 1.295 |
| OB_14 | 1,281 | 0.216 | 1,784 | 0.592 |
| OB_17 | 199 | 0.152 | 647 | 0.396 |
| OB_18 | 25 | 0.166 | 709 | 0.462 |
| OB_20 | 1,093 | 0.414 | 2,101 | 0.943 |
| DWMP_3F1 | 2,306 | 0.329 | 5,552 | 0.390 |
| OB_33 | 224 | 0.175 | 578 | 0.480 |
| DWMP_2C2 | 0 | 1.320 | 67 | 3.430 |
| DWMP_2B | 5,192 | 0.246 | 11,476 | 1.105 |
| DWMP_2A1 | 7,834 | 0.553 | 16,959 | 1.524 |
| DWMP_2A | 19,495 | 1.317 | 54,336 | 2.145 |
| L3_02 | 1,360 | 0.778 | 3,169 | 2.010 |
| DWMP_3C | 3,823 | 1.226 | 10,498 | 2.407 |
| DWMP_4B | 1,418 | 0.681 | 3,349 | 1.785 |
| DWMP_4A | 9,706 | 0.826 | 15,988 | 1.079 |
| W_02 | 27 | 2.577 | 46 | 7.673 |
| W_05 | 365 | 1.022 | 833 | 1.080 |
| OB_23 | 19 | 0.079 | 85 | 0.209 |

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure 12 - Byford district stormwater strategy




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

20% AEP flood depth (m):

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 30,000 at A3

0 600m


Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB. Projection: MGA, zone 50.

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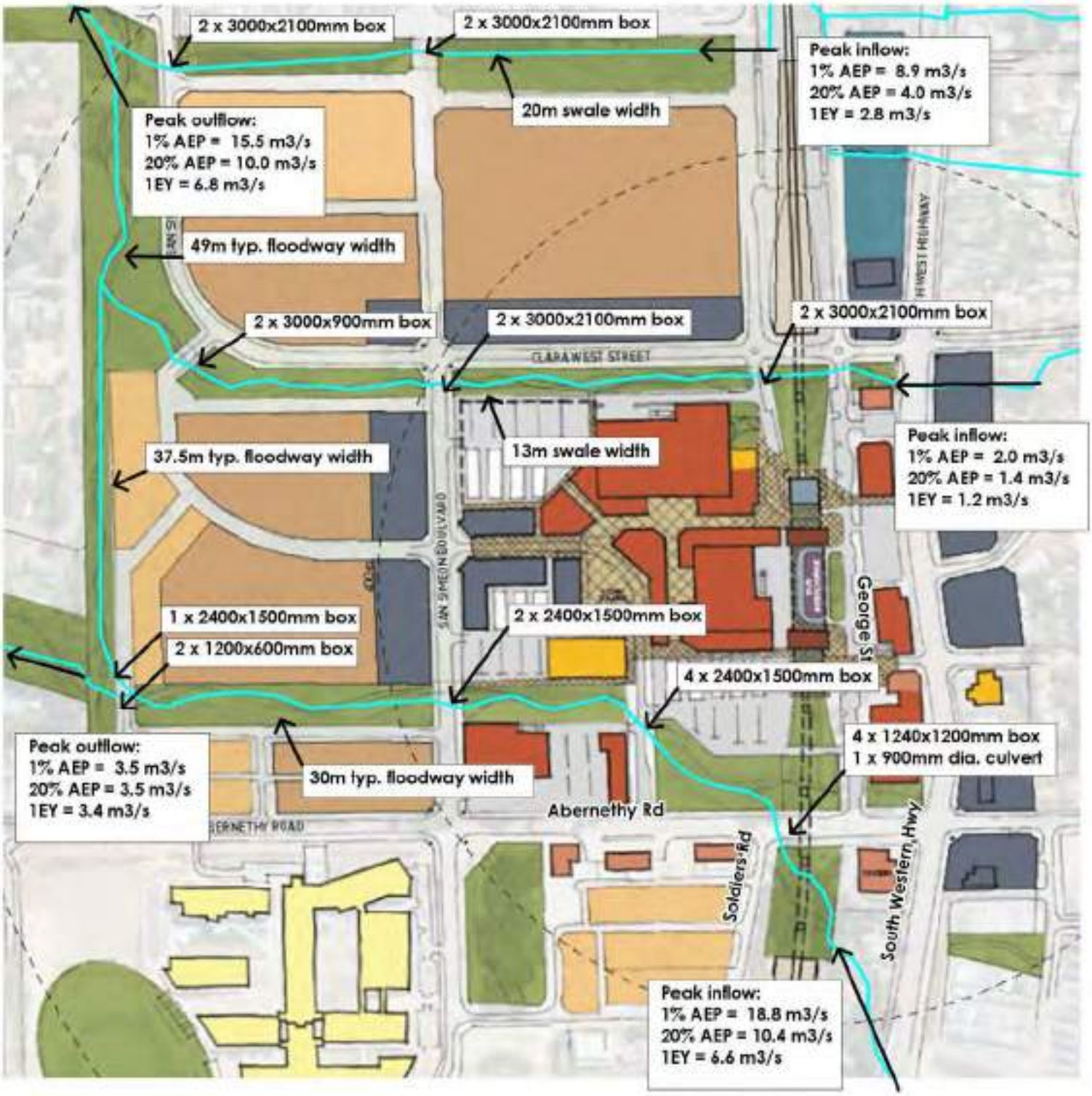
# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure 13 - Byford Town Centre Precinct - Arterial stormwater management strategy

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# 7 GROUNDWATER MANAGEMENT STRATEGY

The key objectives for groundwater management are:

- protecting infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture
- protecting groundwater dependent ecosystems from the impacts of urban runoff
- managing and minimising changes in groundwater levels and groundwater quality following development/redevelopment

## 7.1 Glossary of groundwater terms

| | |
|---|---|
| Capillary fringe | Part of the unsaturated zone, where soil voids are filled (or almost filled) with water due to capillary rise |
| Controlled groundwater system | A groundwater system that is subject to control or management through the provision of drainage infrastructure |
| Controlled groundwater level (CGL) | The invert level of groundwater controlling infrastructure |
| Groundwater | Water in the soil voids of the saturated zone |
| Groundwater level | The non-static top of the saturated zone (can include locally perched groundwater) |
| Perched groundwater | Groundwater that occurs above the regional water table, as a distinct saturated zone embedded within the unsaturated zone due to the presence of an aquiclude or aquitard |
| Engineered phreatic surface | The non-static top of the saturated zone in a controlled groundwater system |
| Engineered phreatic crest level | The highest point on the controlled phreatic surface |
| 50% AEP phreatic surface | The phreatic surface that will be exceeded in 50% of years (50% chance each year). |
| 20% AEP phreatic surface | The phreatic surface that will be exceeded in 20% of years (20% chance each year). |
| Saturated zone | The part of the soil profile where voids are completely filled with water. |
| Seasonally perched groundwater | Perched groundwater that is seasonally connected to the underlying water table |
| Unsaturated zone | The part of the soil profile where voids are only partially filled with water. |
| Water table | The non-static top of the saturated zone (generally does not include locally perched groundwater) |

## 7.2 Groundwater quantity management

### *7.2.1 Manage groundwater levels to protect infrastructure and assets*

When considering development of a site with shallow groundwater there are a number of responses that can be applied:

1. Don't develop, accept that the land value is not sufficient to make its development feasible and allow the land to remain in, or be restored to its natural state.
2. Develop the land in a way that is sympathetic to the existing hydrology and soil conditions of the site, accepting that this will result in portions of some lots and open spaces being seasonally inundated or waterlogged.
3. Drain and/or fill to adapt the land sufficiently for urban development to occur.

#### Hydrologically sympathetic development

Lower density residential developments or industrial areas where lower levels of public amenity may be acceptable and could even be seen as an advantage, enable people to live and work close to and surrounded by natural wetland ecosystems. This type of development can be established without extensive fill.

In this circumstance, larger residential lots and public open spaces can and have been designed with an acceptance of seasonal waterlogging with buildings and other areas that need to remain dry throughout the year elevated to prevent inundation and protect from flooding. Elevation of these areas could be achieved with sand 'pads' or 'stumps' (Figure 14).

This type of development has previously occurred in Western Australia, typically in rural and agricultural areas. Recently however, building and development practices have moved away from this methodology with close to universal adoption of 'brick & tile' houses with filled and flattened lots.

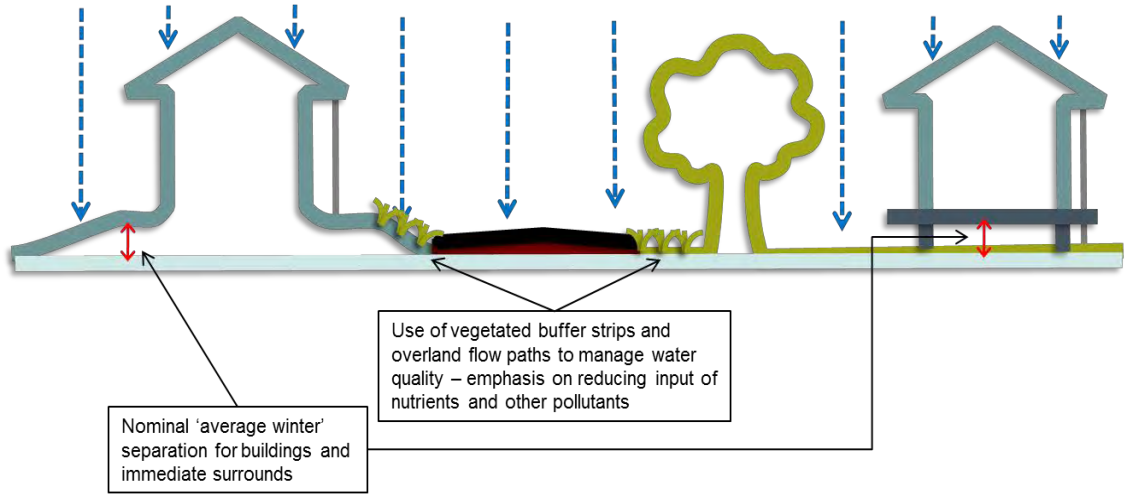


Figure 14: **Options for a 'limited fill' development**

Design considerations necessary for this type of development include:

- Provision of sufficient low-lying land retained to manage groundwater at pre-development levels and to accommodate stormwater flooding
- Grading of lots to minimise standing water and prevent breeding of mosquitos and other nuisance insects

- Maintenance of high water quality standards to maintain healthy natural wetland ecosystems that will biologically control nuisance insects
- Provision of suitable road access to facilitate vehicle and pedestrian movement throughout the winter and during flooding events

In particular, it is critical to gain community acceptance and understanding of the design intent and to ensure that muddy backyards and open spaces in the winter do not become a 'problem' inherited by the relevant local authority.

**When 'no development' is the right answer**

Provided that a parcel of land has not been reserved to reflect its particular value or significance and assuming that services and infrastructure suitable to the proposed land use can be provided, in theory it can be 'developed'.

In practice, the ability of a parcel of land to be developed successfully may be limited by many factors and any proponent of development will inevitably undertake some 'due-diligence' investigations to determine the feasibility of development of a particular site.

The presence of shallow groundwater on a site is one of many considerations for the developer that affect the way that the development can proceed and has implications for the cost of materials and construction. The presence of shallow groundwater should not be seen as something that precludes development. Where the site has sufficient strategic value, through being close to key transport links, employment centres, economic opportunities or desirable locations for recreation, then the potentially higher cost of providing the required site conditions for the preferred land use and the management of any environmental impacts can be justified.

Development with subsoil drains and fill

Medium or high density urban development and commercial areas generally require the use of active groundwater management strategies to provide the high levels of amenity that are expected in urban areas.

These developments will generally apply imported fill to artificially create 'dry-land'. Then to avoid subsequent groundwater rise caused by increased recharge that is a recognised outcome of water sensitive urban development; subsoil drainage may be installed.

In order to drain and fill a site, work must be undertaken to determine the level to which you can drain, and then the separation you require from the groundwater and other influences.

Design criteria

- Where a strategy of subsoil drainage and fill is proposed to control groundwater levels for development design criteria and modelling methodologies provided in the Institute of Public Works Engineers Australia *Specification: Separation distances for groundwater controlled urban development* will apply

### *7.2.2 Manage the shallow aquifer to protect the value of groundwater resources*

The Department of Water recently released *Water Resource Considerations when Controlling Groundwater Levels in Urban Development* (2013). This paper outlines a process for determining an acceptable minimum level for subsoil drainage systems with appropriate consideration of potential water resource and environmental impacts.

The Department of Water expects that a suitable Controlled Groundwater Level (CGL) is defined as a critical part of any local water management strategy and/or urban water management plan. The CGL should be determined to provide appropriate protection to local and regional water resources including wetlands, watercourses and groundwater aquifers.

Design criteria

- The establishment of a CGL requires the endorsement of the Department of Water and Environmental Regulation as the state's groundwater resource manager. Further guidance is provided in *Water resource considerations when controlling groundwater levels in urban development* (DWER, 2013).
- The CGL should be established with due consideration of the likely presence and depth of impermeable soils leading to localised permanent or seasonally perched groundwater.

## 7.3 Groundwater quality management

### *7.3.1 Maintain and, if possible, improve groundwater quality (median winter concentrations)*

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

Design criteria

- Implement water sensitive urban design strategies to treat water from directly connected impervious areas prior to its discharge to waterways, wetlands and groundwater.
- Install water quality treatment systems at controlled groundwater level subsoils and drains and/or at outlet points, unless investigations demonstrate that treatment is not required. See Water resource considerations when controlling groundwater levels (DoW 2013e) for guidance.
- Where appropriate, field investigations must be undertaken to identify acid sulphate soils. Any reduction in groundwater level should not expose acid sulphate soils to the air, as this may cause groundwater contamination. If field investigations identify acid sulphate soils, further advice should be sought from the Department of Water and Environmental Regulation.
- Contaminated sites must be managed in accordance with the Contaminated Sites Act 2003.

# 8 COMMITMENT TO WATER SENSITIVE URBAN DESIGN

In order to meet the design criteria for management of surface water and groundwater quality, it is necessary to use a combination of water sensitive urban design strategies.

In addition, water sensitive urban design strategies, contribute to management of urban heat island effects, reduce risks of flooding on housing and infrastructure while maximising the potential for stormwater to be treated as a resource.

## 8.1 Urban heat island effects

The urban heat island effect is an important urban issue. The urban heat island effect is a phenomenon where local temperatures in built-up, low vegetation areas are increased in comparison to surrounding areas due to heat absorption and radiation of built materials. Tree canopy provides relief from urban heat due to transpiration. Increasing tree canopy can reduce the urban heat island effect and provide cooler urban areas.

The CRC for Water Sensitive Cities has conducted research into the benefits of greening in urban areas. Findings show a single tree can reduce ambient air temperature under its canopy by 1.2 °C. This translates to a Universal Thermal Climate Index (UTCI) temperature difference, which reflects human physiological reactions to temperature (i.e. how much cooler an individual feels), of 7°C. In a streetscape where tree canopy is present, ambient air temperature under the tree canopy can be reduced by 1°C, while the UTCI temperature difference is 12°C (Coutts *et al.* 2015).

The adoption of water sensitive urban design principles in planning and development can assist in minimising urban heat island through the integration of blue and green infrastructure into lots, streets and open spaces. Recommended strategies that can contribute to reduced urban heat island effects include:

- Raingardens and tree-pits
- Green roofs and living walls
- Vegetated conveyance systems

## 8.2 Hierarchy of preferred approaches to water sensitive urban design

Structural and non-structural best management practice strategies must be used in combination to achieve the required stormwater treatment outcomes.

### *8.2.1 Structural strategies*

Key principles for the selection of water sensitive urban design strategies in Byford are:

- Retain, restore and protect existing watercourses and water bodies as integrated elements of the water management system.
- Minimise directly connected impervious area by:
    - Retaining and establishing pervious surfaces wherever possible
    - Providing for runoff from impervious surfaces to flow overland via vegetated surfaces wherever possible prior to discharge into downstream receiving environments

Recommended strategies which satisfy these principles include:

Residential lot scale:

- front of lot raingardens and tree-pits
- on-site soakage devices, where appropriate, with overflow outlets (detention)
- water-wise and nutrient-wise landscaping
- porous pavements
- amended topsoils
- rainwater tanks for harvesting, detention and re-use
- greywater systems for garden irrigation

Commercial lot scale:

- on-site detention and/or retention
- water-wise and nutrient-wise landscaping
- maximised permeable surfaces including green roofs
- porous pavements
- amended topsoils
- landscaped infiltration structures (raingardens and tree-pits)
- hydrocarbon management and sediment traps
- rainwater tanks for harvesting, detention and re-use
- greywater systems for garden irrigation

Estate scale:

- infiltration measures
- sediment traps
- porous pavements (car parking)
- retention of existing waterways and restoration of a pre-development ecology and channel morphology in new and existing waterways
- vegetated conveyance systems (living streams and swales)
- use of imported fill material with a high phosphorous retention capability
- minimised use of retention/detention areas integrated within public open space

### *8.2.2 Non-structural strategies*

Although urban development has been rapid in Byford, the area retains a rural character and has significant environmental values. Development should contribute to the maintenance of community understanding and participation in Byford's sustainability. The following non-structural water sensitive urban design strategies can be applied as a part of development to support this objective:

- interpretive signage
- garden education programs
- native species planting initiatives
- publishing a water-sensitive urban design web-page for the estate
- inviting residents to engage with existing community catchment groups
- development of waterwise community gardens

# 9 IMPLEMENTATION

## 9.1 Requirements for following stages

It is strongly recommended that proponents meet with the Shire of Serpentine-Jarrahdale to discuss proposed water management strategies and to gain further guidance on site-specific requirements at commencement of any water management strategy or plan.

In accordance with *Better Urban Water Management* (WAPC 2008) the implementation of this strategy will be through the land use planning process with proponents of development required to develop water management strategies and plans at each planning stage to support and inform their planning proposals, environmental investigations, engineering, landscaping and urban designs as follows.

1. A District Water Management Strategy is required to support a region scheme amendment for future urban or industrial development not proposed by the Byford District Structure Plan (2018), consistent with *Better Urban Water Management* (WAPC, 2008).

2. A local water management strategy is required to support a local scheme amendment or the preparation of any local structure plan, whichever is the earlier consistent with *Better Urban Water Management* (WAPC, 2008), *Interim: Developing a Local Water Management Strategy* (DWER, 2008) and the *Byford District Water Management Strategy*.

3. Where no approved local water management strategy exists, any application for subdivision in greenfield areas, or where more than 30 lots are proposed in infill or brownfield areas, must be accompanied by a draft urban water management plan, consistent with the Department of Water and Environmental Regulation's *Urban Water Management Plans: Guidelines for preparing plans and for complying with subdivision conditions* (DWER, 2008) and the *Byford District Water Management Strategy*, and developed in consultation with the local government, with advice as necessary from DWER.

4. Where an approved local water management strategy exists, the preparation and implementation of an urban water management plan will be required as conditions of urban or industrial subdivision. In this case, the subdivision application should be supported by a brief document which outlines a broad strategy for water management that has been previously agreed with the Shire. The urban water management plan is to be consistent with the Department of Water and Environmental Regulation's *Urban Water Management Plans: Guidelines for preparing plans and for complying with subdivision conditions* (DWER, 2008) and the *Byford District Water Management Strategy*, and developed in consultation with the Shire of Serpentine-Jarrahdale with advice as necessary from DWER.

5. 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.

Proposals should address groundwater and surface water management, water conservation and efficiency; and water reuse and recycling in an integrated manner, focussing on key issues identified in this strategy.

Proponents of development should demonstrate that their proposals and designs are consistent with the strategies and design criteria presented in this strategy, as well as satisfying other requirements of other relevant agencies.

## 9.2 Review of District Water Management Strategy

It is intended that the District Water Management Strategy be reviewed within ten years or earlier if deemed necessary until development has occurred consistent with the Byford Structure Plan.

## 9.3 Monitoring strategy

Monitoring and site investigations should always be targeted at addressing a specified problem. For instance, if the problem is shallow groundwater then the monitoring program should be targeted to understanding groundwater levels in particularly low-lying or vulnerable parts of the site. If the problem is around understanding a sensitive wetland then the monitoring program should be targeted to capture information about the wetland including both surface and groundwater inputs and outputs. Finally, in some circumstances minimal monitoring may be acceptable, provided targeted site investigation is undertaken and correlated to already available data from the nearest long-term monitoring site.

Early consultation is recommended to assist with definition of monitoring and investigation work.

### *9.3.1 Predevelopment monitoring*

In low-lying shallow groundwater and clay soil environments such as those prevalent in the study area there is a need to fully understand the seasonal, inter-annual and long-term variability of the local groundwater system and the following questions need to be answered:

*Does the local groundwater level reflect the district or regional scale superficial aquifer or is there a localised perching effect due to low in-situ soil permeability and/or the presence of impermeable materials in the soil profile?*

- Localised perching can be permanent or seasonal depending on the extent and level of the impermeable layer. It is critical to develop an understanding of the relationship between the local groundwater system and the geotechnical conditions.
- Local wetlands and waterways may be sustained by a local perched groundwater system or the district or regional scale superficial groundwater system
- Shallow perched groundwater systems are sensitive to changes to the pre-developed water balance, such as a focus on 'at source' infiltration, or importation of irrigation water.
- Poorly draining in-situ soils can limit the ability for water to enter the groundwater system. It is important to understand the extent to which locally generated stormwater contributes to the groundwater system or runs off.

*How close to the natural surface does the pre-development groundwater rise during an average winter?*

- These are the conditions that are likely to be experienced frequently and can impact on the amenity and liveability of the subdivision, in particular reducing the functionality of public open spaces as well as being potentially damaging to infrastructure.

*How close to the natural surface does the groundwater rise during a wet winter?*

- These are less frequent occurrences and may not have occurred at all in recent history, but it remains important to understand how groundwater will behave under them so that the urban form can be designed appropriately.

To answer these questions groundwater level monitoring needs to be undertaken and capture at least two winters locally so that this data can be correlated to the nearest available longer-term record and the long-term patterns can be understood.

Where there is a locally perched groundwater system it is important to consider the extent to which local groundwater levels may be disconnected from the regional groundwater system on a seasonal, annual or inter-annual basis. Monitoring programs should be tailored to include this consideration potentially using paired deep and shallow bores.

Where subsoil drainage is likely to be used to manage a shallow groundwater system the following additional questions will need to be considered:

*What level is acceptable for installation of subsurface drainage (CGL)?*

- The definition of an acceptable CGL should be undertaken consistent with *Water resource considerations when controlling groundwater levels in urban development* (DWER, 2013) in consultation with the Shire of Serpentine-Jarrahdale and for approval by DWER in their role as water resource managers.
- This process generally considers the impact to the regional or district scale superficial aquifer and the wetlands and watercourses that it sustains and may require significant additional monitoring and investigation work.
- There is also a risk of impacts to local wetlands and watercourses as well as potential for significant groundwater export from locally perched systems and these effects need to be fully understood to be managed.

*What is the potential water quality impact from stormwater and groundwater that will be discharged from the drainage system?*

- It is critical to gain an understanding of the in-situ soil and groundwater quality that will be mobilised by the system so that an appropriate level of treatment can be provided.
- Where historic land uses indicate a risk of contamination or there is a known contaminated site present within or in proximity to the site, additional investigations will be necessary.
- Additionally, it is necessary to understand water quality in the receiving environment so that any impacts in the future can be properly identified and understood.

To answer these questions, surface water and groundwater quality information needs to be collected. The data must be sufficient to provide an understanding of seasonal trends and recent enough to capture the current status of the site and surrounding land uses. Generally, this will require sampling to be undertaken on at least four to six occasions timed to provide at least one sample per season.

### *9.3.2 Establishment of trigger values*

Site specific trigger values should be established following completion of any predevelopment monitoring program. Trigger values should be established applying procedures consistent with *ANZECC and ARMCANZ 2000* using local reference data where possible to derive the 80$^{th}$ percentile and applying default trigger values from regional reference data as a fall-back.

### 9.3.3 Post-development monitoring

The key objectives of post-development monitoring are to:

- Determine the quantity and quality of groundwater and surface water on site and downstream of the site post-development;
- Ascertain whether the quantity and quality of groundwater and surface water has significantly changed post-development; and
- Establish the performance of water quality systems that have been installed by the developer and to determine whether they are successful. Where water quality systems are found to be less effective than is desirable, they will act as 'lessons learnt' for future subdivisions.

### 9.3.4 Monitoring specification

Post-development monitoring should commence 2 years after titling of lots and continue for a duration of not less than 3 years.

#### Surface water

Surface water monitoring sites should be selected to address the key objectives of post-development monitoring outlined above. Monitoring should include but not necessarily be limited to:

- Flow
- Quality
- Visual inspection and photographic record of drainage outlets and water quality treatment systems. Any outflows observed at these locations during inspection should be sampled opportunistically to coincide with other sampling.
- Visual inspection and photographic record of overland flowpaths to detect the occurrence of any maintenance and management issues such as the deposition of waste, sediment, and the presence of mosquitoes or algal growth.

The specific methodology for flow data collection may vary from site to site and does not necessarily include continuous monitoring. However, flow monitoring should be undertaken with site specific consideration of an appropriate methodology for estimation of contaminant loads to receiving environments.

Surface water sampling should be undertaken fortnightly from August to October (i.e. six fortnightly monitoring events) to capture peak winter baseflows, and once in March to capture the first baseflows post-summer.

Surface water samples should be submitted to a NATA-accredited laboratory in accordance with Australian Standards and analysed for the following parameters:

- In situ pH, electrical conductivity (EC), dissolved oxygen, temperature;
- pH
- Total suspended solids (TSS);
- Total nitrogen (TN) and total dissolved nitrogen (TDN)
- Ammonia (NH4);
- Nitrate and nitrite (Nox-N);
- Total phosphorous (TP); and
- Filterable reactive phosphorous (FRP).

The following additional parameters should be included in the laboratory analysis on an annual basis:

- Major anions (chloride, bromide and sulphate);
- Major cations (calcium, magnesium, sodium and potassium); and
- Iron (Fe) and aluminium (Al).

Groundwater

Groundwater monitoring sites should be selected to address the key objectives of post-development monitoring outlined above. Monitoring should include but not necessarily be limited to:

- Levels
- Quality

Monitoring of groundwater levels and the collection of groundwater samples should be undertaken on a quarterly basis.

Groundwater samples should be submitted to a NATA-accredited laboratory in accordance with Australian Standards and analysed for the following parameters:

- In situ pH, electrical conductivity (EC), dissolved oxygen, temperature;
- pH
- Total suspended solids (TSS);
- Total nitrogen (TN) and total dissolved nitrogen (TDN);
- Ammonia (NH4);
- Nitrate and nitrite (Nox-N);
- Total phosphorous (TP); and
- Filterable reactive phosphorous (FRP).

The following additional parameters should be included on an annual basis:

- Major anions (chloride, bromide and sulphate);
- Major cations (calcium, magnesium, sodium and potassium); and
- Iron (Fe) and aluminium (Al).

### *9.3.5 Reporting*

The Shire of Serpentine-Jarrahdale should be advised of any trigger value exceedances immediately. The Shire of Serpentine-Jarrahdale requires annual reports to be provided for all post development monitoring programs. Monitoring data should be provided in electronic format, preferably as an excel spreadsheet. Reports should include:

- Summary tables, graphs and maps presenting spatial and temporal variations of flow and quality;
- Estimation of contaminant loads to the downstream environment based on collected water quality and flow data;
- Discussion of findings including investigations undertaken in response to trigger value exceedances;
- Recommendations for modified monitoring regime and/or trigger values where required; and
- Presentation of site inspection findings including photographs and field notes
- Groundwater bore construction logs.

## 9.4 Action plan

Table 4:Actions and responsibilities for implementation of the strategy

| Action | Responsibility | Timing |
|---|---|---|
| Development of water management documents | Proponents of development | As part of the planning and development process |
| Assessment of DWMS and LWMS documents | DWER in consultation with the Shire of Serpentine-Jarrahdale | In accordance with statutory planning process timeframes |
| Assessment of UWMP documents and subdivision designs | Shire of Serpentine-Jarrahdale in consultation with DWER | In accordance with statutory planning process timeframes |

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## 10.1 Local structure plans

A full current list of local structure plans can be accessed via the Shire of Serpentine Jarrahdale website << http://www.sjshire.wa.gov.au/what-we-do/planning-and-building/structure-plans/>> (link correct at 25 January 2018)

## 10.2 Local water management strategies and urban water management plans

A large number of Local Water Management Strategies (LWMS) and Urban Water Management Plans (UWMP) have been prepared to support local structure planning and subdivisions within the study area. The following list is not exhaustive but provides a summary of most of the reports that have been previously approved in the study area:

- Byford Town Centre Local Water Management Strategy (GHD, 2014)
    - Lot 1 Abernethy Road, Byford UWMP (Wave International, 2016)
    - Lot 2 Abernethy Rd, Byford UWMP (JDA, 2015)
    - Lot 4 Abernethy Road, Byford - UWMP (True Civil Consulting, 2018)
    - Lot 5 Abernethy Road, Byford UWMP (GHD, 2017)
    - Lot 15 Abernethy Road, Byford UWMP (RPS, 2016)
- Lots 1,2 & 63 Thomas Road, Larsen Road, Byford (Byford Central) DNMP (Cardno, 2006)
- Lots 4&5 Abernethy Road, Byford (Byford West) DNMP (Cardno, 2007)
- Byford Main Precinct Local Structure Plan (The Glades): LWMS (JDA, 2005)
    - The Glades at Byford: Stages 6, 7 & 8a UWMP (JDA 2011)
    - The Glades at Byford: Woodland Grove North UWMP (JDA 2013)
    - The Glades at Byford: Icaria Stages 1 to 4 UWMP (JDA, 2014)
    - The Glades at Byford: Icaria Stages 5 to 10 UWMP (JDA, 2014)
    - The Glades at Byford: Woodland Grove South UWMP (JDA 2013)
    - The Glades at Byford: Stage 2 UWMP (JDA, 2009)
    - The Glades at Byford: Stage 9 & High School Precinct UWMP (JDA, 2011)
    - The Glades at Byford: Stage 8 UWMP (JDA, 2012)
    - The Glades Cardup Brook, East and West Precinct, UWMP (JDA, 2016)
- Lot 9 Abernethy Road (Kalimna Estate) LWMS (DEC, 2009)
    - Lot 9 Abernethy Rd, Byford, UWMP (DEC, 2010)
- Redgum Brook Estate DNMP (GHD, 2008)
    - Redgum Brook Estate (Northern Section) LWMS (GHD, 2014)
    - Redgum Brook Estate Stages 9-12, UWMP (GHD, 2015)
    - Redgum Brook – East of Kardan Boulevard, UWMP (GHD, ???)
    - Redgum Brook Stage 10A, 10B and Stage 13 UWMP (GHD, 2014)
- Larsen Road Estate (Marri Park), Byford UWMP (Cardno 2008)
- Grange Meadows, Byford UWMP (BPA Engineering, 2013)
- Lot 9500 Thomas Road, Byford (Byford Meadows) LWMS (HyD2o, 2014)
    - Lot 9500 Thomas Road, (Byford Meadows), Stage 1 UWMP (Hyd2o, 2014)
    - Lot 9500 Thomas Road, (Byford Meadows), Stage 2(a&b) UWMP (Hyd2o, 2015)
    - Lot 9500 Thomas Road, (Byford Meadows), Stage 2c UWMP (Hyd2o, 2016)
    - Byford Meadows (Remaining Stages), UWMP (Hyd2o, 2017)
- Byford, Doley Road Precinct Local Water Management Strategy (EE, 2016)
    - Parcel Property Landholding, Byford (Doley Precinct) UWMP (Urbaqua, 2017)
    - Lot 8, 9 & 23 Warrington Road, Byford (Doley Precinct) UWMP (Cardno 2017)
- Lot 2 Nettleton Road, Byford (Brook @ Byford) LWMS (JDA, 2009)
    - Lot 2 Nettleton Road, Byford (Brook @ Byford) LWMS Addendum (Hyd2o, 2012)
    - Lot 2 Nettleton Road, Byford (Brook @ Byford) Stage 1 UWMP (Hyd2o, 2013)
    - The Brook @ Byford Stages 1-3 UWMP (EE, 2016)
- L1, L3 & L128 South Western Highway, Byford - LWMS (GHD, 2012)
- Town Planning Scheme 2 Amendment 77 (Byford on the Scarp) DNMP (Gilbert Rose Consulting, 1999)
    - Byford on the Scarp – Stages 4, 5 & 6 UWMP (JDA, 2008)
    - Byford on the Scarp – Stage 7 UWMP (EE, 2014)
    - Byford on the Scarp – Stage 8a UWMP (EE, 2016)

# APPENDIX A – STORMWATER MODELLING IN INFOWORKS ICM

InfoWorks ICM is a hydraulic modelling package used to simulate stormwater drainage systems. The software package is capable of hydrological modelling of the complete urban water cycle, including stormwater drainage master planning or studies, assessments of flooding in urban drainage systems and hydraulic response of the stormwater network infrastructure to the changes in the land use. The hydraulic software component can resolve open channel and closed conduit flows and model the effect of backwater and reverse flow. The model is used predominantly for calculations of event-based simulations; therefore, the initial conditions are usually set to the worst-case scenario.

Time-varying surface runoff generated by the runoff routing model discharges into the hydraulic network. The hydraulic network consists of interconnected nodes (manholes, outfalls and storage basins) and links (weirs, pipes, culverts and open channels).

InfoWorks ICM is an evolution of InfoWorks CS which was used to develop the original *Byford Townsite DWMP* (DWER 2008) model. The model retains the same 1-Dimensional computational system although stability has been improved and has been integrated with a 2-Dimensional flexible mesh overland flood routing module which can be specified over the whole model domain or at targeted locations where significant breakout flow is known to occur.

The 'base model' presented in sections A.1 to A.4 and Figure A.1 of this report has been constructed using InfoWorks ICM to enable direct comparison to the previous post-development Byford Townsite DWMP model. The 'current system model' presented in sections A.5 to A.7 and Figure A.2 of this report includes the following modifications:

- Expanded study area to include development outside of the Byford Townsite structure plan area;
- Hydrological parameters (catchment loss rates) adjusted consistent with those adopted for the *Birrega Oaklands flood modelling and drainage study* (DWER, 2015);
- Hydraulic system elements and structures modified to reflect changes to the system that have been constructed or approved in UWMPs or engineering design plans; and
- Hydraulic system elements and structures modified to reflect any survey information that can be obtained within the timeframes of the project.

To provide an understanding of the individual impacts of the various updates, a version of the base model incorporating updated hydrological parameters has been developed and both of these models (base and base with revised parameters) have been run with the following design rainfall events:

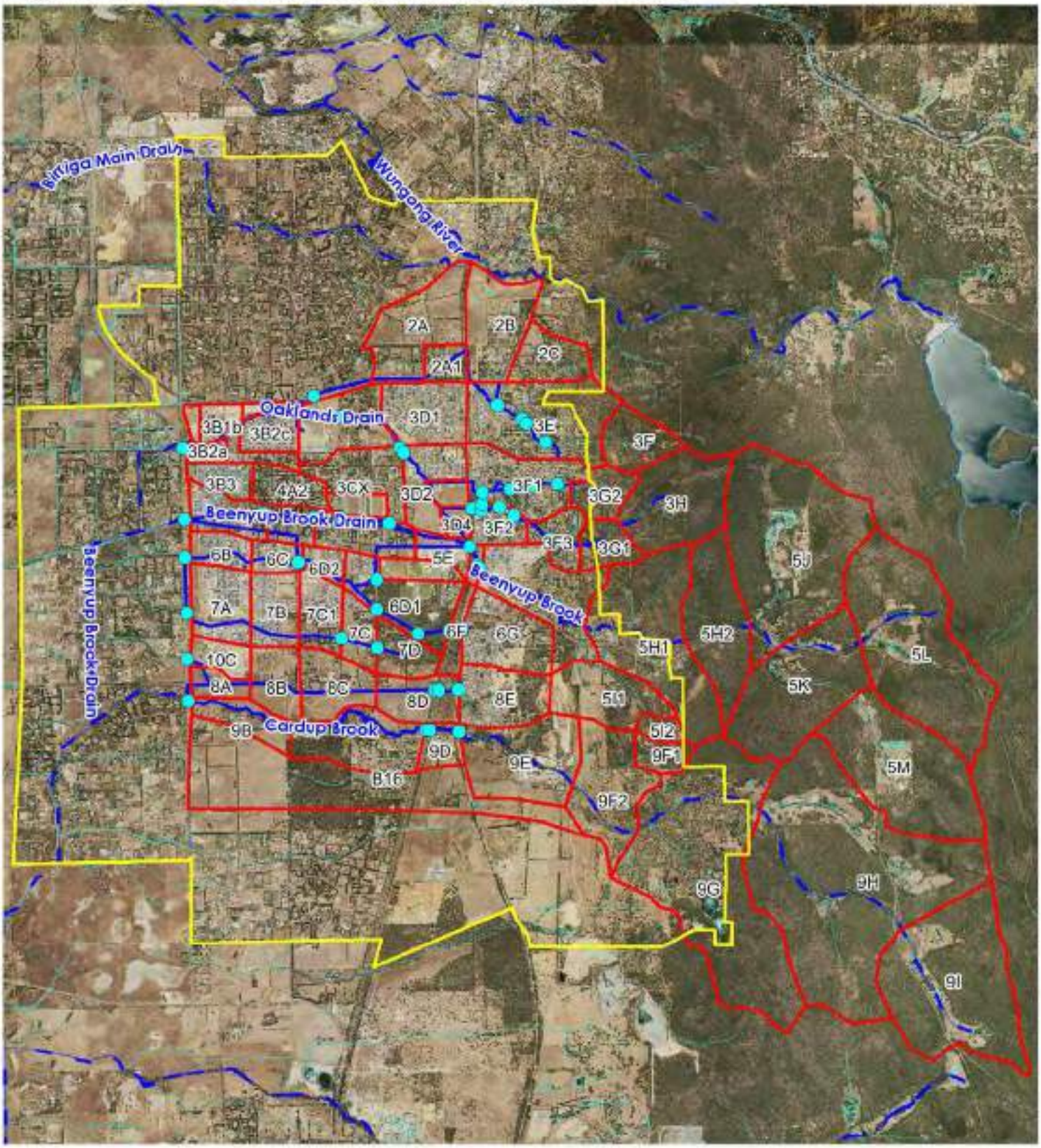
- AR&R 1996 - 1h, 3h, 6h, 12h, 24h, 48h and 72h durations for 5y and 100y ARI; and
- AR&R 2016 – 1h, 3h, 6h, 12h, 24h, 48h and 72h durations for 20% and 1% AEP.

It is recognised that the 5y ARI event is not directly comparable to the 20% AEP. However, it is noted that the 5y ARI is the appropriate event for calibration with previous modelling and the 20% AEP is the appropriate event for application of the 2016 AR&R methodology. Hence these two design events have been selected for use and are presented comparatively in this report.

Finally, the completed 'current system' model incorporating all updates has been run with the following events and was used to develop the stormwater management strategy presented in section 6 of this DWMS:

- AR&R 2016 – 1h, 3h, 6h, 12h, 24h, 48h and 72h durations for 20% and 1% AEP.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure A1 - Model layout, base model




Legend

- DWMS Study Area
- Modelled drain/watercourse
- Modelled subcatchment
- Modelled structures (culverts/bridges)

Scale 1: 60,000 at A4

0 1.2km

N

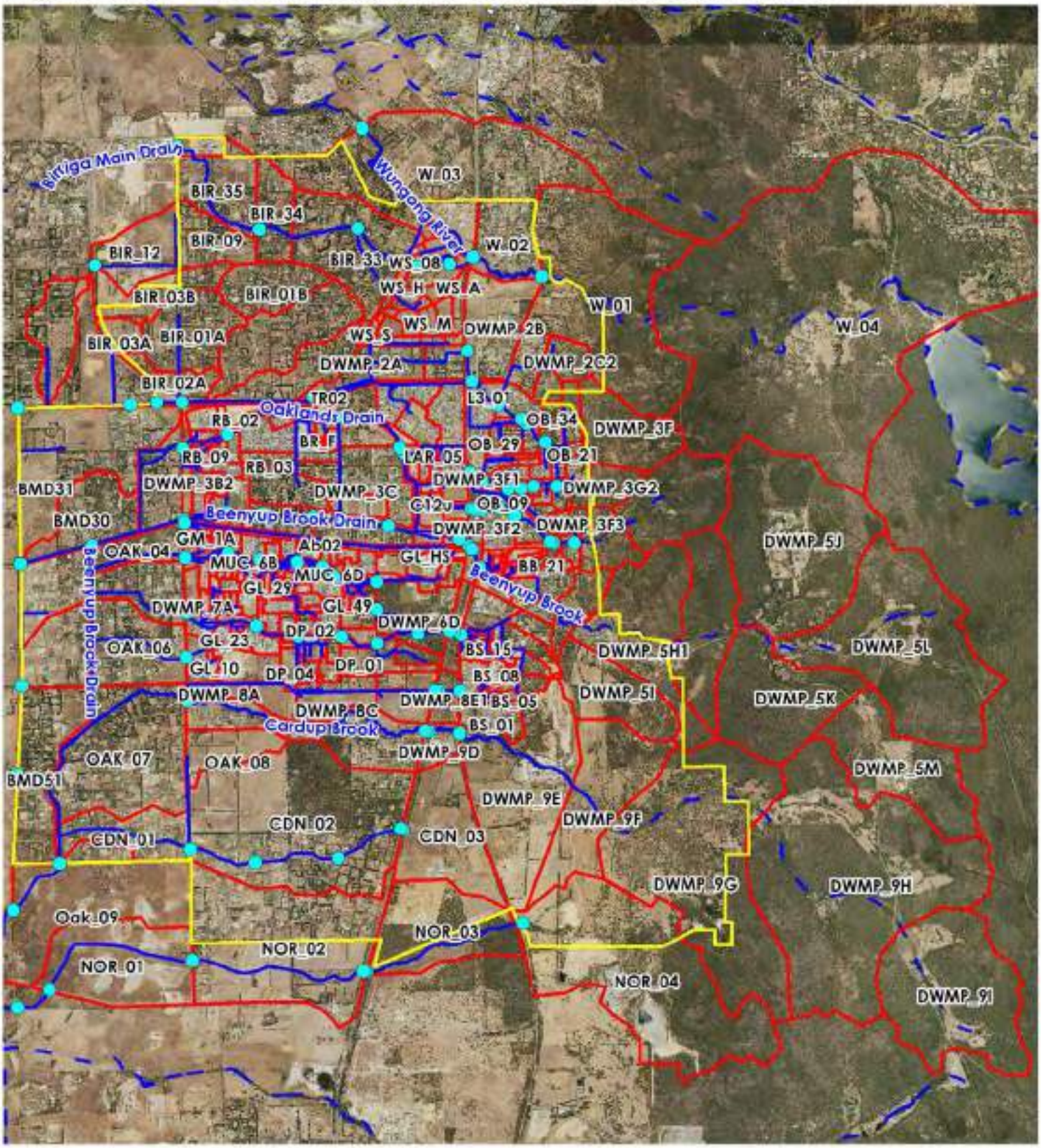
urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER, Created by: HB. Projection: MGA: zone 50.

# Shire of Serpentine Jarrahdale - Byford DWMS

## Figure A2 - Model layout, current system model




Legend

- DWMS Study Area
- Modelled structures
- Modelled drains/watercourses
- Modelled subcatchments

Scale 1: 60,000 at A4

0 1.2km

N

urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER, Created by: HB. Projection: MGA: zone 50.

## A.1 Initial modelling assumptions

The following assumptions developed for the original *Byford Townsite DWMP* (DWER 2008) have been retained in the base model:

- Peak winter groundwater levels (controlled groundwater levels) applied as starting water levels in basins and as baseflows in drains.
- Design rainfall events applied to whole catchment with universal start time.
- 100-year flood levels taken from *the Byford floodplain management strategy* SKM, 2007) applied as constant tailwater at the Hopkinson Road end of each modelled waterway.
- Infiltration modelled at a constant rate of 4 mm/hour.
- Catchment parameterisation (pervious/impervious breakdown, catchment slope, roughness, losses) adapted from *Byford floodplain management strategy* (SKM, 2007).

## A.2 Base model hydraulics

The InfoWorks ICM base model has been developed consistent with the original *Byford Townsite DWMP* (DWER 2008). The hydraulic model consists of a combination of piped drainage, channels with cross-sections derived from 2008 LiDAR data and culvert structures.

All hydraulic components of the system including local detention basins and culvert structures have been modelled in the base model as developed for the original *Byford Townsite DWMP* (DWER, 2008). Table A1 presents the significant culvert structures that have been included within the base model consistent with the original *Byford Townsite DWMP* (DWER, 2008).

The InfoWorks ICM base model has been established applying Manning's roughness coefficients to modelled conduits summarised in Table A2 and consistent with the original *Byford Townsite DWMP* (DWER 2008).

Table A1: Modelled hydraulic structures – base model

| Location X | Y | Shape | Diameter/ width (mm) | Height (mm) | Invert level (mAHD) | Number of barrels |
|---|---|---|---|---|---|---|
| 403208.5 | 6435653 | Rect | 3600 | 1900 | 24.3 | 1 |
| 403229.3 | 6434846 | Rect | 3700 | 1560 | 24.5 | 1 |
| 403239.8 | 6434410 | Circ | 455 | | 26.5 | 2 |
| 403253.7 | 6433783 | Rect | 1200 | 500 | 26.0 | 1 |
| 403262.8 | 6433262 | Circ | 720 | | 26.5 | 2 |
| 403273.1 | 6432784 | Rect | 1800 | 1500 | 26.0 | 1 |
| 404128.2 | 6434914 | Circ | 900 | | 30.2 | 3 |
| 404524.3 | 6434359 | Circ | 750 | | 34.0 | 2 |
| 404696.5 | 6434870 | Circ | 900 | | 34.7 | 3 |
| 404696.9 | 6436247 | Rect | 3200 | 1200 | 30.1 | 1 |
| 405008.4 | 6434863 | Rect | 1210 | 920 | 38.2 | 2 |
| 405010 | 6436013 | Rect | 1880 | 1220 | 31.8 | 1 |
| 405015.2 | 6433493 | Circ | 450 | | 38.6 | 2 |
| 405415.5 | 6433829 | Rect | 1200 | 450 | 44.2 | 1 |

| Location X | Y | Shape | Diameter/ width (mm) | Height (mm) | Invert level (mAHD) | Number of barrels |
|---|---|---|---|---|---|---|
| 405416.3 | 6434165 | Circ | 450 | | 44.1 | 2 |
| 405419.4 | 6433387 | Circ | 450 | | 42.6 | 2 |
| 405555.7 | 6434803 | Rect | 1500 | 600 | 44.4 | 2 |
| 405674.3 | 6435663 | Rect | 1220 | 1220 | 37.7 | 1 |
| 405721.7 | 6435606 | Rect | 1220 | 1200 | 38.6 | 1 |
| 405888.7 | 6433545 | Rect | 1500 | 600 | 51.0 | 1 |
| 405948.4 | 6432459 | Circ | 600 | | 52.0 | 2 |
| 405965.5 | 6432457 | Circ | 1700 | | 50.4 | 1 |
| 406015.3 | 6432454 | Circ | 1700 | | 50.9 | 1 |
| 406075.1 | 6432908 | Circ | 300 | | 56.0 | 3 |
| 406118.2 | 6432906 | Rect | 1220 | 920 | 56.6 | 1 |
| 406240.7 | 6433588 | Rect | 1200 | 450 | 54.4 | 2 |
| 406294.5 | 6433581 | Rect | 1220 | 920 | 55.9 | 1 |
| 406346.6 | 6432438 | Circ | 900 | | 54.9 | 1 |
| 406381.3 | 6433607 | Circ | 380 | | 57.2 | 2 |
| 406470.4 | 6434539 | Rect | 1240 | 1200 | 55.7 | 4 |
| 406493.3 | 6434972 | Rect | 4000 | 1200 | 47.7 | 1 |
| 406560.8 | 6434328 | Rect | 7500 | 1500 | 60.2 | 1 |
| 406577.9 | 6434299 | Rect | 4500 | 1500 | 60.5 | 1 |
| 406604.7 | 6434949 | Circ | 900 | | 54.5 | 3 |
| 406610.4 | 6435019 | Circ | 900 | | 54.4 | 1 |
| 406618.1 | 6435153 | Rect | 1520 | 640 | 54.3 | 2 |
| 406789.4 | 6436146 | Circ | 900 | | 66.0 | 2 |
| 406809.9 | 6434986 | Circ | 900 | | 58.5 | 1 |
| 406926.3 | 6435191 | Circ | 900 | | 62.7 | 1 |
| 406969.5 | 6434893 | Circ | 750 | | 64.1 | 1 |
| 407055.4 | 6435204 | Circ | 900 | | 66.7 | 1 |
| 407064.5 | 6435984 | Circ | 600 | | 78.3 | 2 |
| 407113.2 | 6435934 | Circ | 600 | | 82.0 | 2 |
| 407189.3 | 6435228 | Circ | 900 | | 72.0 | 1 |
| 407334.3 | 6435724 | Circ | 600 | | 92.5 | 2 |
| 407381.5 | 6434623 | Circ | 750 | | 75.0 | 1 |
| 407422.1 | 6434579 | Circ | 750 | | 77.0 | 1 |
| 407462.3 | 6433851 | Circ | 1100 | | 73.5 | 3 |
| 407467.3 | 6435252 | Circ | 300 | | 77.5 | 1 |

Table A2: **Culvert roughness coefficients (Manning's N)**

| Drain Type | Manning's coefficient of roughness |
|---|---|
| Maintained open drain | 0.030 |
| Unmaintained open drain | 0.050 |
| Circular culvert | 0.012 |
| Rectangular culvert | 0.013 |
| Over road flood route | 0.015 |
| Over land flood route | 0.035 |

## A.3 Base model hydrology

The InfoWorks CS model of Byford townsite developed for the *Byford Townsite DWMP* (DWER 2008) used a constant infiltration model to generate rainfall runoff and the SWMM single non-linear reservoir routing model to provide inflows to the hydraulic component of the model. This has been maintained in the new InfoWorks ICM base model.

Each subcatchment in the study area is subdivided into pervious and impervious areas that have surface roughness, initial losses and infiltration losses applied according to land use and consistent with the *Byford Townsite DWMP* (DWER 2008) as shown in Table A3.

Land uses have been retained from the original *Byford Townsite DWMP* (DWER 2008) post-development model (Table A4). The percentage of impervious area for individual catchments was calculated from existing land use and the district structure plan; summarised in Table A5.

Table A3: InfoWorks model runoff area properties

| Land use | Surface roughness (Manning's N) | | Initial loss (mm) | | Infiltration loss (mm/hour | | Fixed runoff coefficient | |
|---|---|---|---|---|---|---|---|---|
| | Perv | Imperv | Perv | Imperv | Perv | Imperv | Perv | Imperv |
| Upper forested | 0.080 | 0.015 | 10 | 1.5 | n/a | n/a | 0.2 – 10y<br>0.5 – 100y<br>0.4 – 100y (design) | 1.0 |
| Rural pasture | 0.050 | 0.015 | 10 | 1.5 | 4 | 0 | n/a | n/a |
| Existing urban | 0.025 | 0.015 | 10 | 1.5 | 4 | 0 | n/a | n/a |
| Constructed urban | 0.025 | 0.015 | 10 | 15 | 4 | 0 | n/a | n/a |

Table A4: InfoWorks model land use surface breakdown

| Land use category | Pervious area 1 (%) | Effective impervious area 2 (%) |
|---|---|---|
| Roads | 30% | 70% |
| Mixed business | 25% | 75% |
| Neighbourhood centres | 45% | 55% |
| Town centres | 40% | 60% |
| Residential (R20-R60) | 50% | 50% |
| Rural residential (R2) | 100% | 0% |
| Schools | 50% | 50% |

*Note: Effective impervious areas presented in this table are for modelling at the catchment scale and are not to be used for individual lot runoff calculations.*

Table A5: InfoWorks model catchment properties for base model scenario

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| 10C | 24.672 | 1.4 | 300.0 | 38.486 |
| 2A | 95.713 | 1.5 | 800 | 3.05 |
| 2A1 | 20.593 | 2 | 250 | 29.799 |
| 2B | 79.625 | 4.1 | 800 | 1.518 |
| 2C | 44.476 | 11.8 | 600 | 1.539 |
| 3B1a | 7.153 | 1.8 | 300 | 28.681 |
| 3B1b | 18.029 | 1.8 | 300 | 28.681 |
| 3B1c | 6.053 | 1.8 | 300 | 28.681 |
| 3B2a | 10.392 | 1.8 | 181.9 | 31.57 |
| 3B2b | 15.68 | 1.8 | 223.4 | 28.8 |
| 3B2c | 29.11 | 1.8 | 304.4 | 21.37 |
| 3B3 | 24.579 | 1.8 | 300 | 28.8 |
| 3C | 68.051 | 1.4 | 700 | 21.37 |
| 3CX | 56.251 | 2 | 750 | 47.953 |
| 3D1 | 65.07 | 3.4 | 800 | 38.265 |
| 3D2 | 49.011 | 2.1 | 600 | 26.702 |
| 3D3 | 12.82 | 2.1 | 200 | 33.162 |
| 3D4 | 11.409 | 2.5 | 200 | 27.361 |
| 3E | 136.379 | 10.8 | 1200 | 42.017 |
| 3F | 45.228 | 26.3 | 1100 | 0 |
| 3F1 | 80.81 | 5.6 | 850 | 53.969 |
| 3F2 | 27.055 | 3.8 | 500 | 60.001 |
| 3F3 | 31.54 | 13 | 750 | 47.97 |
| 3G1 | 30.298 | 24.6 | 700 | 0 |
| 3G2 | 33.347 | 24.3 | 900 | 0 |
| 3H | 109.757 | 16.4 | 950 | 0 |
| 4A2 | 34.352 | 1.8 | 600 | 54.024 |
| 4B | 16.631 | 2 | 250 | 5.989 |
| 5B | 40.298 | 1.6 | 400 | 26.976 |
| 5C | 22.714 | 1.7 | 300 | 36.151 |
| 5D | 47.859 | 2 | 400 | 34.95 |
| 5E | 21.189 | 2.1 | 300 | 31.609 |
| 5F | 6.314 | 3.8 | 200 | 20.449 |
| 5G | 108.901 | 8.1 | 900 | 35.969 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| 5H1 | 182.568 | 17.1 | 1100 | 0 |
| 5H2 | 108.331 | 13.2 | 800 | 0 |
| 5I1 | 74.415 | 17.1 | 700 | 0 |
| 5I2 | 13.563 | 19.8 | 300 | 0 |
| 5J | 268.448 | 8.8 | 1200 | 0 |
| 5K | 163.319 | 11 | 900 | 0 |
| 5L | 246.591 | 5.4 | 1100 | 0 |
| 5M | 188.239 | 5.8 | 1000 | 0 |
| 6B | 26.896 | 1.8 | 500 | 28.798 |
| 6C | 19.783 | 1.9 | 300 | 31.791 |
| 6D1 | 77.237 | 2.1 | 450 | 15.11 |
| 6D2 | 16.049 | 1.5 | 250 | 29.278 |
| 6E | 20.92 | 1.8 | 350 | 39.315 |
| 6F | 17.8 | 3.6 | 300 | 5.331 |
| 6G | 74.373 | 4.3 | 850 | 0 |
| 7A | 57.144 | 1.2 | 500 | 33.378 |
| 7B | 46.18 | 1.4 | 500 | 40.158 |
| 7C | 29.356 | 1.8 | 450 | 39.404 |
| 7C1 | 40.884 | 1.3 | 500 | 40.196 |
| 7D | 34.041 | 1.9 | 300 | 24.176 |
| 8A | 18.977 | 1.3 | 250 | 23.179 |
| 8B | 44.054 | 1.5 | 400 | 39.852 |
| 8C | 54.599 | 1.5 | 500 | 37.906 |
| 8D | 47.806 | 1.9 | 500 | 42.541 |
| 8E | 65.206 | 6.6 | 800 | 1.765 |
| 9B | 37.144 | 2 | 400 | 4.672 |
| 9C | 85.439 | 3.9 | 600 | 11.069 |
| 9D | 22.645 | 4 | 300 | 4.19 |
| 9E | 113.147 | 9.5 | 1000 | 0 |
| 9F1 | 22.219 | 27 | 700 | 0 |
| 9F2 | 101.466 | 21.1 | 1100 | 0 |
| 9G | 355.666 | 15.7 | 1900 | 0 |
| 9H | 463.327 | 10.4 | 2200 | 0 |
| 9I | 232.132 | 5.7 | 1800 | 0 |
| B16 | 224.573 | 2 | 1500 | 0 |

## A.4 Base model validation

Peak flows and levels generated by the InfoWorks ICM base model at various critical locations within the major waterways were compared to peak post-development flows presented in Table 6.2 of the original *Byford Townsite DWMP* (DWER 2008). This comparison is presented in Table A6 and Table A11.

In general, the base model flows and levels compare well to those generated by the original *Byford Townsite DWMP* (DWER 2008) with a small number of discrepancies. Notable level differences (>100mm) are observed at locations 1 and 14 while notable flow differences (>5%) are observed at locations 4 and 14.

Where the new model predicts lower flows and levels, such as at location 14 on Beenyup Brook, it is thought likely that discrepancies are a result of improved model performance with artificial peaks in the 2008 model being caused by minor instabilities. Differences on Oaklands drain however, where the new model predicts higher flows, but similar levels is likely to be associated with small differences in the hydraulic configuration of the model in this location and not reflective of the overall performance of the models compared to each other.

Table A6: Base model peak flow comparison to Byford Townsite DWMP (DWER, 2008) post-development model

| Location | 5-year ARI peak flows | | 100-year ARI peak flows | |
|---|---|---|---|---|
| | Base model | 2008 DWMP | Base model | 2008 DWMP |
| 1. Oaklands drain d/s George Road (north) | 5.5 | 5.5 | 10.2 | 10.2 |
| 2. Oaklands drain d/s George Road (south) | 2.3 | 2.4 | 10.7 | 10.7 |
| 3. Oaklands drain d/s Evans Road | 10.7 | 10.7 | 34.4 | 34.5 |
| 4. Oaklands drain d/s Briggs Road | 11.0 | 11 | 35.1 | 30.2 |
| 5. Oaklands drain at Thomas Road and Masters Road | 9.5 | 9.5 | 25.7 | 25.7 |
| 6. Oaklands drain d/s Malarkey Road | 20.9 | 20.8 | 62.0 | 59.3 |
| 7. Oaklands drain at Hopkinson Road | 15.8 | 15.7 | 51.5 | 48.9 |
| 8. Beenyup Brook d/s South Western Hwy | 8.1 | 8.1 | 31.2 | 31.2 |
| 9. u/s end piped Beenyup Brook d/s Abernethy Road | 2.8 | 2.8 | 3.1 | 3.1 |
| 10. u/s end swale from Beenyup Brook to Oaklands drain | 5.2 | 5.2 | 16.1 | 16.1 |
| 11. u/s end swale down Abernethy Rd from Beenyup Brook to Trib 6 | 0.0 | 0 | 11.5 | 11.5 |
| 12. overland flow down Warrington Road | 0.0 | 0 | 1.3 | 1.3 |
| 13. overland flow down Doley Road | 0.0 | 0 | 2.7 | 2.7 |
| 14. Beenyup Brook at Hopkinson Road | 5.5 | 8.1 | 9.6 | 9.6 |
| 15. Tributary 6 u/s Briggs Road (Extn) | 1.4 | 1.4 | 3.4 | 3.4 |

| Location | 5-year ARI peak flows | | 100-year ARI peak flows | |
|---|---|---|---|---|
| | Base model | 2008 DWMP | Base model | 2008 DWMP |
| 16. Tributary 6 at Hopkinson Road | 1.6 | 1.6 | 6.8 | 6.7 |
| 17. Tributary 7 at Hopkinson Road | 2.1 | 2 | 5.1 | 5.1 |
| 18. Cardup Brook d/s South Western Hwy | 5.8 | 5.8 | 23.5 | 23.5 |
| 19. Cardup Brook at Hopkinson Road | 9.4 | 9.4 | 33.3 | 33.2 |

Table A7: Base model top water level comparison to Byford Townsite DWMP (DWER, 2008) post-development model

| Location | 5-year ARI top water level | | 100-year ARI top water level | |
|---|---|---|---|---|
| | Base model | 2008 DWMP | Base model | 2008 DWMP |
| 1. Oaklands drain d/s George Road (north) | 53.2 | 53.2 | 53.3 | 53.5 |
| 2. Oaklands drain d/s George Road (south) | 51.8 | 51.8 | 52.0 | 52 |
| 3. Oaklands drain d/s Evans Road | 44.3 | 44.3 | 44.6 | 44.6 |
| 4. Oaklands drain d/s Briggs Road | 32.7 | 32.7 | 32.9 | 32.9 |
| 5. Oaklands drain at Thomas Road and Masters Road | 30.9 | 30.9 | 31.1 | 31.1 |
| 6. Oaklands drain d/s Malarkey Road | 29.8 | 29.8 | 30.2 | 30.2 |
| 7. Oaklands drain at Hopkinson Road | 26.4 | 26.4 | 27.0 | 26.9 |
| 8. Beenyup Brook d/s South Western Hwy | 58.5 | 58.5 | 58.7 | 58.7 |
| 9. u/s end piped Beenyup Brook d/s Abernethy Road | 56.5 | 56.5 | 56.6 | 56.6 |
| 10. u/s end swale from Beenyup Brook to Oaklands drain | 56.5 | 56.5 | 56.6 | 56.6 |
| 11. u/s end swale down Abernethy Rd from Beenyup Brook to Trib 6 | 56.3 | 56.3 | 56.8 | 56.8 |
| 12. overland flow down Warrington Road | 44.5 | 44.5 | 45.4 | 45.4 |
| 13. overland flow down Doley Road | 34.5 | 34.5 | 35.5 | 35.5 |
| 14. Beenyup Brook at Hopkinson Road | 25.6 | 26 | 26.0 | 26.3 |
| 15. Tributary 6 u/s Briggs Road (Extn) | 41.6 | 41.6 | 41.7 | 41.7 |
| 16. Tributary 6 at Hopkinson Road | 27.5 | 27.6 | 27.7 | 27.7 |
| 17. Tributary 7 at Hopkinson Road | 27.0 | 27.1 | 27.2 | 27.2 |
| 18. Cardup Brook d/s South Western Hwy | 55.1 | 55.1 | 57.1 | 57.1 |
| 19. Cardup Brook at Hopkinson Road | 27.6 | 27.6 | 27.9 | 27.9 |

### *A.4.1 Results comparison to Birrega Oaklands flood modelling and drainage study*

The *Birrega Oaklands flood modelling and drainage study* (DoW, 2015) provides a table (5-9) which compares peak flows at three locations to the Byford DWMP (DWER, 2008). Table A8 provides a comparison of these flows with those predicted by the base model.

It is noted that the base model compares reasonably well to the Birrega Oaklands model for the Oaklands drain and Cardup Brook sites with some minor discrepancies. However, the base model predicts much larger 100-year ARI peak flows for the Beenyup Brook site. The completion of a drainage survey in the Byford old townsite and a thorough review of LiDAR data has revealed the presence of a large sump/storage area on the Beenyup Brook course upstream of Old Brickworks Road which was not modelled in the base model. It is thought that this storage area may largely account for the discrepancy in flows at this location.

Table A8: Birrega Oaklands model peak flow comparison to base model

| Location | Base model | | Birrega Oaklands study | |
|---|---|---|---|---|
| | 5-year ARI | 100-year ARI | 5-year ARI | 100-year ARI |
| 1. Oaklands drain d/s George Road (north) | 5.5 | 10.2 | 4.2 | 11.7 |
| 2. Beenyup Brook d/s South Western Hwy | 8.1 | 31.2 | 5.4 | 26.8 |
| 3. Cardup Brook d/s South Western Hwy | 5.8 | 23.5 | 8.0 | 22.7 |

## A.5 Revised parameterisation

Hydrological parameters (catchment loss rates) have been adjusted consistent with those adopted for the *Birrega Oaklands flood modelling and drainage study* (DoW, 2015). Adjustments include adoption of a revised infiltration loss rate of 2.9 mm/h (70mm/day), revised runoff coefficients for the upper forested catchments and the addition of a new catchment land use definition; Foothills. Revised parameters are presented in Table A9.

Table A9: InfoWorks model runoff area properties – revised

| Land use | Surface roughness **(Manning's N)** | | Initial loss (mm) | | Infiltration loss (mm/hour) | | Fixed runoff coefficient | |
|---|---|---|---|---|---|---|---|---|
| | Perv | Imperv | Perv | Imperv | Perv | Imperv | Perv | Imperv |
| Upper forested | 0.080 | 0.015 | 0 | 1.5 | n/a | n/a | 0.13 – 5y/20%<br>0.19 – 100y | 1.0 |
| Foothills | 0.050 | 0.015 | 0 | 1.5 | n/a | n/a | 0.26 – 5y/20%<br>0.42 – 100y | 1.0 |
| Rural pasture | 0.050 | 0.015 | 10 | 1.5 | 2.9 | 0 | n/a | n/a |
| Existing urban | 0.025 | 0.015 | 10 | 1.5 | 2.9 | 0 | n/a | n/a |
| Constructed urban | 0.025 | 0.015 | 10 | 15 | 2.9 | 0 | n/a | n/a |

### *A.5.1 Results comparison to base model*

Peak flows generated by the InfoWorks ICM base model with revised parameterisation were compared to peak flows generated by the original base model at various critical locations within the major waterways. This comparison is presented in Table A10 and Table A11.

Because the change in parameterisation reduces the upper forested pervious area runoff coefficient but introduces a new land use category and reduces the infiltration loss rate applied to other pervious areas the effects on various locations in the model are inconsistent. However, in general, the combined effect of these changes has increased peak flows and levels. This effect is apparent in results presented below in Table A10 and Table A11.

Table A10: Base model peak flow comparison to base model with revised parameters

| Location | 5-year ARI peak flows | | 100-year ARI peak flows | |
|---|---|---|---|---|
| | Base model | Base model (revised param.) | Base model | Base model (revised param.) |
| 1. Oaklands drain d/s George Road (north) | 5.5 | 6.0 | 10.2 | 10.5 |
| 2. Oaklands drain d/s George Road (south) | 2.3 | 3.9 | 10.7 | 11.7 |
| 3. Oaklands drain d/s Evans Road | 10.7 | 15.7 | 34.4 | 36.9 |
| 4. Oaklands drain d/s Briggs Road | 11.0 | 16.3 | 35.1 | 37.6 |
| 5. Oaklands drain at Thomas Road and Masters Road | 9.5 | 12.3 | 25.7 | 27.4 |
| 6. Oaklands drain d/s Malarkey Road | 20.9 | 29.2 | 62.0 | 66.2 |
| 7. Oaklands drain at Hopkinson Road | 15.8 | 27.5 | 51.5 | 53.8 |
| 8. Beenyup Brook d/s South Western Hwy | 8.1 | 11.1 | 31.2 | 32.2 |
| 9. u/s end piped Beenyup Brook d/s Abernethy Road | 2.8 | 2.9 | 3.1 | 3.1 |
| 10. u/s end swale from Beenyup Brook to Oaklands drain | 5.2 | 8.2 | 16.1 | 16.2 |
| 11. u/s end swale down Abernethy Rd from Beenyup Brook to Trib 6 | 0.0 | 0.0 | 11.5 | 11.9 |
| 12. overland flow down Warrington Road | 0.0 | 0.0 | 1.3 | 1.3 |
| 13. overland flow down Doley Road | 0.0 | 0.0 | 2.7 | 2.9 |
| 14. Beenyup Brook at Hopkinson Road | 5.5 | 6.3 | 9.6 | 10.2 |
| 15. Tributary 6 u/s Briggs Road (Extn) | 1.4 | 1.8 | 3.4 | 3.5 |
| 16. Tributary 6 at Hopkinson Road | 1.6 | 1.6 | 6.8 | 8.3 |
| 17. Tributary 7 at Hopkinson Road | 2.1 | 3.2 | 5.1 | 10.1 |
| 18. Cardup Brook d/s South Western Hwy | 5.8 | 10.4 | 23.5 | 28.1 |
| 19. Cardup Brook at Hopkinson Road | 9.4 | 12.6 | 33.3 | 27.5 |

Table A11: Base model top water level comparison to base model with revised parameters

| Location | 5-year ARI top water level | | 100-year ARI top water level | |
|---|---|---|---|---|
| | Base model | Base model (revised param.) | Base model | Base model (revised param.) |
| 1. Oaklands drain d/s George Road (north) | 53.2 | 53.2 | 53.3 | 53.3 |
| 2. Oaklands drain d/s George Road (south) | 51.8 | 51.9 | 52.0 | 52.0 |
| 3. Oaklands drain d/s Evans Road | 44.3 | 44.4 | 44.6 | 44.6 |
| 4. Oaklands drain d/s Briggs Road | 32.7 | 32.8 | 32.9 | 32.9 |
| 5. Oaklands drain at Thomas Road and Masters Road | 30.9 | 31.0 | 31.1 | 31.2 |
| 6. Oaklands drain d/s Malarkey Road | 29.8 | 29.9 | 30.2 | 30.3 |
| 7. Oaklands drain at Hopkinson Road | 26.4 | 26.6 | 27.0 | 27.0 |
| 8. Beenyup Brook d/s South Western Hwy | 58.5 | 58.6 | 58.7 | 58.7 |
| 9. u/s end piped Beenyup Brook d/s Abernethy Road | 56.5 | 56.6 | 56.6 | 56.6 |
| 10. u/s end swale from Beenyup Brook to Oaklands drain | 56.5 | 56.6 | 56.6 | 56.6 |
| 11. u/s end swale down Abernethy Rd from Beenyup Brook to Trib 6 | 56.3 | 56.3 | 56.8 | 56.8 |
| 12. overland flow down Warrington Road | 44.5 | 44.5 | 45.4 | 45.4 |
| 13. overland flow down Doley Road | 34.5 | 34.5 | 35.5 | 35.5 |
| 14. Beenyup Brook at Hopkinson Road | 25.6 | 25.8 | 26.0 | 26.1 |
| 15. Tributary 6 u/s Briggs Road (Extn) | 41.6 | 41.6 | 41.7 | 41.7 |
| 16. Tributary 6 at Hopkinson Road | 27.5 | 27.6 | 27.7 | 27.7 |
| 17. Tributary 7 at Hopkinson Road | 27.0 | 27.1 | 27.2 | 27.2 |
| 18. Cardup Brook d/s South Western Hwy | 55.1 | 55.1 | 57.1 | 56.9 |
| 19. Cardup Brook at Hopkinson Road | 27.6 | 27.7 | 27.9 | 27.9 |

### *A.5.2 Results comparison to Birrega Oaklands flood modelling and drainage study*

Table A12 provides a comparison of *Birrega Oaklands flood modelling and drainage study* (DoW, 2015) peak flows at selected locations with those predicted by the base model and base model with revised parameterisation.

In all cases, the effect of the parameterisation changes have been to increase peak flows and levels. This suggests that the peak flows presented in the *Birrega Oaklands flood modelling and drainage study* (DoW, 2015) were not reduced in comparison to earlier work because of hydrological parameter changes and may in fact be caused by hydraulic differences. Because the Birrega Oaklands model is a 2D model it is able to more accurately represent overland flow paths and catchment storage areas.

Table A12: Birrega Oaklands model peak flow comparison to base model with revised parameters

| Location | Base model | | Base model (revised param.) | | Birrega Oaklands study | |
|---|---|---|---|---|---|---|
| | 5-year ARI | 100-year ARI | 5-year ARI | 100-year ARI | 5-year ARI | 100-year ARI |
| 1. Oaklands drain d/s George Road (north) | 5.5 | 10.2 | 6.0 | 10.5 | 4.2 | 11.7 |
| 2. Beenyup Brook d/s South Western Hwy | 8.1 | 31.2 | 11.1 | 32.2 | 5.4 | 26.8 |
| 3. Cardup Brook d/s South Western Hwy | 5.8 | 23.5 | 10.4 | 28.1 | 8.0 | 22.7 |

## A.6 Australian Rainfall & Runoff 2016 methodology

Design rainfall events were derived from the Bureau of Meteorology's 2016 Intensity Frequency Durations combined with temporal patterns from the 2016 release of Australian Rainfall and Runoff (ARR16) for 1h, 3h, 6h, 12h, 24h, 48h and 72h durations at 1Exceedance per Year (1EY), 20% AEP, 10% AEP and1% AEP. Critical events were selected for presentation from the following groupings:

1. ARR16: 1EY; 1h(S1-10), 3h(S1-10), 6h(S1-10), 12h(S1-10), 24h(S1-10), 48h(S1-10) and 72h(S1-10).
2. ARR16: 20%AEP; 1h(S1-10), 3h(S1-10), 6h(S1-10), 12h(S1-10), 24h(S1-10), 48h(S1-10) and 72h(S1-10).
3. ARR16: 1%AEP; 1h(S1-10), 3h(S1-10), 6h(S1-10), 12h(S1-10), 24h(S1-10), 48h(S1-10) and 72h(S1-10).

The selected critical events are:

- For peak flow (at key culvert locations):
  - 1EY – 3h (S8) *[3h (S10 is very close second]*
  - 20%AEP – 6h(S10) *[3h (S10 is very close second]*
  - 1%AEP – 3h(S2)
- For detention volumes:
  - 1EY – 3h (S8) *[3h (S10 is very close second]*
  - 20%AEP – 6h(S10) *[3h (S10 is very close second]*
  - 1%AEP – 3h(S2)

### *A.6.1 Results comparison to base model*

Peak flows in critical 20% AEP and 1% AEP events generated by the InfoWorks ICM base model applying the revised AR&R2016 methodology were compared to peak flows generated by the original base model at various critical locations within the major waterways. This comparison is presented in Table A13 and Table A14.

It is noted that the 20% AEP is not the same as the 5-year ARI but rather the 4.48-year ARI. However, for the purposes of this investigation, the comparison of these events is considered a reasonable simplification.

Adoption of the Australian Rainfall & Runoff 2016 methodology has resulted in small and quite variable changes when the 5-year ARI and 20% AEP events are compared, there is no across the board change.

The comparison of the 100-year ARI event to the 1% AEP event however, results in a much more consistent increase in peak flows throughout the model, with some increases being quite significant as observed in Table A13 and Table A14 below.

Table A13: Base model peak flow comparison to base model with AR&R 2016 methods

| Location | 5-year ARI/20% AEP peak flows | | 100-year ARI/1% AEP peak flows | |
|---|---|---|---|---|
| | Base model | Base model (AR&R 2016) | Base model | Base model (AR&R 2016) |
| 1. Oaklands drain d/s George Road (north) | 5.5 | 4.1 | 10.2 | 16.0 |
| 2. Oaklands drain d/s George Road (south) | 2.3 | 2.3 | 10.7 | 17.4 |
| 3. Oaklands drain d/s Evans Road | 10.7 | 11.1 | 34.4 | 50.2 |
| 4. Oaklands drain d/s Briggs Road | 11.0 | 11.5 | 35.1 | 52.6 |
| 5. Oaklands drain at Thomas Road and Masters Road | 9.5 | 8.1 | 25.7 | 30.9 |
| 6. Oaklands drain d/s Malarkey Road | 20.9 | 19.6 | 62.0 | 70.2 |
| 7. Oaklands drain at Hopkinson Road | 15.8 | 15.0 | 51.5 | 53.3 |
| 8. Beenyup Brook d/s South Western Hwy | 8.1 | 8.7 | 31.2 | 45.4 |
| 9. u/s end piped Beenyup Brook d/s Abernethy Road | 2.8 | 2.8 | 3.1 | 3.2 |
| 10. u/s end swale from Beenyup Brook to Oaklands drain | 5.2 | 5.9 | 16.1 | 17.6 |
| 11. u/s end swale down Abernethy Rd from Beenyup Brook to Trib 6 | 0.0 | 0.0 | 11.5 | 21.7 |
| 12. overland flow down Warrington Road | 0.0 | 0.0 | 1.3 | 1.9 |
| 13. overland flow down Doley Road | 0.0 | 0.0 | 2.7 | 7.1 |
| 14. Beenyup Brook at Hopkinson Road | 5.5 | 5.5 | 9.6 | 13.4 |
| 15. Tributary 6 u/s Briggs Road (Extn) | 1.4 | 1.3 | 3.4 | 4.0 |
| 16. Tributary 6 at Hopkinson Road | 1.6 | 1.1 | 6.8 | 9.5 |
| 17. Tributary 7 at Hopkinson Road | 2.1 | 2.1 | 5.1 | 9.7 |
| 18. Cardup Brook d/s South Western Hwy | 5.8 | 6.1 | 23.5 | 26.2 |
| 19. Cardup Brook at Hopkinson Road | 9.4 | 9.1 | 33.3 | 36.7 |

Table A14: Base model top water level comparison to base model with AR&R 2016 methods

| Location | 5-year ARI/20% AEP top water level | | 100-year ARI/1% AEP top water level | |
|---|---|---|---|---|
| | Base model | Base model (AR&R 2016) | Base model | Base model (AR&R 2016) |
| 1. Oaklands drain d/s George Road (north) | 53.2 | 53.2 | 53.3 | 53.3 |
| 2. Oaklands drain d/s George Road (south) | 51.8 | 51.8 | 52.0 | 52.0 |
| 3. Oaklands drain d/s Evans Road | 44.3 | 44.3 | 44.6 | 44.7 |
| 4. Oaklands drain d/s Briggs Road | 32.7 | 32.7 | 32.9 | 33.0 |
| 5. Oaklands drain at Thomas Road and Masters Road | 30.9 | 30.9 | 31.1 | 31.2 |
| 6. Oaklands drain d/s Malarkey Road | 29.8 | 29.8 | 30.2 | 30.3 |
| 7. Oaklands drain at Hopkinson Road | 26.4 | 26.4 | 27.0 | 27.0 |
| 8. Beenyup Brook d/s South Western Hwy | 58.5 | 58.5 | 58.7 | 58.8 |
| 9. u/s end piped Beenyup Brook d/s Abernethy Road | 56.5 | 56.5 | 56.6 | 56.6 |
| 10. u/s end swale from Beenyup Brook to Oaklands drain | 56.5 | 56.5 | 56.6 | 56.6 |
| 11. u/s end swale down Abernethy Rd from Beenyup Brook to Trib 6 | 56.3 | 56.3 | 56.8 | 57.0 |
| 12. overland flow down Warrington Road | 44.5 | 44.5 | 45.4 | 45.4 |
| 13. overland flow down Doley Road | 34.5 | 34.5 | 35.5 | 35.8 |
| 14. Beenyup Brook at Hopkinson Road | 25.6 | 25.6 | 26.0 | 26.5 |
| 15. Tributary 6 u/s Briggs Road (Extn) | 41.6 | 41.6 | 41.7 | 41.7 |
| 16. Tributary 6 at Hopkinson Road | 27.5 | 27.5 | 27.7 | 27.7 |
| 17. Tributary 7 at Hopkinson Road | 27.0 | 27.0 | 27.2 | 27.2 |
| 18. Cardup Brook d/s South Western Hwy | 55.1 | 55.1 | 57.1 | 57.2 |
| 19. Cardup Brook at Hopkinson Road | 27.6 | 27.6 | 27.9 | 27.9 |

### *A.6.2 Results comparison to Birrega Oaklands flood modelling and drainage study*

Table A15 provides a comparison of *Birrega Oaklands flood modelling and drainage study* (DoW, 2015) peak flows at selected locations with those predicted by the base model and base model applying the revised AR&R2016 methodology.

Minor variable changes are observed when the 5-year ARI and 20% AEP events are compared. Whilst the comparison of the 100-year ARI event to the 1% AEP event results in consistently increased peak flows throughout the model, with increases in Beenyup Brook being the largest.

Table A15: Birrega Oaklands model peak flow comparison to base model with AR&R 2016 methods

| Location | Base model | | Base model (AR&R 2016) | | Birrega Oaklands study | |
|---|---|---|---|---|---|---|
| | 5-year ARI | 100-year ARI | 5-year ARI | 100-year ARI | 5-year ARI | 100-year ARI |
| 1. Oaklands drain d/s George Road (north) | 5.5 | 10.2 | 4.1 | 16.0 | 4.2 | 11.7 |
| 2. Beenyup Brook d/s South Western Hwy | 8.1 | 31.2 | 8.7 | 45.4 | 5.4 | 26.8 |
| 3. Cardup Brook d/s South Western Hwy | 5.8 | 23.5 | 6.1 | 26.2 | 8.0 | 22.7 |

## A.7 Current system model development

In order to provide an up-to-date assessment of the performance of urban and rural drainage systems in the study area a substantial number of changes have been made to the both the hydrological and hydraulic structure of the model. These changes include:

- Expanded study area to include development outside of the Byford Townsite structure plan area;
- Catchment delineation modified to reflect updated survey information (Old Townsite) and changes to the system that have been constructed or approved in UWMPs or engineering design plans;
- Hydraulic system elements and structures modified to reflect changes to the system that have been constructed or approved in UWMPs or engineering design plans;
- Hydraulic system elements and structures modified to reflect any survey information that can be obtained within the timeframes of the project; and
- Integration of a 2D flood-flow surface to improve representation of overland flood flows and catchment storage.

Figure A.2 provides an overview of the current system model layout.

### *A.7.1 Current system hydrology*

#### Catchment delineation

Catchments upstream of the Byford Townsite area (rural, hills catchments) remain largely unchanged although some minor boundary realignment has been necessary for some catchments where they adjoin developed or developing areas.

Catchments within the Byford Townsite have been altered and there are a large number of new catchments. Catchment delineation in this area has been undertaken utilising a combination of LiDAR ground elevation data, survey information (where available), site inspection, and review of water management documents including D-SPEC drawings, LWMS and UWMPs.

Catchments outside of the base model domain, principally to the north and east of Byford Townsite have been added to provide full coverage of the Byford District Structure Plan area.

In these areas, where development has not significantly altered ground levels, LiDAR ground elevation data has been used as the principal data source coupled with site inspection.

Figure A.3 provides an overview of the principal data sources used in different parts of the study area.

### Land use

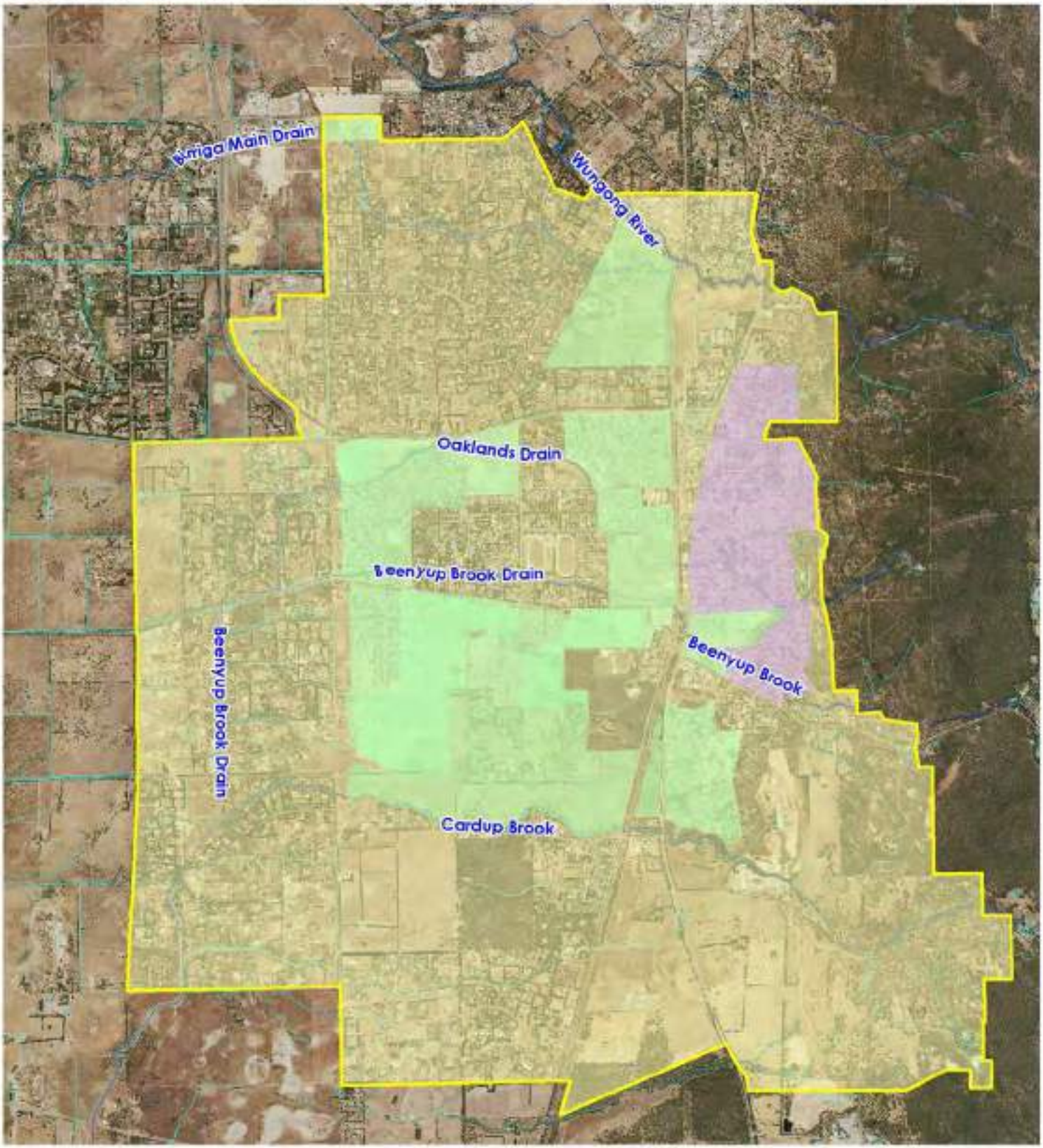
Land uses throughout the model domain have been reviewed and updated based on recent aerial imagery and planning information including:

- Byford District Structure Plan (Draft, 2018)
- Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2
- Approved local structure plans and subdivision plans

Figure A.4 provides an overview of the land uses applied in the current system model.

Land use descriptions and parameterisation are consistent with the base model (Table A4). The percentage of impervious area for individual catchments in the current system model are presented in Table A16.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure A3 - Principal data sources for model updates




Legend

DWMS Study Area

Data source:

Old Byford Survey

Water Management Documents

LIDAR and site inspection

Scale 1: 50,000 at A4

0 2km

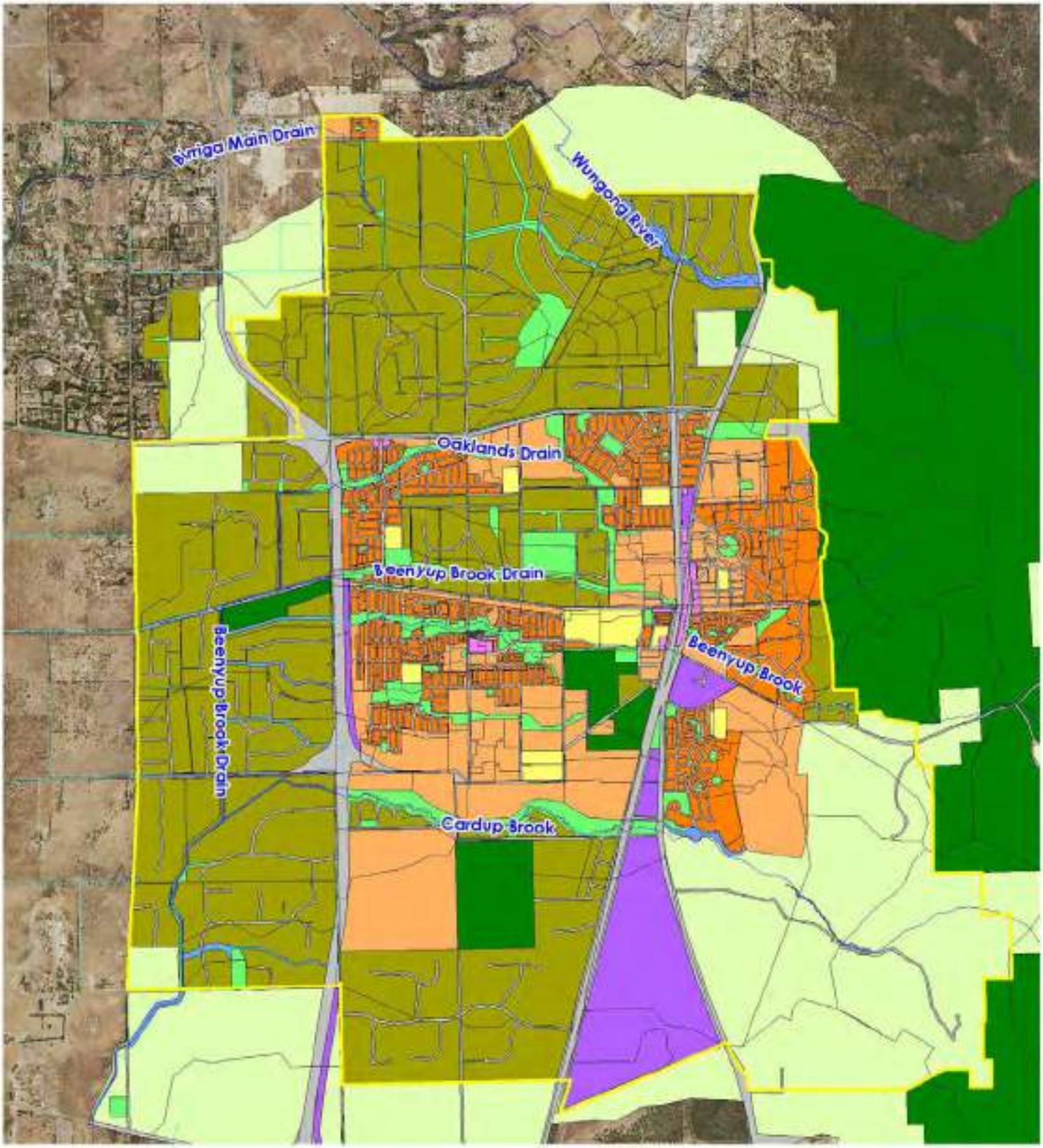
N

urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB. Projection: MGA: zone 50.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure A4 - Modelled land uses




Legend

DWMS Study Area

Landuse categories:

- Residential
- Development
- School
- Rural Residential
- Rural
- POS
- Conservation
- Road
- Drainage / waterway
- Town/local Centre
- Mixed Business

Scale 1:50,000 at A4

0 2km

N

urbaqua
land and water solutions



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB. Projection: MGA: zone 50.

Table A16: InfoWorks model catchment properties for current system model scenario

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| DWMP_2A | 43.410 | 0.015 | 800.0 | 5.604 |
| DWMP_2A1 | 18.872 | 0.020 | 250.0 | 8.970 |
| DWMP_2B | 77.394 | 0.041 | 800.0 | 9.063 |
| DWMP_2C2 | 20.542 | 0.118 | 600.0 | 1.793 |
| MUC_3B | 7.430 | 0.018 | 300.0 | 38.244 |
| RB_02 | 7.281 | 0.018 | 300.0 | 58.399 |
| DWMP_3B1 | 4.811 | 0.018 | 300.0 | 67.885 |
| DWMP_3B2 | 8.471 | 0.018 | 181.9 | 69.705 |
| RB_03 | 9.738 | 0.018 | 223.4 | 17.960 |
| RB_04 | 21.539 | 0.018 | 304.4 | 54.970 |
| BM_02 | 32.611 | 0.014 | 700.0 | 41.247 |
| DWMP_3C | 62.412 | 0.019 | 750.0 | 7.124 |
| DWMP_3F | 77.951 | 0.263 | 1100.0 | 0.610 |
| DWMP_3F1 | 11.907 | 0.056 | 850.0 | 70.172 |
| DWMP_3F2 | 6.399 | 0.038 | 500.0 | 66.959 |
| DWMP_3F3 | 6.182 | 0.130 | 750.0 | 50.101 |
| DWMP_3G1 | 37.063 | 0.246 | 700.0 | 3.439 |
| DWMP_3G2 | 29.543 | 0.243 | 900.0 | 10.213 |
| DWMP_3H | 101.696 | 0.164 | 950.0 | 0.000 |
| DWMP_4A | 35.696 | 0.018 | 600.0 | 5.146 |
| DWMP_4B | 16.631 | 0.020 | 250.0 | 3.423 |
| MUC_5A | 3.949 | 0.016 | 400.0 | 17.419 |
| DWMP_5C | 23.548 | 0.017 | 300.0 | 5.767 |
| DWMP_5D | 32.971 | 0.020 | 400.0 | 4.789 |
| DWMP_6D | 53.155 | 0.021 | 450.0 | 10.080 |
| MUC_6D | 3.080 | 0.015 | 250.0 | 3.510 |
| DWMP_6F | 16.668 | 0.036 | 300.0 | 60.444 |
| DWMP_6G2 | 11.701 | 0.043 | 850.0 | 60.441 |
| DWMP_8A | 12.152 | 0.013 | 250.0 | 62.348 |
| DWMP_8C | 24.382 | 0.015 | 500.0 | 60.245 |
| DWMP_8D | 20.142 | 0.019 | 500.0 | 60.207 |
| DWMP_9B | 36.816 | 0.020 | 400.0 | 18.753 |
| DWMP_9C | 74.316 | 0.039 | 600.0 | 6.446 |
| DWMP_9D | 19.586 | 0.040 | 300.0 | 61.716 |
| DWMP_9E | 205.602 | 0.095 | 1000.0 | 17.251 |
| DWMP_9F | 140.232 | 0.211 | 1100.0 | 1.352 |
| DWMP_9G | 379.307 | 0.157 | 1900.0 | 0.898 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| DWMP_9H | 494.404 | 0.104 | 2200.0 | 0.390 |
| DWMP_9I | 229.579 | 0.057 | 1800.0 | 0.575 |
| CDN_02 | 345.238 | 0.020 | 1500.0 | 18.480 |
| BB_06 | 0.465 | 0.019 | 38.5 | 56.256 |
| BB_07 | 0.811 | 0.016 | 50.8 | 59.634 |
| BB_01 | 0.712 | 0.015 | 47.6 | 55.979 |
| BB_02 | 0.718 | 0.098 | 47.8 | 57.362 |
| BB_03 | 1.356 | 0.000 | 65.7 | 59.068 |
| BB_04 | 0.923 | 0.001 | 54.2 | 56.299 |
| BB_05 | 0.223 | 0.016 | 26.6 | 69.473 |
| BB_09 | 4.042 | 0.007 | 113.4 | 55.644 |
| BB_19 | 4.336 | 0.009 | 117.5 | 59.781 |
| BB_22 | 1.175 | 0.025 | 61.2 | 55.212 |
| BB_23 | 0.431 | 0.012 | 37.0 | 4.314 |
| BB_24 | 1.433 | 0.006 | 67.5 | 57.783 |
| BB_25 | 0.352 | 0.037 | 33.5 | 0.783 |
| OB_01 | 15.570 | 0.081 | 222.6 | 50.996 |
| MUC_5G | 3.102 | 0.014 | 99.4 | 0.477 |
| MUC_5H | 3.066 | 0.000 | 98.8 | 3.714 |
| OB_02 | 9.680 | 0.081 | 175.5 | 52.950 |
| DWMP_5G | 11.558 | 0.081 | 191.8 | 43.816 |
| BB_20 | 5.586 | 0.012 | 133.3 | 60.193 |
| BB_21 | 3.084 | 0.081 | 99.1 | 1.616 |
| BB_26 | 1.502 | 0.000 | 69.1 | 2.088 |
| OB_03 | 5.485 | 0.081 | 132.1 | 50.813 |
| DWMP_5H1 | 151.649 | 0.171 | 1100.0 | 2.407 |
| DWMP_5H2 | 111.847 | 0.132 | 800.0 | 1.036 |
| DWMP_5I | 86.297 | 0.171 | 700.0 | 9.534 |
| DWMP_5J | 285.259 | 0.088 | 1200.0 | 1.248 |
| DWMP_5K | 155.704 | 0.110 | 900.0 | 1.535 |
| DWMP_5L | 302.476 | 0.054 | 1100.0 | 1.299 |
| DWMP_5M | 148.011 | 0.058 | 1000.0 | 1.101 |
| BB_28 | 2.450 | 0.013 | 88.3 | 57.173 |
| DWMP_5F | 7.296 | 0.038 | 200.0 | 65.897 |
| DWMP_8B | 16.760 | 0.015 | 400.0 | 60.836 |
| BS_01 | 26.339 | 0.066 | 800.0 | 43.273 |
| DP_01 | 13.032 | 0.000 | 203.7 | 56.647 |
| DP_02 | 7.058 | 0.000 | 149.9 | 60.273 |
| DWMP_7D | 11.683 | 0.019 | 300.0 | 61.146 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| DWMP_8D2 | 14.465 | 0.019 | 500.0 | 60.233 |
| DP_03 | 4.351 | 0.000 | 117.7 | 59.960 |
| DP_04 | 8.682 | 0.006 | 166.2 | 61.184 |
| DWMP_7B | 9.833 | 0.000 | 176.9 | 13.155 |
| DP_05 | 1.684 | 0.007 | 73.2 | 60.000 |
| DP_06 | 3.311 | 0.000 | 101.0 | 61.151 |
| DP_07 | 5.266 | 0.012 | 129.5 | 60.000 |
| DP_08 | 10.022 | 0.013 | 178.6 | 55.581 |
| DP_09 | 1.573 | 0.000 | 70.8 | 69.015 |
| DP_10 | 5.054 | 0.013 | 126.8 | 60.000 |
| DP_11 | 3.292 | 0.001 | 102.4 | 60.000 |
| DP_12 | 2.124 | 0.002 | 82.2 | 60.000 |
| DP_13 | 4.891 | 0.013 | 124.8 | 61.448 |
| BS_08 | 6.174 | 0.008 | 140.2 | 49.472 |
| BS_09 | 0.114 | 0.000 | 19.0 | 69.741 |
| BS_10 | 1.454 | 0.039 | 68.0 | 53.432 |
| BS_04 | 0.484 | 0.009 | 39.2 | 60.366 |
| BS_14 | 0.879 | 0.026 | 52.9 | 49.702 |
| BS_15 | 0.608 | 0.006 | 44.0 | 24.396 |
| BS_16 | 0.884 | 0.008 | 53.0 | 54.936 |
| BS_17 | 1.994 | 0.000 | 79.7 | 55.851 |
| BS_18 | 0.521 | 0.033 | 40.7 | 56.324 |
| BS_19 | 2.021 | 0.024 | 80.2 | 46.327 |
| BS_20 | 1.080 | 0.024 | 58.6 | 55.658 |
| BS_21 | 0.555 | 0.006 | 42.0 | 57.829 |
| BS_22 | 0.438 | 0.023 | 37.3 | 59.260 |
| BS_23 | 0.534 | 0.028 | 41.2 | 57.851 |
| BS_05 | 4.604 | 0.000 | 121.1 | 52.122 |
| BS_06 | 1.343 | 0.000 | 65.4 | 41.566 |
| BS_26 | 0.234 | 0.000 | 27.3 | 56.998 |
| BS_27 | 3.656 | 0.036 | 107.9 | 56.545 |
| BS_28 | 1.353 | 0.055 | 65.6 | 21.972 |
| BS_12 | 1.533 | 0.060 | 69.9 | 49.745 |
| BS_07 | 0.360 | 0.022 | 33.9 | 55.377 |
| BS_03 | 5.986 | 0.060 | 138.0 | 45.355 |
| DWMP_8E2 | 6.801 | 0.060 | 147.1 | 59.991 |
| DWMP_6G4 | 6.149 | 0.060 | 139.9 | 60.000 |
| DWMP_6G3 | 15.651 | 0.060 | 223.2 | 57.741 |
| BS_24 | 1.131 | 0.001 | 60.0 | 52.275 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| BS_25 | 1.354 | 0.006 | 65.6 | 51.795 |
| BS_11 | 0.388 | 0.056 | 35.1 | 57.743 |
| BS_13 | 1.103 | 0.034 | 59.3 | 50.000 |
| DWMP_8E1 | 17.962 | 0.000 | 239.1 | 72.518 |
| BS_02 | 11.402 | 0.020 | 190.5 | 52.473 |
| OB_04 | 18.430 | 0.000 | 242.2 | 60.968 |
| OB_05 | 4.725 | 0.000 | 122.6 | 59.629 |
| OB_06 | 6.749 | 0.043 | 146.6 | 53.163 |
| OB_07 | 6.231 | 0.071 | 140.8 | 53.031 |
| OB_08 | 8.147 | 0.051 | 161.0 | 52.388 |
| OB_09 | 7.494 | 0.029 | 154.4 | 52.646 |
| OB_10 | 4.495 | 0.234 | 119.6 | 52.096 |
| OB_11 | 2.874 | 0.028 | 95.6 | 55.132 |
| OB_12 | 8.013 | 0.000 | 159.7 | 42.016 |
| OB_13 | 3.110 | 0.070 | 99.5 | 51.294 |
| OB_14 | 3.440 | 0.000 | 104.6 | 52.428 |
| OB_15 | 3.821 | 0.015 | 110.3 | 52.991 |
| OB_16 | 4.779 | 0.007 | 123.3 | 54.190 |
| OB_17 | 2.167 | 0.000 | 83.0 | 55.673 |
| OB_18 | 2.717 | 0.000 | 93.0 | 40.230 |
| OB_19 | 5.554 | 0.011 | 133.0 | 54.714 |
| OB_20 | 4.554 | 0.021 | 120.4 | 61.180 |
| OB_21 | 3.825 | 0.001 | 110.3 | 53.622 |
| OB_22 | 14.514 | 0.020 | 214.9 | 48.812 |
| OB_23 | 0.967 | 0.000 | 55.5 | 55.013 |
| OB_24 | 8.038 | 0.000 | 160.0 | 54.073 |
| OB_25 | 2.526 | 0.028 | 89.7 | 55.204 |
| OB_26 | 1.538 | 0.000 | 70.0 | 59.756 |
| OB_27 | 3.690 | 0.027 | 108.4 | 55.882 |
| OB_28 | 1.872 | 0.025 | 77.2 | 62.295 |
| OB_29 | 4.260 | 0.022 | 116.4 | 62.277 |
| OB_30 | 8.420 | 0.000 | 163.7 | 60.119 |
| OB_31 | 6.480 | 0.021 | 143.6 | 48.874 |
| OB_32 | 1.544 | 0.007 | 70.1 | 63.349 |
| OB_33 | 2.488 | 0.000 | 89.0 | 63.471 |
| OB_34 | 6.660 | 0.015 | 145.6 | 53.868 |
| OB_35 | 15.000 | 0.000 | 218.5 | 32.327 |
| DWMP_2C1 | 23.060 | 0.099 | 270.9 | 9.780 |
| DWMP_2C3 | 11.046 | 0.000 | 187.5 | 22.414 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| L3_01 | 8.083 | 0.018 | 160.4 | 49.044 |
| BIR_02C | 59.856 | 0.003 | 436.5 | 7.110 |
| BIR_02B | 99.489 | 0.009 | 562.7 | 5.065 |
| BIR_02A | 32.337 | 0.004 | 320.8 | 20.708 |
| BIR_01A | 77.656 | 0.000 | 497.2 | 5.041 |
| BIR_03A | 17.214 | 0.005 | 234.1 | 17.095 |
| BIR_01B | 55.914 | 0.000 | 421.9 | 5.336 |
| BIR_03B | 55.349 | 0.005 | 419.7 | 2.762 |
| BIR_09 | 47.384 | 0.001 | 388.4 | 5.997 |
| BIR_12 | 58.695 | 0.001 | 432.2 | 1.113 |
| W_01 | 311.123 | 0.006 | 995.2 | 0.724 |
| W_02 | 61.846 | 0.289 | 443.7 | 25.050 |
| W_03 | 278.768 | 0.005 | 942.0 | 0.724 |
| W_04 | 1010.825 | 0.006 | 1793.8 | 0.000 |
| GL_09 | 25.418 | 0.013 | 284.4 | 58.221 |
| GL_10 | 3.189 | 0.039 | 100.7 | 62.863 |
| DWMP_10A | 14.226 | 0.011 | 212.8 | 68.167 |
| GL_11 | 0.710 | 0.014 | 47.5 | 58.834 |
| GL_13 | 2.149 | 0.015 | 82.7 | 57.043 |
| GL_17 | 10.290 | 0.007 | 181.0 | 55.643 |
| GL_23 | 5.132 | 0.024 | 127.8 | 57.378 |
| GL_24 | 1.602 | 0.001 | 71.4 | 31.514 |
| DWMP_7A | 16.947 | 0.000 | 232.3 | 68.727 |
| WS_09 | 1.393 | 0.006 | 66.6 | 0.000 |
| WS_10 | 2.404 | 0.000 | 87.5 | 0.841 |
| WS_07 | 1.854 | 0.001 | 76.8 | 0.000 |
| WS_01 | 4.453 | 0.000 | 119.1 | 0.460 |
| WS_02 | 4.121 | 0.000 | 114.5 | 0.000 |
| WS_03 | 0.519 | 0.004 | 40.6 | 0.673 |
| WS_04 | 0.306 | 0.004 | 31.2 | 0.000 |
| WS_08 | 1.568 | 0.008 | 70.6 | 0.000 |
| WS_05 | 0.151 | 0.000 | 21.9 | 0.000 |
| WS_11 | 2.897 | 0.003 | 96.0 | 7.945 |
| WS_06 | 2.899 | 0.026 | 96.1 | 0.000 |
| W_05 | 28.624 | 0.006 | 301.9 | 36.736 |
| BIR_33 | 124.142 | 0.003 | 628.6 | 3.507 |
| BIR_34 | 44.671 | 0.002 | 377.1 | 2.279 |
| BIR_35 | 69.695 | 0.000 | 471.0 | 3.919 |
| OAK_08 | 43.595 | 0.001 | 372.5 | 61.119 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| OAK_07 | 196.622 | 0.001 | 791.1 | 7.858 |
| OAK_06 | 92.734 | 0.001 | 543.3 | 17.570 |
| OAK_05 | 56.964 | 0.001 | 425.8 | 11.007 |
| OAK_04 | 35.507 | 0.003 | 336.2 | 11.250 |
| OAK_02 | 50.283 | 0.003 | 400.1 | 14.650 |
| GL_26 | 0.959 | 0.000 | 55.3 | 56.529 |
| GL_27 | 0.347 | 0.019 | 33.3 | 60.000 |
| GL_28 | 1.463 | 0.012 | 68.2 | 56.227 |
| GL_29 | 3.376 | 0.019 | 103.7 | 56.804 |
| GL_30 | 1.618 | 0.013 | 71.8 | 58.124 |
| GL_69 | 0.240 | 0.016 | 27.7 | 59.357 |
| GL_31 | 0.903 | 0.005 | 53.6 | 51.110 |
| GL_32 | 1.527 | 0.009 | 69.7 | 59.845 |
| GL_33 | 3.451 | 0.011 | 104.8 | 56.454 |
| GL_34 | 0.985 | 0.011 | 56.0 | 55.799 |
| GL_35 | 6.172 | 0.014 | 140.2 | 40.152 |
| BW_01 | 1.284 | 0.004 | 63.9 | 55.509 |
| BW_02 | 1.424 | 0.018 | 67.3 | 55.783 |
| BW_03 | 2.751 | 0.017 | 93.6 | 31.297 |
| BW_04 | 0.848 | 0.001 | 52.0 | 54.019 |
| BW_05 | 3.243 | 0.000 | 101.6 | 56.533 |
| BW_07 | 1.628 | 0.006 | 72.0 | 56.418 |
| BW_09 | 2.604 | 0.012 | 91.0 | 55.489 |
| BW_10 | 2.559 | 0.006 | 90.2 | 55.880 |
| BW_11 | 1.890 | 0.009 | 77.6 | 57.618 |
| BW_12 | 1.667 | 0.061 | 72.8 | 55.383 |
| BW_13 | 1.992 | 0.000 | 79.6 | 58.578 |
| MUC_7B | 1.695 | 0.000 | 73.5 | 1.632 |
| MUC_7A | 4.770 | 0.000 | 123.2 | 21.822 |
| GL_36 | 1.279 | 0.012 | 63.8 | 58.381 |
| GL_37 | 0.491 | 0.002 | 39.5 | 55.412 |
| GL_38 | 1.942 | 0.000 | 78.6 | 50.716 |
| GL_39 | 2.022 | 0.001 | 80.2 | 62.604 |
| GL_71 | 0.398 | 0.002 | 35.6 | 69.981 |
| GL_40 | 1.736 | 0.007 | 74.3 | 58.161 |
| GL_73 | 0.342 | 0.005 | 33.0 | 45.279 |
| GL_72 | 0.665 | 0.026 | 46.0 | 29.347 |
| MUC_6B | 1.917 | 0.007 | 78.1 | 1.488 |
| GL_42 | 1.912 | 0.007 | 78.0 | 1.035 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| MUC_6C | 1.475 | 0.013 | 68.5 | 0.445 |
| GL_44 | 2.508 | 0.003 | 89.4 | 54.991 |
| GL_47 | 1.563 | 0.013 | 70.5 | 55.964 |
| GL_49 | 1.822 | 0.079 | 76.2 | 56.670 |
| GL_50 | 1.286 | 0.040 | 64.0 | 2.551 |
| GL_59 | 2.106 | 0.004 | 81.9 | 57.289 |
| GL_74 | 0.530 | 0.004 | 41.1 | 69.682 |
| GL_60 | 3.855 | 0.018 | 110.8 | 56.979 |
| GL_61 | 1.326 | 0.013 | 65.0 | 61.542 |
| MUC_6E | 2.317 | 0.007 | 85.9 | 37.543 |
| GL_62 | 0.851 | 0.000 | 52.1 | 1.115 |
| KAL_03 | 3.447 | 0.005 | 104.7 | 53.481 |
| KAL_04 | 1.424 | 0.001 | 67.3 | 48.255 |
| KAL_05 | 3.638 | 0.009 | 107.6 | 58.387 |
| KAL_07 | 10.204 | 0.005 | 180.2 | 55.819 |
| KAL_13 | 6.216 | 0.007 | 140.7 | 54.224 |
| KAL_16 | 0.528 | 0.007 | 41.0 | 19.938 |
| KAL_22 | 1.224 | 0.010 | 62.4 | 15.630 |
| KAL_23 | 1.495 | 0.000 | 69.0 | 56.115 |
| DWMP_6B | 7.724 | 0.000 | 156.8 | 71.538 |
| GL_63 | 0.719 | 0.009 | 47.8 | 50.161 |
| GL_64 | 0.891 | 0.000 | 53.3 | 48.806 |
| BR_E | 13.824 | 0.017 | 209.8 | 42.173 |
| RB_09 | 4.543 | 0.025 | 120.2 | 52.497 |
| RB_06 | 9.052 | 0.002 | 169.7 | 50.390 |
| RB_07 | 3.005 | 0.006 | 97.8 | 42.945 |
| RB_08 | 2.845 | 0.018 | 95.2 | 58.326 |
| MUC_3A | 3.604 | 0.000 | 107.1 | 4.802 |
| OB_36 | 21.945 | 0.081 | 264.3 | 18.168 |
| DWMP_6G1 | 19.263 | 0.009 | 247.6 | 74.296 |
| OB_37 | 10.884 | 0.000 | 186.1 | 56.523 |
| GL_65 | 5.248 | 0.002 | 129.2 | 47.342 |
| GL_66 | 4.684 | 0.004 | 122.1 | 58.907 |
| GL_70 | 0.981 | 0.001 | 55.9 | 3.028 |
| GL_67 | 8.163 | 0.016 | 161.2 | 46.532 |
| GL_68 | 3.304 | 0.006 | 102.5 | 42.031 |
| BW_14 | 2.783 | 0.068 | 94.1 | 56.582 |
| BW_15 | 1.882 | 0.083 | 77.4 | 57.623 |
| MUC_6A | 2.626 | 0.005 | 91.4 | 39.287 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| BW_16 | 2.769 | 0.076 | 93.9 | 56.777 |
| BTC_A | 6.875 | 0.030 | 147.9 | 60.084 |
| BTC_B | 1.483 | 0.022 | 68.7 | 60.037 |
| BTC_C | 4.620 | 0.039 | 121.3 | 60.000 |
| BTC_E | 3.401 | 0.022 | 104.0 | 60.061 |
| BTC_D | 2.156 | 0.003 | 82.9 | 60.000 |
| MUC_5F | 0.877 | 0.017 | 52.8 | 61.242 |
| C2d | 1.349 | 0.000 | 65.5 | 60.573 |
| C12u | 4.077 | 0.000 | 113.9 | 60.000 |
| C5d | 6.236 | 0.000 | 140.9 | 60.000 |
| C13u | 4.492 | 0.000 | 119.6 | 60.064 |
| MUC_3F | 6.131 | 0.032 | 139.7 | 12.826 |
| C11d | 2.669 | 0.000 | 92.2 | 44.841 |
| Kalimna DOS | 10.899 | 0.003 | 186.3 | 20.533 |
| BC_Central | 16.113 | 0.001 | 226.5 | 48.750 |
| BC_East | 24.599 | 0.006 | 279.8 | 54.472 |
| BC_West | 21.592 | 0.024 | 262.2 | 49.797 |
| MUC_3E | 4.672 | 0.000 | 121.9 | 16.018 |
| Marri Gr School | 4.670 | 0.012 | 121.9 | 51.335 |
| LAR_04 | 0.755 | 0.003 | 49.0 | 58.142 |
| LAR_06 | 7.297 | 0.009 | 152.4 | 57.861 |
| LAR_01 | 2.659 | 0.010 | 92.0 | 56.898 |
| LAR_07 | 3.360 | 0.010 | 103.4 | 55.558 |
| LAR_05 | 1.395 | 0.008 | 66.6 | 54.013 |
| LAR_03 | 1.739 | 0.011 | 74.4 | 58.228 |
| LAR_02 | 2.578 | 0.010 | 90.6 | 55.315 |
| L3_02 | 17.278 | 0.000 | 234.5 | 60.953 |
| TR12 | 1.344 | 0.000 | 65.4 | 67.826 |
| TR04 | 3.597 | 0.001 | 107.0 | 65.083 |
| TR02 | 4.094 | 0.002 | 114.1 | 67.970 |
| Stage 4_S56 | 1.889 | 0.011 | 77.5 | 57.729 |
| RB_10 | 4.068 | 0.285 | 113.8 | 57.058 |
| RB_11 | 4.939 | 0.018 | 125.4 | 56.710 |
| BR_C | 3.356 | 0.014 | 103.4 | 60.000 |
| BR_D | 2.428 | 0.015 | 87.9 | 60.206 |
| BR_School | 3.859 | 0.002 | 110.8 | 50.051 |
| BR_G | 4.246 | 0.024 | 116.3 | 60.293 |
| BR_F | 1.167 | 0.004 | 61.0 | 59.789 |
| BR_B | 3.834 | 0.008 | 110.5 | 60.303 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| MUC_3C | 1.495 | 0.000 | 69.0 | 60.107 |
| MUC_5B | 1.664 | 0.000 | 72.8 | 4.243 |
| MUC_5D | 4.251 | 0.041 | 116.3 | 60.000 |
| MUC_5E | 0.666 | 0.000 | 46.0 | 60.000 |
| Ab01b | 3.724 | 0.000 | 108.9 | 47.599 |
| Ab01c | 3.266 | 0.000 | 102.0 | 63.347 |
| Ab02 | 3.288 | 0.009 | 102.3 | 62.055 |
| Ab03 | 4.470 | 0.008 | 119.3 | 62.044 |
| GM_1A | 1.745 | 0.008 | 74.5 | 52.989 |
| Ab05 | 2.182 | 0.000 | 83.3 | 68.928 |
| GL_HS | 3.210 | 0.011 | 101.1 | 50.025 |
| GL10 | 1.367 | 0.436 | 66.0 | 50.000 |
| L15_A | 1.543 | 0.016 | 70.1 | 19.463 |
| L15_B | 1.138 | 0.003 | 60.2 | 58.956 |
| L15_C | 1.174 | 0.010 | 61.1 | 56.943 |
| L15_D | 0.673 | 0.001 | 46.3 | 61.896 |
| Ab01a | 1.238 | 0.013 | 62.8 | 71.142 |
| RB_12 | 3.685 | 0.014 | 108.3 | 55.467 |
| GM_1B | 2.444 | 0.007 | 88.2 | 55.406 |
| GM_2 | 4.479 | 0.011 | 119.4 | 57.872 |
| GM_3 | 3.631 | 0.001 | 107.5 | 57.668 |
| GL_75 | 2.526 | 0.011 | 89.7 | 49.021 |
| GL_76 | 2.318 | 0.000 | 85.9 | 50.577 |
| GL_77 | 5.151 | 0.008 | 128.0 | 47.218 |
| GL_78 | 9.490 | 0.012 | 173.8 | 48.604 |
| GL_79 | 5.267 | 0.022 | 129.5 | 57.926 |
| GL_80 | 8.503 | 0.001 | 164.5 | 50.039 |
| GL_HS2 | 9.914 | 0.001 | 177.6 | 49.851 |
| GL81 | 2.194 | 0.003 | 83.6 | 56.190 |
| GL_82 | 9.680 | 0.000 | 175.5 | 34.588 |
| War_01 | 8.068 | 0.005 | 160.3 | 60.096 |
| War_02 | 2.701 | 0.002 | 92.7 | 62.044 |
| GL_81 | 6.816 | 0.018 | 147.3 | 51.247 |
| GL_83 | 5.647 | 0.000 | 134.1 | 55.768 |
| GL_84 | 9.641 | 0.006 | 175.2 | 53.108 |
| GL_85 | 8.758 | 0.005 | 167.0 | 53.663 |
| BMD28 | 55.655 | 0.002 | 420.9 | 3.977 |
| BMD27 | 73.550 | 0.001 | 483.9 | 13.535 |
| BMD31 | 166.384 | 0.003 | 727.7 | 7.197 |

| Subcatchment ID | Total area (ha) | Vector slope (%) | Catchment width (m) | % Impervious |
|---|---|---|---|---|
| BMD30 | 73.081 | 0.003 | 482.3 | 8.291 |
| BMD41 | 55.068 | 0.001 | 418.7 | 6.988 |
| BMD42 | 60.858 | 0.075 | 440.1 | 9.323 |
| BMD51 | 106.943 | 0.002 | 583.4 | 3.310 |
| MUC_7F | 1.154 | 0.000 | 60.6 | 60.000 |
| MUC_7E | 3.204 | 0.000 | 101.0 | 60.027 |
| MUC_7D | 2.341 | 0.000 | 86.3 | 60.000 |
| MUC_7C | 1.657 | 0.000 | 72.6 | 59.997 |
| DP_14 | 1.493 | 0.000 | 68.9 | 60.056 |
| DP_15 | 5.779 | 0.000 | 135.6 | 60.712 |
| DP_16 | 2.909 | 0.000 | 96.2 | 60.655 |
| WS_A | 4.309 | 0.003 | 117.1 | 4.624 |
| WS_B | 5.176 | 0.003 | 128.4 | 0.000 |
| WS_G | 11.677 | 0.000 | 192.8 | 0.000 |
| WS_H | 3.688 | 0.000 | 108.4 | 0.000 |
| WS_D | 5.045 | 0.000 | 126.7 | 0.000 |
| WS_12 | 1.212 | 0.003 | 62.1 | 0.000 |
| WS_C | 2.035 | 0.003 | 80.5 | 0.000 |
| WS_J | 5.875 | 0.083 | 136.7 | 5.059 |
| WS_L | 7.801 | 0.092 | 157.6 | 0.000 |
| WS_M | 6.423 | 0.092 | 143.0 | 0.000 |
| WS_O | 6.946 | 0.067 | 148.7 | 0.000 |
| WS_E | 1.947 | 0.000 | 78.7 | 0.000 |
| WS_P | 5.487 | 0.067 | 132.2 | 0.000 |
| WS_F | 2.172 | 0.000 | 83.1 | 0.000 |
| WS_R | 2.331 | 0.001 | 86.1 | 0.000 |
| WS_S | 3.182 | 0.001 | 100.6 | 0.000 |
| WS_K | 2.711 | 0.083 | 92.9 | 3.689 |
| WS_N | 2.792 | 0.092 | 94.3 | 0.242 |
| WS_Q | 5.681 | 0.067 | 134.5 | 0.008 |
| BMD10 | 11.817 | 0.000 | 193.9 | 57.047 |
| NOR_04 | 351.694 | 0.000 | 1058.1 | 2.591 |
| NOR_01 | 148.540 | 0.006 | 687.6 | 12.324 |
| CDN_03 | 122.824 | 0.100 | 625.3 | 74.509 |
| CDN_01 | 66.440 | 0.001 | 459.9 | 16.076 |
| NOR_02 | 284.277 | 0.092 | 951.3 | 7.880 |
| NOR_03 | 131.795 | 0.207 | 647.7 | 44.347 |
| Oak_09 | 202.581 | 0.016 | 803.0 | 10.158 |

### *A.7.2 Current system hydraulics*

Channel and structure dimensions throughout the model domain have been reviewed.

Channels, and structures upstream of the Byford Townsite area (rural, hills catchments) remain largely unchanged although some minor realignment has been necessary for some channels where they adjoin developed or developing areas.

Channels, pipes and structures within the Byford Townsite have been altered and there are a large number of new hydraulic elements. System definition in this area has been undertaken utilising a combination of LiDAR ground elevation data, survey information (where available), site inspection, and review of water management documents including D-SPEC drawings, LWMS and UWMPs.

Channels, and structures outside of the base model domain, principally to the north and east of Byford Townsite have been added to provide full coverage of the Byford District Structure Plan area. In these areas, where development has not significantly altered ground levels, LiDAR ground elevation data has been used as the principal data source for channel cross section definition coupled with site inspection to provide dimensions for structures.

Table A17 presents the significant structures that have been included within the current system model. Photographs for selected structures (indicated by an *) are provided in Appendix B.

Table A17: Modelled hydraulic structures – current system model

| Site ref | Location | X | Y | Shape | Width (mm) | Height (mm) | Invert (mAHD) | Barrels | Source | Image | Field ref |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Wungong R - SW Hwy | 407288.2 | 6437608.4 | Bridge | 10000 | 2500 | 42.60 | 1 | Observed | | |
| 2 | Wungong R - Railway | 406508.2 | 6437826 | Bridge | 10000 | 2000 | 39.70 | 1 | Observed | | |
| 3 | Wungong R - Rowley Rd | 405252.7 | 6439291.8 | Bridge | 10000 | 2000 | 29.40 | 1 | Observed | y | 1.23 |
| 4 | Birrega MD - Dalray CtE | 406238.8 | 6437748.4 | RECT | 900 | 450 | 38.00 | 2 | UWMP | | |
| 5 | Birrega MD - Dalray CtW | 405869 | 6437720.7 | RECT | 1200 | 600 | 35.80 | 4 | UWMP | | |
| 6 | Birrega MD - Wungong Sth Rd | 405199.7 | 6438154.1 | CIRC | 600 | 600 | 32.50 | 4 | Observed | y | 1.22 |
| 7 | Birrega MD - Masters Rd | 404079.5 | 6438142.1 | CIRC | 700 | 700 | 29.40 | 4 | Observed | y | 1.21 |
| 8 | Birrega MD - Hopkinson Rd | 403143.1 | 6439077.6 | CIRC | 900 | 900 | 25.20 | 1 | Observed | y | 1.1 |
| 9 | Thomas Rd Drn - Linton St | 407324.5 | 6435727.1 | CIRC | 600 | 600 | 73.66 | 2 | Survey | | |
| 10 | Thomas Rd Drn - Stanley Rd | 407120.8 | 6435935.3 | CIRC | 600 | 600 | 61.81 | 2 | Survey | | |
| 11 | Thomas Rd Drn - Pound Cl | 407062.4 | 6435988.7 | CIRC | 600 | 600 | 59.13 | 2 | Survey | | |
| 12 | Thomas Rd Drn - SW Hwy | 406789.4 | 6436145.7 | CIRC | 900 | 900 | 50.75 | 2 | DWMP | | |
| 13 | Thomas Rd Drn - Thomas Rd | 406498.2 | 6436415 | CIRC | 600 | 600 | 40.50 | 2 | DWMP | | |
| 14 | Thomas Rd Drn - Railway | 406443.2 | 6436763.6 | CIRC | 600 | 600 | 35.80 | 1 | DWMP | | |
| 15 | Thomas Rd Drn - Thomas Rd | 404692.2 | 6436240.1 | RECT | 3200 | 1200 | 30.09 | 2 | DWMP | | |
| 16 | Birrega BD - Tonkin Hwy | 402213.3 | 6437729.9 | Bridge | 5000 | 1000 | 25.10 | 1 | Aerial image | | |
| 17 | Birrega BD - Hopkinson Rd | 403207.3 | 6436174.4 | RECT | 900 | 900 | 26.20 | 1 | Observed | y | 1.4 |
| 18 | Birrega BD - Tonkin Hwy | 402920.7 | 6436176.5 | RECT | 1200 | 1200 | 24.80 | 1 | Observed | y | 1.5 |
| 19 | Birrega BD - Ballak Pl | 402616 | 6436150.1 | CIRC | 1050 | 1050 | 24.40 | 1 | Observed | y | 1.5 |
| 20 | Birrega BD - Kargotich Rd | 401335.8 | 6436112.8 | Bridge | 5000 | 1500 | 21.10 | 1 | Observed | y | 1.6 |
| 21 | Oaklands Drn - Old Brickworks Rd | 407655.2 | 6434580.5 | CIRC | 300 | 300 | 89.48 | 1 | Survey | | |

| Site ref | Location | X | Y | Shape | Width (mm) | Height (mm) | Invert (mAHD) | Barrels | Source | Image | Field ref |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | Oaklands Drn - Beenyup Rd | 407420.7 | 6434579.3 | RECT | 900 | 600 | 79.80 | 1 | Survey | | |
| 23 | Oaklands Drn - Bower Pl | 407386.5 | 6434593.8 | CIRC | 750 | 750 | 78.03 | 1 | Survey | | |
| 24 | Oaklands Drn - South Cr | 406984.8 | 6434896.3 | CIRC | 750 | 750 | 63.35 | 1 | Survey | | |
| 25 | Oaklands Drn - Edward Cr | 406802.8 | 6434982 | CIRC | 900 | 900 | 58.46 | 1 | Survey | | |
| 26 | Reservoir Drn - Stevenson Pl | 407461.9 | 6435226.5 | CIRC | 375 | 375 | 79.26 | 1 | Survey | | |
| 27 | Reservoir Drn - Helen Cr | 407192.5 | 6435225.7 | CIRC | 900 | 900 | 71.34 | 1 | Survey | | |
| 28 | Reservoir Drn - John Cr | 407054.9 | 6435195.5 | CIRC | 900 | 900 | 65.84 | 1 | Survey | | |
| 29 | Reservoir Drn - Park Rd | 406910.2 | 6435190.6 | CIRC | 900 | 900 | 61.00 | 1 | Survey | | |
| 30 | Reservoir Drn - SW Hwy | 406617.3 | 6435282.8 | CIRC | 900 | 900 | 52.59 | 1 | Survey | | |
| 31 | Reservoir Drain - Railway | 406475.1 | 6435373.2 | Bridge | 3500 | 500 | 51.40 | 1 | Aerial image | | |
| 32 | Oaklands Drn - SW Hwy | 406604.7 | 6434948.6 | CIRC | 900 | 900 | 55.50 | 3 | UWMP | Y | 1.15 |
| 33 | Oaklands Drn - Railway | 406481.8 | 6434972.3 | Bridge | 4000 | 1200 | 53.25 | 1 | UWMP | Y | 1.15 |
| 34 | Oaklands Drn - George St | 406528.9 | 6434965.9 | RECT | 1200 | 600 | 54.60 | 3 | UWMP | y | 1.15 |
| 35 | Oaklands Drn - Thatcher Rd | 405721.7 | 6435605.8 | RECT | 1220 | 1200 | 37.97 | 1 | UWMP | | |
| 36 | Oaklands Drn - Larsen Rd | 405674.3 | 6435663.3 | RECT | 1220 | 1220 | 37.60 | 1 | UWMP | | |
| 37 | Oaklands Drn - Briggs Rd | 405010 | 6436012.8 | RECT | 1880 | 1220 | 32.40 | 1 | UWMP | | |
| 38 | Oaklands Drn - Kardan Bvd | 403720 | 6435812.3 | RECT | 1200 | 1200 | 25.50 | 3 | Observed | y | 1.14 |
| 39 | Oaklands Drn - Hopkinson Rd | 403208.5 | 6435653.1 | RECT | 3600 | 1900 | 24.34 | 1 | DWMP | | |
| 40 | Beenyup Brk - Old Brickworks Rd | 407489.7 | 6433818.3 | CIRC | 1200 | 1200 | 72.73 | 3 | Survey | | |
| 41 | Beenyup Brk - SW Hwy | 406579.2 | 6434299.6 | Bridge | 13030 | 1200 | 59.13 | 1 | Observed | y | 1.2 |
| 42 | Beenyup Brk - Railway | 406494.1 | 6434503.1 | Bridge | 4200 | 1200 | 55.85 | 1 | Observed | y | 1.2 |
| 43 | Beenyup Brk - Abernethy Rd | 406463.2 | 6434546.2 | RECT | 1240 | 1200 | 55.70 | 4 | Observed | y | 1.16 |

| Site ref | Location | X | Y | Shape | Width (mm) | Height (mm) | Invert (mAHD) | Barrels | Source | Image | Field ref |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 44 | Beenyup Brk - Won Niche Rd | 406352 | 6434627.7 | RECT | 2400 | 1500 | 53.36 | 4 | Observed | y | 1.3 |
| 45 | Beenyup Brk - Thatcher Rd | 405547.2 | 6434770.1 | RECT | 1500 | 600 | 44.40 | 2 | DWMP | | |
| 46 | Beenyup Brk - Briggs Rd | 405013.7 | 6434855.8 | RECT | 1210 | 920 | 38.60 | 2 | DWMP | | |
| 47 | Beenyup Brk - Malarkey Rd | 404691.1 | 6434872.7 | CIRC | 900 | 900 | 34.80 | 3 | DWMP | | |
| 48 | Beenyup Brk - Renaud Wy | 404123.9 | 6434915 | CIRC | 900 | 900 | 30.00 | 3 | DWMP | | |
| 49 | Beenyup Brk - kardan Bvd | 403719.8 | 6434922.9 | RECT | 1200 | 750 | 28.50 | 7 | UWMP | | |
| 50 | Beenyup Brk - Hopkinson Rd | 403225.5 | 6434844.6 | RECT | 3700 | 1560 | 25.20 | 1 | Observed | y | 1.24 |
| 51 | Abernethy Rd Drn - Abernethy Rd | 403228.7 | 6434813.5 | CIRC | 300 | 300 | 25.90 | 2 | Observed | y | 1.24 |
| 52 | Oaklands Drn - Abernethy Rd | 402179.7 | 6434547.8 | Bridge | 5000 | 1500 | 20.25 | 1 | Observed | y | 1.8 |
| 53 | Birrega BD - Bifurcation | 402179.7 | 6434547.8 | WIER | 2000 | 1500 | 20.50 | 1 | Observed | y | 1.8 |
| 54 | Oaklands Drn - Orton Rd | 402192 | 6432956 | Bridge | 5000 | 1500 | 18.80 | 1 | Observed | y | 1.9 |
| 55 | Oaklands Drn - Gossage Rd | 401813.1 | 6430935.4 | RECT | 1200 | 1800 | 15.90 | 3 | Observed | y | 1.10 |
| 56 | Brickwood Drn - Warrington Rd | 405415.5 | 6433829.2 | RECT | 1200 | 450 | 43.41 | 1 | Observed | y | 1.20 |
| 57 | Brickwood Drain N - Warrington Rd | 405413.9 | 6434137.4 | CIRC | 450 | 450 | 44.00 | 2 | UWMP | | |
| 58 | Brickwood Drn - Mead St | 404934.3 | 6434193.7 | RECT | 1200 | 450 | 38.40 | 4 | Observed | y | 1.20 |
| 59 | Brickwood Drn - Woolandra Dr | 404800 | 6434307.5 | RECT | 1200 | 450 | 36.70 | 4 | UWMP | | |
| 60 | Brickwood Drn - Doley Rd | 404515.5 | 6434361.2 | RECT | 1200 | 450 | 34.40 | 4 | Observed | y | 1.20 |
| 61 | Brickwood Drn - Kokoda Bvd | 404087.4 | 6434390.4 | RECT | 1200 | 450 | 30.50 | 4 | UWMP | | |
| 62 | Brickwood Drn - Tourmaline Bvd | 403723.9 | 6434466.3 | RECT | 900 | 900 | 28.19 | 4 | Observed | y | 1.20 |
| 63 | Brickwood Drn - Hopkinson Rd | 403239.8 | 6434410.1 | CIRC | 455 | 455 | 26.00 | 3 | DWMP | | |
| 64 | Brickwood Drn - SW Hwy | 406374.8 | 6433536.4 | CIRC | 380 | 380 | 57.20 | 2 | DWMP | | |
| 65 | Brickwood Drn - Railway | 406289.7 | 6433584.4 | RECT | 1220 | 920 | 55.92 | 1 | DWMP | | |

| Site ref | Location | X | Y | Shape | Width (mm) | Height (mm) | Invert (mAHD) | Barrels | Source | Image | Field ref |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 | Brickwood Drn - Soldiers Rd | 406240.7 | 6433587.6 | RECT | 1200 | 450 | 54.45 | 2 | DWMP | | |
| 67 | Brickwood Drn - Turner Rd | 405888.7 | 6433544.6 | RECT | 1500 | 600 | 48.80 | 1 | DWMP | | |
| 68 | Doley Precinct Drn - Warrington Rd | 405419.4 | 6433387.3 | CIRC | 450 | 450 | 45.80 | 2 | DWMP | | |
| 69 | Doley Precinct Drn - Lawrence Wy | 405015.2 | 6433492.6 | CIRC | 450 | 450 | 40.50 | 2 | UWMP | | |
| 70 | Doley Precinct Drn - Doley Rd | 404524.1 | 6433516 | RECT | 1200 | 600 | 36.15 | 1 | UWMP | | |
| 71 | Doley Precinct Drn - Kokoda Bvd | 404052.5 | 6433637.7 | CIRC | 1200 | 1200 | 31.91 | 2 | UWMP | | |
| 72 | Doley Precinct Drn - Hopkinson Rd | 403253.7 | 6433782.9 | RECT | 1200 | 500 | 25.40 | 1 | DWMP | | |
| 73 | Glades Drn - Hopkinson Rd | 403252.7 | 6433278.1 | CIRC | 720 | 720 | 26.20 | 2 | DWMP | | |
| 74 | Orton Rd Drn - SW Hwy | 406359.1 | 6432899.8 | CIRC | 600 | 600 | 58.40 | 1 | DWMP | | |
| 75 | Orton Rd Drn - Railway | 406117.9 | 6432898.5 | Bridge | 1220 | 920 | 55.60 | 1 | DWMP | | |
| 76 | Orton Rd Drn - Soldiers Rd | 406074.1 | 6432896.1 | CIRC | 300 | 300 | 54.95 | 3 | DWMP | | |
| 77 | Cardup Brk - SW Hwy | 406358.8 | 6432416.4 | CIRC | 900 | 900 | 54.61 | 1 | DWMP | | |
| 78 | Cardup Brk - Railway | 406000.9 | 6432439.4 | CIRC | 1700 | 1700 | 51.21 | 1 | DWMP | | |
| 79 | Cardup Brk - Soldiers Rd | 405962.6 | 6432449.4 | CIRC | 1700 | 1700 | 50.75 | 1 | DWMP | | |
| 80 | Cardup Brk - Hopkinson Rd | 403265.6 | 6432787.6 | RECT | 1800 | 1500 | 26.00 | 1 | Observed | y | 1.25 |
| 81 | DWMP 2018 | 401372.2 | 6434340 | Bridge | 5000 | 1500 | 17.80 | 1 | Observed | y | 1.7 |
| 82 | Birrega BD - Orton Rd/Kargotich Rd | 401382.2 | 6432953.1 | Bridge | 5000 | 1000 | 16.50 | 1 | Observed | y | 1.11 |
| 83 | Birrega BD - Kargotich Rd | 401331.5 | 6431946.7 | Bridge | 5000 | 1000 | 15.40 | 1 | Observed | y | 1.12 |
| 84 | Oaklands Drn - Kargotich Rd | | | Bridge | | | | 1 | Observed | y | 2.2 |
| 85 | Oaklands Drn - Railway | | | Bridge | | | | 1 | Aerial image | | |
| 86 | Cardup Drn - Railway | | | CIRC | 1100 | 1100 | | 3 | Observed | y | 2.10 |
| 87 | Cardup Drn - Walk trail | | | CIRC | 600 | 600 | | 2 | Observed | y | 2.10 |

| Site ref | Location | X | Y | Shape | Width (mm) | Height (mm) | Invert (mAHD) | Barrels | Source | Image | Field ref |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 88 | Cardup Drn - Soldiers Rd | | | CIRC | 750 | 750 | | 2 | Observed | y | 2.10 |
| 89 | Cardup Drn - Pollard Cross | | | CIRC | 750 | 750 | | 2 | Observed | y | 2.11 |
| 90 | Cardup Drn - Baigup Loop | | | CIRC | 600 | 600 | | 1 | Observed | y | 2.13 |
| 91 | Cardup Drn - Hopkinson Rd | | | RECT | 1200 | 700 | | 2 | Observed | y | 2.14 |
| 92 | Norman Drn - SW Hwy | | | CIRC | 1800 | 1800 | | 2 | Observed | y | 2.9 |
| 93 | Norman Drn - Railway | | | Bridge | | | | 1 | Observed | y | 2.8 |
| 94 | Norman Drn - Walk trail | | | CIRC | 600 | 600 | | 2 | Observed | y | 2.8 |
| 95 | Norman Drn - Soldiers Rd | | | CIRC | 1800 | 1800 | | 1 | Observed | y | 2.8 |
| 96 | Norman Drn - Hopkinson Rd | | | CIRC | 900 | 900 | | 2 | Observed | y | 2.7 |
| 97 | Norman Drn - Railway | | | Bridge | | | | 1 | Aerial image | | |
| 98 | Norman Drn - Kargotich Rd | | | CIRC | 750 | 750 | | 2 | Observed | y | 2.5 |

### *A.7.3 2-Dimensional domain*

To provide improved understanding of flood water behaviour within the study area, an integrated 2-dimensional model domain has been added to the current system model. This domain allows excess water to exit the hydraulic model, flow overland across a 2-dimensional surface and re-enter the hydraulic model further downstream as appropriate.

The 2-dimensional domain has been developed as a terrain-sensitive triangular mesh from a LiDAR ground elevation model (2008) updated to reflect the elevation of developed and developing areas with imported fill. An assumption of 1.5m fill has been applied to all lots (residential, commercial and industrial) developed since 2008. Roads, public open spaces, multiple use corridors and rural areas have been retained at 2008 elevations.

It should be noted that this methodology does not provide a perfectly realistic post-development ground model for the study area. However, it is useful to provide a somewhat improved understanding of flood water behaviour in urban parts of the study area, and rural parts of the study area are expected to be well represented by 2008 elevations. In future, to provide improved model performance, consideration should be given to undertaking an update to the LiDAR elevation model.

### *10.2.1 Critical duration assessment*

Design rainfall events were derived from the Bureau of Meteorology's 2016 Intensity Frequency Durations combined with temporal patterns from the 2016 release of Australian Rainfall and Runoff (ARR16) for 1h, 3h, 6h, 12h, 24h, 48h and 72h durations at 1Exceedance per Year (1EY), 20% AEP, 10% AEP and1% AEP. Critical events were selected for presentation from the following groupings:

4. ARR16: 1EY; 1h(S1-10), 3h(S1-10), 6h(S1-10), 12h(S1-10), 24h(S1-10), 48h(S1-10) and 72h(S1-10).
5. ARR16: 20%AEP; 1h(S1-10), 3h(S1-10), 6h(S1-10), 12h(S1-10), 24h(S1-10), 48h(S1-10) and 72h(S1-10).
6. ARR16: 1%AEP; 1h(S1-10), 3h(S1-10), 6h(S1-10), 12h(S1-10), 24h(S1-10), 48h(S1-10) and 72h(S1-10).

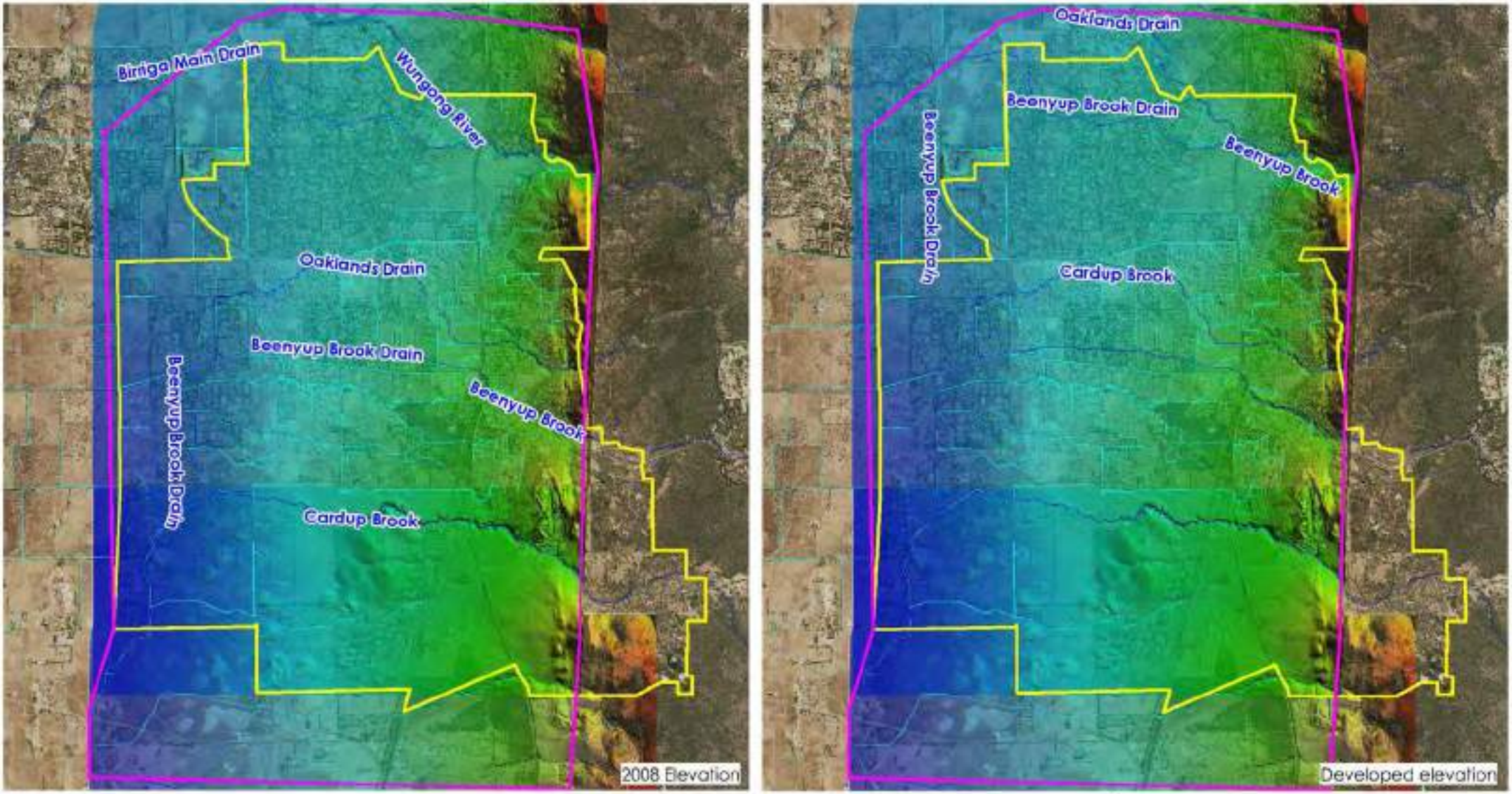
The selected critical events are:

- For peak flow (at key culvert locations):
  - 1EY – 3h (S10)
  - 20%AEP – 3h(S7)
  - 1%AEP – 3h(S2)
- For detention volumes:
  - 1EY – 3h (S10)
  - 20%AEP – 3h(S7)
  - 1%AEP – 3h(S2)

It is interesting to note that the revisions to the model have resulted in a general shortening of the critical duration from 3-6 hours in the base model to 1-3 hours in the current system model. This is largely due to the extent of additional development in the system and reflects a generally shorter time of concentration for drainage within those developments. For this reason, to ensure that peak catchment flows are captured, analysis and design using the current system model has included the 20% AEP – 6h(S10) and the 1% AEP – 1h (S2) which are the critical events at these durations.

# Shire of Serpentine Jarrahdale - Byford DWMS

## Figure A5 - 2-Dimensional model domain and ground model




Legend

DWMS Study Area

2-Dimensional model domain

Scale 1: 75,000 at A4

0 1.5km

N



Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HR. Projection: MGA1 zone 50.

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### *A.7.4 Results comparison to base model*

Peak flows generated by the InfoWorks ICM current system model applying revised hydrological parameters and the revised AR&R2016 methodology were compared to peak flows generated by the original base model at various critical locations within the major waterways. This comparison is presented in Table A18 and Table A19.

Differences in peak flows and levels are observed at all sites. It is important to note that whilst similar locations have been presented in these tables, in several cases the modelled network has changed significantly and therefore a direct comparison is not strictly possible. This is particularly the case for flood levels where large differences may be caused by non-identical locations. Explanatory notes relating to the key differences at each of the selected sites follow:

1. Oaklands drain d/s George Road (north)
    - 20% AEP flow is reduced from the upstream catchment which includes a large area of the old townsite.
    - Survey information from the upstream catchment combined with the addition of 2D overland flow routing has improved representation of catchment storage in this area.
    - 1% AEP flow is increased because of overland flooding from the south re-entering the system just upstream of this site.
2. Oaklands drain d/s George Road (south)
    - 20% AEP flow is reduced from the upstream catchment which includes a large area of the old townsite.
    - Survey information from the upstream catchment combined with the addition of 2D overland flow routing has improved representation of catchment storage in this area.
    - 1% AEP flow is reduced because of overland flooding to the north re-entering the system just upstream of site 1.
3. Oaklands drain d/s Evans Road
    - Flow at this location is reduced for reasons consistent with the results at sites 1 and 2 above.
4. Oaklands drain u/s Malarkey Road
    - Flow at this location is reduced for reasons consistent with the results at sites 1, 2 and 3 above.
5. Thomas Road drain u/s Malarkey Road
    - Flow at this location is reduced from the upstream catchment which is mostly rural residential.
    - The addition of 2D overland flow routing has improved representation of catchment storage in this area.
6. Oaklands drain d/s Malarkey Road
    - Flow at this location is reduced for reasons consistent with the results at sites 4 and 5 above.
7. Oaklands drain at Hopkinson Road
    - Flow at this location is reduced for reasons consistent with the results at sites 4, 5 and 6 above.
8. Beenyup Brook d/s South Western Hwy
    - 20% AEP flow is slightly increased from the upstream catchment resulting from changes to catchment delineation, rainfall patterns and hydrological parameters.
    - 1% AEP is significantly reduced resulting from incorporation of the Old Brickworks Road Sump which contains a significant volume of storage in this event.
    - This reduction removes any need to upgrade the Abernethy Road culverts.

9. Beenyup Brook d/s Byford Town Centre
    - The flow through the old trotting track area is slightly reduced, alleviating flood risk in this section of Byford.
10. Beenyup Brook to Oaklands drain link
    - 20% AEP flow towards the Oaklands drain is increased because of reduced flow through the trotting track area. This could be amended if required although it has little impact on the downstream Oaklands system which has been designed to accommodate larger flows.
    - 1% AEP flow towards the Oaklands drain is reduced consistent with reductions noted at sites 8 and 9 from the upstream catchment.
11. Beenyup Brook at Hopkinson Road
    - Flows at this site are reasonably consistent with previous modelling.
12. Brickwood drain u/s Doley Road
    - Flows are slightly increased from the upstream catchment resulting from changes to catchment delineation, rainfall patterns and hydrological parameters.
    - The downstream MUC has the capacity to accommodate this additional flow.
13. Brickwood drain at Hopkinson Road
    - Flows at this site are reasonably consistent with previous modelling.
14. Doley drain at Hopkinson Road
    - Flows at this site are increased because of changes in overland flow distribution between Orton Road drain and Doley drain. This has also resulted in some reduction in Cardup Brook flows at Hopkinson road which ultimately receives flow from Orton Road drain.
15. Cardup Brook d/s South Western Hwy
    - Flows are significantly reduced resulting from incorporation of 2D overland flow routing which has enabled representation of a significant volume of storage upstream of South Western Hwy and the Railway, neither of which are overtopped.
16. Cardup Brook at Hopkinson Road
    - Flow is reduced for reasons consistent with results at site 15 above as well as through overland flow changes identified for site 14 above.

Table A18: Current system model peak flow comparison to base model

| Location | 5-year ARI/20% AEP peak flows | | 100-year ARI/1% AEP peak flows | |
|---|---|---|---|---|
| | Base model | Current system model | Base model | Current system model |
| 1. Oaklands drain d/s George Road (north) | 5.5 | 4.0 | 10.2 | 8.9 |
| 2. Oaklands drain d/s George Road (south) | 2.3 | 1.4 | 10.7 | 2.0 |
| 3. Oaklands drain d/s Evans Road | 10.7 | 10.0 | 34.4 | 15.5 |
| 4. Oaklands drain u/s Malarkey Road | 11.0 | 9.9 | 35.1 | 19.0 |
| 5. Thomas Road drain u/s Malarkey Road | 9.5 | 4.3 | 25.7 | 9.2 |
| 6. Oaklands drain d/s Malarkey Road | 20.9 | 13.8 | 62.0 | 28.6 |
| 7. Oaklands drain at Hopkinson Road | 15.8 | 12.5 | 51.5 | 31.2 |

| Location | 5-year ARI/20% AEP peak flows | | 100-year ARI/1% AEP peak flows | |
|---|---|---|---|---|
| | Base model | Current system model | Base model | Current system model |
| 8. Beenyup Brook d/s South Western Hwy | 8.1 | 10.4 | 31.2 | 18.8 |
| 9. Beenyup Brook d/s Byford Town Centre | 2.8 | 3.6 | 3.1 | 3.5 |
| 10. Beenyup Brook to Oaklands drain link | 5.2 | 5.4 | 16.1 | 9.2 |
| 11. Beenyup Brook at Hopkinson Road | 5.5 | 3.9 | 9.6 | 7.0 |
| 12. Brickwood drain u/s Doley Road | 1.4 | 2.9 | 3.4 | 6.2 |
| 13. Brickwood drain at Hopkinson Road | 1.6 | 3.6 | 6.8 | 7.4 |
| 14. Doley Drain at Hopkinson Road | 2.1 | 4.0 | 5.1 | 9.4 |
| 15. Cardup Brook d/s South Western Hwy | 5.8 | 4.0 | 23.5 | 20.7 |
| 16. Cardup Brook at Hopkinson Road | 9.4 | 3.9 | 33.3 | 10.6 |

Table A19: Current system model top water level comparison to base model

| Location | 5-year ARI/20% AEP top water level | | 100-year ARI/1% AEP top water level | |
|---|---|---|---|---|
| | Base model | Current system model | Base model | Current system model |
| 1. Oaklands drain d/s George Road (north) | 53.2 | 49.4 | 53.3 | 49.5 |
| 2. Oaklands drain d/s George Road (south) | 51.8 | 51.3 | 52.0 | 51.4 |
| 3. Oaklands drain d/s Evans Road | 44.3 | 42.3 | 44.6 | 42.4 |
| 4. Oaklands drain u/s Malarkey Road | 32.7 | 30.7 | 32.9 | 30.7 |
| 5. Thomas Road drain u/s Malarkey Road | 30.9 | 30.6 | 31.1 | 31.2 |
| 6. Oaklands drain d/s Malarkey Road | 29.8 | 30.0 | 30.2 | 30.2 |
| 7. Oaklands drain at Hopkinson Road | 26.4 | 25.8 | 27.0 | 26.0 |
| 8. Beenyup Brook d/s South Western Hwy | 58.5 | 59.1 | 58.7 | 59.3 |
| 9. Beenyup Brook d/s Abernethy Road | 56.5 | 47.9 | 56.6 | 48.1 |
| 10. Beenyup Brook to Oaklands drain link | 56.5 | 48.8 | 56.6 | 49.5 |
| 11. Beenyup Brook at Hopkinson Road | 56.3 | 26.1 | 56.8 | 26.5 |
| 12. Brickwood drain u/s Doley Road | 44.5 | 35.4 | 45.4 | 36.1 |
| 13. Brickwood drain at Hopkinson Road | 34.5 | 27.4 | 35.5 | 27.9 |
| 14. Doley Drain at Hopkinson Road | 25.6 | 26.8 | 26.0 | 27.4 |

| Location | 5-year ARI/20% AEP top water level | | 100-year ARI/1% AEP top water level | |
|---|---|---|---|---|
| | Base model | Current system model | Base model | Current system model |
| 15. Cardup Brook d/s South Western Hwy | 41.6 | 55.8 | 41.7 | 55.9 |
| 16. Cardup Brook at Hopkinson Road | 27.5 | 27.5 | 27.7 | 28.3 |

### *A.7.5 Results comparison to Birrega Oaklands flood modelling and drainage study*

Table A20 provides a comparison of *Birrega Oaklands flood modelling and drainage study* (DoW, 2015) peak flows at selected locations with those predicted by the base model and current system model. Additional locations, outside the base model domain are included based flows obtained from longitudinal sections presented in *Birrega Oaklands flood modelling and drainage study* (DoW, 2015).

Flows predicted by the current system model are generally reduced, with the exception of site 1, where a substantial adjustment of overland flow paths has resulted in a localised increase that is not reflected further downstream (see section A.7.4 above for details).

The significant flow reductions observed in the Beenyup and Cardup Brooks are generated through the combination of detailed 1-dimensional and 2-dimensional modelling upstream of South Western Highway where large storage areas have been identified. The Birrega Oaklands model, although capable of reflecting the available storage through its 2-dimensional surface, operates with a 10m fixed grid size resulting in premature overtopping of the Highway at Cardup Brook and Old Brickworks Road at Beenyup Brook.

Table A20: Birrega Oaklands model top water level comparison to current system model

| Location | Base model | | Current system model | | Birrega Oaklands study | |
|---|---|---|---|---|---|---|
| | 5-year ARI | 100-year ARI | 20% AEP | 1% AEP | 5-year ARI | 100-year ARI |
| 1. Oaklands drain d/s George Road (north) | 5.5 | 10.2 | 4.0 | 8.9 | 4.2 | 11.7 |
| 2. Beenyup Brook d/s South Western Hwy | 8.1 | 31.2 | 10.4 | 18.8 | 5.4 | 26.8 |
| 3. Cardup Brook d/s South Western Hwy | 5.8 | 23.5 | 4.0 | 7.8 | 20.7 | 22.7 |

## A.8 Current system detailed modelling results

Detailed flood maps and longitudinal sections of significant watercourses for critical duration 1EY, 20% AEP and 1% AEP flood events are provided in Appendix C.

Critical 1EY, 20% AEP and 1% AEP event longitudinal sections for significant watercourses are provided to assist with the design of subdivisional drainage and may be used to accurately determine flows and levels.

# APPENDIX B – SITE INSPECTION PHOTOGRAPHS AND NOTES

Structure No 3: Site 1.23 – Wungong River at Rowley Road

Structure No 6: Site 1.22 – Birrega Drain at Wungong South Road

Structure No 7: Site 1.21 – Birrega Drain at Masters Road

Structure No 8: Site 1.1 – Hopkinson Road at Darling Downs

Structure No 17: Site 1.4 – Thomas Road, Hopkinson Road Intersection

Structure No 19: Site 1.5 – Thomas Road, Ballak Place Intersection

Structure No 30: Site 1.15 – Oaklands Drain at South Western Highway

Structure No 30a: Site 1.15 – Oaklands Drain at George Street

Structure No 31: Site 1.15 – Oaklands Drain at Railway

Structure No 36: Site 1.14 – Redgum Brook Multiple Use Corridor at Kardan Boulevard

Structure No 39: Site 1.2 – Beenyup Brook at South West Highway

Structure No 40: Site 1.2 – Beenyup Brook at Railway

Structure No 41: Site 1.16 – Beenyup Brook at Abernethy Road

Structure No 42: Site 1.3 – Beenyup Brook at Won Niche Street


Structure No 49: Site 1.24 – Beenyup Brook at Hopkinson Road

Structure No 50: Site 1.24 – Beenyup Brook Subdrain at Abernethy Road

Structure No 51: Site 1.8 – Oaklands Drain at Abernethy Road

Structure No 52: Site 1.8 – Oaklands Drain Bifurcation

Structure No 53: Site 1.9 – Oaklands Drain at Orton Road

Structure No 54: Site 1.10 – Oaklands Drain at Gossage Road

Structure No 56: Site 1.20 – Glades Multiple Use Corridor at Warrington Road

Structure No 58: Site 1.20 – Glades Multiple Use Corridor at Mead Street

Structure No 60: Site 1.20 – Glades Multiple Use Corridor at Doley Road

Structure No 62: Site 1.20 – Glades Multiple Use Corridor at Tourmaline Boulevard

Structure No 80: Site 1.25 – Cardup Brook at Hopkinson Road

Structure No 81: Site 1.7 – Birrega Subdrain at Abernethy Road, Kargotich Road Intersection

Structure No 82: Site 1.11 – Birrega Subdrain at Orton Road, Kargotich Road Intersection

Structure No 83: Site 1.12 – Birrega Subdrain at Kargotich Road

Structure No 84: Site 2.1 – Rowley Road at Darling Downs

Structure No 84: Site 2.2 – Oaklands Drain at Kargotich Road

Structure No 86: Site 2.10 – Cardup Drain at Railway

Structure No 87: Site 2.10 – Cardup Drain at Railway walk trail

Structure No 88: Site 2.10 – Cardup Drain at Soldiers Road

Structure No 89: Site 2.11 – Cardup Drain at Pollard Cross

Structure No 90: Site 2.13 – Cardup Drain at Baigup Loop

Structure No 91: Site 2.14 – Cardup Drain at Hopkinson Road

Structure No 92: Site 2.9 – Norman Drain at South West Highway

Structure No 93: Site 2.8 – Norman Drain at Railway

Structure No 94: Site 2.8 – Norman Drain at Railway walk trail

Structure No 95: Site 2.8 – Norman Drain at Soldiers Road

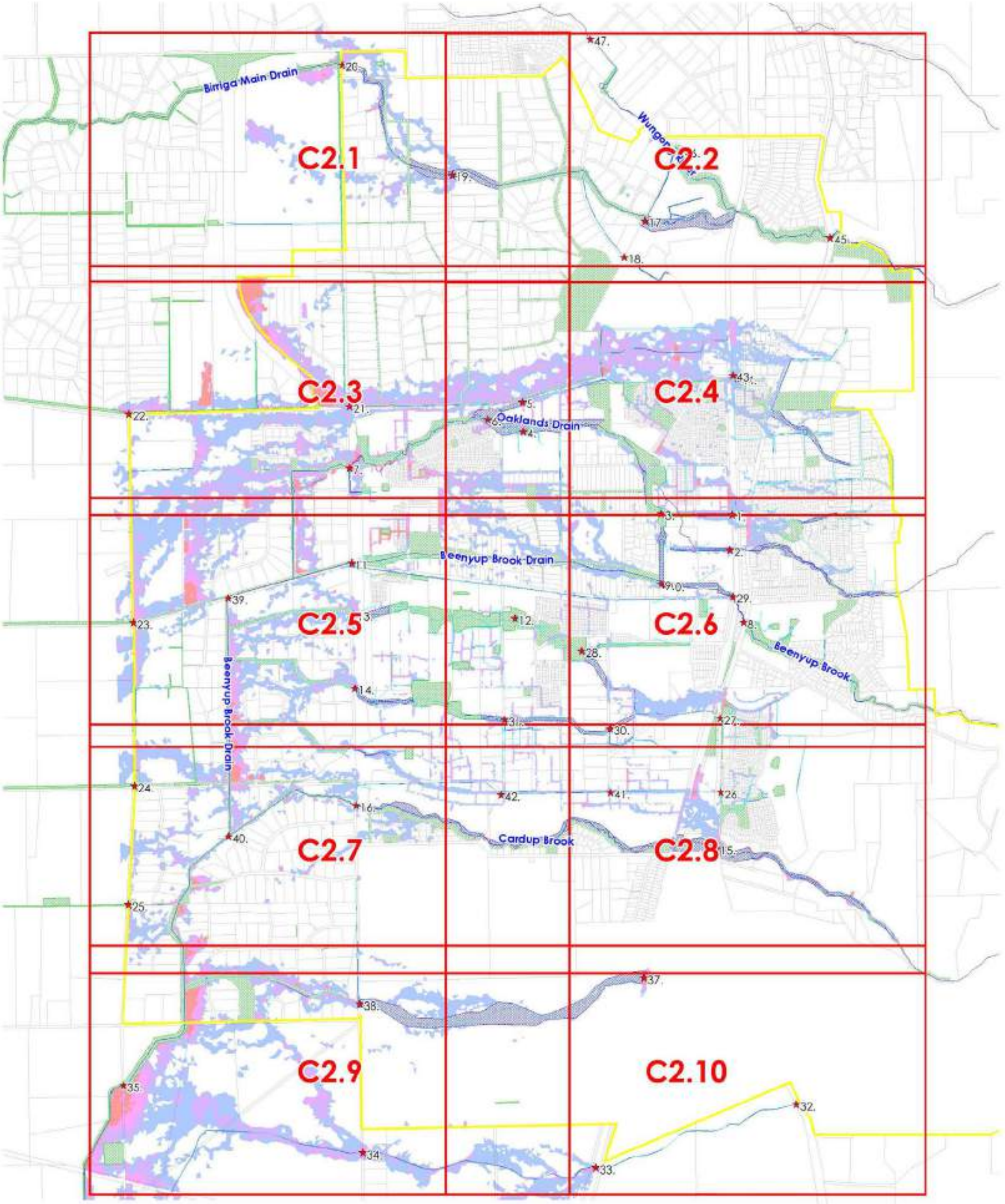
Structure No 96: Site 2.7 – Norman Drain at Hopkinson Road

Structure No 98: Site 2.5 – Norman Drain at Kargotich Road

# APPENDIX C – DETAILED FLOOD MAPPING AND LONGITUDINAL SECTIONS

- Figure C1: Flood mapping overview
- Figure C2.1-10: Detailed flood mapping
- Figure C2.11-20: Longitudinal sections – 20% AEP
- Figure C2.21-30: Longitudinal sections – 1% AEP

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C1 - Flood mapping overview




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- ★ Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 30,000 at A3

0 600m

N


Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB. Projection: MGA, zone 50.

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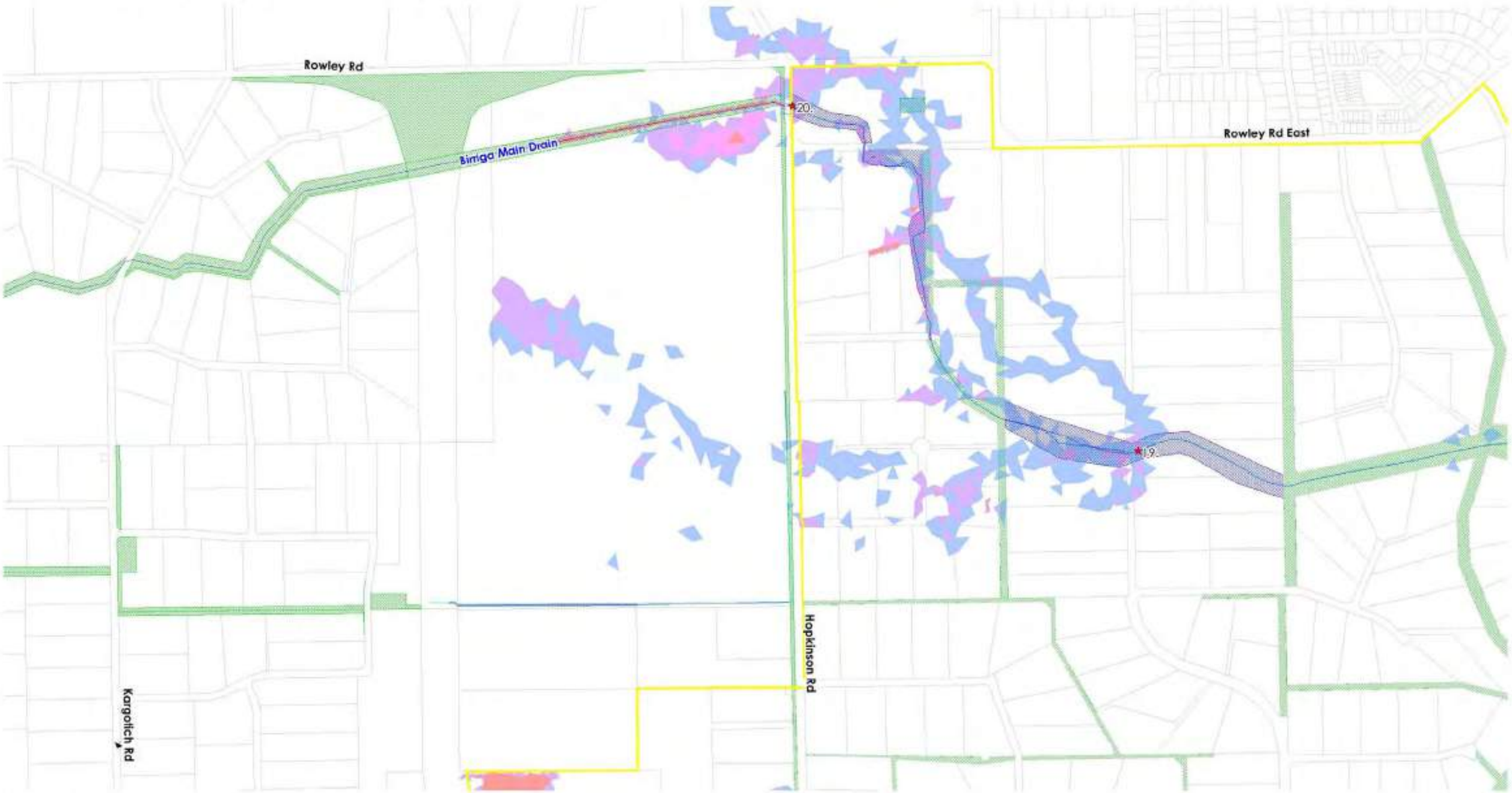
# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.1 - Detailed flood mapping




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 10,000 at A3

0 200m



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# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.2 - Detailed flood mapping


Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

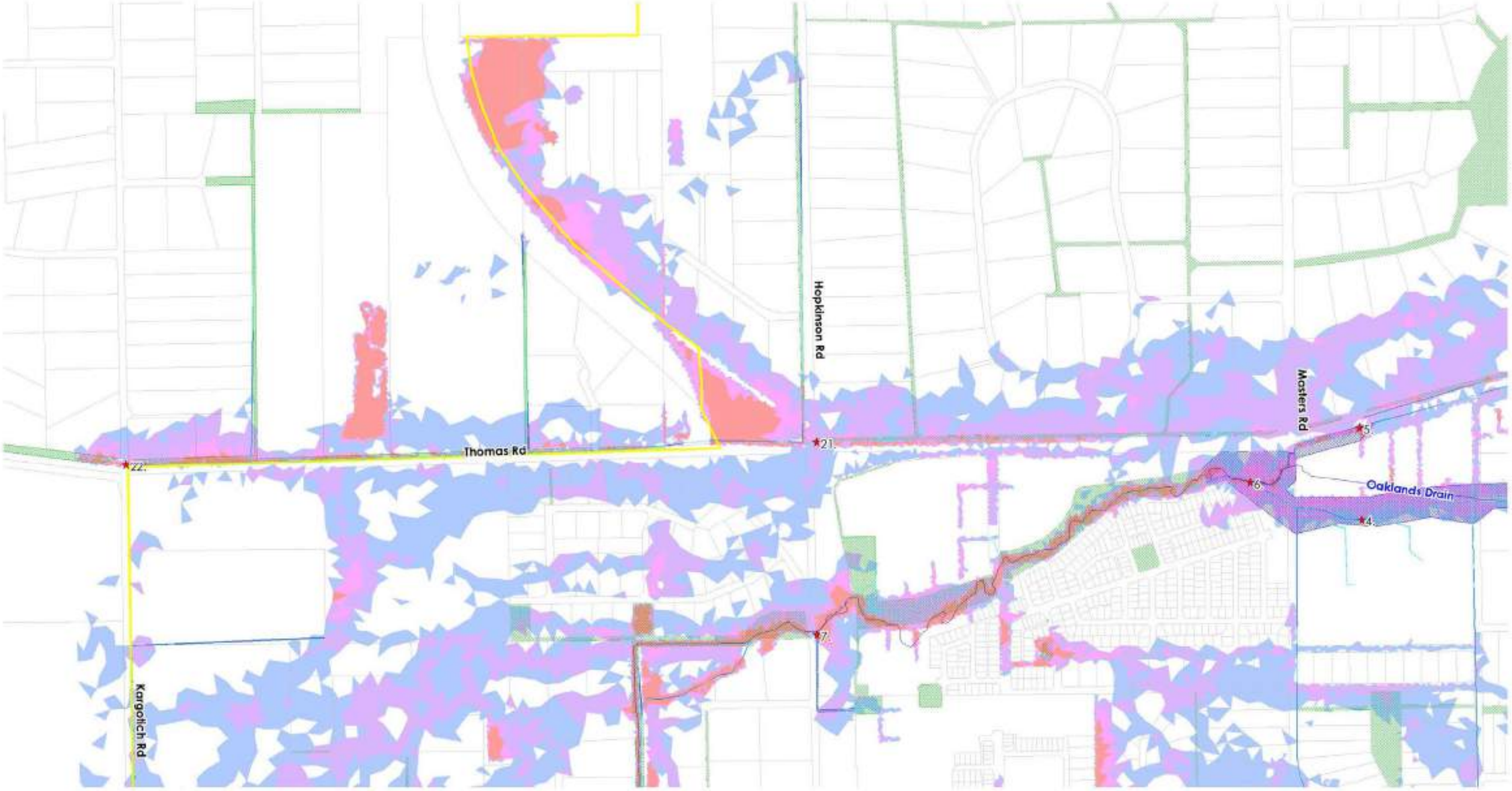
- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- ★ Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 10,000 at A3

0 200m

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.3 - Detailed flood mapping




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

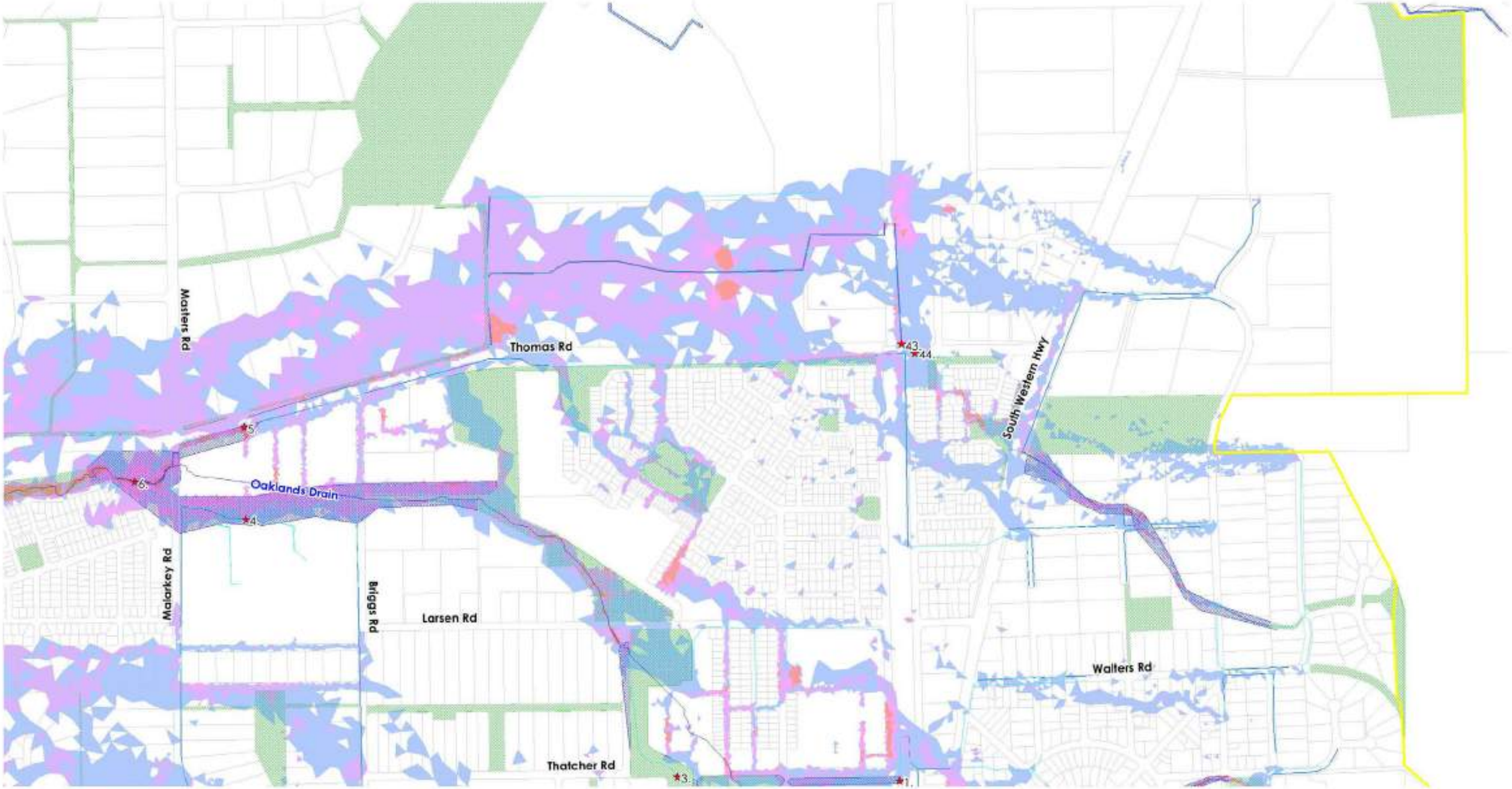
- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 10,000 at A3

0 200m


Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB. Projection: MGA; zone 50.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.4 - Detailed flood mapping




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

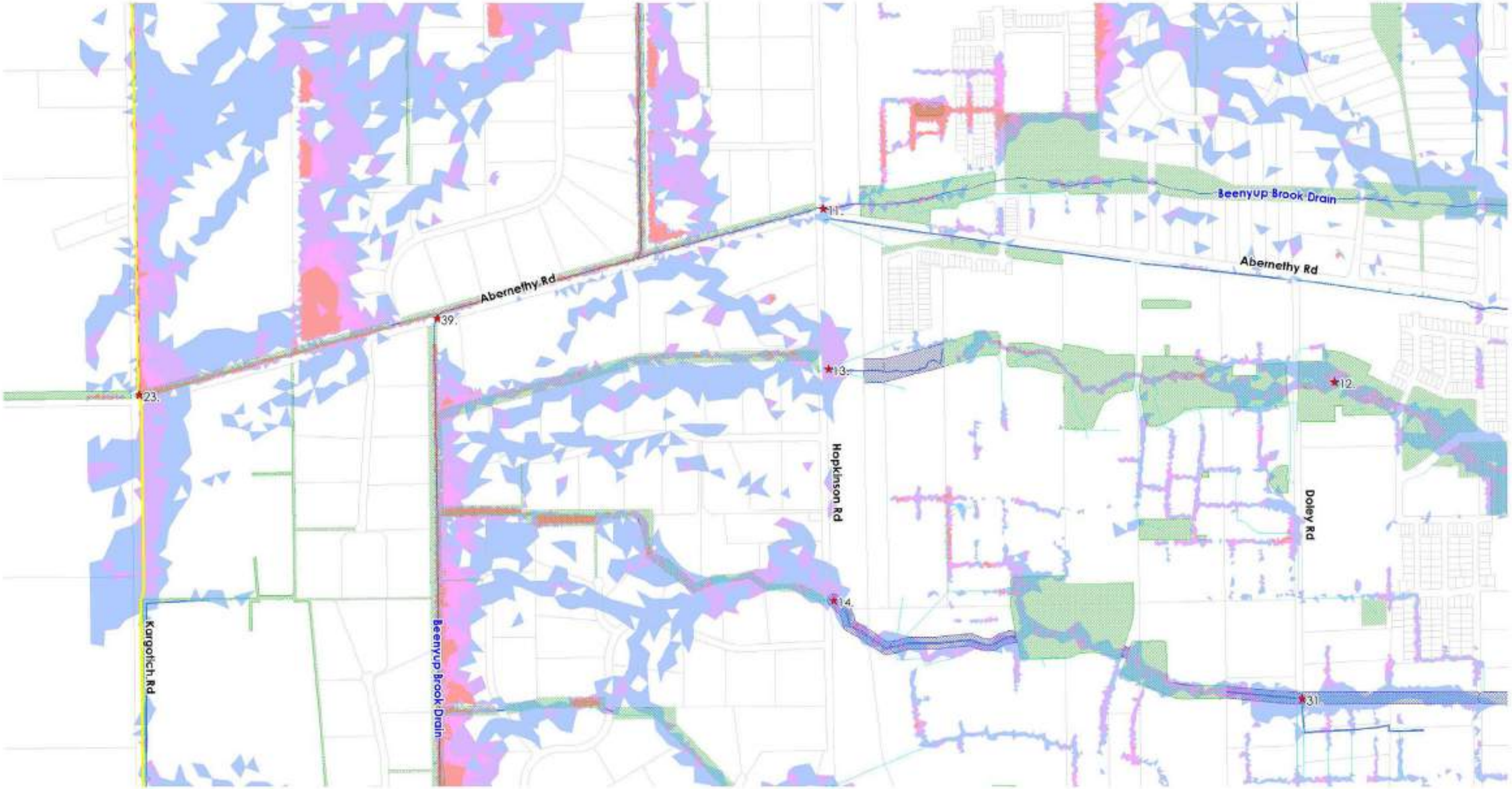
Scale 1: 10,000 at A3

0 200m


Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB Projection: MGA: zone 50.

urbaqua

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.5 - Detailed flood mapping




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

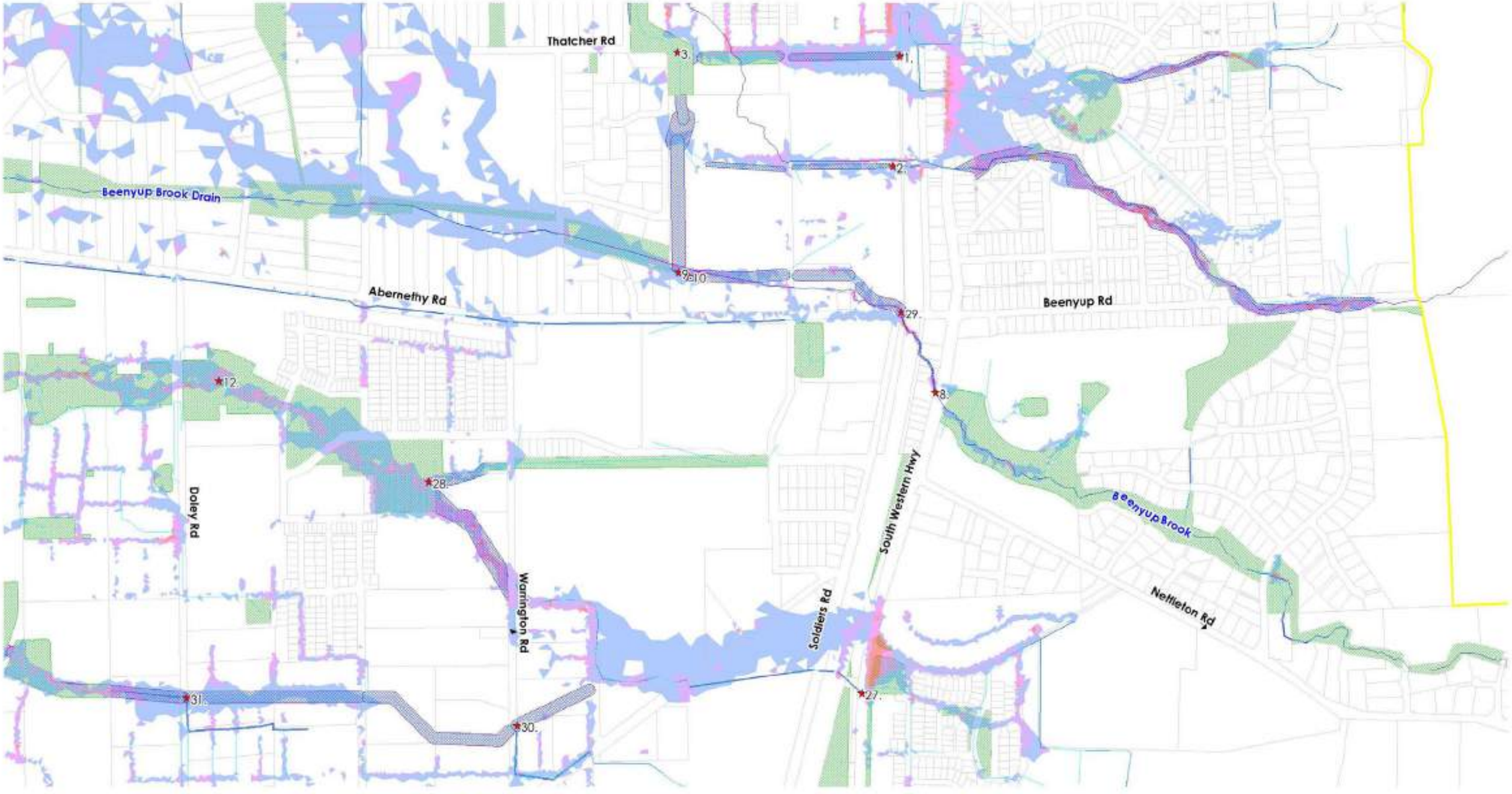
- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 10,000 at A3

0 200m

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.6 - Detailed flood mapping




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves


Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB. Projection: MGA: zone 50.

Scale 1: 10,000 at A3

0 200m

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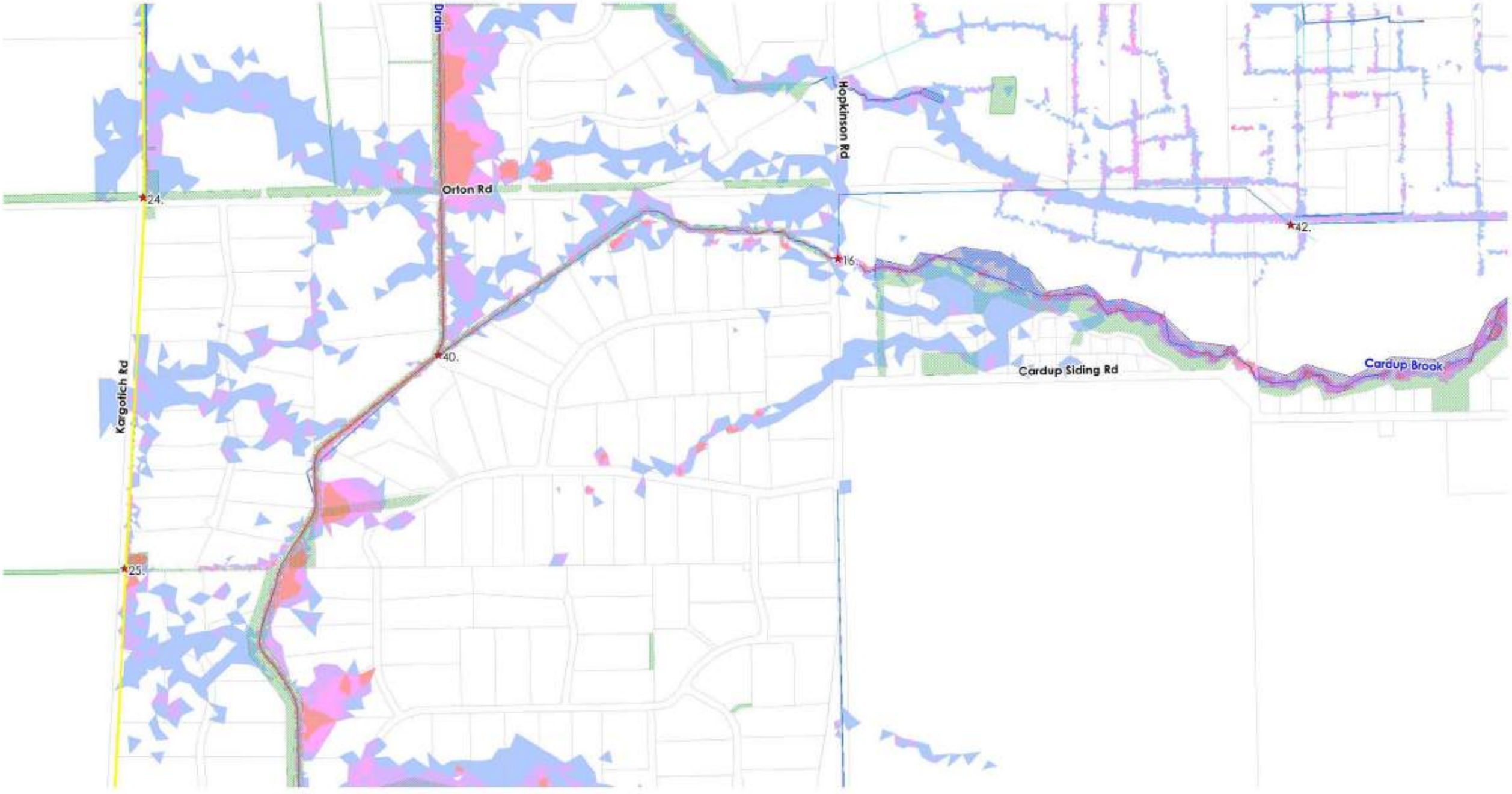
# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.7 - Detailed flood mapping




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 10,000 at A3

0 200m


Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB Projection: MGA: zone 50.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.8 - Detailed flood mapping


Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 10,000 at A3

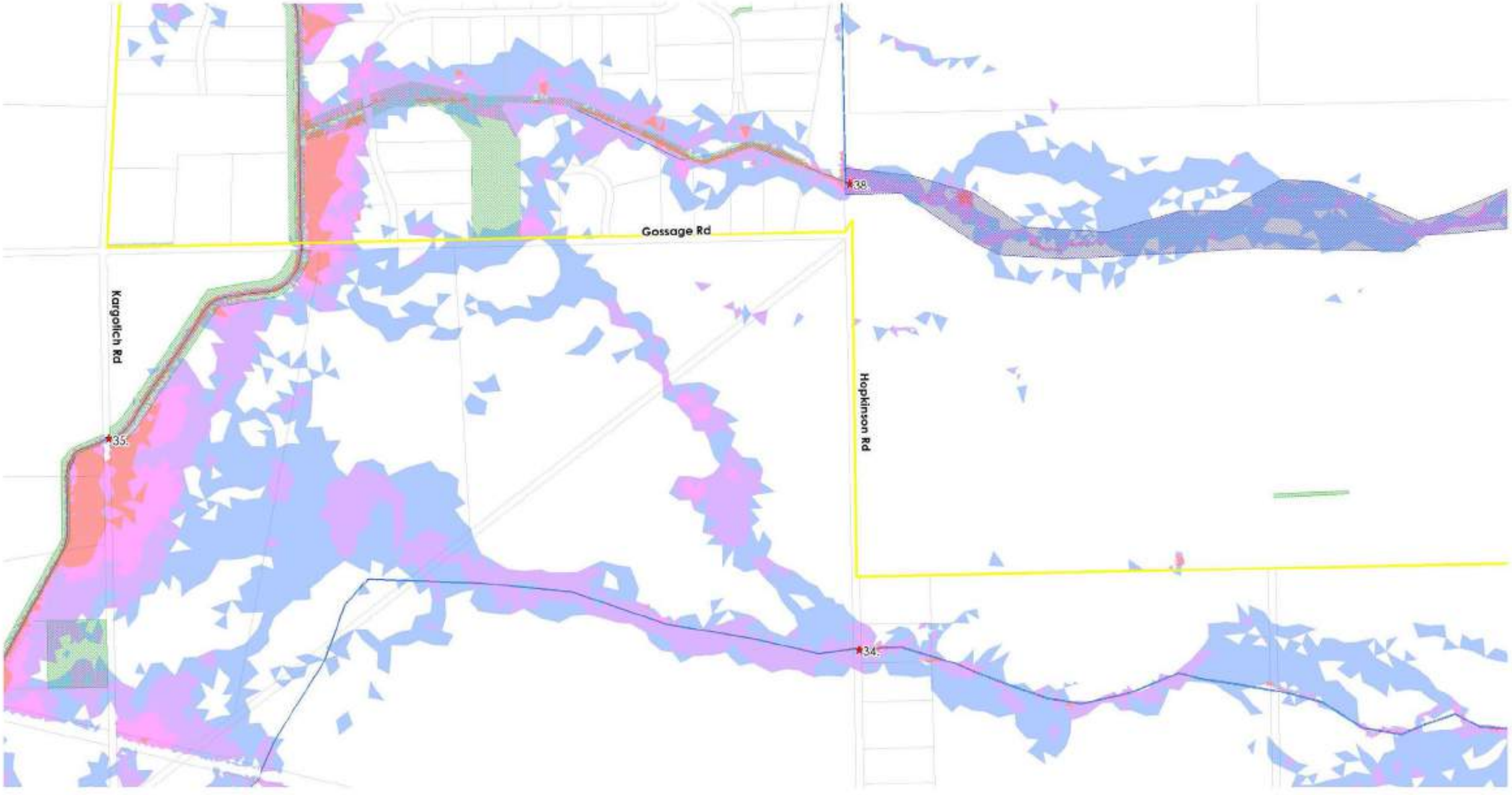
0 200m

N

urbaqua


Data source: Landgate; Shire of Serpentine-Jarrahdale; DWER. Created by: HB. Projection: MGA; zone 50.

# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.9 - Detailed flood mapping




Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

1% AEP flood depth

- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 10,000 at A3

0 200m


Data source: Landgate, Shire of Serpentine-Jarrahdale, DWER. Created by: HB Projection: MGA: zone 50.

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# Shire of Serpentine Jarrahdale - Byford DWMS
## Figure C2.10 - Detailed flood mapping


Legend:

- DWMS Study Area
- Major Watercourses
- Modelled other drains and watercourses
- Existing POS and drainage reserves

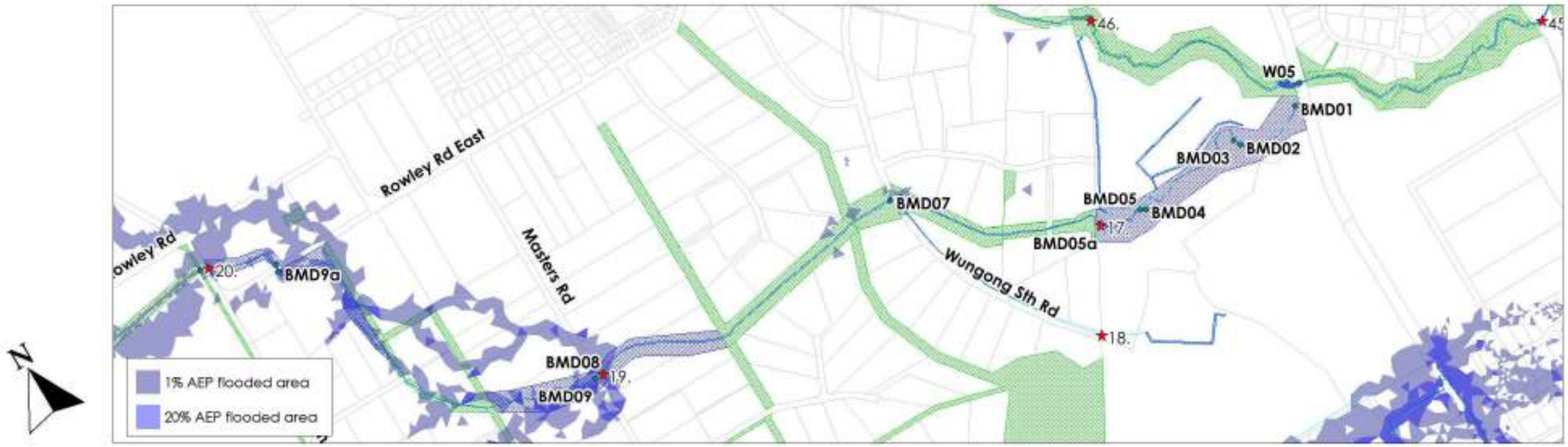
1% AEP flood depth

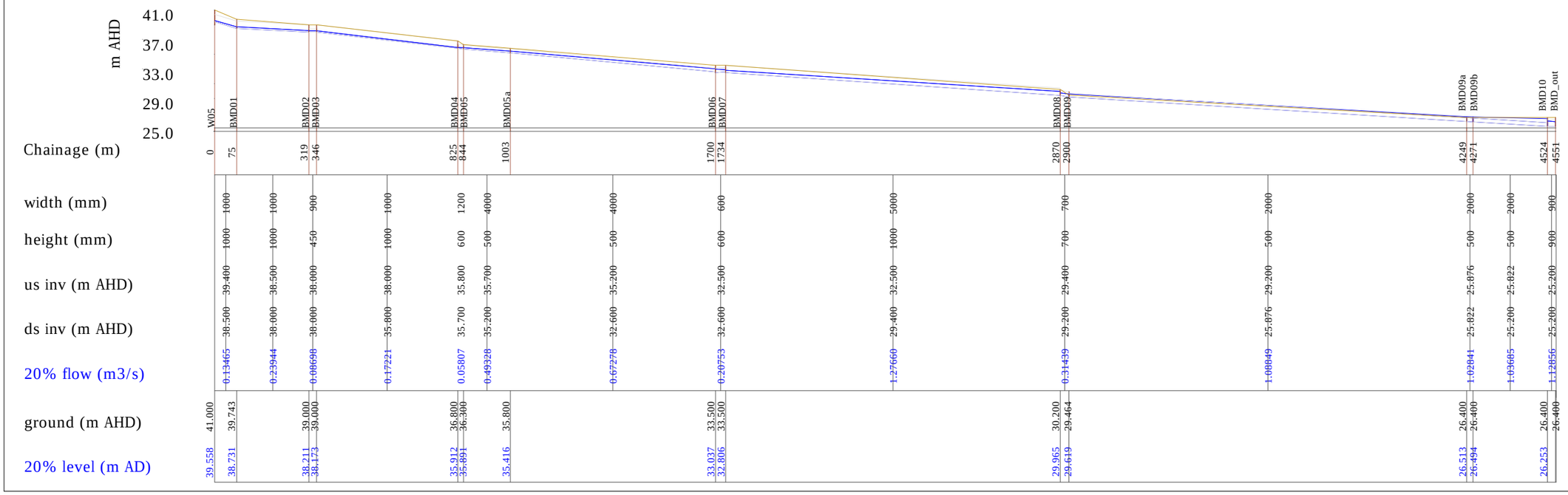
- >0.5
- 0.3 to 0.5
- 0.1 to 0.3
- 0.03 to 0.1

- Critical flow and top water level locations (Table 2)
- Reporting subcatchments (Table 3)
- Recommended new drainage reserves

Scale 1: 10,000 at A3

0 200m




# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.11 - Birrega Drain - 20% AEP



| ISSUE | DATE | DESIGN | CHECK |
|---|---|---|---|
| A | 18 Jun 2018 | AN | HB |

DATA SOURCES
Landgate
Depart of Planning

N.T.S

Projection: N/A

Datum: N/A

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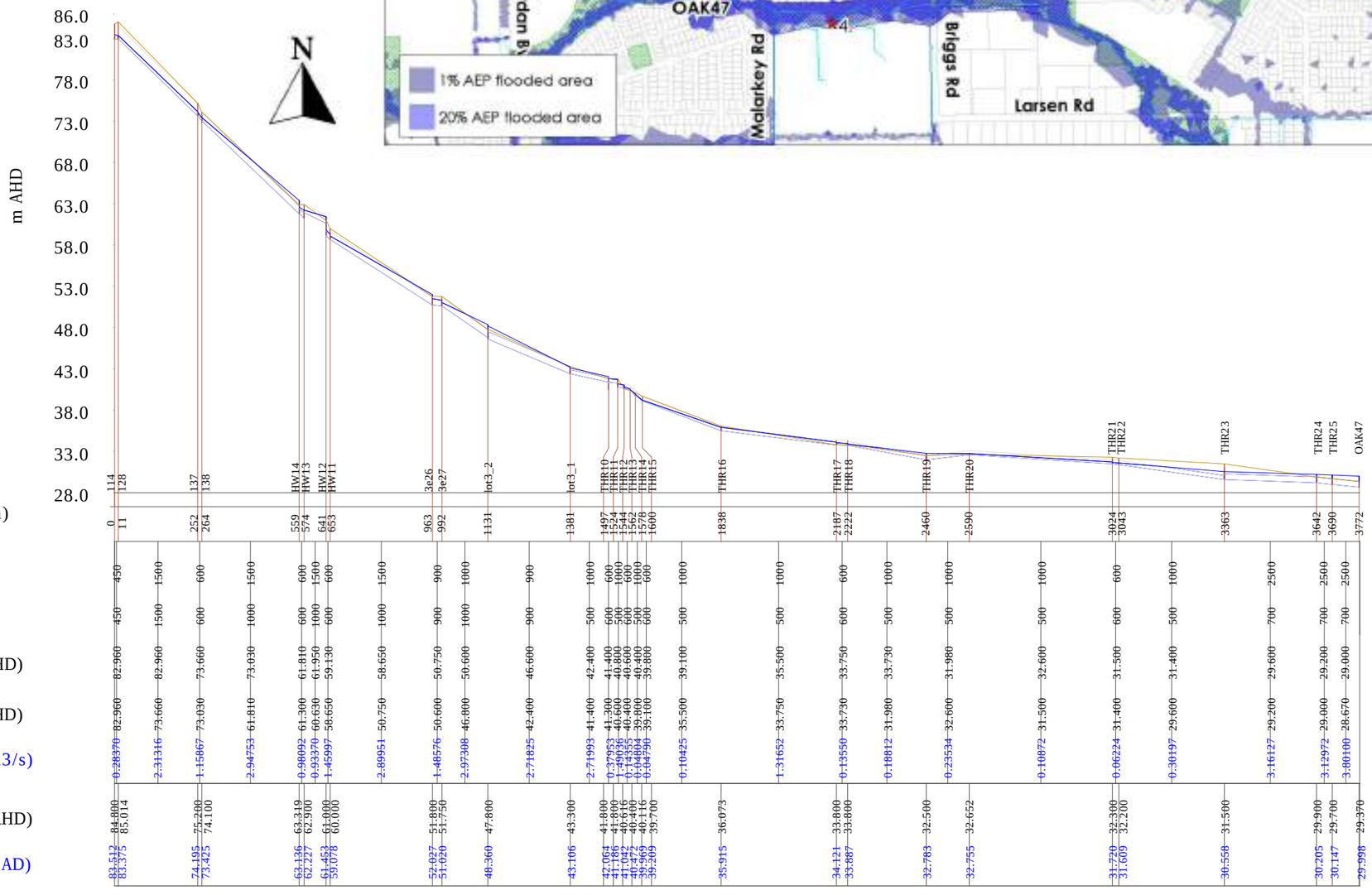
land and water solutions


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.12 - Oaklands Drain North - 20% AEP

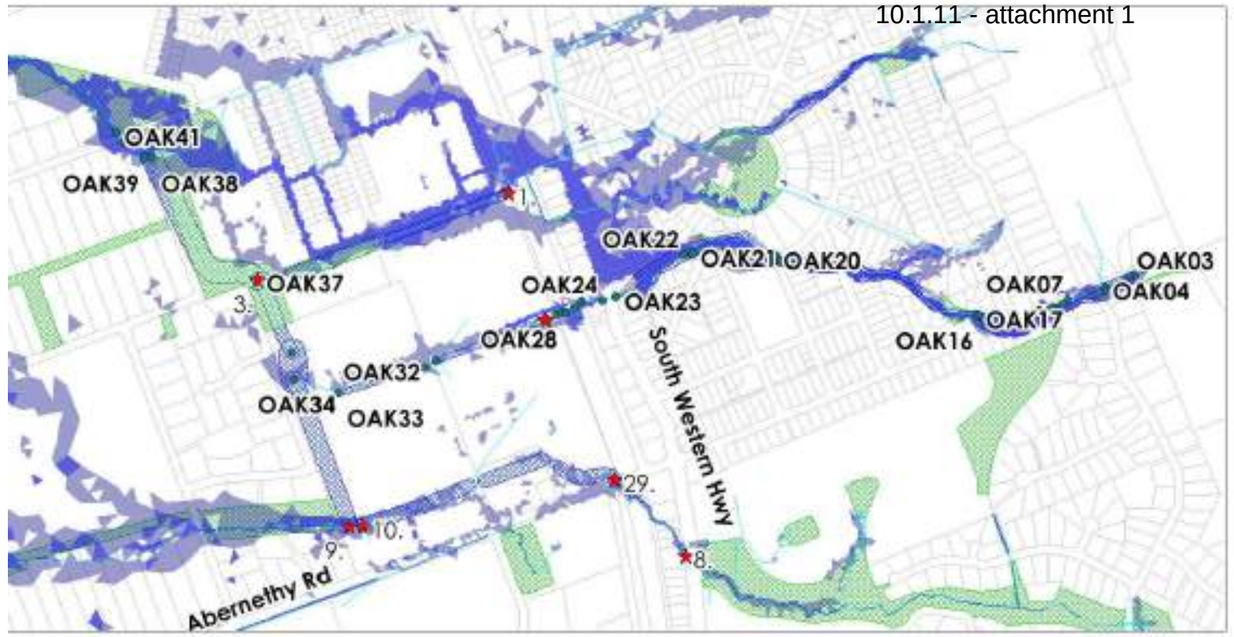
| ISSUE | DATE | DESIGN | CHECK |
|---|---|---|---|
| A | 19 Jun 2018 | AN | HB |

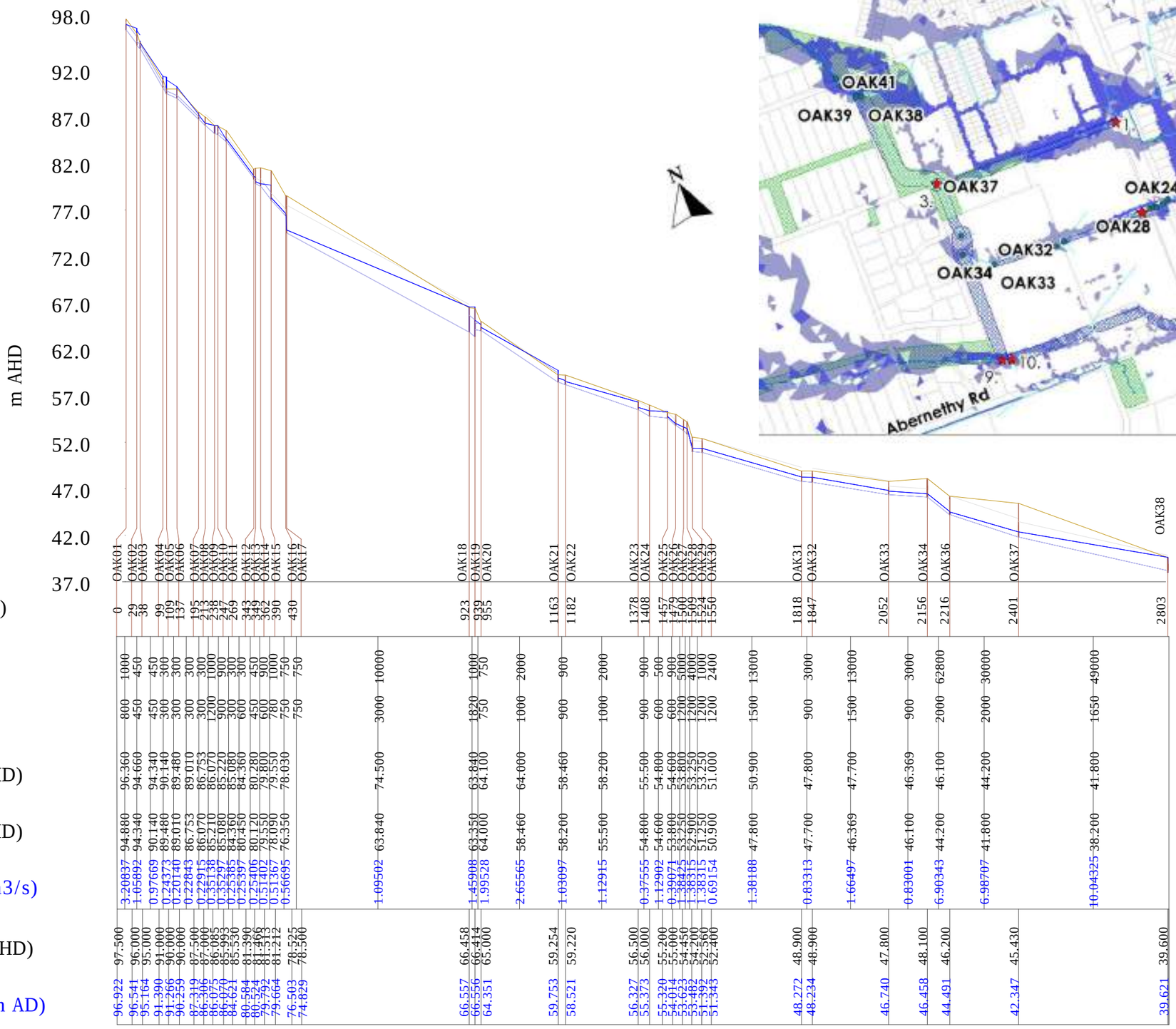
DATA SOURCES
Landgate
Depart of Planning

N.T.S

Projection: N/A | Datum: N/A

urbaqua land and water solutions




# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.13 - Oaklands Drain - 20% AEP (Sheet 1 of 4)

| ISSUE | DATE | DESIGN | CHECK |
|---|---|---|---|
| A | 19 Jun 2018 | AN | HB |

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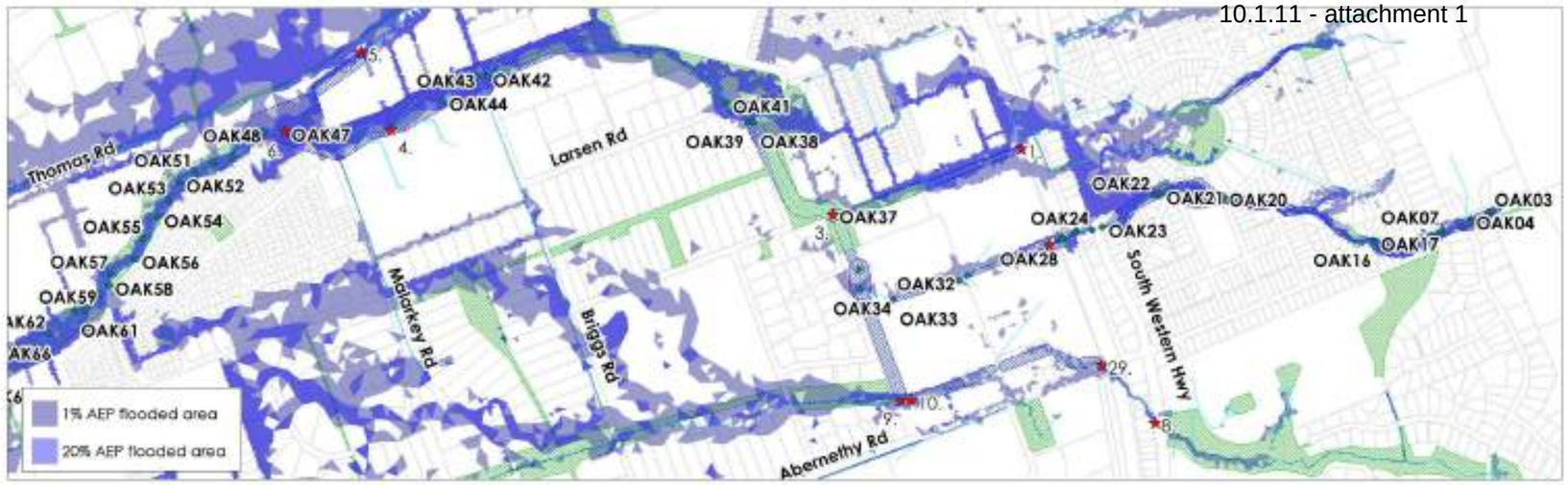


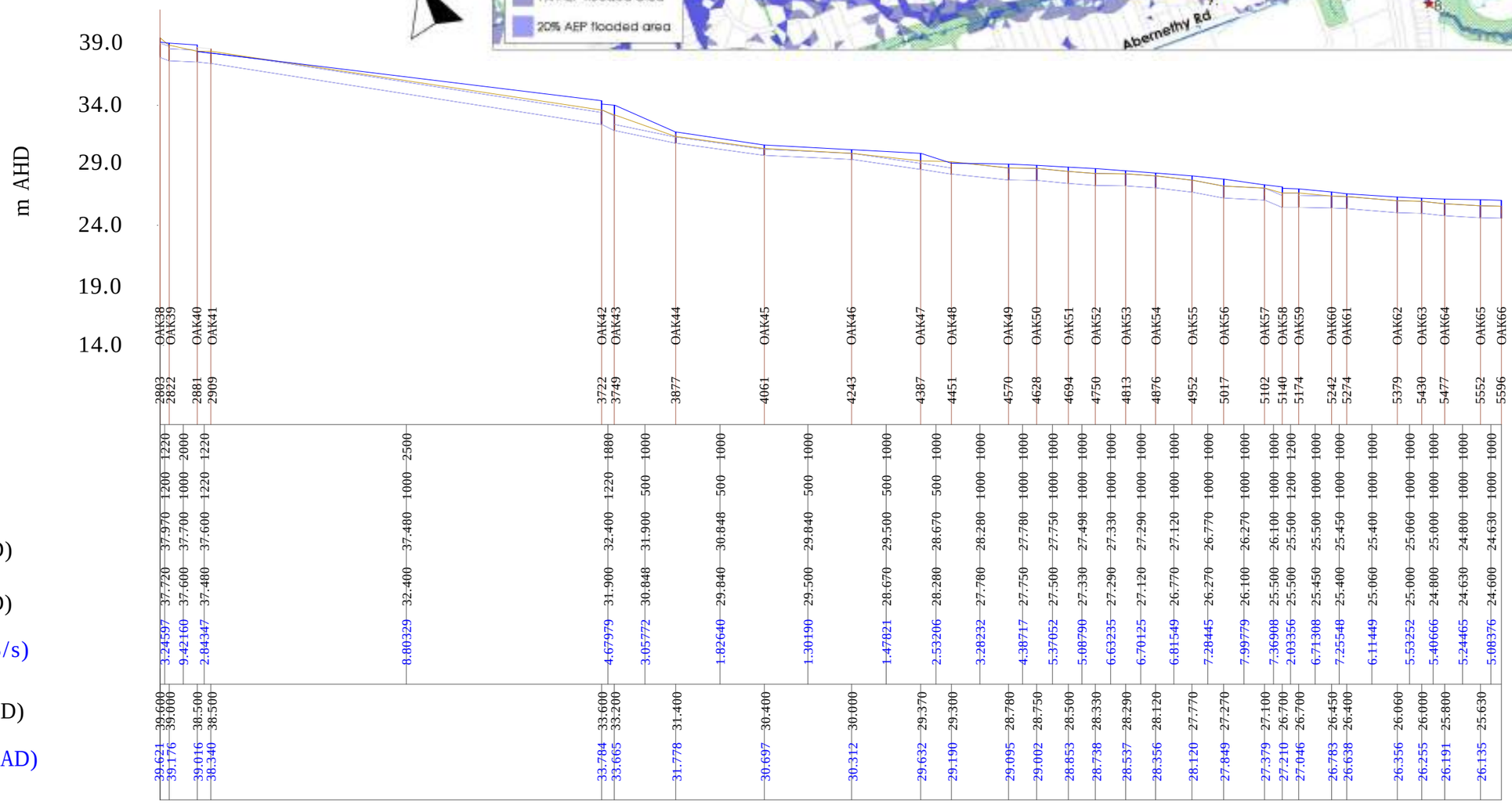


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.13 - Oaklands Drain - 20% AEP (Sheet 2 of 4)

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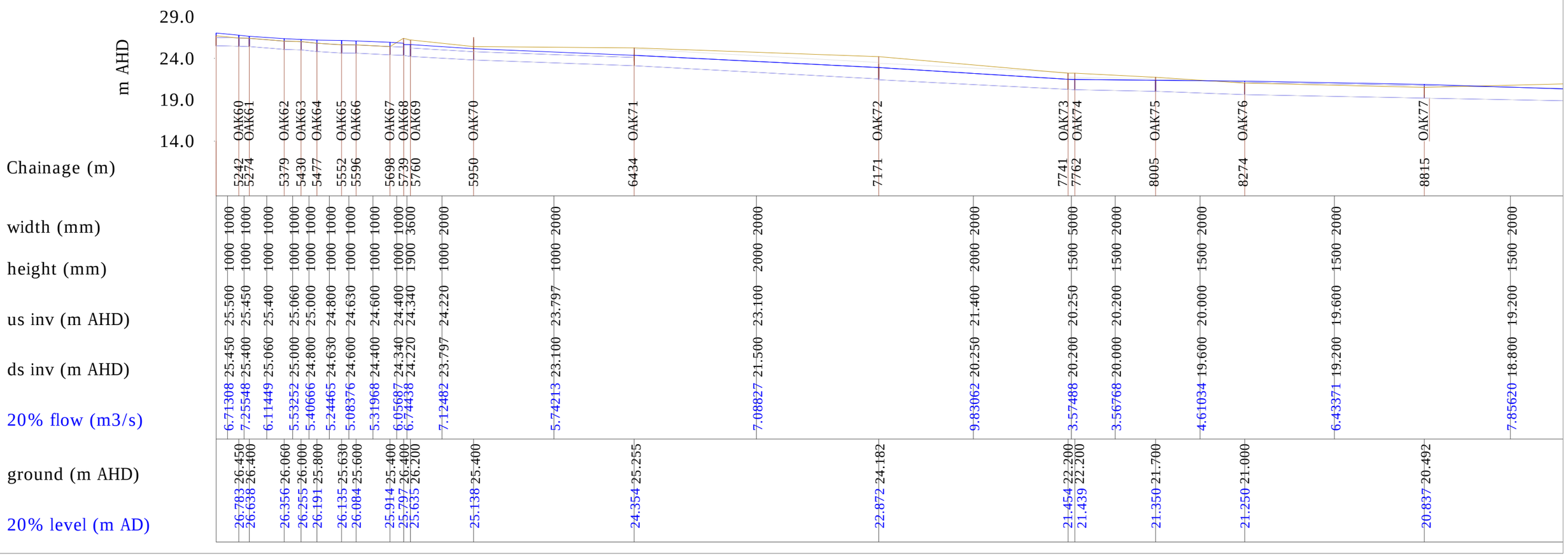


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.13 - Oaklands Drain - 20% AEP (Sheet 3 of 4)

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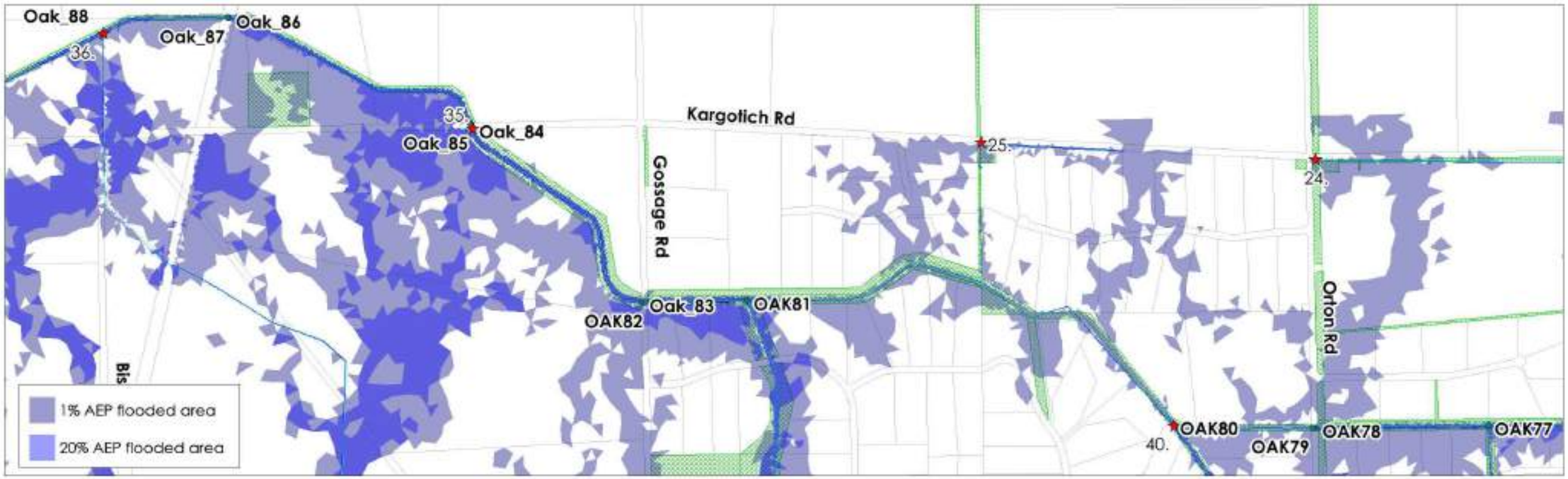


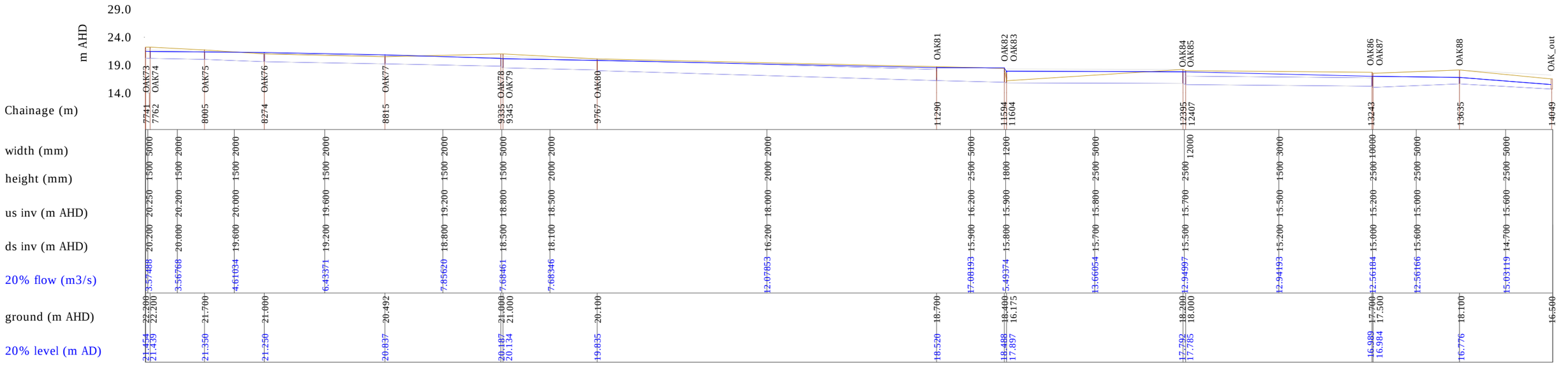


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.13 - Oaklands Drain - 20% AEP (Sheet 4 of 4)



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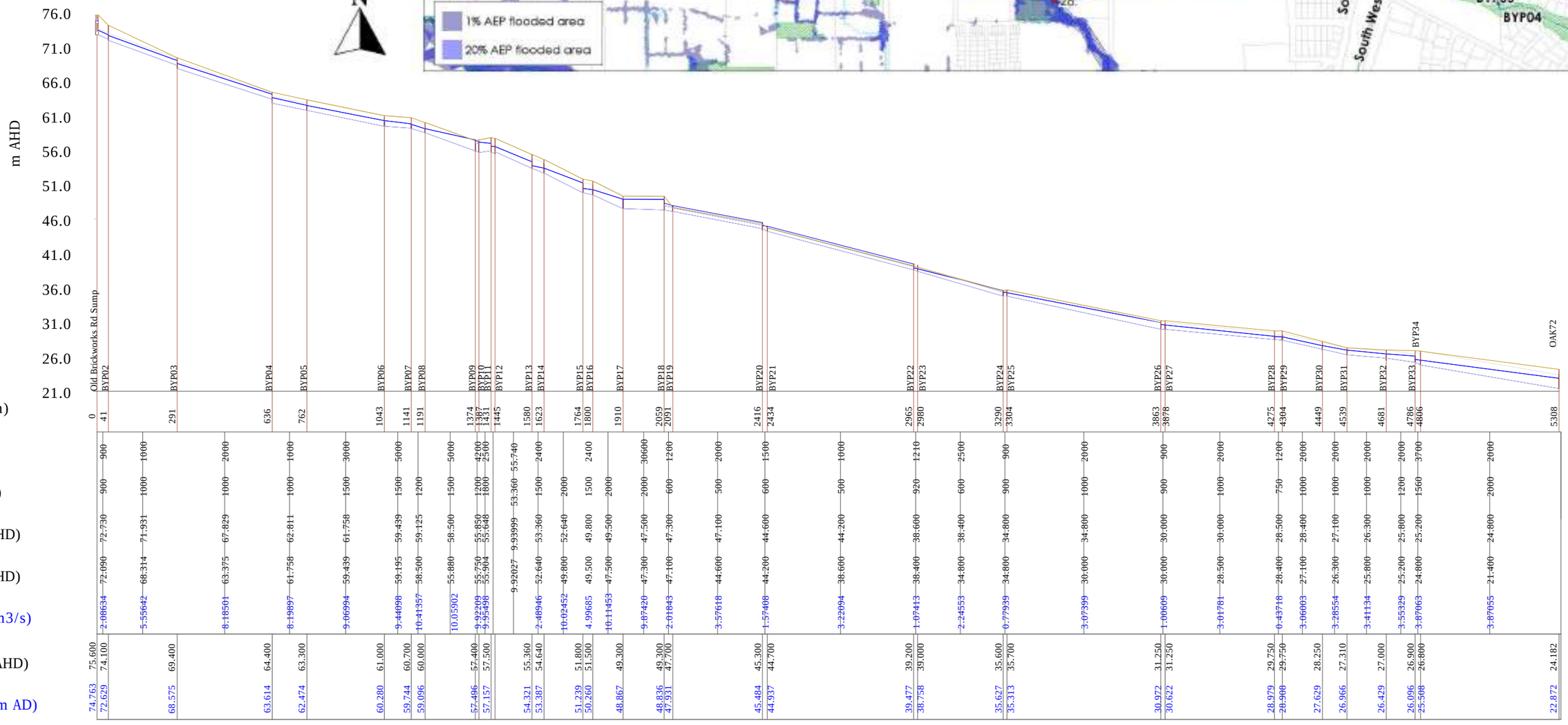


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.14 - Beenyup Brook - 20% AEP



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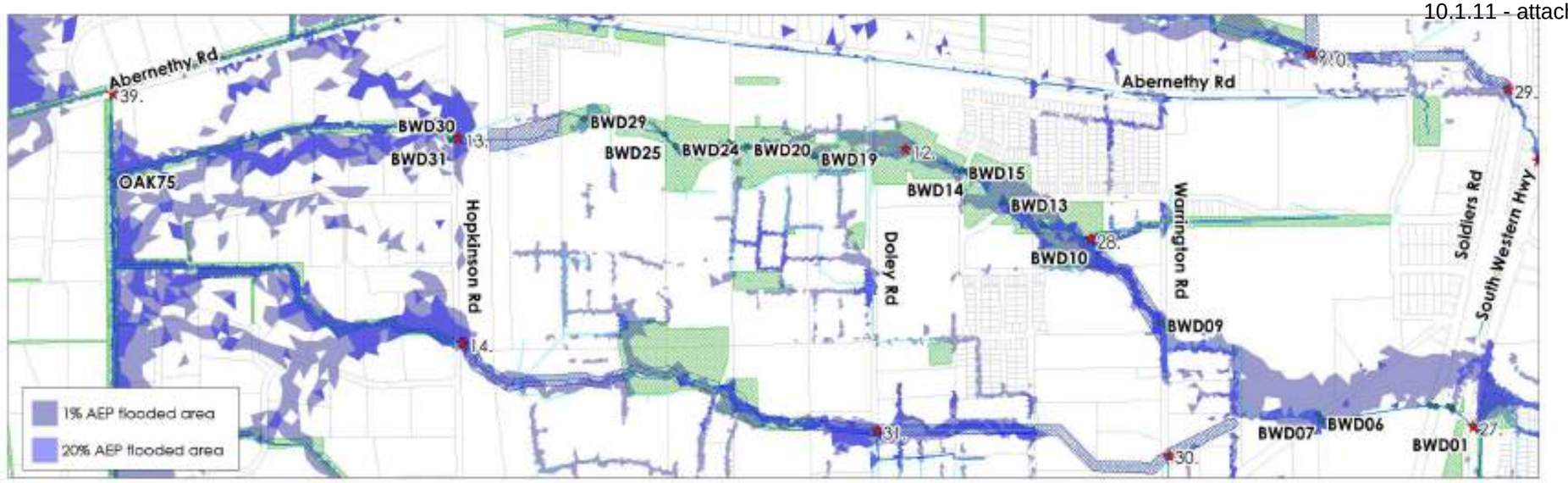


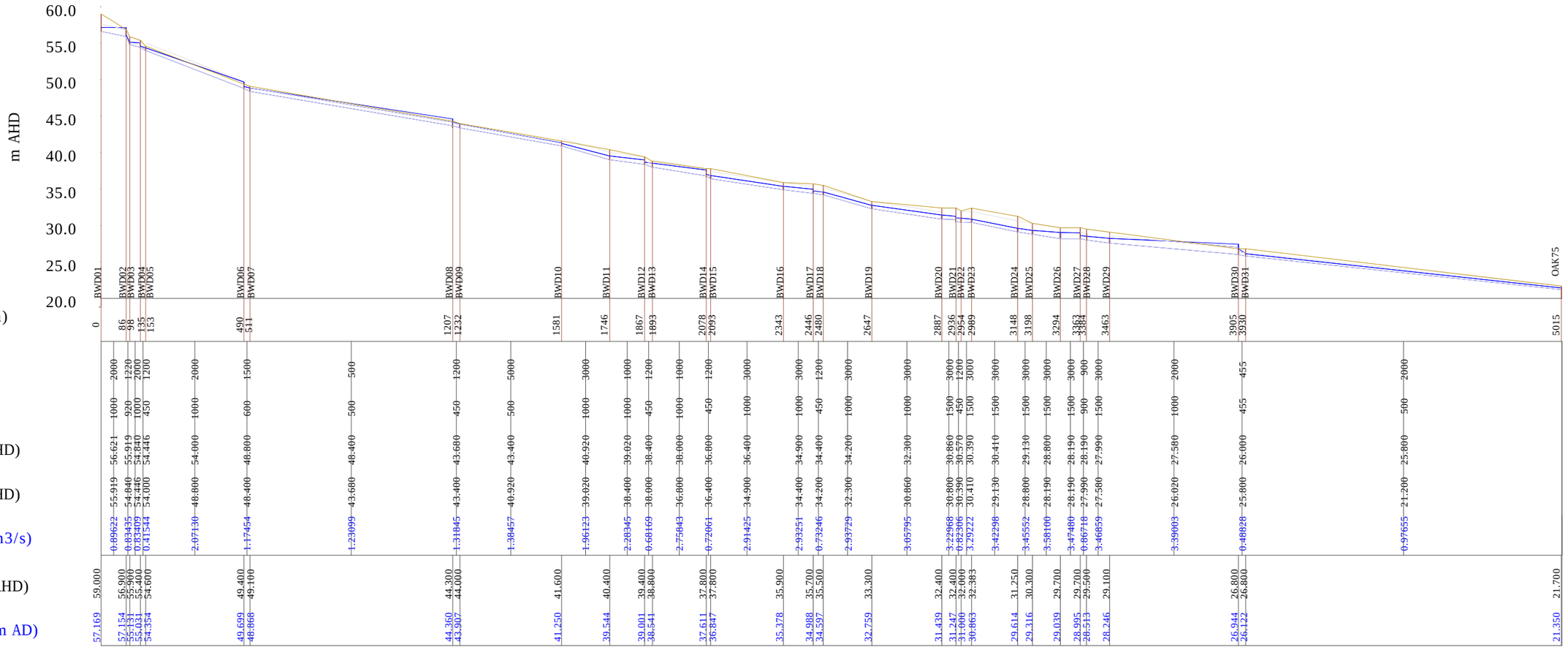


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.15 - Brickwood Drain - 20% AEP



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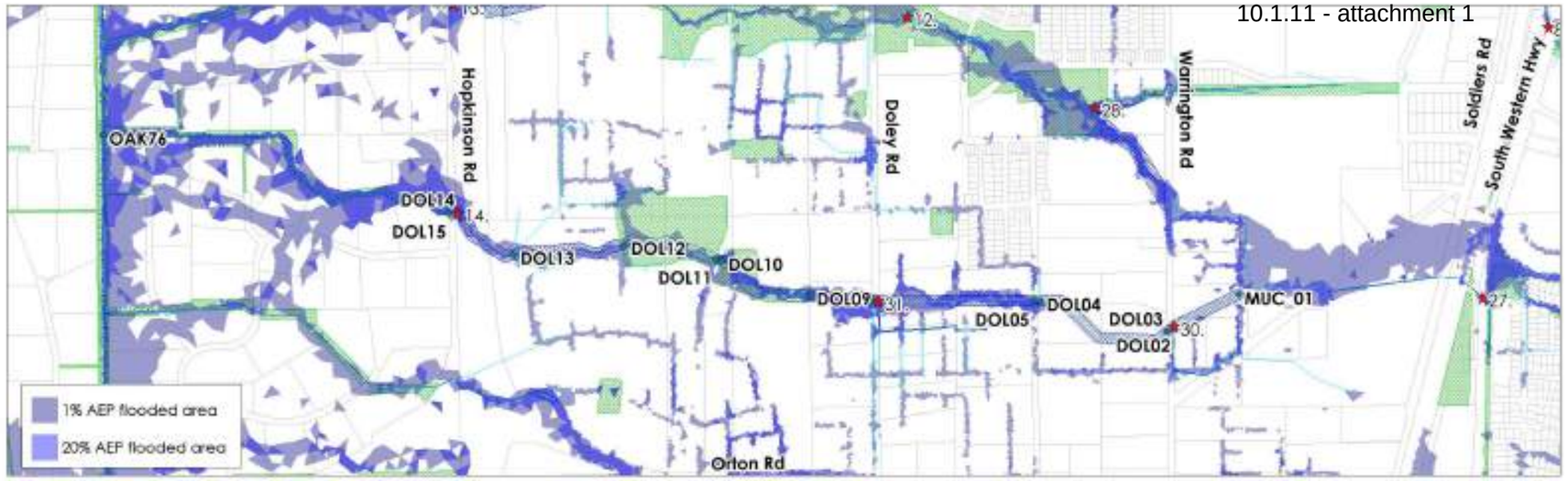


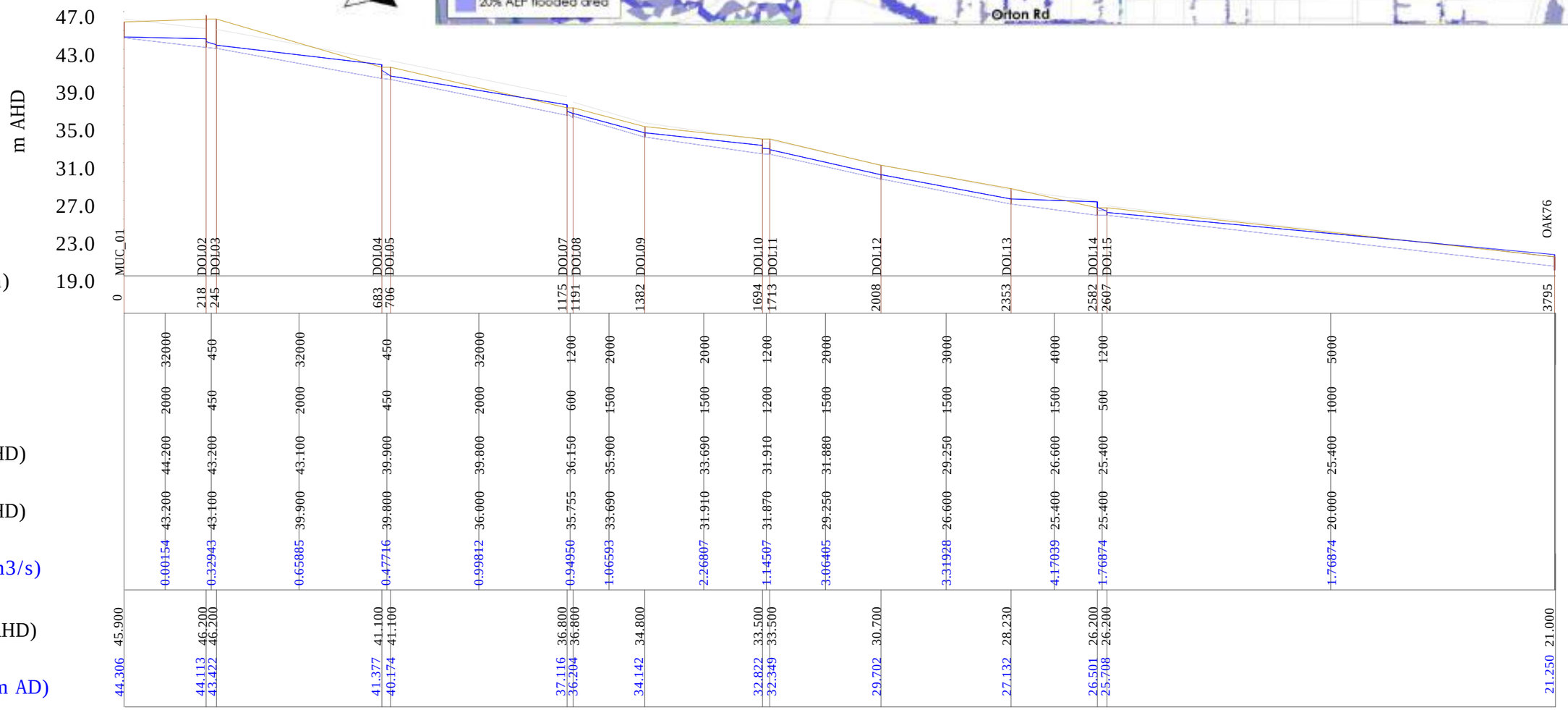


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.16 - Doley Precinct Drain - 20% AEP



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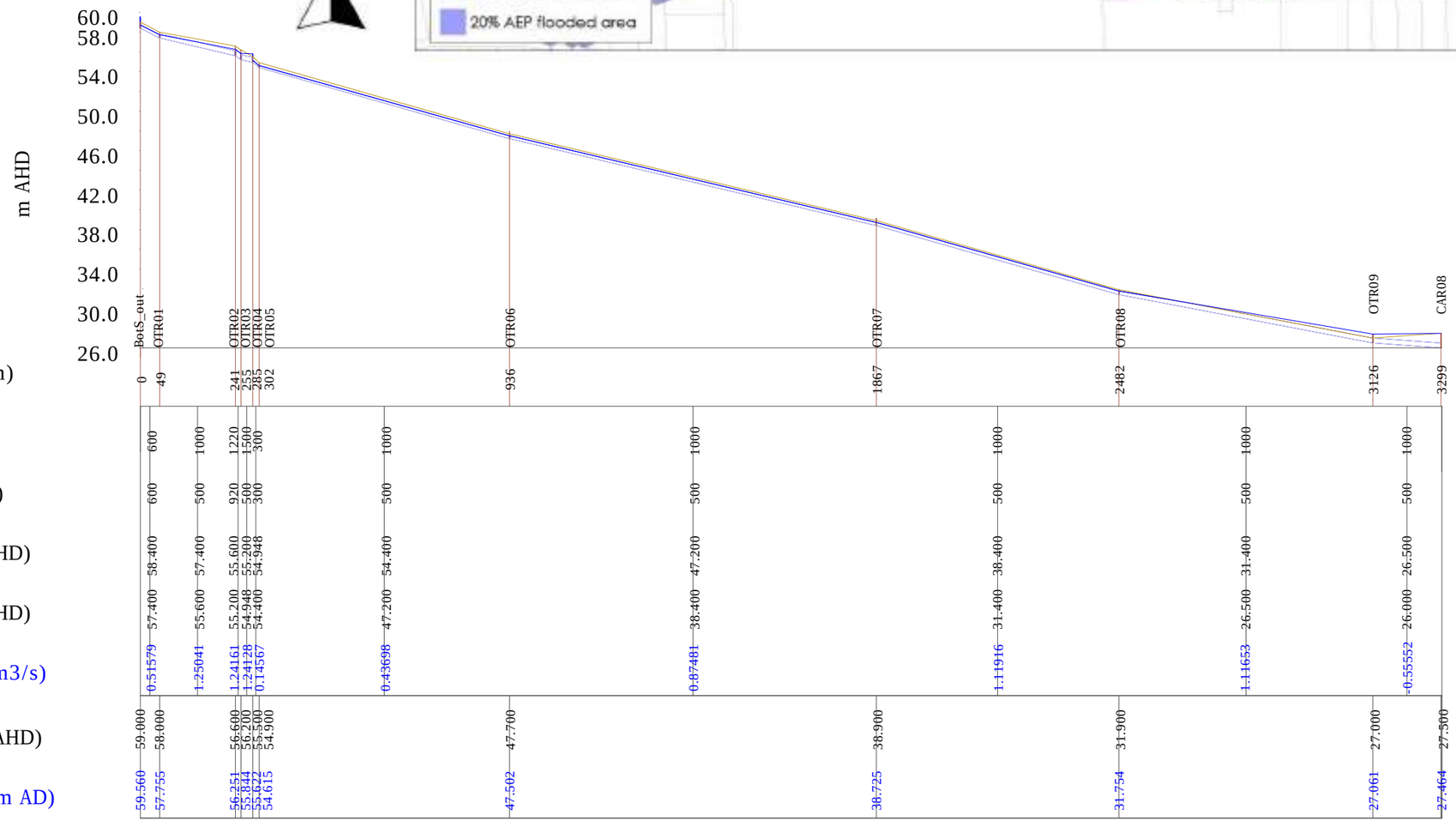


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.17 - Orton Rd Drain - 20% AEP



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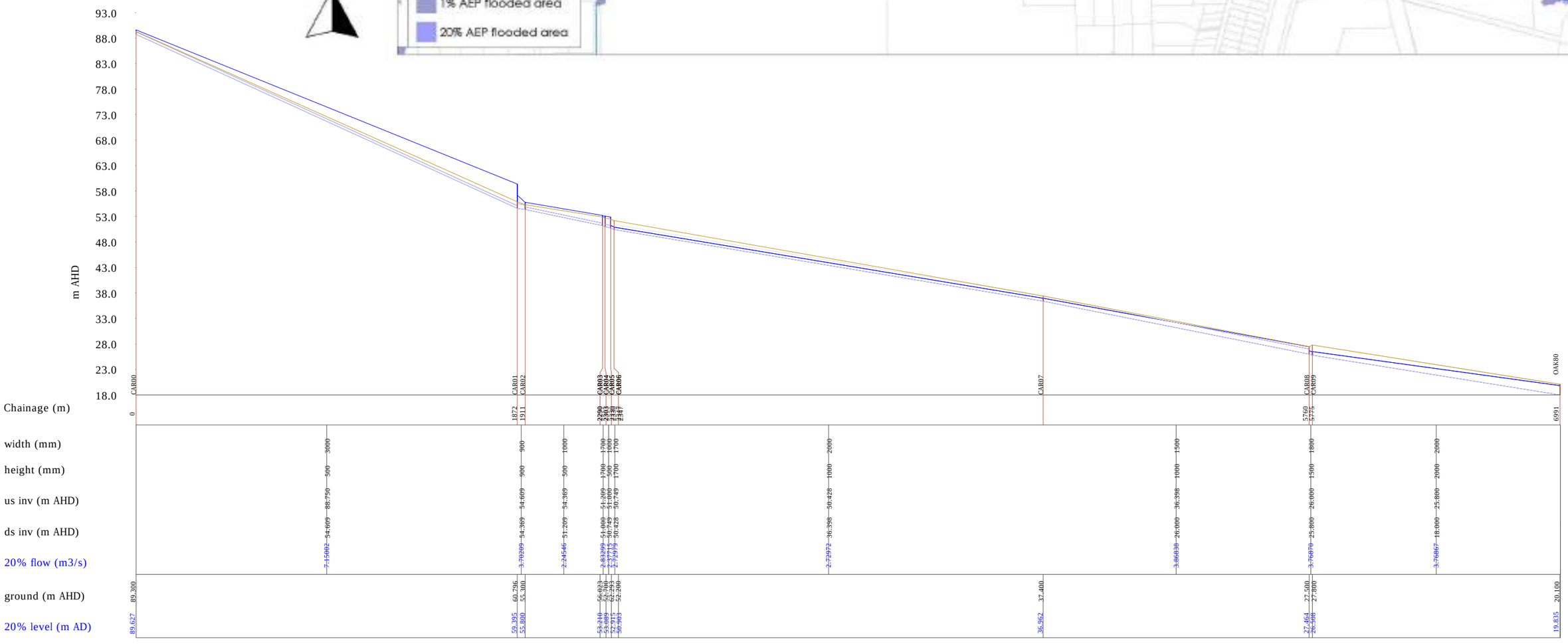


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.18 - Cardup Brook - 20% AEP



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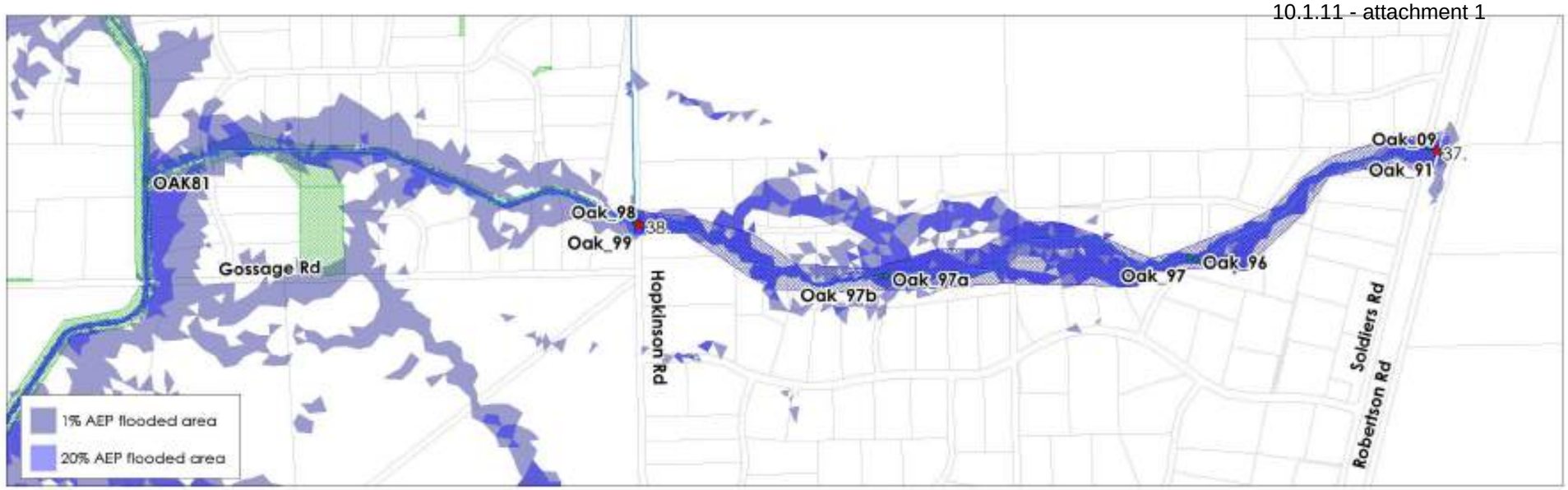


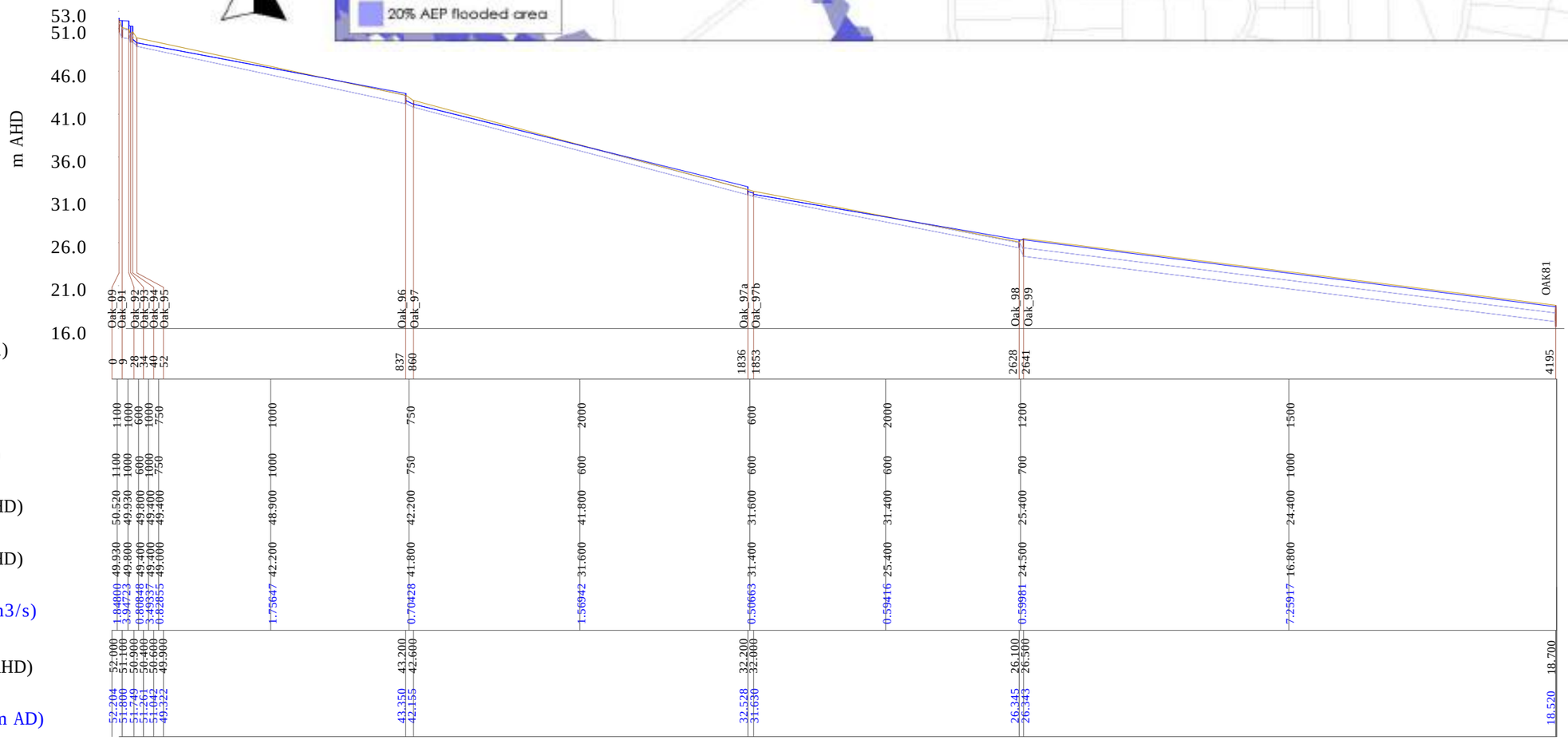


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.19 - Cardup Drain - 1% AEP



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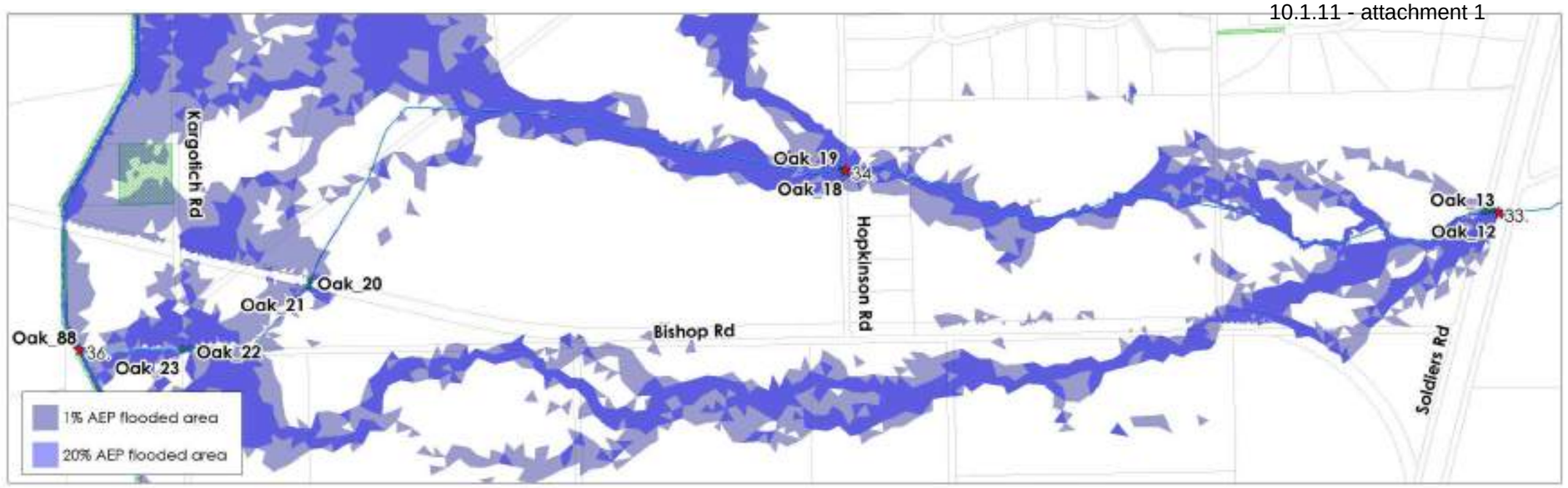





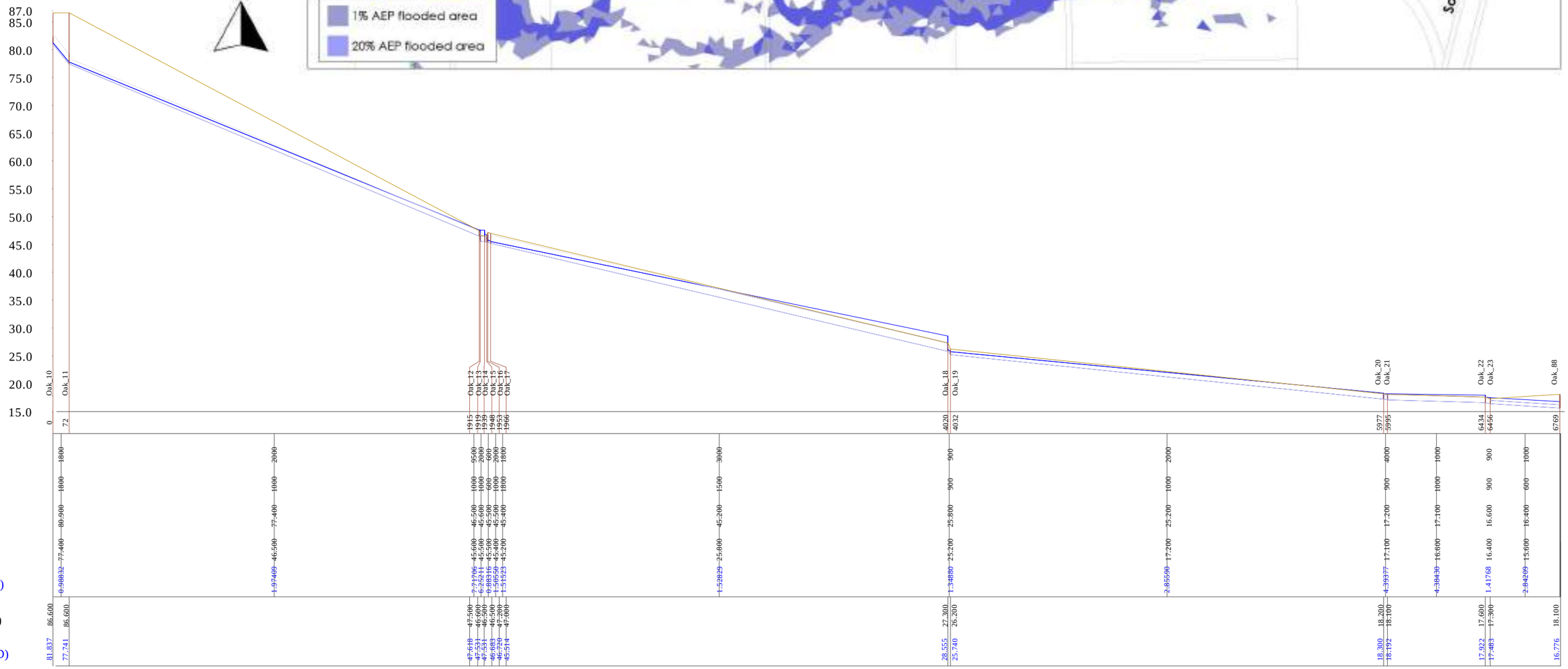


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.20 - Norman Drain - 20% AEP



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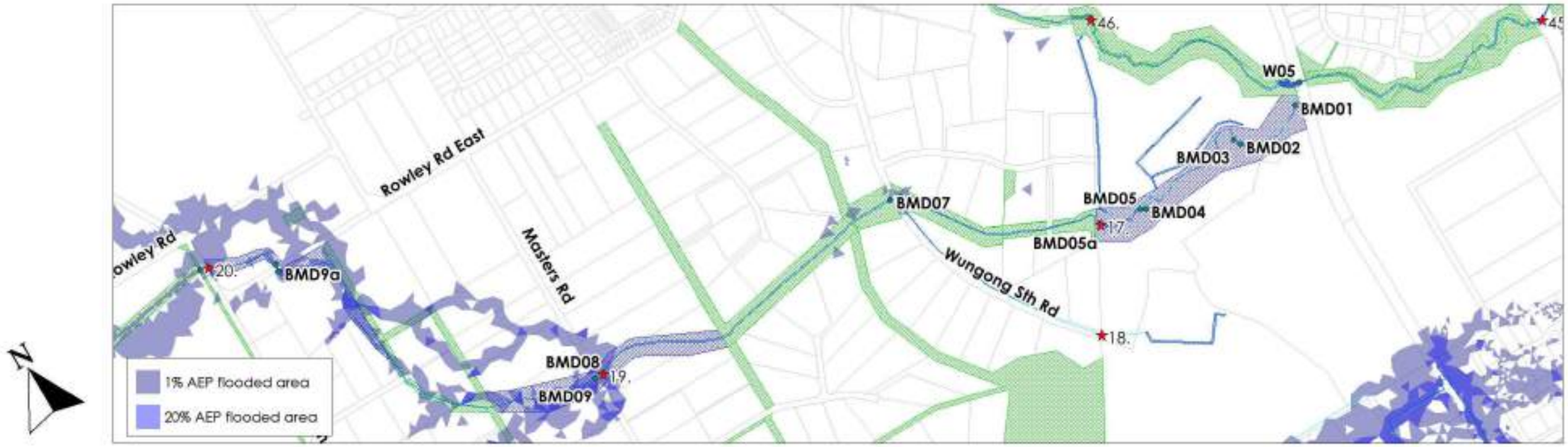


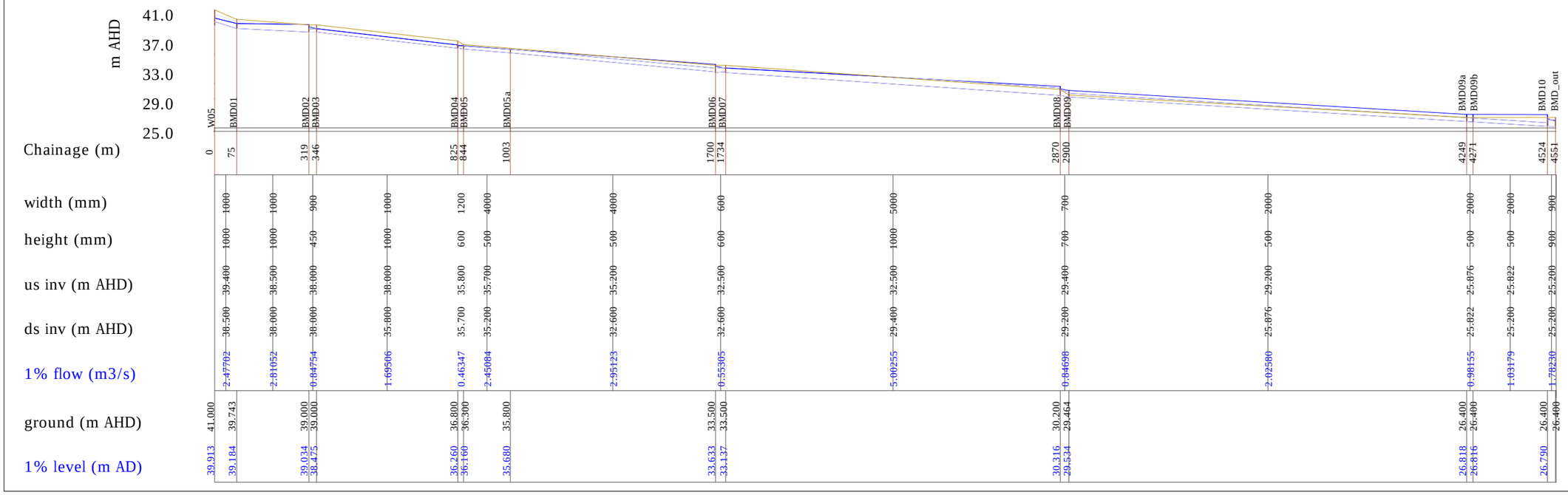


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.21 - Birrega Drain - 1% AEP



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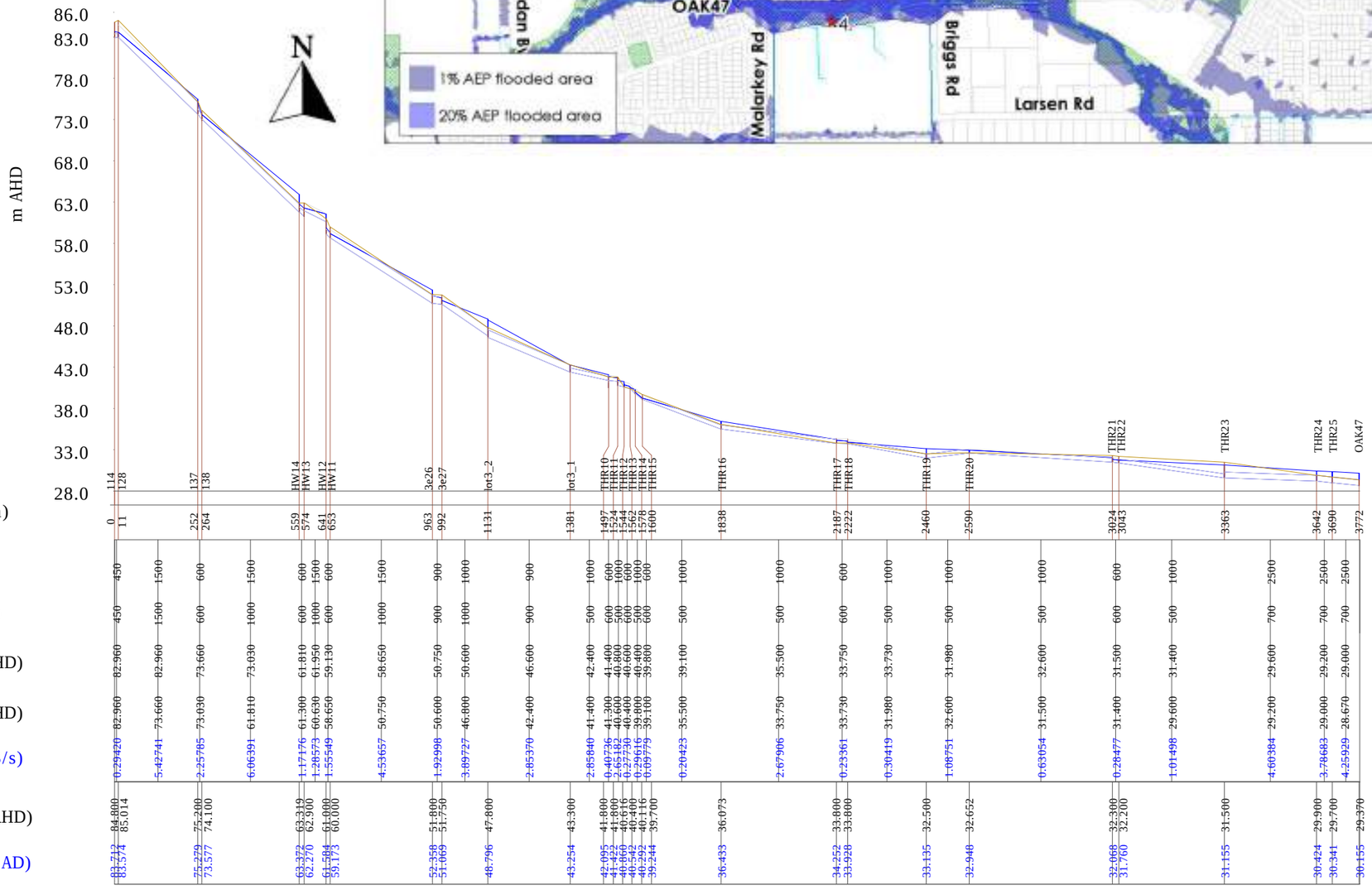


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.22 - Oaklands Drain North - 1% AEP



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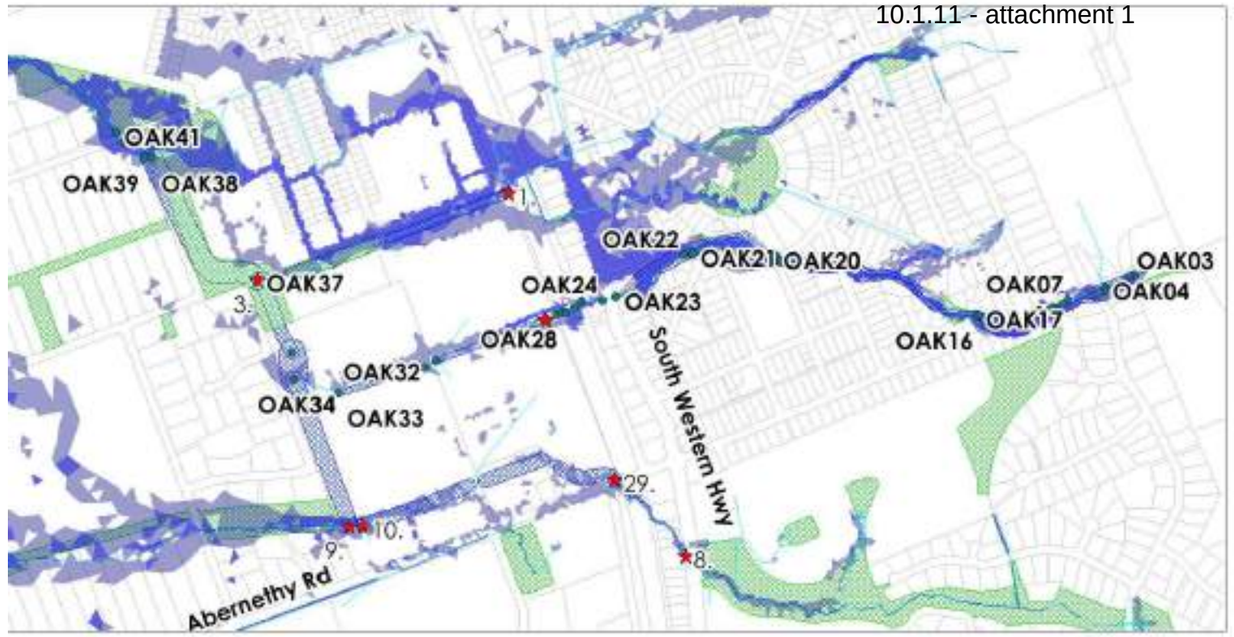


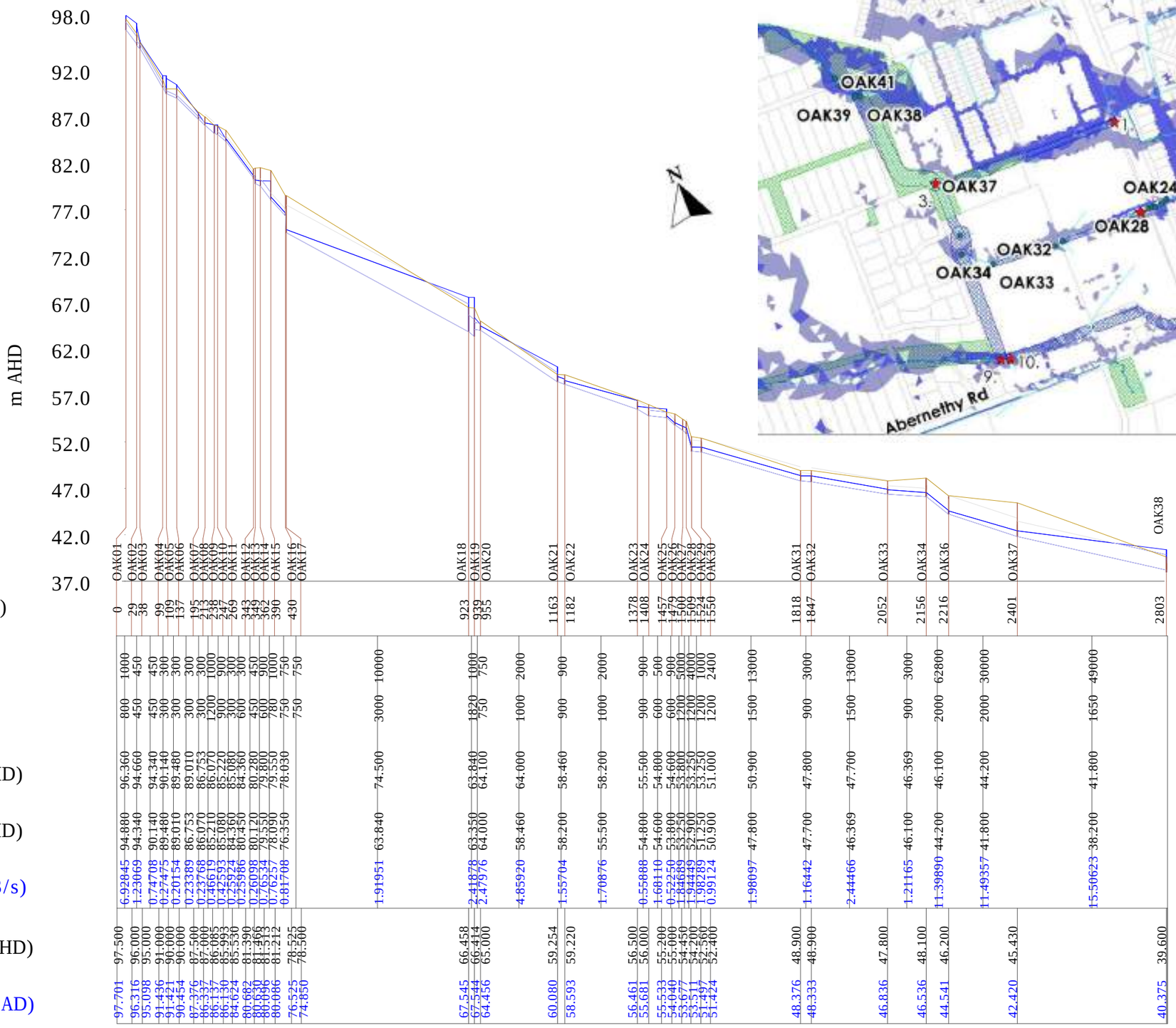


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.23 - Oaklands Drain - 1% AEP (Sheet 1 of 4)

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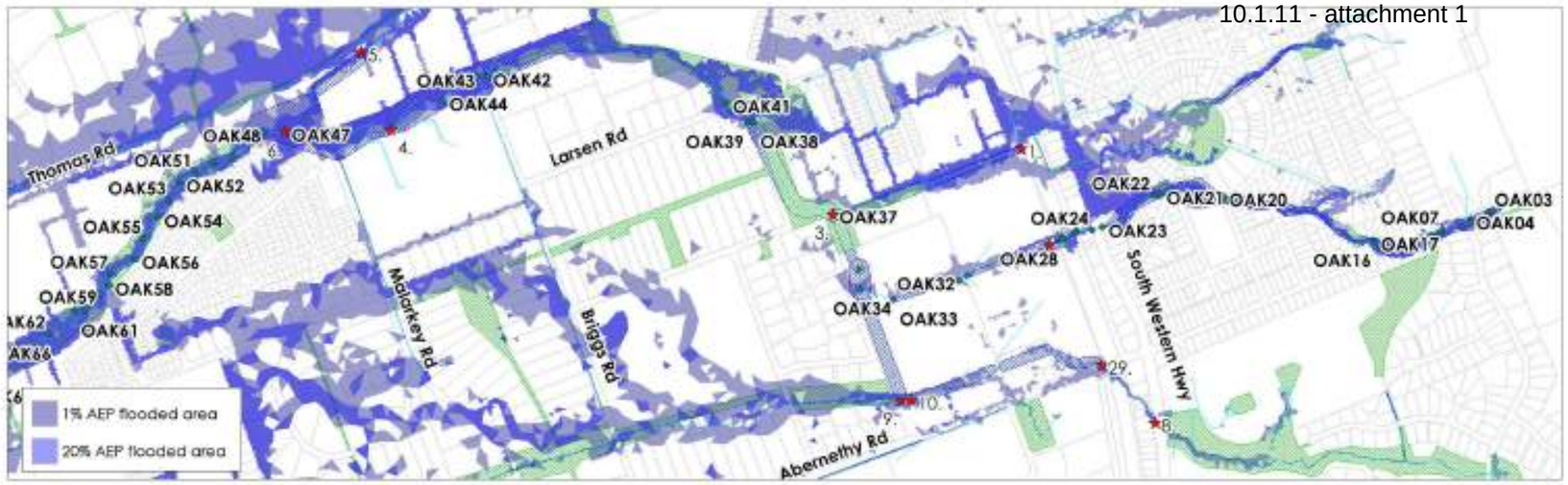


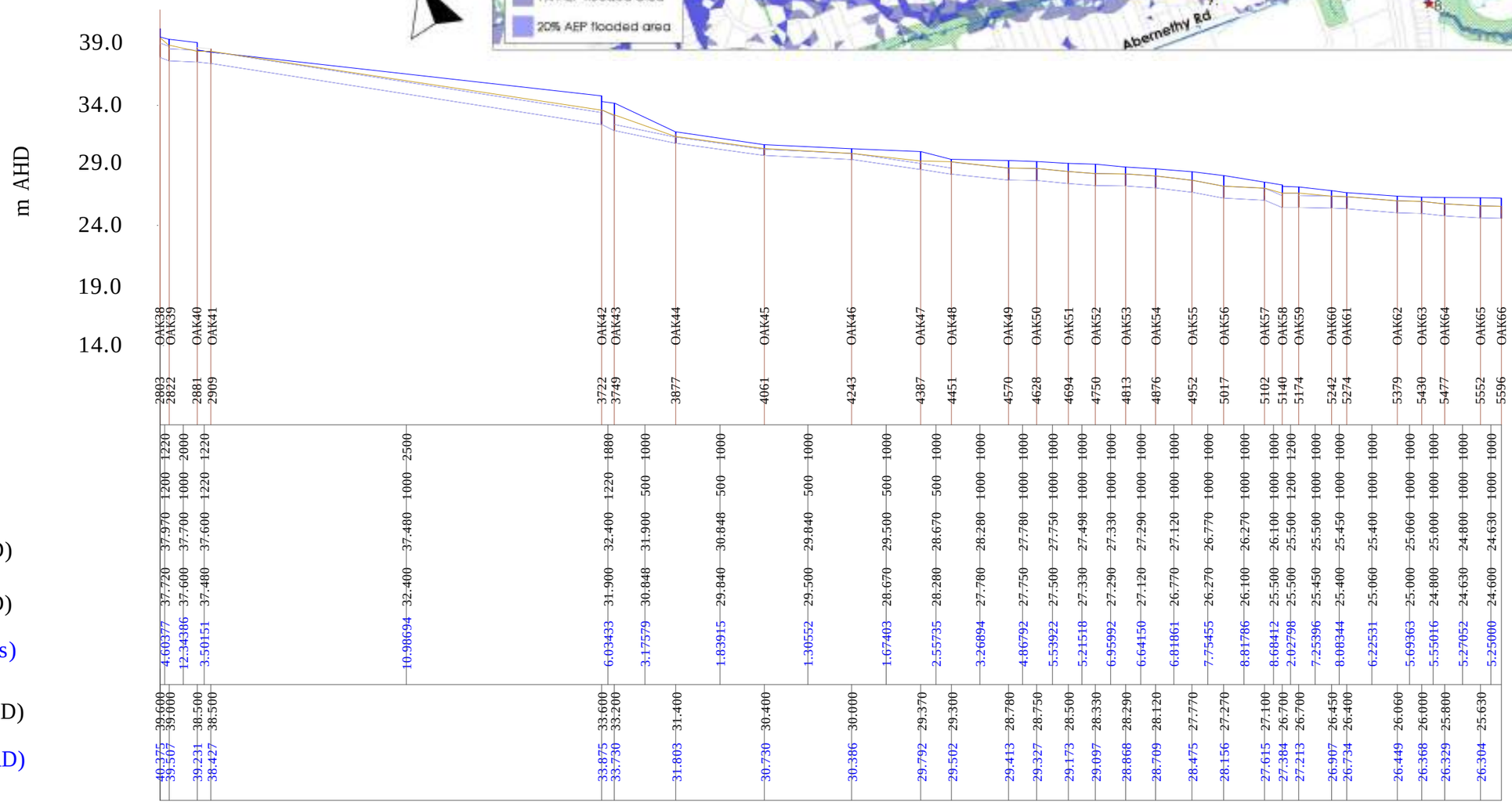


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.23 - Oaklands Drain - 1% AEP (Sheet 2 of 4)

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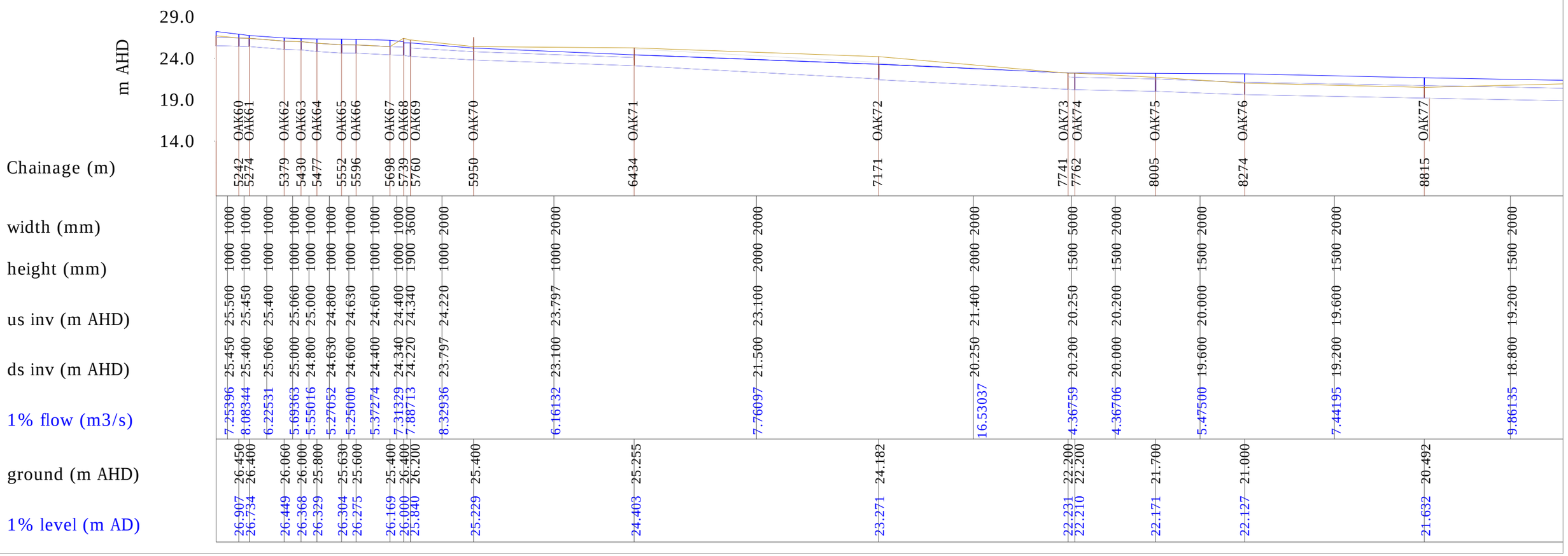


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.23 - Oaklands Drain - 1% AEP (Sheet 3 of 4)

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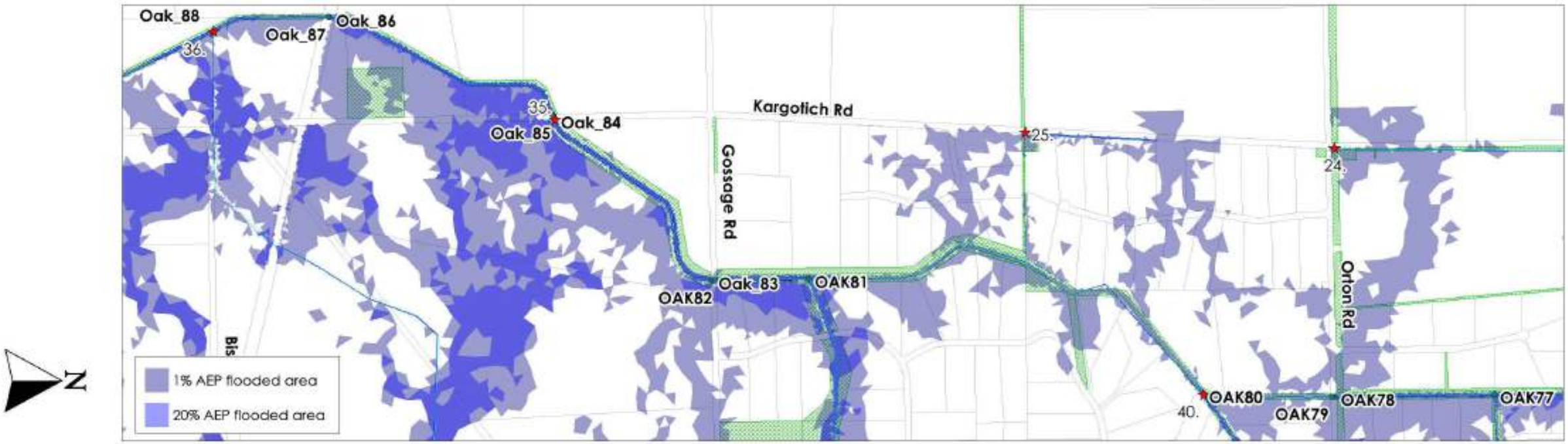


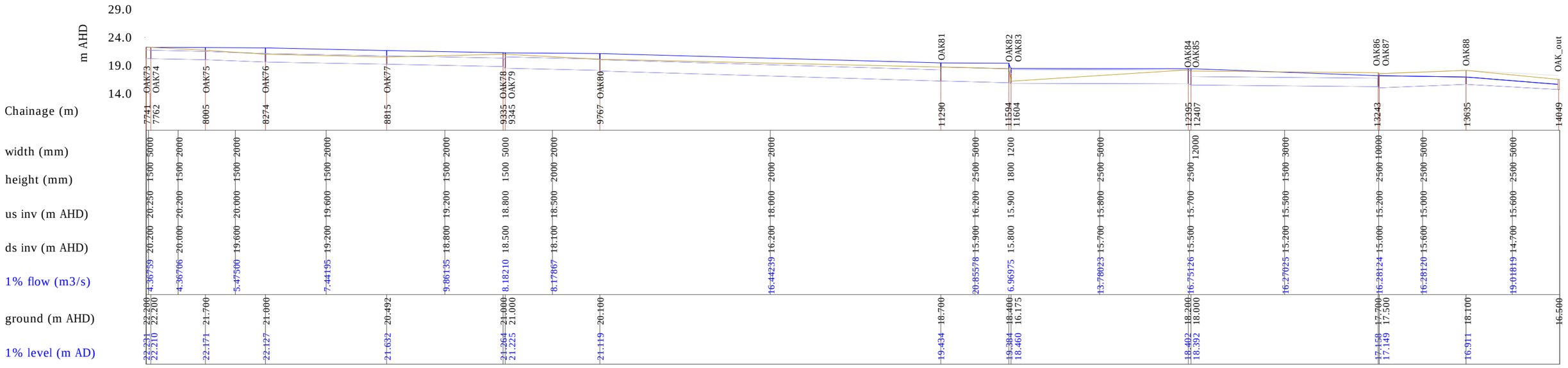


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.23 - Oaklands Drain - 1% AEP (Sheet 4 of 4)



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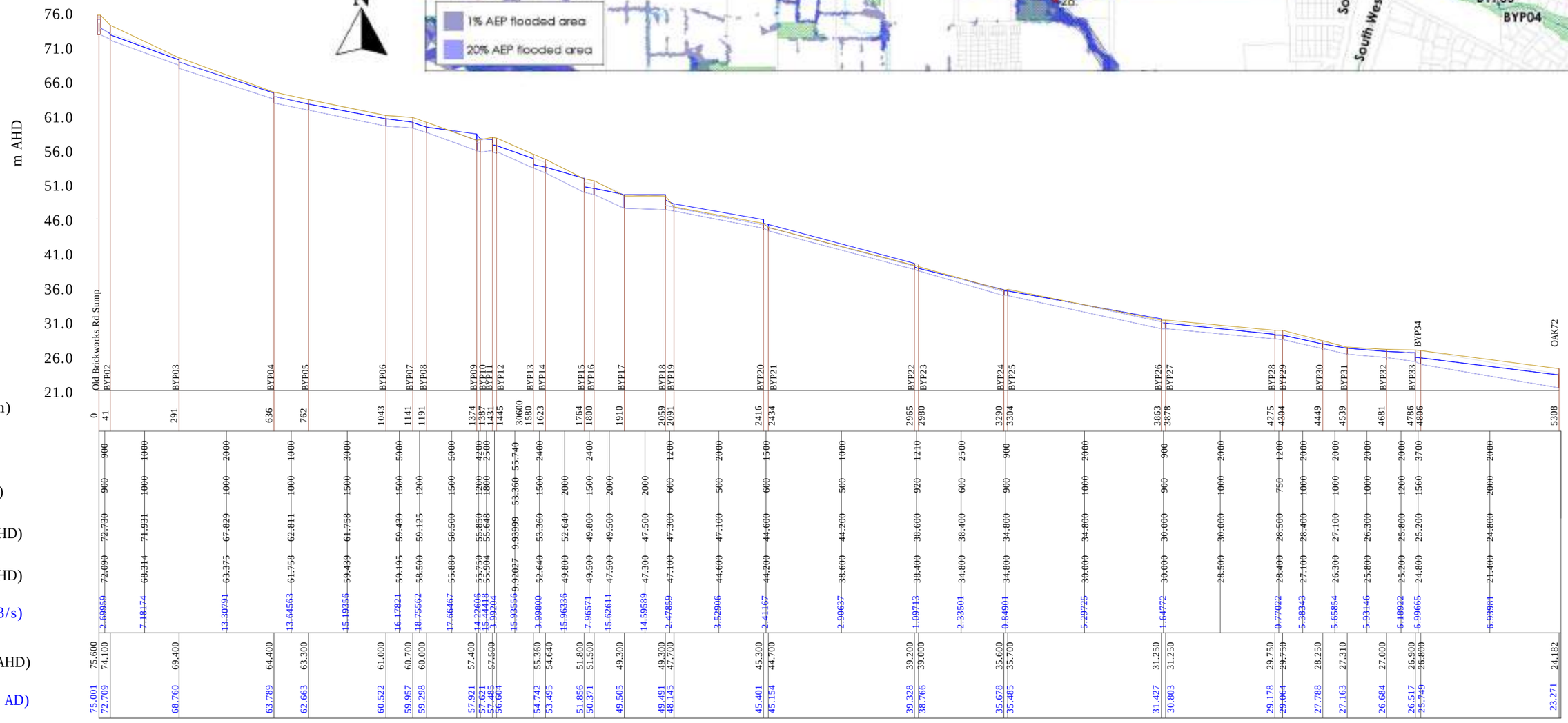


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.24 - Beenyup Brook - 1% AEP



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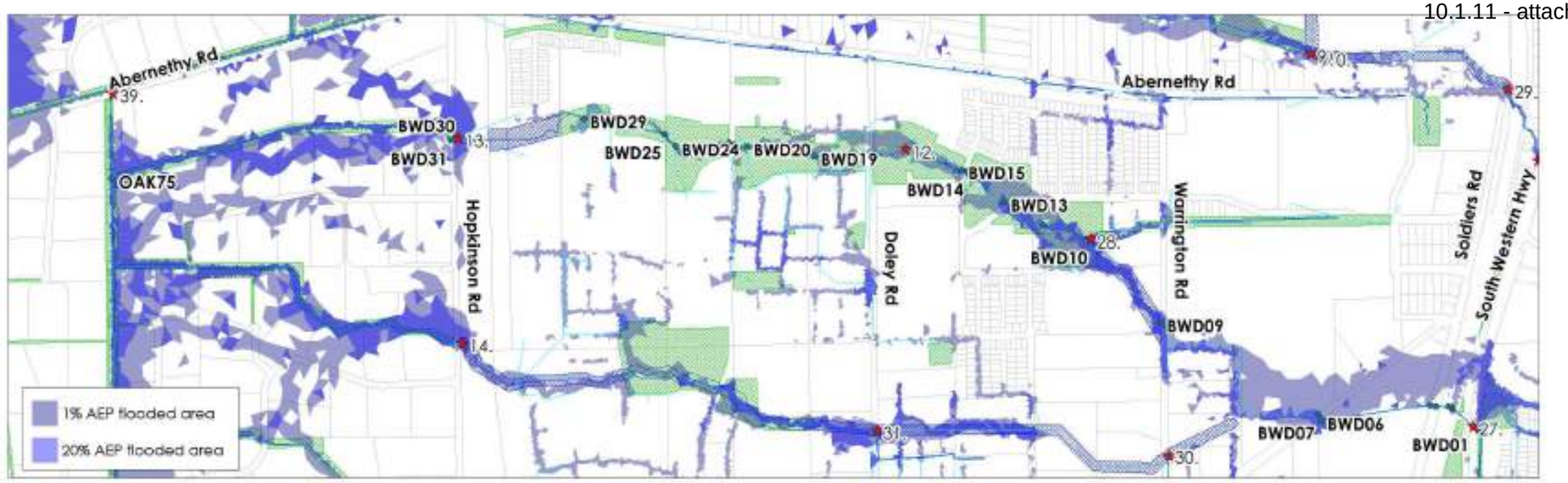


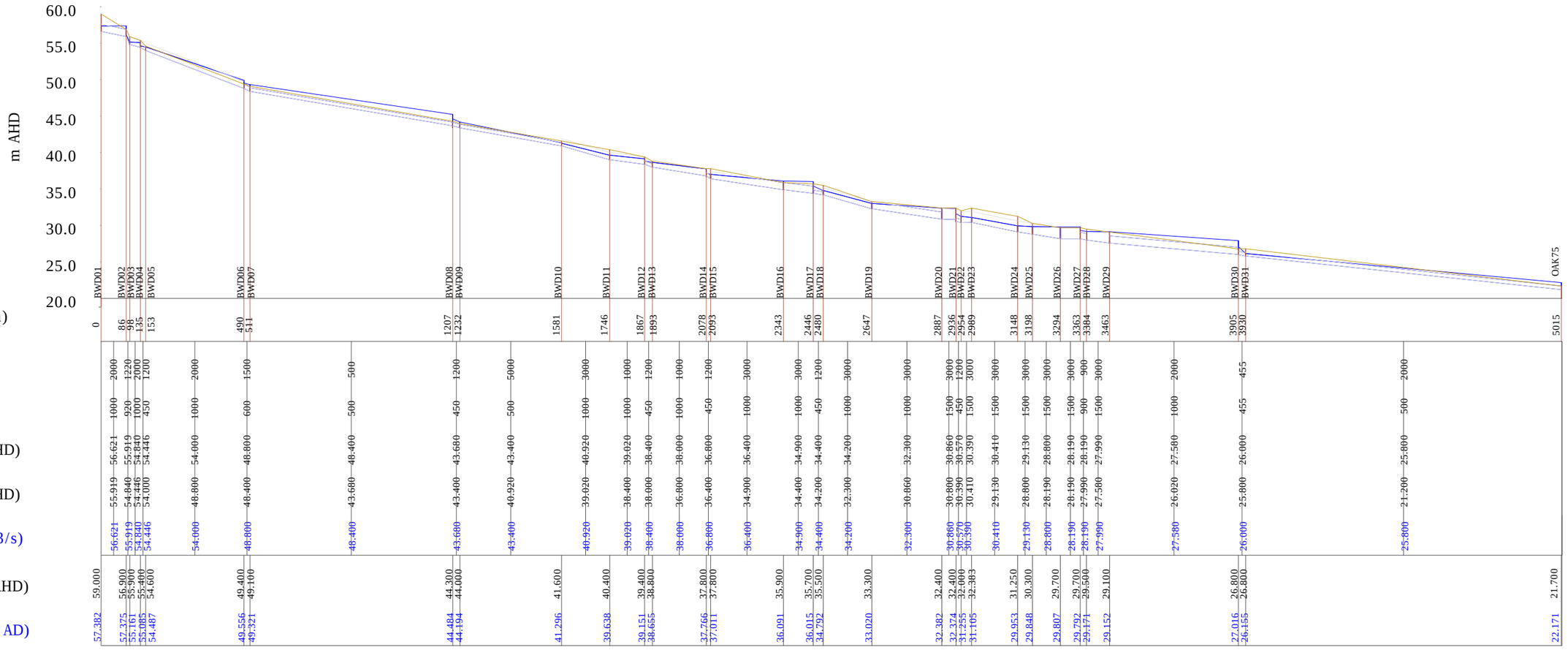


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.25 - Brickwood Drain - 1% AEP



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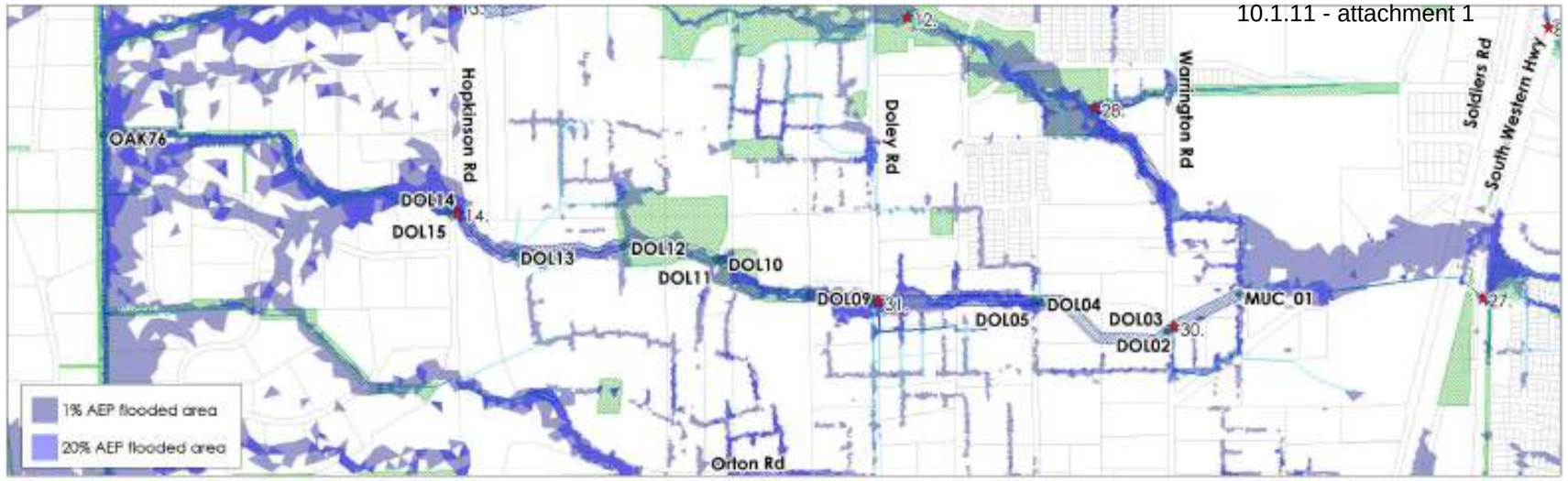


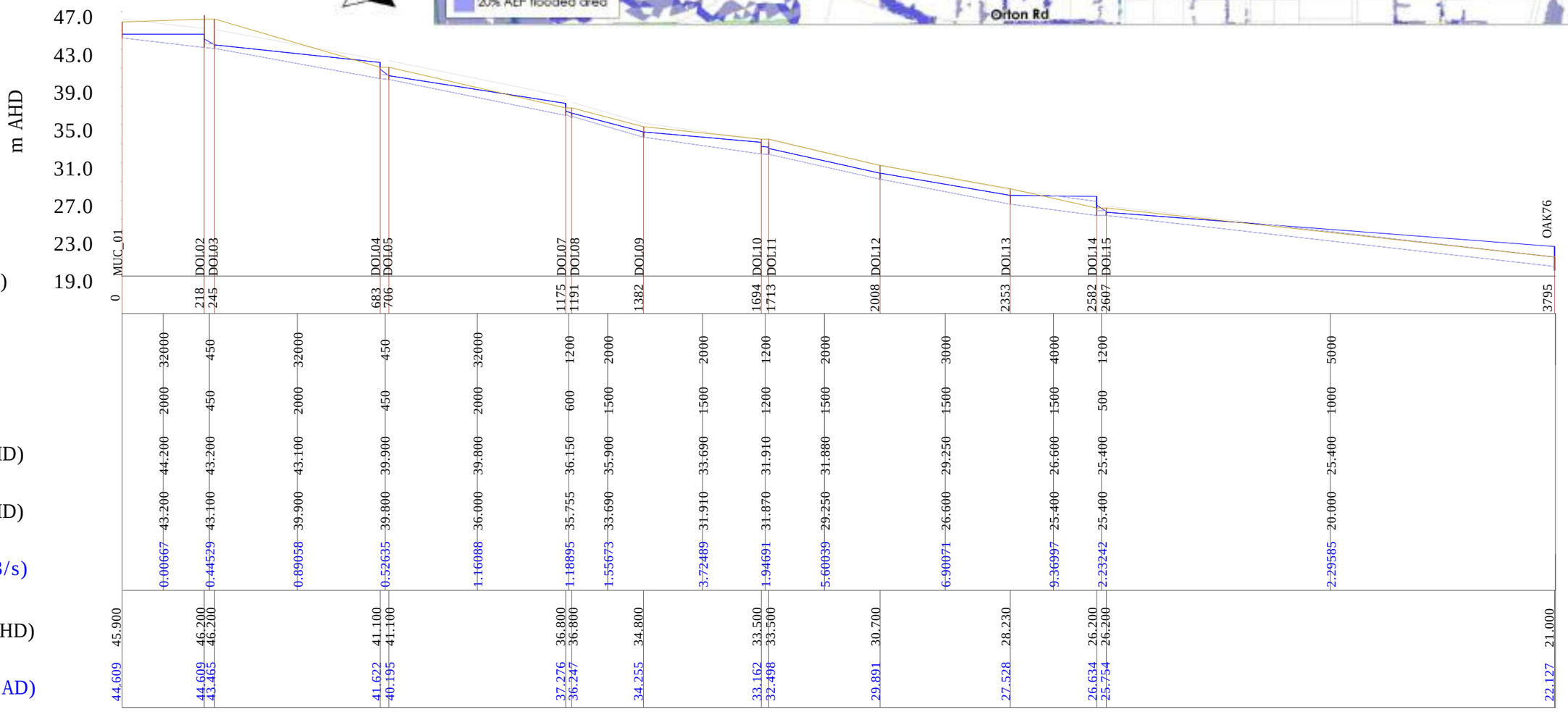


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.26 - Doley Precinct Drain - 1% AEP



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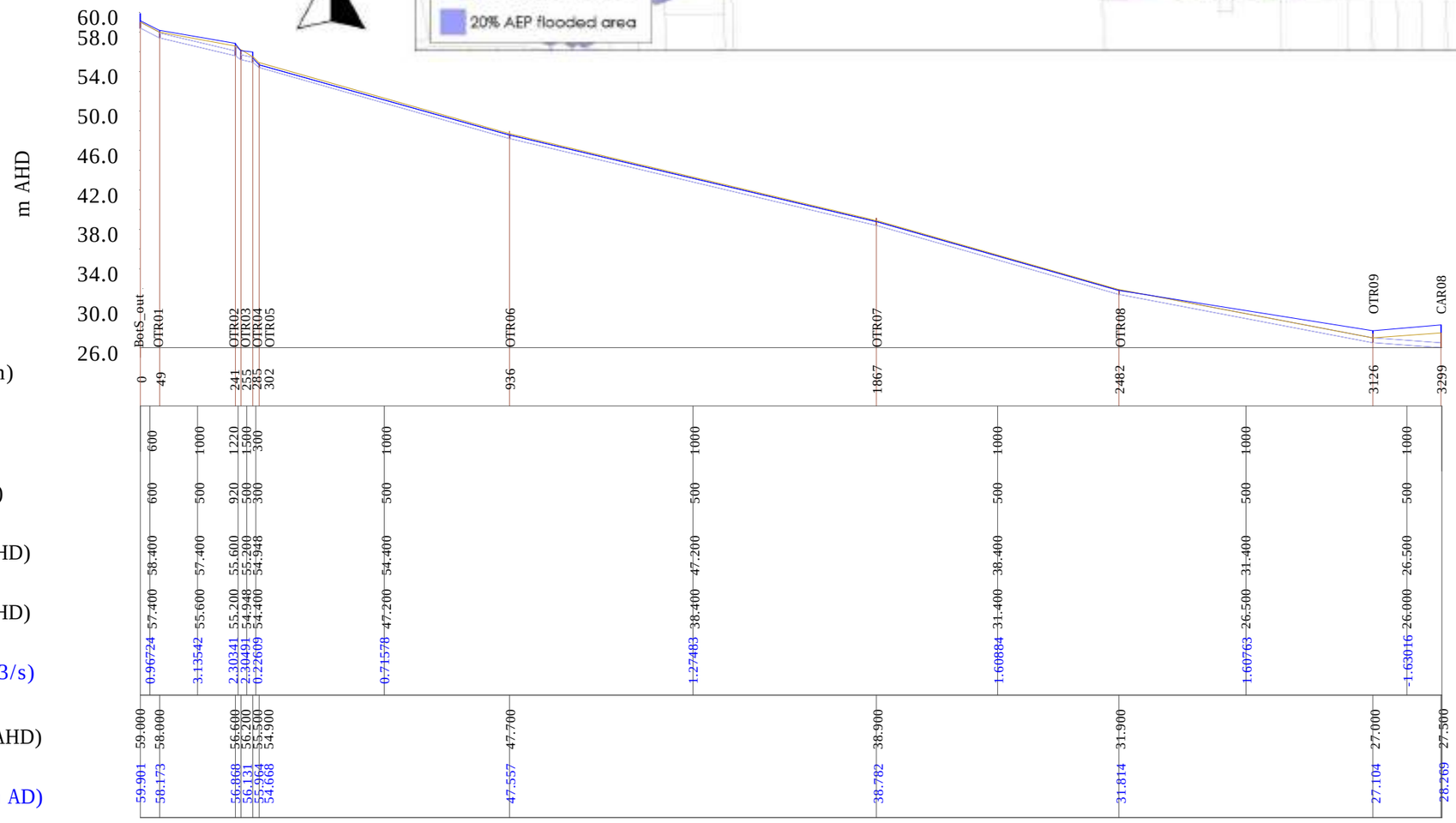


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.27 - Orton Rd Drain - 1% AEP



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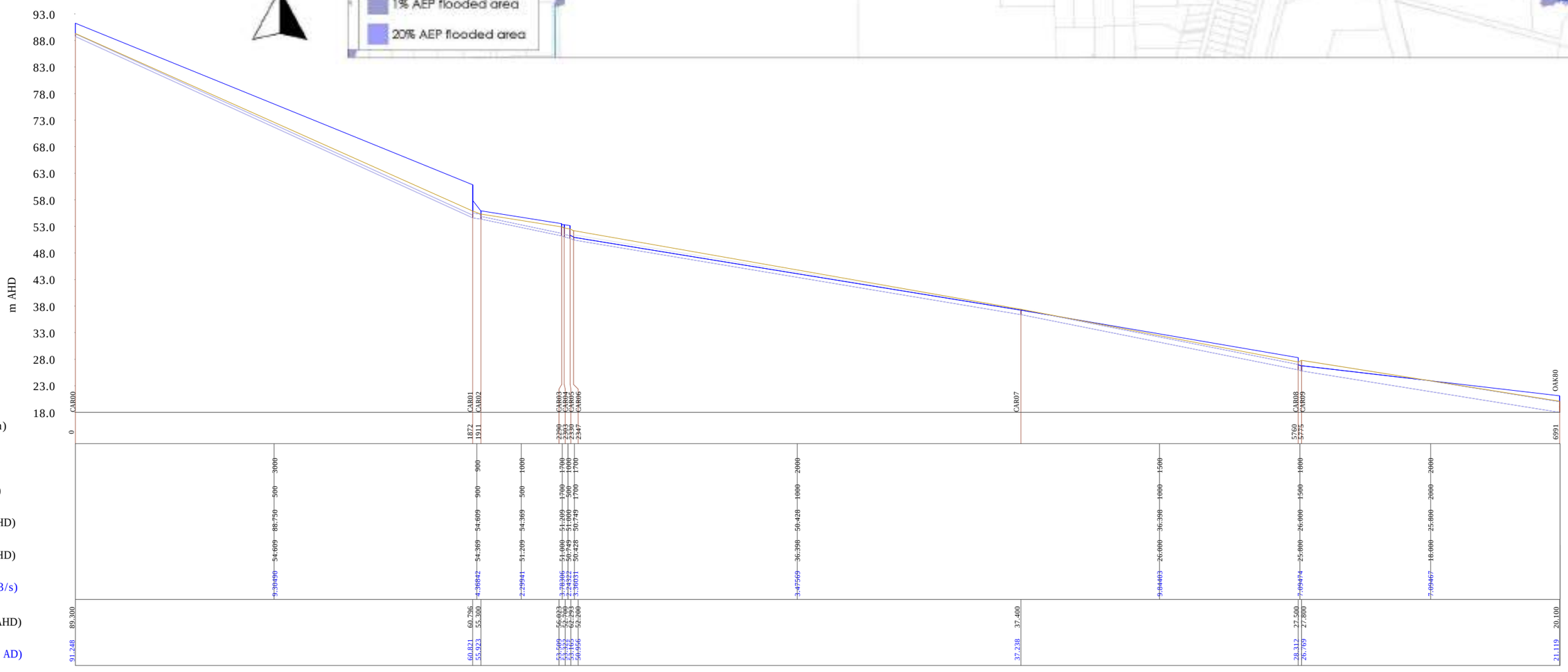


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.28 - Cardup Brook - 1% AEP



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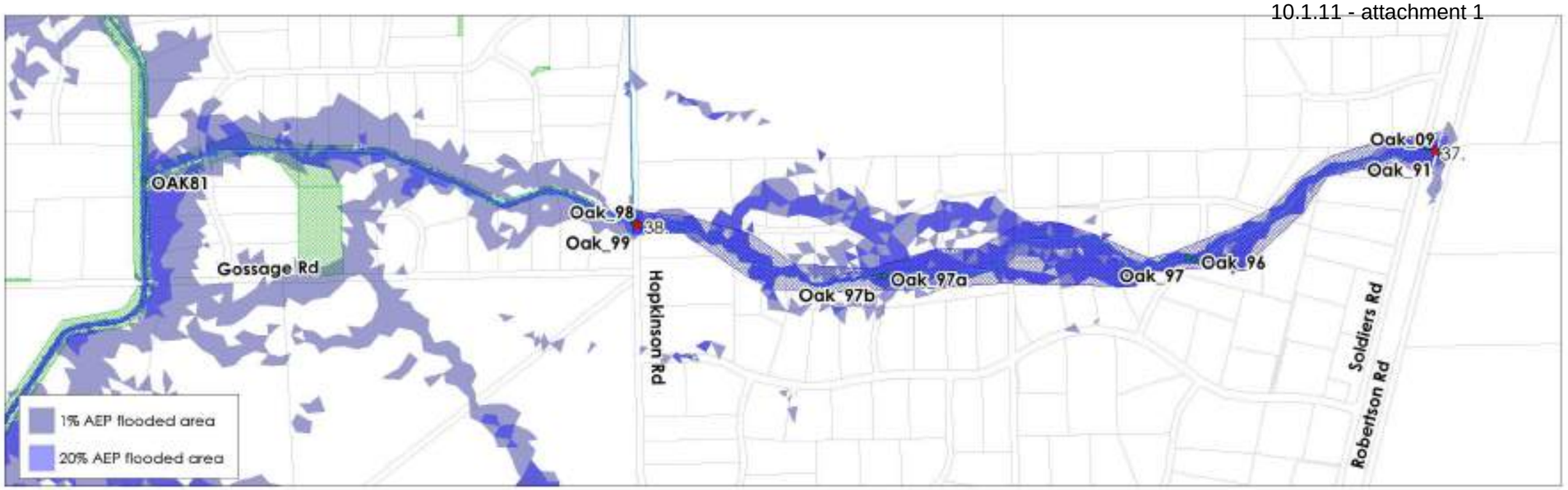


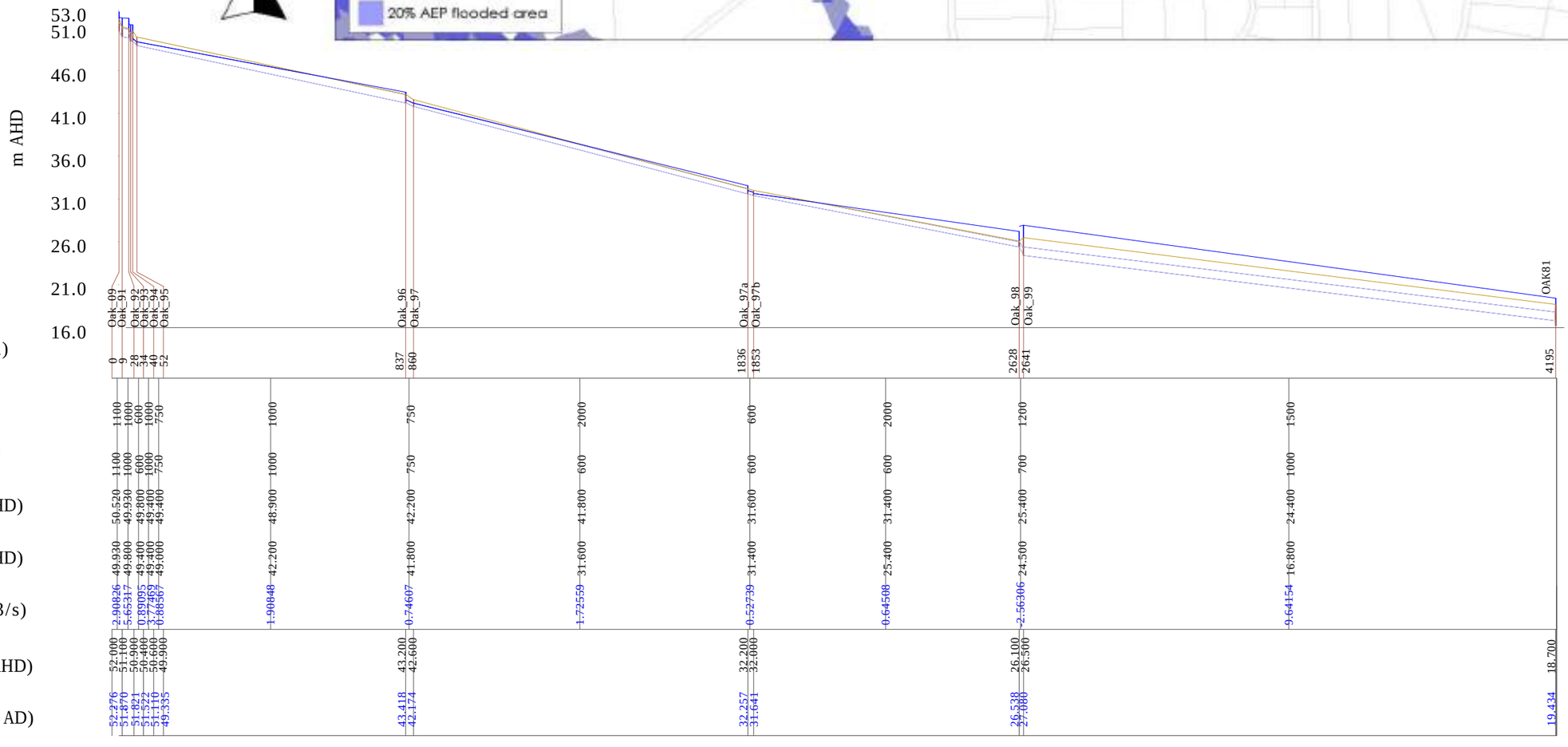


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.29 - Cardup Drain - 1% AEP



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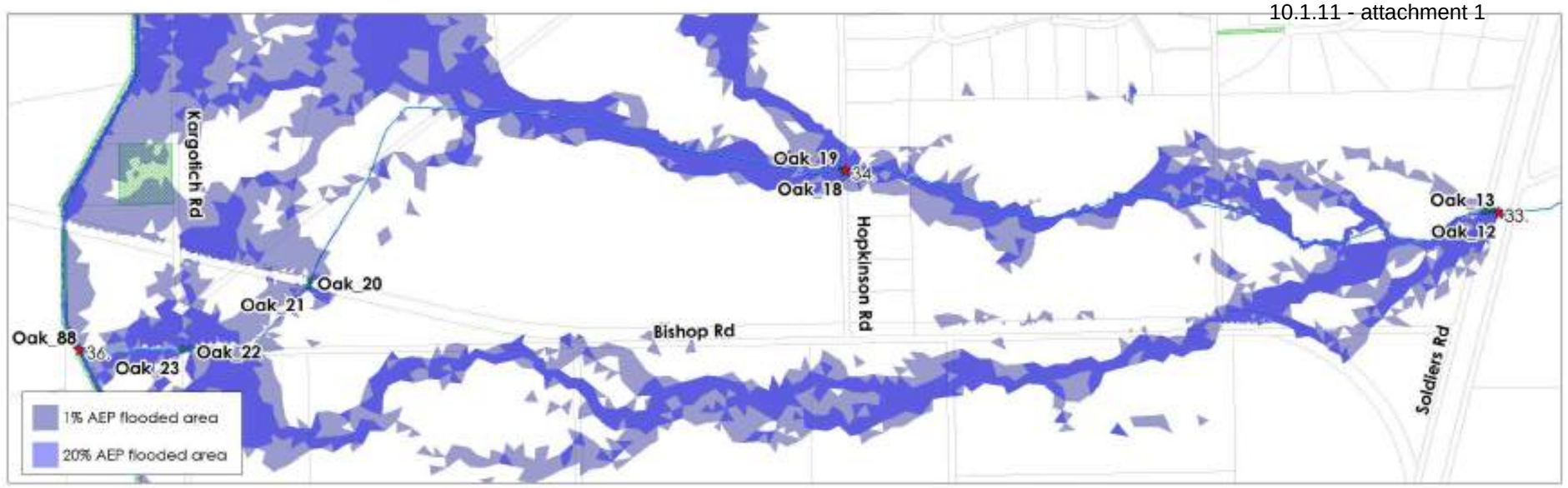





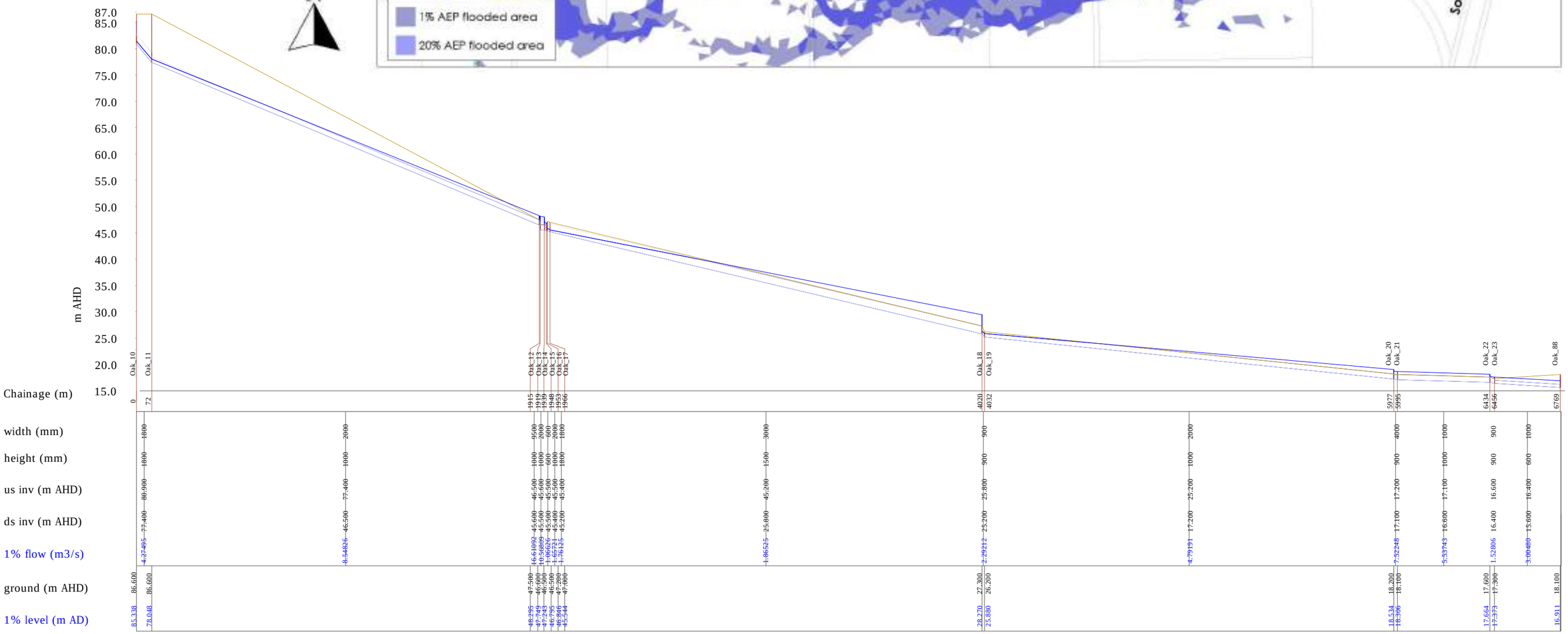


# Shire of Serpentine-Jarrahdale - Byford DWMS
# Figure C2.30 - Norman Drain - 1% AEP

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|---|---|---|---|---|---|
| | | | | Copies | Date |
| Preliminary draft | V1 | HBr | SSh | Electronic | March 2018 |
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| | | | | | |

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