APPENDIX 1

Environmental Report

Environmental Report: Doley Rd, Byford

Prepared for ABN Group

By Essential Environmental

March 2017

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EXECUTIVE SUMMARY

ABN Group has engaged Essential Environmental to prepare an environmental report to support structure planning for proposed lots in the vicinity of Orton Rd, Byford, within the Shire of Serpentine Jarrahdale.

This report provides an analysis of the environmental constraints and considerations to development and proposes broad approaches to mitigate any impacts and/or constraints on the basis of future residential use.

The majority of the site has been historically cleared, although a number of significant trees have been established predominantly along driveways and boundaries with little or no understory remaining. The study area abuts Brickwood Reserve, which is a Bush Forever site and contains threatened ecological communities. Development of the study area will require adequate management of bushfire risk (the subject of a separate management plan) and potential impacts on fauna species.

The Local Structure Plan has been designed to retain and incorporate significant trees where possible in the multiple use corridor or public open spaces across the development (Figure 1).

In addition a range of management strategies have been proposed to effectively manage or mitigate any potential environmental impact caused as a result of the development. Proposed management actions are summarised on the table below. It is considered that urban development of the site is an acceptable land use given the current environmental condition and lack of significance of the site, and in consideration of the proposed management strategies outlined in this report.

Issue	Action	Frequency	Responsibility
Preconstruction phase			
Contamination	Complete preliminary site investigation for contamination in accordance with Contaminated Sites Act 2003	Once	Developer
Acid sulfate soils	Complete self-assessment checklist and consider need for a preliminary site assessment	Once	Developer Consistent with DoP and DER guidelines
Vegetation and flora	Clearly delineate in accordance with Australian Standards 4970 – Protection of Trees on Development Sites, POS areas and trees to be retained. Identify Bush Forever and ensure setbacks are fenced. No clearing of the Bush Forever site is to occur	Once	Arboriculturist and Licensed Surveyor (Developer)
Fauna and habitat	All site staff to participate in Environment, Health and Safety inductions which provide requirements for management of significant fauna and reporting procedures for environmental incidents.	Once	Developer and Construction contractor
Water management	A Local water management strategy will be completed and used as the basis for detailed design. Following approval of the LWMS, UWMP(s) will be prepared prior to subdivision for approval by SJShire.	Once	Developer, in accordance with SPP 2.9: Water Resources

Issue	Action	Frequency	Responsibility
Bushfire	A Bushfire Management Plan will be prepared to support the LSP. The Bushfire Management Plan will be updated and implemented at subdivision.	Once	Developer, in accordance with SPP 3.7: Planning for Bushfire Risk Management (WAPC 2015).
Construction phase			
Soils and topography	Ground disturbing activities should be kept to a minimum and carried out 'as required' (in stages) immediately prior to lots being released for sale as part of a 'staged' development of the site	Ongoing during construction phase.	Construction Contractor (Developer)
Contamination	Management of any identified contamination in accordance with the Contaminated Sites Act 2003	Ongoing during construction phase.	Construction Contractor (Developer)
Acid sulfate soils	Management of any identified ASS consistent with DoP and DER guidelines	Ongoing during construction phase.	Construction Contractor (Developer)
Vegetation and flora	Maintain markings and fencing around vegetation and trees to be retained. Cleared vegetation to be mulched and stored on site	Ongoing during construction phase.	Construction Contractor (Developer)
Fauna and habitat	Undertake clearing in the direction of existing bushland to allow fauna to escape.	Ongoing during construction phase.	Construction Contractor (Developer)
Water management	Manage sediment transport to waterways and drainage systems	Ongoing during construction phase.	Construction Contractor (Developer)
Aboriginal heritage	In the event a site is discovered, all work in the area will cease and the Department of Aboriginal Affairs will be contacted	Ongoing during construction phase.	Construction Contractor (Developer)
Construction impacts	Ensure dust and sediment runoff is adequately managed. Ensure appropriate waste disposal of building materials.	Ongoing during construction phase.	Construction Contractor (Developer)
Post construction phase			
Soils and topography	Landscape or stabilise cleared areas immediately	Once	Construction Contractor (Developer)
Brickwood reserve	Provide adjacent landowners with a copy of the management plan. Develop and provide adjacent landowners a "Living next to Brickwood Reserve" booklet outlining environmental issues of pet animals, garden weeds, reducing spread of plant disease and inappropriateness of certain air conditioning systems in fire hazard zones.	Once As required	Subdivider / Local Government
Vegetation and flora	Inspect fencing (if applicable) and replace if required. Ensure ongoing maintenance of retained vegetation and any revegetation areas / native landscaping prior to handover.	6 months Ongoing until handover.	Developer until hand over to SJ Shire

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1 INTRODUCTION

ABN Group has engaged Essential Environmental to prepare an environmental report to support structure planning for proposed lots in the vicinity of Orton Rd, Byford, within the Shire of Serpentine Jarrahdale (SJ Shire).

This report provides an analysis of the environmental constraints and considerations to development and proposes broad approaches to mitigate any impacts and/or constraints on the basis of future residential use.

1.1 Study area

The study area consists of approximately 120 hectares of land in the vicinity of Orton Rd, Doley Rd and Warrington Rd in Byford. The study area currently comprises single dwelling rural residential lots of between 1 and 6 hectares in size.

The study area is zoned 'Urban' under the Metropolitan Region Scheme and 'Urban Development' under Serpentine-Jarrahdale Shire Town Planning Scheme No. 2.

The study area is within the Doley / Warrington Rd Precinct of the Byford District Structure Plan area (2009).

1.2 Methodology

This report considers the following environmental aspects of the study area to inform preparation of a local structure plan and the future residential development of the area:

- Topography, soils (including acid sulfate soils), contamination;
- Vegetation, flora and fauna;
- Water resources; and
- Heritage.

The following information has been provided on the basis of a desktop investigation only, using data and information that is publically available. No attempt has been made to ground-truth the information at this stage.

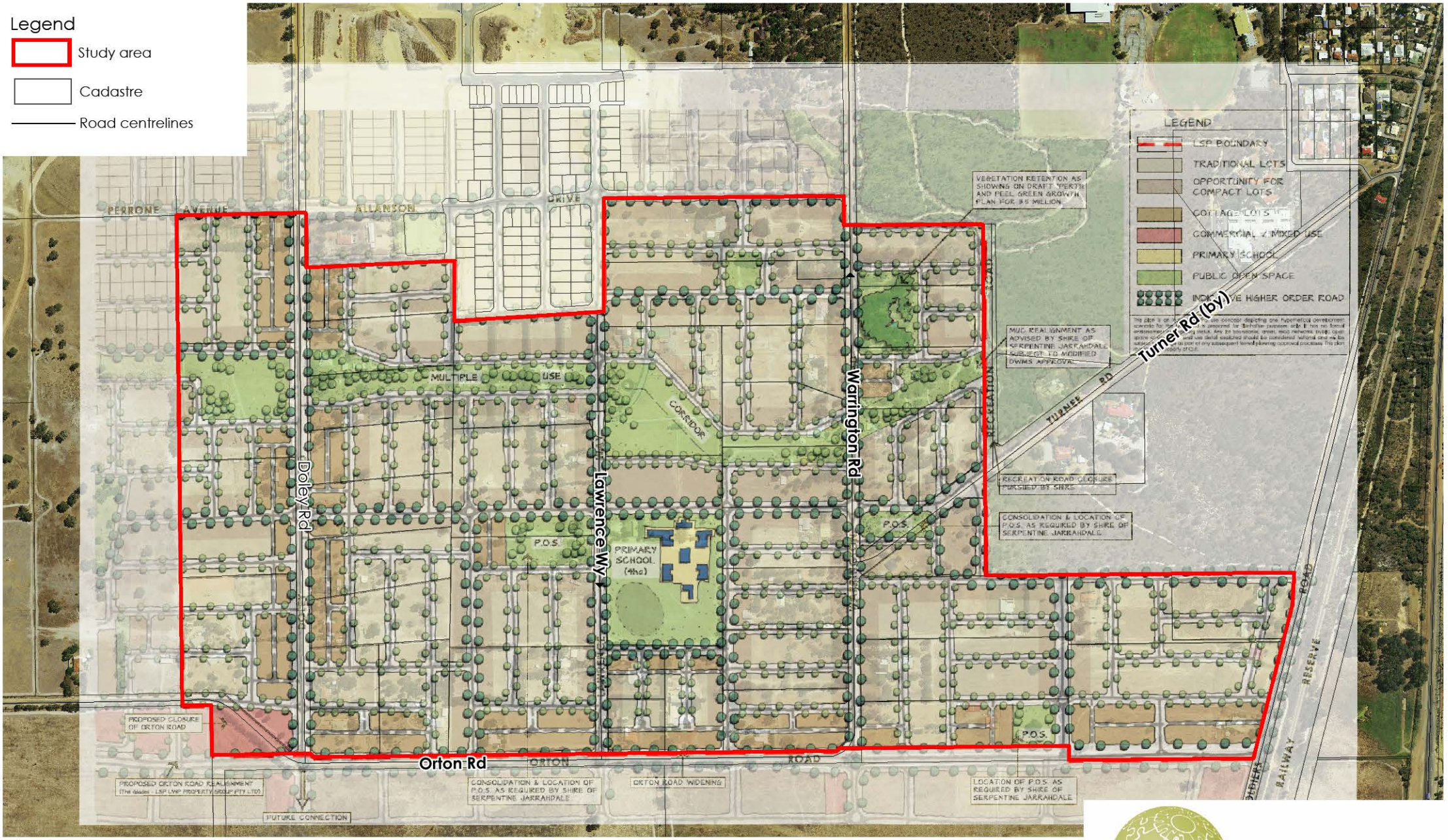
1.3 Previous environmental assessments

Limited environmental assessment has been undertaken for the site to date. The following water management investigations have been completed and are being considered as part of the preparation of a local water management strategy for the site:

- Byford Townsite Drainage and Water Management Plan (DoW, 2008)
- Byford Urban Stormwater Management Plan Developer Guidelines (Parsons Brinkerhoff, 2005)

Serpentine Jarrahdale Shire have also prepared the *Brickwood Reserve & Briggs Park Management Plan* (2009), which contains recommendations to guide and prioritise the use and management of the reserve in the longer term.

ABN Group: Doley Rd, Byford - Environmental report
Figure 1: Study area location and conceptual structure plan



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1.4 Key environmental requirements

There are a number of pieces of legislation which govern management of the environment and have been considered as part of this assessment. These are listed in Table 1.

Table 1: Relevant environmental legislation

Legislation	Summary of relevant intent
Aboriginal Heritage Act 1972	Protects significant Aboriginal heritage, registered or unregistered.
Biosecurity and Agriculture Management Act 2007	Provides for the management of declared pests.
Contaminated Sites Act 2003	Requires the reporting of potential contaminated sites to the Department of Environment Regulation.
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act)	Provides protection for Matters of National Environmental Significance (MNES).
Environmental Protection Act 1986	Provides protection for the environment as well as the licencing of prescribed premises and regulation of the clearing of remnant vegetation.
Fire and Emergency Services Act 1998	Provides for the management of bushfire risk
Heritage of Western Australia Act 1990	Protection of places listed by the Heritage Council of WA
Swan and Canning Rivers Management Act 2006	Establishes the Swan Canning River park and provides for the assessment of planning proposals within this area by the Swan River Trust Board.
Wildlife Conservation Act 1950 (WC Act)	Protects species of flora & fauna and communities that are listed.

The following environmental policies are also considered relevant to the management of potential environmental impacts on the site.

- SJ Shire's *Plan For The Future and Vision 2025*;
- Serpentine Jarrahdale Shire *Local Biodiversity Strategy* (2008);
- Serpentine Jarrahdale Shire *Brickwood Reserve & Briggs Park Management Plan* (2009)
- Local policies of the SJ Shire which include;
    - LPP06 - Water sensitive design
    - LPP08 - Landscape protection policy
    - LPP18 – Subdivision clearances
    - LPP21 – Management Plans
    - LPP26 – Biodiversity planning
    - LPP27 – Stakeholder engagement in land use planning
    - LPP28 – Street trees
    - LPP60 – Public open space
    - LLP 67 – Landscape and vegetation
    - LLP 68 – Sustainability assessment
    - LLP 69 – Doley Road precinct planning framework
- EPA Guidance Statement No. 33 – Environmental Guidance for Land Development (EPA, 2008); and
- Liveable Neighbourhoods (WAPC, 2011).

2 PROPOSED DEVELOPMENT

2.1 Planning context

The study area is zoned 'Urban' under the Metropolitan Regional Scheme and 'Urban Development' under the SJ Shires Town Planning Scheme No. 2.

The *Byford District Structure Plan*, adopted in August 2005, provides a district level framework to guide more detailed planning for the Byford area between the proposed Tonkin Hwy and the Darling Scarp, from Thomas Rd to Cardup Siding Rd. It requires local structure plans to be prepared to provide the level of detailed planning required to facilitate subdivision and development within the district structure plan area. The Byford District Structure Plan recommends that a road reserve is provided adjacent to Brickwood Reserve, separating it from the residential area. It also recommends that public open space link is provided between Brickwood Reserve and the multiple use corridor on Turner Road. The study area is within the Doley / Warrington Rd Precinct.

'The Glades' development flanks the north, west and southern boundaries of the study area. The local structure plan for this development was adopted in April 2011. As of mid-2015, the development is largely completed to the north and half completed to the west. No works have been undertaken south of the study area, where the development flanks the Cardup Brook.

2.2 Local structure plan

The local structure plan will guide the subdivision and development of approximately 120 hectares in Byford. The structure plan contains

- approximately 12.2 ha of public open space (POS);
- Multiple use corridor (MUC) through the northern portion of the structure plan, tying in with adjacent developments;
- 4ha for a primary school;
- Commercial/Mixed Use site; and
- a mixture of residential lots.

This Environmental Report aims to facilitate the retention of key environmental values as part of the future development of the site, minimising potential environmental impacts.

During the preparation of this report, the design of the local structure plan has been modified to incorporate natural areas into the plan where possible, based on their environmental value in order to minimise any potential environmental impacts resulting from the development.

The local structure plan design has responded to as many of the environmental opportunities presented as practicable in a residential area. These are discussed below.

- Aligning roads to coincide with existing trees to allow a higher number of tree retention, with particular attention to trees with higher significance (mid-maturity, foraging and nesting for local fauna);
- The existing water course is to be retained, rehabilitated and incorporated into a multiple use corridor as a feature of the public open space; and
- Alignment of roads to provide buffers to the adjacent Bush Forever site (Brickwood Reserve).

3 EXISTING ENVIRONMENT

A desktop environmental investigation of the study area has been undertaken, the findings of which are presented below.

3.1 Land use context

3.1.1 Historical land use

Department of Planning historical mapping shows previous zoning was for 'Rural' landuse. Historical aerial photography from Landgate suggests the land was parcelled and single dwellings built during the late 70's to early 80's. Prior to this, aerial photography indicated the land may have been used for farming, after being cleared prior to the earliest available photography in 1953. No further significant changes to land use from the 1980's onwards are indicated in the aerial photography.

Given that the study area has been used for largely rural activities for the past 60 years, contamination risks may exist. These risks include hydrocarbons from farm plant, legacy nutrients from farming practice and other contamination that may occur on rural land parcels. However, a search of the Department of Environment Regulation contaminated sites database shows no registered contaminated sites within or near the study area.

3.1.2 Current land use

The study area currently has single dwelling lots ranging between 1 and 6 hectares, averaging 4 hectares. Current land use is largely rural residential, with some properties containing livestock, large sheds and farming equipment. Most properties have been largely cleared, with many containing non-endemic lines of significant trees flanking boundaries and driveways.

One property (Lot 2 Lawrence Way) contains a significant number of car bodies and a number of small mounds of dirt. It is possible that this site may present a risk of contamination and it is recommended that a preliminary site inspection is undertaken prior to development of this lot.

3.1.3 Surrounding land use

The Brickwood Reserve abuts the study area along its eastern boundary. The Brickwood Reserve is a Bush Forever site and contains a number of Threatened Ecological Communities (TEC). Appropriate buffers to TEC are required, and discussed further in Section 3.3 The Brickwood Reserve is also considered a Conservation Category Wetland which requires a buffer typically a minimum of 50m as determined by the Department of Parks and Wildlife, however this is subject to negotiation.

'The Glades' housing development flanks the north, west and southern boundaries of the study area. As of March 2015 the development is partially complete along the norther and western boundaries only.

3.2 Topography, geology and soils

3.2.1 Topography

The study area has generally flat topography and grades gently from 43m AHD in the east to 37.5mAHD in the west. The study area has a few high points of approximately 1m higher than the surrounding topography, coinciding with the pad of existing dwellings, as shown in Figure **2**.

3.2.2 Geology

The surface geology is described broadly as Guildford formation: Alluvial sand and clay with shallow-marine and estuarine lenses and local basal conglomerate (WA surface geology 1:250,000 scale geological maps, Geological Survey of WA, and Geoscience Australia)

This is further classified as Sandy Clay (Figure **2**) and described as white grey to brown, fine to coarse grained, sub-angular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp.

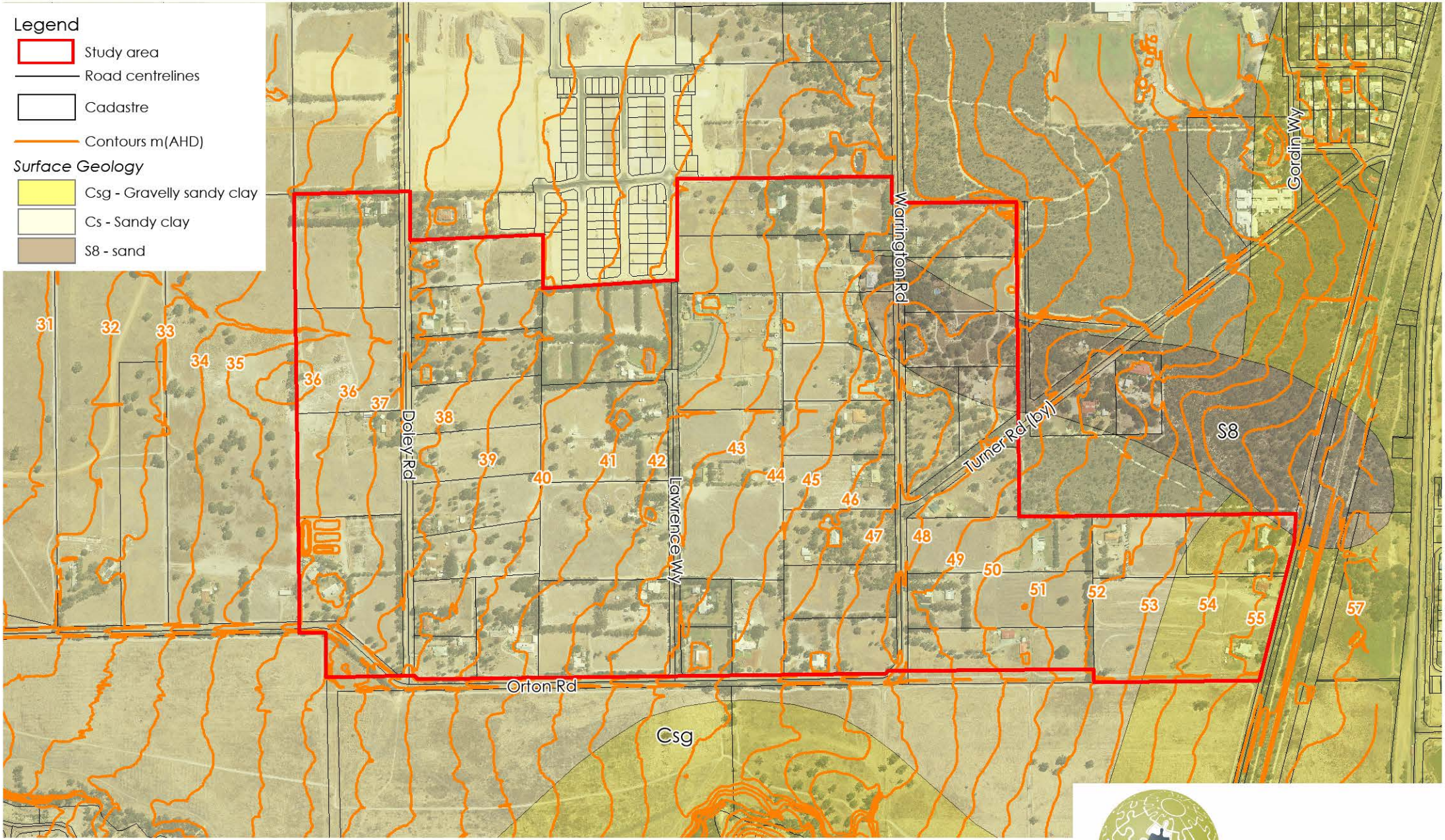
3.2.3 Acid sulfate soils

A review of Department of Environment Regulation acid sulfate soils risk mapping identifies the site as containing a Class II 'low to moderate' risk of acid sulfate soils (ASS) occurring within 3m of the natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface (Figure 3).

Consistent with Department of Environment Regulation guidelines, sites should be investigated for ASS if any of the following works are proposed:

- acid sulfate soil disturbing subdivision or development that is subject to conditional approval requiring the investigation and management of acid sulfate soils;
- soil or sediment disturbance of 100m3 or more in an area depicted on an ASS risk map as Class I 'high to moderate risk of ASS occurring within 3m of natural soil surface' (e.g. construction of roads, foundations, installation of underground infrastructure, drainage works, land forming works, dams and aquaculture ponds or sand or gravel extraction);
- soil or sediment disturbance of 100m3 or more with excavation from below the natural watertable in an area depicted on an ASS risk map as Class II 'moderate to low risk of ASS occurring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface';
- lowering of the watertable, whether temporary or permanent (e.g. for groundwater abstraction, dewatering, installation of new drainage, modification to existing drainage), in areas depicted in an ASS risk map as Class I 'high to moderate risk of actual acid sulfate soils (AASS) or potential acid sulfate soils (PASS) occurrence' or Class II 'moderate to low risk of AASS or PASS occurrence within 3m of natural soil surface';
- any dredging operations;
- extractive industry works (e.g. mineral sand mining) in any of the areas listed in Table 1; and
- flood mitigation works, including construction of levees and flood gates, in any of the areas listed in Table 1.

ABN Group: Orton Rd, Byford - Environmental report
Figure 2: Topography and soils



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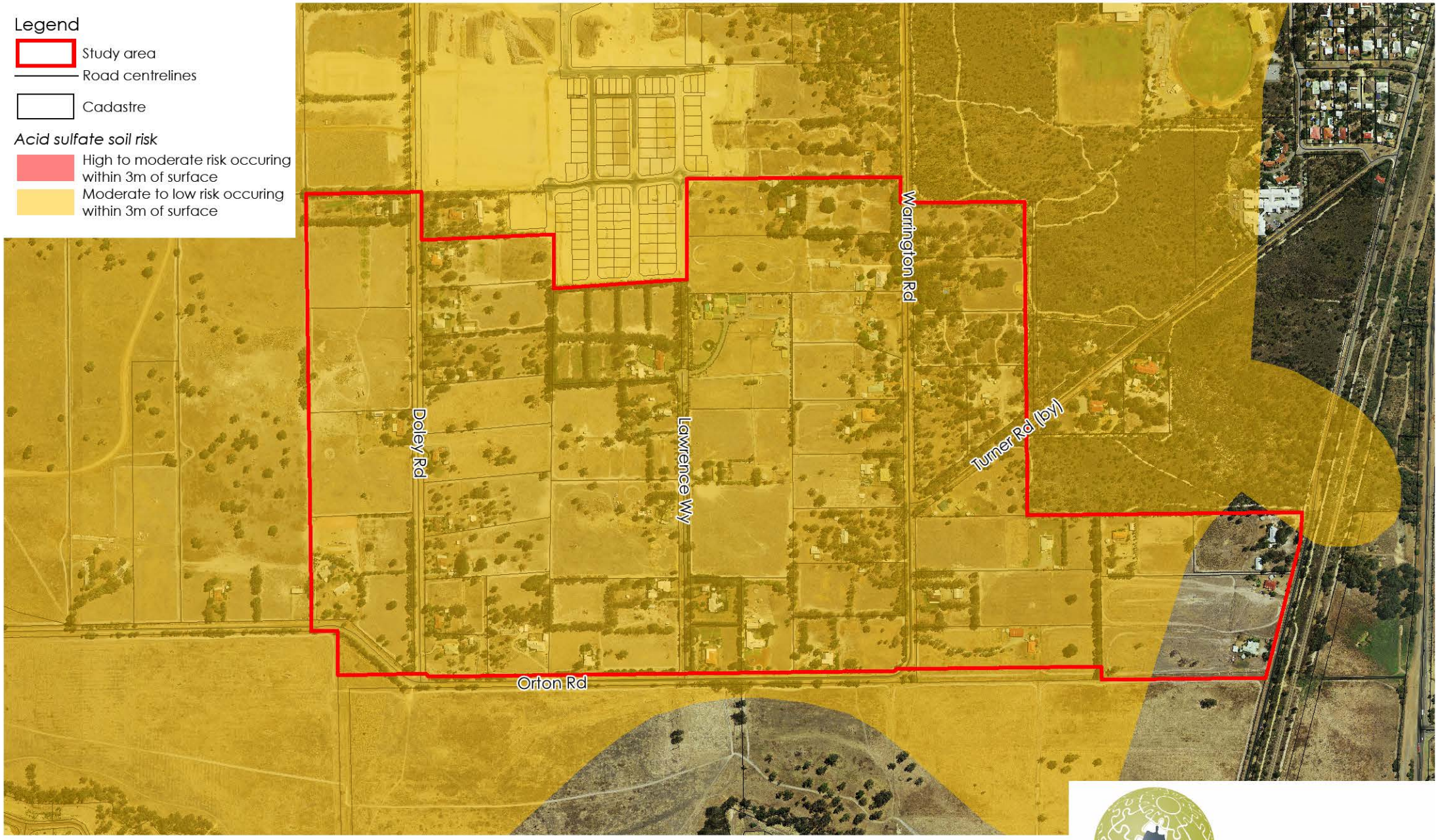
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ABN Group: Doley Rd, Byford - Environmental report
Figure 3: Acid sulfate soils risk



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Given the Class II classification for ASS, it is recommended that a self-assessment checklist is completed for the study area. Some further investigation for ASS may be required, particularly if the installation of any infrastructure or servicing requires excavation of the site beyond 3m depth. Should this occur on-site testing is to be undertaken to determine the presence, if any, of acid sulfate soils prior to subdivision.

If there is ASS present at the site, all site works must be carried out in accordance with a DER-approved ASS management plan. Completed forms must accompany relevant reports for assessment by DER officers.

3.3 Flora, fauna and vegetation

3.3.1 Conservation areas

There are no Bush Forever sites within the study area.

Bush Forever site 350, Brickwood Reserve and Railway Reserve abuts the study area to the east. Bush Forever site 351 covers a portion of the Cardup Brook, south of the study area and Bush Forever Site 352, Cardup Nature Reserve and Adjacent Bushland, Cardup is located further to the south, as shown in Figure 4.

The *Brickwood Reserve & Briggs Park Management Plan* (SJ Shire, 2009) is currently the subject of public consultation and the Shire has advised that it is subject to change (G French, pers comm, 15 Dec15). The *Brickwood Reserve & Briggs Park Management Plan* makes a number of recommendations for management of the Bush Forever Site, TEC and associated recreation reserve including the eventual incorporation of Lot 48 Turner Road into the Brickwood Reserve. This lot abuts the study area.

3.3.2 Vegetation complex

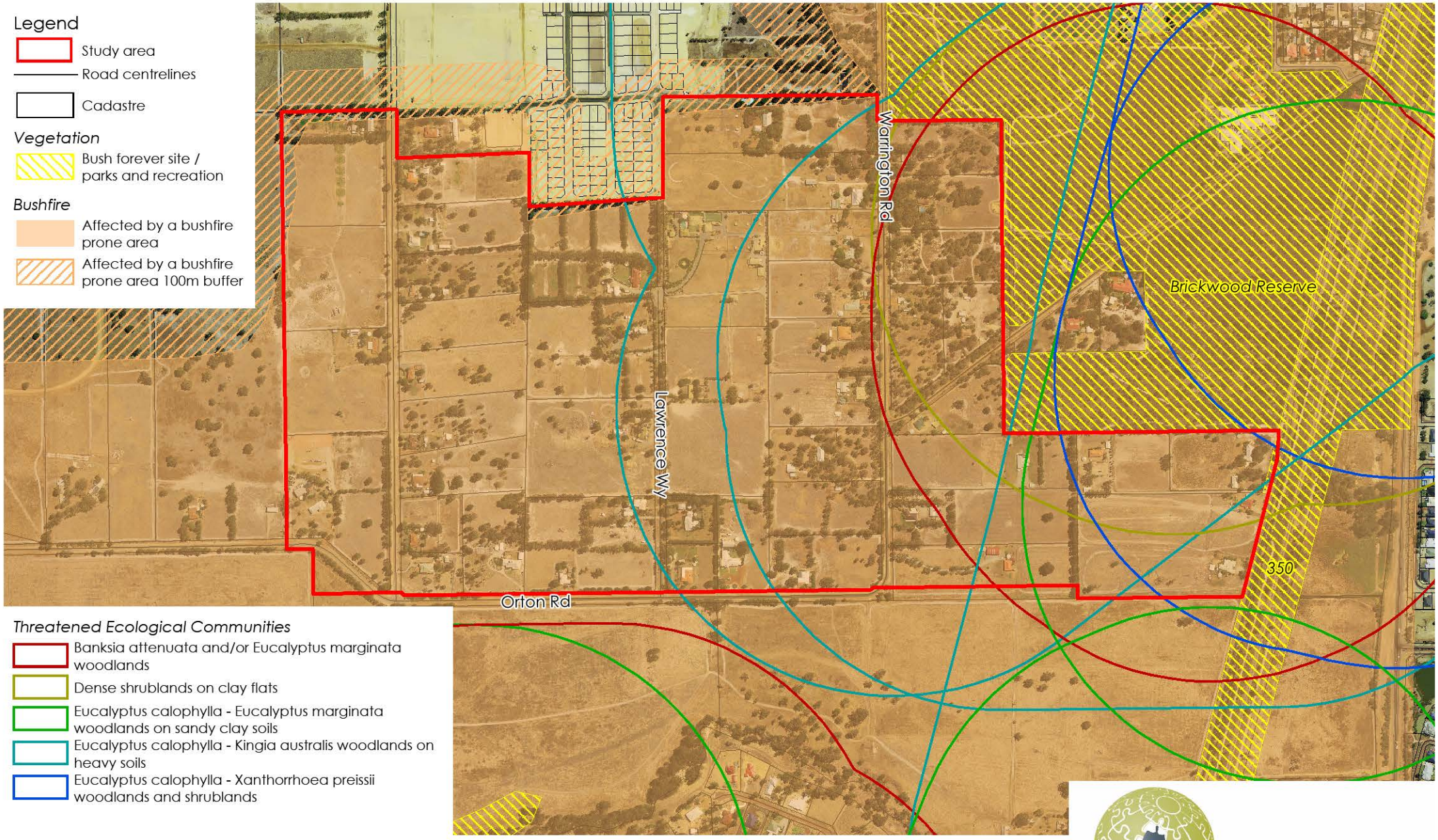
The vegetation complex that exists within and adjacent to the study area is the Forrestfield Complex (Ridge Hill Shelf, Darling Plateau).

The vegetation of the Forrestfield Complex ranges from open forest of *E. calophylla - E. wandoo - E. marginata* to open forest of *E. marginata - E. calophylla - C. fraseriana* - Banksia species. Fringing woodland of *E. rudis* may be present in the gullies that dissect this landform (WAPC, 2000). Table 2 provides the conservation status of the vegetation complex, as described in *Bush Forever* (WAPC, 2000) and SJ Shire *Local Biodiversity Strategy* (2008).

Table 2: Regional and local conservation status of Forrestfield Complex

Complex	Percentage of pre-European extent remaining	Percentage of pre-European extent protected
Serpentine Jarrahdale Shire	266ha (6%)	145 (4%)
Perth metropolitan area	1020 (9%)	219 (2%)

ABN Group: Doley Rd, Byford - Environmental report
Figure 4: Vegetation and bushfire prone areas



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Although it is noted that less than the critical threshold of 10% of the Forrestfield Complex is remaining on the metropolitan portion of the Swan Coastal Plain, the study area is not identified in the Serpentine Jarrahdale Shire *Local Biodiversity Strategy* (2008) as containing conservation values. The vegetation within the study area is not considered to be a good representation of the Forrestfield Complex due to the extent of clearing and degradation that has occurred.

3.3.3 Flora

Searches of the EPBC Protected Matters Search Tool, NatureMap and Department of Parks and Wildlife databases were undertaken to identify flora species of conservation significance potentially occurring in the study area.

Table 2 outlines the results from the DPaW Threatened (Declared Rare) and Priority Flora (TPFL) and Western Australian Herbarium Specimen databases (with additional 2km buffer to the site) and EPBC Act Protected maters search.

Table 3: Conservation significant flora likely to occur in the study area

Taxa	Conservation status		Likelihood, preferred habitat
	WC Act	EPBC Act	
Andersonia gracilis (Slender Andersonia)	Threatened	Endangered	Unlikely, shrub near swamps
Caladenia huegelii (King Spider-orchid)	Threatened	Endangered	Unlikely, clay loam soils
Darwinia foetida (Muchea Bell)	Threatened	Critically Endangered	Unlikely, swampy, seasonally wet
Diuris micrantha (Dwarf Bee-orchid)	Threatened	Vulnerable	Unlikely, swampy, seasonally wet
Diuris purdiei (Purdie's Donkey-orchid)	Threatened	Endangered	Unlikely, swampy, seasonally wet
Drakaea elastic (Glossy-leafed Hammer-orchid)	Threatened	Endangered	Unlikely, swampy, seasonally wet
*Drakaea micrantha (*Dwarf Hammer-orchid)	Threatened	Vulnerable	Unlikely, white grey sand
Drosera occidentalis subsp. occidentalis	Priority 4		Unlikely, swampy, seasonally wet
*Eucalyptus balanites (*Cadda Road Mallee)	Threatened	Endangered	Unlikely, Sandy soils, lateritic gravel
Grevillea curviloba subsp. Incurve (Narrow curved-leaf Grevillea)	Threatened	Endangered	Unlikely, Peaty and clay soils
Johnsonia pubescens subsp. Cygnorum	Priority 2		Unlikely, swampy, seasonally wet
Meeboldina decipiens subsp. *Decipiens*	Priority 3		Unlikely, swampy, seasonally wet
Schoenus pennisetis	Priority 3		Unlikely, swampy, seasonally wet
Synaphea sp. Fairbridge Farm (D.Papenfus 696) (Selena's Synaphea)	Threatened	Critically Endangered	Unlikely, Sandy with lateritic pebbles
Synaphea sp. Serpentine	Threatened		Unlikely, Brown sandy clay

Taxa	Conservation status WC Act	EPBC Act	Likelihood, preferred habitat
Thelymitra stellata (Star Sun-orchid)	Threatened	Endangered	Unlikely, swampy, seasonally wet
Trichocline sp. Treeton			Unlikely, swampy, seasonally wet

Preferred habitat sourced from Florabase (DEC, 2015), Department of Environment Database (2015) as well as the DPaW database searches.

Many of the species listed can be found in wetland areas of which the site has a large extent. However the site has been extensively cleared and grazed for at least 60 years. Therefore species on the list that may have once occurred on the site are not likely to be present now. Areas that contain some native trees have a completely cleared understorey in which the conservation significant species would not occur.

3.3.4 *Vegetation communities*

Two Bush Forever sites abut the study area on the eastern boundary; Brickwood Reserve (site ID 321) and Railway Reserve (site ID 350). These Bush Forever sites contain several recorded TECs and as such their associated buffers cross into the study area. Table 4 and Figure 4 depict the recorded TECs associated with the study area, in order of conservation status.

Table 4: Threatened ecological communities database search

Status	Community Name
Critically endangered	*Eucalyptus calophylla-Xanthorrhoea preissii* woodlands and shrublands
	Eucalyptus calophylla – Kingia australias woodlands
Endangered	*Banksia attenuate* and/or *Eucalyptus marginate* woodlands
Vulnerable	*Eucalyptus calophylla - Eucalyptus marginata*
	Dense shrubs on clay flat

3.3.5 *Fauna*

A search of the DPaW Threatened (Declared Rare) and Priority Fauna database identified six (6) species of conservation significance as being located within the study area and/or a 5km buffer. The results are summarised in Table 5.

Table 5: Conservation significant fauna likely to occur in the study area

Taxa	Common Name	Conservation status WC Act	EPBC Act	Likelihood
Calyptorhynchus latirostris	Carnaby's Cockatoo	Threatened	Endangered	Likely
Calyptorhynchus baudinii	Bauldin's Cockatoo	Threatened	Vulnerable	Likely

Taxa	Common Name	Conservation status		Likelihood
		WC Act	EPBC Act	
Calyptorhynchus banksia subsp.naso	Forest Red-tailed Black-Cockatoo	Threatened	Vulnerable	Likely
Merops ornatus	Rainbow bee-eater	Protected under international agreement	Migratory	Likely
Acanthophis antarcticus	Southern Death Adder	Priority 3	-	Unlikely
Isoodon obesulus fusciventer	Quenda	Priority 5	-	Likely

Due to the likelihood of the study area containing habitat which supports species of conservation significance, a Level 1 Fauna assessment and Black Cockatoo habitat assessment was undertaken for part of the study area. The results of this assessment are outlined in further detail below.

3.3.6 A Level 1 Fauna and Cockatoo habitat assessment

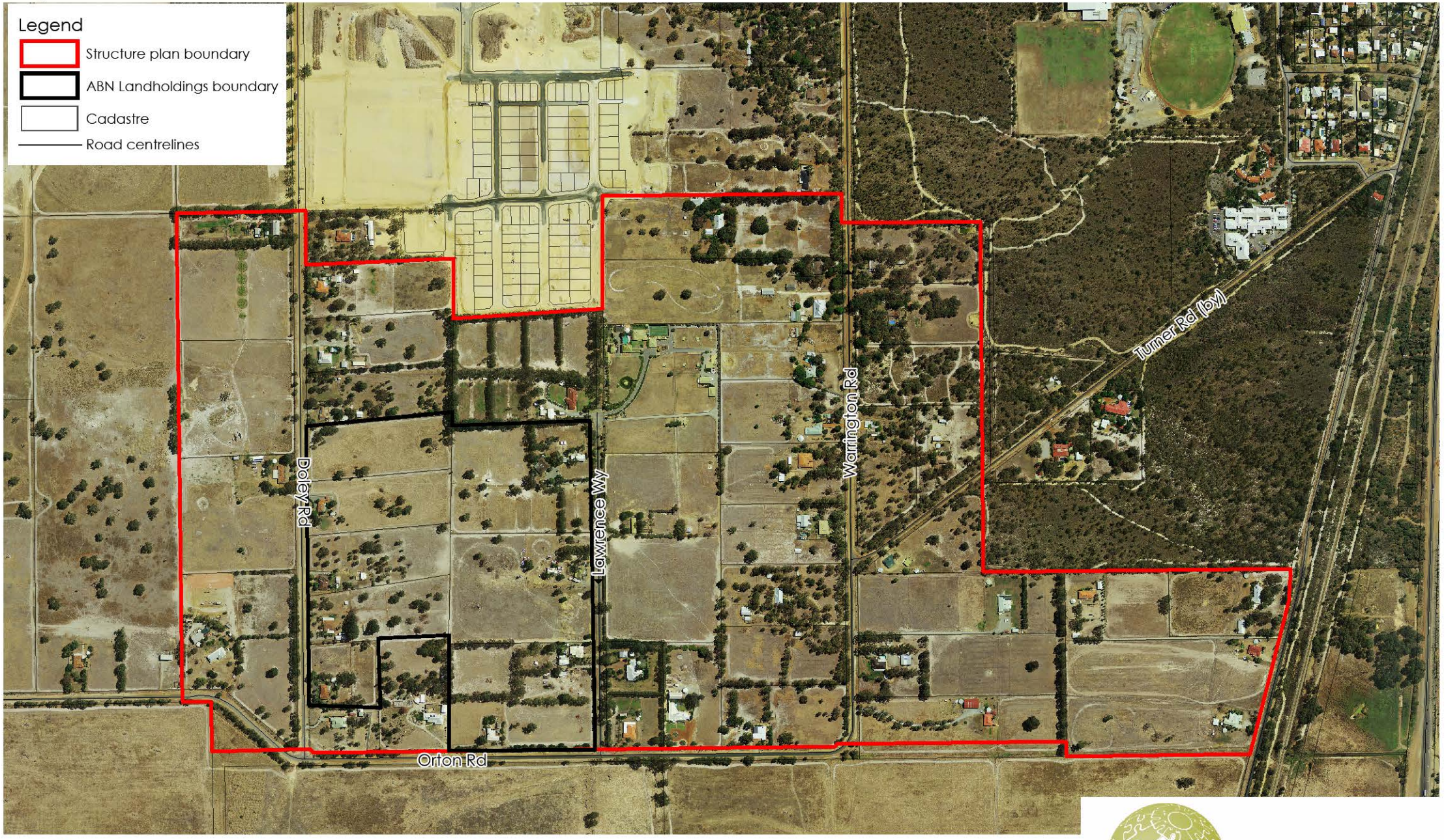
A Level 1 Fauna assessment and a Black Cockatoo Site assessment was completed by 360 Environmental on 22nd October 2015 over a portion of the site, referred to as the ABN landholdings (Figure 5). The assessment involved a database search for conservation significant fauna and a site reconnaissance to assess the foraging and breeding potential for Black Cockatoos.

The following summary is taken from the executive summary. The complete report is provided in Attachment 1.

> Database searches showed 23 conservation significant vertebrate species, from 16 families have been recorded as potentially occurring in the vicinity of the Survey Area (ABN landholdings). Of these, two were reptiles from two families, 13 were bird species from nine families, and eight were mammals from five families.
>
> During the field survey 19 bird species, from ten families and one mammal species were recorded. Four species of conservation significance was recorded during the field survey, the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*), Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*), the Rainbow Bee-eater (*Merops ornatus*) and the Southern Brown Bandicoot (*Isoodon obesulus fusciventer*).
>
> During the Black Cockatoo Assessment, 33 potential breeding trees were recorded. The potential breeding trees were all *Corymbia calophylla* and none contained any observable hollows. Foraging evidence in the way of chewed Marri nuts was found throughout the Survey Area. Due to the chew-marks on the nuts, it is believed they were from both Forest Red-tailed Black Cockatoo and Carnaby's Black Cockatoo.
>
> One native fauna habitat (Eucalypt Remnants) and one non-native fauna habitat were identified in the Survey Area. The remaining areas were cleared, or comprised of completely degraded areas or roadways.

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Figure 5: Extent of Level 1 Fauna and Cockatoo habitat assessment



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3.3.7 Bushfire risk

The study area is identified by the Serpentine Jarrahdale Shire as bushfire prone (Figure 4). Bushfire risk will be addressed in a bushfire risk management plan which is being prepared separately.

3.4 Water resources

3.4.1 Public Drinking Water Source Area

There are no Public Drinking Water Source Areas within the study area.

3.4.2 Surface water resources

The study area has been classified as multiple use wetland by the Department of Parks and Wildlife in its Swan Coastal Plain geomorphic wetlands database (mapped in Figure 6) identified as the Armadale Palusplain: seasonally waterlogged flat land.

A surface water feature (water course) referred to in the Byford Townsite DWMP as tributary 7 lies within the northern portion of the study area. The water course shown begins in Brickwood Reserve and flows though the study area to The Glades development on the western boundary. The water course is proposed to become a Multiple Use Corridor (MUC), providing overland drainage, passive recreational area and public open space. The MUC shall provide an opportunity for rehabilitation of the riparian and surrounding vegetation.

The Byford Townsite DWMP identified water courses and associated 100 year ARI floodways. Tributary 7 should not pose a flood risk if the tributary is maintained as per pre-development conditions.

3.4.3 Groundwater resources

The study area is within the Serpentine groundwater area and Byford 3 sub-area. The Department of Water's Water Register shows available allocation within the study area, as shown in Table 6.

Table 6: Groundwater resource allocation and availability

Resource	Perth - Superficial Swan	Combined - Fractured Rock West - Fractured Rock	Perth - Cattamarra Coal Measures.	Perth - Leederville.	Perth - Yarragadee North.
Management Area	Serpentine	Serpentine	Serpentine	Serpentine	Serpentine
Management Sub Area	Byford 3	Byford 3	Byford 3	Byford 3	Byford 3
Component	General	General	General	General	General
Component Status	G1	G4	G3	G3	G1
Allocation Limit	13,291,660	8,500	1,130,000	2,270,000	0
Allocated Volume	952,712	92,150	556,414	2,018,500	0

Resource	Perth - Superficial Swan	Combined - Fractured Rock West - Fractured Rock	Perth - Cattamarra Coal Measures.	Perth - Leederville.	Perth - Yarragadee North.
Committed Volume	205,000	0	365,001	0	0
Remaining Volume	**12,133,948**	**-83,650**	**208,585**	**251,500**	**0**
% Allocated and Committed	**8.71%**	**1,084.12%**	**81.54%**	**88.92%**	**0.00%**
Additional Requested	448,805	0	275,875	176,060	0

There are five current groundwater licences within the study area:

- Two bores within Lot 3 Lawrence Way (both 8180kL);
- One bore within Lot 4 Lawrence Way (10300kL);
- One bore within Lot 61 Lawrence Way (15650kL), and;
- One bore within Lot 47 Turner Road (5000L)

The Department of Water's Perth Ground Water Atlas groundwater levels do not extend to the study area. However, the surrounding 'The Glades' development undertook groundwater level monitoring from September 2005 to August 2006, and inferred design groundwater levels are presented in Figure 7. The inferred groundwater contours show parts of the study area, especially towards the eastern portion, result in the groundwater being at or close to the natural surface.

3.5 Heritage

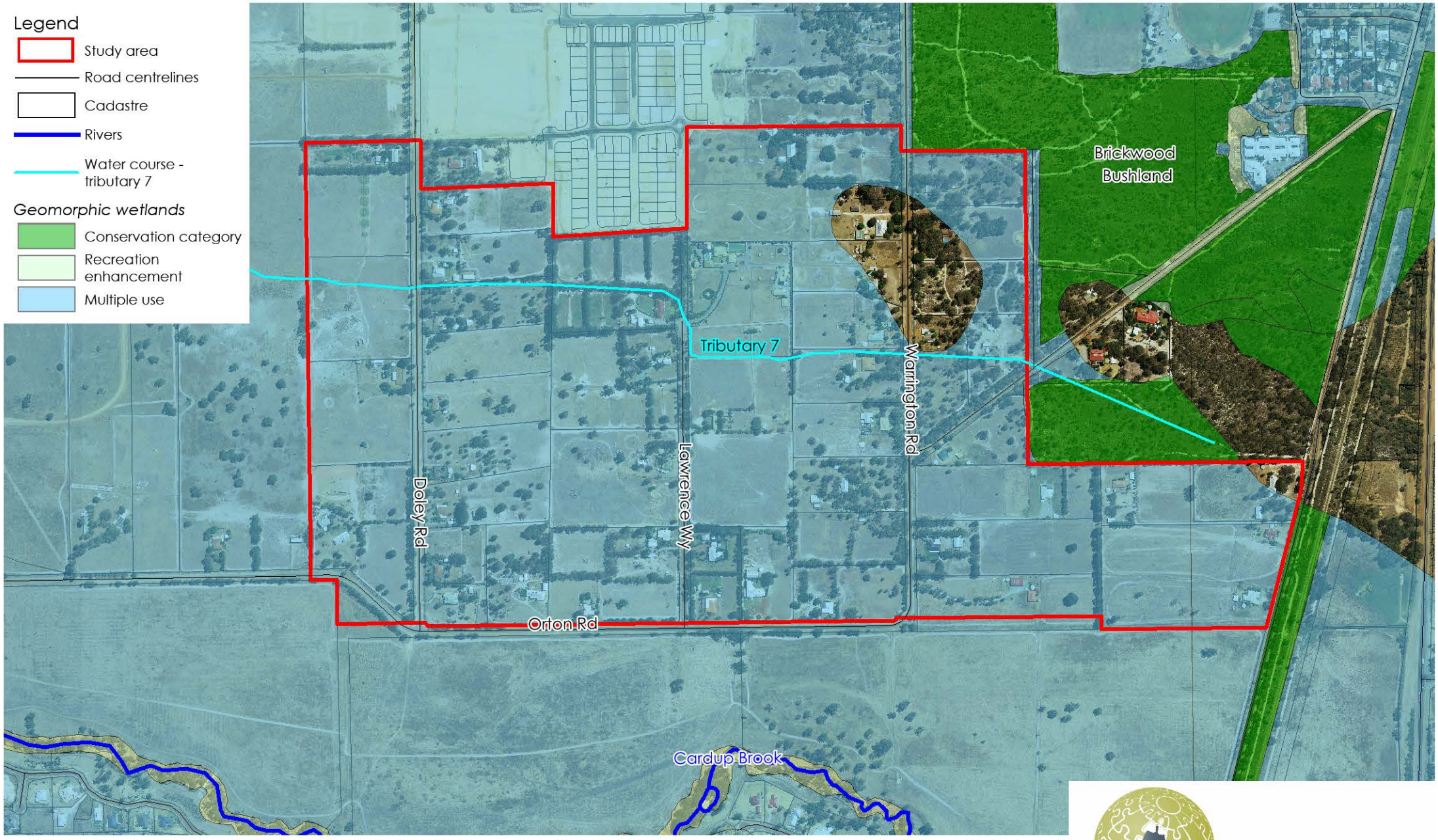
3.5.1 Aboriginal heritage

A search of the Department of Aboriginal Affairs of Western Australia aboriginal heritage enquiry system showed no registered Aboriginal sites within or adjacent to the study area. The closest site is the Cardup Brook, south of the study area categorised as 'other heritage places: mythological'

3.5.2 European heritage

A search of the State Heritage Register showed no current listing of state heritage within the study area.

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Figure 6: Surface water resources



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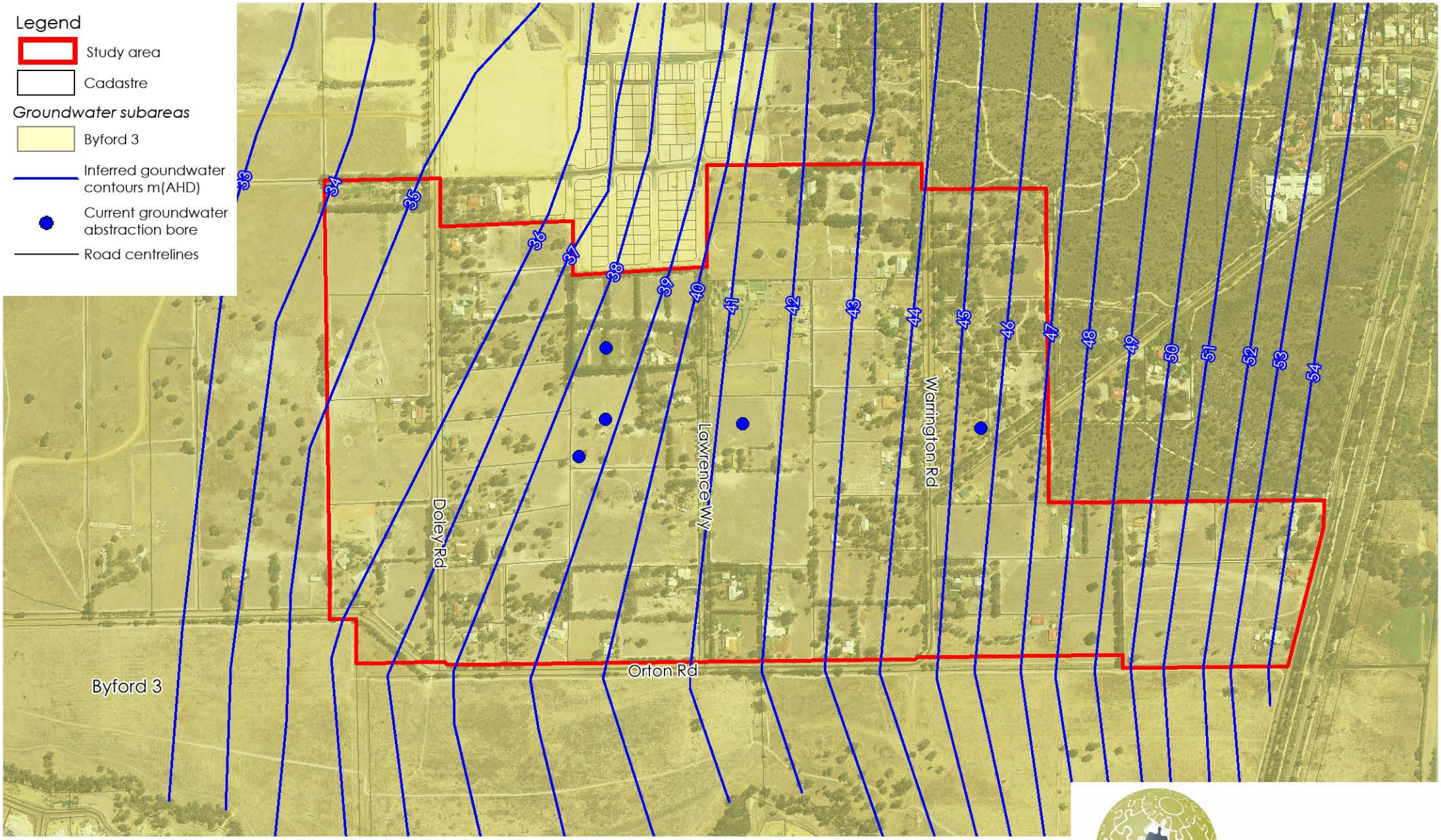
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ABN Group: Doley Rd, Byford - Environmental report
Figure 7: Groundwater resources



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4 FINDINGS AND RECOMMENDATIONS

In consideration of the existing environment as outlined in Section 3, the following management measures are proposed. These measures are designed to mitigate and manage any potential environmental impacts resulting from development of the site, in accordance with Local, State and Federal environmental agency objectives.

4.1 Soils and topography

The site does not contain any unique topographical or geological formations and therefore these factors are not considered an impediment to the development of the site for residential purposes.

To minimise potential for soil erosion to occur, the following management measures are recommended:

- Ground disturbing activities should be kept to a minimum and carried out 'as required' (in stages) immediately prior to lots being released for sale as part of a 'staged' development of the site; and
- Landscaping/stabilising/dust suppression of areas where ground disturbance has occurred should be scheduled to occur immediately after clearing/and or infrastructure construction has been completed.

4.2 Contamination

Past land uses indicate that rural activities may have resulted in some small localised areas that are at risk from contamination. It is suggested that a Preliminary Site Investigation is undertaken at subdivision stage to identify if there is any potential contamination present that may require further investigation and remediation in order for the site to be suitable for the proposed residential development.

4.3 Acid Sulfate Soils

ASS Risk on the site is mapped as being Moderate to Low (<3m from the surface). The WAPC *Acid Sulfate Soils Planning Guidelines* (WAPC, 2008) indicate that "acid sulphate soils are technically manageable in the majority of cases". ASS Investigation and, if required, Management Plans should be prepared at subdivision stage once the detailed design of the site is finalised. Consideration should be given to areas where excavation below 3m is likely to be required. This should be undertaken in accordance with the Acid Sulphate Soils Guideline Series: *Identification and Investigation of Acid Sulphate Soils and Acidic Landscapes* (DER, 2015a) and *Treatment and Management of Soils and Water in Acid Sulphate Soil Landscapes* (DER, 20 15b).

4.4 Surrounding land use and buffer requirements

The surrounding land uses to the west, north and south are predominantly existing or proposed urban development and therefore no buffer issues are identified.

To the east, Brickwood Reserve poses some risk to the development as a result of bushfire hazard. Bushfire risk management is being addressed separately and a Bushfire Management Plan is being prepared to accompany the structure plan.

It is recognised that the Brickwood Reserve provides a haven to many native plants and animals and has internationally recognised conservation significance. Appropriate buffers will need to be established to protect the conservation values of the site, achieved through the creation of local roads within the structure plan boundary that do not impact on the vegetation associated with the reserve. Recommendations will be made for native landscaping which minimises risk of tranferral of weeds to the reserve.

The risk of spreading dieback (*Phytophthora cinnamomi*) from Brickwood Reserve via the stormwater system into the multiple use corridor was considered as part of this report. However it is recognised that the upstream catchment of Tributary 7 (which becomes the multiple use corridor) is from an area of Brickwood Reserve that is disease free. Stormwater flows from the remainder of Brickwood Reserve will be conveyed by the existing drain along Recreation Road to the north.

4.5 Vegetation and flora

The vegetation on the site is degraded and the site does not contain any areas with an intact understorey. No Declared Rare Flora are likely to be on the site and no priority species are likely to be present. It is recommended that no further study on the site is required and therefore flora is not an impediment to the development of the area.

Development will require clearing of the majority of remaining vegetation on site. This vegetation is not ecologically significant; however, during the detailed design process it is recommended that any trees that can be retained in street verges, landscaped areas, parking areas and in road/entry areas should be identified and included in the detailed design plans for the area. Mature trees to be retained or transplanted must be identified and clearly and visibly marked prior to commencement of any pre-construction activities.

4.6 Fauna and habitat

Due to the degradation onsite, historic clearing activities and lack of native remnant vegetation, particularly understory, any fauna habitat is considered of low value to native fauna that may have previously utilised the site.

Development of the site has the potential to increase the ecological value of the site through creation of an ecological linkage along the proposed multiple use corridor. This corridor may provide habitat for the Southern Brown Bandicoot (sedges and grasses are a preferred habitat) as the corridor provides a linkage between Brickwood Reserve and other areas of public open space, continuing westward through the suburb.

The Black Cockatoo assessment identified no trees with obvious hollows suitable for Black Cockatoo breeding (only potential breeding), with less than 1 ha of foraging habitat (only isolated trees) identified within the central portion of the site. It is therefore considered that development of the ABN landholdings is highly unlikely to have a significant impact according to the Significant Impact Guidelines 1.1.

A Black Cockatoo Habitat assessment is recommended to be undertaken across the balance of the site to determine the degree of impact under the EPBC Act prior to any clearing.

To minimise impacts to fauna resulting from any clearing activities, the following management strategies are proposed:

- During construction, the extent of authorised clearing will be clearly defined and demarcated to avoid accidental clearing;
- Loud noises (e.g. air horns) will be made just prior to commencement of clearing.
- Clearing works will occur in the direction of a conservation area where possible, to allow animals time to escape.
- If any injured or distressed fauna are encountered during site works the Site Supervisor will be instructed to immediately call the DPaW Wildcare Hotline (08) 9474 9055, to allow for the closest appropriate DPaW registered wildlife rehabilitator to attend the site.
- Long-term fencing for conservation areas will be relatively permeable to most species of fauna (reptiles, small mammals) with a 30 cm gap between ground level and the first rail/wire.
- Where possible, local native species will be planted along road verges and median strips in and near conservation areas and strategic ecological linkages to enhance the value of the linkage to fauna.
- Provide landowners within one kilometre of Brickwood Reserve with a copy of the Brickwood Reserve Management Plan; and
- Develop and provide adjacent landowners a "Living next to Brickwood Reserve" booklet outlining environmental issues of pet animals, garden weeds, reducing spread of plant disease and inappropriateness of certain air conditioning systems in fire hazard zones.

4.7 Flood protection, groundwater and water quality management

Broad-scale planning for the site has proposed a multiple use corridor for the management of surface water. The corridor should be designed as a living stream which will also act as an ecological corridor and provide for passive recreation. Development of the site therefore has the potential to increase the ecological value of the degraded channel through rehabilitation.

Although limited assessment of groundwater levels has been undertaken at this stage, it is inferred from available reports and bore logs that groundwater is likely to be close to or at the surface in winter in many areas of the site. It is recognised that the need to protect the Brickwood Reserve TECs and support conventional building practices may result in the use of fill on the site. This has the potential to impact on the ability to retain mature trees and so alternative practices are recommended to be considered to facilitate development in areas of high groundwater.

Surface water and groundwater management will be described in the Local Water Management Strategy and any future Urban Water Management Plans that will be prepared for each stage of development. Therefore potential impacts on surface water and groundwater can be mitigated and managed in order to achieve the objectives of State Planning Policy 2.9: Water Resources (WAPC, 2006).

A local water management strategy is being prepared in accordance with *Better Urban Water Management* (WAPC, 2008) to addresses the following:

- Identification of the site's current hydrological regime and existing environment;
- Identification of the constraints within the development area which may affect the design of the development with respect to urban stormwater drainage and management of groundwater;
- A description of the stormwater management strategy for minor and major events, including details on the proposed management practices to be employed;

- Identification and description of mechanisms to protect the water regime, including water quality and water levels. This will include a discussion of the overarching engineering principles that will be employed to mitigate any impact from run-off, groundwater and water quality issues, and ensure that the environment and the development will not be adversely impacted upon;
- Identification of the proposed water supply (including irrigation requirements) and wastewater disposal;
- Identification of monitoring requirements and derivation of agreed performance criteria for the urban water management system; and
- Identification of contingency measures to be implemented in the event that the system is not achieving agreed performance targets.

4.8 Heritage

Although no sites of Aboriginal or European heritage have been identified within the study area, all contractors working on the development will need to be made aware of their responsibilities under the *Aboriginal Heritage Act 1972* with regard to finding potential archaeological sites. In the event a site is discovered, all work in the area will cease and the Department of Aboriginal Affairs will be contacted.

4.9 Construction impacts

Construction activities need to be managed to minimise the impact to nearby bushland, surrounding residents and the retained vegetation on-site. Impacts can include:

- Nuisance dust generation during bulk earthworks;
- Disturbance of ASS during earthworks and/or installation of services;
- Silt and sediment run-off to waterways and drains from uncontrolled run-off during site works;
- Inadvertent damage to trees and other vegetation earmarked for retention;
- Impacts to new stormwater drainage systems and existing bushland areas from wind- and water-borne sediment during construction; and
- Inappropriate disposal of waste building material and poor housekeeping on building sites leading to wind-blown litter.

All of these potential impacts are manageable through appropriate engineering design and/or good site management practices.

4.10 Conclusion

It is considered that there are no significant environmental constraints to the development of the site for residential development, providing bushfire risk can be adequately managed and the actions identified in sections **Error! Reference source not found.** and 5 are undertaken.

5 IMPLEMENTATION STRATEGY

Table 7 provides a preliminary schedule of activities which should be undertaken at Preconstruction, Construction and Post-construction phases of the project to mitigate and manage potential impacts to the environment. This advice is based on the current predominantly desk top assessment contained within this report. More detailed management measures may be determined as part of more detailed investigation and planning as the proposed development progresses.

Table 7: Implementation strategy

Issue	Action	Frequency	Responsibility
Preconstruction phase			
Contamination	Complete preliminary site investigation for contamination in accordance with Contaminated Sites Act 2003	Once	Developer
Acid sulfate soils	Complete self-assessment checklist and consider need for a preliminary site assessment	Once	Developer Consistent with DoP and DER guidelines
Vegetation and flora	Clearly delineate , in accordance with Australian Standards 4970 – Protection of Trees on Development Sites, POS areas and trees to be retained. Identify Bush Forever and ensure setbacks are fenced. No clearing of the Bush Forever site is to occur	Once	Arboriculturist and Licensed Surveyor (Developer)
Fauna and habitat	All site staff to participate in Environment, Health and Safety inductions which provide requirements for management of significant fauna and reporting procedures for environmental incidents.	Once	Developer and Construction contractor
Water management	A Local water management strategy will be completed and used as the basis for detailed design. Following approval of the LWMS, UWMP(s) will be prepared prior to subdivision for approval by SJShire.	Once	Developer, in accordance with SPP 2.9: Water Resources
Bushfire	A Bushfire Management Plan will be prepared to support the LSP. The Bushfire Management Plan will be updated and implemented at subdivision.	Once	Developer, in accordance with SPP 3.7: Planning for Bushfire Risk Management (WAPC 2015).
Construction phase			
Soils and topography	Ground disturbing activities should be kept to a minimum and carried out 'as required' (in stages) immediately prior to lots being released for sale as part of a 'staged' development of the site	Ongoing during construction phase.	Construction Contractor (Developer)
Contamination	Management of any identified contamination in accordance with the Contaminated Sites Act 2003	Ongoing during construction phase.	Construction Contractor (Developer)
Acid sulfate soils	Management of any identified ASS consistent with DoP and DER guidelines	Ongoing during construction phase.	Construction Contractor (Developer)

Issue	Action	Frequency	Responsibility
Vegetation and flora	Maintain markings and fencing around vegetation and trees to be retained. Cleared vegetation to be mulched and stored on site	Ongoing during construction phase.	Construction Contractor (Developer)
Fauna and habitat	Undertake clearing in the direction of existing bushland to allow fauna to escape.	Ongoing during construction phase.	Construction Contractor (Developer)
Water management	Manage sediment transport to waterways and drainage systems	Ongoing during construction phase.	Construction Contractor (Developer)
Aboriginal heritage	In the event a site is discovered, all work in the area will cease and the Department of Aboriginal Affairs will be contacted	Ongoing during construction phase.	Construction Contractor (Developer)
Construction impacts	Ensure dust and sediment runoff is adequately managed. Ensure appropriate waste disposal of building materials.	Ongoing during construction phase.	Construction Contractor (Developer)
Post construction phase			
Soils and topography	Landscape or stabilise cleared areas immediately	Once	Construction Contractor (Developer)
Brickwood reserve	Provide adjacent landowners with a copy of the management plan Provide adjacent landowners with a copy of the management plan. Develop and provide adjacent landowners a "Living next to Brickwood Reserve" booklet outlining environmental issues of pet animals, garden weeds, reducing spread of plant disease and inappropriateness of certain air conditioning systems in fire hazard zones.	Once As required	Subdivider / Local Government
Vegetation and flora	Inspect fencing (if applicable) and replace if required. Ensure ongoing maintenance of retained vegetation and any revegetation areas / native landscaping prior to handover.	6 months Ongoing until handover.	Developer until hand over to SJ Shire

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Client: ABN Group

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
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Final report	V2	SSh	HBr	electronic	17 December 2015
Final Report – Amended to reflect WAPC approved SP	V3	SSh	HBr	electronic	8 March 2017

Essential Environmental
land & water solutions
622 Newcastle St Leederville 6007
p: 08 9328 4663 | f: 08 6316 1431
e: info@essentialenvironmental.com.au
www.essentialenvironmental.com.au

APPENDIX 2

Fire Management Plan

Bushfire Management Plan

Orton Rd, Byford

Prepared for ABN Group

By Essential Environmental

June 2016

essential environmental

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This Bushfire Management Plan provides strategic assessment of the subject site only. A subsequent detailed Bushfire Management Plan is required for future subdivision and development. The mitigation strategies contained in this Bushfire Management Plan are considered to be prudent minimum standards only, based on the author's experience as well as standards prescribed by relevant authorities. It is expressly stated that Essential Environmental and the author do not guarantee that if such standards are complied with or if a property owner exercises prudence, that a building or property will not be damaged or that lives will not be lost in a bush fire.

Fire is an extremely unpredictable force of nature. Changing climatic factors (whether predictable or otherwise) either before or at the time of a fire can also significantly affect the nature of a fire and in a bushfire prone area it is not possible to completely guard against bushfire.

Further, the growth, planting or removal of vegetation; poor maintenance of any fire prevention measures; addition of structures not included in this report; or other activity can and will change the bushfire threat to all properties detailed in the report. The achievement of the level of implementation of fire precautions will depend on the actions of the landowner or occupiers of the land, over which Essential Environmental has no control. If the proponent becomes concerned about changing factors then a new Bushfire Management Plan should be requested.

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EXECUTIVE SUMMARY

This bushfire management plan is a strategic plan that has been prepared to support structure planning for lots in the vicinity of Orton Rd, Doley Rd and Warrington Rd in Byford (the 'subject land').

This plan provides preliminary advice consistent with the strategic nature of a local structure plan. Details in this report are consistent with *State Planning Policy 3.7: Planning for Bushfire Prone Areas (*WAPC, 2015) and will establish a framework for more detailed planning to occur at subdivision stage.

The subject land is located within the Shire of Serpentine Jarrahdale (SJ Shire), approximately 30 kilometres south east of the Perth central business district. It comprises approximately 120 hectares, the majority of which has been cleared of native vegetation to allow for rural pursuits and rural residential activities.

A vegetation class and bushfire hazard assessment was conducted for the subject land and adjacent areas for a minimum of 100 metres. A Bushfire attack level (BAL) contour plan has been developed to show the indicative future BALs. Bushfire hazard on the site currently ranges from low to moderate to extreme.

Development of the subject land will result in the removal of the majority of the bushfire fuels, although some important remnant vegetation, identified in the draft *Perth and Peel Green Growth Plan for 3.5 Million Strategic conservation plan* (Government of WA, 2015) is proposed to be retained, posing an extreme bushfire hazard. Individual trees are also proposed to be retained in areas of low threat public open space. Brickwood Reserve which abuts the development to the east is designated as an extreme bushfire hazard.

Consistent with long term strategic planning endorsed by the Western Australian Planning Commission (WAPC), neighbouring sites to the north, south and east have been identified for future urban development, so any bushfire hazards along these boundaries will be removed over time. It is recommended that subdivision of the western-most portions of the subject land does not occur until the neighbouring vegetation has been cleared. Development along the southern boundary of the subject land can proceed subsequent to the upgrade of Orton Road, as this will provide sufficient separation to ensure that adjacent development can occur if constructed to BAL 12.5 standards. This requirement will be removed should the clearing of the land to the south occur prior to development of the subject land.

Management of bushfire risk is proposed in response to an assessment of bushfire protection criteria consistent with *Guidelines for Planning in Bushfire Prone Areas* (WAPC, 2015). The acceptable solutions include establishment of a 21m hazard separation zone around Brickwood Reserve, the establishment and maintenance of a low fuel buffer around POS No7, and increased construction standards to align with the appropriate BAL for the location in accordance with the *Standards Australia 2009, Construction of buildings in bushfire prone areas* (AS3959-2009). No lots are proposed to be created in areas of BAL-FZ or BAL-40.

A traffic and transport assessment of the proposed development confirms that access and egress from all the proposed lots will adequately service residents and fire fighters within the development. The development design has several access options to surrounding public roads.

Water will be adequate for residential needs and for a water supply during bushfire suppression operations.

This plan demonstrates the site is suitable for residential development as bushfire risk can be adequately managed through the future subdivision and development approvals processes, consistent with the *Local Planning Scheme Amendment Regulations 2015 and Building Code of Australia*.

This bushfire management plan is required to be reviewed and updated where necessary at each future subdivision stage.

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1 INTRODUCTION

ABN Group has engaged Essential Environmental to prepare Bushfire Management Plan to support structure planning for proposed lots in the vicinity of Orton Rd, Byford, within the Shire of Serpentine Jarrahdale (SJ Shire).

The subject land is identified as a bush fire prone area, designated by the Fire and Emergency Services (FES) Commissioner. This report has been prepared to meet the requirements of *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) (2015) and the *Guidelines for Planning in Bushfire Prone Areas* (WAPC, 2015).

Consistent with SPP 3.7 and the accompanying *Guidelines for planning for Bushfire Prone Areas*, this bushfire management plan is a strategic level plan which comprises a bushfire hazard assessment and proposes bushfire management measures which address the bushfire protection criteria to mitigate and manage current and future bushfire risk.

The bushfire management plan will be implemented by the developer through the subdivisional process, with ongoing mitigation and management responsibilities passing to the individual lot owners and the Shire once the lots are created. It is anticipated that the Shire will adopt and enforce this bushfire management plan under its Annual Firebreak Notice and Fuel Hazard Reduction Notice. Should subdivision not occur within 3 years of the endorsement of this bushfire management plan, it is recommended that a revised bushfire management plan is prepared.

1.1 Study area

The study area consists of approximately 120 hectares of land in the vicinity of Orton Rd, Doley Rd and Warrington Rd in Byford (Figure 1). The study area currently comprises single dwelling rural residential lots of between 1 and 6 hectares in size.

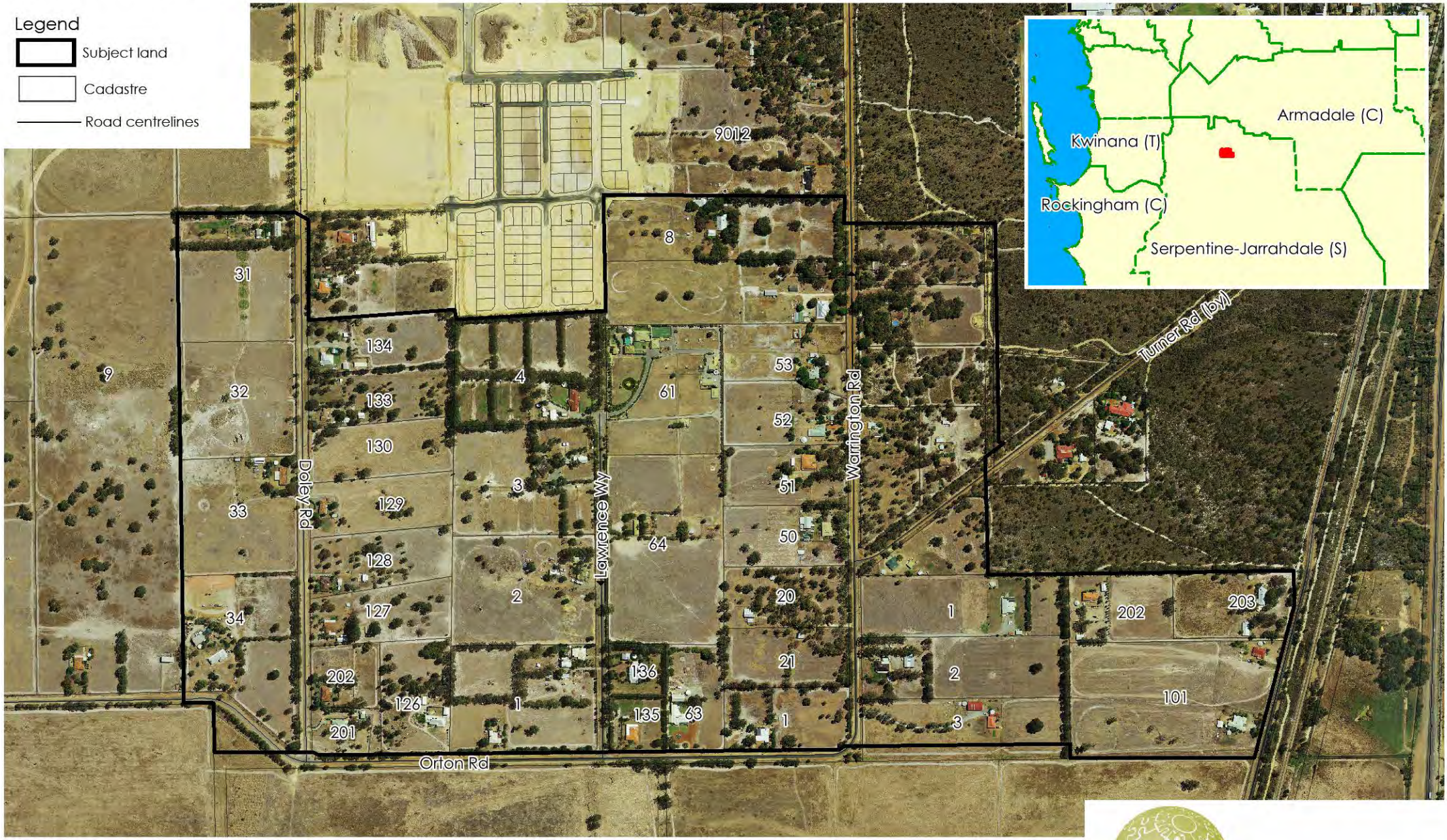
The study area is within the Doley / Warrington Rd Precinct of the Byford District Structure Plan area (2009).

1.2 Planning context

The study area is zoned 'Urban' under the Metropolitan Region Scheme and 'Urban Development' under Shire of Serpentine Jarrahdale Shire Town Planning Scheme No. 2.

The *Byford District Structure Plan*, adopted in August 2005, provides a district level framework to guide more detailed planning for the Byford area between the proposed Tonkin Hwy and the Darling Scarp, from Thomas Rd to Cardup Siding Rd. It requires local structure plans to be prepared to provide the level of detailed planning required to facilitate subdivision and development within the district structure plan area. The Byford District Structure Plan recommends that a road reserve is provided adjacent to Brickwood Reserve, separating it from the residential area. It also recommends that public open space link is provided between Brickwood Reserve and the multiple use corridor on Turner Road. The study area is within the Doley / Warrington Rd Precinct.

ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 1: Subject land location



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Scale 1: 8000 at A4

0 160m

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'The Glades' development flanks the north, west and southern boundaries of the study area. The local structure plan for this development was adopted in April 2011. As of mid-2015, the development is largely completed to the north and half completed to the west. No works have been undertaken south of the study area, where the development flanks the Cardup Brook.

1.2.1 Local structure plan

The local structure plan will guide the subdivision and development of approximately 120 hectares in Byford. The structure plan contains

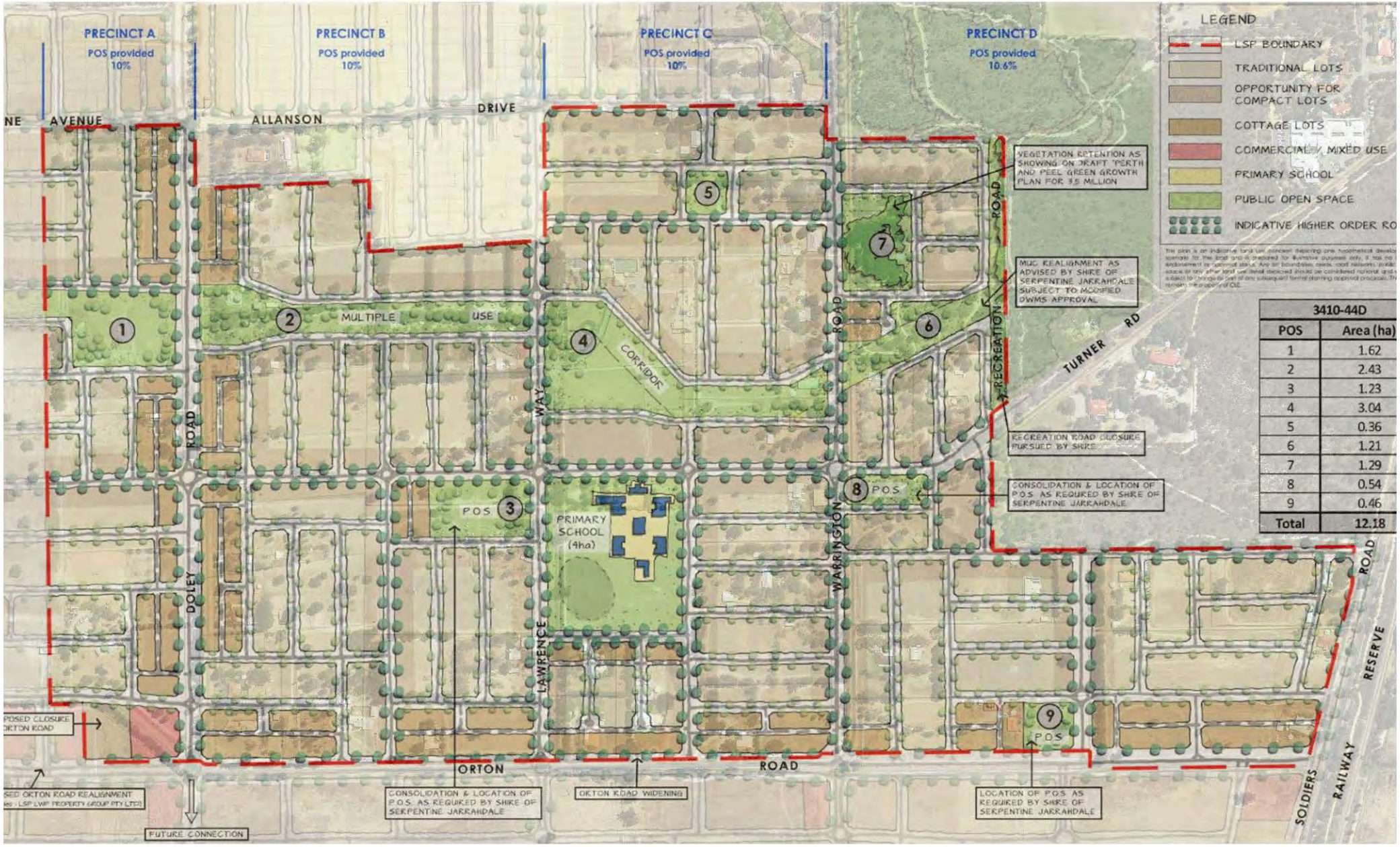
- approximately 12.2 ha of public open space (POS);
- Multiple use corridor (MUC) through the northern portion of the structure plan, tying in with adjacent developments (3.91ha);
- 4ha for a primary school;
- Neighbourhood nodes; and
- a mixture of residential lots.

1.3 Bushfire management guidelines, specifications and minimum standards

Specifications or standards relevant to this bushfire management plan are derived from and consistent with:

- *State Planning Policy 3.7: Planning in Bushfire Prone Areas*(WAPC, 2015);
- *Guidelines for Planning for Bushfire Prone Areas* and appendices (WAPC, 2015)
- Australian Standards (AS3959-2009): Construction of buildings in bushfire prone areas;
- SJ Shire Firebreak Notice and Fuel Hazard Reduction Notice 2015-2016;
- SJ Shire Local Planning Policy No.43: Hazards and Natural Disasters; and
- Visual Fuel Load Guide for the Scrub Vegetation of the Swan Coastal Plain and Darling Scarp including Geraldton Sandplains & Leeuwin Ridge Regions of Western Australia – Edition 2. (DFES, 2012).

ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 2: Proposed local structure plan



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Scale 1: 7,000 @ A4

0 140m

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2 OBJECTIVES

The objectives of this bushfire management plan are to:

- reduce the threat to life, properties and for emergency response personnel in the event of a bushfire within or near the subject site either during staged development construction or once construction is complete;
- reduce vulnerability to bushfire through the identification and assessment of bushfire hazards and risk;
- achieve a responsible and balanced approach between bushfire risk management and management measures, and landscape amenity and biodiversity conservation objectives; and
- achieve consistency with objectives and policy measures of SPP 3.7 and the *Guidelines for Planning in Bushfire Prone Areas*.

The following tasks have been undertaken to achieve the objectives of this bushfire management plan:

- Identification of assets and values of the subject land (section 3);
- Assessment of bushfire hazard of the subject land and preparation of BAL contour map (Section 4);
- Identification of bushfire management measures for the subject land, with due regard for life, property and the environment (section 5); and
- Nomination of individuals and organisations responsible for bushfire management and associated works within the subject land (section 6).

3 DESCRIPTION OF THE SUBJECT AREA

3.1 General

The study area is situated in the south-east corridor of the Perth metropolitan area, in the Shire of Serpentine Jarrahdale. The study area currently comprises single dwelling lots ranging between 1 and 6 hectares, in the vicinity of Orton Rd, Doley Rd, Laurance Way and Warrington Rd. It is bounded on three sides by the Glades residential development. Brickwood Reserve and Soldiers Rd is located to the east (Figure 1).

3.2 Climate

Byford, where the subject land is located, lies approximately 40 km to the south east of Perth on the Swan Coastal Plain close to the foot of the Darling Scarp. The climate is typically Mediterranean having hot summers and mild winters with low annual rainfall.

Average annual rainfall recorded at the nearest Bureau of Meteorology weather station at Cardup (no. 9137) (approx. 4 km to the south) since 1971 is 857 mm but has declined in recent years to an average of 799 mm since 1995. The minimum recorded annual rainfall was in 2010 at just 488 mm and the maximum recorded was in 1973 at 1,168 mm.

The majority of rainfall is experienced in the winter between May and September with the driest months being December to February.

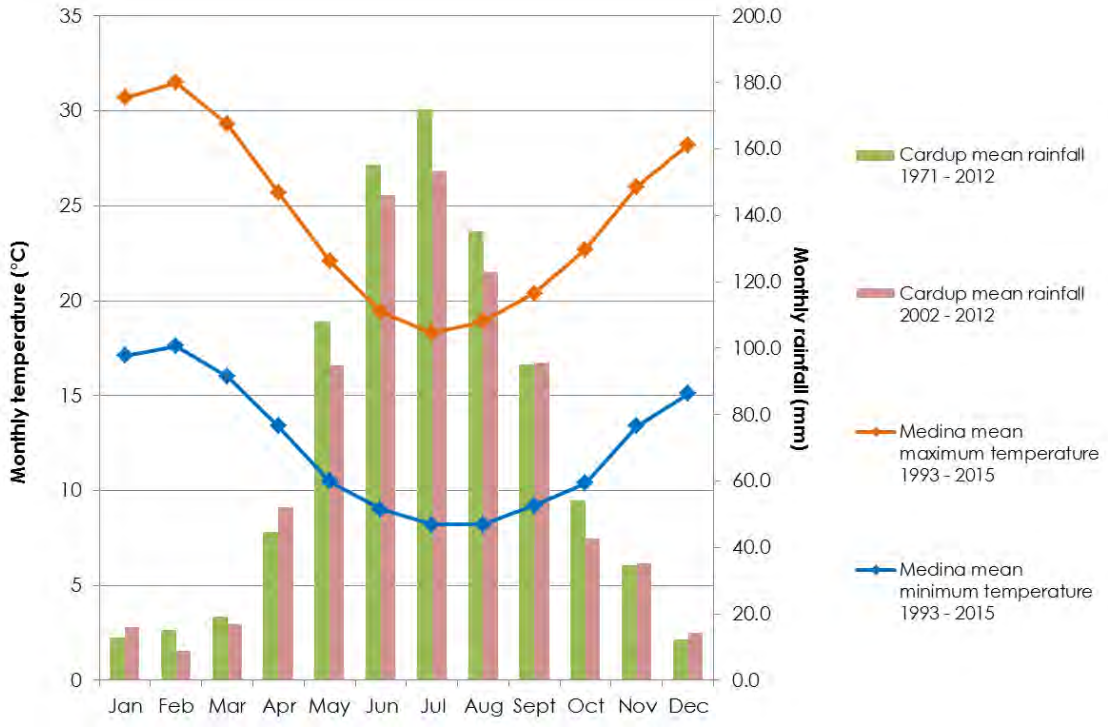


Chart 1: Climate summary data (Rainfall: Cardup, Temperature: Medina, BoM, 2015)

The nearest weather station with a temperature record is Medina Research Centre (no. 9294) (approx. 18 km to the west). Average maximum temperatures range between 18.3°C in July and 31.5°C in February, while average minimum temperatures range between 8.2°C in July and 17.6°C in February.

Wind speed and direction is also recorded at the Medina Research Centre (no. 9294). The remoteness of this centre from the subject land together with its more coastal location provides limited confidence that it is an appropriate climate station for wind speed and direction purposes. For this reason a second comparison site has been selected (Gosnells City, station no. 9106) that is located a similar distance from the subject land but has a similarly inland location.

During the hottest, driest months of the year, December to February), at both Medina and Gosnells, the highest average wind speeds are also recorded as seen in charts 2 and 3.

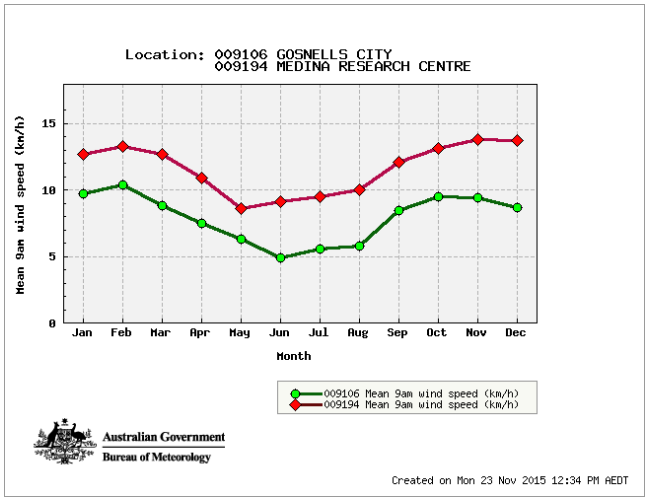


Chart 2: Climate summary data (9am wind speed: Gosnells & Medina, BoM, 2015)

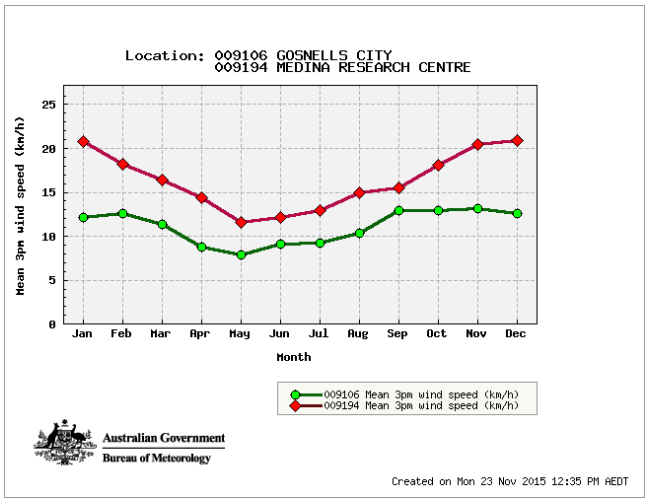


Chart 3: Climate summary data (3pm wind speed: Gosnells & Medina, BoM, 2015)

Typically the strongest winds are experienced in the afternoon with average speeds of over 20 km/hour at Medina and over 12 km/hour at Gosnells.

Wind direction varies significantly through the day at both weather stations but generally remains quite consistent through the year. Wind direction in the morning is consistently easterly with both Medina and Gosnells showing similar patterns. Afternoon winds are also highly consistent at Medina where strong coastal south westerly winds dominate. The pattern is far less consistent at Gosnells where the influence of the Scarp is clearly evident and wind direction varies greatly; from westerly, through southerly and to easterly. Northerly winds are rare.

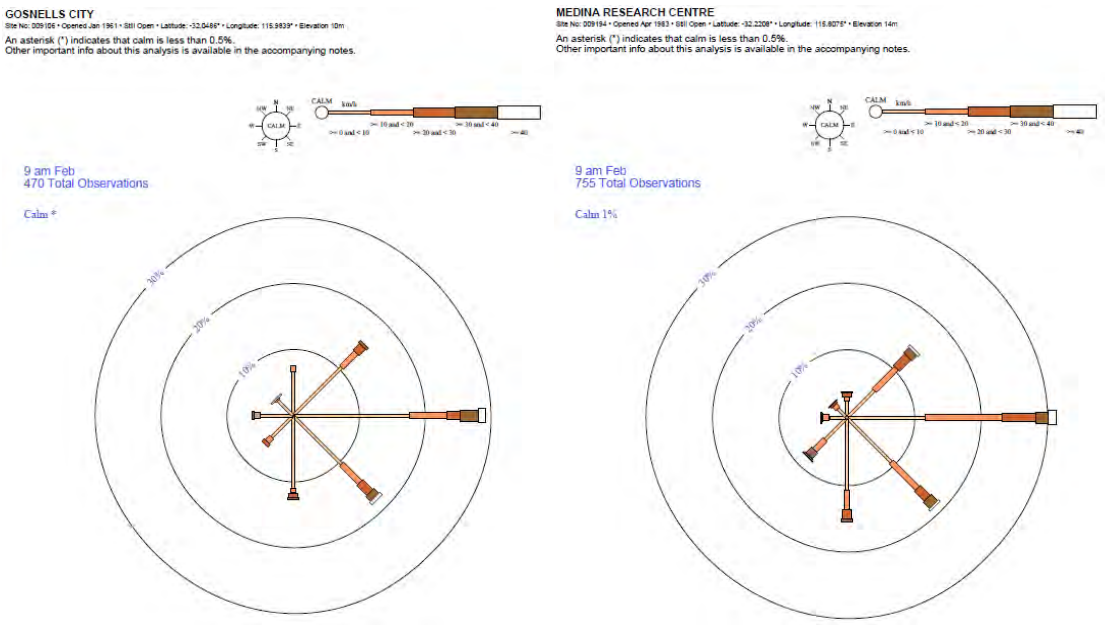


Chart 4: Climate summary data (February 9am wind direction: Gosnells & Medina, BoM, 2015)

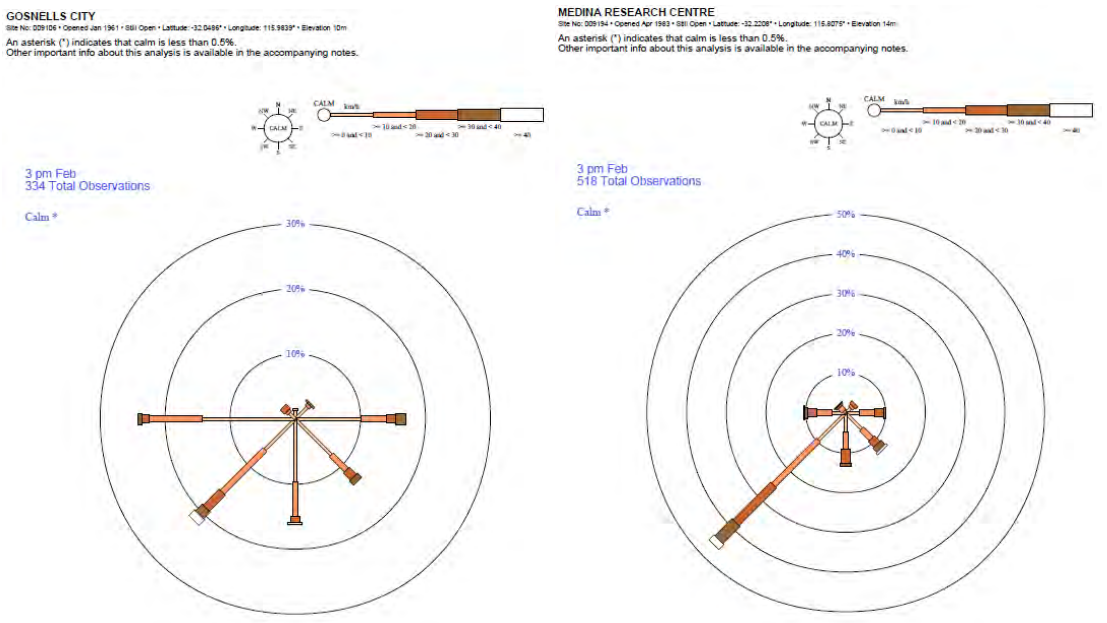


Chart 5: Climate summary data (February 3pm wind direction: Gosnells & Medina, BoM, 2015)

3.2.1 Fire weather

In the Southwest Western Australia, the weather conditions that represent the greatest risk of bushfires occur between December and March, as a result of long, hot and dry summers. The potential for bushfire occurrence is at its peak during this dry period, particularly when a low pressure trough forms off the west coast coupled with low relative humidity and strong winds from the north, east or northeast.

The subject site is located approximately 22 km from the coast and therefore sea breezes will have some influence, however, breeze generated from the surrounding land areas is likely to have a larger impact.

Having consideration of the predominant summer climatic conditions of the local area, high fire risk fire weather conditions are considered to have the potential to occur only for a small proportion of the time during the designated bushfire season.

3.3 Topography

The study area grades gently from 43m AHD in the east to 37.5mAHD in the west at a slope of around 1%. The study area has a few high points of approximately 1m higher that the surrounding topography, coinciding with the pad of existing dwellings.

3.4 Soils

The surface geology is described broadly as Guildford formation: Alluvial sand and clay with shallow-marine and estuarine lenses and local basal conglomerate (WA surface geology 1:250,000 scale geological maps, Geological Survey of WA, and Geoscience Australia)

This is further classified as Sandy Clay, as shown in Figure 3. Described as white grey to brown, fine to coarse grained, sub-angular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp.

The subject land has been classified as multiple use wetland by the Department of Parks and Wildlife in its Swan Coastal Plain geomorphic wetlands database identified as the Armadale Palusplain: seasonally waterlogged flat land. This is reflective of the shallow depth to groundwater in the area, as groundwater is generally at the surface in winter, receding slightly in the summer months.

3.5 Bushfire fuels

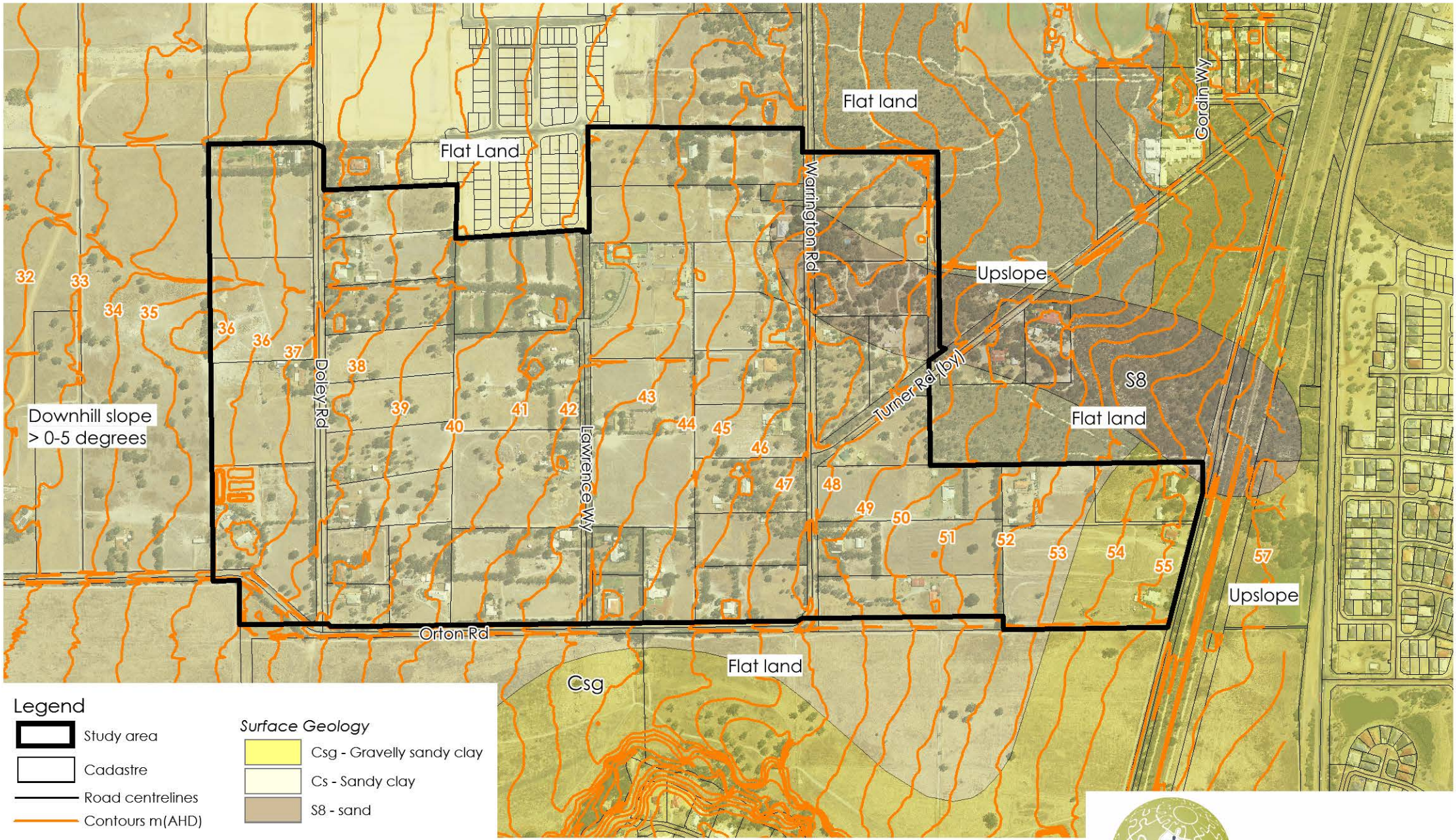
The vegetation complex that exists within and adjacent to the study area is the Forrestfield Complex (Ridge Hill Shelf, Darling Plateau). The vegetation of the Forrestfield Complex ranges from open forest of *Eucalyptus calophylla - E. wandoo - E. marginata* to open forest of *E. marginata - E. calophylla - C. fraseriana* - Banksia species. Fringing woodland of *E. rudis* may be present in the gullies that dissect this landform (WAPC, 2000).

Current land use across the subject land has resulted in a highly modified environment compared to the pre-clearing vegetation extent. Rural-residential pursuits have resulted in large portions of the subject land being completely cleared of native vegetation, with only small pockets of degraded or modified vegetation remaining in most areas. The remnant eucalyptus woodland is largely devoid of understory and consists of scattered mature trees, interspersed with non-native trees, grasses and garden shrubs planted around houses and along pathways. There are also a large number of windbreaks in some portions of the site which provide shade and protection for livestock and horses.

Some portions of the study area are not as well maintained as other areas; however, it is assumed that these properties will undertake appropriate management actions to comply with SJ Shire Firebreak Notice and Fuel Hazard Reduction Notice 2015-2016.

The proposed development will result in a predominantly cleared and built environment. This will remove the majority of on-site vegetation and bushfire hazard.

ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 3: Site topography and soils



Legend

- Study area
- Cadastre
- Road centrelines
- Contours m(AHD)

Surface Geology

- Csg - Gravelly sandy clay
- Cs - Sandy clay
- S8 - sand

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Scale 1: 9,000 @ A4

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Consistent with the conservation commitments in the draft *Strategic Conservation Plan for the Perth and Peel Regions*, a portion of remnant vegetation is proposed to be retained in POS area No 7 (Figure 2). This vegetation has significant environmental value and is recognised as an extreme bushfire hazard.

There will also be minor retention of mature trees in public open space and road reserves and any vegetated areas will be actively managed by the Shire of Serpentine Jarahdale in a low threat state.

The primary fuel load (subsequent to the development of the subject land) is that of Brickwood Reserve, to the east of the subject land. Brickwood Reserve contains one of the largest and most intact areas of remnant vegetation found on the alluvial soils of the eastern side of the Swan Coastal Plain. The most extensive community type vegetation is broadly described as Marri Woodland with Scattered Kingia, transitioning into Marri and Jarrah Woodland.

The following Threatened Ecological Communities have also been identified:

- *Eucalyptus calophylla-Xanthorrhoea preissii* woodlands and shrublands;
- *Eucalyptus calophylla – Kingia australias* woodlands;
- *Banksia attenuate* and/or *Eucalyptus marginata* woodlands;
- *Eucalyptus calophylla - Eucalyptus marginata; and*
- Dense shrubs on clay flat.

Brickwood Reserve is managed by SJ Shire consistent with the *Brickwood Reserve and Briggs Park Management Plan* (2009) and its attached Brickwood Reserve Fire Management Plan; however it is noted that this management plan is currently out for public comment and is likely to be revised in accordance with changes in bushfire policy (G French, SJ Shire, pers. comm, December, 2015).

The subject land is currently flanked to the south and west by pasture (grassland). This vegetation will be progressively cleared as the development of The Glades proceeds.

3.6 Land uses

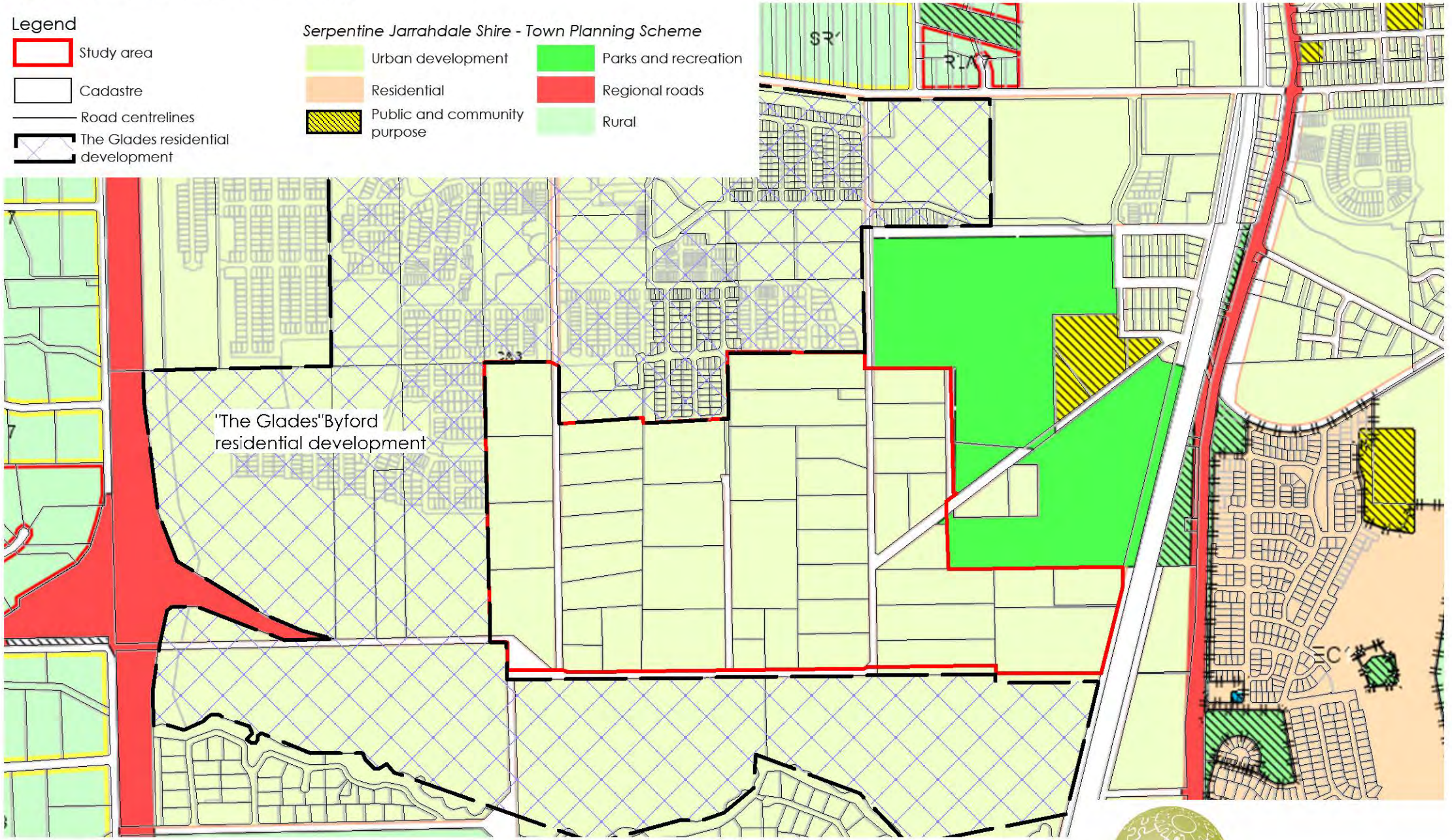
The predominant land use is Rural (Figure 4). Historical aerial photography from Landgate shows the land was parcelled and single dwellings built during the late 70's to early 80's. Prior to this, aerial photography indicated the land may have been used for crop farming. No further changes to land use from the 1980's onwards are indicated in the aerial photography.

Current land use is largely rural residential, with some properties containing livestock, large sheds and farming equipment. Most properties have been largely cleared, with many containing non-endemic lines of significant trees flanking boundaries and driveways.

3.6.1 Proposed land use

The future land use is for residential development. The subject land will contain small areas of public open space including a multiple use corridor, a primary school and potentially some neighbourhood nodes which may accommodate higher density residential and some mixed use (Figure 2).

ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 4: Land use and zoning



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Scale 1: 8000 at A4

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3.6.2 Surrounding land uses

Brickwood Reserve abuts the study area along its eastern boundary. This reserve is recognised as having significant environmental values, as it is designated as a Bush Forever site, a Conservation Category Wetland and contains a number of Threatened Ecological Communities protected under environmental legislation.

'The Glades' housing development flanks the north, west and southern boundaries of the study area. As of March 2015 the development is partially complete along the norther and western boundaries only.

3.7 Assets

The current assets within the subject land include dwellings, sheds, machinery and a small amount of livestock. It is recognised that the current life and property assets will be removed on development of the project area.

The project area contains limited on-site environmental assets due to historic clearing and the level of vegetation disturbance associated with current on-site land uses, although the remnant vegetation in POS No 7 has been recognised as having significant value in the *Draft Strategic Conservation Plan for the Perth and Peel Regions*.

3.7.1 Proposed assets

When the subject land is fully developed it will consist of around 1850 new residential dwellings a number of commercial or mixed use buildings within the neighbourhood node and a primary school. These buildings will be required to comply with the current endorsed version of AS3959-2009 based on an assessment of the vegetation conditions and implementation of this bushfire management plan at the particular location.

In addition, the subject land will contain a number of areas of public open space including a multiple use corridor which will be designed to address urban water management requirements as well as deliver recreation and biodiversity outcomes. These public open space areas will be managed to ensure the retained environmental assets do not adversely contribute to the bushfire risk.

The future subdivision will also result in the introduction of other assets to service the subdivision, including lot access roads, water supply, power and telecommunications infrastructure.

3.8 Access

Accessibility to the subject land is currently good with Orton Road providing access from the west and Turner Rd to the east. North-south connectivity is provided by Doley Rd, Lawrence Way, Warrington Road and Soldiers Road.

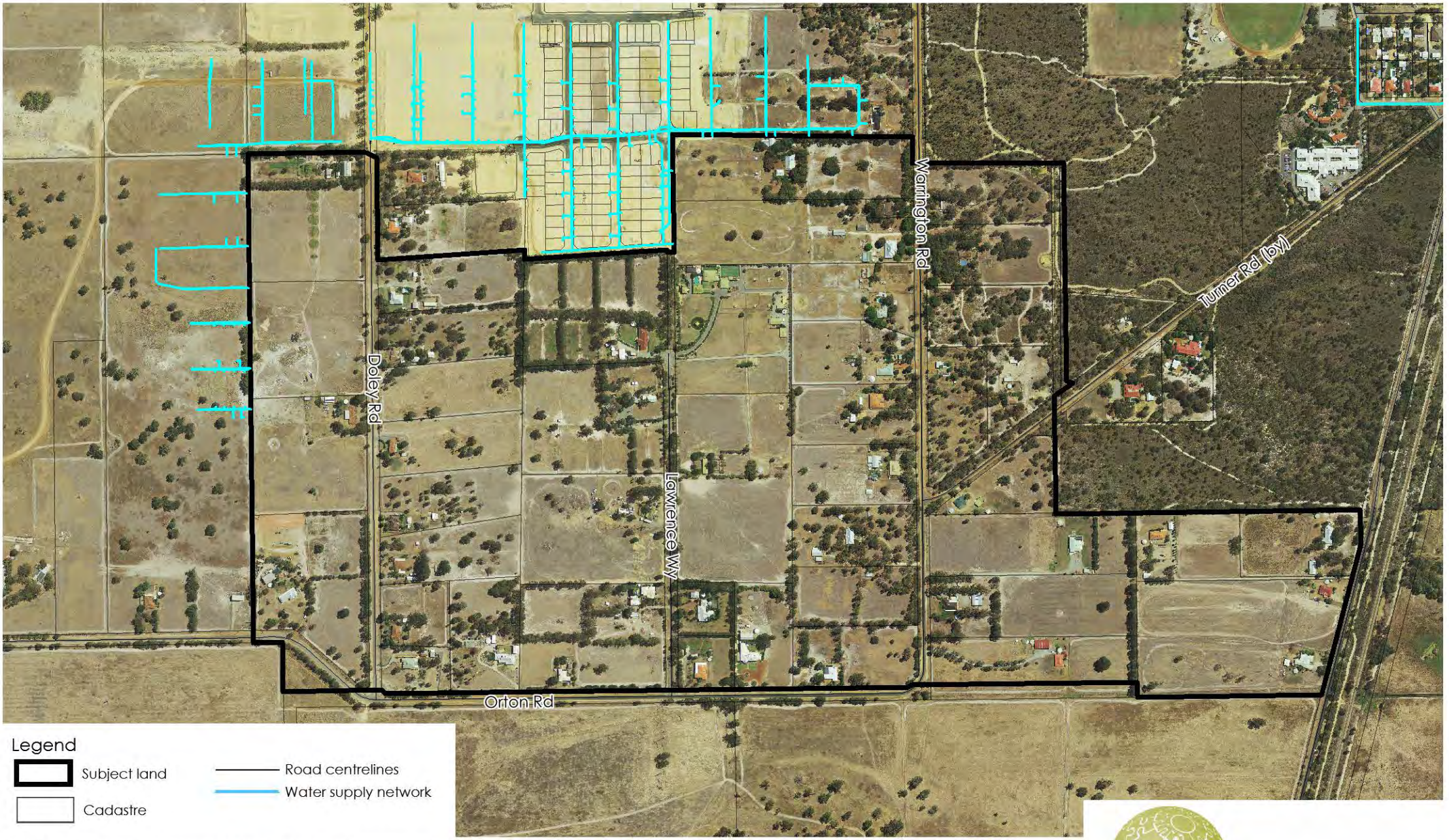
A comprehensive internal public road network will be provided throughout the project area to service the proposed development, as outlined in Figure 2. The proposed road network also provides buffers to adjacent bushland areas and is sufficient for the provision of access for emergency fire service vehicles.

3.9 Water supply

Reticulated water is to be provided to the entire subdivision and for emergency purposes.

Existing water infrastructure is available to the north and west (Figure 5). Shared fire hydrants are to be spaced to Water Corporation and Department of Fire and Emergency Services (DFES) standards and provide emergency response personnel access to adequate water supply. Standard water supply provision requires that fire hydrants be installed at 200m intervals along the public road system and in a fashion readily accessible to emergency vehicles. Hydrants will need to be clearly identifiable, with markings installed by the developer prior to sign off.

ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 5: Water supply network



Legend

- Subject land
- Cadastre
- Road centrelines
- Water supply network

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Scale 1: 8000 at A4

0 160m

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4 BUSHFIRE ASSESSMENT

In order to identify the potential bushfire risks and mitigation strategies, it is necessary to describe the bushfire problem associated with the subject land. The assessment takes into consideration the:

- type and classification of vegetation present on and adjacent to the subject land;
- distances between the classifiable vegetation;
- the topography and slope of the subject land; and
- current and proposed future land use.

4.1 Bushfire history

Byford Volunteer Bush Fire Brigade attended 66 fire incidents within a three kilometre radius during the 2013/2014 fire season.

At the date of this report there is no documented history of bushfire within or immediately adjacent to the site that was of a nature that threatened life or property.

4.2 Vegetation types

Vegetation at the site was classified according to the descriptions provided in AS 3959 – 2009, and includes the following four vegetation types:

- Class A Forest Low open forest (A4): Trees 10-30m high. 30-70% foliage cover (may include understory of sclerophyllous low trees and tall scrubs or grass). Typically dominated by eucalypts.
- Class B Woodland – Woodland (B5): Trees 10-30m high. 10-30% foliage cover donimated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina.
- Class B Woodland- Low woodland (B7): Low trees and shrubs 2 – 10m high. Foliage cover less than 10%. Dominated by Eucalypts and Acacias. Often have a grassy understory or low shrubs.
- Class B Woodland - Open shrubland (B9): Low trees and shrubs 2 – 10m high. Foliage cover less than 10%. Dominated by Eucalypts and Acacias. Often has a grassy understory or low shrubs.
- Class G Grassland – closed tussock grassland (G22): all forms of grassland including situations with shrubs and trees if the foliage cover is less than 10%

Table 1 provides a description of each vegetation type within the subject land and 100m surrounding. The location of photo points is shown in Plate 1.

The classified vegetation is mapped in Figure 6.

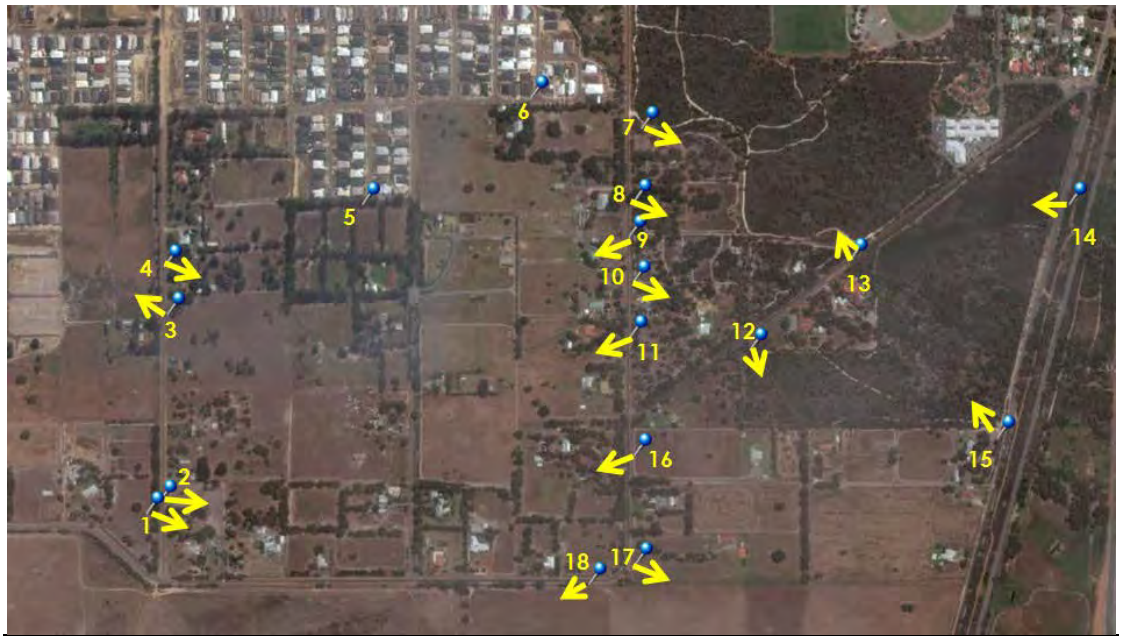


Plate 1: Key to photo points

Table 1: Vegetation classification

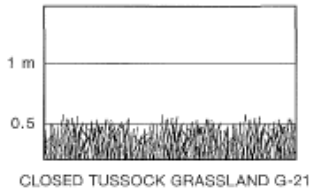
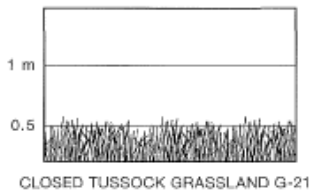
Photo point		Vegetation class	Vegetation type	Description
1		Class G Grassland	Closed tussock grassland 	All forms, including situations with shrubs and trees, if the overstorey coverage is less than 10%.
2		Class G Grassland	Closed tussock grassland 	All forms, including situations with shrubs and trees, if the overstorey coverage is less than 10%.

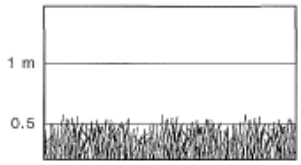
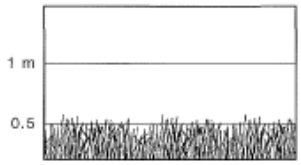
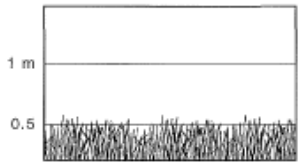
Photo point		Vegetation class	Vegetation type	Description
3		Class G Grassland	Closed tussock grassland  CLOSED TUSSOCK GRASSLAND G-21	All forms, including situations with shrubs and trees, if the overstorey coverage is less than 10%.
4		Class G Grassland	Closed tussock grassland  CLOSED TUSSOCK GRASSLAND G-21	All forms, including situations with shrubs and trees, if the overstorey coverage is less than 10%.
5		Class G Grassland	Closed tussock grassland  CLOSED TUSSOCK GRASSLAND G-21	All forms, including situations with shrubs and trees, if the overstorey coverage is less than 10%.

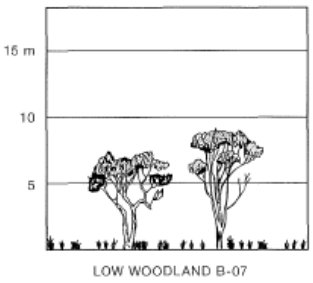
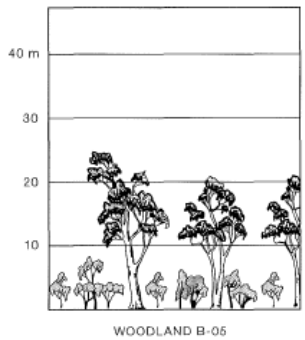
Photo point		Vegetation class	Vegetation type	Description
6		Low threat	Exclusion 2.2.3.2 (f)	Windbreak
7		Class B Woodland  LOW WOODLAND B-07	Low woodland	Low trees and shrubs 2 – 10m high. Foliage cover less than 10%. Dominated by Eucalypts and Acacias. Often have a grassy understory or low shrubs.
8		Class B Woodland  WOODLAND B-05	Woodland	Trees 10-30m high. 10-30% foliage cover donimated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina.

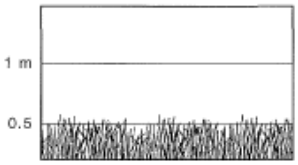
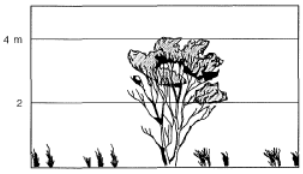
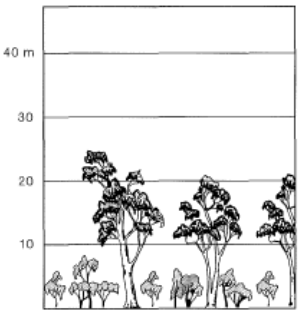
Photo point		Vegetation class	Vegetation type	Description
9		Class G Grassland	Closed tussock grassland  CLOSED TUSSOCK GRASSLAND G-21	All forms, including situations with shrubs and trees, if the overstorey coverage is less than 10%.
10		Class B Woodland	Open shrubland  OPEN SHRUBLAND B-09	Low trees and shrubs 2 – 10m high. Foliage cover less than 10%. Dominated by Eucalypts and Acacias. Often have a grassy understory or low shrubs.
11		Class B Woodland	Woodland  WOODLAND B-05	Trees 10-30m high. 10-30% foliage cover donimated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina.

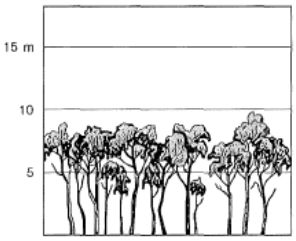
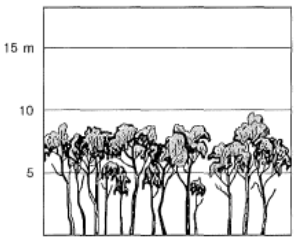
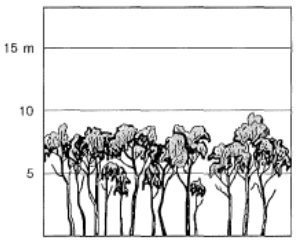
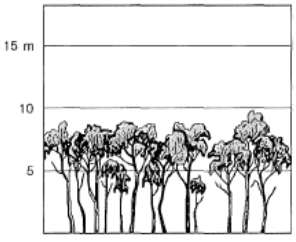
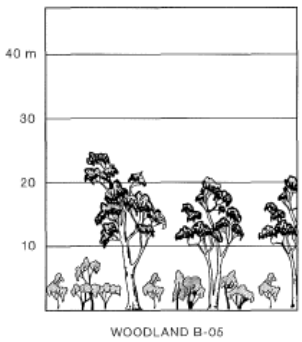
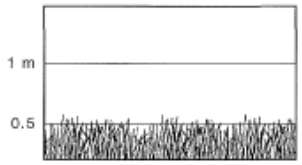
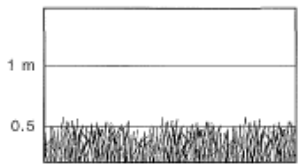
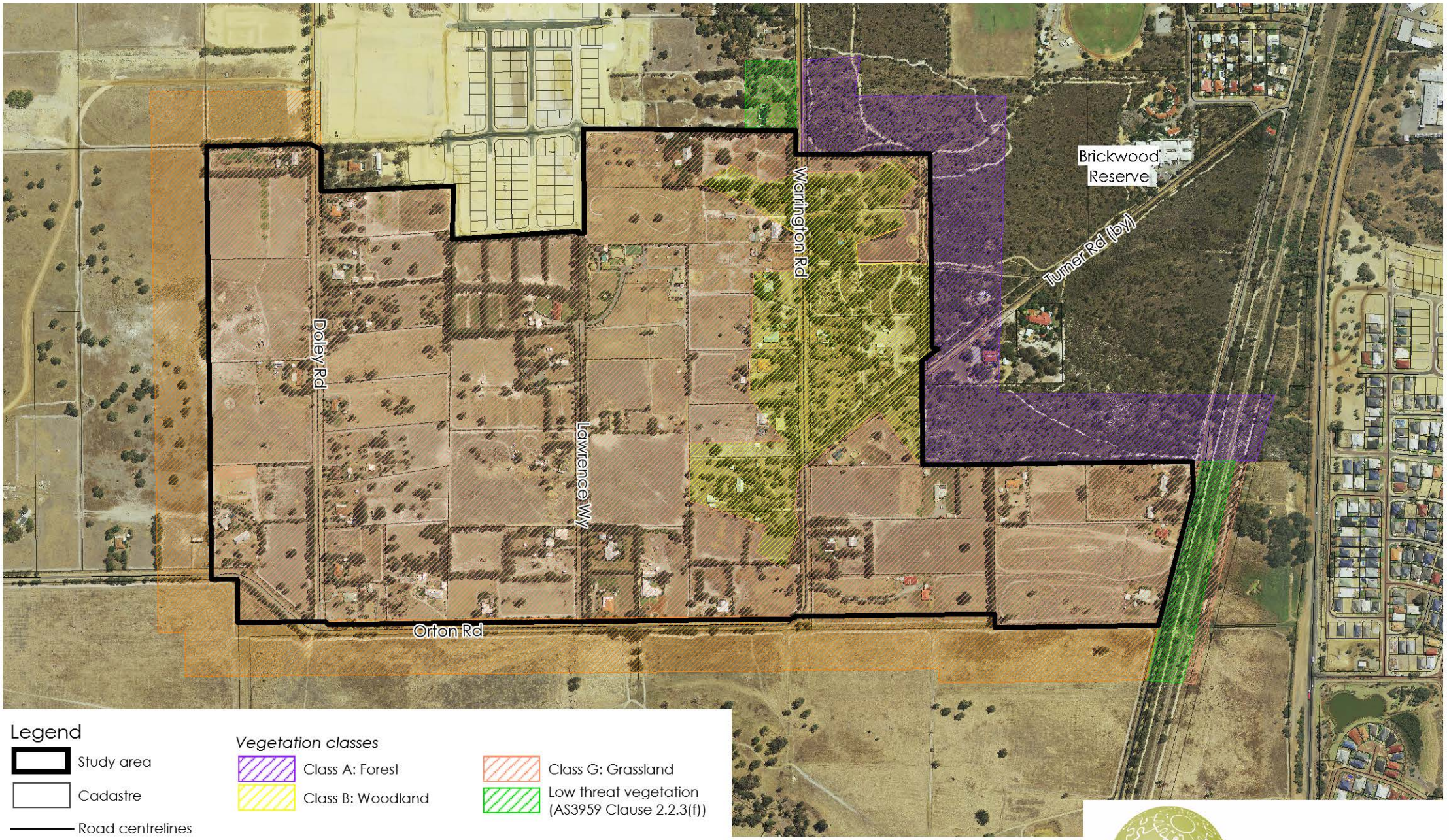
Photo point		Vegetation class	Vegetation type	Description
12		Class A Forest	Low open forest  LOW OPEN FOREST A-04	Trees 10-30m high. 30-70% foliage cover (may include understory of sclerophyllous low trees and tall scrubs or grass). Typically dominated by eucalypts.
13		Class A Forest	Low open forest  LOW OPEN FOREST A-04	Trees 10-30m high. 30-70% foliage cover (may include understory of sclerophyllous low trees and tall scrubs or grass). Typically dominated by eucalypts.
14		Class A Forest	Low open forest  LOW OPEN FOREST A-04	Trees 10-30m high. 30-70% foliage cover (may include understory of sclerophyllous low trees and tall scrubs or grass). Typically dominated by eucalypts.
15		Class A Forest	Low open forest  LOW OPEN FOREST A-04	Trees 10-30m high. 30-70% foliage cover (may include understory of sclerophyllous low trees and tall scrubs or grass). Typically dominated by eucalypts.

Photo point		Vegetation class	Vegetation type	Description
16		Class B Woodland  WOODLAND B-05	Woodland	Trees 10-30m high. 10-30% foliage cover donimated by Eucalypts; understory or low trees to tall shrubs typically dominated by Acacia, Callitris or Casuarina.
17		Class G Grassland  CLOSED TUSSOCK GRASSLAND G-21	Closed tussock grassland	All forms, including situations with shrubs and trees, if the overstorey coverage is less than 10%.
18		Class G Grassland  CLOSED TUSSOCK GRASSLAND G-21	Closed tussock grassland	All forms, including situations with shrubs and trees, if the overstorey coverage is less than 10%.

4.3 Topography

Slope is not considered to be a significant factor of bushfire risk as the most significant portion of on-site vegetation is situated effectively downslope from the rest of the development. In addition, Brickwood Reserve, which is the most significant area of vegetation adjacent to the subject land, is located effectively downslope or on flat land in relation to the subject land (Figure 3).

ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 6: Vegetation classes



Legend

- Study area
- Cadastre
- Road centrelines

Vegetation classes

- Class A: Forest
- Class B: Woodland
- Class G: Grassland
- Low threat vegetation (AS3959 Clause 2.2.3(f))

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Scale 1: 9,000 @ A4

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4.4 Bushfire hazard

The *Guidelines for Planning in Bushfire Prone Areas* (WAPC, 2015) propose a methodology which rates bushfire hazards using vegetation type, classifying the results into three potential categories: low, moderate or extreme (Table 2). It is based on the assumption that land in Western Australia is predominantly undulating with relatively short, steep inclines.

Table 2: Hazard levels and characteristics (WAPC, 2015)

HAZARD LEVEL	CHARACTERISTICS
Low	• devoid of standing vegetation (less than 0.25ha cumulative area); • areas which, due to climatic conditions or vegetation (e.g. rainforest), do not experience bushfires; • inner urban or suburban areas with maintained gardens and very limited standing vegetation (less than 0.25ha cumulative area); • low threat vegetation, including grassland managed in a minimal fuel condition (i.e. to a nominal height of 100mm), maintained lawns, vineyard and orchards; and • pasture or cropping areas with very limited standing vegetation that is shrubland, woodland or forest with an effective up slope*, on flat land or an effective down slope* of less than 10 degrees, for a distance greater than 100 metres.
Moderate	• areas containing pasture or cropping with an effective down slope* in excess of 10 degrees for a distance greater than 100 metres; • unmanaged grasslands; • open woodlands; • open shrublands; • low shrubs on areas with an effective up slope*, on flat land or an effective down slope* of less than 10 degrees, for a distance greater than 100 metres or flat land; • suburban areas with some tree cover; and • forest and woodlands with a permanent grass understorey or at most, a scrub understory structure consisting of multiple areas of <0.25ha and not within 20 metres of each other or single areas of <1ha and not within 100 metres of other scrub areas.
Extreme	• forests with a scrub understorey which is multi-tiered; • woodlands with a scrub understorey which is multi-tiered; • tall shrubs; and • any area of vegetation not otherwise categorised as low or moderate.

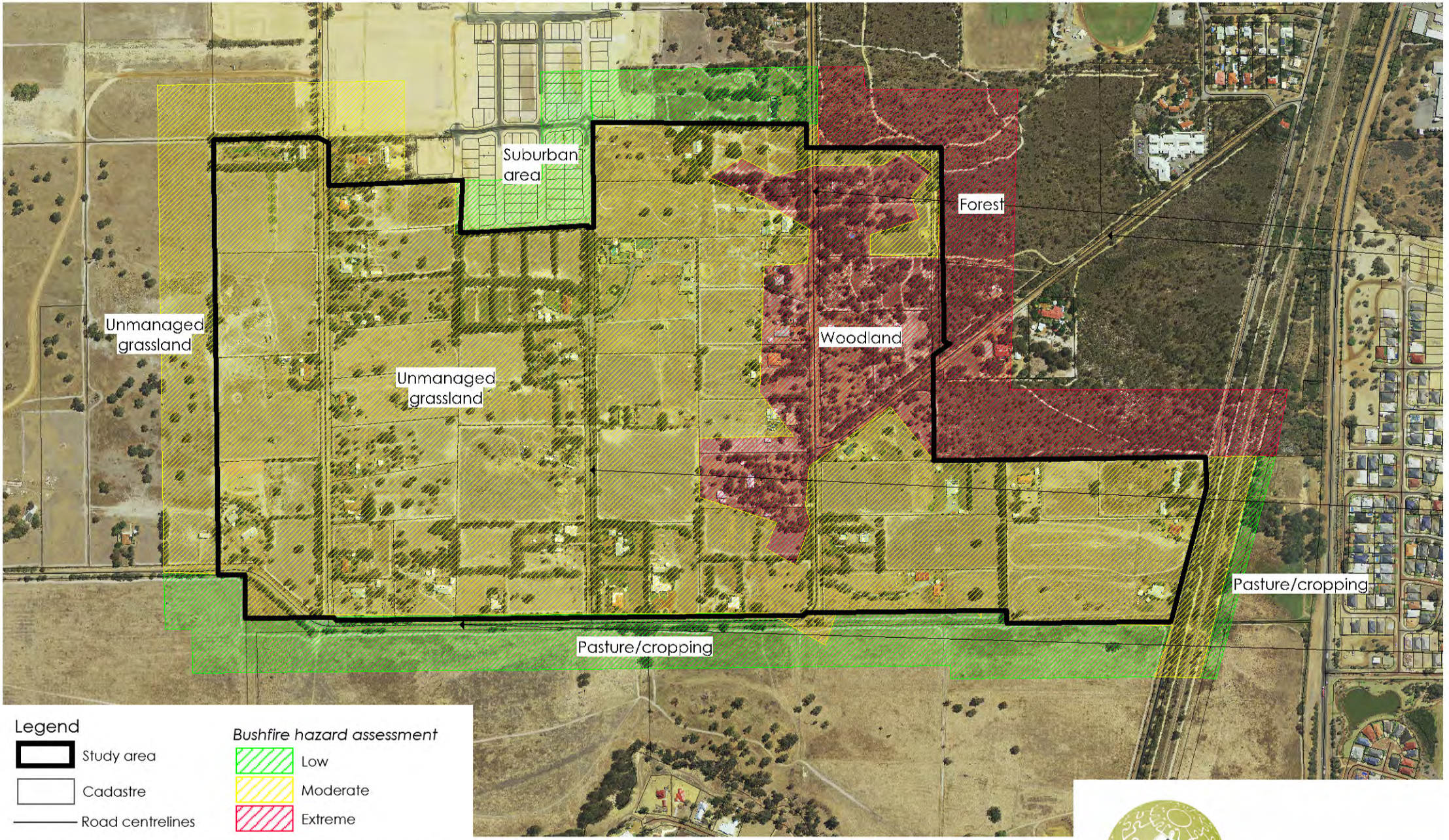
*NOTE Effective slope refers to the slope under the classified vegetation in relation to the subject site. Distances less than 100 metres will be deemed to be undulating land, rather than a nominated slope.

In compliance with the *Guidelines for Planning for Bushfire Prone Areas* (WAPC, 2015), the vegetation in and around the subject land is rated as having either an extreme or moderate level of hazard.

Figure 7 shows the pre-development hazard rating based on the current site characteristics. As development at the site proceeds, the hazard rating within the site will decrease (Figure 8); however, it should also be noted that land to the west and south will ultimately be developed consistent with long term strategic planning outlined in the WAPC-endorsed Byford Structure Plan (2005, amended 2009).

As a concept for the future layout of the development has been prepared, a Bushfire Attack Level (BAL) contour map has also been created which shows indicative BAL ratings for the subject land (Figure 9). The BAL contour map was prepared on the basis of FDI 80; the vegetation classification shown in Table 1and Figure 6; and slope shown on Figure 3.

ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 7: Bushfire hazard assessment (current)



Legend

- Study area
- Cadastre
- Road centrelines

Bushfire hazard assessment

- Low
- Moderate
- Extreme

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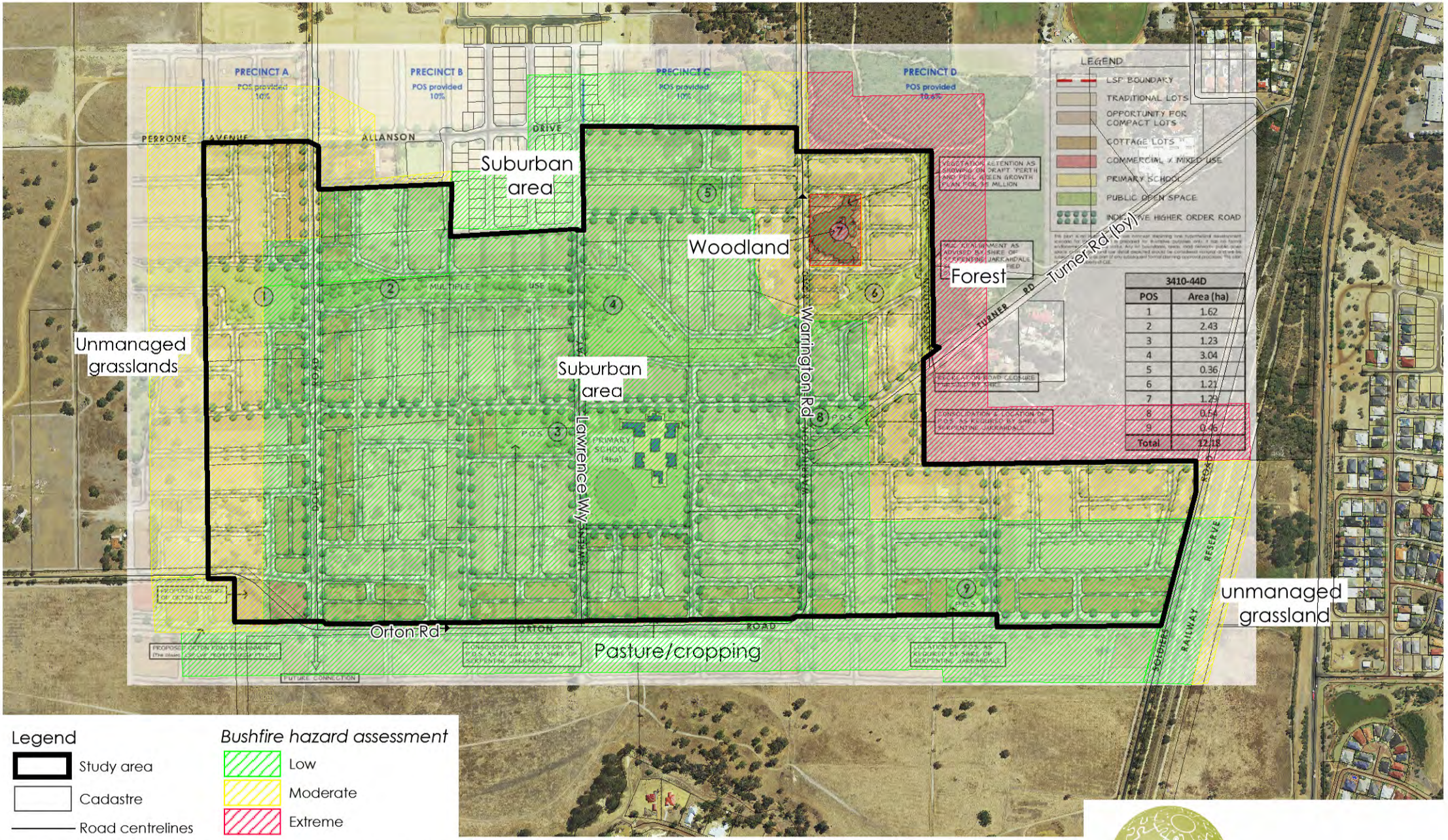
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ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 8: Bushfire hazard assessment (post development)



Legend

- Study area
- Cadastre
- Road centrelines

Bushfire hazard assessment

- Low
- Moderate
- Extreme

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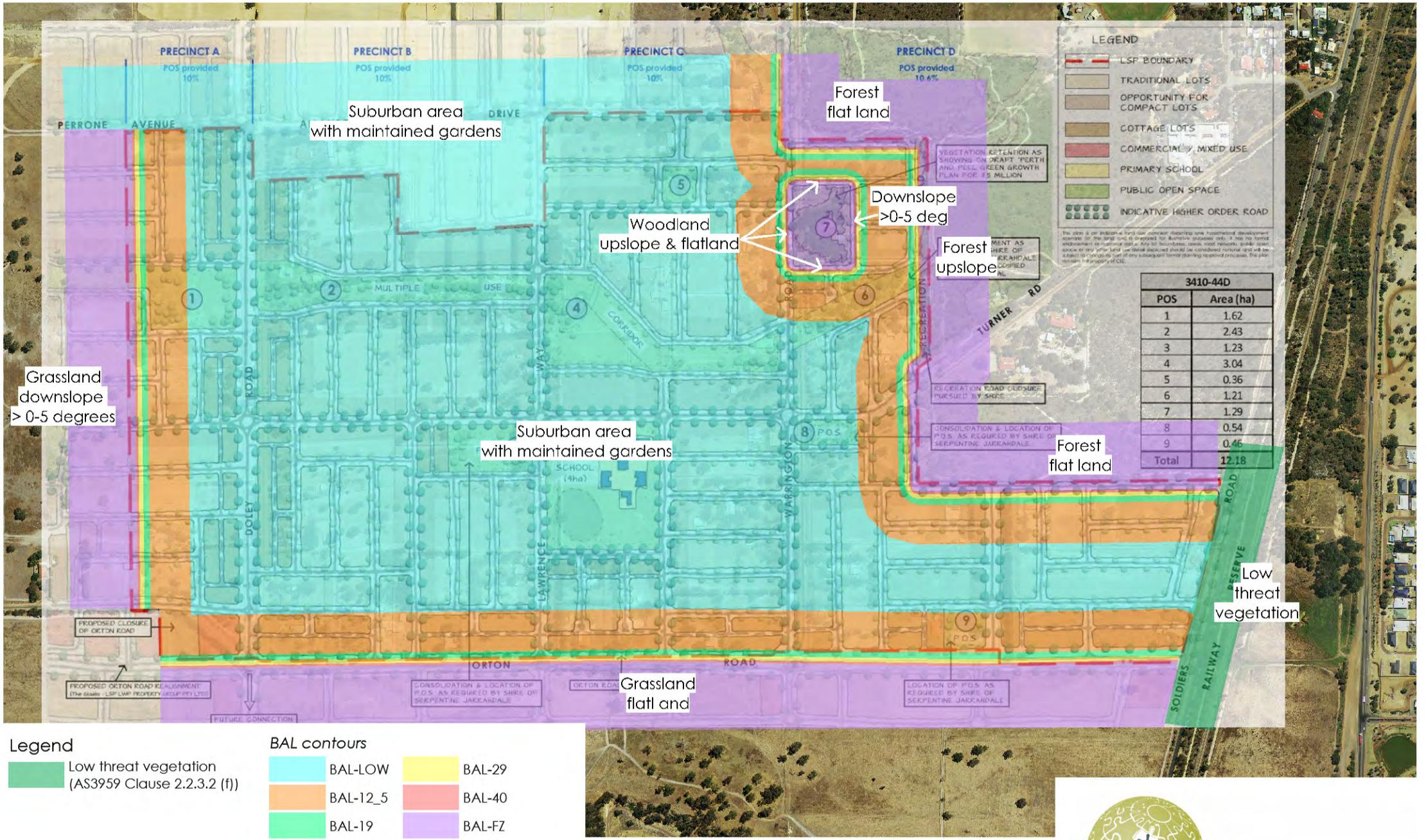
Scale 1: 9,000 @ A4

0 180m

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ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 9: BAL contour map



3410-44D	
POS	Area (ha)
1	1.62
2	2.43
3	1.23
4	3.04
5	0.36
6	1.21
7	1.29
8	0.54
9	0.46
Total	12.18

Legend

Low threat vegetation (AS3959 Clause 2.2.3.2 (f))

BAL contours

- BAL-LOW
- BAL-12_5
- BAL-19
- BAL-29
- BAL-40
- BAL-FZ

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Scale 1: 8,000 @ A4

0 160m

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4.5 Bushfire protection criteria assessment

The subject land contains and is adjacent to areas with an 'Extreme' bush fire hazard level. This is in conflict with SPP 3.7 which aims to facilitate the avoidance of placing people, property and infrastructure in areas of extreme bushfire risk. A comprehensive suite of bushfire risk mitigation and management measures will need to be implemented to reduce and maintain the bushfire hazard to a 'Moderate' level or lower. This will be achieved through clearing of the subject land to facilitate the proposed development as well as implementation of a number of design and management measures.

The *Guidelines for Planning in Bushfire Prone Areas* (WAPC, 2015) identifies four elements to be considered in order to mitigate and manage bushfire risk. These elements are location, siting and design of development, vehicular access and water supply and they are discussed further below and mapped in Figure 9.

4.5.1 Element 1: Location

Intent: To ensure that the subdivision, development or land use is located in areas with the least possible risk of bushfire, to help minimise risk to people, property and infrastructure.

Discussion

Noting the future urban development proposed through the WAPC endorsed Byford Structure Plan (2009), the proposed development is located in an area where the bushfire hazard assessment classification is or will be moderate or low (Figure 8), and the risk can be managed. The proposed roads fronting Brickwood Reserve and POS No 7 will provide adequate separation to achieve BAL-29 rating for adjacent development.

Conclusion

The proposed development meets acceptable solution *A1.1 Development location* as, on completion of the development proposed in the Byford Structure Plan, the development will be located in an area that is not subject to either an extreme bushfire hazard level classification, or a Bushfire Attack Level of BAL-40 or BAL-FZ (Figure 10). Any temporary risk that remains prior to the completion of the proposed development is able to be managed, as demonstrated in the remainder of this management plan.

4.5.2 Element 2: Siting and design of development

Intent: To ensure that the siting of development minimises the level of bushfire impact.

Discussion

Bushfire hazard levels rated as extreme or moderate within the subject land will largely be removed during land clearing and subdivisional earthworks. Some vegetation is intended to be retained within public open space areas.

The most significant bushfire hazard within the proposed development is associated with the retained vegetation in POS No 7. The retention of this vegetation is consistent with Objective 4 of SPP 3.7 which is to:

> *"Achieve a responsible approach between bushfire management measures and biodiversity conservation values, environmental protection and biodiversity management and landscape amenity, with consideration of the potential impacts of climate change".*

Bushfire hazard from the retained vegetation will be managed to ensure that no lot is subject to a Bushfire Attack Level of BAL-40 or BAL-FZ through the creation of a road around the public open space (15m reserve) and the establishment and maintenance of a low fuel zone of at least 5m within the public open space. This area will be managed consistent with this management plan and any future landscape management plan by the Shire of Serpentine Jarrahdale. The low threat vegetation is to have the following characteristics:

- Fine fuel load: reduced to and maintained at 2 tonnes per hectare and maintained in accordance with AS 3959-2009 s2.2.3.2 (f) stated here as "Including grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks. NOTE: Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognisable as short-cropped grass for example, to a nominal height of 100 mm";
- Trees (crowns) are a minimum distance of ten metres apart. A small group of trees within close proximity to one another may be treated as one crown provided the combined crowns do not exceed the area of a large or mature crown size for that species;
- No tall shrubs or trees located within 2 metres of a building;
- No tree crowns overhanging the building; and
- Fences and sheds within 100m of vegetation are constructed using non-combustible materials (e.g. iron, brick, limestone, metal post and wire) and shed are not to contain flammable materials.

Other vegetation proposed to be retained in areas of public open space is located greater than 20m from Brickwood Reserve, POS No 7 and the grassland to the south and west, is less than 0.25ha in size and will be maintained in a low threat state.

Temporary bushfire hazard exists for development proposed on the western boundary of the subject land until such time as the land is cleared for development. It is therefore not recommended that his portion of the subject land is subdivided until this hazard has been removed.

Development proposed along Orton Rd is also currently subject to a likely BAL-12.5 rating (Figure 9). Should this land be subdivided and developed prior to the clearing of the land to the south, any dwellings will need to be built in accordance with *AS 3959: Construction of buildings in bushfire prone areas.*

Residual hazard will remain; however, in the eastern portion of the subject land as a result of the Class A (Forest) vegetation in Brickwood Reserve. A hazard separation of 21m will be provided by the establishment of a 21m Road Reserve and construction of a road around Brickwood reserve. The road reserve will be maintained in a low threat state.

The vast majority of dwellings in the subject land are not located within 100m of moderate or extreme bushfire risk and so are not required to be constructed to particular bushfire standards. Maximum Bushfire Attack Level is predicted to be BAL-29 if a dwelling is sited 21 metres from Brickwood Reserve or within 14 or 17m of POS No 7. Additional separation may also be provided by an asset protection zone, should one be desired at time of subdivision, to reduce BAL levels.

Appropriate mitigation and/or construction methodologies to manage bushfire risk in accordance with *AS 3959: Construction of buildings in bushfire prone areas* will be reassessed at time of subdivision and will be required as part of the building approvals process. All proposed lots situated within 100 m of permanent 'Moderate' or 'Extreme' bushfire hazard areas (as depicted in Figure 8) will require consideration of the requirements of AS 3959–2009 and application of increased building construction standards where required, in accordance with the BALs and minimum separation distances highlighted in AS3959 Table 2.4.3. An excerpt of the separation requirements and BALs is provided in Table 3.

Table 3: Excerpt from AS 3959, Table 2.4.3, Distance (m) of the site from the predominant vegetation class

FDI 80 (1090 K)	Vegetation classification and slope				
Bushfire attack levels (BALs)	**Class A: Forest Flat land**	**Class B: Woodland Upslope & flat land**	**Class B: Woodland Downslope 0 to 5 degrees**	**Class G: Grassland Flat land**	**Class G: Grassland Downslope 0 to 5 degrees**
BAL-FZ	<16m	<10m	<13m	< 6m	< 7m
BAL-40	16-<21	10-<14	13-<17	6-< 8	7-< 9
BAL-29	21-<31	14-<20	17-<25	8-< 12	9-< 14
BAL-19	31-<42	20-<29	25-<35	12-<17	14-< 20
BAL-12.5	42-<100	29-<100	35-<100	17-< 50	20-< 50
BAL-LOW	Beyond 100m	Beyond 100m	Beyond 100m	Beyond 50m	Beyond 50m

Measures will also be incorporated to manage the temporary bushfire risk from on-site vegetation during internal staging. This includes the maintenance of a 105 m wide low fuel hazard separation zone between stages undergoing development and future undeveloped stages that have a 'Moderate' to 'Extreme' bushfire hazard level.

Conclusion

The proposed structure plan design meets acceptable solution *A2.2: Hazard separation zone* which allows that where a building cannot be located a minimum distance of 100m from the vegetation, the building must be constructed to a higher standard as described in AS3959, and that the requirement does not exceed BAL-29.

The 21m hazard separation around Brickwood Reserve will be established through creation of the road reserve at time of subdivision. A 17m separation around POS No 7 will be created through the establishment of a 15m road reserve, construction of the road and creation and maintenance of a low fuel zone within the area of public open space managed by the Shire in a low threat state.

4.5.3 Element 3: Vehicular access

Intent: To ensure that the vehicular access serving a subdivision/development is available during a bushfire event.

Discussion

The existing road network surrounding and within the subject land includes Orton Road to the south (Neighbourhood connector), Doley Road to the west (District entry road), Perrone Avenue, Allanson Drive (Access St B), Patridge Bend, Haliday Road, Dearden Road and Lawrence Way (Neighbourhood connector) to the north and Warrington Road (Neighbourhood connector), Turner Road (District entry road), Soldiers Road (Neighbourhood connector) to the east.

Orton Rd, Doley Rd, Turner Rd, Warrington Rd and Soldiers Rd provide excellent transport links to the surrounding region, connecting to the regional distribution system provided by Hopkinson Rd, Abernethy Rd, Soldiers Rd and South Western Highway (Plate 2).



Plate 2: Regional transport network (KCTT, 2015).

As part of the local structure planning process a Transport Impact Assessment was prepared by KCTT to provide, amongst other objectives, a broad framework for consideration of vehicle access requirements for the proposed land uses.

The Transport Impact Assessment proposes the following recommended cross sections. These comply with the requirements for public roads as defined in the *Guidelines for Planning in Bushfire Prone Areas*, Appendix Four, Element 3, Table 4 (WAPC, 2015).

- District Entry Road 'A' - 13.4m wide pavement in 30.0m wide reservation;
- Neighbourhood Connector 'A' - 7.0m wide pavement in 24.4m wide reservation;
- Neighbourhood Connector 'B' - 7.0m wide pavement in 19.4m wide reservation;
- Access Street B - 5.5m wide pavement in 17.9m wide reservation;
- Access Street C - 7.2m wide pavement in 15.4m wide reservation;
- Access Street D - 6m wide pavement in 14.2m wide reservation;
- Access Street D' - 6m wide pavement in 12.4m wide reservation (adjacent to the proposed POS); and
- Laneway - 6m wide pavement in 6.0m wide reservation.

Conclusion

The proposed structure plan complies with the performance criteria by applying the following acceptable solutions:

- *A3.1 Two access routes* - Two different vehicular access routes are provided, both of which connect to the public road network, provide access and egress to two different destinations and are available to all residents/the public at all times and under all weather conditions.
- *A3.2 Public roads* - Public roads are to meet the requirements in Table 4, Column 1.

No other acceptable solutions are considered relevant to the concept structure plan.

4.5.4 Element 4: Water supply

Intent: To ensure that water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.

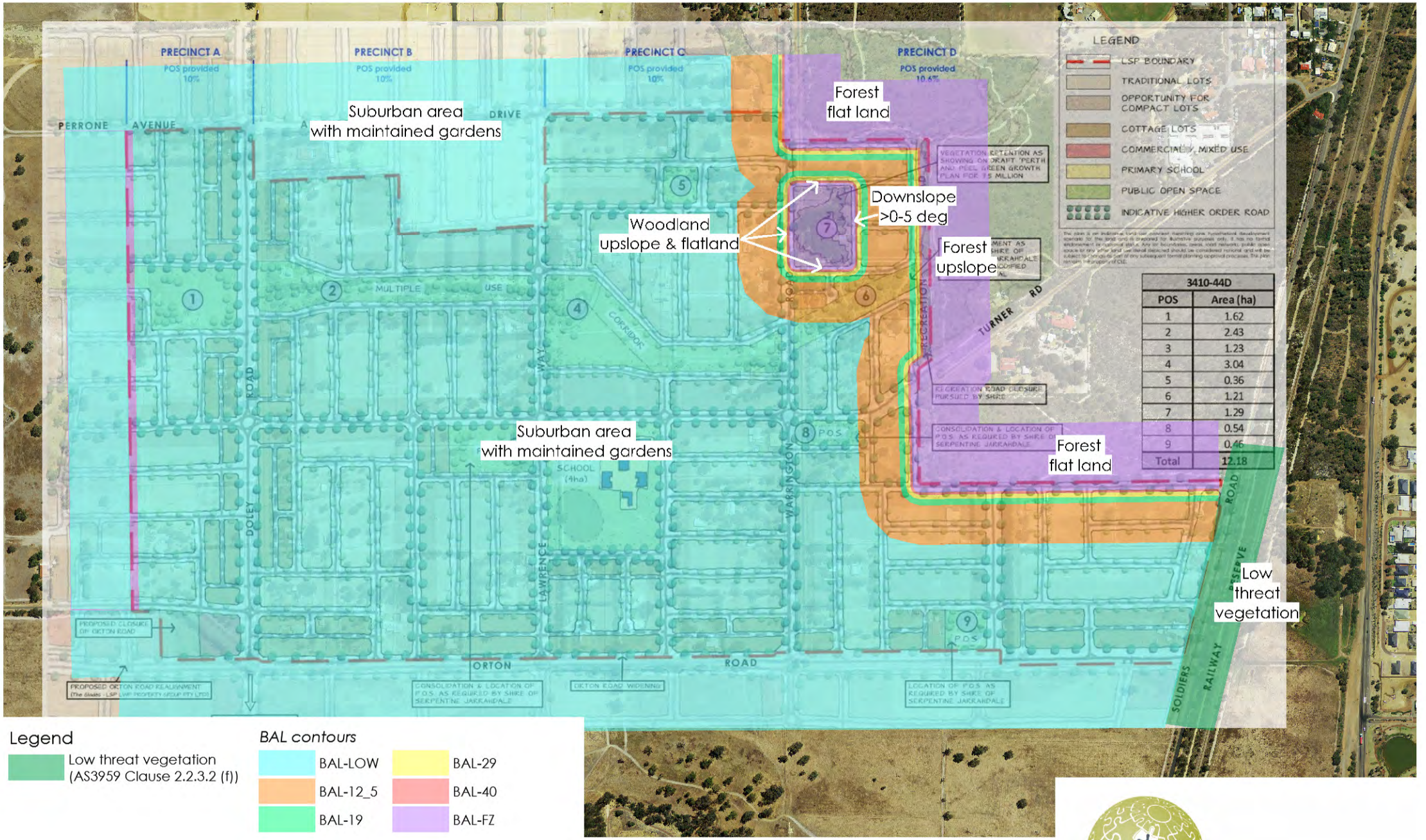
Discussion

The proposed residential development is to be provided with a reticulated water supply, together with fire hydrants, in accordance with the specifications of the Water Corporation and Department of Fire and Emergency Services (DFES).

Conclusion

The proposed structure plan complies with acceptable solution *A4.1 Reticulated areas*.

ABN Group: Doley Rd, Byford - Bushfire Management Plan
Figure 10: BAL contour map after completion of Byford structure plan



3410-44D	
POS	Area (ha)
1	1.62
2	2.43
3	1.23
4	3.04
5	0.36
6	1.21
7	1.29
8	0.54
9	0.46
Total	12.18

Legend

Low threat vegetation (AS3959 Clause 2.2.3.2 (f))

BAL contours

- BAL-LOW
- BAL-12_5
- BAL-19
- BAL-29
- BAL-40
- BAL-FZ

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Scale 1: 8,000 @ A4

0 160m

N

essential environmental

5 BUSHFIRE RISK MANAGEMENT MEASURES

The following management measures are recommended to be implemented as part of the future subdivision and development of the subject land for residential development. It is noted that these are high-level, strategic recommendations and are likely to be refined through the subdivision and development process.

The measures aim to mitigate the inherent bushfire risk to life, property and the environment and achieve a suitable and effective bushfire management outcome for the site. This will be achieved by meeting performance criteria and associated acceptable solutions in accordance with the *Guidelines for Planning in Bushfire Prone Areas* (WAPC, 2015).

Although the following management measures are considered to mitigate bushfire risk, there is a need for individual landowners to protect their property in line with this bushfire management plan noting that, despite any management measures outlined in the bushfire management plan, during a bushfire event, fire appliances may not be available to protect each house.

5.1 Location

Consideration of the strategic location, layout and management of future development during structure planning can reduce future bushfire threat and risk to critical life and property assets.

Development of the subject land will remove the majority of on-site vegetation to provide for the creation of a residential area consisting of maintained gardens and limited bushfire fuels. Some individual overstorey trees are proposed to be retained in selected areas of public open space; however, the trees are at least 100m from Brickwood Reserve; comprise less than 0.25ha of overstorey vegetation; are separated from each other by at least 20m; and will be actively managed as low threat vegetation. This will result in creation of a 'Low' bushfire hazard across the majority of the study area.

Consistent with the conservation commitments in the draft *Strategic Conservation Plan for the Perth and Peel Regions*, a portion of remnant vegetation is proposed to be retained in POS area No 7 (Figure 2). This vegetation has significant environmental value and is recognised as an extreme bushfire hazard. It is proposed that this hazard is managed through the creation of a low fuel buffer between it and the proposed lots, which ensures that the lots are not subject to a bushfire attack level of either BAL-FZ or BAL-40. This will be achieved through the creation of a road (proposed road reserve width of 15m) and, where necessary, a low fuel zone within the area of public open space which is managed and maintained by the Shire of Serpentine-Jarradale. The width of the low fuel zone required is 14m around the northern, western and southern border (which can be achieved through construction of the road) and 17m on the eastern edge of POS No 7 as indicated by Table 3.

The remaining public open space areas including the multiple use corridor will have managed understoreys, so will not adversely contribute to the bushfire risk to life and property assets of the development. Vegetation to be used in landscaping will consider SJ Shire's *Indicative List of Low Flammability Plants* (Shire of Serpentine Jarrahdale, 2010). Available fuel loads will be maintained annually within 2 t/ha through mowing of understorey grasses, trash and litter fuels prior to the onset of the designated bushfire season.

Subdivision of land within 50m of the grassland to the west will not occur until such time as this land has been cleared for development as indicated through long term strategic planning, or the bushfire risk is considered to be adequately managed in accordance with AS3959.

The above measures ensure that the development, when completed, is not located on land subject to either an extreme bushfire hazard level or construction standards applicable to BAL 40 or BAL FZ. This meets performance criteria for development location (Element 1) by adopting acceptable solution A1.1.

5.2 Siting and design of development

When considering the overall bushfire management of the subject area, protection should be provided to critical life and property assets (i.e. residents, visitors and built assets) as a minimum requirement. Low fuel buffers between bushfire hazard areas and critical assets, as well as application of AS 3959–2009 can be implemented to achieve this.

The construction of a road within a 15m road reserve provides sufficient separation to ensure lots to the north, south and west of POS No 7 will not be subject to a bushfire attack level of BAL-FZ or BAL-40. The 17m separation required from the eastern edge of PO No 7 to lots will be achieved through the establishment and maintenance of an area of low threat vegetation on the edge of the POS which is maintained in a low fuel state by the Shire.

The subject land abuts Brickwood Reserve which is designated as an 'Extreme' bushfire hazard. A 21 m wide hazard separation will be established around Brickwood Reserve at time of subdivision through creation of an appropriate road reserve. The BAL contours provided in Figure 9 flag the need for implementation of AS 3959–2009 within 100m of this hazard.

All proposed lots situated within 100 m from Brickwood Reserve and POS No 7 will require a BAL Assessment to be submitted at the time of lodgement of a building permit. This BAL Assessment will determine construction levels consistent with AS 3959–2009. Preliminary BAL ratings are provided in Figure 9. A notification will be placed on the Title of these lots which advises that the site is located in a bushfire prone area and is subject to a Bushfire Management Plan.

With regards to lots abutting Orton Rd, should the grassland to the south not be cleared prior to subdivision, it is noted that the proposed upgrade of Orton Rd (24.4m wide reservation) will provide adequate separation such that the risk is able to be managed through the construction of dwellings within 50m of the grassland to BAL-12.5 standard. This requirement will be established through the bushfire management plan that will accompany the application for subdivision.

Measures will also be incorporated to manage the temporary bushfire risk from on-site vegetation during internal staging, such as maintenance of a 100 m wide low fuel hazard separation zone between stages undergoing development and future undeveloped stages that have a 'Moderate' to 'Extreme' bushfire hazard level.

The range of measures outlined in Sections 4.5 and 5.2 will ensure the development meets performance criteria for siting of development (Element 2) by adopting acceptable solution A2.2.

5.3 Vehicular access

The proposed development is already services by an effective district and local road network, with good links to the regional distributor system. Development of the subject land will also result in provision of a comprehensive internal road network.

The current and proposed road network ensures all residents and visitors of the development are provided with at least two vehicular access routes connecting to the surrounding public road network at all times. This network is also considered to be sufficient to provide access for emergency fire service vehicles in the event that uncontrolled bushfire threatens the project area from adjoining bushland areas.

All public roads and private driveways will be constructed to specifications in accordance with Main Roads WA and DFES requirements to align with acceptable solutions A3.2, A3.3 and A3.5.

Other acceptable solutions for vehicular access including emergency access ways, fire service access routes, gates, firebreaks and signage are not considered necessary as part of the development, due to the adequate level of vehicular access proposed and the lack of on-site bushfire hazards to warrant higher level access requirements.

5.4 Water supply

A reticulated water supply will be provided for the proposed development through extension of the existing reticulated water supply to the subject land from the north and west.

A network of hydrants will also be provided along the internal road network at locations which meet Water Corporation and DFES requirements. Hydrants will be marked via the following:

- a blue 'cats eye' reflective indicator to the left of the centre line of the road;
- a small blue 'H' painted on the curbing; and
- a white and red stripe around the power pole nearest to the hydrant.

Contractors or others carrying out building or other works at the site must not cover hydrants and/or the markings indicating their location. In the event activities occur that do result in hydrants or markings being covered, damaged, or removed, it will be the responsibility of the relevant contractor to rectify the situation.

The above measures will ensure the development meets performance criteria for water supply (Element 4) by adopting acceptable solution A4.1.

6 IMPLEMENTATION

Implementation of this Plan will commence immediately and will be the responsibility of the Developer until such time as the site is formerly handed over to SJ Shire or the new owners of the lots. Likely tasks that will be involved with the implementation of this plan are described in Table 4.

Although implementation of the following management measures are considered to mitigate bushfire risk, there is a need for individual landowners to protect their property in line with this bushfire management plan noting that, despite any management measures outlined in the bushfire management plan, during a bushfire event, fire appliances may not be available to protect each house.

Table 4: Implementation plan

Activity	Responsibility	Maintenance	Responsibility
Ensuring bushfire protection of land and property during the various stages of the development	Developer	Checking and maintaining fire breaks, 100m low fuel zones and other protection mechanisms during staging activities	Developer
For those lots within 100m of Brickwood Reserve, POS No 7 or 50m of grassland to the south and east, implement AS 3959–2009 and associated construction standards in accordance with Figure 9	Developer through subdivision process and via notification on titles.	Implement requirements of AS3929 through review of management plan to support subdivision applications.	Developer, until lots are sold when it is the responsibility of individual landowners
Establish a low threat vegetation buffer of at least 2m in width on the eastern border of POS No 7.	Developer	Maintain the buffer vegetation in a low threat state as defined in Section 4.5.2.	Developer, until hand over to SJ Shire
Construct all public roads, and private driveways in accordance with Main Roads WA and DFES requirements	Developer	Will include installation of signage as appropriate	Developer, until hand over to SJ Shire
Install signage identifying emergency access ways and similar	Developer	Will include checking of condition, legibility, visibility	Developer, until hand over to SJ Shire
Provide a reticulated water supply through extension of the existing reticulated water supply	Developer	Meet relevant water supply authority and DFES requirements.	Developer, until hand over to Water Corp
Provide a network of hydrants along the internal road network at locations which meet relevant water supply authority and DFES requirements.	Developer	Meet relevant water supply authority and DFES requirements.	Developer, until hand over to Water Corp
Assessing bushfire fuel loading in public open space and maintaining it at <2t/ha	Developer	Annually	Developer, until hand over to SJ Shire

Activity	Responsibility	Maintenance	Responsibility
Assess bushfire management implications of proposed landscape plans	Developer	As required, during landscape design phase	Developer
Undertake an inspection of fuel hazards across individual lots to assess compliance with the FMP and annual fire control notice.	SJ Shire staff, DFES	Issue work orders or fines where compliance with the Bush Fires Act 1954, the FMP or the annual fire control notice has been compromised.	SJ Shire staff, DFES
Education - Distribution of bushfire information booklets and community attendance at annual DFES bushfire awareness briefings	Developer & SJ Shire	Updating materials and information to reflect current policies, plans, knowledge, or accepted practice	Developer – during sale process Shire – during normal administrative activities to residents and rate payers
Bushfire management plan review	Developer in consultation with SJ Shire	Ensure continued suitability of Bushfire management plan by reviewing contents in conjunction with current site conditions	Developer, until sale of lots of completed and hand over of nominated areas to SJ Shire

6.1 Responsibilities

Responsibilities for bushfire preparedness and response within the subject land are shared by SJ Shire, the Developer, DFES, and lot owners.

6.1.1 Developer Responsibilities

The Developer is responsible for implementing key portions of this Bushfire Management Plan, including:

- considering bushfire hazards and risks associated with POS No 7 and the adjacent Brickwood reserve, neighbouring grassland, areas of public open space and other vegetated areas in and around the development during the subdivision design process, and ensuring the risks are as low as reasonably practicable,
- implementing requirements associated with installation and maintenance of appropriate personnel and vehicle access point in compliance with relevant WAPC, DoP and DFES guidelines at an appropriate stage of the development process;
- maintaining any firebreak areas or similar in accordance with SJ Shire requirements and guidelines,
- providing appropriate information, including a copy of this bushfire management plan, to potential purchasers and owners of lots within the development that have a BAL of 12.5 or greater about the bushfire risks and minimum building standard requirements,
- arrange for the Section 70A notification on the titles of lots subject to the requirements of this Bushfire Management Plan,

6.1.2 SJ Shire

It should be noted that SJ Shire has the responsibility and powers under the Bush Fires Act 1954 to ensure that this bushfire management plan, SJ Shire Fire Control notice and any Special orders issued under the Bush Fires Act 1954 are complied with.

SJ Shire will be responsible for:

- Maintaining District Fire Fighting Facilities;
- Maintaining equipment and apparatus for fire fighting purposes in good condition;
- Upkeep of bushfire access points and routes, including any emergency and strategic access ways after handover from the developer;
  Providing appropriate advice in relation to requirements for firebreaks, hazard reduction, and similar to the Developer and property owners as required; and
- Taking over Developer responsibilities for maintenance of fire protection facilities at the nominated sites after they are ceded to the Shire.

6.1.3 DFES Responsibilities

DFES will be responsible for:

- Maintaining fire fighting equipment in good condition and repair, and
- Responding to large bushfires within and adjacent to the subject land in a timely manner in an effort to minimise the spread of bushfire and damage to nearby housing from ember attack.

6.1.4 Owner Responsibilities

It is the responsibility of individual property owners building houses near the vegetated areas to respond to advice from SJ Shire, DFES, or the Developer in relation to maintaining properties in a manner that will reduce potential damage from ember attack.

6.2 Other recommendations

After considering the available information known about the subject land, the following is recommended:

- Strategic firebreaks/ access ways and similar are installed and maintained to assist sequential development of the structure plan area
- Prospective property purchasers be advised of the possible increased level of building construction standards that might apply within bushfire prone areas and that a BAL assessment may also be required;
- Prospective property purchasers be made aware that in the event of a large bushfire occurring, fire appliances may not be available for every dwelling, and provided a copy of local government and DFES bushfire information booklets that are currently available;
- Grassed and weedy areas be kept to a minimum, with slashing to 50 mm occurring prior to summer each year;
- Where required, fire breaks to be maintained in accordance with SJ Shire requirements; and

- Ensure rehabilitation plans are also considered in terms of a bushfire management perspective.

6.3 Plan Review

This bushfire management plan has been developed based on current conditions at the site, but recognises that changes will occur over time. Accordingly, it is recommended that this plan be reviewed twelve months after initial endorsement and implementation to ensure its continued suitability, and in the event any of the following occur:

- A bushfire occurs within the site boundary or a neighbouring property that spreads to the site;
- The design of the structure plan area is altered in a manner that materially effects the provisions of this bushfire management plan;
- During detailed design phases, when expected fill levels are available or change, resulting in altered slopes (both upward and downward slopes);
- Revegetation activities do or are likely to result in areas of classified vegetation greater than 0.25 ha (as defined by AS 3959-2009);
- If the vegetation to be retained on site is altered, and will or is likely to result in an area of classified vegetation greater than 0.25 ha.

7 REFERENCES

Australian Standards 3959 – 2009 Construction of Buildings in Bushfire-Prone Areas (Amendment 2 – February 2011), Standards Australia, NSW.

DFES, 2012, Visual Fuel Load Guide for the Scrub Vegetation of the Swan Coastal Plain and Darling Scarp including Geraldton Sandplains & Leeuwin Ridge Regions of Western Australia – Edition 2

SJ Shire Firebreak Notice and Fuel Hazard Reduction Notice 2015-2016

SJ Shire Local Planning Policy No.43: Hazards and Natural Disasters

Shire of Serpentine Jarrahdale, 2010, Indicative List of Low Flammability Plants, SJ Shire, Mundijong, WA.

WAPC, 2014, draft State Planning Policy 3.7: Planning for Bushfire Risk Management, Department of Planning, Perth, WA

WAPC, 2014, Planning for Bushfire Risk Management Guidelines and appendices, draft, Department of Planning, Perth, WA

Client: ABN Group

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
Draft report	V1	RM/SSh	HBr	electronic	September 2015
Final report	V2	SSh	GFr	electronic	23 January 2016
Final report	V3	SSh	HBr	electronic	10 June 2016

Essential Environmental
land & water solutions
622 Newcastle St Leederville 6007
p: 08 9328 4663 | f: 08 6316 1431
e: info@essentialenvironmental.com.au
www.essentialenvironmental.com.au

APPENDIX 3

Landscape Masterplan

ORTON ROAD, BYFORD - OVERALL LANDSCAPE MASTER PLAN



*** DESIGN SUBJECT TO WATER ALLOCATION

HIGHER ORDER ROADS

LD TOTAL
LEADERS IN LANDSCAPING
172 BURSWOOD ROAD
BURSWOOD, WA 6100
T +61 8 6436 1111
F +61 8 9367 2034

PARCEL

Orton Road, Byford - Preliminary Landscape Design

17TH MARCH 2017 - N.T.S

ORTON ROAD, BYFORD - POS 1 CONCEPT

*** DESIGN SUBJECT TO WATER ALLOCATION





LOCATION PLAN

CHARACTER IMAGES



SHELTER



FEATURE PLANTING

LEGEND

1 VIEWING NODE
2 MAIN WATERWAY BUFFER / MUC (30m)
3 SEATING NODE
- PICNIC SETTING

4 TURF SPACE
5 SHADE TREES
6 FEATURE PLANTING
- ORGANIC PATTERN PLANTING WITH NATIVE/ LOW WATER USAGE SHRUBS AND GRASSES
- CONCRETE KERB EDGING

7 SEATING ALCOVE/RESPITE AREA

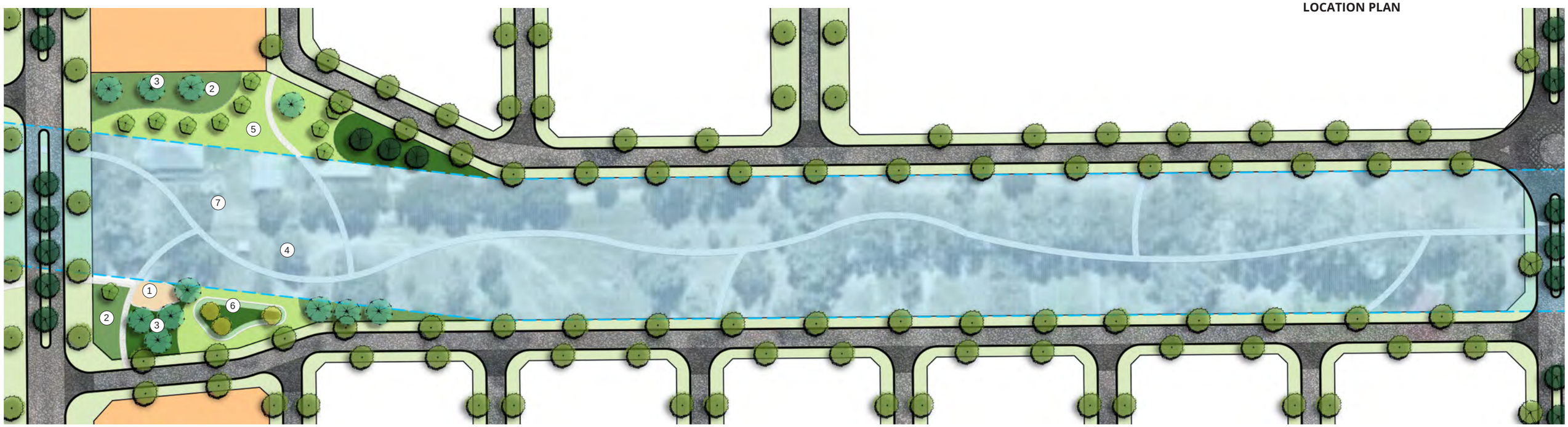
LD TOTAL
LEADERS IN LANDSCAPING
172 BURSWOOD ROAD
BURSWOOD, WA 6100
T +61 8 6436 1111
F +61 9367 2034
PARCEL

ORTON ROAD, BYFORD - POS 2 CONCEPT

*** DESIGN SUBJECT TO WATER ALLOCATION



LOCATION PLAN



LEGEND

1 EXERCISE STATION

2 FEATURE PLANTING
- ORGANIC PATTERN LOW NATIVE/LOW WATER USAGE SHRUBS AND GRASSES

3 SHADE TREES

4 RETAINED VEGETATION
- FEATURE PLANTING UNDER EXISTING TREES AND SHRUBS WITH MULCH AND CONCRETE KERB EDGING

5 OPEN TURF AREA

6 FEATURE PLANTING
- ORGANIC PATTERN PLANTING WITH NATIVE/ LOW WATER USAGE SHRUBS AND GRASSES
- CONCRETE KERB EDGING

7 MAIN WATERWAY BUFFER / MUC (30m)

CHARACTER IMAGES



FEATURE PLANTING



EXERCISE NODE



RETAINED VEGETATION

LD TOTAL
LEADERS IN LANDSCAPING
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BURSWOOD, WA 6100
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Orton Road, Byford - Preliminary Landscape Design

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ORTON ROAD, BYFORD - POS 3 CONCEPT

*** DESIGN SUBJECT TO WATER ALLOCATION



LEGEND

1 BBQ AND SEATING AREA
2 PLAYGROUND
- THEMED CHILDRENS PLAY AREA WITH SOFTFALL BELOW

3 SHELTER
4 FEATURE PLANTING
- ORGANIC PATTERN LOW NATIVE/ LOW WATER USAGE SHRUBS AND GRASSES
- NATIVE TREES

5 KICKABOUT TURF OVAL
6 EXERCISE NODE
7 SHADE TREES

CHARACTER IMAGES



RETAINED VEGETATION



KICKABOUT TURF AREA



OPEN SPACE TURF AREA



THEMED PLAY AREAS



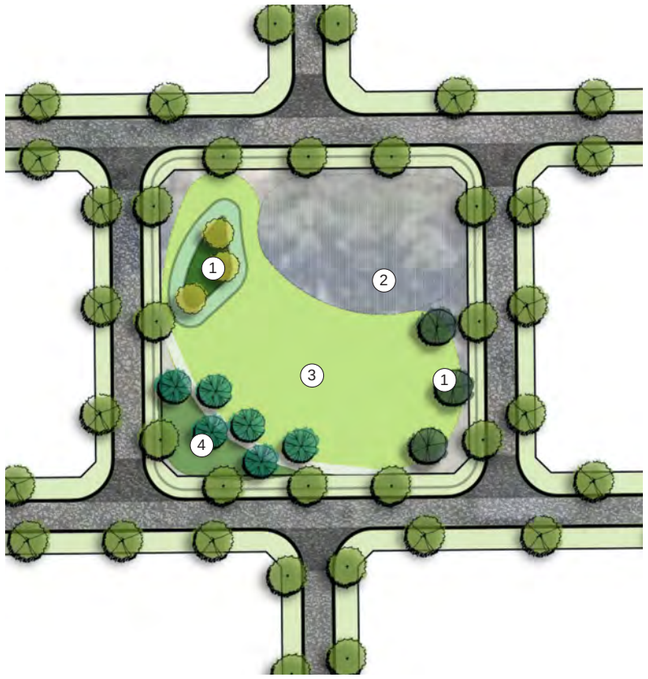
FEATURE PLANTING



LOCATION PLAN

ORTON ROAD, BYFORD - POS 4 CONCEPT

*** DESIGN SUBJECT TO WATER ALLOCATION



LEGEND

1 SHADE TREES
2 RETAINED VEGETATION
- NATIVE PLANTING UNDER EXISTING TREES AND SHRUBS WITH MULCH AND CONCRETE KERB EDGING

3 KICKABOUT TURF AREA
4 FEATURE PLANTING
- ORGANIC PATTERN PLANTING WITH NATIVE/ LOW WATER USAGE SHRUBS AND GRASSES
- CONCRETE KERB EDGING

LD TOTAL
LEADERS IN LANDSCAPING
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ORTON ROAD, BYFORD - POS 5 CONCEPT

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LOCATION PLAN



RETAINED VEGETATION



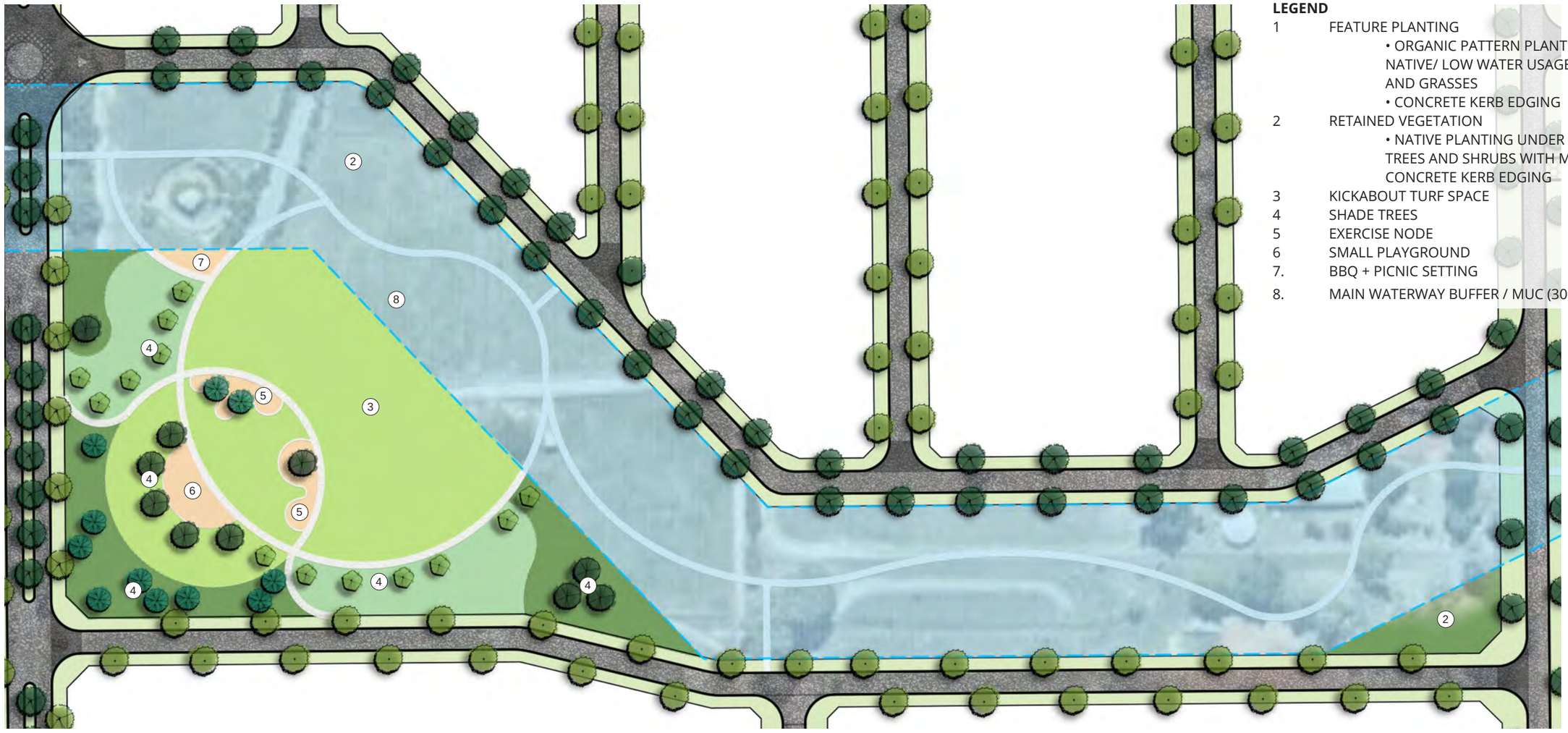
FEATURE PLANTING



EXERCISE NODE



THEMED PLAY AREAS



LEGEND

1 FEATURE PLANTING
- ORGANIC PATTERN PLANTING WITH NATIVE/ LOW WATER USAGE SHRUBS AND GRASSES
- CONCRETE KERB EDGING

2 RETAINED VEGETATION
- NATIVE PLANTING UNDER EXISTING TREES AND SHRUBS WITH MULCH AND CONCRETE KERB EDGING

3 KICKABOUT TURF SPACE

4 SHADE TREES

5 EXERCISE NODE

6 SMALL PLAYGROUND

7. BBQ + PICNIC SETTING

8. MAIN WATERWAY BUFFER / MUC (30m)

LD TOTAL
LEADERS IN LANDSCAPING

172 BURSWOOD ROAD
BURSWOOD, WA 6100
T +61 8 6436 1111
F +61 8 9367 2034

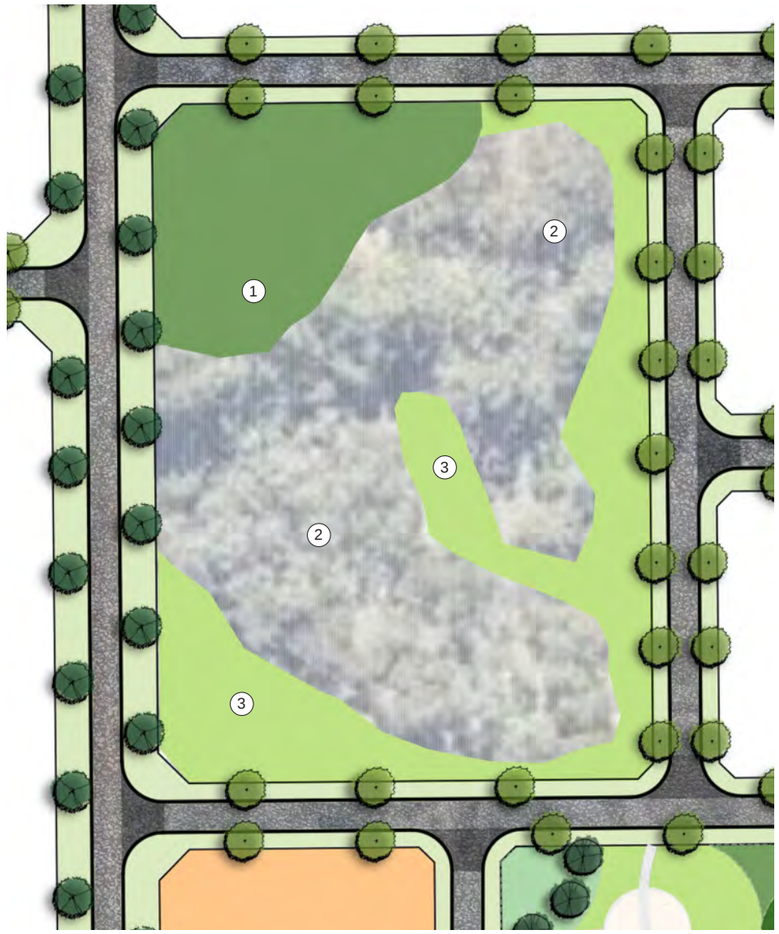
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Orton Road, Byford - Preliminary Landscape Design

17TH MARCH 2017 - N.T.S

ORTON ROAD, BYFORD - POS 6 CONCEPT

*** DESIGN SUBJECT TO WATER ALLOCATION



LEGEND

1 FEATURE PLANTING
- ORGANIC PATTERN PLANTING WITH NATIVE/ LOW WATER USAGE SHRUBS AND GRASSES
- CONCRETE KERB EDGING

2 RETAINED VEGETATION
- NATIVE PLANTING UNDER EXISTING TREES AND SHRUBS WITH MULCH AND CONCRETE KERB EDGING

3 TURF AREA

CHARACTER IMAGES



RETAINED VEGETATION



KICKABOUT TURF AREA



OPEN SPACE TURF AREA



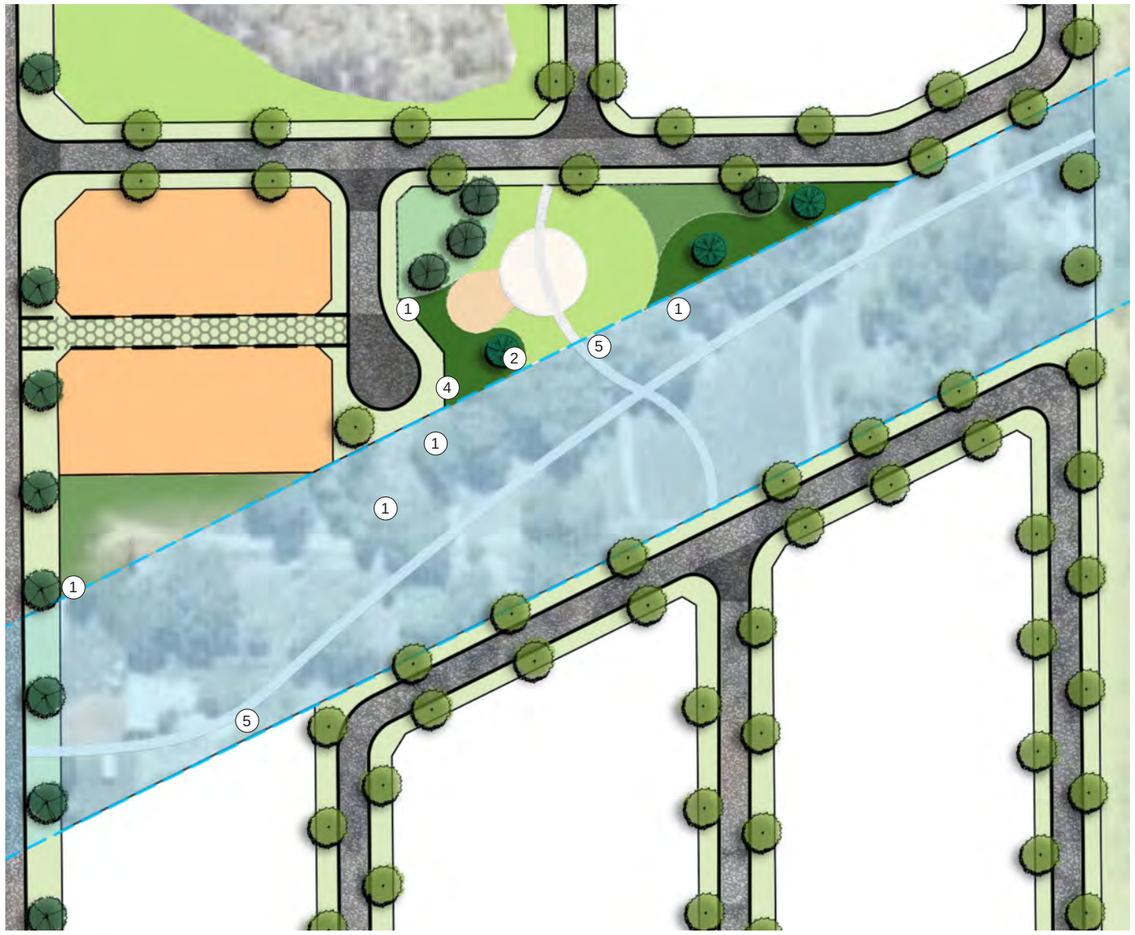
THEMED PLAY AREAS



LOCATION PLAN

ORTON ROAD, BYFORD - POS 7 CONCEPT

*** DESIGN SUBJECT TO WATER ALLOCATION



LEGEND

1 FEATURE PLANTING
- ORGANIC PATTERN PLANTING WITH NATIVE/ LOW WATER USAGE SHRUBS AND GRASSES, CONCRETE KERB EDGING

2 SMALL PLAYGROUND
- THEMED CHILDRENS PLAY AREA WITH SOFTFALL BELOW

3 SHADE TREES

4 PICNIC AREA

5 MAIN WATERWAY BUFFER / MUC (30m)

LD TOTAL
LEADERS IN LANDSCAPING
172 BURSWOOD ROAD
BURSWOOD, WA 6100
T +61 8 6436 1111
F +61 8 9367 2034

PARCEL

ORTON ROAD, BYFORD - POS 8 CONCEPT

*** DESIGN SUBJECT TO WATER ALLOCATION



LEGEND

1 FEATURE PLANTING
- ORGANIC PATTERN PLANTING WITH NATIVE/ LOW WATER USAGE SHRUBS AND GRASSES, CONCRETE KERB EDGING

2 SMALL PLAYGROUND
- THEMED CHILDRENS PLAY AREA WITH SOFTFALL BELOW

3 SHADE TREES

4 RETAINED VEGETATION
- NATIVE PLANTING UNDER EXISTING TREES AND SHRUBS WITH MULCH AND CONCRETE KERB EDGING

5 OPEN SPACE TURF AREA

CHARACTER IMAGES



THEMED PLAY AREAS



FEATURE PLANTING



RETAINED VEGETATION



OPEN SPACE TURF AREA



LOCATION PLAN

ORTON ROAD, BYFORD - POS 9

*** DESIGN SUBJECT TO WATER ALLOCATION



LEGEND

1 FEATURE PLANTING
- ORGANIC PATTERN PLANTING WITH NATIVE/LOW WATER USAGE SHRUBS AND GRASSES, CONCRETE KERB EDGING

2 TURF AREA

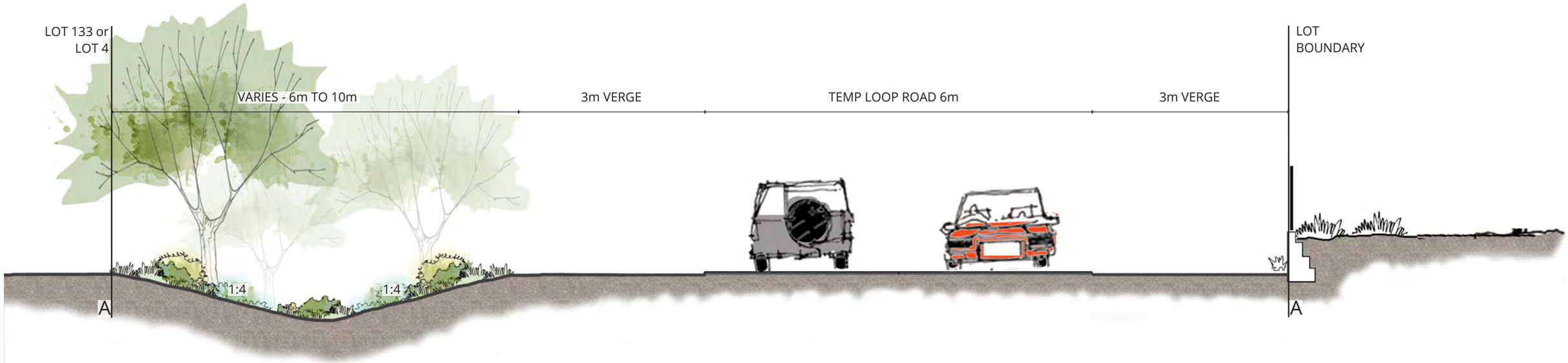
3 PICNIC AREA

4 PLAY ITEM

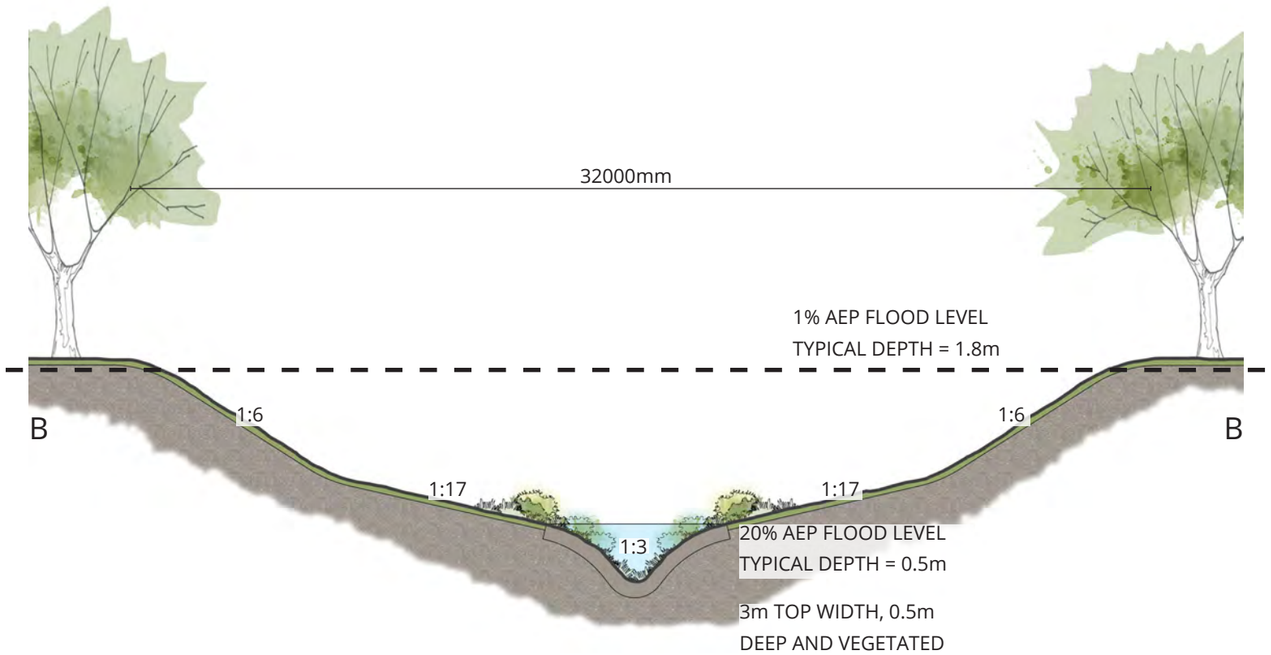
5 SHADE TREES

LD TOTAL
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T +61 8 6436 1111
F +61 8 9367 2034

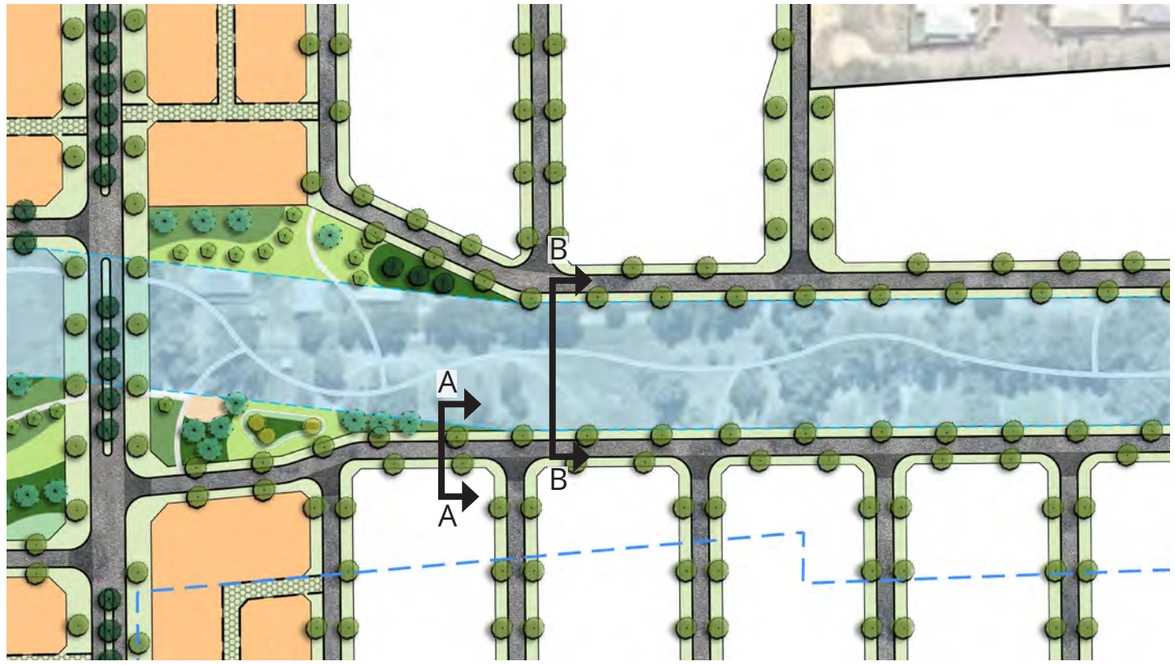
PARCEL



NORTHERN INTERIM DRAIN CROSS SECTION (TYP)
NTS



TYPICAL MUC CROSS SECTION
NTS



NORTHERN INTERIM DRAINAGE
NTS



LOCATION PLAN

LD TOTAL
LEADERS IN LANDSCAPING
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Orton Road, Byford - Preliminary Landscape Design

17TH MARCH 2017 - N.T.S

APPENDIX 4

Transport Impact Assessment

TRANSPORT IMPACT ASSESSMENT

Doley Road Precinct LSP

Byford

March 2017,

Rev D

kctt

HISTORY AND STATUS OF THE DOCUMENT

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Project Manager	Marina Kleyweg
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Appendix 1 - The layout of the proposed development

Appendix 2 - Transport Planning and Traffic Plans

Appendix 3 – SIDRA Intersection Analysis

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1. Introduction

1.1 Transport Impact Assessment Layout

KCTT have been requested to provide a Transport Impact Assessment for the development of landholdings in the Doley Road Precinct LSP, Byford. The purpose of this document is to provide detailed commentary and analysis on the potential traffic and transport impacts that the proposed development of this Local Structure Plan area may have on both the surrounding road and transportation networks. The scope of this report is to provide a detailed assessment of the following: -

- Review future public transportation servicing generally and its potential impact on the development of the subject sites;
- Develop a trip generation matrix for the future land development based on the planners layout;
- Provide a plan showing likely traffic volumes on each of the roads and advice regarding road pavement widths, road reserve widths and footpath requirements;
- Review intersection design requirements;
- Provide a Paramics Model showing the movement of vehicles into the local road network. The Paramics model will be for the ultimate development + 10 year model and will show likely levels of service at key road legs.
- SIDRA analysis at the intersection of
    - Orton Road / Doley Road
    - Orton Road / Lawrence Way
    - Orton Road / Warrington Road
    - Warrington Road / Turner Road
- Provide colour graphics showing:-
    - Expected traffic volumes on each road in the proposed subdivision layout;
    - Expected road widths and road reservation widths;
    - Levels of service for each leg of the development (from Paramics)
    - Future and existing public transport routes;
    - Locality Plan (showing the site and 2km radius of major features inclusive of schools, shopping etc)
    - Plan showing pedestrian path networks.

This Transport Impact Assessment is presented in the following logical sequence: -

- Section 1 – Introduction

This section provides a brief description on the role of this report in the Structure Planning process, the general layout of the report and a list of the guideline and reference documents used in its composition.

- Section 2 – Transport Impact Assessment

This section provides research and analysis of the key items required for submission of a Transport Impact Assessment for Structure Plans in accordance with the Transport Assessment Guidelines nominated above. In this section, KCTT have examined the following subject areas: -

- Section 2.1 – Structure Plan Outline

In consultation with ABN Group, we will provide a brief description of the Structure Plan area and its proposed land uses.

- Section 2.2 – Existing Situation and External Traffic Networks

This section provides a description of the existing land uses within the Structure Plan Area and collates all available traffic data from both within, and external to the Structure Plan Area. The transportation networks are examined for 2km radius from the edge of the Structure Plan Area.

- Section 2.3 – Traffic Modelling for the Proposed Development

This section describes KCTT's 4-step model which is used to determine the future traffic generation / attraction to and from the proposed Structure Plan Area.

- Section 2.4 – Vehicle Access and Parking Requirements

This section generically describe vehicle access and parking requirements for individual land uses within the Structure Plan Area. Each development proposal will be required to address on-site vehicular access and parking requirements in detail. This section will discuss a broad framework for the consideration of these issues.

- Section 2.5 – Provision for Service Vehicles

This section provides generic descriptions for service vehicle requirements throughout the Structure Plan Area. Each of the proposed land uses will be required to examine requirements for service vehicles, pending confirmation of the land uses proposed.

- Section 2.6 – Hours of Operation

This section describes the general operating times for the land uses as they are proposed in the Structure Plan Area. This information assists in determining the likely timing of the AM and PM peaks, and therefore the peak impact on the existing and surrounding transportation network. The peak vehicle generation is the key for determining intersection capacities within a road network.

- Section 2.7 – Public Transport Access

This section provides a summary of the existing public transportation services available within a 2km radius of the Structure Plan Area's boundaries and provides commentary on whether any services are likely to be extended into the Structure Plan Area.

- Section 2.8 – Pedestrian and Cyclist Access

This section provides a summary of the existing pedestrian and cyclist infrastructure in close proximity of the Structure Plan Area's boundaries and provides commentary on the infrastructure likely to be extended into the Structure Plan Area.

- Section 3 – Transport Impact Assessment Checklist

This section provides a concise, tabulated summary and review of the detailed information presented in Section 2 of this report. The intention of this checklist is to document the findings of this report, and / or any of the likely transportation / safety issues which should be considered as part of the submission. This checklist has been developed in accordance with the requirements of the Transport Assessment Guidelines for Developments: Structure Plan Submissions.

1.2 Notes Pertaining to This Report

This report has been provided as one of the key preliminary inputs into the overall documentation required for the Structure Planning approvals. Whilst the final site yields and land-uses are subject to change prior to the finalisation of the Structure Plan, the traffic and transportation requirements discussed in this report are based on the land uses and yields proposed through the Structure Planning process, in accordance with the Structure Plan Area.

1.3 Available Information and Technical Literature

This section provides a brief description of the inputs used in the compilation of this report:

- WAPC Transport Impact Assessment Guidelines – Volume 2 – Planning Schemes, Structure Plans & Activity Centre Plans (August 2016);
- WAPC Transport Impact Assessment Guidelines – Volume 5 – Technical Guidance (August 2016) (referenced for PM peak hour and traffic splits);
- RTA NSW Guide to Traffic Generating Developments Version 2.2 October 2002 (referenced to determine trip generation / attraction rates for various land uses);
- Guide to Traffic Management – Part 3: Traffic Studies and Analysis, Austroads, 2008 (referenced to discuss requirements for provision of car parking for various land use types, and how trip attraction / generation rates can be cross-checked in this report to provide a robust and consistent transportation model);
- Guide to Traffic Management – Part 11: Parking, Austroads, 2008 (referenced to discuss requirements for provision of car parking for various land use types, and how trip attraction / generation rates can be cross-checked in this report to provide a robust and consistent transportation model);
- Guide to Traffic Management – Part 12: Traffic Impacts of Developments, Austroads, 2008 (referenced to discuss requirements for provision of car parking for various land use types, and how trip attraction / generation rates can be cross-checked in this report to provide a robust and consistent transportation model);
- Shire of Serpentine - Jarrahdale Town Planning Scheme No 2, Updated *to include AMD 189 GG 22/05/2015*, Original Town Planning Scheme Gazettal Date: 4 August 1989.
- Shire of Serpentine - Jarrahdale's Local Planning Policy No 58.

2. Transport Impact Assessment

2.1 Structure Plan Outline

The development proposes to subdivide the Doley Road LSP, Byford into approximately 2,393[1] residential lots (887 lots with an assumed R25 yield, 764 lots with an assumed R40 yield and 742 lots with an assumed R60 yield), a Neighbourhood Centre, a Primary School and accompanying POS. The subject site is under jurisdiction of the Shire of Serpentine - Jarrahdale. The land occupies an area of approximately 84.23 ha.

" Serpentine Jarrahdale Shire is a predominantly rural area which is experiencing rapid residential and rural residential growth. The largest townships are Byford and Mundijong, followed by Serpentine and Jarrahdale. The eastern areas of the Shire are dominated by conservation, timber and water catchment uses. The central spine of the Shire features many of the urban centres and the main transport corridor. The western part of the Shire remains predominantly rural, with a relatively small population. The Shire encompasses a total land area of over 900 square kilometres. Rural land is used mainly for agriculture and equine activities."
(http://profile.id.com.au/ngaa/about?WebID=300)

Table 1 - Quantities of Proposed Uses

Proposed Land Use	Area	Yield
Residential - Traditional Lots (Assume R25)	54.58ha [35.48ha + 19.10ha]	887 Lots
Opportunity for Compact lots (Assume R40) app 35% of Traditional Lots		764 Lots
Residential - Cottage Lots (Assume R60)	12.36ha	742 Lots
Neighbourhood Centre (Assume 35% of area for retail development GFA, with approximately 95%GFA = GLFA and 75%GFA = NLA)	1.11ha	3,885m^2 GFA 3,691m^2 GLFA 2,914m^2 NLA
Primary School (Assume 700 students)	4.0ha	-
P.O.S. *	12.18ha	-
Total - The Proposed Development	**84.23ha**	**2,393 Lots + 2,914m^2 NLA Retail**

*Note: * This land use will not be taken into consideration when calculating both the parking provision and the traffic generated from the proposed development.*

Plans showing the proposed development have been provided in Appendix 1 of this report.

2.2 Existing Situation and External Traffic Networks

The existing road network surrounding and within the subject area includes Orton Road to the south, Doley Road to the west, Perrone Avenue, Allanson Drive, Partridge Bend, Halliday Road, Dearden Road and Lawrence Way to the north and Warrington Road, Turner Road, Soldiers Road to the east. A plan showing the existing network and distribution of the existing traffic volumes is provided in Appendix 2.

Orton Road is a two-way undivided road, classified as a Rural Local Road / Local Distributor. There are no bus services running along this road. Pedestrian paths are not provided. Orton Road has a speed limit of 70kph (SLK 6.54 - SLK 8.43) and 50kph (SLK 8.43 - SLK 10.65).

[1] Please note this calculation is approximation of yield for purposes of traffic impact estimate.

Doley Road is a two-way undivided road classified as an Urban Local Road / Access Road. This road is under construction between Allanson Drive and Kinsella Avenue. Doley Road is 3.5m wide south of Allanson Drive with a 20m wide road reserve. The legal speed limit on this road is 50kph. Pedestrian paths are not provided along this road within the subject site. Bus route 254 operates on this road north of Mead Street.

Perrone Avenue, Allanson Drive, Partridge Bend, Halliday Road, Dearden Road and Lawrence Way are two-way, two-lane roads and are classified as Urban Local Road / Access Road by Main Roads WA. The legal speed limit on these roads is 50kph. There is no bus service running along these roads in the vicinity of the subject site.

Warrington Road is a two-way undivided road classified as a Rural Local Road / Local Distributor (SLK 0.00-SLK 0.28) and Urban Local Road / Access Road (SLK 0.28-SLK 1.63). The legal speed limit on this road is 50kph. Pedestrian paths are not provided along this road. There is no bus service running along these roads.

Turner Road is a two-way undivided road classified as a Rural Local Road / Local Distributor. The legal speed limit on this road is 50kph.

Soldiers Road is a two-way undivided road classified as a Rural Local Road / Regional Distributor. Soldiers Road has a speed limit of 60kph (SLK 0.00 - SLK 0.72), 80kph (SLK 0.72 - SLK 2.26), 60kph (SLK 2.26 - SLK 3.09) and 80kph (SLK 3.09 - SLK 5.92). Pedestrian paths are provided on the western side of the road reservation. Bus routes 252 and 253 operate on this road.

Hopkinson Road is a two-way, two-lane undivided road, classified as a Rural Local Road / Regional Distributor. Hopkinson Road has a speed limit of 90kph (SLK 0.00 - SLK 5.27), 70kph (SLK 5.27 - SLK 6.89), 60kph (SLK 6.89 - SLK 8.22) and 80kph (SLK 8.22 - SLK 8.42).

The following existing traffic volume information has been sourced from MRWA and the Shire of Serpentine - Jarrahdale.

Table 2 - Traffic Volumes for Roads Adjacent to the Subject Site

Road Name	Functional Classification / Road Hierarchy	Location of Traffic Count	Vehicles Per Day (VPD)	Vehicles per Peak Hour (VPH)	Heavy Vehicle %	Year	Legal Speed Limit
Hopkinson Road	Rural Local Road / Regional Distributor	North of Abernethy Road [SLK 5.53] *	7,760	AM 0730 - 600 PM 1645 - 728	8.7	Jul 2015	70kph
		300m South of Abernethy Road [SLK 5.23]	3,097	AM 08:00 – 251 PM 16:00 - 307	n/a	April 2015	90kph
Cardup Siding	Urban Local Road / Access Road	East of Hopkinson Road	552	AM 0700 - 38 PM 1600 - 67	n/a	Mar 2014	60kph
		West of Alice Road	594	AM 0800 - 43 PM 1700 - 63	n/a	Apr 2014	
Doley Road	Urban Local Road / Access Road	South of Abernethy Road	2,743	AM 08:00 - 232 PM 1600 - 239	n/a	June 2014	50kph
		300m North of Orton Road	164	AM 08:00 – 16 PM 16:00 - 14	n/a	April 2015	

Soldiers Road	Rural Local Road / Regional Distributor	South of Bishop Road [SLK 5.35]	2,051	AM 0800 - 217 PM 1500 - 232	n/a	Mar 2014	80kph
		South of Cardup Sidings [SLK 2.26]	2,268	AM 0800 - 244 PM 1500 - 245	n/a	Mar 2014	60kph
		300m South of Bishop Road [SLK 5.35]	2,012	AM 08:00 – 178 PM 15:00 - 214	n/a	April 2015	80kph
South Western Highway	Rural Highway / Primary Distributor	550m North of Abernethy Road [SLK 8.26]	13,835	AM 08:00 – 1,017 PM 16:00 – 1,242	n/a	April 2015	60kph
		250m South of Abernethy Road [SLK 8.26]	12,899	AM 08:00 – 916 PM 16:00 – 1,094	n/a	April 2015	
Abernethy Road	Rural Local Road / Access Road	East of Kargotich Road [SLK 5.34]	1,127	AM 07:00 – 95 PM 16:00 - 96	n/a	April 2013	80kph
	Rural Local Road / Regional Distributor	East of Soldiers Road [SLK 0.16]	7,086	AM 08:00 – 587 PM 15:00 - 687	n/a	Jun 2014	60kph
	Rural Local Road / Local Distributor	West of Hopkinson Road [SLK 3.41]	1,280	AM 08:00 – 116 PM 15:00 - 115	n/a	Jun 2014	80kph
		200 East of Briggs Road [SLK 1.61]	5,719	AM 08:00 – 486 PM 17:00 - 517	n/a	April 2015	60kph
		250m East of Hopkinson Road [SLK 3.41]	6,347	AM 08:00 – 473 PM 17:00 - 564	n/a	April 2015	60kph
Mead Street	Urban Local Road / Access Road	Near School	396	AM 08:00 – 41 PM 17:00 - 34	n/a	Jul 2013	50kph
Nettleton Road	Rural Local Road / Regional Distributor	East of South Western Highway [SLK 0.00]	1,897	AM 11:00 – 124 PM 15:00 - 177	n/a	Jun 2014	60kph
Orton Road	Rural Local Road / Local Distributor	300m East of Hopkinson Road	449	AM 08:00 – 36 PM 15:00 - 50	n/a	April 2015	50kph
Warrington Road	Rural Local Road / Local Distributor [0.00-0.28]	North of Orton Road [SLK 0.00]	309	AM 08:00 – 29 PM 15:00 - 33	n/a	Jun 2014	50kph
	Rural Local Road / Access Road [0.28-1.23]						

*Note * - This volume was obtained from MRWA.*

Formal peak hour data has been recorded and shown in Table 2. An analysis of available traffic data suggests:

Orton Road (300m East of Hopkinson Road):

- AM peak occurs in the period between 08:00-09:00. Traffic volumes in the AM peak are approximately 8.02% of total daily volumes; and
- PM peak occurs in the period between 15:00-16:00. Traffic volumes in the PM peak are approximately 11.14% of total daily volumes.

Once the project is completed the traffic network will change significantly. Peak hours are more likely to coincide with standard peak hours for outer laying suburbs. i.e. (AM peak – 07:30 – 08:30 and PM peak 17:00 – 18:00). The profile of the existing roads will be amended to suit sub-urban environment.

2.2.1 Crash Data

The following table shows a collation of crash data from the Main Roads WA database for crashes and incidents for roads adjacent to the subject site between the 1st January 2011 and 31st December 2015.

Table 3 - Crash Data

Road Name	Road Hierarchy	Functional Classification	Speed Limit	MR Type
Orton Road [8.43 – 10.65]	Local Distribution	Rural Local Road	50kph [8.43 – 10.65]	Total of 3 incidents: • 1 Hospital • 2 PDO Major MR Type: • 3 Other / Unknown
Doley Road [0.00 – 0.90]	Access Road	Urban Local Road	50kph	Total of 1 incident: • 1 PDO Major MR Type: • 1 Other / Unknown
Turner Road [0.00 – 1.11]	Local Distributer	Rural Local Road	50kph	Total of 2 incidents: • 1 PDO Major • 1 PDO Major MR Type: • 1 Involving Parking • 1 Other / Unknown
Hopkinson Road [3.14 – 5.53]	Regional Distributer	Rural Local Road	90kph [0.00 – 5.27] 70kph [5.27 – 6.89]	Total of 18 incidents: • 1 Fatal • 4 Hospital • 5 Medical • 7 PDO Major • 1 PDO Minor MR Type: • 1 Involving Overtaking • 1 Involving Animal • 16 Other / Unknown
Warrington Road [0.00 – 1.63]	Local Distributor [0.00-0.26]	Rural Local Road	50kph	Total of 6 incidents: • 2 Medical

	Access Road [0.28-1.63]			• 3 PDO Major • 1 PDO Minor MR Type: • 6 Other / Unknown
Soldiers Road [0.40 – 2.26]	Regional Distributor	Rural Local Road	60kph [0.00 – 0.72] 80kph [0.72 – 2.26]	Total of 6 incidents: • 1 Hospital • 1 Medical • 2 PDO Major • 2 PDO Minor MR Type: • 6 Other / Unknown

KCTT believe that this location does not raise outstanding safety concerns.

2.3 Traffic Modelling for the Proposed Development

This section provides a detailed description of how traffic volumes are calculated for the proposed development. Our traffic model uses a 4-step approach for the estimation of transportation demand into and out of the area:

- Step 1 - Confirm the size and quantum of the proposed land uses;
- Step 2 - Confirm how these land uses impact travel patterns and the generation / attraction of transportation trips;
- Step 3 - Confirm where the likely origins of travel external to the development are located and confirm the likely destinations for travel from the subject landholdings; and
- Step 4 - Distribute the traffic through the network.

The purpose of the Transport Impact Assessment is to determine the likely impact of the proposed development upon the local road network within an 800 metre radius of the Structure Plan Area.

2.3.1 Step 1 - Quantum of Proposed Land Uses

The subject site proposes usage of the landholdings for residential purposes complemented with a primary school and a neighborhood centre.

The WAPC Transport Assessment Guidelines for Developments (Volume 5) offers the following vehicle trip generation rates for the land uses proposed within the development: -

- **Residential** - 0.8 vehicular trips per dwelling for the AM and PM peak hours. An 20% IN/ 80% OUT split has been adopted for the AM peak and a 67% IN / 33% OUT split for the PM peak hour;
- **School -** The rates are based on data from the PARTS surveys that indicate that around 65% - 70% of students are driven to primary school, with an average occupancy of around 1.4 - 1.5 children per car. This equates to: 0.5 trips per child to school and 0.5 trips per child from school in each of the AM and PM peak hours. For secondary schools the PARTS data indicate that the proportion driven to school is generally a little lower but, to simplify the process of determining the level of assessment required and for the broad assessment of structure plans, it is suggested that the primary school rates be used for all schools.
- **Retail / Shopping Centres (with significant food retail component)** - 10 vehicular trips per 100m^2 of GFA for PM Peak and 2.5 trips per 100m^2 for the AM peak hour. A 50%IN / 50%OUT split has been adopted for the PM peak and an 80%IN / 20%OUT split for the AM peak hour.

Given that the WAPC does not offer daily vehicle trip generation rates for the land uses proposed within the development, the following rates are provided in the NSW RTA Guide to Traffic Generating Developments:

- **Residential** (dwelling houses) - 9 vehicular trips per dwelling;
- **Retail** (less than 10,000 m^2) - 121 vehicular trips per 100m^2 of GFA.

The NSW RTA Guide to Traffic Generating Developments suggests developments of this type in Sydney tend to generate between 4 and 5 vehicular trips per dwelling. In Perth, the Department of Planning and Infrastructure conducted a series of studies in the late 1990's / early 2000's which showed that higher density dwellings tended to average closer to 5.5 vehicle movements per day. These studies assumed that anywhere between 50% and 60% of commuters were travelling to the work by car as a driver. Therefore, KCTT propose to use a VPD of 5.5 vehicular trips per day per residence for R40.

KCTT believe that a rate of 6.7 vehicular trips per dwelling is suitable for the proposed residential land use R25.

Given that neither the WAPC Transport Assessment Guidelines for Developments nor the NSW RTA Guide to Traffic Generating Developments offer daily vehicle trip generation rates for the education related land-use proposed within the development, the following rates are provided from the ITE Common Trip Generation Rates (9th edition): -

- **Elementary School**
  - **Students:** 1.29 vehicular trips per day per student with 0.45 vehicular trips per student in AM peak hour and 0.15 vehicular trips per student in PM peak hour; A 55% IN/ 45% OUT split has been adopted for the AM peak and a 49% IN / 51% OUT split for the PM peak hour;
  - **Yield:** 15.43 vehicle trip per day per KSF[2] with 5.20 vehicular trips per AM peak hour and 1.21 vehicular trips per PM peak hour. A 56% IN/ 44% OUT split has been adopted for the AM peak and a 45% IN / 55% OUT split for the PM peak hour;
  - **Employees:** 15.71 vehicular trips per day per employees with 5.33 vehicular trips per AM peak hour and 1.76 vehicular trips per PM peak hour; A 54% IN/ 46% OUT split has been adopted for the AM peak and a 49% IN / 51% OUT split for the PM peak hour.

The following table outlines the traffic generation of the proposed development based on the above rates.

Table 4 - Traffic Generation of the Proposed Development

Land Use	Yield	WAPC Transport Assessment Guidelines for Developments / NSW RTA Guide To Traffic Generating Developments Requirement / ITE Common Trip Generation Rates (9th edition	Total VPD	Total VPH
Assumed LSP Boundary				
Residential - Traditional Lots (Assume R25)	887 Lots	6.7 vehicle trips per lot (daily traffic); 0.8 vehicle trips per lot (AM / PM Peak)	3,863 (5,943*)	462 (710*)
Residential Compact lots (Assume R40)	764 Lots	6.0 vehicle trips per lot (daily traffic); 0.8 vehicle trips per lot (AM / PM Peak)	2,980 (4,584*)	397 (611*)
Residential - Cottage Lots (Assume R60)	742 Lots	5.5 vehicle trips per lot (daily traffic); 0.8 vehicle trips per lot (AM / PM Peak)	2,653 (4,081*)	386 (594*)
Neighbourhood Centre	2,914m^2 NLA	121 vehicular trips per 100m^2 of NLA (daily traffic); 10 vehicular trips per 100m^2 of NLA (PM Peak) and 2.5 trips per 100m^2 (AM peak)	3,526	291

Primary School	700 students	1.3 vehicle trips per child (daily traffic); 0.5 vehicle trips per child (AM / PM Peak)	910	350
Total - The Proposed Development (Assumed LSP Boundary)			**13,931 (19,044*)**	**1,886 (2,556*)**

*Note * - The number in brackets ( ) represents the cumulative value without reciprocity for complementary purposes (ie. Retail – residential, education – residential etc). It is expected that future residents will complete 60% of their shopping and 40% of their trips for socialisation purposes internally to the suburb. Furthermore it is expected that the proposed Neighbourhood Centre will provide some employment opportunities. Approximately 40% of the traffic generated by the proposed residential land use for education purposes will directed towards the proposed Primary School. Taking all of these factors into account, KCTT believe that the cumulative traffic volume generated by the proposed residential land use should be minimised by 35% in order to get a more realistic impact on the road network.*

In summary we believe that, the proposed development is expected to generate approximately up to 14,000 vehicular movements per day with a forecasted impact of around 2,000 vehicles per hour in the peak hour upon completion.

2.3.2 Step 2 - Trip Purposes

To understand the likely demand for alternative transportation modes (including public transportation trips; cyclist and pedestrian trips; and the impact of the vehicular traffic on the adjacent road network, it is important to understand why people are travelling into and out of the Structure Plan Area. These general trip purposes include employment, shopping, social, education and other general purposes. Each land usage will generate / attract a unique matrix of trip purposes. For example, the following table shows the likely percentage share for different trip purposes based on the land usage: -

Table 5 - Trip Purposes by Land Use

Land Use Type	Employment	Shopping	Education	Social / Recreational
Residential	40%	25%	17.5%	17.5%
Neighbourhood Centre	10%	60%	n/a	30%
Primary School	20%	n/a	80%	n/a

2.3.3 Step 3 - Expected Origin / Destination

The expected origin / destination matrix is important to determine the likely route of vehicular and other travel. Table 6 (below) describes the expected trip purposes for trips generated / attracted by the proposed land uses within the Structure Plan Area and the likely destinations.

Table 6 - Table of Trip Purposes and Likely Destinations

Land Use Type	Trip Purpose	Likely Destination
Residential	• Employment	The 2011 population for Shire of Serpentine - Jarrahdale is 17,746, with a population density of 0.20 persons per hectare. Land area of Shire of Serpentine - Jarrahdale is 90,534 hectares (905 Km^2), and approximately 2,500 people are employed. The economic profile in the Shire of Serpentine - Jarrahdale provides the information for National Growth Areas Alliance (NGAA) not the Shire of Serpentine Jarrahdale itself. In 2011, of 796,548 people who worked in the National Growth Areas Alliance (NGAA), 527,029 or 66.2% also lived in the area, and other 33.8% lived in the area but worked outside. Therefore, the majority of employment trips will be external to the proposed Structure Plan Area. Given that the Shire of Serpentine - Jarrahdale i.d. website does not suggest a breakdown for employment destinations for residents, KCTT have determined the following breakdown based on the i.d. for the surrounding councils: • Armadale - 1,053 people - 42% • Canning - 707 people - 28% • Rockingham - 297 people - 15% • Kwinana - 248 people - 10% • Other - 5% (http://profile.id.com.au/ngaa/about?WebID=300) The Shire of Serpentine - Jarrahdale is served by: • Albany Highway, • South Western Highway, • Tonkin Highway and • Perth-Bunbury railway line. Excluding work from home, the likely source of employment in this Structure Plan Area is the proposed Neighbourhood Centre and Primary School (assumed 700 students).
	• Shopping	• Assume 60% of all trips for shopping purposes to the proposed Neighbourhood Centre and 40% of shopping trips will be external to the proposed Structure Plan Area. • Supermarket is located approximately 2km to the north-east of the subject area.
	• Education	• Assume 40% of all trips for education purposes to the proposed Primary School and 60% of education trips will be external to the proposed Structure Plan Area. • West Byford Primary School is located approximately 2.2km to the north-west of the subject area. • Byford Primary School is located approximately 2km to the north-east of the subject area. • Byford Secondary College is located approximately 1.5km to the north of the subject area.

		• Byford John Calvin School is located approximately 1.5km to the north-east of the subject area.
	• Social / Recreational	• Assume 40% of all trips for social purposes to the proposed Neighbourhood Centre and 60% of social trips will be external to the proposed Structure Plan Area. • Southgate Church, Recreation Centre and Playing Field are located 400 meters to the north of the subject area. • Brickwood Reserve is in immediate vicinity of the subject area to the east. • Cardup Nature Reserve is located 800 meters to the south of the subject area. • Cohunu Koala Park is located 800 meters to the east of the subject area. • Byford Trotting Complex is located 2,000 meters to the north of the subject area.
Neighbourhood Centre	• Employment	• The Neighbourhood Centre is not expected to be a large attractor for employment purposes.
	• Shopping / Social	• At this point the full range of uses that will be located within the Neighbourhood Centre has not been determined. Therefore, the Neighbourhood Activity Centre is treated as retail premises for the purposes of this report.
Primary School	• Employment	• The Primary School is not expected to be a large attractor for employment purposes.
	• Education	• The Primary School is expected to be a strong attractor for Education purposes.

2.3.4 Step 4 - Destination Matrix and Distribution of Traffic / Transport

Land uses can be generally classified as trip generators and / or trip attractors. Given the nature of the development, the Structure Plan Area will generate approximately 90% of its trips from internal sources and attract around 10% of its trips to internal sources. The Structure Plan area will be accessed via existing roads including Orton Road to the south, Doley Road to the west, Perrone Avenue, Allanson Drive, Partridge Bend, Halliday Road, Dearden Road and Lawrence Way to the north and Warrington Road, Turner Road, Soldiers Road to the east.

In summary, the proposed development is expected to generate approximately up to **14,000 vehicular movements per day** with a forecasted impact of around **2,000 vehicles per hour in the peak hour** upon completion.

Taking into consideration the breakdown for the typical residents' locations of work in the Shire of Serpentine - Jarrahdale (refer the Shire of Serpentine - Jarrahdale ID profile above), and the locations of the nearest shopping centres, schools and recreational centres, KCTT believe that the traffic from the proposed Structure Plan Area will be distributed into the adjacent road network as follows:

- 30% to / from the northeast via Soldiers Road - 0.30*14,000= 4,200 VPD;
- 10% to / from the southwest via Soldiers Road - 0.10*14,000 = 1,400 VPD;
- 19% to / from the north via Doley Road - 0.19*14,000 = 2,660 VPD;
- 6% to / from the south via the future road (Doley Road Extension) - 0.06*14,000 = 840 VPD
- 10% to / from the north via Warrington Road - 0.10*14,000 = 1,400 VPD;
- 3% to / from the north via Lawrence Way - 0.03*14,000 = 420 VPD;
- 16% to / from the west via Orton Road - 0.16*14,000 = 2,240 VPD.

- 6% to / from the west via Perrone Avenue - 0.03*14,000 = 420 VPD

Table 7 below considers the traffic generation from the proposed development of the Doley Road, Byford and its impact upon the road network adjacent to the Structure Plan Area.

Table 7 - Forecasted Traffic Volumes on Existing Roads adjacent to the Structure Plan Area

Road Name	Location of Traffic Count	Existing Traffic Volumes (VPD)	Estimated traffic growth at the rate of 3% per annum - 2026 (VPD)	Estimated traffic growth at the rate of 3% per annum - 2036 (VPD)	Traffic generated by the development site (VPD)	Total VPD (2036)
Doley Road	300m North of Orton Road	164 (2015)	226	303	2,885	3,188
Soldiers Road	South of Cardup Sidings [SLK 2.26]	2,268 (2014)	3,224	4,320	3,464	7,784
Orton Road	300m East of Hopkinson Road	449 (2015)	620	831	5,089	5,920
Warrington Road [SLK 0.00]	North of Orton Road	309 (2014)	439	588	1,655	2,243

Plans with the estimated vehicular traffic flow and distribution are shown in Appendix 2 (KC00400.000_S08a, KC00400.000_S08b and KC00400.000_S08c).

2.4 Vehicular Access and Parking Requirements

The Structure Plan area will be accessed via existing roads including Orton Road to the south, Doley Road to the west, Perrone Avenue, Allanson Drive, Partridge Bend, Halliday Road, Dearden Road and Lawrence Way to the north and Warrington Road, Turner Road, Soldiers Road to the east.

The Shire of Serpentine - Jarrahdale Town Planning Scheme No 2 stipulates that parking provisions should be made in accordance with the following ratios and rates (Table V - Parking Requirements):

- **Residential -** As per R Codes
- **Primary School -** 1.25 spaces per classroom;
- **Shop** - 1 space per 15 square metres gross leasable area;
- **Shopping Centre -** 1 space per 12.5 square metres gross leasable area.

Using Table V - Parking Requirements, The Shire of Serpentine - Jarrahdale Town Planning Scheme No 2, we have determined the car parking requirements as shown below: -

Table 8 - Vehicle Parking Requirements (The Shire of Serpentine - Jarrahdale Town Planning Scheme No 2)

Land Use	Yield	Requirement	Total
Residential - Traditional Lots R25	887 Lots	As per R Codes	-
Residential Compact lots (Assume R40)	764 Lots		-
Residential - Cottage Lots	742 Lots		-
Neighbourhood Centre	3,691m^2 GLFA	1 space per 12.5 square metres gross leasable area	295

Primary School	Assume 700 students and 70 staff / 28 classrooms	1.25 spaces per classroom	35
Total - The Proposed Development			**330**

In accordance with the Shire of Serpentine - Jarrahdale Town Planning Scheme No 2 the approximate number of parking bays required is 330. This should be assessed in greater detail once individual development applications are submitted.

On street parking should be considered particularly in the area surrounding Public Open Space. KCTT believe that every house will have their own garage, providing parking for the owner in the garage and visitors in front of garage.

The parking requirements and vehicular access requirements for the proposed landholdings within the Structure Plan Area will be examined in detail as the Structure Planning process continues, and as specific Development Applications are provided for each of the proposed allotments within the Structure Plan Area.

2.4.1 Bicycle Parking

The Shire of Serpentine - Jarrahdale Local Planning Policy No 58 offers guidance on the requirements for bicycle parking provision for the land uses proposed within the subject site. The Table Schedule 1 - Bicycle Parking Requirement stipulates that bicycle parking provisions should be made in accordance with ratios as shown in the table below.

Table 9 - Bicycle Parking Requirements (Shire of Serpentine - Jarrahdale Local Planning Policy No 58, Schedule 1 - Bicycle Parking Requirement)

Land Use	Yield	Minimum required		No of Parking Spaces	Preferred		No of Parking Spaces
		Long Term parking (Employee/Resident Spaces)	Short Term Parking (Visitor/Shopper Spaces)		Long Term parking (Employee/Resident Spaces)	Short Term Parking (Visitor/Shopper Spaces)	
Residential - Traditional Lots (Assume R25)	887 Lots	-	-	0	2 spaces	Within private courtyard	0 (1,774)
Residential Compact lots (Assume R40)	764 Lots	-	-	0	2 spaces	Within private courtyard	0 (1,528)
Residential - Cottage Lots (Assume R60)	742 Lots	-	-	0	2 spaces	Within private courtyard	0 (1,484)
Neighbourhood Centre	2,914m^2 NLA	1 space per 300m^2 sales floor	1 space per 500m^2 sales floor	10+6	1 space per 100m^2 NLA	1 space per 500m^2 NLA	29+6
Primary School	Assume 700 students and 70 staff	1 space per 5 students over Year 4	1 space per 50 full time students	60+14	1 space per 8 staff members	2 space per 5 students over Year 4	9+120
Total - The Proposed Development				**90**			**164 (4,950)**

A total of **164 bicycle parking spaces** are therefore considered appropriate and preferred if the Shire of Serpentine - Jarrahdale standards are utilised on this site after the completion of the proposed development (Assumed LSP Boundary).

It is most likely that with the Neighbourhood Centre, the utilisation of bicycles within the subject site will be more viable and attractive to residents. Cycling is further promoted through a network of shared paths connecting all residential areas to the main attractors.

To support cycle planning, effective bicycle parking facilities would be required at all "end of trip" destinations. For residential land use, adequate space for storage of bicycles is available within each of the proposed dwellings. The focus in residential areas is to provide suitable infrastructure within road reserves that promotes safe and efficient cycling.

2.4.2 ACROD Parking

The commercial component of the subject development can be classified as Class 6 while the Primary School can be classified as 9b according to the Australian Building Code and requires provision for the minimum number of ACROD bays as follows:-

Class 6 - (*A shop or other building for the sale of goods by retail or the supply of services direct to the public. Example: café, restaurant, kiosk, hairdressers, showroom or service station)*:

- Up to 1,000 carparking spaces - 1 ACROD bay for every 50 carparking spaces and 1 ACROD bay for each additional 100 carparking spaces or part thereof in excess of 1,000 carparking spaces.

Class 9b - *(An assembly building, including a trade workshop, laboratory or the like, in a primary or secondary school, but excluding any other parts of the building that are of another class)*:

- School - 1 ACROD bay for every 100 carparking spaces or part thereof.
- Other assembly building -
  - Up to 1,000 carparking spaces - 1 ACROD bay for every 50 carparking spaces or part thereof and 1 ACROD bay for each additional 100 carparking spaces or part thereof in excess of 1,000 carparking spaces.

These requirements will be reviewed as part of the respective Development Applications for each of the sites.

2.5 Provision for Delivery and Service Vehicles

It is expected that the delivery and service vehicles (such as waste removal vehicles) servicing the residential area will not require designated parking space given that they can operate safely within the road reserve.

Service and delivery vehicles for the neighbourhood centre and the primary school will require appropriate parking allocated on site. The crossover should be designed to accommodate movement of service vehicles as a minimum.

2.6 Hours of Operation

The majority of land uses within the Structure Plan Area are residential; however, some proposed landholdings in the Structure Plan Area are likely to influence morning and afternoon peak trip attractions in the future.

It is likely that AM and PM peaks will coincide with journey to / from work times. As such morning and afternoon peaks are likely to be between 7:30 – 8:30 and 17:00 - 18:00 during work days.

The exact hours of operation for the Neighbourhood Activity Centre will be determined once the range of uses within the Centre becomes known. However, it is reasonable to expect that the Centre will be operational between 8:00 to 20:00 with peak usage in weekday evenings and on Saturdays and it is likely peaks from 11:00 to 12:00 and from 18:00 to 19:00 Mondays to Fridays.

The Primary School is expected to be operational from 08:00 to 16:00. The expected peak usage of the facility will be between 08:15 - 09:15 in the AM peak and between 14:45 - 15:45 in the PM peak. It is expected that this land use will be operational on weekdays only.

2.7 Management of Traffic Generated by the Structure Plan Area

Structure Plan area will be accessed via existing roads including Orton Road to the south, Doley Road to the west, Perrone Avenue, Allanson Drive, Partridge Bend, Halliday Road, Dearden Road and Lawrence Way to the north and Warrington Road, Turner Road, Soldiers Road to the east.

In 2012 a Community Working Group (CWG) was established in order to identify options to extend Tonkin Highway beyond Thomas Road in Byford. Several options for the proposed alignment were considered. At this stage the preferred alignment will see Tonkin Highway aligning with Hopkinson Road.

The official Planning Western Australia website states the following:

Tonkin Highway currently only extends as far south as Thomas Road in Byford and it is anticipated to extend Tonkin Highway to access South-western Highway near Mundijong as traffic increases on the existing South-western Highway between Byford and Mundijong. This is the major north - south route through the area and there are still many traffic signalised intersections that will ultimately need to be grade separated. The extent and rate of these traffic increases will largely be dictated by urban development in both the Byford and Mundijong areas. Constructed as a four-lane controlled access road to Thomas Road. There is a road reservation from Thomas Road to Mundijong Road at which point it is planned that Tonkin Highway will then link into the South-Western Highway. Options for the extension of the Tonkin Highway require investigation.
(http://www.planning.wa.gov.au/dop_pub_pdf/plan_Outer_Metro_Perth_Peel_Part4.pdf)

Although this project is in planning phase, MRWA considers it a long term project given it is not in any of the existing scopes and forward estimates (this was confirmed via email on 05.01.2016).

Once Tonkin Highway extension is completed, a full interchange with Orton Road is planned. This interchange will greatly improve the connectivity of the area. However, given the uncertainty over the timeframes for completion, we have conducted the analysis of the select number of intersections in both scenarios (with and without interchange).

2.7.1 Forecasted Traffic Volumes on the Proposed Roads within the Structure Plan Area

The following table shows the forecasted traffic volumes on the proposed roads within the Structure Plan Area as well as the Proposed Road Cross Sections. Please note that those Road Cross Sections show minimal required dimensions and road classifications from the traffic consultant's perspective.

Table 10 - Forecasted Traffic Volumes on the Proposed Roads within the Structure Plan Area

Road Name	Classification	Recommended Cross Sections	Projected Traffic volumes for 2036 (VPD)	Forecast Vehicles per PM Peak Hour (VPH)
Orton Road (this road can be classified as Integrator B* or Neighbourhood Connector A)	Neighbourhood Connector A	*In this phase of the development road reservation of Orton Road will be widened from 20m to 25m as an interim solution.* 2x7.1m wide pavement (inclusive of parking and bicycle lanes) in 25m wide reservation.	7,000	700
Doley Road	Neighbourhood Connector A	2x7.1m wide pavement (inclusive of parking and bicycle lanes) in 24.4m wide reservation (road reservation is likely to be widened for tree retention purpose)	4,000	400
Allanson Drive *(Future road by others)*	Access Street B	9.7m wide pavement (inclusive of on street parking) in 17.9m wide reservation (road reservation is likely to be widened for tree retention purpose)	1,800	180
Lawrence Way**	Neighbourhood Connector B	2x5.6m (inclusive of on street parking) wide pavement in 19.4m wide reservation	2,600	260
Warrington Road	Neighbourhood Connector A	2x7.1m wide pavement (inclusive of parking and bicycle lanes) in 24.4m wide reservation (*existing road reservation is approximately 20m wide)	4,000	400
Turner Road	Neighbourhood Connector A	2x7.1m wide pavement (inclusive of parking and bicycle lanes) in 24.4m wide reservation (*existing road reservation is 30m wide - around 525m long section of road northeast of Warrington Road and 20m wide – around 565m long section of road southwest of Soldiers Road)	2,500	250
Soldiers Road	Neighbourhood Connector A	2x8.2m wide pavement (inclusive of parking and bicycle lanes) in 30.0m wide reservation (*existing road reservation is 30m wide - around 700m long section of road south of Bateman Street and around 125m north of Bateman Street; and 20m wide - the above section excluded)	10,500	1,050
Road 15	Access Street D	6m wide pavement in 14.2m wide reservation	700	70
Road 20	Access Street D	6m wide pavement in 14.2m wide reservation	600	60
Road 24 [below 27]	Access Street D	6m wide pavement in 14.2m wide reservation	600	60

Road 27	Neighbourhood Connector B *Potential bus route*	2x5.6m (inclusive of on street parking) wide pavement in 19.4m wide reservation	1,300	130
Road 49			3,000	300
Road 41	Access Street D	6m wide pavement in 14.2m wide reservation	500	50
Road 47	Access Street C	7.2m wide pavement in 15.4m wide reservation	1,500	150
Road 48	Access Street D	6m wide pavement in 14.2m wide reservation	700	70
Road 62	Access Street D	6m wide pavement in 14.2m wide reservation	315	32
Road 72	Access Street D	6m wide pavement in 14.2m wide reservation	600	60
Road 74	Access Street D	6m wide pavement in 14.2m wide reservation	280	28

*Note *- Orton Road can be classified as Neighbourhood Connector A in interim and as Integrator B once the development of adjoining properties is completed. In its final configuration Orton Road could have 2x8.2m wide pavement (inclusive of bicycle lanes) in 32.0m wide road reservation.*
*Note ** - We believe that projected traffic volumes on Lawrence Way do not warrant classification of this road as a Neighbourhood Connector A, therefore we have chosen Neighbourhood Connector B as the appropriate classification.*

All roads have been classified in accordance with the current Liveable Neighbourhoods. Road reservations that are shown in the table above represent the minimum required (according to Liveable Neighbourhoods) to accommodate traffic requirements. The road reservations can be further expanded to take into account drainage requirements, tree retention etc. (Doley Road, Allanson Drive, Road 07, Road 20, Road 27, Road 47 etc.).

Roads that were not mentioned in the table can be classified as Access Street D or Access Street C. Soldiers Road is classified as Neighbourhood Connector A (as a minimum) because it will be one of the main north-south connectors in the future when surrounding areas are built.

This traffic flow has been distributed in accordance with the Paramics modelling completed by KCTT.

KCTT have developed a high-level Paramics Model suitable for use in Local Structure Plan submissions of this scale and size. The proposed roads were classified and sized to cater for the expected traffic volumes. Key intersections were analysed in more detail. Years 2026 and 2036 were taken as assessment years. The intersections are expected to perform to a satisfying level.

The proposed road hierarchy plan has been provided in Appendix 2 of this report, while results of SIDRA analysis were provided in Appendix 3.

2.7.2 Cross Sections within the Structure Plan Area

All roads internal to the Structure Plan Area will have less than 3,000 VPD generated by the subject development. However, the traffic assessment was completed with all of the surrounding developments accounted for (The Glades) while the passing traffic on the existing roads was derived utilising 3% annual growth rate (for 2026 and 2036). KCTT proposes the following road classification for the existing and proposed roads:

- **Integrator B** – activity centre main street; 2x8.2m (inclusive of parking and bicycle lanes) in 32m wide reservation for Orton Road final configuration, a future Other Regional Road;
- **Neighbourhood Connector 'A'** - 2x7.1m wide pavement (inclusive of parking and bicycle lanes) in 24.4m wide road reservation (25m wide reservation for interim Orton Road according to Shire of Serpentine-Jarrahdale, and 2x8.2m in 30m wide reservation for Soldiers Road);
- **Neighbourhood Connector 'B'** – 2x5.6m (inclusive of on street parking) wide pavement in 19.4m wide reservation;
- **Access Street B** – 9.7m wide pavement (inclusive of on street parking) in 17.9m wide reservation;
- **Access Street C** – 7.2m wide pavement in 15.4m wide reservation;
- **Access Street D** – 6m wide pavement in 14.2m wide reservation,
- **Laneway** - 6m wide pavement in 6.0m wide reservation.

The following figures show the typical cross-sections within the proposed development.

Figure 1 - Integrator B

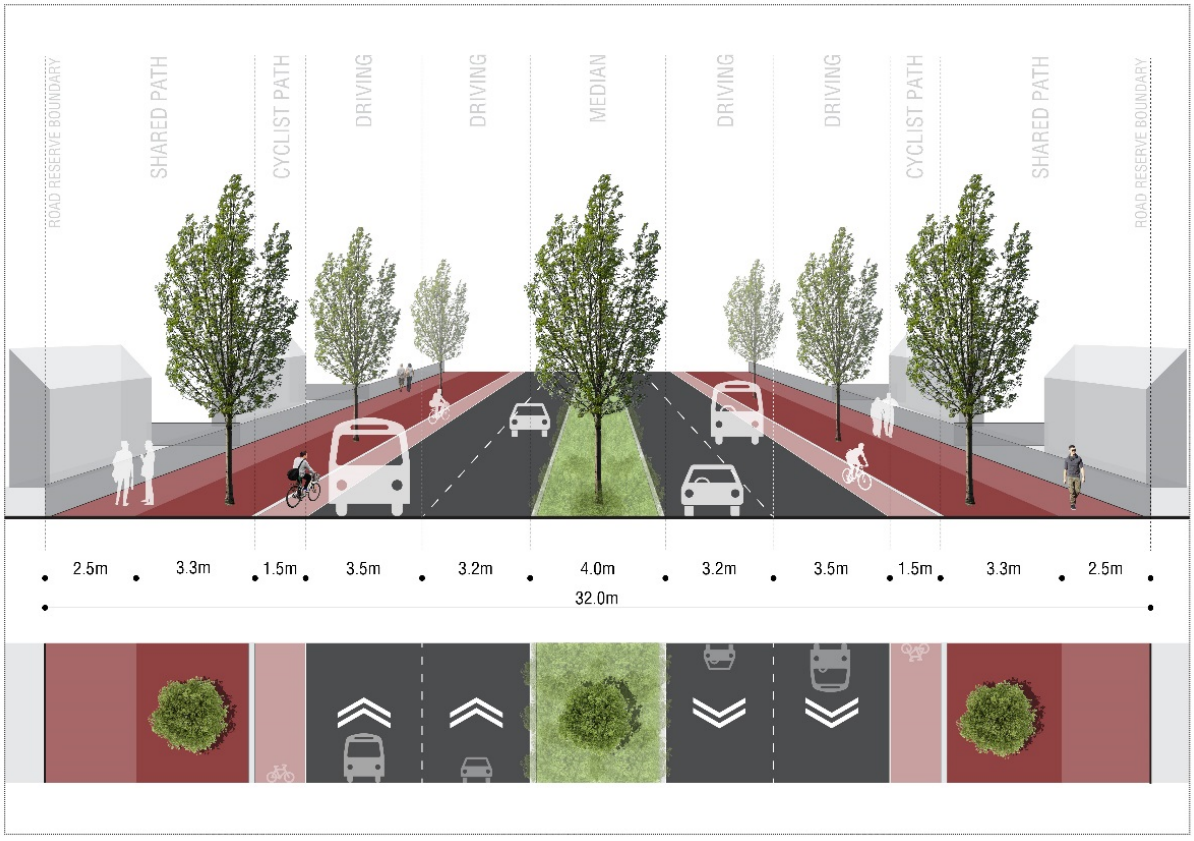


Figure 2 - Neighbourhood Connector 'A' modified - Orton Road – interim solution

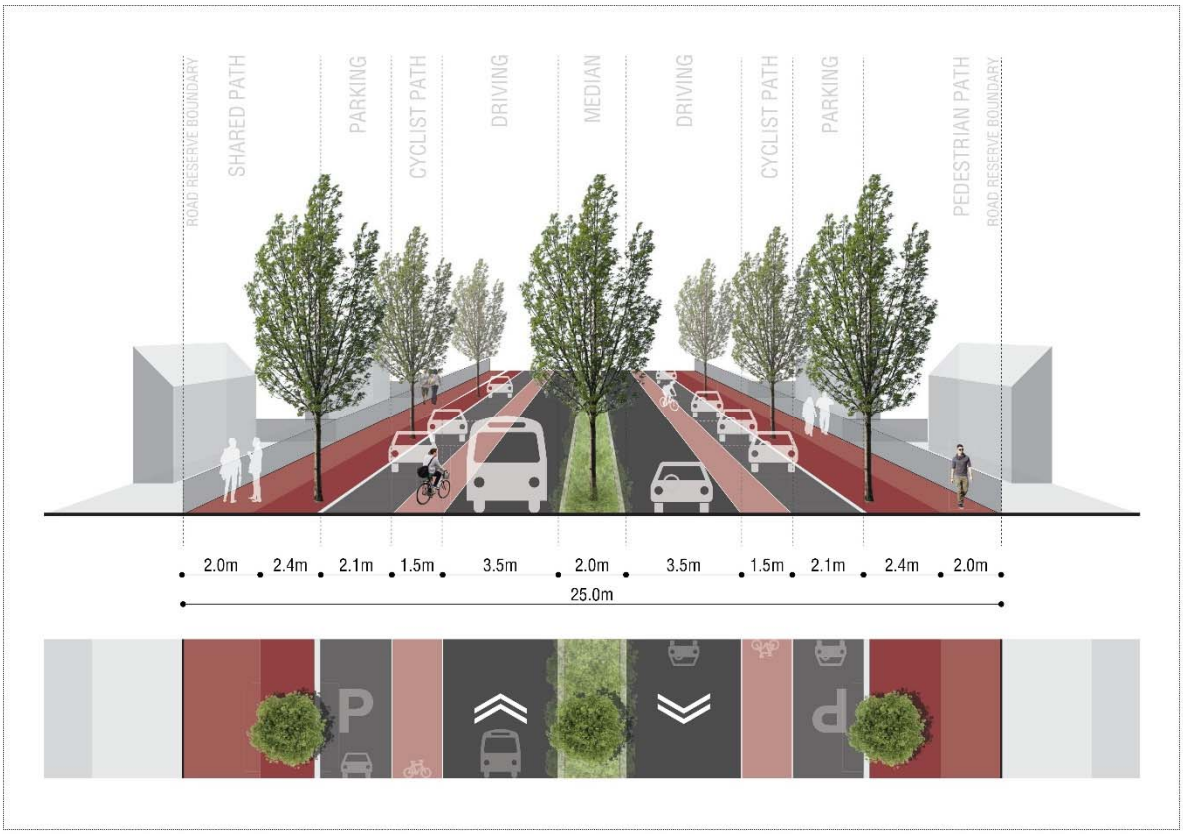
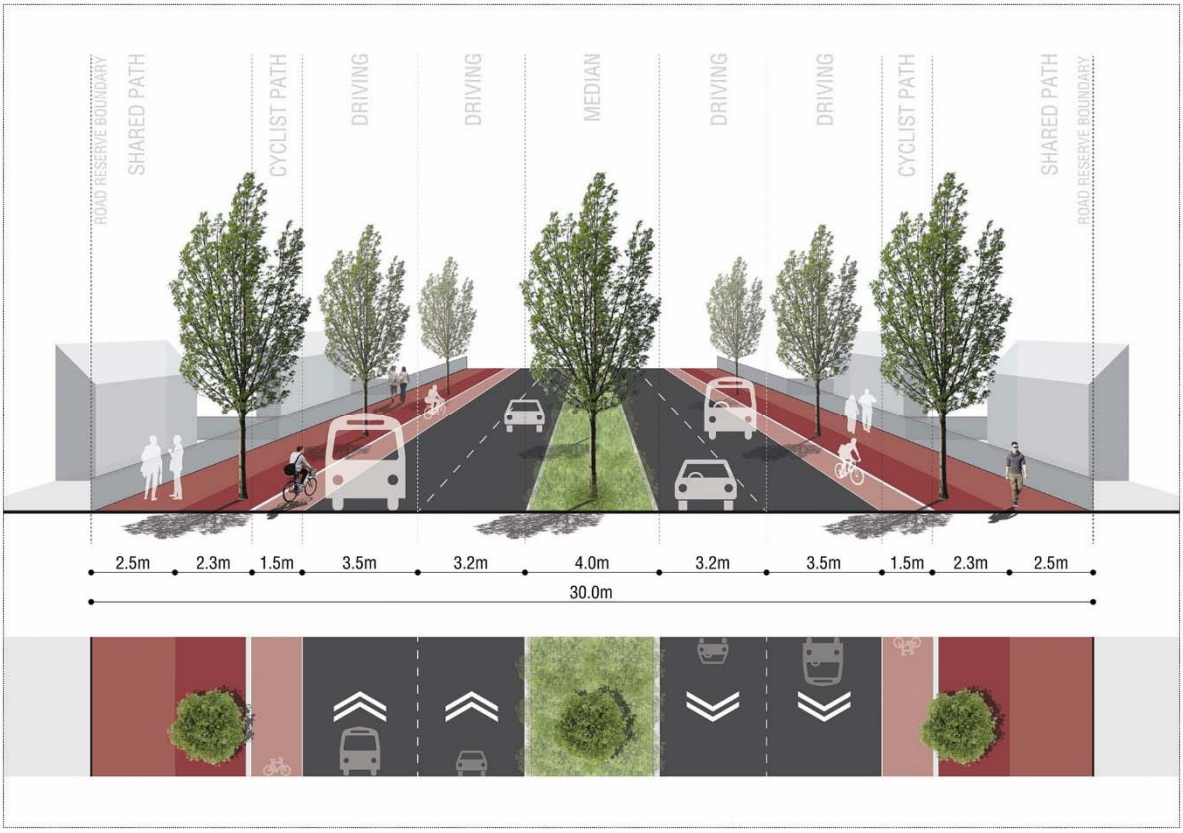


Figure 3 - Neighbourhood Connector 'A'



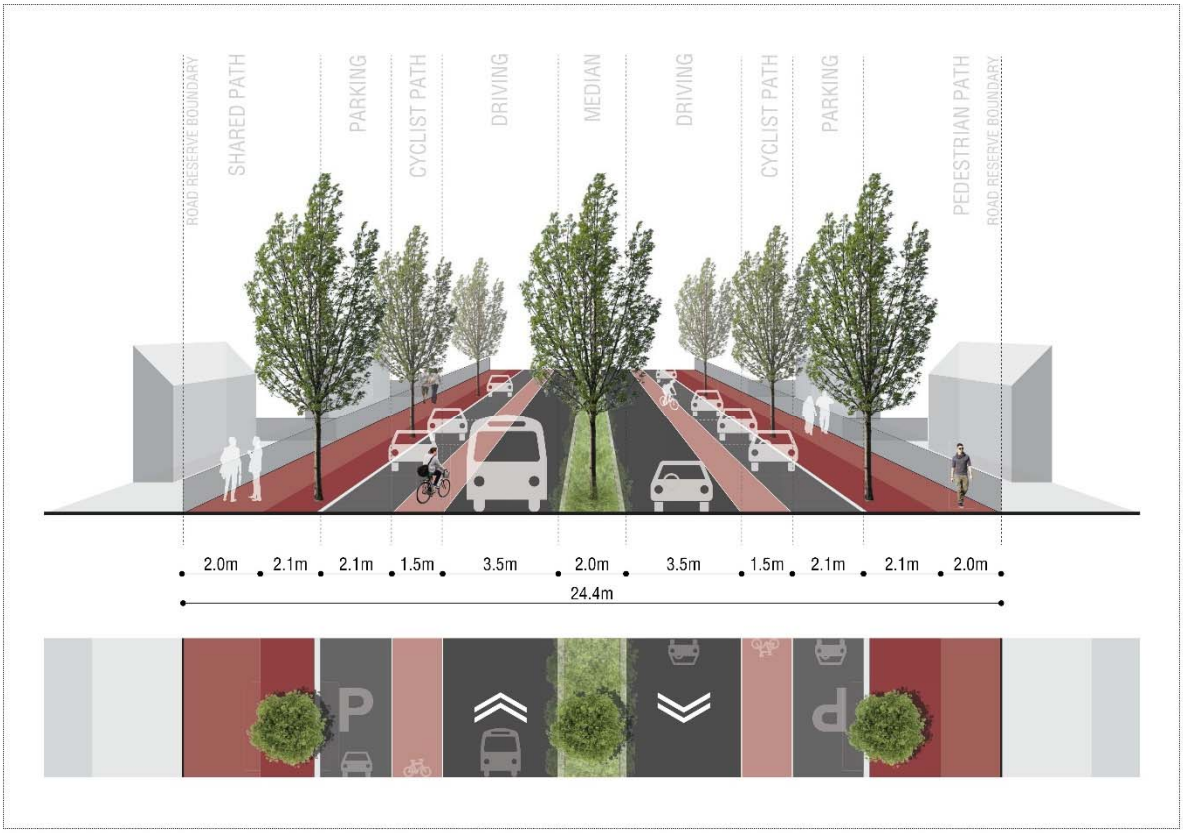


Figure 4 - Neighbourhood Connector 'B'

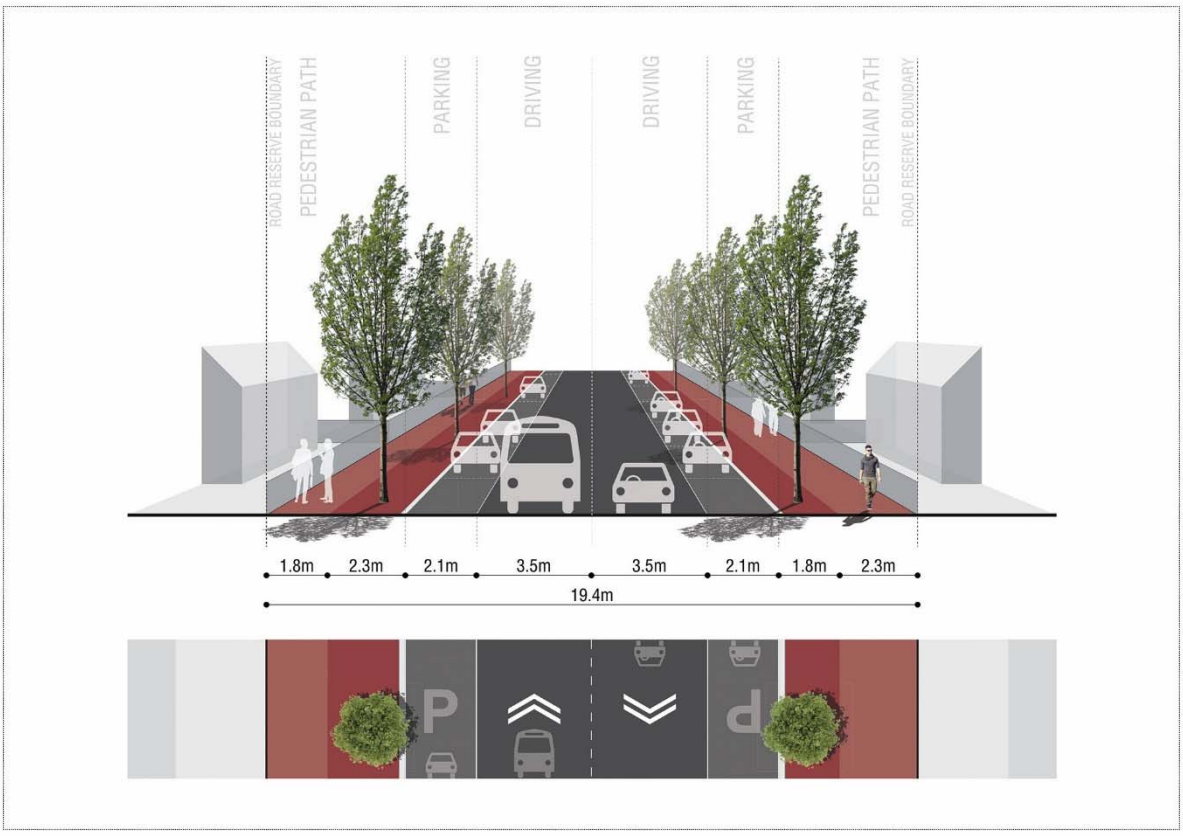


Figure 5 - Access Street B

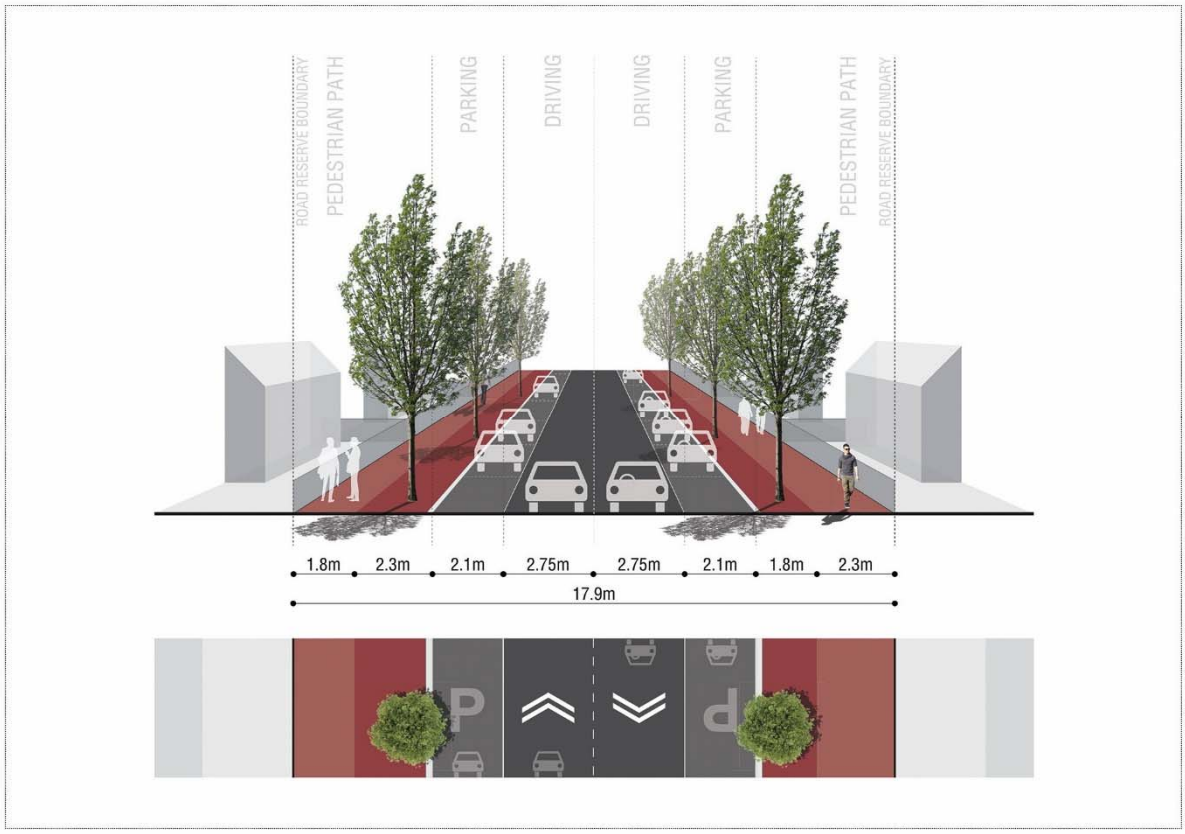


Figure 6 - Access Street C

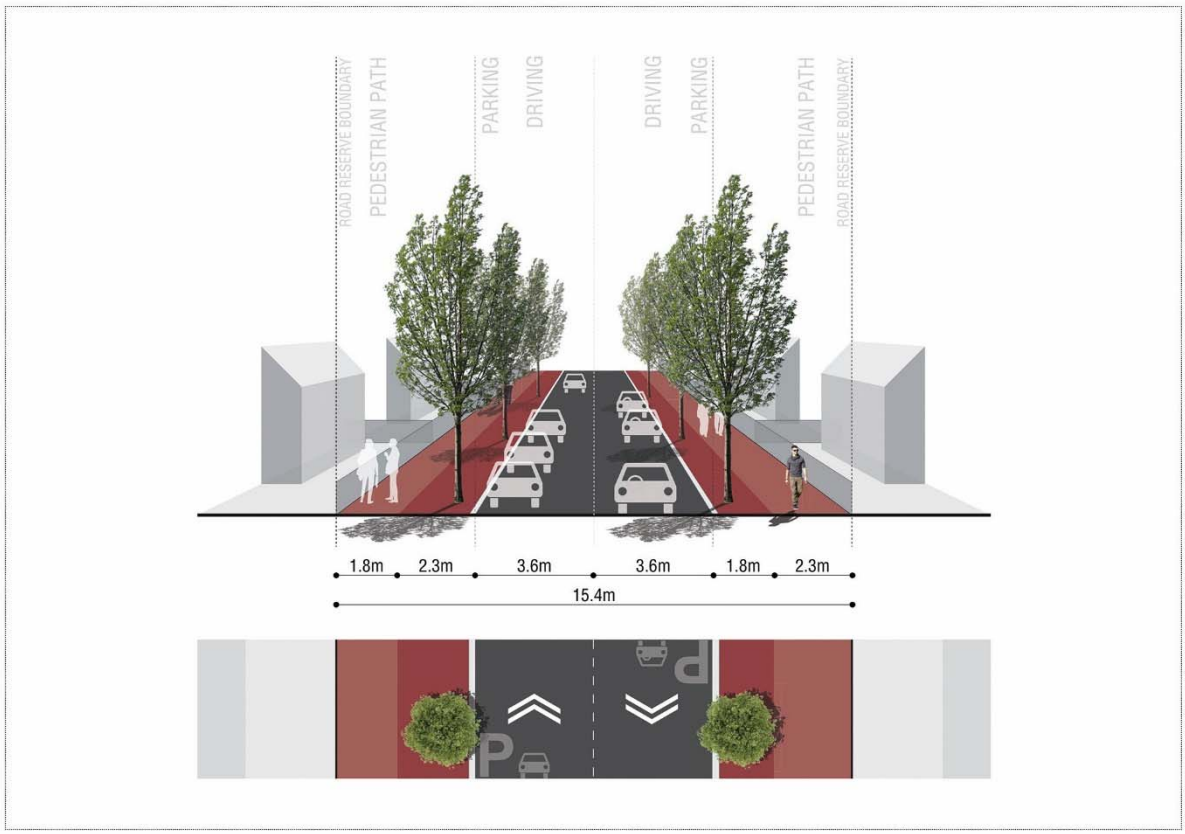


Figure 7 - Access Street D

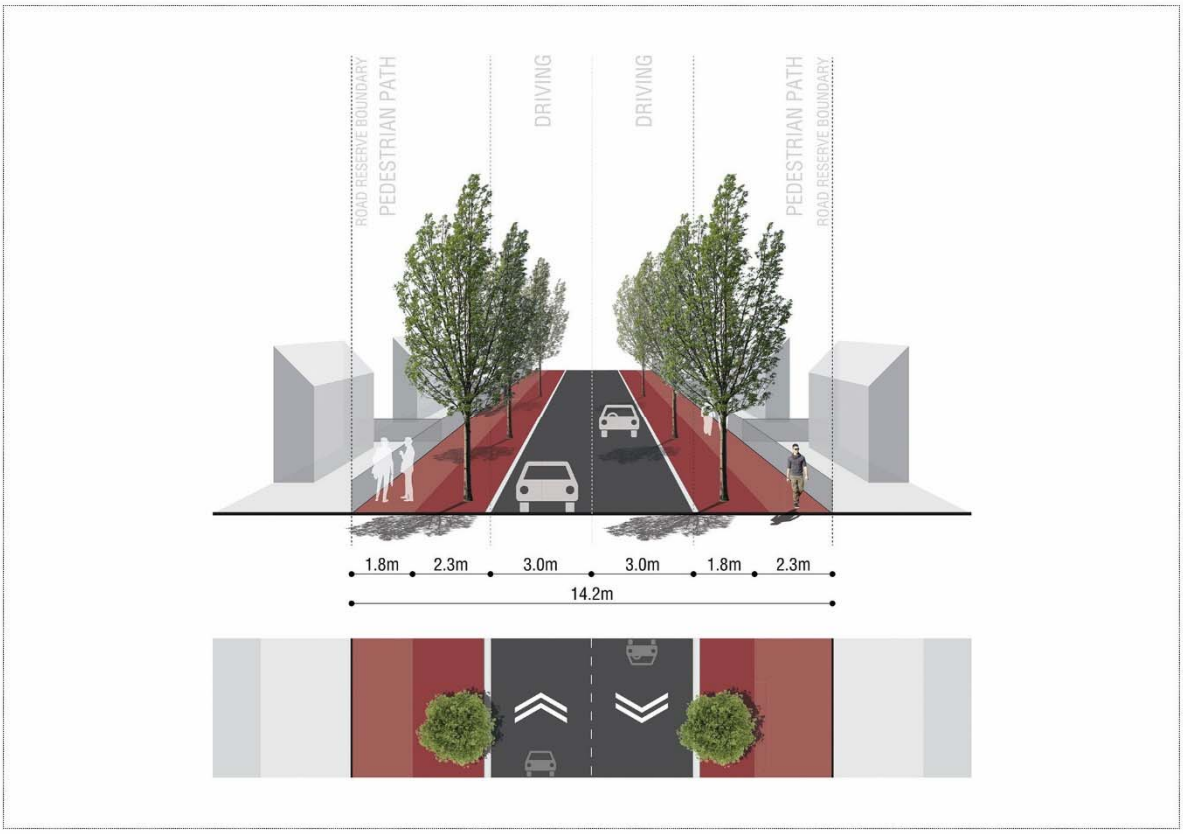
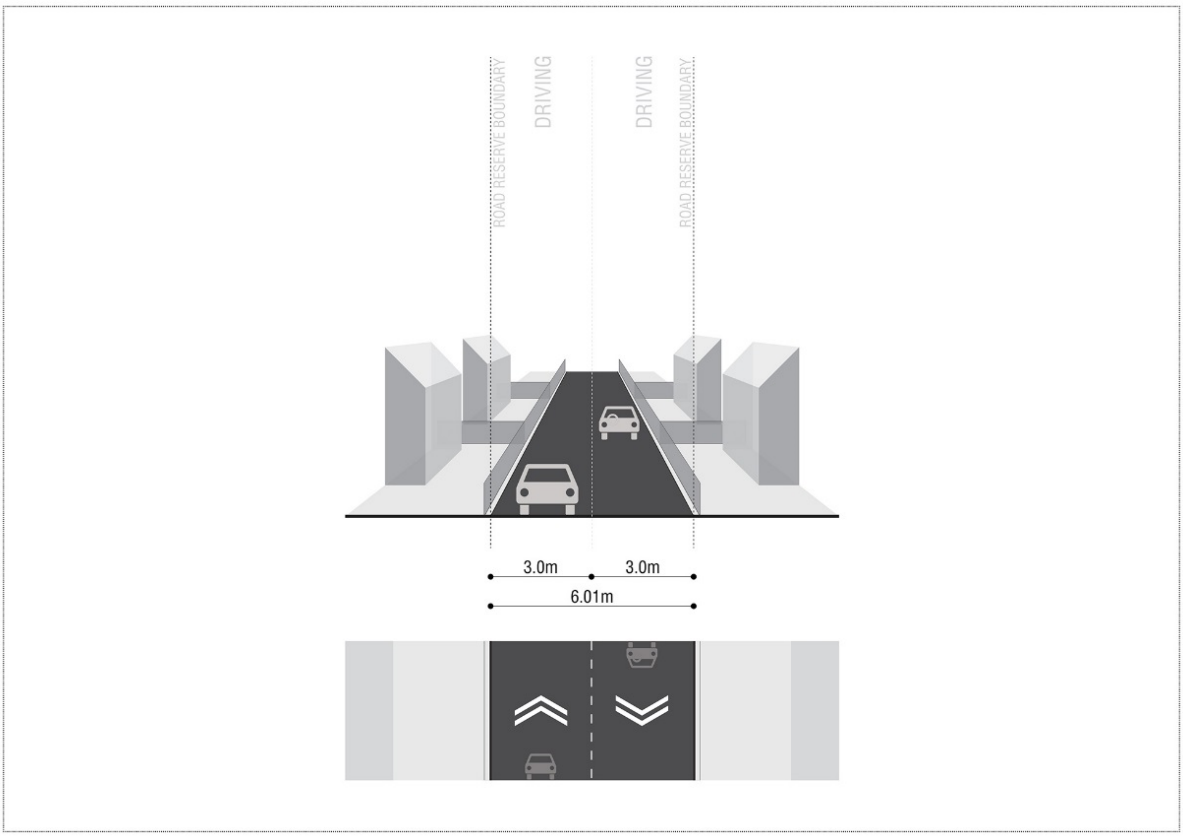


Figure 8 - Laneway



For the roads abutting the P.O.S, the road reservation widths will be reduced by 1 metre on the P.O.S. side of the road reservation.

All roads classified as Access Street D within the proposed Structure Plan Area will have standard footpaths on one side of the road only, while roads which provide a higher function will have dual use paths on one side of the road and standard footpaths on the other.

2.7.3 Proposed Intersection Controls

The following is the list of the proposed intersection configurations: -

- Doley Road / Allanson Drive / Perrone Avenue (roundabout);
- Doley Road / Road 11 / Road 27 (roundabout);
- Doley Road / Orton Road / Road 35 [North] (roundabout);
- Doley Road / Orton Road [South] (roundabout);
- Doley Road / All Laneways from/to Cottage Lots (LILO);
- Orton Road / Lawrence Way (roundabout);
- Orton Road / Warrington Road (roundabout);
- Orton Road / Road 31 (LILO);
- Orton Road / Road 24 (LILO);
- Orton Road / Road 48 (LILO);
- Orton Road / Road 73 (LILO);
- Orton Road / Road 74 (LILO);
- Orton Road / Road 78 (LILO);
- Orton Road / Road 85 (LILO);
- Orton Road / All Laneways from/to Cottage Lots (LILO);
- Warrington Road / Turner Road (roundabout);
- Turner Road / Road 66 (LILO);
- Turner Road / Road 67 (LILO);
- Road 49 / Road 48 (roundabout);
- Lawrence way / Allanson Drive (roundabout);
- Lawrence way / Road 46 / Road 19 (roundabout);
- Lawrence way / Road 49 / Road 27 (roundabout);
- Lawrence way / All Laneways from/to Cottage Lots (LILO);
- Road 24 / Road 27 (roundabout);
- Road 77 / Road 78 / Road 84 (roundabout);

Remaining intersections within the development can be configured as yield intersections.

The intersections of Turner Road and Roads 66 and 67 should be nominally configured as LILO give-way intersection. This should be revisited once the design information for Turner Road (section between Warrington Road and existing Recreation Road) becomes available. Recreation Road closure is pursued by Shire of Serpentine – Jarrahdale. If the vertical alignment of Turner Road proves to affect sight distances for vehicles exiting Recreation Road (Road 67) the intersection configuration should be revisited.

We believe that 6.0 metre kerb radii (as per Liveable Neighbourhoods) discourages reckless driving therefore it would be prudent to allow for 6.0 metres kerb radii for all intersections to Access Street D roads.

The proposed Structure Plan Area have predominantly Access Street D in the typology of the streets. Majority of the intersections will be priority controlled, therefore it is highly important to reduce any possible opportunity for anti-social behaviour. Following methods can be considered:

- Smaller kerb radii - kerb radius should be 6 metres wherever possible; the visual narrowing of the intersection drives the road users to reduce the operating speed limit;
- Paved / Raised intersections - this should be considered on longer stretches of road; while it a strong visual cue for the road users the change in the tactile surface signals the requirement for caution and reduction of the operating speed; this type of traffic management can help defining the visual identity of the future place.
- Slow Points / Blisters - this should be considered on longer stretches of the road; this type of traffic management method can be combined with the retention of selected existing vegetation;
- Pedestrian Crossings - pedestrian crossings should be positioned so that they offer unobstructed sight distances to the pedestrians preparing to cross. Pedestrians should be clearly visible to the drivers in the on-coming traffic. Pedestrian crossings should have pram-ramps which would allow for vulnerable road users safer environment.

2.7.4 SIDRA Intersection Modelling

KCTT have completed SIDRA modelling of following intersections:-

- Orton Road / Doley Road;
- Orton Road / Lawrence Way;
- Orton Road / Warrington Road;
- Warrington Road / Turner Road.

Each of these intersections was modelled in AM and PM peak for years 2026 and 2036. The intersections were assessed in the scenario where Orton Road / Tonkin Highway interchange is constructed prior to assessment year 2036 and in the scenario where it is not (2026).

All of the intersections mentioned perform to the highest level of service. The details of the analysis are available in the Appendix 3.

2.7.5 Additional planning information

According to the Department of Planning the following is noted through this Transport Impact Assessment:

- Orton Road, a future Other Regional Road, is to be widened from 20 metres to 32 metres (6 metres to be ceded by landholdings north and south of the road).
- Soldiers Road, a future Other Regional Road, is to be widened from 20 metres to 30 metres (10 metres to be ceded by landholdings abutting Soldiers Road).
- Land is required to accommodate a roundabout at the intersection of Orton and Soldiers Road. The land to be ceded and the design of the roundabout is to be to the satisfaction of the Shire on advice from the Department of Planning.
- Direct access to Soldiers Road is not permitted and an internal road will be required between residential lots and Soldiers Road to provide appropriate access and frontage. Double storey, rear-loaded and dual frontage lots are not permitted in this location due to interface and noise attenuation objectives.
- Notwithstanding the Shire's endorsed LSP Map, intersections to Orton Road shall be:

  - restricted and rationalised where possible in accordance Development Control Policy 1.4 and Liveable Neighbourhoods,
  - reduced from six to three intersections between Warrington and Soldiers Roads, and
  - left-in-left-out only at the intersection with Road 82 unless a roundabout is coordinated with the LSP area south of Orton Road (whichever is preferred by the Shire).
- Direct lot access is not permitted to lots abutting Orton Road and Doley Road and rear laneway arrangements shall be provided.
- The construction of Recreation Road is not supported due to BF 321 and TECs. Closure of Recreation Road is recommended and its management and restoration is expected to be outlined and ensured within the Draft Brickwood Reserve Management Plan (authored by the Shire of Serpentine-Jarrahdale) currently being assessed by the Department of Planning.
- Road paving is not permitted to straddle lot boundaries unless a subdivision application is received that is signed by all landowners.
- The lots fronting the proposed road which straddles Lot 50 (No. 124) Warrington Road and Lot 20 (No. 142 Warrington Road) will not be supported for creation (via subdivision) until such time as the entire road is created/constructed

2.8 Public Transport Access

This section describes the accessibility to public and alternative modes of transportation. KCTT have reviewed Transperth and Walk Score for the information found below.

2.8.1 Transperth Bus Routes

The following public transport routes are within proximity of the subject site. The key information provided below includes: -

- Bus route number;
- Description of the bus route; and
- Their indicative peak and off-peak frequencies.

These bus routes are available within an 800m radius vicinity:

- To the east: Bus routes 251, 252 and 253;
- To the north: Bus route 254.

Table 11 - Bus Routes and Frequencies

Bus Route	Description	Peak and Off-Peak Frequencies		
		Monday to Friday	Saturday	Sunday
251	Armadale Station - Mundijong & Jarrahdale	60 minutes	60 minutes	120 minutes
252	Armadale Station - Mundijong & Jarrahdale	74 minutes	-	
253	Armadale Station - Mundijong & Jarrahdale	once per day		-
254	Armadale Station - Byford	15 minutes	60 minutes	-

2.8.2 Accessibility to Public Transportation

The following table highlights the proximity of the various bus routes to the subject site and highlights the "walkability" to alternative transport modes. This information has been sourced from "Walk Score" at http://www.walkscore.com

Table 12 - Bus Route Description and Walkable Distance to / from the Subject Site

Bus Route	Description	Distance from Subject Site
251	Armadale Station - Mundijong & Jarrahdale	0.3km
252	Armadale Station - Mundijong & Jarrahdale	0.3km
253	Armadale Station - Mundijong & Jarrahdale	0.3km
254	Armadale Station - Byford	0.4km

The nearest railway station is not in the walking distance of the Structure Plan Area.

In recent years the surrounding area has undergone a major transformation from generally rural to sub-urban area. It is expected that as urban development continues west and south of the Structure Plan Area, that the local bus services will be extended.

The proposed layout of the development allows for a bus route to be aligned from Turner Road through the Structure Plan Area via Road 27, turning south via Doley Road and further west via Orton Road. The proposed road network provides Neighbourhood Connector B class of the road, which is suitable for buses in accordance with the Bus Planning and Design Guidelines for Efficient People Movement (PTA). Furthermore, several roundabouts will be introduced on Road 27 which will have strong effect on traffic calming.

The map of existing and future public transportation routes is provided in Appendix 2 on drawing S03.

2.9 Pedestrian and Cyclist Access

There are no existing separate pedestrian and cyclist paths provided along the roads within the proposed development. Given the location and the proposed land uses within the subject site, we believe that there will be a requirement for pedestrian and cyclist paths in the future.

The Perth Bicycle Network in the vicinity of the subject site is shown on the drawing KC00400.000_S02 PBN Plan. The following is the list of the major infrastructure within a 2,000 metre radius of the subject site: -

- Abernethy Road is classified as a PBN "Good Road Riding Environment" route.

KCTT have reviewed the Walk Score (information has been sourced from "Walk Score" at http://www.walkscore.com) and found the following information for the roads surrounding the proposed development: -

Table 13 - Walk Score Ratings

Location	Walk Score	Description
Orton Road	0	Car-Dependent Almost all errands require a car.
Turner Road	28	Car-Dependent. Most errands require a car.
Partridge Bend	0	Car-Dependent Almost all errands require a car.

This location is a Car-Dependent neighbourhood so most errands require a car.

The proposed streets through the Structure Plan Area are good riding environments due to their low traffic volumes. Pedestrian paths should be provided on all road reservations within the Structure Plan Area.

The existing and proposed networks of pedestrian and shared paths are shown on the drawing KC00400.000_S04.

Pedestrian and cyclist provision

Walking and cycling have an important role within the overall transportation system of an urban area. When integrated with compatible land uses, a strong walk/cycle network can:

- Reduce private car dependency for residents;
- Increase accessibility to employment and other urban activities for residents;
- Reduce the adverse environmental impacts of vehicular and motorised transport;
- Increase resource efficiency in a multi-modal transport system; and,
- Reduce transport-related crashes or injuries.

The objective of a pedestrian and cycle network is to provide for the convenient and safe movement of pedestrians and cyclists through and between urban developments, having regard for the need to service schools, shops, recreation and other land uses as well as public transport access points.

Proposed roads should have dedicated cyclist facilities given its connectivity to the proposed primary school, with footpaths provided along all other Structure Plan Area roads, in accordance with Liveable Neighbourhoods.

3. Transport Impact Assessment Checklist for a Structure Plan

The following is the summary / checklist for a Transport Impact Assessment as shown in the Department for Planning and Infrastructure's Transport Assessment Guidelines – Part 2: Structure Plans.

Item	Status	Comments / Proposals
Summary	Y	The development proposes to subdivide the Doley Road LSP, Byford into approximately 2,393 residential lots (887 lots with an assumed R25 yield, 764 lots with an assumed R40 yield and 742 lots with an assumed R60 yield), a Neighbourhood Centre, a Primary School and accompanying POS. The subject site is under jurisdiction of the Shire of Serpentine - Jarrahdale. The land occupies an area of approximately 84.23 ha.
Introduction / Background	Y	KCTT have completed a Transport Impact Assessment using the data related to the Structure Plan Area. We have completed this report and all supporting graphics in accordance with the full requirements of the WAPC Guidelines for the preparation of a Transport Impact Assessment - Part 2 (Structure Plans).
Structure Plan Proposal		
Regional Context	Y	The proposed Structure Plan fits within the general regional context.
Proposed Land Uses	Y	The subject site proposes usage of the landholdings for residential purpose along with a Neighbourhood Centre, Primary School and a POS.
Table of Land Uses and Quantities	Y	Refer to Appendix 1 of this report for a plan of the proposed subject area. Refer to Section 2.1 of this report for a summary of the quantities of the proposed uses.
Major Attractors / Generators	Y	The major trip generators in this locality will be: • Residential - likely peaks from 07:30 to 08:30 and from 17:00 to 18:00 Mondays to Fridays. The major trip attractors in this locality will be: • Neighbourhood Centre - likely peaks from 11:00 to 12:00 and from 18:00 to 19:00 Mondays to Fridays. • Primary School - 08:15 - 09:15 in the AM peak and between 14:45 - 15:45 in the PM peak
Specific Issues	Y	An indicative development concept plan for Doley Road LSP, Byford has been utilised for the purpose of this analysis in order to identify the future development scenario and its potential issues. • The proposed bridge to the north-east
Existing Situation		
Existing Land Uses Within The Structure Plan Area	Y	The existing land zoning is rural agricultural, with the recreational centre to the east of the proposed development.
Existing Land Uses Within 800 metres	Y	Residential and rural agricultural land use, school, parks and recreation.

of the Structure Plan Area		
Existing Road Network Within the Structure Plan Area	Y	The existing road network surrounding and within the subject area includes Orton Road to the south, Doley Road to the west, Perrone Avenue, Allanson Drive, Partridge Bend, Halliday Road, Dearden Road and Lawrence Way to the north and Warrington Road, Turner Road, Soldiers Road to the east. A plan showing the existing network and distribution of the existing traffic volumes is provided in Appendix 2.
Existing Pedestrian / Cyclist Network Within the Structure Plan Area	N	None.
Existing Public Transport Services Within The Structure Plan Area	N	None.
Existing Road Network Within 2 (or 5) km of Structure Plan Area	Y	Key desire lines: - • Hopkinson Road • Cardup Siding • Doley Road • Soldiers Road • South Western Highway • Abernethy Road • Kargotich Road • Mead Street • Nettleton Road • North of Bishop Road • Orton Road • Warrington Road
Traffic Flows on Roads Within the Structure Plan Area (PM and/or AM Peak Hours)	Y	Refer to Section 2.2 for the existing traffic flows on the roads within the subject area.
Traffic Flows on Roads within 2 (or 5) km of Structure Plan Area (AM and/or PM Peak Hours)	Y	Refer to Section 2.2 for the existing traffic flows on the adjacent road network.
Existing Pedestrian / Cycle Networks Within 800 metres of the Structure Plan Area	Y	• Abernethy Road is classified as a PBN "Good Road Riding Environment" route.

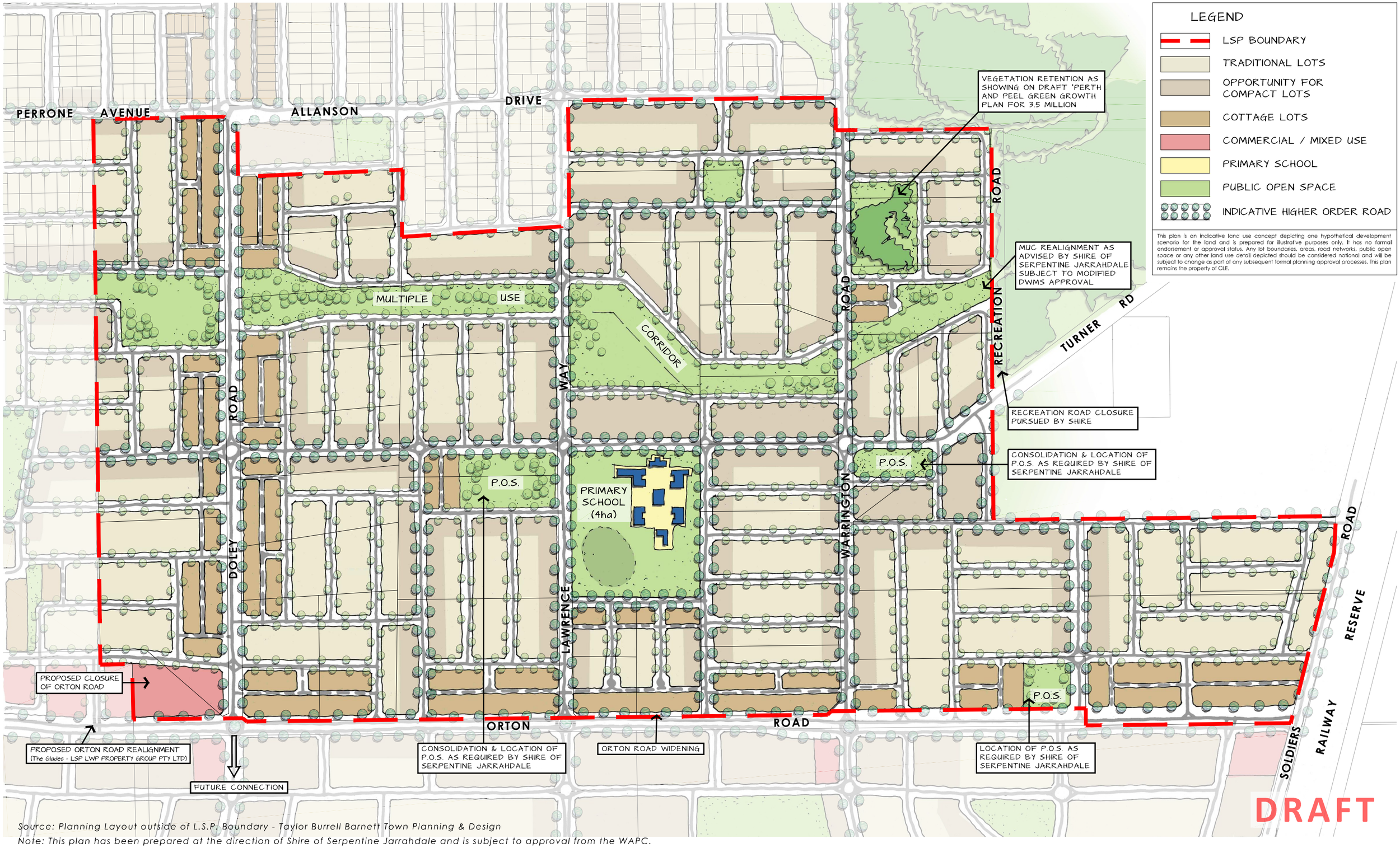
Existing Public Transport Services Within 800 metres of the Structure Plan Area	Y	Refer to Section 2.8.
Proposed Internal Transport Networks		
Changes / Additions to Existing Road Network or Proposed Road Network	Y	It is expected that that there will be a significant number of new roads within the proposed subject area. There will be some changes to the existing roads. Refer to Section 2.7.
Road Reservation Widths	Y	Refer to Section 2.7.1 for the Road Reservation Widths within the subject area.
Road Cross-Sections and Speed Limits	Y	Refer to Section 2.7.2 for the Road Cross-Sections within the subject area. All proposed roads will have speed limit of 50kph.
Intersection Controls	Y	Refer to Section 2.7.4 for Intersection Controls
Pedestrian / Cycle Networks and Crossing Facilities	Y	Internal pedestrian and cyclist networks should be considered along internal roads within the subject site.
Public Transport Routes	N/A	N/A
Changes to External Transport Networks		
Road Network	Y	Refer Section 2.7.1 Table 10.
Intersection Controls	Y	Refer Section 2.7.4. Proposed Intersection Controls
Pedestrian Cycle Networks and Crossing Facilities	Y	Existing cycle networks have been noted.
Public Transport Services	Y	Existing Public Transport Services have been noted.
Integration with Surrounding Area		
Trip Attractors / Generators Within 800 metres of the Structure Plan Area	Y	Residential (generator) and rural agricultural land use (generator/ attractor), schools, parks and recreation (attractor).
Proposed Changes to Land Uses Within	Y	Serpentine Jarrahdale Shire is a predominantly rural area which is experiencing rapid residential growth.

800 metres of the Structure Plan Area		
Travel Desire Lines from the Structure Plan Area to Trip Attractors / Generators Within 800 metres of the Structure Plan Area	Y	Key desire lines: - • Hopkinson Road • Doley Road • Soldiers Road • South Western Highway • Orton Road • Warrington Road
Adequacy of External Transport Networks	Y	In recent years the surrounding area has undergone a major transformation from generally rural to sub-urban area. It is expected that as urban development continues west and south of the Structure Plan Area, that the local bus services will be extended. Extension of Tonkin Highway is planned with no definitive timeframes for completion. Once completed the proposed Orton Road / Tonkin Highway interchange will greatly improve connectivity of the Structure Plan Area to the Metro Area.
Deficiencies in External Transport Networks	Y	Refer Section 2.7.1 and Section 2.7.4.
Remedial Measures to Address These Deficiencies	N/A	Not applicable.
Analysis of Internal Transport Networks		
Assessment Year(s) and Time Period(s)	Y	It is envisaged that the development will be done in stages. However, for the purpose of this analysis, the proposed Structure Plan Area was observed as fully constructed. The assessment was done for 2026 (assumed year of completion) and 2036.
Structure Plan Generated Traffic	Y	Refer to Table 4 - Section 2.3.
Extraneous (Through) Traffic	Y	Refer to Table 7 - Section 2.3.
Design Traffic Flows (i.e. Total Traffic)	Y	Proposed development traffic flows + existing Main Roads WA and Shire of Serpentine - Jarrahdale data provides the likely total vehicular flows for the current Structure Plan assessment. Refer to Section 2.3.
Road Cross-Sections	Y	Refer to Section 2.7.2 for the Road Cross-Sections within the subject area.
Intersection Controls	Y	Refer to Section 2.7.4 for Intersection Controls
Access Strategy	Y	The Structure Plan area will be accessed via existing roads including Orton Road to the south, Doley Road to the west, Perrone Avenue, Allanson Drive, Partridge Bend, Halliday Road, Dearden Road and Lawrence Way to the north and Warrington Road, Turner Road, Soldiers Road to the east.

Pedestrian / Cycle Networks	Y	Internal pedestrian and cyclist networks should be considered along internal roads within the subject site. Refer Appendix 2.
Safe Routes to Schools	Y	Pedestrian / Cyclist paths along Lawrence Way and other proposed roads within the Structure Plan Area will provide direct connection to and from the proposed Primary school.
Pedestrian Permeability and Efficiency	Y	The proposed improvements and additions to the pedestrian path network promote connectivity, permeability and efficiency as per Appendix 2.
Access to Public Transport	N/A	N/A
Analysis of External Transport Networks		
Extent of Analysis	Y	Review of road and transportation networks undertaken to within an 800m radius of the Structure Plan Area.
Base Flows for Assessment Year(s)	Y	Traffic assessed as a base case, based on 2008 and 2015 traffic volumes from MRWA and the Shire of Serpentine - Jarrahdale. KCTT have used a traffic growth rate of 3% per annum for all existing roads adjacent to / within the Structure Plan Area. The traffic impact of the development has been calculated for the years 2026 and 2036.
Total Traffic Flows	Y	Refer to Table 7 - Section 2.3.
Road Cross-Sections	N/A	Not applicable.
Intersection Layouts and Controls	N/A	Not applicable
Pedestrian/Cycle Networks	N/A	Not applicable
Conclusions		
Conclusions	Y	The proposed development has a notable impact on the existing road network, however the proposed new network and upgrades to the existing network allow for this impact to be appropriately accommodated.

Appendix 1

The Layout of the Proposed Development



Source: Planning Layout outside of L.S.P. Boundary - Taylor Burrell Barnett Town Planning & Design

Note: This plan has been prepared at the direction of Shire of Serpentine Jarrahdale and is subject to approval from the WAPC.

0 50 100 150 200 250 300 350 400 450 500m

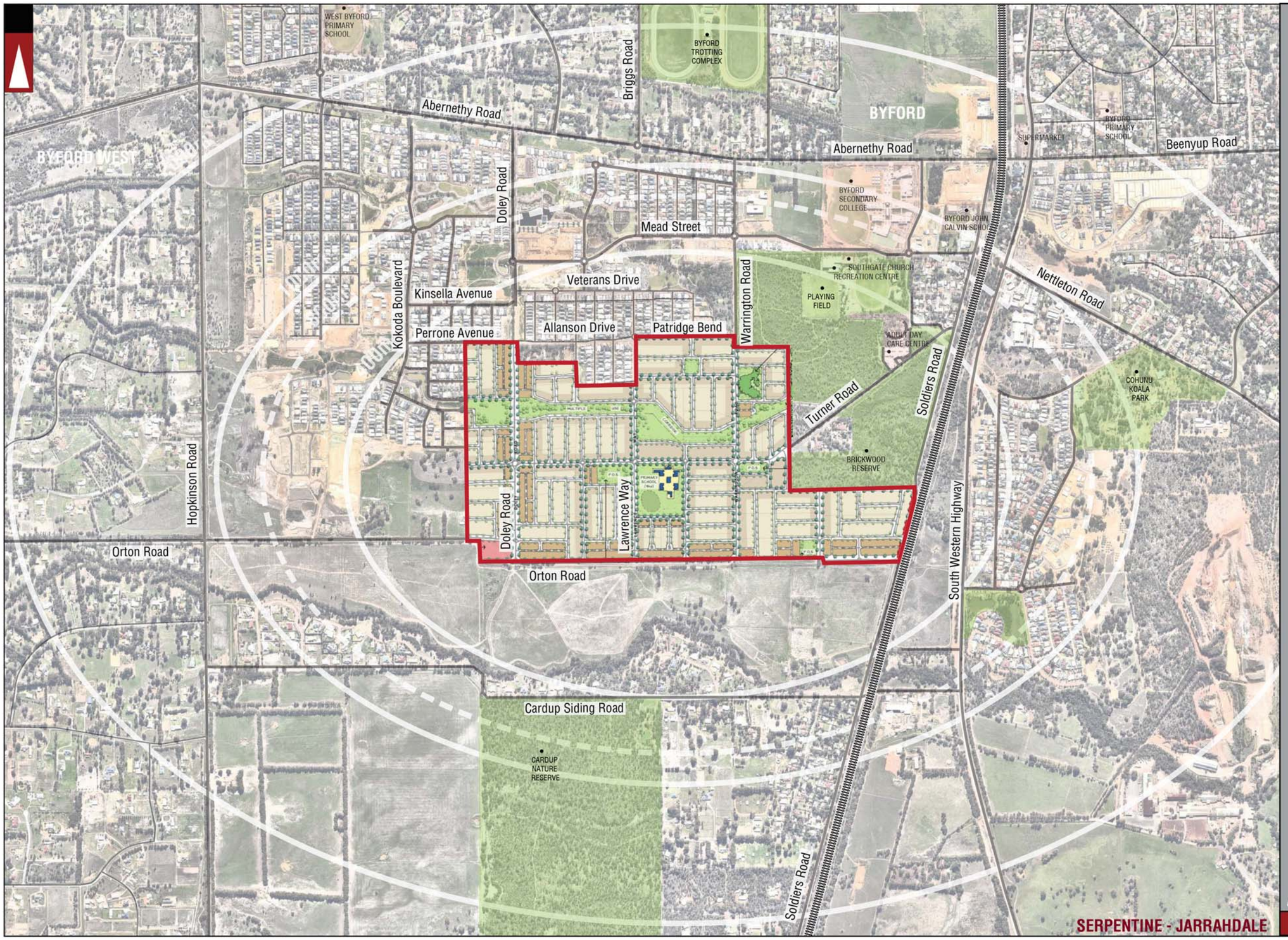
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SHIRE OF SERPENTINE JARRAHDALE ALTERNATIVE CONCEPT PLAN (CONSOLIDATED POS)

Orton Road, Byford

Appendix 2

Transport Planning and Traffic Plans



LOCATION BOUNDARY

DISTANCE FROM LOCATION

PARKS AND RECREATION

PUBLIC FACILITIES

WATER

BYFORD — LOCAL GOVERNMENT NAME

Turner Road — STREET NAME

ROAD (VARIED WITH ROAD WIDTH)

PROPOSED ROAD

RAILWAY

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

SERPENTINE - JARRAHDALE

LEGEND

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	25-05-2016	PROPOSED LAYOUT AMENDED
B	12-01-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

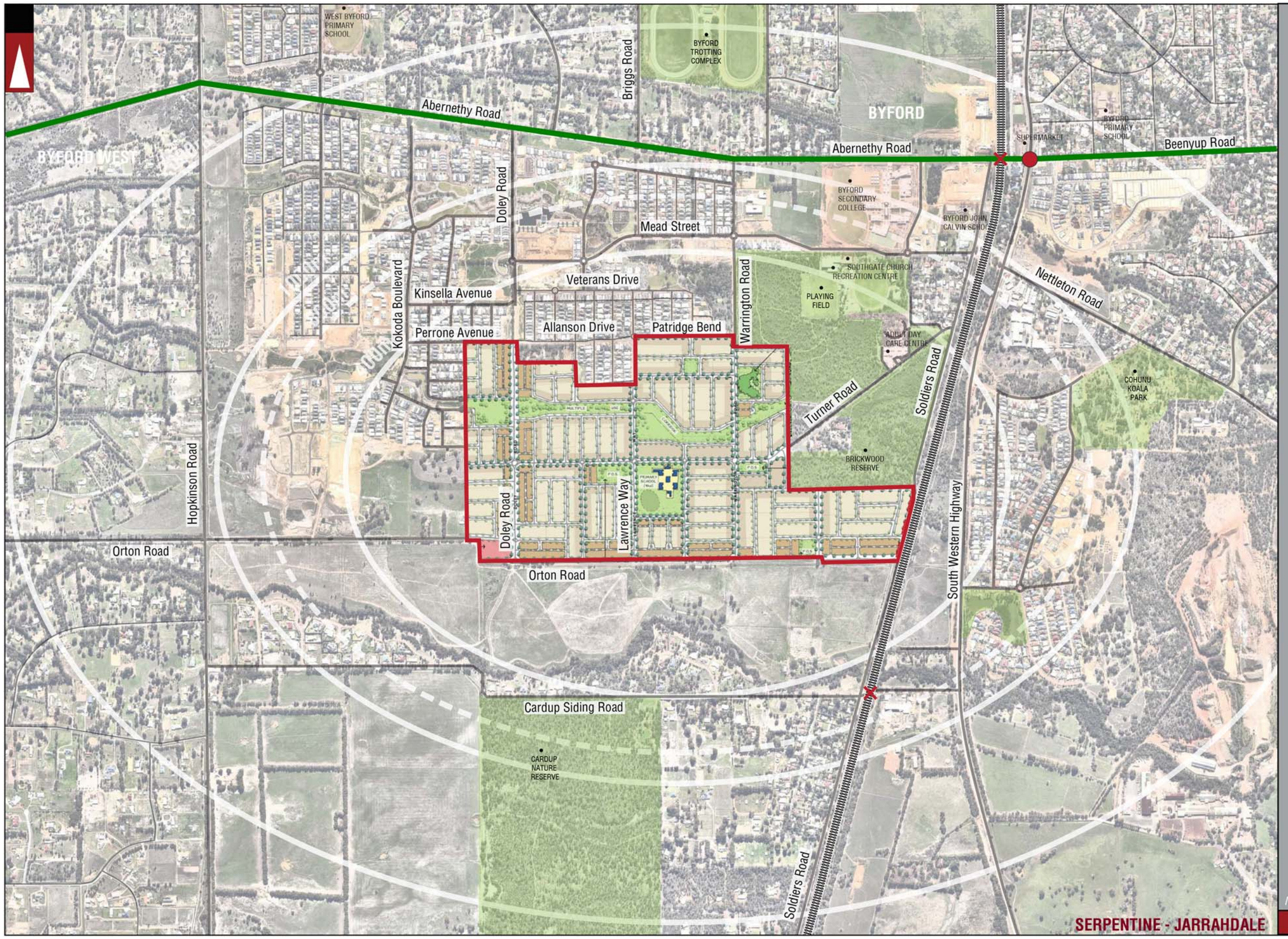
TITLE: Locality Plan

DRAWING NUMBER: KC00400.000_S01

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au

kctt



NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

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LEGEND

Certified System Quality ISO 9001 SAI GLOBAL

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	25-05-2016	PROPOSED LAYOUT AMENDED
B	12-01-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

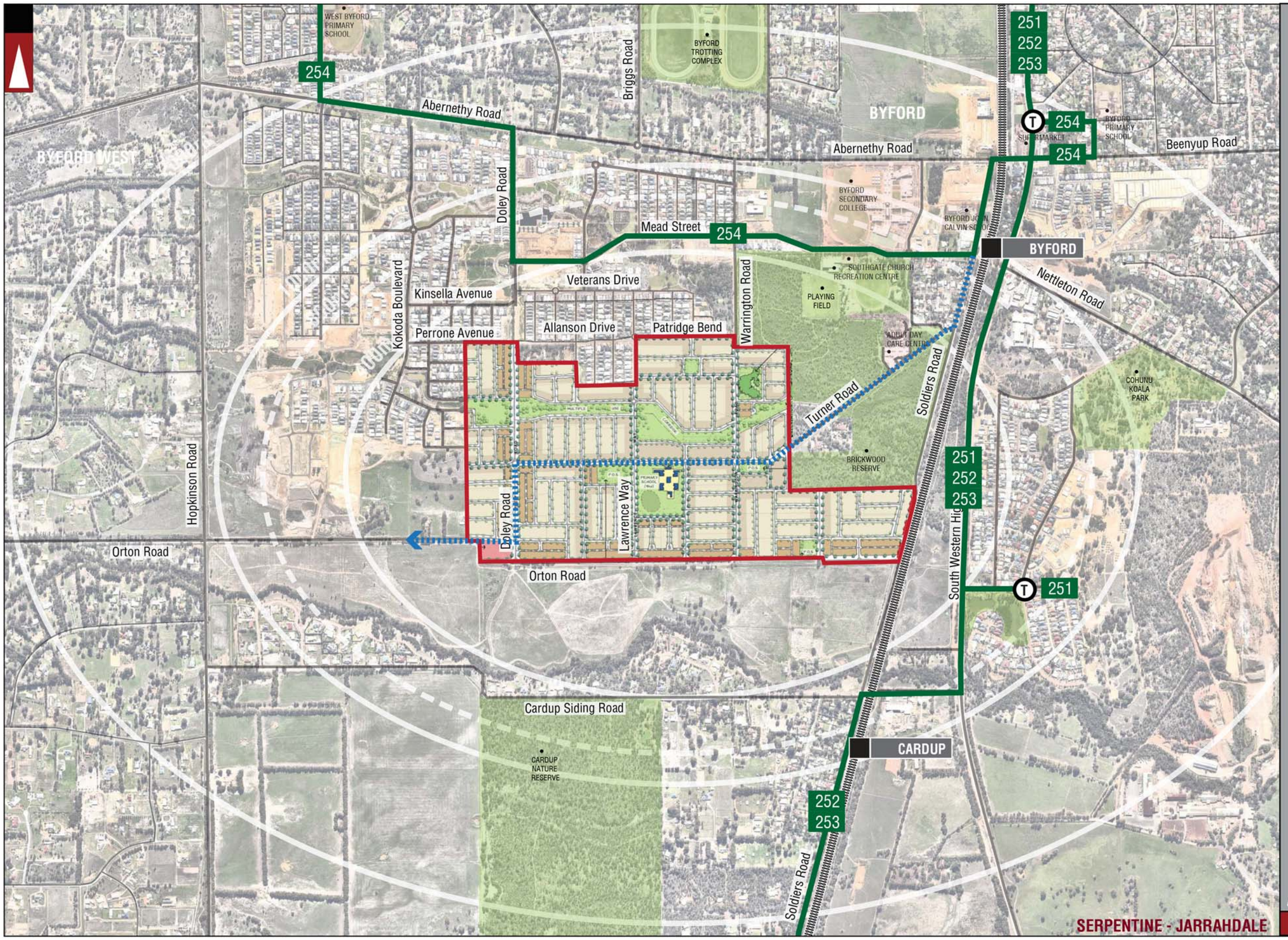
TITLE: Bicycle Network Plan

DRAWING NUMBER: KC00400.000_S02

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au

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LOCATION BOUNDARY

DISTANCE FROM LOCATION

PARKS AND RECREATION

PUBLIC FACILITIES

WATER

BYFORD — LOCAL GOVERNMENT NAME

Turner Road — STREET NAME

ROAD (VARIED WITH ROAD WIDTH)

PROPOSED ROAD

RAILWAY

TRAIN STATION

251 — BUS ROUTE NUMBER

BUS ROUTES / STOPS

T — BUS TERMINUS

251 — ARMADALE STATION - BYFORD (VIA SOUTH WESTERN HIGHWAY)

252 — ARMADALE STATION - MUNDIJONG (VIA BYFORD)

253 — ARMADALE STATION - JARRAHDALE (VIA BYFORD & MUNDIJONG)

254 — ARMADALE STATION - BYFORD (VIA KARDAN BOULEVARD)

PROPOSED BUS ROUTES WITHIN LSP

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	25-05-2016	PROPOSED LAYOUT AMENDED
B	12-01-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Public Transport Plan

DRAWING NUMBER: KC00400.000 _S03

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au

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PARKS AND RECREATION
PUBLIC FACILITIES
LOCATION BOUNDARY
BYFORD — LOCAL GOVERNMENT NAME
ROAD (VARIED WITH ROAD WIDTH)
PROPOSED ROAD
RAILWAY
Orton Road — STREET NAME
TRADITIONAL LOTS
OPPORTUNITY FOR COMPACT LOTS
COTTAGE LOTS
COMMERCIAL / MIXED USE
PRIMARY SCHOOL
PUBLIC OPEN SPACE
EXISTING PEDESTRIAN PATH
PROPOSED PEDESTRIAN PATH ON ONE SIDE OF THE ROAD
PROPOSED DUAL USE PATH ON ONE SIDE OF THE ROAD AND PROPOSED PEDESTRIAN PATH ON THE OTHER SIDE OF THE ROAD

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	27-05-2016	PROPOSED LAYOUT AMENDED
B	13-01-2016	PROPOSED LAYOUT AMENDED

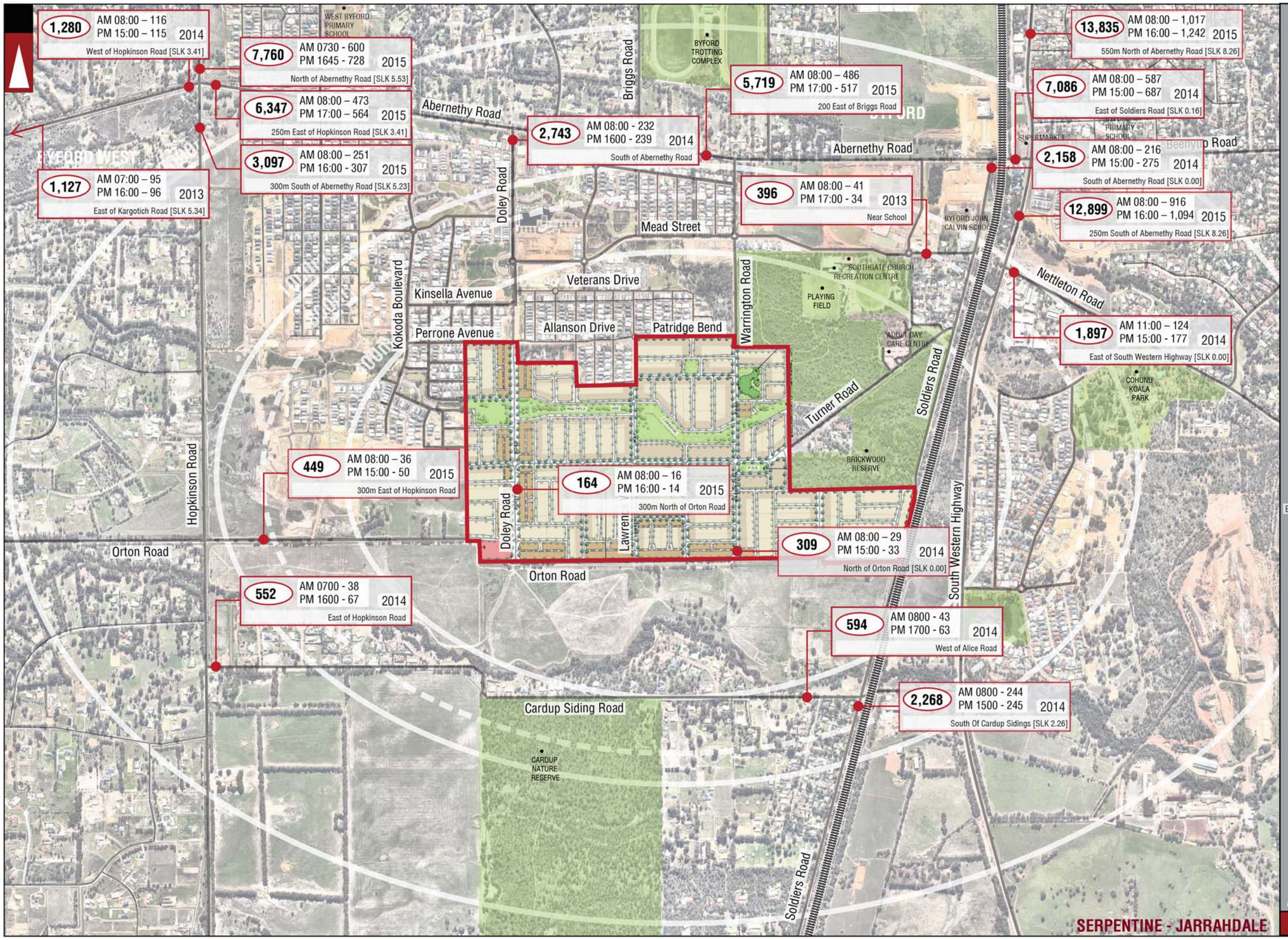
PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Proposed Pedestrian Paths

DRAWING NUMBER: KC00400.000 _S04

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au
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LEGEND

Certified System Quality ISO 9001 SAI GLOBAL

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	25-05-2016	PROPOSED LAYOUT AMENDED
B	12-01-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Existing Traffic Counts

DRAWING NUMBER: KC00400.000_S05

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au
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Quality
ISO 9001
SAI GLOBAL

PARKS AND RECREATION
PUBLIC FACILITIES
LOCATION BOUNDARY
BYFORD — LOCAL GOVERNMENT NAME
ROAD (VARIED WITH ROAD WIDTH)
PROPOSED ROAD
RAILWAY
Orton Road — STREET NAME
TRADITIONAL LOTS
OPPORTUNITY FOR COMPACT LOTS
COTTAGE LOTS
COMMERCIAL / MIXED USE
PRIMARY SCHOOL
PUBLIC OPEN SPACE
554 — DAILY TRAFFIC (VPD) DERIVED FROM PARAMICS - ONLY CONSIDERING THE INTERACTION OF THE PROPOSED DEVELOPMENT WITH THE SURROUNDING NETWORK

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	27-05-2016	PROPOSED LAYOUT AMENDED
B	13-01-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Traffic Flow Diagram

DRAWING NUMBER: KC00400.000_S08a

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au

kctt



PARKS AND RECREATION
PUBLIC FACILITIES
LOCATION BOUNDARY
BYFORD — LOCAL GOVERNMENT NAME
ROAD (VARIED WITH ROAD WIDTH)
PROPOSED ROAD
RAILWAY
Orton Road — STREET NAME
TRADITIONAL LOTS
OPPORTUNITY FOR COMPACT LOTS
COTTAGE LOTS
COMMERCIAL / MIXED USE
PRIMARY SCHOOL
PUBLIC OPEN SPACE
621 — DAILY TRAFFIC (VPD) DERIVED FROM PARAMICS - WHOLE NETWORK 2026

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	27-05-2016	PROPOSED LAYOUT AMENDED
B	13-01-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Traffic Flow Diagram

DRAWING NUMBER: KC00400.000_S08b

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au

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PARKS AND RECREATION
PUBLIC FACILITIES
LOCATION BOUNDARY
BYFORD — LOCAL GOVERNMENT NAME
ROAD (VARIED WITH ROAD WIDTH)
PROPOSED ROAD
RAILWAY
Orton Road — STREET NAME
TRADITIONAL LOTS
OPPORTUNITY FOR COMPACT LOTS
COTTAGE LOTS
COMMERCIAL / MIXED USE
PRIMARY SCHOOL
PUBLIC OPEN SPACE
7,418 — DAILY TRAFFIC (VPD) DERIVED FROM PARAMICS - WHOLE NETWORK 2036

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	27-05-2016	PROPOSED LAYOUT AMENDED
B	13-01-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Traffic Flow Diagram

DRAWING NUMBER: KC00400.000_S08c

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au
kctt



PARKS AND RECREATION
PUBLIC FACILITIES
LOCATION BOUNDARY
BYFORD — LOCAL GOVERNMENT NAME
ROAD (VARIED WITH ROAD WIDTH)
PROPOSED ROAD
RAILWAY
Orton Road — STREET NAME
TRADITIONAL LOTS
OPPORTUNITY FOR COMPACT LOTS
COTTAGE LOTS
COMMERCIAL / MIXED USE
PRIMARY SCHOOL
PUBLIC OPEN SPACE
7,418 — DAILY TRAFFIC (VPD) DERIVED FROM PARAMICS - WHOLE NETWORK WITH FUTURE TONKIN HIGHWAY / ORTON ROAD INTERCHANGE INCLUDED 2036

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
C	10-03-2017	LOCATION BOUNDARY AMENDED
B	21-06-2016	PROPOSED LAYOUT AMENDED
A	07-06-2016	ISSUED FOR REVIEW

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

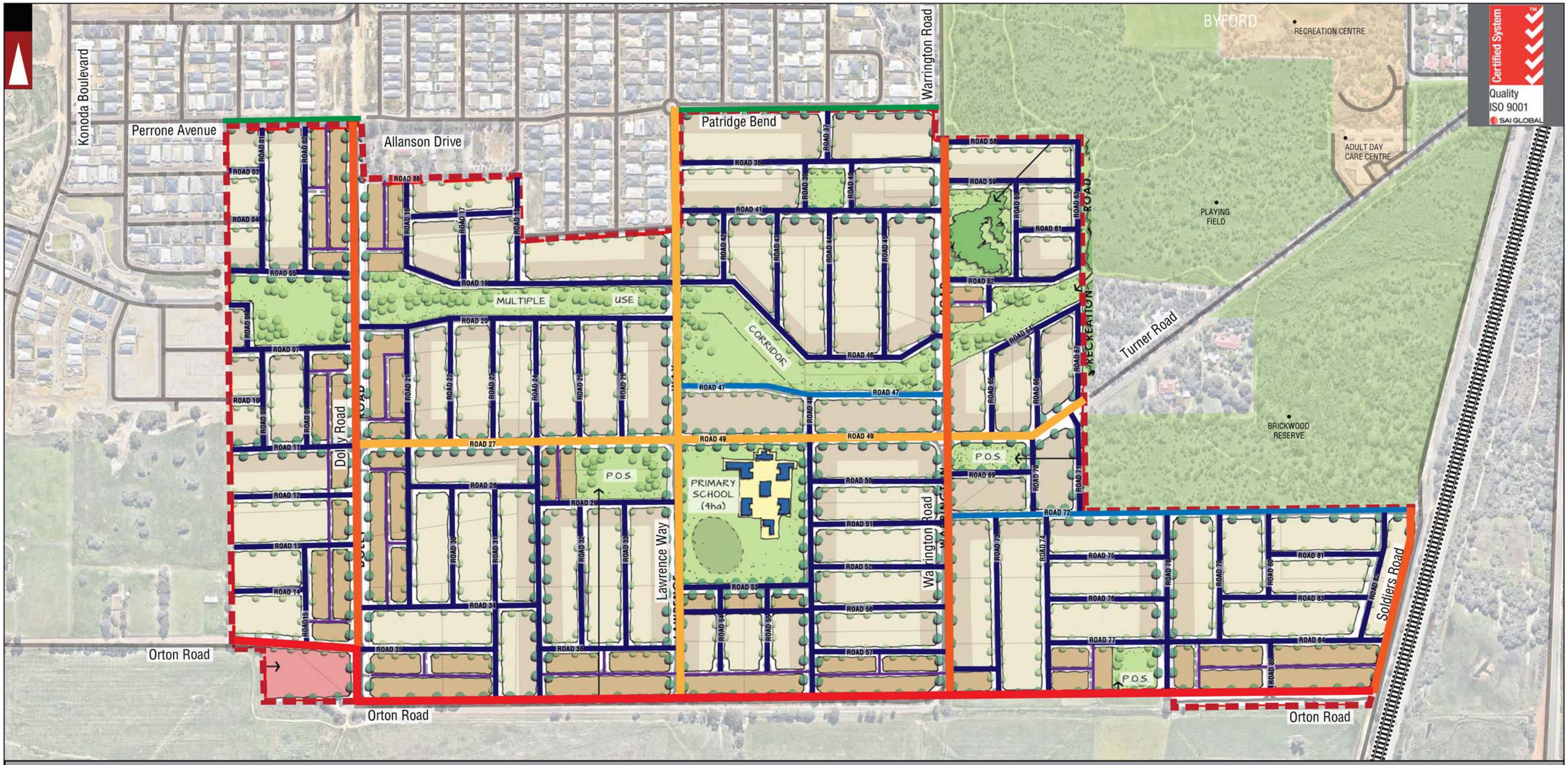
TITLE: Traffic Flow Diagram

DRAWING NUMBER: KC00400.000_S08d

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au

kctt



PARKS AND RECREATION
PUBLIC FACILITIES
LOCATION BOUNDARY
BYFORD — LOCAL GOVERNMENT NAME

ROAD (VARIED WITH ROAD WIDTH)
PROPOSED ROAD
RAILWAY
Orton Road — STREET NAME

TRADITIONAL LOTS
OPPORTUNITY FOR COMPACT LOTS
COTTAGE LOTS

COMMERCIAL / MIXED USE
PRIMARY SCHOOL
PUBLIC OPEN SPACE

INTEGRATOR B*
NEIGHBOURHOOD CONNECTOR 'A'
NEIGHBOURHOOD CONNECTOR 'B'

ACCESS STREET B
ACCESS STREET C
ACCESS STREET D
LANE WAY

NOTE: ORTON ROAD CAN BE CLASSIFIED AS INTEGRATOR B OR NEIGHBOURHOOD CONNECTOR A.*

INTEGRATOR B WILL BE IN A SECOND PHASE ACCOUNTING THE PROPOSED DEVELOPMENT WITH THE FUTURE DEVELOPMENTS IN SURROUNDING. IT COULD HAVE 2X8.2M WIDE PAVEMENT (INCLUSIVE OF BICYCLE LANES) IN 32.0M WIDE ROAD RESERVATION

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
F	10-03-2017	LOCATION BOUNDARY AMENDED
E	02-03-2017	ROAD RESERVE UPDATED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	07-06-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Road Hierarchies Sketch

DRAWING NUMBER: KC00400.000_S10

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au
kctt



PARKS AND RECREATION
PUBLIC FACILITIES
LOCATION BOUNDARY
BYFORD — LOCAL GOVERNMENT NAME
ROAD (VARIED WITH ROAD WIDTH)
PROPOSED ROAD
RAILWAY
Orton Road — STREET NAME
TRADITIONAL LOTS
OPPORTUNITY FOR COMPACT LOTS
COTTAGE LOTS
COMMERCIAL / MIXED USE
PRIMARY SCHOOL
PUBLIC OPEN SPACE
ROUNDABOUT
LEFT-IN / LEFT-OUT (LILO)

NOTE: ALL OTHER INTERSECTIONS WITHIN THE DEVELOPMENT OF ORTON ROAD & WARRINGTON ROAD LSP, BYFORD WILL HAVE GIVE-WAY TRAFFIC CONTROL.

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	27-05-2016	PROPOSED LAYOUT AMENDED
B	13-01-2016	PROPOSED LAYOUT AMENDED

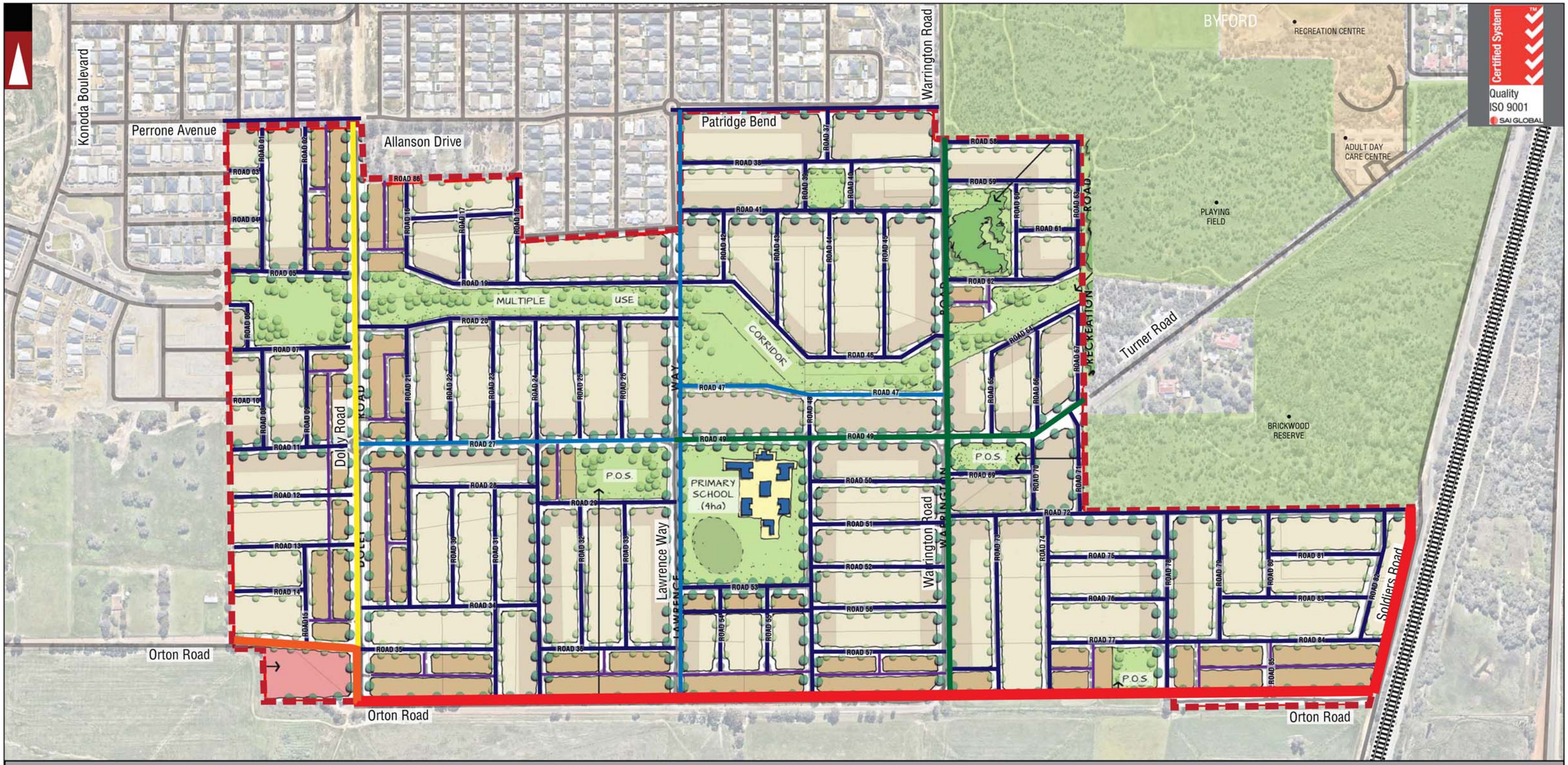
PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Proposed Intersection Configurations

DRAWING NUMBER: KC00400.000_S11

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au
kctt



PARKS AND RECREATION
PUBLIC FACILITIES
LOCATION BOUNDARY
BYFORD — LOCAL GOVERNMENT NAME

ROAD (VARIED WITH ROAD WIDTH)
PROPOSED ROAD
RAILWAY
Orton Road — STREET NAME

TRADITIONAL LOTS
OPPORTUNITY FOR COMPACT LOTS
COTTAGE LOTS

COMMERCIAL / MIXED USE
PRIMARY SCHOOL
PUBLIC OPEN SPACE

MORE THAN 7,000VPD*
5,000VPD TO 7,000VPD
3,000VPD TO 5,000VPD

2,000VPD TO 3,000VPD
1,000VPD TO 2,000VPD
500VPD TO 1,000VPD
LESS THAN 500VPD

NOTE: ORTON ROAD WILL HAVE 7,000VPD IN THE FIRST PHASE (THE EXISTING TRAFFIC AND THE PROPOSED TRAFFIC) AND UP TO 15,000VPD IN THE SECOND PHASE (INCLUDING THE FUTURE DEVELOPMENTS IN SURROUNDING)*

NOTE: THE PLAN IS COURTEOUSY OF CLEPLAN

LEGEND

No	DATE	AMENDMENT
E	10-03-2017	LOCATION BOUNDARY AMENDED
D	21-06-2016	PROPOSED LAYOUT AMENDED
C	27-05-2016	PROPOSED LAYOUT AMENDED
B	13-01-2016	PROPOSED LAYOUT AMENDED

PROJECT: ORTON ROAD & WARRINGTON ROAD LSP

TITLE: Future Trafic Volumes - Heat Plan (2036)

DRAWING NUMBER: KC00400.000_S13

DRAWN BY: A.N.

Civil & Traffic Engineering Consultants
Suite 7 No 10 Whipple Street Balcatta WA 6021
PH: 08 9441 2700
WEB: www.kctt.com.au
kctt

Appendix 3

SIDRA Intersection Analysis

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1. Introduction

This short report provides details on the SIDRA Analysis conducted to support the findings of the report KC00400.000 Orton Road – Warrington Road Byford, Rev A. The intersections have been modelled in the AM and PM peak hours for 2026 and 2036.

The dimensions of the intersection elements have been scaled from aerial imagery which was obtained through our commercial arrangement with Nearmaps and through publically available Intramaps. These images are suitable for use in concept drafting applications with a level of accuracy to within +/- 10 centimetres.

Base traffic data utilised for the modelling was obtained from MRWA and from the Shire of Serpentine - Jarrahdale. The data was collected between 2008 and 2015. These results were utilised for creating base SIDRA models.

It is likely that AM and PM peaks will coincide with journey to / from work times. As such morning and afternoon peaks are likely to be between 7:30 – 8:30 and 17:00 - 18:00 during work days. In summary, the proposed development is expected to generate approximately up to **14,000 vehicular movements per day** with a forecasted impact of around **2,000 vehicles per hour in the peak hour** upon completion.

Taking into consideration the breakdown for the typical residents' locations of work in the Shire of Serpentine - Jarrahdale (refer the Shire of Serpentine - Jarrahdale ID profile above), and the locations of the nearest shopping centres, schools and recreational centres, KCTT believe that the traffic from the proposed Structure Plan Area will be distributed into the adjacent road network as follows:

- 30% to / from the northeast via Soldiers Road - 0.30*14,000= 4,200 VPD;
- 10% to / from the southwest via Soldiers Road - 0.10*14,000 = 1,400 VPD;
- 19% to / from the north via Doley Road - 0.19*14,000 = 2,660 VPD;
- 6% to / from the south via the future road (Doley Road Extension) - 0.06*14,000 = 840 VPD
- 10% to / from the north via Warrington Road - 0.10*14,000 = 1,400 VPD;
- 3% to / from the north via Lawrence Way - 0.03*14,000 = 420 VPD;
- 16% to / from the west via Orton Road - 0.16*14,000 = 2,240 VPD.
- 6% to / from the west via Perrone Avenue - 0.03*14,000 = 420 VPD

The traffic assessment was completed with all of the surrounding developments accounted for (The Glades) while the passing traffic on the existing roads was derived utilising 3% annual growth rate (for 2026 and 2036).

It should be noted that the models named _V1 for the year 2036 show the impact on the specific intersection when the Tonkin Highway / Orton Road interchange is completed.

Summary of Results

SIDRA modelling has shown that the development will have minimal impact on the operation of the surrounding road network and namely the following intersections: -

- Orton Road / Doley Road;
- Orton Road / Lawrence Way;
- Orton Road / Warrington Road;
- Turner Road / Warrington Road.

Each intersection was analysed in the AM and PM peaks with the expected traffic volumes in 2026 and 2036.

The results and findings of the SIDRA Intersection analysis show that the development has a notable impact on the adjacent road network; however, there is sufficient spare capacity in the existing and the proposed network to cater for the proposed development.

A summary of the results of the SIDRA analysis are shown on the following pages. The full SIDRA output report can be provided on request.

2. Intersection Analysis

2.1 Intersection 1 – Orton Road – Doley Road



Figure 1 – Location

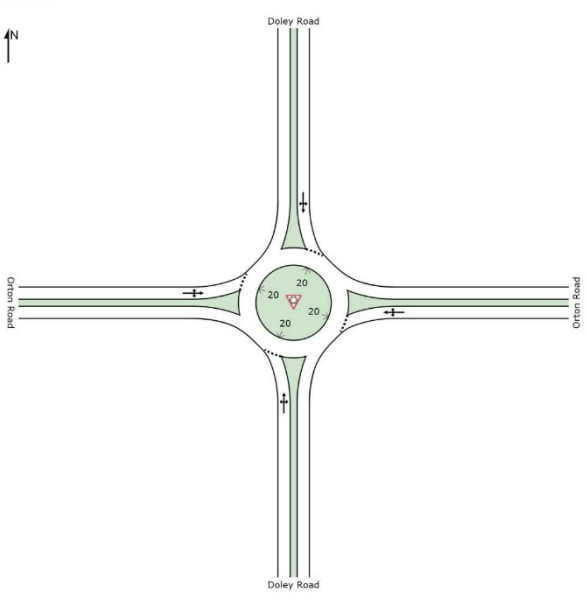


Figure 2- Schematic Geometry

2.1.1 1.1a Orton Road - Doley Road - 2026 AM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Doley Road													
Lane 1 d	98	2.0	1066	0.092	100	6.8	LOS A	0.5	3.7	Full	65	0.0	0.0
Approach	98	2.0		0.092		6.8	LOS A	0.5	3.7				
East: Orton Road													
Lane 1 d	267	3.0	1270	0.211	100	6.3	LOS A	1.3	9.5	Full	172	0.0	0.0
Approach	267	3.0		0.211		6.3	LOS A	1.3	9.5				
North: Doley Road													
Lane 1 d	132	2.0	1084	0.121	100	4.9	LOS A	0.7	5.0	Full	65	0.0	0.0
Approach	132	2.0		0.121		4.9	LOS A	0.7	5.0				
West: Orton Road													
Lane 1 d	206	3.0	1164	0.177	100	6.7	LOS A	1.0	7.5	Full	129	0.0	0.0
Approach	206	3.0		0.177		6.7	LOS A	1.0	7.5				
Intersection	703	2.7		0.211		6.2	LOS A	1.3	9.5				

Figure 3 - LOS Table (Model 1.1a Orton Road - Doley Road - 2026 AM)

2.1.2 1.1p Orton Road - Doley Road - 2026 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Doley Road													
Lane 1 d	102	2.0	1055	0.097	100	6.9	LOS A	0.5	3.8	Full	65	0.0	0.0
Approach	102	2.0		0.097		6.9	LOS A	0.5	3.8				
East: Orton Road													
Lane 1 d	266	3.0	1322	0.201	100	6.2	LOS A	1.3	9.2	Full	172	0.0	0.0
Approach	266	3.0		0.201		6.2	LOS A	1.3	9.2				
North: Doley Road													
Lane 1 d	162	2.0	1110	0.146	100	5.1	LOS A	0.9	6.1	Full	65	0.0	0.0
Approach	162	2.0		0.146		5.1	LOS A	0.9	6.1				
West: Orton Road													
Lane 1 d	234	3.0	1166	0.200	100	5.5	LOS A	1.2	8.7	Full	129	0.0	0.0
Approach	234	3.0		0.200		5.5	LOS A	1.2	8.7				
Intersection	764	2.7		0.201		5.8	LOS A	1.3	9.2				

Figure 4 - LOS Table (Model 1.1p Orton Road - Doley Road - 2026 PM)

2.1.3 1.2a Orton Road - Doley Road - 2036 AM

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Doley Road													
Lane 1 d	118	2.0	999	0.118	100	7.3	LOS A	0.7	4.8	Full	65	0.0	0.0
Approach	118	2.0		0.118		7.3	LOS A	0.7	4.8				
East: Orton Road													
Lane 1 d	354	3.0	1345	0.263	100	6.2	LOS A	1.7	12.5	Full	172	0.0	0.0
Approach	354	3.0		0.263		6.2	LOS A	1.7	12.5				
North: Doley Road													
Lane 1 d	112	2.0	1062	0.105	100	5.3	LOS A	0.6	4.3	Full	65	0.0	0.0
Approach	112	2.0		0.105		5.3	LOS A	0.6	4.3				
West: Orton Road													
Lane 1 d	281	3.0	1120	0.251	100	6.1	LOS A	1.6	11.3	Full	129	0.0	0.0
Approach	281	3.0		0.251		6.1	LOS A	1.6	11.3				
Intersection	864	2.7		0.263		6.2	LOS A	1.7	12.5				

Figure 5 - LOS Table (Model 1.2a Orton Road - Doley Road - 2036 AM)

2.1.4 1.2a_V1 Orton Road - Doley Road - 2036 AM

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Doley Road													
Lane 1 d	115	2.0	944	0.122	100	7.0	LOS A	0.7	5.0	Full	65	0.0	0.0
Approach	115	2.0		0.122		7.0	LOS A	0.7	5.0				
East: Orton Road													
Lane 1 d	392	3.0	1261	0.311	100	6.5	LOS A	2.2	15.5	Full	172	0.0	0.0
Approach	392	3.0		0.311		6.5	LOS A	2.2	15.5				
North: Doley Road													
Lane 1 d	138	2.0	1015	0.136	100	6.3	LOS A	0.8	5.7	Full	65	0.0	0.0
Approach	138	2.0		0.136		6.3	LOS A	0.8	5.7				
West: Orton Road													
Lane 1 d	329	3.0	1128	0.292	100	6.2	LOS A	1.9	13.8	Full	129	0.0	0.0
Approach	329	3.0		0.292		6.2	LOS A	1.9	13.8				
Intersection	974	2.7		0.311		6.4	LOS A	2.2	15.5				

Figure 6 - LOS Table (Model 1.2a_V1 Orton Road - Doley Road - 2036 AM)

2.1.5 1.2p Orton Road - Doley Road - 2036 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Doley Road													
Lane 1 d	132	2.0	999	0.132	100	7.4	LOS A	0.8	5.4	Full	65	0.0	0.0
Approach	132	2.0		0.132		7.4	LOS A	0.8	5.4				
East: Orton Road													
Lane 1 d	354	3.0	1344	0.263	100	6.2	LOS A	1.7	12.6	Full	172	0.0	0.0
Approach	354	3.0		0.263		6.2	LOS A	1.7	12.6				
North: Doley Road													
Lane 1 d	112	2.0	1054	0.106	100	5.3	LOS A	0.6	4.3	Full	65	0.0	0.0
Approach	112	2.0		0.106		5.3	LOS A	0.6	4.3				
West: Orton Road													
Lane 1 d	281	3.0	1106	0.254	100	6.2	LOS A	1.6	11.5	Full	129	0.0	0.0
Approach	281	3.0		0.254		6.2	LOS A	1.6	11.5				
Intersection	878	2.7		0.263		6.2	LOS A	1.7	12.6				

Figure 7 - LOS Table (Model 1.2p Orton Road - Doley Road - 2036 PM)

2.1.6 1.2p_V1 Orton Road - Doley Road - 2036 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Doley Road													
Lane 1 d	114	2.0	943	0.121	100	7.0	LOS A	0.7	5.0	Full	65	0.0	0.0
Approach	114	2.0		0.121		7.0	LOS A	0.7	5.0				
East: Orton Road													
Lane 1 d	386	3.0	1249	0.309	100	6.6	LOS A	2.2	15.5	Full	172	0.0	0.0
Approach	386	3.0		0.309		6.6	LOS A	2.2	15.5				
North: Doley Road													
Lane 1 d	147	2.0	978	0.151	100	6.5	LOS A	0.9	6.4	Full	65	0.0	0.0
Approach	147	2.0		0.151		6.5	LOS A	0.9	6.4				
West: Orton Road													
Lane 1 d	385	3.0	1141	0.338	100	6.1	LOS A	2.3	16.7	Full	129	0.0	0.0
Approach	385	3.0		0.338		6.1	LOS A	2.3	16.7				
Intersection	1033	2.7		0.338		6.4	LOS A	2.3	16.7				

Figure 8 - LOS Table (Model 1.2p_V1 Orton Road - Doley Road - 2036 PM)

2.2 Intersection 2 – Orton Road – Lawrence Way



Figure 9 -Location

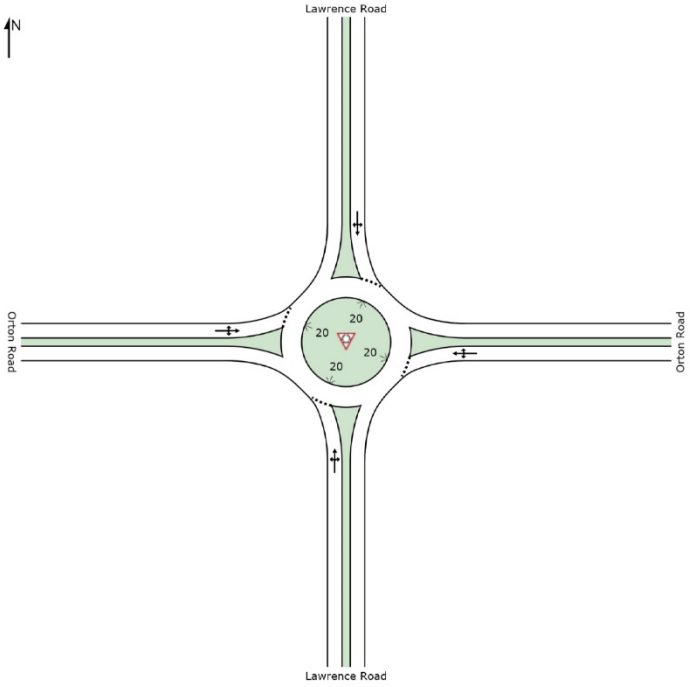


Figure 10- Schematic Geometry

2.2.1 2.1a Orton Road - Lawrence Way - 2026 AM

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Lawrence Way													
Lane 1 d	96	2.0	1058	0.090	100	6.8	LOS A	0.5	3.6	Full	65	0.0	0.0
Approach	96	2.0		0.090		6.8	LOS A	0.5	3.6				
East: Orton Road													
Lane 1 d	256	3.0	1278	0.200	100	6.3	LOS A	1.2	9.0	Full	172	0.0	0.0
Approach	256	3.0		0.200		6.3	LOS A	1.2	9.0				
North: Lawrence Way													
Lane 1 d	181	2.0	1095	0.165	100	5.2	LOS A	1.0	7.0	Full	65	0.0	0.0
Approach	181	2.0		0.165		5.2	LOS A	1.0	7.0				
West: Orton Road													
Lane 1 d	256	3.0	1186	0.216	100	5.7	LOS A	1.3	9.5	Full	180	0.0	0.0
Approach	256	3.0		0.216		5.7	LOS A	1.3	9.5				
Intersection	788	2.6		0.216		5.9	LOS A	1.3	9.5				

Figure 11 - LOS Table (Model 2.1a Orton Road - Lawrence Way - 2026 AM)

2.2.2 2.1p Orton Road - Lawrence Way - 2026 PM

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Lawrence Way													
Lane 1 d	93	2.0	1053	0.088	100	6.9	LOS A	0.5	3.5	Full	65	0.0	0.0
Approach	93	2.0		0.088		6.9	LOS A	0.5	3.5				
East: Orton Road													
Lane 1 d	266	3.0	1286	0.207	100	6.3	LOS A	1.3	9.3	Full	172	0.0	0.0
Approach	266	3.0		0.207		6.3	LOS A	1.3	9.3				
North: Lawrence Way													
Lane 1 d	162	2.0	1080	0.150	100	5.2	LOS A	0.9	6.3	Full	65	0.0	0.0
Approach	162	2.0		0.150		5.2	LOS A	0.9	6.3				
West: Orton Road													
Lane 1 d	278	3.0	1187	0.234	100	5.7	LOS A	1.5	10.4	Full	180	0.0	0.0
Approach	278	3.0		0.234		5.7	LOS A	1.5	10.4				
Intersection	799	2.7		0.234		6.0	LOS A	1.5	10.4				

Figure 12 - LOS Table (Model 2.1p Orton Road - Lawrence Way - 2026 PM)

2.2.3 2.2a Orton Road - Lawrence Way - 2036 AM

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Lawrence Way													
Lane 1 d	117	2.0	1006	0.116	100	7.3	LOS A	0.7	4.7	Full	65	0.0	0.0
Approach	117	2.0		0.116		7.3	LOS A	0.7	4.7				
East: Orton Road													
Lane 1 d	325	3.0	1289	0.252	100	6.3	LOS A	1.7	11.9	Full	172	0.0	0.0
Approach	325	3.0		0.252		6.3	LOS A	1.7	11.9				
North: Lawrence Way													
Lane 1 d	167	2.0	1049	0.160	100	5.4	LOS A	0.9	6.7	Full	65	0.0	0.0
Approach	167	2.0		0.160		5.4	LOS A	0.9	6.7				
West: Orton Road													
Lane 1 d	303	3.0	1138	0.266	100	6.0	LOS A	1.7	12.2	Full	180	0.0	0.0
Approach	303	3.0		0.266		6.0	LOS A	1.7	12.2				
Intersection	913	2.7		0.266		6.2	LOS A	1.7	12.2				

Figure 13 - LOS Table (Model 2.2a Orton Road - Lawrence Way - 2036 AM)

2.2.4 2.2a_V1 Orton Road - Lawrence Way - 2036 AM

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Lawrence Way													
Lane 1 d	119	2.0	932	0.128	100	7.1	LOS A	0.7	5.3	Full	65	0.0	0.0
Approach	119	2.0		0.128		7.1	LOS A	0.7	5.3				
East: Orton Road													
Lane 1 d	367	3.0	1190	0.309	100	6.3	LOS A	2.1	15.4	Full	172	0.0	0.0
Approach	367	3.0		0.309		6.3	LOS A	2.1	15.4				
North: Lawrence Way													
Lane 1 d	211	2.0	1011	0.208	100	6.5	LOS A	1.3	9.1	Full	65	0.0	0.0
Approach	211	2.0		0.208		6.5	LOS A	1.3	9.1				
West: Orton Road													
Lane 1 d	319	3.0	1193	0.267	100	5.8	LOS A	1.7	12.5	Full	180	0.0	0.0
Approach	319	3.0		0.267		5.8	LOS A	1.7	12.5				
Intersection	1016	2.7		0.309		6.3	LOS A	2.1	15.4				

Figure 14 - LOS Table (Model 2.2a_V1 Orton Road - Lawrence Way - 2036 AM)

2.2.5 2.2p Orton Road - Lawrence Way - 2036 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Lawrence Way													
Lane 1 d	108	2.0	974	0.111	100	7.5	LOS A	0.6	4.5	Full	65	0.0	0.0
Approach	108	2.0		0.111		7.5	LOS A	0.6	4.5				
East: Orton Road													
Lane 1 d	367	3.0	1297	0.283	100	6.3	LOS A	1.9	13.8	Full	172	0.0	0.0
Approach	367	3.0		0.283		6.3	LOS A	1.9	13.8				
North: Lawrence Way													
Lane 1 d	167	2.0	1053	0.159	100	5.4	LOS A	0.9	6.7	Full	65	0.0	0.0
Approach	167	2.0		0.159		5.4	LOS A	0.9	6.7				
West: Orton Road													
Lane 1 d	303	3.0	1127	0.269	100	6.1	LOS A	1.7	12.3	Full	180	0.0	0.0
Approach	303	3.0		0.269		6.1	LOS A	1.7	12.3				
Intersection	946	2.7		0.283		6.2	LOS A	1.9	13.8				

Figure 15 - LOS Table (Model 2.2p Orton Road - Lawrence Way - 2036 PM)

2.2.6 2.2p_V1 Orton Road - Lawrence Way - 2036 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Lawrence Way													
Lane 1 d	117	2.0	922	0.127	100	7.2	LOS A	0.7	5.3	Full	65	0.0	0.0
Approach	117	2.0		0.127		7.2	LOS A	0.7	5.3				
East: Orton Road													
Lane 1 d	384	3.0	1185	0.324	100	6.3	LOS A	2.3	16.4	Full	172	0.0	0.0
Approach	384	3.0		0.324		6.3	LOS A	2.3	16.4				
North: Lawrence Way													
Lane 1 d	199	2.0	957	0.208	100	6.9	LOS A	1.3	9.2	Full	65	0.0	0.0
Approach	199	2.0		0.208		6.9	LOS A	1.3	9.2				
West: Orton Road													
Lane 1 d	393	3.0	1203	0.326	100	5.9	LOS A	2.3	16.2	Full	180	0.0	0.0
Approach	393	3.0		0.326		5.9	LOS A	2.3	16.2				
Intersection	1093	2.7		0.326		6.4	LOS A	2.3	16.4				

Figure 16 - LOS Table (Model 2.2p_V1 Orton Road - Lawrence Way - 2036 PM)

2.3 Intersection 3 – Orton Road – Warrington Road



Figure 17 - Location

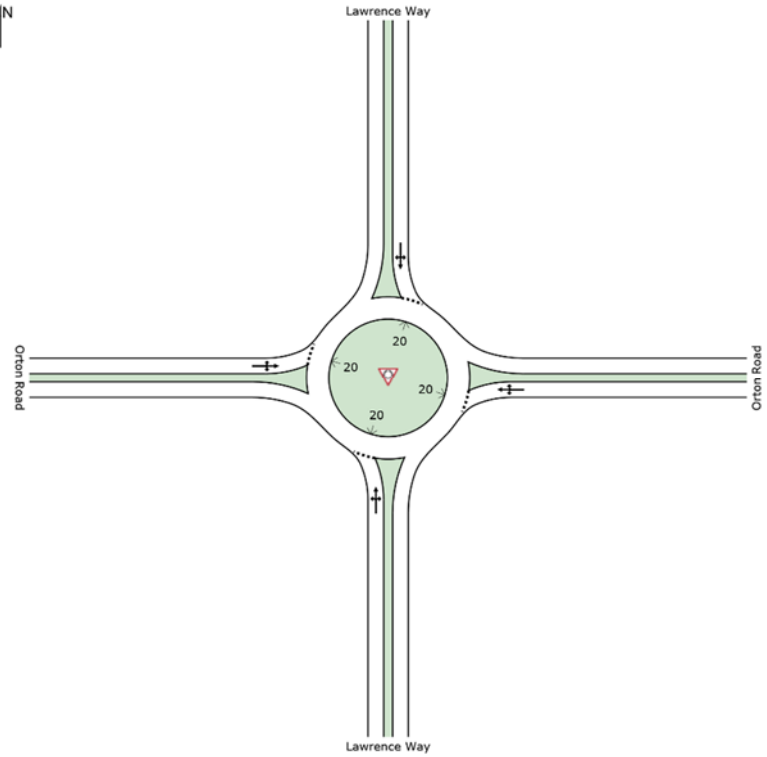


Figure 18- Schematic Geometry

2.3.1 3.1a Orton Road - Warrington Road - 2026 AM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	98	2.0	1060	0.092	100	5.6	LOS A	0.5	3.7	Full	65	0.0	0.0
Approach	98	2.0		0.092		5.6	LOS A	0.5	3.7				
East: Orton Road													
Lane 1 d	256	3.0	1307	0.196	100	4.1	LOS A	1.2	8.9	Full	65	0.0	0.0
Approach	256	3.0		0.196		4.1	LOS A	1.2	8.9				
North: Warrington Road													
Lane 1 d	84	2.0	1005	0.084	100	6.2	LOS A	0.5	3.3	Full	65	0.0	0.0
Approach	84	2.0		0.084		6.2	LOS A	0.5	3.3				
West: Orton Road													
Lane 1 d	326	3.0	1329	0.246	100	5.0	LOS A	1.6	11.7	Full	170	0.0	0.0
Approach	326	3.0		0.246		5.0	LOS A	1.6	11.7				
Intersection	764	2.8		0.246		4.9	LOS A	1.6	11.7				

Figure 19 - LOS Table (Model 3.1a Orton Road - Warrington Road - 2026 AM)

2.3.2 3.1p Orton Road - Warrington Road - 2026 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	74	2.0	1047	0.070	100	5.9	LOS A	0.4	2.8	Full	65	0.0	0.0
Approach	74	2.0		0.070		5.9	LOS A	0.4	2.8				
East: Orton Road													
Lane 1 d	268	3.0	1293	0.208	100	4.2	LOS A	1.3	9.5	Full	65	0.0	0.0
Approach	268	3.0		0.208		4.2	LOS A	1.3	9.5				
North: Warrington Road													
Lane 1 d	95	2.0	1008	0.094	100	6.1	LOS A	0.5	3.8	Full	65	0.0	0.0
Approach	95	2.0		0.094		6.1	LOS A	0.5	3.8				
West: Orton Road													
Lane 1 d	324	3.0	1349	0.240	100	5.0	LOS A	1.6	11.4	Full	170	0.0	0.0
Approach	324	3.0		0.240		5.0	LOS A	1.6	11.4				
Intersection	761	2.8		0.240		4.9	LOS A	1.6	11.4				

Figure 20 - LOS Table (Model 3.1p Orton Road - Warrington Road - 2026 PM)

2.3.3 3.2a Orton Road - Warrington Road - 2036 AM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	100	2.0	1022	0.098	100	6.0	LOS A	0.6	3.9	Full	65	0.0	0.0
Approach	100	2.0		0.098		6.0	LOS A	0.6	3.9				
East: Orton Road													
Lane 1 d	288	3.0	1265	0.228	100	4.3	LOS A	1.5	10.7	Full	65	0.0	0.0
Approach	288	3.0		0.228		4.3	LOS A	1.5	10.7				
North: Warrington Road													
Lane 1 d	118	2.0	989	0.119	100	6.2	LOS A	0.7	4.9	Full	65	0.0	0.0
Approach	118	2.0		0.119		6.2	LOS A	0.7	4.9				
West: Orton Road													
Lane 1 d	338	3.0	1310	0.258	100	5.1	LOS A	1.7	12.5	Full	170	0.0	0.0
Approach	338	3.0		0.258		5.1	LOS A	1.7	12.5				
Intersection	844	2.7		0.258		5.1	LOS A	1.7	12.5				

Figure 21 - LOS Table (Model 3.2a Orton Road - Warrington Road - 2036 AM)

2.3.4 3.2a_V1 Orton Road - Warrington Road - 2036 AM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	97	2.0	995	0.097	100	6.1	LOS A	0.6	3.9	Full	65	0.0	0.0
Approach	97	2.0		0.097		6.1	LOS A	0.6	3.9				
East: Orton Road													
Lane 1 d	317	3.0	1247	0.254	100	4.7	LOS A	1.7	12.0	Full	65	0.0	0.0
Approach	317	3.0		0.254		4.7	LOS A	1.7	12.0				
North: Warrington Road													
Lane 1 d	109	2.0	972	0.113	100	7.0	LOS A	0.6	4.6	Full	65	0.0	0.0
Approach	109	2.0		0.113		7.0	LOS A	0.6	4.6				
West: Orton Road													
Lane 1 d	360	3.0	1311	0.275	100	5.4	LOS A	1.8	13.2	Full	170	0.0	0.0
Approach	360	3.0		0.275		5.4	LOS A	1.8	13.2				
Intersection	883	2.8		0.275		5.4	LOS A	1.8	13.2				

Figure 22 - LOS Table (Model 3.2a_V1 Orton Road - Warrington Road - 2036 AM)

2.3.5 3.2p Orton Road - Warrington Road - 2036 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	111	2.0	974	0.113	100	6.3	LOS A	0.7	4.7	Full	65	0.0	0.0
Approach	111	2.0		0.113		6.3	LOS A	0.7	4.7				
East: Orton Road													
Lane 1 d	348	3.0	1278	0.273	100	4.3	LOS A	1.9	13.4	Full	65	0.0	0.0
Approach	348	3.0		0.273		4.3	LOS A	1.9	13.4				
North: Warrington Road													
Lane 1 d	112	2.0	949	0.118	100	6.5	LOS A	0.7	4.9	Full	65	0.0	0.0
Approach	112	2.0		0.118		6.5	LOS A	0.7	4.9				
West: Orton Road													
Lane 1 d	382	3.0	1293	0.296	100	5.2	LOS A	2.1	14.9	Full	170	0.0	0.0
Approach	382	3.0		0.296		5.2	LOS A	2.1	14.9				
Intersection	953	2.8		0.296		5.2	LOS A	2.1	14.9				

Figure 23 - LOS Table (Model 3.2p Orton Road - Warrington Road - 2036 PM)

2.3.6 3.2p_V1 Orton Road - Warrington Road - 2036 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	107	2.0	973	0.110	100	6.4	LOS A	0.6	4.5	Full	65	0.0	0.0
Approach	107	2.0		0.110		6.4	LOS A	0.6	4.5				
East: Orton Road													
Lane 1 d	348	3.0	1236	0.282	100	4.7	LOS A	1.9	13.6	Full	65	0.0	0.0
Approach	348	3.0		0.282		4.7	LOS A	1.9	13.6				
North: Warrington Road													
Lane 1 d	115	2.0	938	0.122	100	7.3	LOS A	0.7	5.1	Full	65	0.0	0.0
Approach	115	2.0		0.122		7.3	LOS A	0.7	5.1				
West: Orton Road													
Lane 1 d	399	3.0	1311	0.304	100	5.4	LOS A	2.1	15.2	Full	170	0.0	0.0
Approach	399	3.0		0.304		5.4	LOS A	2.1	15.2				
Intersection	969	2.8		0.304		5.5	LOS A	2.1	15.2				

Figure 24 - LOS Table (Model 3.2p_V1 Orton Road - Warrington Road - 2036 PM)

2.4 Intersection 4 – Turner Road – Warrington Road



Figure 25 - Location

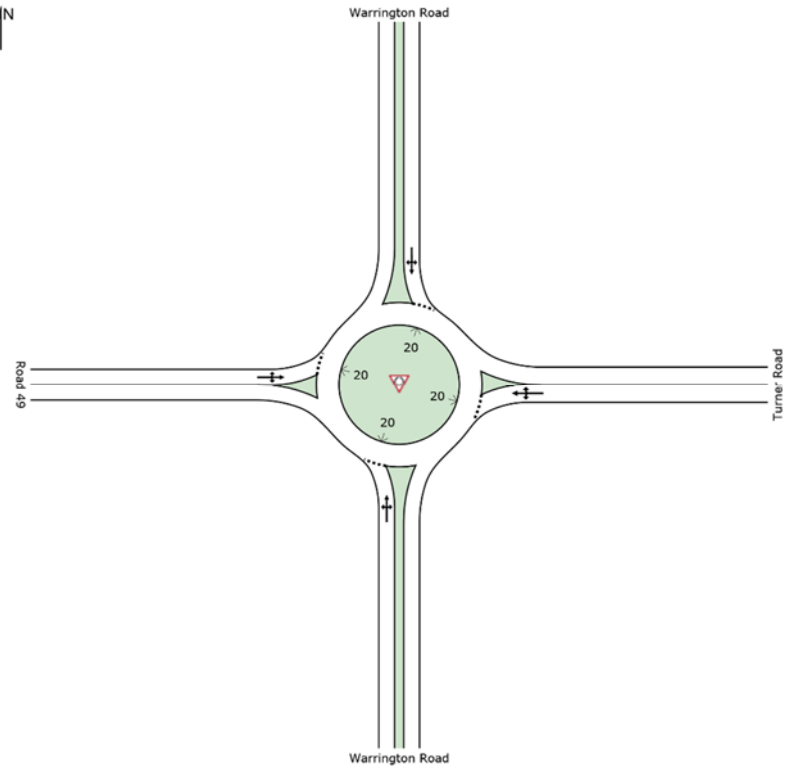


Figure 26- Schematic Geometry

2.4.1 4.1a Turner Road - Warrington Road - 2026 AM

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	93	2.0	1199	0.077	100	4.1	LOS A	0.4	3.0	Full	45	0.0	0.0
Approach	93	2.0		0.077		4.1	LOS A	0.4	3.0				
East: Turner Road													
Lane 1 d	129	2.0	1350	0.096	100	6.4	LOS A	0.5	3.5	Full	60	0.0	0.0
Approach	129	2.0		0.096		6.4	LOS A	0.5	3.5				
North: Warrington Road													
Lane 1 d	195	2.0	1381	0.141	100	3.4	LOS A	0.8	5.9	Full	50	0.0	0.0
Approach	195	2.0		0.141		3.4	LOS A	0.8	5.9				
West: Road 49													
Lane 1 d	33	2.0	1159	0.028	100	5.4	LOS A	0.1	1.0	Full	176	0.0	0.0
Approach	33	2.0		0.028		5.4	LOS A	0.1	1.0				
Intersection	449	2.0		0.141		4.6	LOS A	0.8	5.9				

Figure 27 - LOS Table (Model 4.1a Turner Road - Warrington Road - 2026 AM)

2.4.2 4.1p Turner Road - Warrington Road - 2026 PM

Lane Use and Performance													
	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	102	2.0	1187	0.086	100	4.1	LOS A	0.5	3.3	Full	45	0.0	0.0
Approach	102	2.0		0.086		4.1	LOS A	0.5	3.3				
East: Turner Road													
Lane 1 d	142	2.0	1362	0.104	100	6.4	LOS A	0.5	3.8	Full	60	0.0	0.0
Approach	142	2.0		0.104		6.4	LOS A	0.5	3.8				
North: Warrington Road													
Lane 1 d	186	2.0	1384	0.135	100	3.4	LOS A	0.8	5.6	Full	50	0.0	0.0
Approach	186	2.0		0.135		3.4	LOS A	0.8	5.6				
West: Road 49													
Lane 1 d	28	2.0	1140	0.025	100	5.5	LOS A	0.1	0.9	Full	176	0.0	0.0
Approach	28	2.0		0.025		5.5	LOS A	0.1	0.9				
Intersection	459	2.0		0.135		4.6	LOS A	0.8	5.6				

Figure 28 - LOS Table (Model 4.1p Turner Road - Warrington Road - 2026 PM)

2.4.3 4.2a Turner Road - Warrington Road - 2036 AM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	118	2.0	1193	0.099	100	4.1	LOS A	0.5	3.9	Full	45	0.0	0.0
Approach	118	2.0		0.099		4.1	LOS A	0.5	3.9				
East: Turner Road													
Lane 1 d	133	2.0	1318	0.101	100	6.5	LOS A	0.5	3.7	Full	60	0.0	0.0
Approach	133	2.0		0.101		6.5	LOS A	0.5	3.7				
North: Warrington Road													
Lane 1 d	248	2.0	1390	0.179	100	3.3	LOS A	1.1	7.7	Full	50	0.0	0.0
Approach	248	2.0		0.179		3.3	LOS A	1.1	7.7				
West: Road 49													
Lane 1 d	29	2.0	1134	0.026	100	5.5	LOS A	0.1	1.0	Full	176	0.0	0.0
Approach	29	2.0		0.026		5.5	LOS A	0.1	1.0				
Intersection	528	2.0		0.179		4.4	LOS A	1.1	7.7				

Figure 29 - LOS Table (Model 4.2a Turner Road - Warrington Road - 2036 AM)

2.4.4 4.2a_V1 Turner Road - Warrington Road - 2036 AM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	78	2.0	1210	0.064	100	4.2	LOS A	0.3	2.5	Full	45	0.0	0.0
Approach	78	2.0		0.064		4.2	LOS A	0.3	2.5				
East: Turner Road													
Lane 1 d	127	2.0	1294	0.098	100	6.5	LOS A	0.5	3.5	Full	60	0.0	0.0
Approach	127	2.0		0.098		6.5	LOS A	0.5	3.5				
North: Warrington Road													
Lane 1 d	186	2.0	1393	0.134	100	3.2	LOS A	0.8	5.5	Full	50	0.0	0.0
Approach	186	2.0		0.134		3.2	LOS A	0.8	5.5				
West: Road 49													
Lane 1 d	33	2.0	1171	0.028	100	6.8	LOS A	0.1	1.0	Full	176	0.0	0.0
Approach	33	2.0		0.028		6.8	LOS A	0.1	1.0				
Intersection	424	2.0		0.134		4.6	LOS A	0.8	5.5				

Figure 30 - LOS Table (Model 4.2a_V1 Turner Road - Warrington Road - 2036 AM)

2.4.5 4.2p Turner Road - Warrington Road - 2036 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	120	2.0	1214	0.099	100	4.1	LOS A	0.5	3.9	Full	45	0.0	0.0
Approach	120	2.0		0.099		4.1	LOS A	0.5	3.9				
East: Turner Road													
Lane 1 d	121	2.0	1355	0.089	100	6.4	LOS A	0.5	3.2	Full	60	0.0	0.0
Approach	121	2.0		0.089		6.4	LOS A	0.5	3.2				
North: Warrington Road													
Lane 1 d	185	2.0	1357	0.136	100	3.3	LOS A	0.8	5.6	Full	50	0.0	0.0
Approach	185	2.0		0.136		3.3	LOS A	0.8	5.6				
West: Road 49													
Lane 1 d	33	2.0	1141	0.029	100	5.5	LOS A	0.1	1.1	Full	176	0.0	0.0
Approach	33	2.0		0.029		5.5	LOS A	0.1	1.1				
Intersection	459	2.0		0.136		4.5	LOS A	0.8	5.6				

Figure 31 - LOS Table (Model 4.2p Turner Road - Warrington Road - 2036 PM)

2.4.6 4.2p_V1 Turner Road - Warrington Road - 2036 PM

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Warrington Road													
Lane 1 d	111	2.0	1225	0.090	100	4.1	LOS A	0.5	3.5	Full	45	0.0	0.0
Approach	111	2.0		0.090		4.1	LOS A	0.5	3.5				
East: Turner Road													
Lane 1 d	116	2.0	1316	0.088	100	6.5	LOS A	0.4	3.1	Full	60	0.0	0.0
Approach	116	2.0		0.088		6.5	LOS A	0.4	3.1				
North: Warrington Road													
Lane 1 d	167	2.0	1359	0.123	100	3.2	LOS A	0.7	5.0	Full	50	0.0	0.0
Approach	167	2.0		0.123		3.2	LOS A	0.7	5.0				
West: Road 49													
Lane 1 d	40	2.0	1149	0.035	100	5.7	LOS A	0.2	1.3	Full	176	0.0	0.0
Approach	40	2.0		0.035		5.7	LOS A	0.2	1.3				
Intersection	434	2.0		0.123		4.5	LOS A	0.7	5.0				

Figure 32 - LOS Table (Model 4.2p_V1 Turner Road - Warrington Road - 2036 PM)

Appendix 4

Paramics Modelling

Rev C

Figure 1 – Whole network



Figure 2 – LOS (Daily) - Only considering development interaction with surrounding network (2026)



Figure 3 - LOS (Daily) Theoretical Full Network 2026



Figure 4 – LOS (Daily) Theoretical Full Network 2036

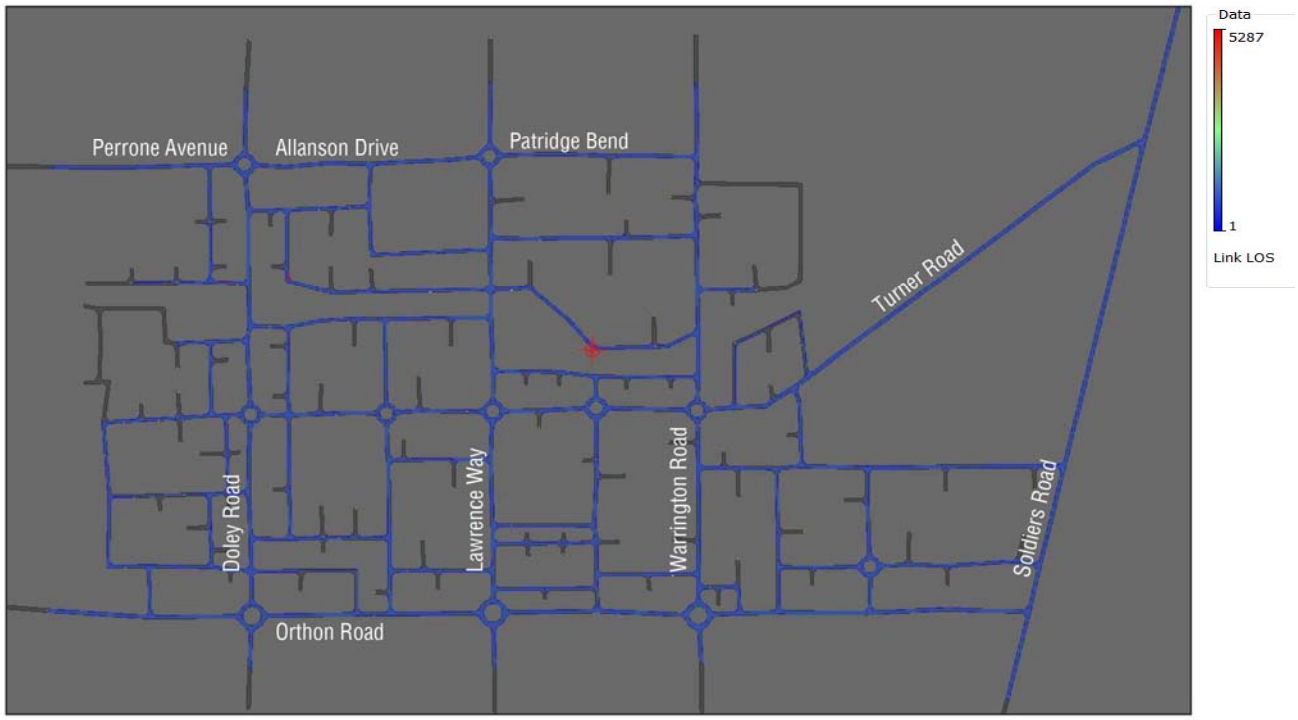


Figure 5 – LOS (Daily) Theoretical Full Network 2036 (with future Tonkin Highway / Orton Road Interchange completed)



Figure 6 – Intersection LOS (Daily) - Only considering development interaction with surrounding network (2026)



Figure 7 – Intersection LOS (Daily) – Theoretical full network (2026)



Figure 8 – Intersection LOS (Daily) – Theoretical full network (2036)



Figure 9 – Intersection LOS (Daily) – Theoretical full network (2036) - with future Tonkin Highway / Orton Road Interchange completed



APPENDIX 5

Local Water Management Strategy

Byford, Doley Road

Local Water Management Strategy

Prepared for ABN Group

By Essential Environmental

July 2016

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1 INTRODUCTION

ABN Group has commissioned Essential Environmental to produce a Local Water Management Strategy (LWMS) to support development of a Local Structure Plan for their landholdings as well as surrounding land.

1.1 Principles and design objectives

Consistent with *State Planning Policy 2.9: Water Resources* and *Better urban water management* (WAPC, 2008), a local water management strategy is required to be submitted to support any rezoning of land in a Local Planning Scheme or adoption of a Local Structure Plan to ensure that appropriate water management strategies are identified at the appropriate time.

The position of this strategy within the state government planning framework is defined in *Better urban water management* (WAPC 2008a) and *Planning bulletin no. 92, urban water management* (WAPC 2008c) and is outlined in Figure 1.

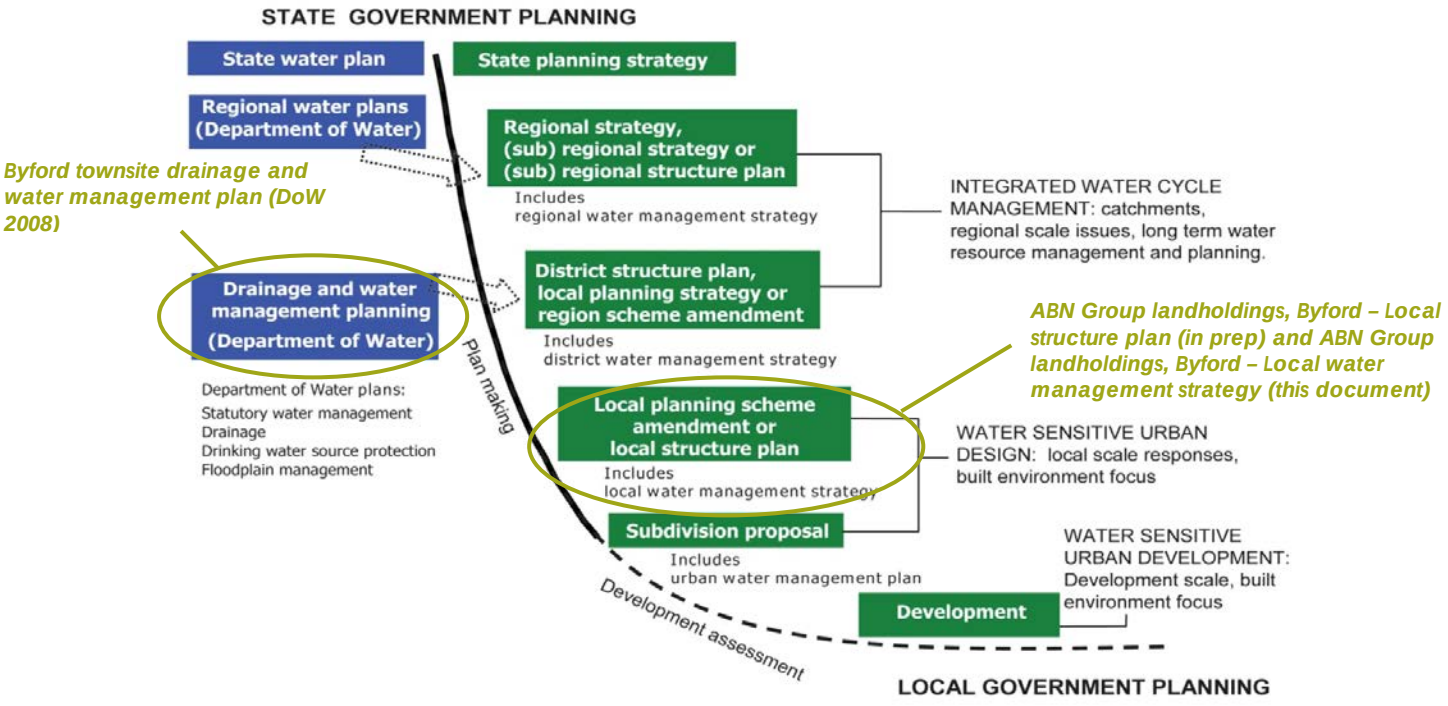


Figure 1: Planning framework, integrating drainage planning with the land planning process (WAPC 2008)

In accordance with *Better urban water management* (WAPC 2008) preparation of a local structure plan is to be supported by a local water management strategy (LWMS) prepared in accordance with the department's *Interim: Developing a local water management strategy* (2008). The LWMS should demonstrate to the satisfaction of the WAPC in accordance with this plan and any approved DWMS:

- how the key principles and strategies of this plan have been addressed
- how the urban structure will address water use and management
- existing and required water management infrastructure
- detailed land requirements for water management

The principles and strategies contained within section 4 of this *Local water management strategy* will be implemented as part of detailed land use planning and development requirements and are consistent with the framework and requirements in *Better urban water management* (WAPC 2008).

This strategy provides local level water management strategies that will be addressed during subsequent stages of the planning process.

Subdivision is the next stage of the planning process and should be supported by an urban water management plan (UWMP) prepared in accordance with the department's Urban water management plan: Guidelines for preparing plans and complying with subdivision conditions (DoW 2008). The UWMP should demonstrate in accordance with this plan and any approved DWMS and/or LWMS:

- how the key principles and strategies of this plan have been addressed
- how the final urban form will use and manage water

The UWMP should present key aspects of a finalised urban water management design and commit to a final engineering design for drainage infrastructure.

Table 8 summarises the roles and responsibilities relating to implementation of this *Local water management strategy*.

1.2 Strategy area

The strategy area consists of approximately 120 hectares of land in the vicinity of Orton Rd, Doley Rd and Warrington Rd in Byford. The area currently comprises single dwelling rural residential lots of between 1 and 6 hectares in size.

ABN Group landholdings, within the strategy area are bound by Orton Road to the south, Doley Road to the west and Lawrence Way to the east and have an area of 21.75ha.

1.3 Planning background

The strategy area is zoned 'Urban' under the Metropolitan Regional Scheme and 'Urban Development' under Serpentine-Jarrahdale Shire's Town Planning Scheme No. 2.

The study area is within the Doley / Warrington Rd Precinct of the *Byford District Structure Plan* area.

The *Byford District Structure Plan*, adopted in August 2005, provides a district level framework to guide more detailed planning for the Byford area between the proposed Tonkin Hwy and the Darling Scarp, from Thomas Rd to Cardup Siding Rd. It requires local structure plans to be prepared to provide the level of detailed planning required to facilitate subdivision and development within the district structure plan area. The Byford District Structure Plan recommends that a road reserve is provided adjacent to Brickwood Reserve, separating it from the residential area. It also recommends that public open space link is provided between

Brickwood Reserve and the multiple use corridor on Turner Road. The strategy area is within the Doley / Warrington Rd Precinct.

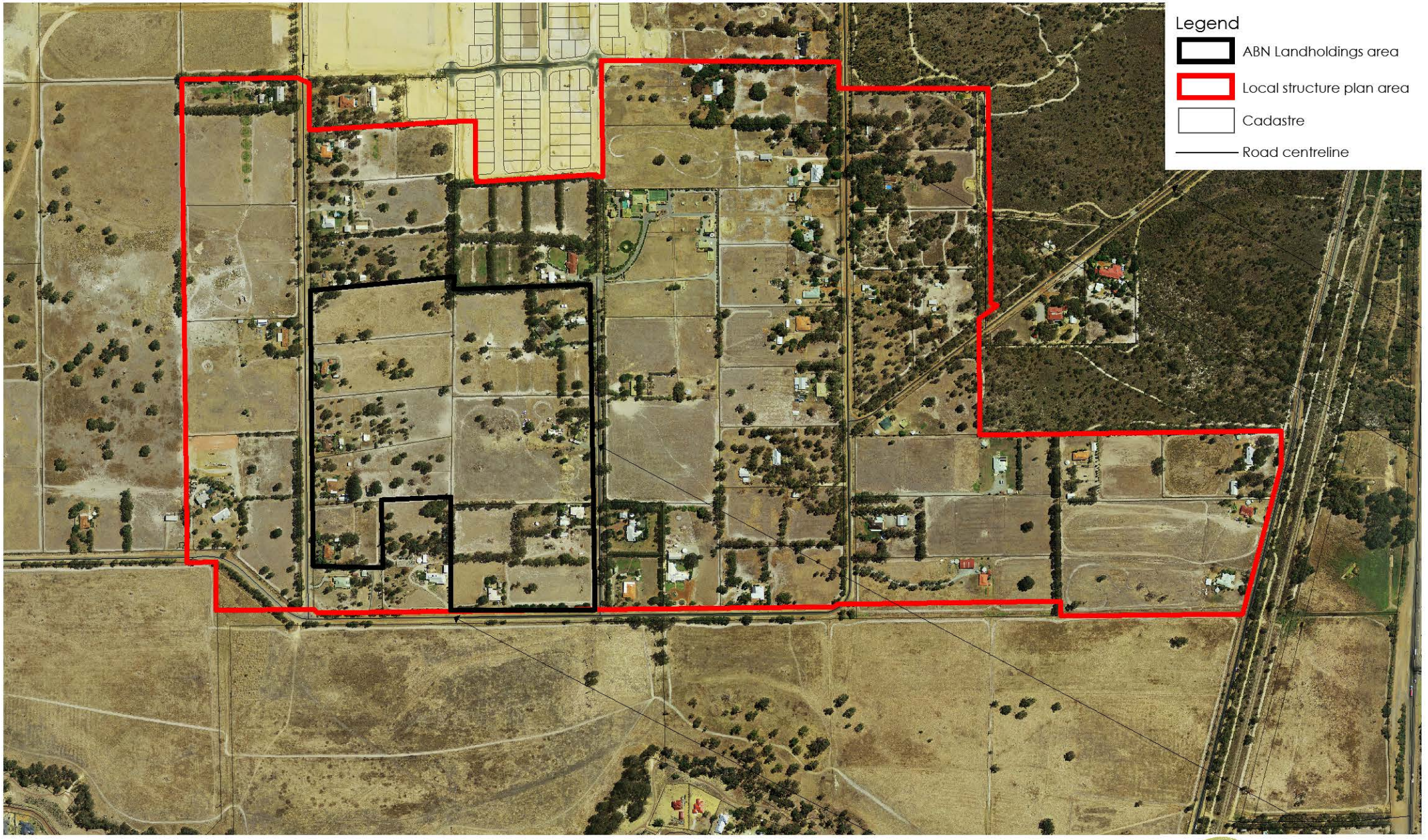
'The Glades' development flanks the north, west and southern boundaries of the strategy area. The local structure plan for this development was adopted in April 2011. As of mid-2015, the development is largely completed to the north and half completed to the west. No works have been undertaken south of the strategy area, where the development flanks the Cardup Brook.

1.4 Previous studies

A number of previous studies have been undertaken that are relevant to this strategy area. In addition to *State Planning Policy 2.9*, these documents inform the strategies and management principles contained within this Local Water Management Strategy:

- *Byford townsite drainage and water management plan* (GHD and DoW, 2008) presents a drainage and water management plan (DWMP) to address water issues in proposed development areas.
- Lower Serpentine hydrological studies
- *Local Scale Groundwater Modelling of Byford* (CyMod, 2007). Prepared for the Department of Water. Modelling was undertaken to assess any impacts from variations in climate or planned development in the strategy area which includes the Byford area.
- *Byford Floodplain Management Strategy* (SKM, 2007). Prepared for the Department of Water. A floodplain management study including two-dimensional flood modelling has been completed by SKM (2007) for DoW. 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.

ABN Group: Doley Rd, Byford - Local Water Management Strategy
Figure 2: Study area location



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2 PROPOSED DEVELOPMENT

2.1 Key elements of the structure plan

The local structure plan will guide the subdivision and development of approximately 120 hectares in Byford. The structure plan contains:

- approximately 13.4 ha of public open space (POS);
- Multiple use corridor (MUC) through the northern portion of the structure plan, tying in with adjacent developments (3.91ha);
- 3.5 Ha for a primary school;
- a neighbourhood node; and
- a mixture of residential lots.

During the preparation of this report, the design of the local structure plan has been modified to incorporate water quality treatment and flood detention areas into the plan, based on the natural hydrology of the strategy area in order to minimise any potential environmental impacts resulting from the development. Importantly, the existing water course present on the strategy area is to be retained, rehabilitated and incorporated into a multiple use corridor as a feature of the public open space. Landscape plans are provided in Appendix 8.

2.2 Previous land use

Department of Planning historical mapping shows the strategy area as 'Rural' under the previous regional scheme.

Historical aerial photography from Landgate shows the land was parcelled and single dwellings built during the late 70's to early 80's. Prior to this, aerial photography indicated the land may have been used for crop farming. No further changes to land use from the 1980's onwards are indicated in the aerial photography.

Given that the strategy area has been used for largely rural activities for the past 60 years, contamination risks may exist. These risks include hydrocarbons from farm plant, legacy nutrients from farming practice and other contamination that may occur on rural land parcels. However, a search of the Department of Environment Regulation contaminated sites database shows no registered contaminated sites within or near the strategy area.

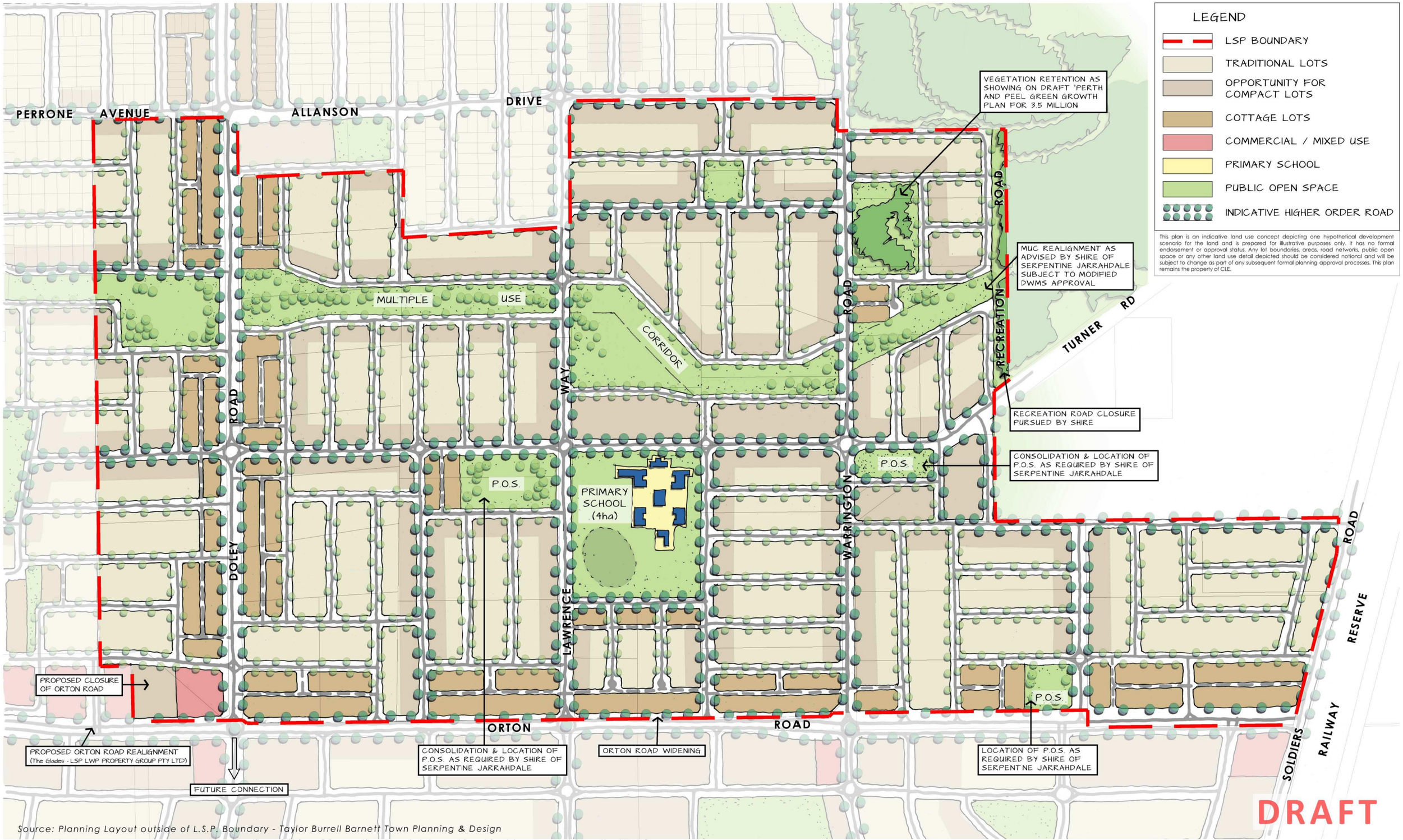
2.3 Finished lot levels

Finished lot levels will be developed as a part of detailed design process and presented in a future UWMP. Preliminary assessment of earthworks and drainage for the strategy area has been undertaken to inform the development of this strategy. The proposed landform of the strategy area will typically provide 1.2 m of sand over the underlying clay surface.

2.4 Identification of key risks

Key water resource risks to the development include:

- large parts of the strategy area are seasonally inundated or saturated by shallow groundwater with maximum groundwater level less than two metres below ground level;
- water balance assessment suggests that reduced evapotranspiration at the strategy area may result in increased groundwater levels which will require management through installation of subsoil drainage; and
- release of legacy nutrients that have been stored in the surficial soil profile through decades of agricultural land uses.



This plan is an indicative land use concept depicting one hypothetical development scenario for the land and is prepared for illustrative purposes only. It has no formal endorsement or approval status. Any lot boundaries, areas, road networks, public open space or any other land use detail depicted should be considered notional and will be subject to change as part of any subsequent formal planning approval processes. This plan remains the property of CLE.

Source: Planning Layout outside of L.S.P. Boundary - Taylor Burrell Barnett Town Planning & Design

Note: This plan has been prepared at the direction of Shire of Serpentine Jarrahdale and is subject to approval from the WAPC.

0 50 100 150 200 250 300 350 400 450 500m

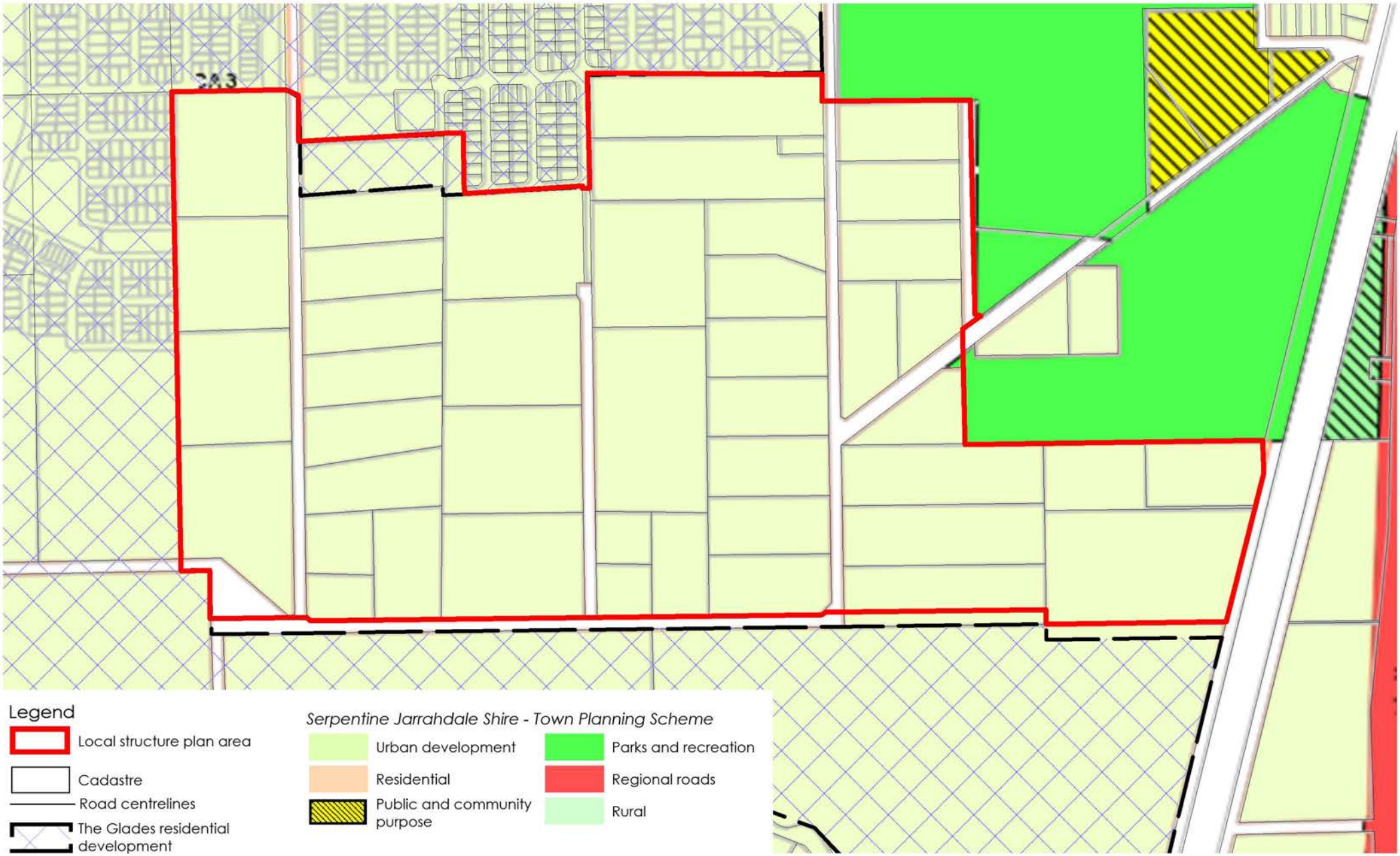
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SHIRE OF SERPENTINE JARRAHDALE ALTERNATIVE CONCEPT PLAN (CONSOLIDATED POS)

Orton Road, Byford

ABN Group: Doley Rd, Byford - Local Water Management Strategy

Figure 4: Land use and zoning



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3 EXISTING SITE CHARACTERISTICS

3.1 Location and climate

Byford, where the strategy area is located, lies approximately 40 km to the south east of Perth on the Swan Coastal Plain close to the foot of the Darling Scarp. The climate is typically Mediterranean having hot summers and mild winters with low annual rainfall.

Average annual rainfall recorded at the nearest Bureau of Meteorology weather station at Cardup (no. 9137) (approx. 4 km to the south) since 1971 is 857 mm but has declined in recent years to an average of 799 mm since 1995. The minimum recorded annual rainfall was in 2010 at just 488 mm and the maximum recorded was in 1973 at 1,168 mm.

The majority of rainfall is experienced in the winter between May and September with the driest months being December to February.

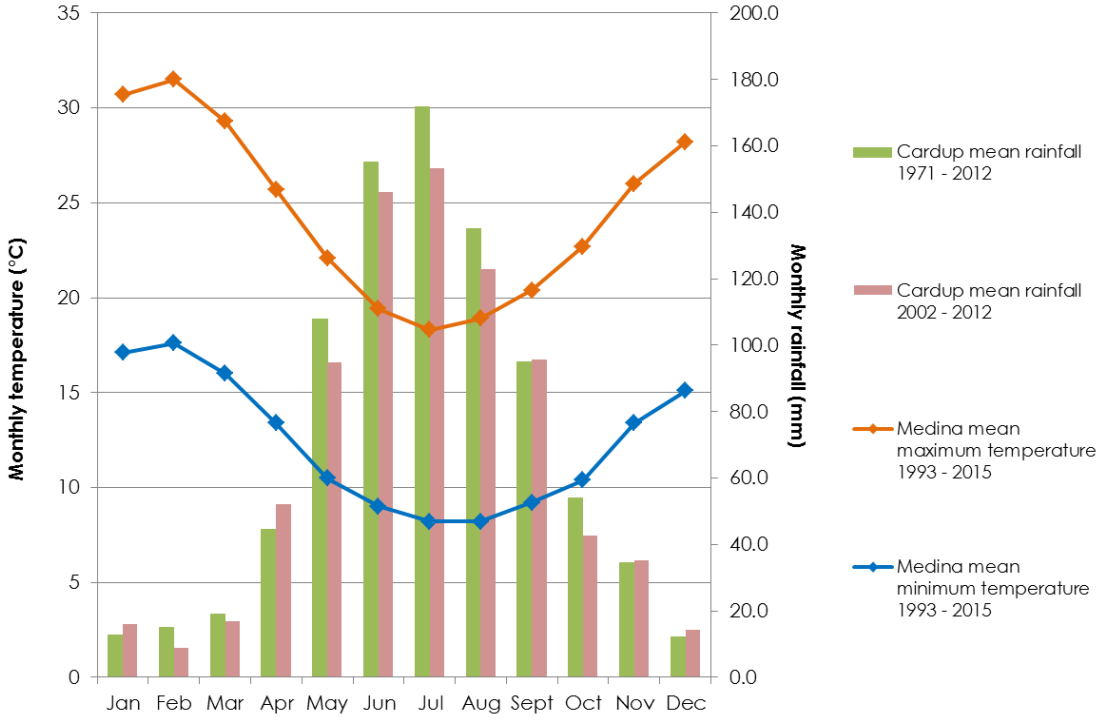


Figure 5: Climate summary data (Rainfall: Cardup, Temperature: Medina, BoM, 2015)

The nearest weather station with a temperature record is Medina Research Centre (no. 9294) (approx. 18 km to the west). Average maximum temperatures range between 18.3°C in July and 31.5°C in February, while average minimum temperatures range between 8.2°C in July and 17.6°C in February.

3.2 Topography and landform

3.2.1 Topography

The structure plan area generally grades gently from 50m AHD in the south east to 35mAHD along the western boundary as shown in . Existing dwellings are generally elevated from the surrounding landform by as much as 1m to protect buildings and property from stormwater flooding and groundwater inundation during winter.

3.3 Soils and geotechnical

3.3.1 Surface geology and soils

The surface geology of the structure plan area is described broadly as Guildford formation: Alluvial sand and clay with shallow-marine and estuarine lenses and local basal conglomerate (WA surface geology 1:250,000 scale geological maps, Geological Survey of WA, and Geoscience Australia).

Environmental geology (soils) mapping (1:50,000 scale geological maps, Geological Survey of WA) further classifies the soils throughout the structure plan area as Sandy Clay; described as white grey to brown, fine to coarse grained, sub-angular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp (Figure 6).

3.3.2 Acid sulfate soils

A review of Department of Environment Regulation acid sulfate soils risk mapping identifies as Class II 'low to moderate risk of acid sulfate soils (ASS) within the strategy area (Figure 7).

3.3.3 Geotechnical

A desktop geotechnical study has been undertaken for the strategy area by Galt Geotechnics (see Appendix 2) supported by limited fieldwork within the ABN landholdings area undertaken during September 2015.

The report finds that the strategy area is predominantly underlain by Sandy Clay, described as:

- SANDY CLAY – white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity, gravel and silt layers near scarp.

In the east of the site, there are two isolated areas of SAND and Gravelly Sandy CLAY. These are described as follows:

- SAND – white to pale grey at surface, yellow at depth, fine to medium grained, moderately sorted, subangular
- to sub-rounded; and
- Gravelly Sandy CLAY - variable, with lenses of silt and gravel, quartz sand, subangular with eolian rounded
- component, heavy minerals common, gravel rounded of colluvial origin.

Groundwater was not encountered in any of the boreholes during the field investigation.

Predevelopment site classification

Galt Geotechnics found that based on the current state of the strategy area the following preliminary site classifications apply:

- "Class A" where the overlying sand thickness is greater than 1.8 m;
- "Class S" where the overlying sand thickness is between 0.3 m and 1.8 m;
- "Class M" where the overlying sand thickness is between 0 m and 0.3 m.

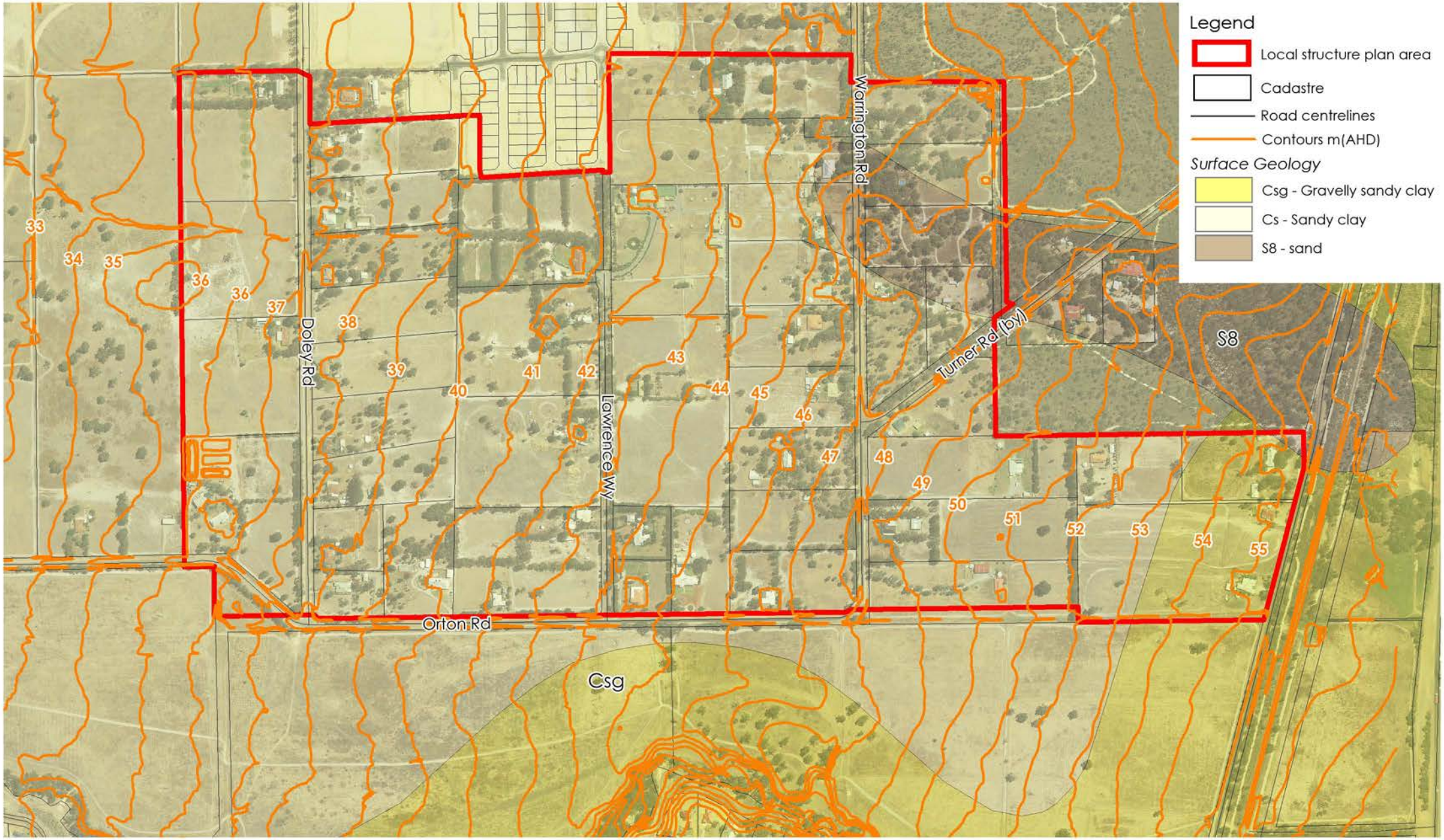
Drainage characteristics

Galt Geotechnics indicated that the in-situ sands and sand fill at the site are suitable for the disposal of stormwater by infiltration by means of soakwells. Notwithstanding the results of the permeability testing, they recommended a design value of permeability (k) not greater than 1 m/day for the sand fill to allow for the variability in materials and reduced permeability as a consequence of:

- densification of sand during site preparation works;
- natural variation in sands; and
- clogging of the sand around soakwells and soakage basins over time with fines.

It is noted that imported sand fill may have a higher permeability. Typically an infiltration rate of 5 m/day is considered suitable for imported (yellow) sand fill.

ABN Group: Orton Rd, Byford - Local Water Management Strategy
Figure 6: Topography and soils



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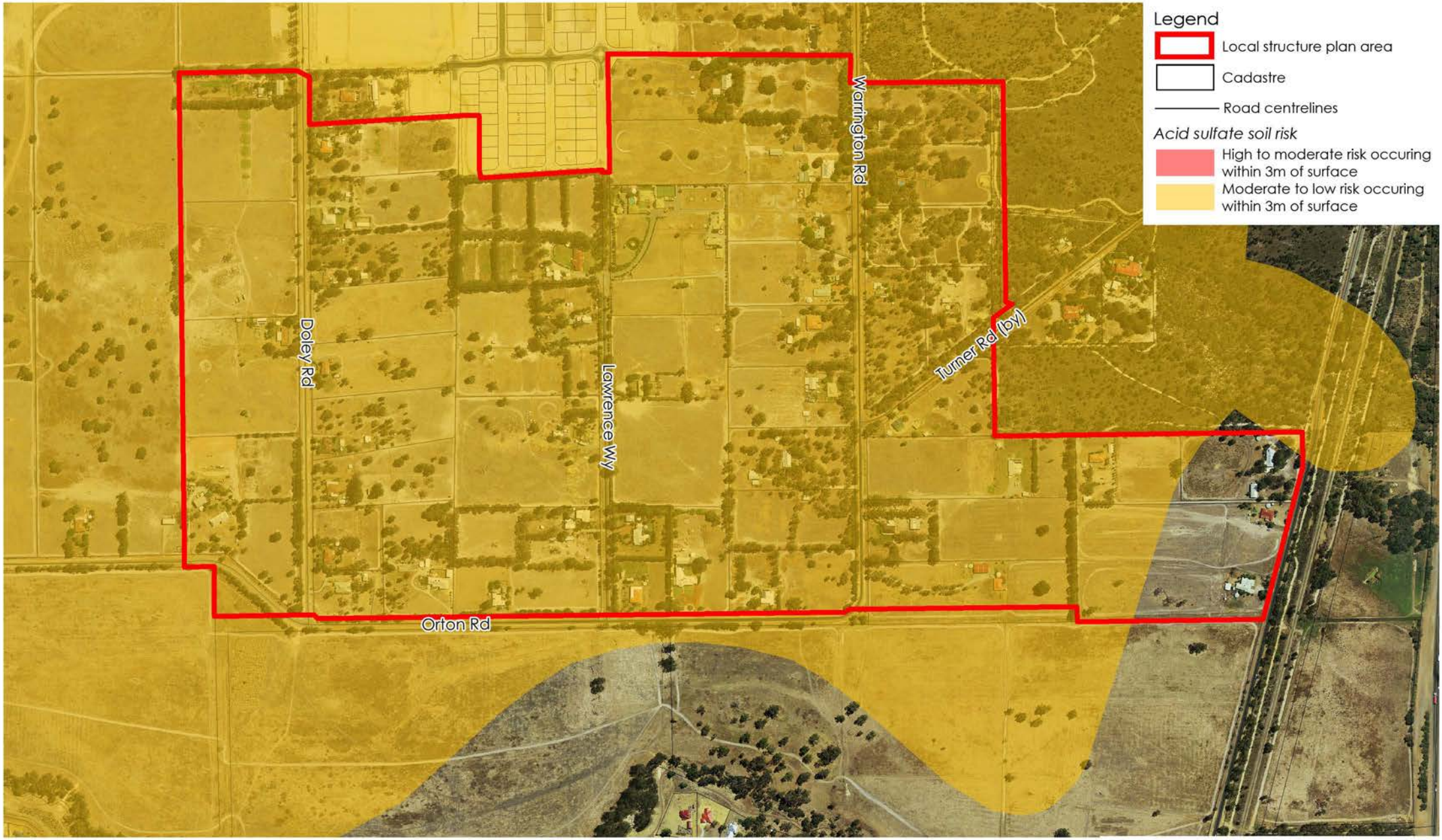
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ABN Group: Doley Rd, Byford - Local Water Management Strategy
Figure 7: Acid sulfate soils risk



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Scale 1: 8000 at A4

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3.4 Hydrology

3.4.1 Surface water resources

The structure plan area is generally flat with gentle undulations and sits astride the boundary between two catchments of contributing watercourses to the Birrega Drain catchment (see Figure 8).

The northern portion of the structure plan area drains to a minor water course referred to in the *Byford Townsite DWMP* (DoW 2008) as 'tributary 7'. The watercourse traverses the strategy area east to west approximately 100 m from the northern boundary. The *Byford Townsite DWMP* proposes modification of this watercourse into a living stream embedded within a multiple use corridor and provides peak flows, levels and catchment contribution requirements for development of the surrounding land which are presented in Table 1.

The southern portion of the structure plan area drains to a small drain located within the Orton Road reserve which is to be upgraded under the Byford Townsite Development Contribution Plan. It is understood that designs have not yet been prepared for Orton Road or associated drainage.

The strategy area has been modelled using an updated version of the InfoWorks model originally developed for the *Byford Townsite DWMP* (DoW 2008). The model provides predevelopment peak flows and top water levels at key locations. Two key locations from the Byford Townsite DWMP are of interest; termed 7c1 located upstream of Doley Road at Tributary 7 and Location 8c located at the junction of Orton and Doley Road. These predevelopment characteristics, presented in Table 1, provide the basis for drainage designs associated with this structure plan area.

Table 1: Predevelopment flow characteristics

	1 EY		20% AEP		1% AEP	
Location	Peak flow	Top water level	Peak flow	Top water level	Peak flow	Top water level
Tributary 7:						
7c1 - upstream of Doley Rd			1.5	n/a	2.51	36.1
Orton Road drain:						
8c - junction of Orton and Doley Rd			3.45	39.3	8.16	39.3

Note: All flows are expressed as m3/s and all top water levels are expressed as mAHD

Surface water quality

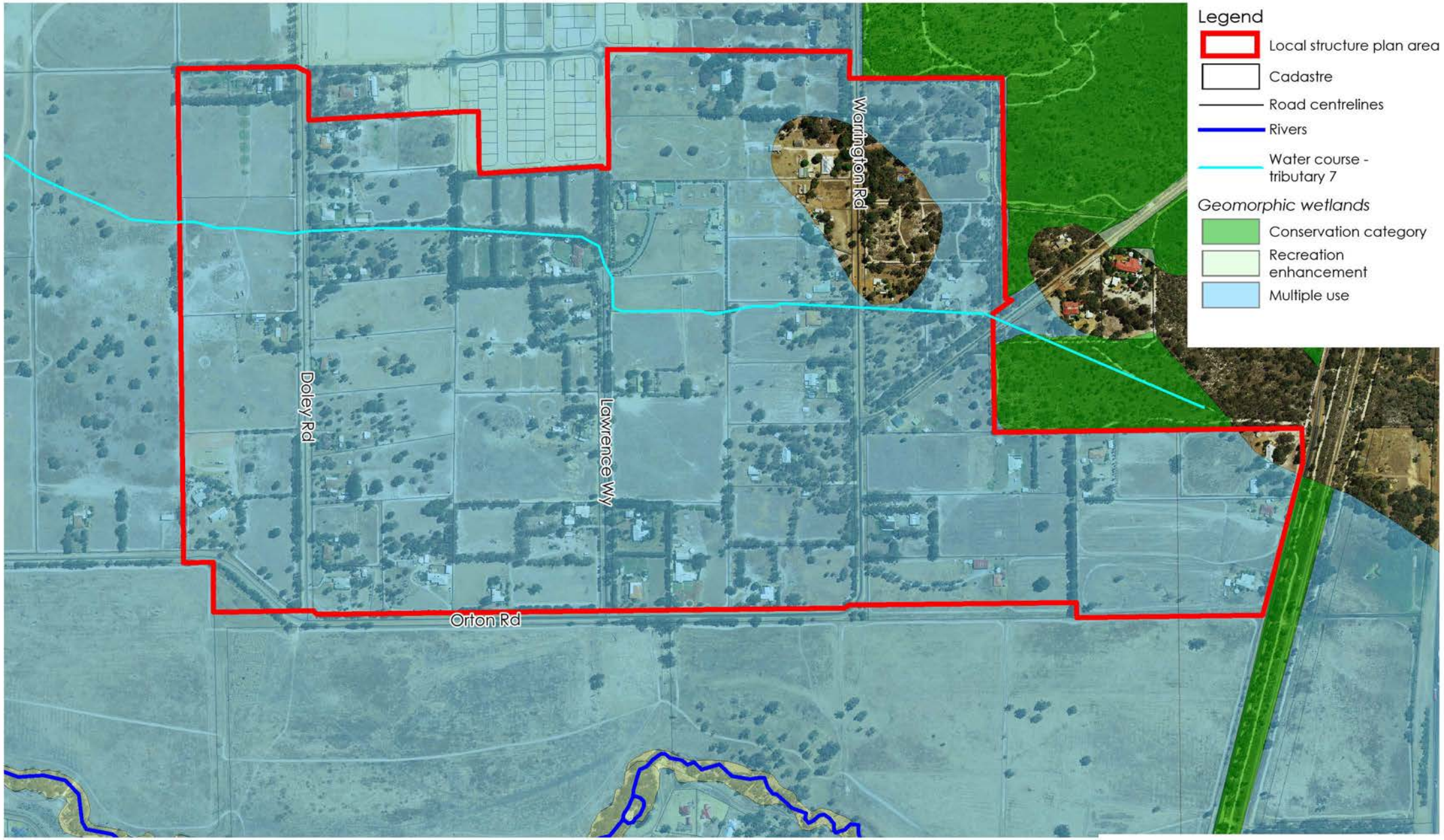
Surface water sampling has been undertaken by JDA from August 2006 to September 2009 and the values provided in Table 2 are averages over the three year period. Sites of particular interest to this LWMS are S3 which is located on Orton Road drain upstream of its discharge into Cardup Brook, and S6 which is located on Tributary 7 downstream of the Orton/Warrington precinct.

Results show that on average total nitrogen exceeds the Swan Canning WQIP target for total nitrogen at sites S1, S2 and S3 but not the ANZECC target. Conversely, total phosphorous exceeds the ANZECC target at sites S1 and S2 but not the Swan Canning WQIP target.

Table 2 - Pre-development average surface water quality values (JDA, 2009)

Parameter and unit of measurement	ANZECC values	Mean ARQ Urban Stormwater Concentration	Peel-Harvey Estuary WQIP Target for the Upper Serpentine	S1	S2	S3	S4	S5	S6
Electrical conductivity (mS/cm)	0.12-0.3	-	-	0.52	0.43	0.53	0.51	0.44	0.54
pH	6.5-8.0	6.8	-	7.09	6.92	7.15	6.75	6.75	6.92
Total Nitrogen (mg/L)	1.2	2.7	1.0	1.02	1.02	1.26	0.53	0.55	0.69
Nitrate/Nitrite NOx as N (mg/L)	0.15	-	-	0.46	0.24	0.84	0.23	0.24	0.41
Total Kjeldahl Nitrogen (mg/L)	-	-	-	0.6	0.83	0.43	0.29	0.31	0.32
Total Phosphorus (mg/L)	0.06	0.29	0.1	0.07	0.09	0.02	0.05	0.03	0.03
Filterable Reactive Phosphorus (mg/L)	0.04	-	-	0.05	0.026	0.003	0.012	0.003	0.002

ABN Group: Orton Rd, Byford - environmental report
Figure 8: Surface water resources



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Scale 1: 8000 at A4

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3.4.2 Groundwater resources

Groundwater levels

The Department of Water's Perth Ground Water Atlas groundwater levels do not extend to the strategy area. However, the strategy area has been subject to a number of groundwater investigations including both monitoring and modelling in recent years.

Groundwater monitoring and modelling undertaken to support the *Byford Townsite DWMP* (DoW 2008) and reported therein indicates that maximum groundwater levels range from approximately 36 m at Warrington Road to 32 m at the western boundary of the strategy area. At the time of this investigation, it was suggested that these levels are representative of the regional groundwater table and that locally perched shallow groundwater exists extensively throughout Byford typically located at or near the natural surface as a result of the local geotechnical conditions (Figure 9).

More recently, integrated surface and groundwater modelling has been undertaken by the Department of Water as a part of the Lower Serpentine hydrological studies. The results of this model suggest groundwater levels that are typically 10 m higher than those presented in the DWMP and are virtually at natural surface level throughout the strategy area (Figure 10).

Groundwater level monitoring was undertaken to support development at 'The Glades' from September 2005 to August 2006. The Glades strategy area wraps around the strategy area but groundwater monitoring occurred at two locations within the strategy area. Contours based on design groundwater levels developed for the Glades LWMS are presented in Figure 11. These inferred groundwater contours largely agree with the Department of Water's recent modelling, indicating that the groundwater is at or close to the natural surface.

Figure 12 presents a cross section through the strategy area (marked by the yellow line in Figure 11) with groundwater levels from both of these sources plotted together with the surface elevation. Blue markers identify the contours derived from The Glades monitoring data, whilst the red dotted line indicates the Department of Water's modelled maximum groundwater level surface. Red and black markers indicate where the cross section intersects the strategy area boundary and landholding boundary.

Groundwater quality

Groundwater quality monitoring was undertaken by JDA from 2006 to 2009 monthly, the results bellow are average values of the listed parameters at each bore location over the thee year time frame. Only two of these bores are located within the strategy area (BDM 10 and BDM 11) however, the complete data set is presented in Table 2 to provide a broader understanding of groundwater quality in the vicinity.

It is noted that total nitrogen is greater than the ANZECC & ARMCANZ guideline level (1.5 mg/L) at all bores except BDM7, BDM10, BDM11 and BDM12. Interestingly, these bores are clustered within the catchment of surface water tributary 7. This catchment differs from Tributary 6, Orton Road drain (Tributarty 8) and Cardup Brook through having no extension into the hills.

Nitrogen oxide concentrations (NOx-N) were greater than the ANZECC & ARMCANZ guideline level (0.1 mg/L) at all bores. The lowest concentrations were again recorded in bores clustered around tributary 7 including BDM 10 and BDM 11 within the strategy area. The high proportion of NOx-N present at the majority of bores may be indicative of fertilizer use.

Total phosphorous concentrations exceeded the ANZECC & ARMCANZ guideline level for wetlands in south-west Australia (0.06 mg/L) at six bores (BDM1, BDM2, BDM5, BDM10, BDM 11

and BDM 12). Four of these bores, including BDM10 and BDM11 located within the strategy area, produced a single elevated sample during August 2007 whilst a fifth (BDM1) produced a single elevated sample during September 2007. However, it is likely that average values at these bores would still have exceeded guidelines had these outliers been excluded from calculations.

Filterable reactive phosphorus (FRP) concentrations were less than the limit of reporting at all bores.

Table 2: Pre-development average groundwater quality (JDA, 2009)

Site	EC (mS/cm)	pH	Total Nitrogen (mg/L)	NOx (as N) (mg/L)	Total Kjeldahl Nitrogen	Total Phosphorus	Filterable Reactive Phosphorus
BDM1	0.11	5.34	3.8	2.44	1.34	0.4	<0.005
BDM2	0.3	6.42	6.4	5.14	1.29	0.13	<0.005
BDM3	0.21	6.25	8.22	5.9	2.25	0.04	<0.005
BDM5	0.37	5.13	4.26	4.47	0.55	0.53	<0.005
BDM6	1.6	6.49	2.18	1.66	0.67	0.05	<0.005
BDM7	0.28	5.99	0.93	0.69	0.27	0.04	<0.005
BDM8	0.29	5.65	3.84	3.96	0.76	0.05	<0.005
BDM9	0.63	6.39	2.04	1.3	0.39	0.05	<0.005
BDM10	0.21	5.74	0.51	0.19	0.37	0.4	<0.005
BDM11	0.59	5.81	0.97	0.74	0.45	0.47	<0.005
BDM12	1.28	5.05	1.2	0.75	0.43	0.12	<0.005
BDM13	0.15	5.51	1.93	1.5	0.56	0.07	<0.005

Groundwater use and availability

The structure plan area is within the groundwater area of Serpentine and sub-area of Byford 3. The aquifers present in this part of the sub-area are (in order of increasing depth):

- Superficial Swan
- Cattamarra Coal Measures
- Leederville

Groundwater within the Byford 3 subarea is reported to be available in the above three aquifers.

There are four current groundwater licenses within the structure plan area:

- One license (two drawpoints)within lot 3 Lawrence Way (8180kL) – No: 175890
- One license within Lot 4 Lawrence Way (10300kL) – No:156048
- One license within Lot 61 Lawrence Way (15650kL) – No:178331
- One license within Lot 47 Turner Road (5000L) – licence 178688

One of these (License No: 175890) is located within the ABN landholdings, arrangements are underway for the transfer of this license.

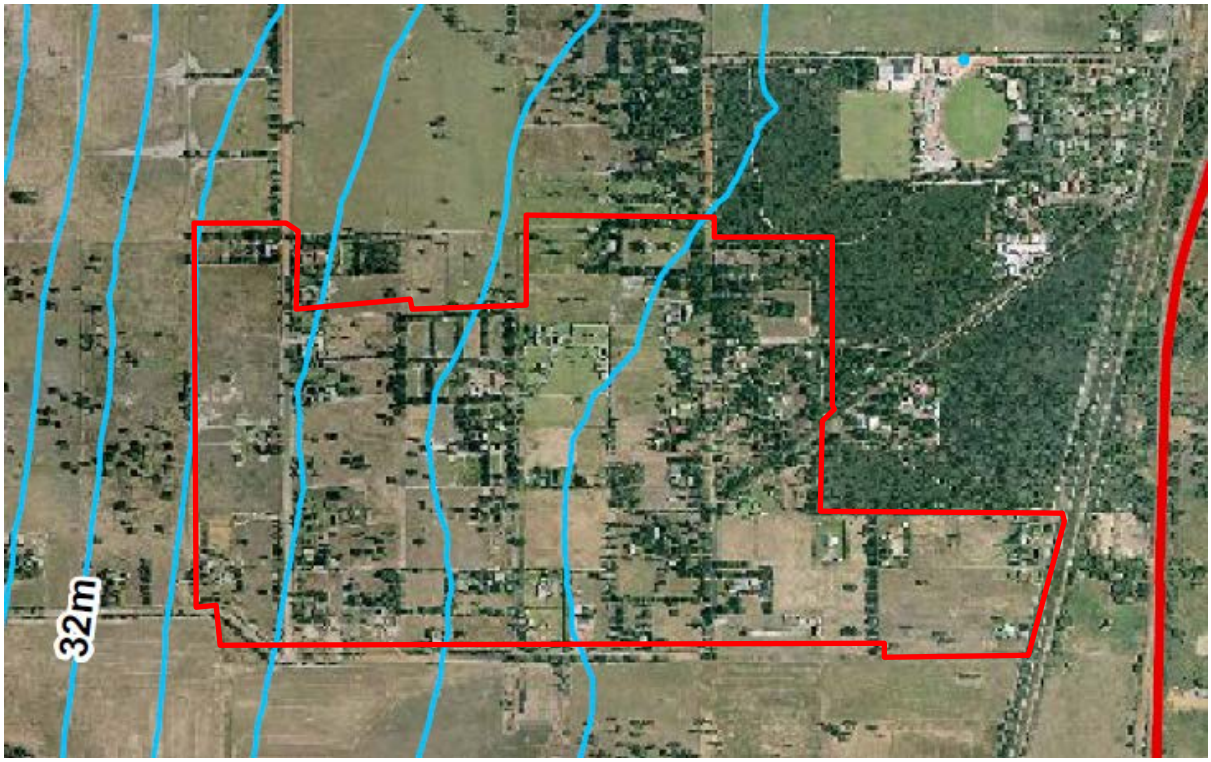


Figure 9: Snapshot of groundwater level contours from *Byford Townsite DWMP* (DoW 2008)

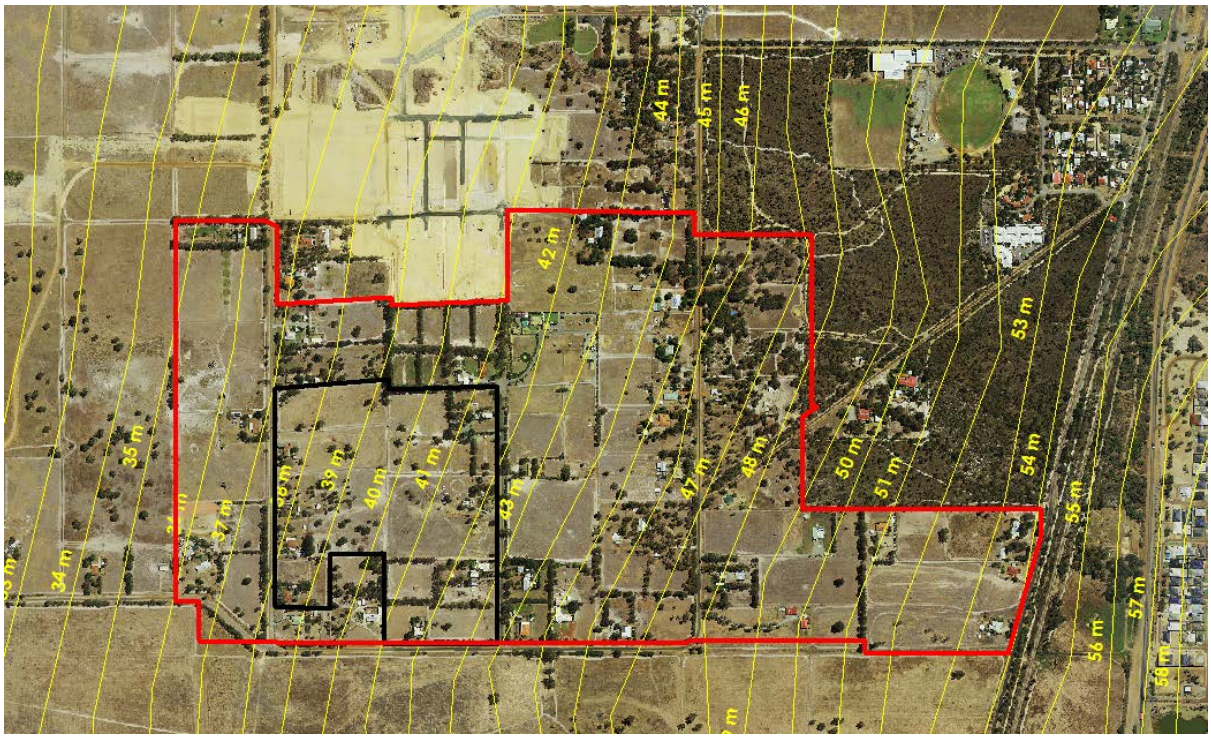


Figure 10: Modelled maximum groundwater level (S0 scenario) from Lower Serpentine Hydrological Studies (DoW 2012)

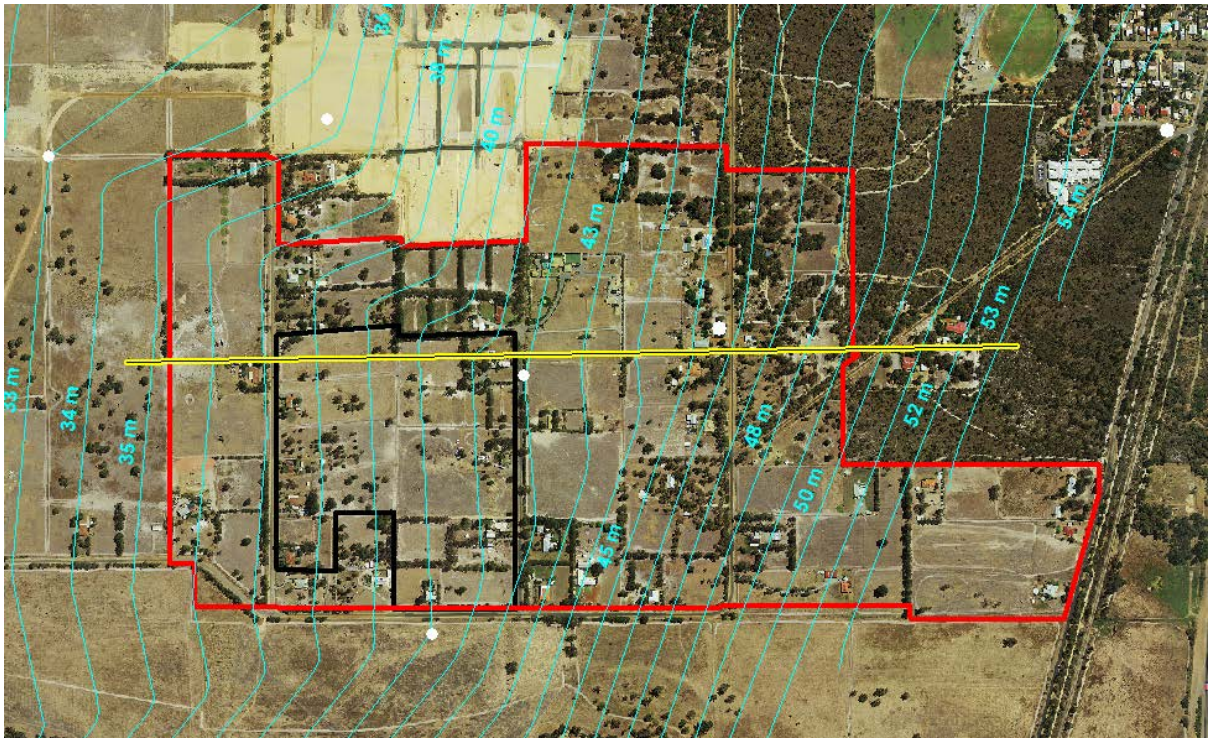


Figure 11: Inferred groundwater contours based on data presented in the Glades LWMS (JDA 2009)

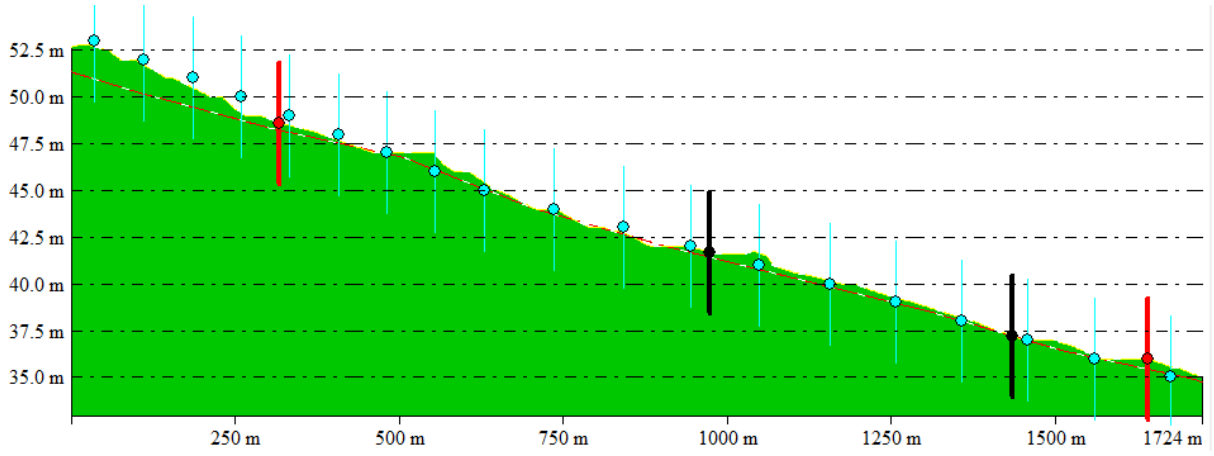


Figure 12: Cross section through the strategy area showing natural surface, modelled maximum groundwater levels (DoW 2012) and contours derived from monitoring data (JDA 2009)

3.4.3 Site water balance

Development of land for urban uses has potential to significantly alter the local water balance, reducing evapotranspiration and changing the volumes and rates by which rainfall is stored, infiltrated and discharged from the site. These changes affect seasonal variations in shallow groundwater systems creating additional management considerations and potential impacts to adjacent wetlands or downstream systems.

Groundwater monitoring indicates the maximum groundwater level is close to or at the existing ground level surface. The general approach to groundwater management involves provision of subsoil drainage and filling of development sites to reduce the potential of surface expressions of groundwater and to control soil moisture.

A site water balance for shallow groundwater was prepared to consider the potential impact of the land use change, and how different scenarios could assist in minimising off-site impacts. The water balance model was developed using the 18 months (2007-08) of rainfall record selected to allow comparison of model results against observed groundwater levels at the site. The Jan-07 to Dec-07 record has a total annual rainfall of 879 m while the Jul-07 to Jun-08 had 1042 mm. For comparison the average total annual rainfall at Cardup since 1971 is 857 mm.

The water balance allows us to estimate the net transport of groundwater into and out of the site in the predevelopment environment by balancing evapotranspiration against the daily rainfall flux and observed groundwater levels. Once this baseline is established, we can modify the scenario to illustrate the change in land use (through addition of fill, changes to infiltration and/or installation of subsurface drainage) can have on annual hydrological fluxes. The results of the analysis are presented in Table 4 and calculation sheets are presented in Appendix 3.

Two post-development scenarios are described below and summarised in Table 5. In both developed scenarios, irrigation water is sourced from the local superficial aquifer at a demand rate of 7,500 kL/Ha of public open space. It is recognised that additional groundwater licenses will be required to meet the non-potable demands for the site. Applications for licenses to take water should be specified for superficial aquifers in the Byford 3 subarea, where groundwater is available.

Table 3: Broad scale site water balance

Scenario	INPUTS	OUTPUTS				
	Rainfall	Evapo-transpiration	Surface Drainage	Subsoil Drainage	GW Draw	Net Recharge
Predevelopment	1581.4 (100%)	615.0 (39%)	356.4 (23%)	0	65.5 (4%)	544.5 (34%)
Traditional development	1581.4 (100%)	52.8 (3%)	955.4 (60%)	0	123.6 (8%)	449.6 (28%)
Proposed development	1581.4 (100%)	52.8 (3%)	356.4 (23%)	345.4 (22%)	123.6 (8%)	676.8 (42%)

Notes:

- All quantities are in ML for the 18 month model period Jan-08 to June-09
- Assumptions and predicted water levels for each model are included in Appendix 3.

Traditional development

The post-development (traditional) scenario demonstrates that development will reduce evapotranspiration from the site through the loss of vegetation, introduction of fill increasing the depth to groundwater and the construction of buildings and other impervious areas. This scenario also results in significantly increased surface water drainage. Overall recharge reduces which, without changes to the water balance of surrounding land would result in a decline in local groundwater levels.

The assumed coverage of deep rooted trees reduces from 15% (predevelopment) to 10% to reflect clearing of the area to be used for lots, roads and POS but retention of trees in the local parklands within the development area.

Proposed development

This scenario adopts the standard design approach used elsewhere on the Swan Coastal Plain where drainage maximises infiltration at source to result in reduced surface drainage discharge and increased recharge.

Increased evapotranspiration is achieved through retention and/or replacement of trees and other deep-rooted vegetation to maintain the predevelopment site coverage of 15%. Subsurface drainage is provided at the natural surface level to impede groundwater level rise as a consequence of increased recharge.

Table 4: Summary of development option benefits and challenges:

Scenario	Benefits	Challenges
Traditional	• Maximises developable area • Reduced reliance on subsoil drainage system	• Reduced local recharge causing changes to the groundwater levels and impact on external environment • Increased annual volumes of stormwater flow to downstream environment potentially causing water quality impacts
Proposed development	• Water quality impacts of increased annual flows to downstream environment managed through treatment • Increased recharge partially offset by tree planting	• Net increase in groundwater level; reliance on subsoil drainage • Treatment of subsoil flow for discharge to downstream environment

3.5 Environmental and social

The strategy area has been classified as multiple use wetland by the Department of Parks and Wildlife in its Swan Coastal Plain geomorphic wetlands database (mapped in Figure 5) identified as the Armadale Palusplain: seasonally waterlogged flat land. No otherwise classified surface water features are present within the structure plan area.

Brickwood Bushland Reserve, which is classified as a Bush Forever Site and Conservation Category Wetland, is adjacent to the eastern boundary of the structure plan but is upstream of the strategy area and therefore no surface water hydrological impacts are likely.

Cardup Brook, which is classified as a Resource Enhancement Wetland, traverses east to west for the full extent of the structure plan area approximately 350m to the south. None of the land within the structure plan area is within the catchment of Cardup Brook and therefore no hydrological impacts are likely.

Environmentally sensitive areas associated with bushfire prone areas, identified protected species and threatened ecological communities (Figure 13) within the Brickwood Reserve extend partially across the structure plan area but do not have significant implications for water management since they originate in the upstream environment.

3.5.1 Vegetation and flora

An environmental report has been prepared for the strategy area by Essential Environmental. The report identifies the following key findings:

The vegetation on the site is degraded and the site does not contain any areas with an intact understorey. No Declared Rare Flora are likely to be on the site and no priority species are likely to be present. It is recommended that no further study on the site is required and therefore flora is not an impediment to the development of the area.

Development will require clearing of the majority of remaining vegetation on site. This vegetation is not ecologically significant; however, during the detailed design process it is recommended that any trees that can be retained in street verges, landscaped areas, parking areas and in road/entry areas should be identified and included in the detailed design plans for the area. Mature trees to be retained or transplanted must be identified and clearly and visibly marked prior to commencement of any pre-construction activities.

There were no specific findings or recommendations for water management strategies required for protection of vegetation and flora in the strategy area

3.5.2 Fauna

An environmental report has been prepared for the strategy area by Essential Environmental. The report identifies the following key findings:

Due to the degradation onsite, historic clearing activities and lack of native remnant vegetation, particularly understory, any fauna habitat is considered of low value to native fauna that may have previously utilised the site.

The Black Cockatoo assessment identified no trees with obvious hollows suitable for Black Cockatoo breeding (only potential breeding), with less than 1 ha of foraging habitat (only isolated trees) identified within the central portion of the site. It is therefore considered that development of the ABN landholdings is highly unlikely to have a significant impact according to the Significant Impact Guidelines 1.1.

There were no specific findings or recommendations for water management strategies required for protection of fauna.

3.5.3 Aboriginal heritage

A search of the Department of Aboriginal Affairs of Western Australia aboriginal heritage enquiry system showed no registered Aboriginal sites within or adjacent to the structure plan area. The closest site is the Cardup Brook, south of the strategy area categorised as 'other heritage places: mythological'.

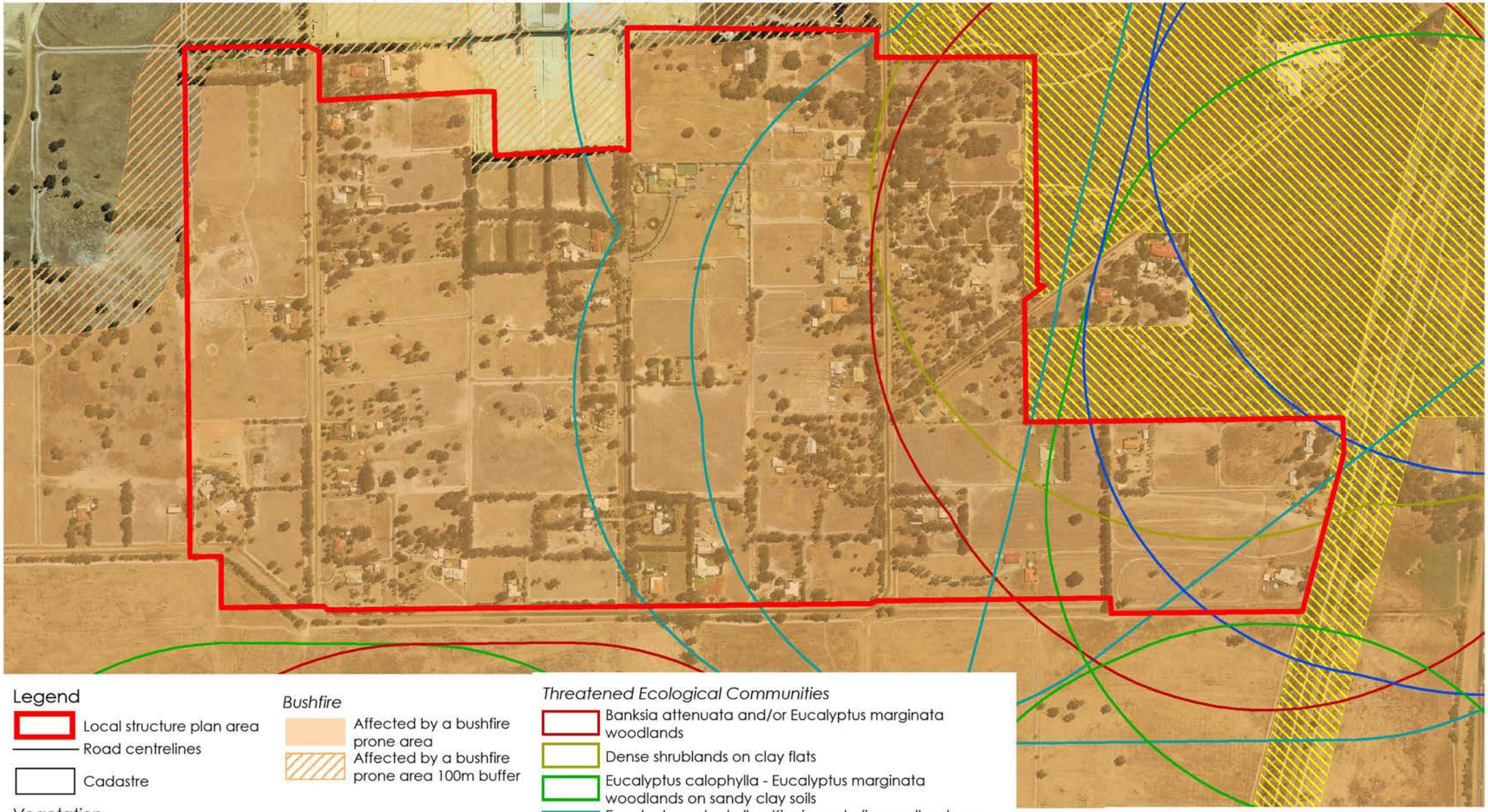
3.5.4 European heritage

A search of the State Heritage Register showed no current listing of state heritage within the structure plan area.

3.5.5 Infrastructure

The strategy area contains approximately 10 residential properties throughout. No other infrastructure is present in the area.

ABN Group: Doley Rd, Byford - Local Water Management Strategy
Figure 13: Vegetation and bushfire prone areas



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Data source: Landgate, ABN Group, SJ Shire, DER, DPaw. Created by: RM. Projection: MGA: zone 50.

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4 WATER MANAGEMENT STRATEGY

Water management strategies for the strategy area are informed by statutory requirements, relevant policies, by-laws and guidelines.

The following proposed strategies adapt previous objectives identified in the *Byford Townsite DWMP* (DoW, 2008) and the *Byford floodplain management strategy* (SKM, 2007) to provide strategies that address site specific risks and opportunities.

4.1 Water sustainability initiatives

- Ensure the efficient use of all water resources in the newly-developing urban form and aim to achieve highest value use of fit-for-purpose water;
- maintain opportunities for future generations by using water more efficiently.

4.1.1 Post development water demands

A broad scale water demand model has been developed, using Essential Environmental's Water Balance Tool, to identify the various post-development water demands from residential and non-residential areas. Summary results of this water balance modelling are presented in Table 5 and details are provided in Appendix 4.

The analysis is based on the development comprising 1,567 traditional lots (average lot size of 386m2) and 341 cottage lots (average lot size of 245m2), with an approximate population of 4,900 residents. Analysis assumes the use of standard water efficiency measures within households and irrigation of up-to 25% of the total lot area consistent with current State Government policies (watering for 2 days per week through summer).

These demands are consistent with a target of less than100 kilolitres per person per year which is expressed in the *Byford Townsite DWMP* (DoW 2008). The most significant non-drinking water demand for the development (public open space irrigation) is proposed to be sourced from groundwater. Other non-drinking water demands include toilets and washing machines in homes and garden irrigation. Although there is no proposal to provide for these demands through a non-drinking water scheme there remains potential for significant reductions in scheme water use to be achieved through resident uptake of rainwater tanks plumbed into toilets and washing machines and/or greywater recycling systems to meet irrigation demands.

Table 5: Annual summary water demands

Scenario	Drinking	Non-drinking	Total
Residential (kL)	164,729	270,351	435,080
Commercial (kL)	7,287	4,858	12,145
Public Open Space (kL)	-	70,140	11,362
Total (kL)	172,016	275,209	69,117
Estimated Household Consumption (kL/person/year)	34	60	89

Drinking water supply

The strategy area is located in an area served by the Water Corporation's integrated water supply scheme. All dwellings will be connected reticulated drinking water distribution network.

Non-drinking water supply

Groundwater will be used as the primary non-drinking water source for public open space irrigation. Additional groundwater licenses will be required to implement this strategy, as outlined in section 3.4.3.

Analysis of the various water sources available within the strategy area suggests that there is sufficient 'light-grey' (showers and wash-hand basins) water to supply approximately 75% of the predicted domestic irrigation demand (see Table 6). Similarly; provision of a 5 kL rainwater tank for each traditional residential lot and 2.5 kL rainwater tank for each cottage lot could supply approximately 75% of the in-house domestic non-drinking water demand (toilets and washing machines).

It is proposed that developments in the strategy area will provide advice and incentives to future lot-purchasers to inform them of the opportunities for grey-water and rainwater use and promote the uptake of water saving initiatives. These will include:

- Provision of information and advice for the purchase and installation of rainwater tanks and grey water systems
- Provision of waterwise gardening packages and advice

A summary of non-drinking water requirements and availability for the site, relevant source, and volume demand is presented in Table 6 below.

Table 6: Annual non-drinking water demands, sources and volumes

Non-drinking water demand	Source	Volume required (kL)	Volume available (kL)
Domestic - irrigation	Domestic greywater	135,960	102,137
Domestic – in house	Rainwater	134,391	30??
Public Open Space	Groundwater	70,140	70,140*
TOTAL (permanent)		**340,491**	
Temporary (construction & dust suppression)	Groundwater	X	

*Additional groundwater licenses will be required, as per section 3.4.3

Wastewater management

The strategy area is located in an area served by the Water Corporation's integrated sewerage scheme and all dwellings will be connected to a reticulated sewerage network.

4.2 Stormwater management

The key objectives for surface water management are:

- Protection of wetlands and waterways from the impacts of urban runoff
- Protection of infrastructure and assets from flooding and inundation

The following planning measures are adopted from the DWMP to achieve the above objectives:

- Residential, industrial or commercial premises in existing or proposed areas must have their floor levels elevated 500 mm above the 1% AEP flood level in the MUC and 300 mm above the 1% AEP flood level in the local drainage system
- The design of the new urban areas should incorporate current best practice in water-sensitive urban design to mitigate the impacts of urbanisation in the catchments on regional water quantity and quality.
- For the first 15 mm of rainfall, the post-development discharge volume and peak flow rates shall be maintained relative to predevelopment conditions in all parts of the catchment.
- The catchment runoff shall be managed up to and including the1% AEP event within the development area to predevelopment peak flow rates.
- Water-sensitive urban design and best management practices promoting on-site retention of the first 15 mm of rainfall form the basis of the surface water quantity management strategy for minor events.

4.2.1 Small event management

The development will retain no less than the first 15 mm of rainfall on-site within lots and streets.

Residential lots will be required to install soakwells with grated lids within the front setback, which will be graded to allow for runoff into the street when the capacity of soakwells is exceeded.

Streets and commercial areas will be required to provide for on-site retention within raingardens and tree-pits within the streetscape. These systems are expected to provide for infiltration of the first 15 mm of rainfall which will be ultimately discharged via subsoil drainage into the downstream environment to prevent local groundwater levels from rising and becoming a nuisance to the future community.

Modelling, based on a robust unit-hydrograph method assuming a typical infiltration rate of 5 m/day for imported sand fill suggests that soakwell or raingarden capacity of 0.01 m^3/m^2 of connected impervious area is required on lots and streets. This equates to three 1.2m diameter, 0.6 m deep soakwells for a typical 300 m^2 lot and 2 m^2 of raingarden/treepit (with 300 mm detention depth) per 100 m^2 of road reserve.

While the Galt Geotechnics report recommends an infiltration rate of 1 m/day (section 3.3.3), a rate of 5 m/day was used in modelling to reflect the likely infiltration rate of imported sand fill which is proposed for the site. Drainage structures (soakwells and raingardens) will be located within this imported fill and subsoil drainage will be installed to prevent groundwater level rise and manage soil moisture.

Indicative locations for small event management are presented in Figure 14. These indicative locations provide a greater area than will ultimately be required as presented in Table 6.

These locations will be refined at future stages of planning and design and the excess allocation at this stage provides confidence that sufficient area can be ultimately provided.

Typical raingarden and tree-pit arrangements are presented in Figure 15.

Table 7: Raingarden requirements (interim and ultimate)

	Interim (ABN landholdings) area	Strategy area
Total land area (m^2)	215,200	1,205,000
Road reserve area (m^2)	57,600	367,300
Required raingarden area (m^2)	1,152	7,346
Raingarden area indicated (m^2)	6,000	27,000

4.2.2 Minor event management

Stormwater in excess of the capacity of on-site retention systems will be conveyed through a combination of piped and overland drains to discharge into a rehabilitated living stream within the northern multiple use corridor or the drain within Orton Road reserve.

Surface conveyance will be used wherever possible, with piped drains used only where gutter flows are predicted to exceed stipulated standards and where swale drains cannot be reasonably accommodated. This will include the utilisation of flush kerbing adjacent to public open space areas where practical. Broken kerbing may also be considered as an alternative.

Critical flowpaths with peak flows and top water levels for the minor event are presented in Figure 16.

4.2.3 Floodplain (major event) management

Major flood events will be conveyed in drains and road reserves to join major flowpaths in the multiple use corridor or Orton Road.

Critical flowpaths with peak flows and top water levels for the major event are presented in Figure 17.

4.2.4 Stormwater modelling and design

Stormwater modelling undertaken to support the preparation of the Doley/Warrington precinct structure plan was guided by the following key design criteria:

- Peak discharge and flood levels are not to exceed the figures provided in the DWMP at key locations post-development
- Flood storage is to be provided in the Multiple Use Corridor (MUC) and along the current waterway alignment
- The first 15 mm of rainfall from lots is to be infiltrated on site
- The first 15 mm of rainfall from roads is to be treated on site using bio-retention structures and infiltrated in the road reserve
- Swales to be provided where possible within road reserves (typically where the reserve is larger than 20m)
- The minor drainage system to be designed to convey runoff generated from the 20% AEP (5yr ARI) rainfall event.

Three land use scenarios were modelled during the study:

- Existing land use (existing)

- ABN landholdings 'interim development' scenario
- Ultimate development in the Doley/Warrington precinct

Details of stormwater modelling undertaken including parameters, subcatchments and conceptual cross sections are presented in in Appendix 5.

Each of the three modelled scenarios was run with the 1% AEP (100yr ARI) and 20% AEP (5yr ARI) storm events with a range of durations to obtain a worst cast (critical) duration for both top water level and peak flow at each location.

Two key locations from the Byford Townsite DWMP are of interest; termed 7c1 located upstream of Doley Road at Tributary 7 and Location 8c located at the Junction of Orton and Doley Road. These locations, at the downstream boundary of the structure plan area enable a direct comparison of the modelled scenarios. A summary of results from the model runs are provided in Table 7. Volumes detained at key locations at the site during the 1% AEP event are presented in Table 9 below.

Table 8: Peak flow and flood levels at key locations

Event	1% AEP						20% AEP					
	Existing (DWMP)		Interim		Ultimate		Existing (DWMP)		Interim		Ultimate	
Location	Q	TWL	Q	TWL	Q	TWL	Q	TWL	Q	TWL	Q	TWL
7C1	4.46	37.2	2.55	36.1	2.46	36.8	1.87	37.1	1.55	36.1	1.11	36.6
8C	9.28	39.4	7.40	39.3	4.49	39.2	3.51	39.3	2.34	39.2	1.43	39.2

Note: All flows are expressed as m3/s and all top water levels are expressed as mAHD

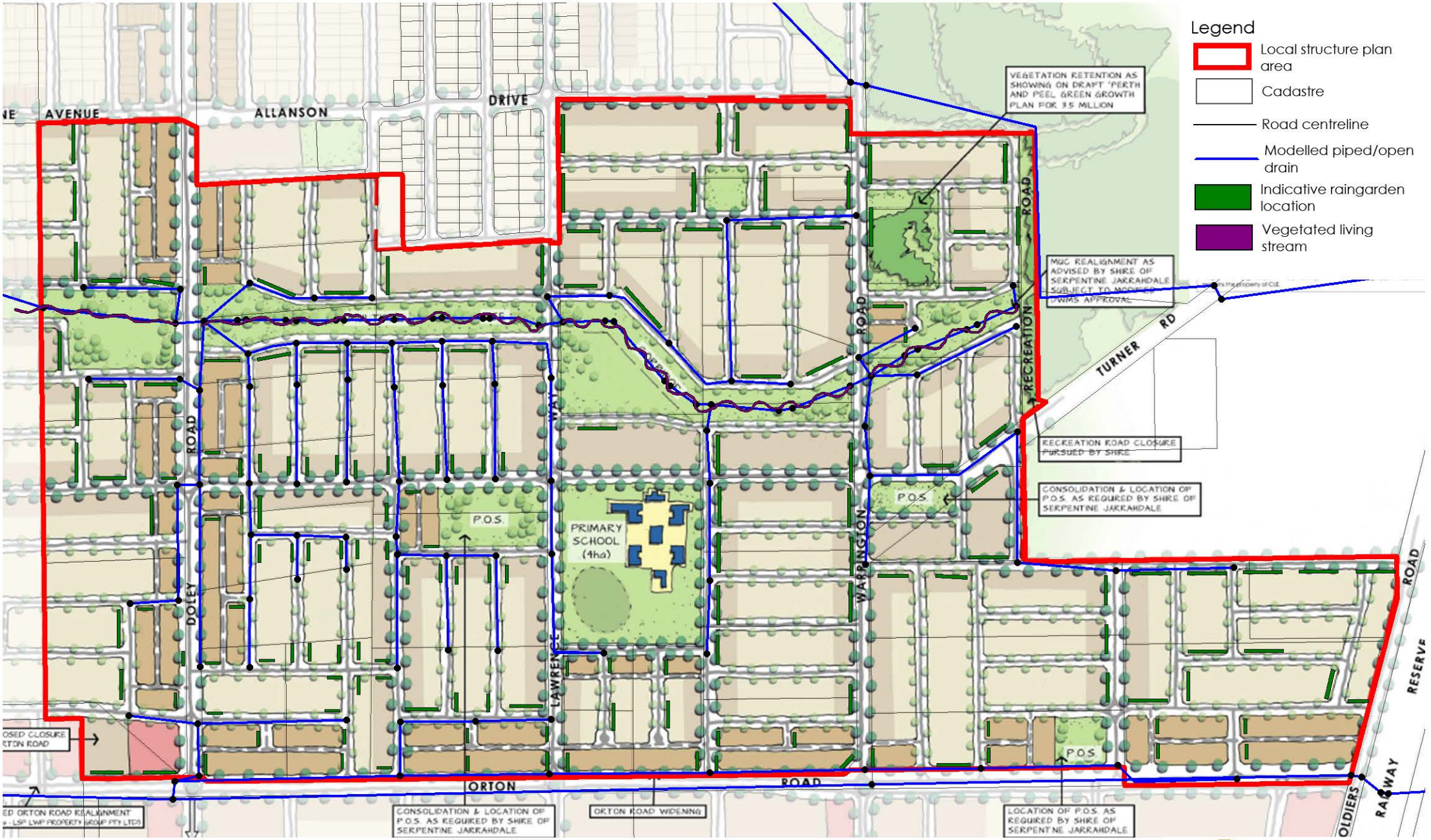
Staging and interim provisions

Lots under the ownership of ABN Group (Figure 1) are proposed to be developed in advance of the balance of the strategy area. These landholdings will be the subject of a future urban water management plan to be prepared to support their subdivision.

The multiple use corridor; where the bulk of major and minor storm event management is proposed to occur, is located outside of the ABN Group landholdings. An interim solution is proposed to enable development of these lots prior to the creation of the multiple use corridor. Peak flow rates and top water levels at critical locations are presented as the "interim" model scenario in Table 8.

Lots along the northern boundary of the landholdings will be retained in ABN Group ownership and a cut-off drain will be provided to convey stormwater discharges from the site towards Doley Road. An easement in favour of the Shire of Serpentine Jarrahdale will be placed over this temporary drain until the Multiple Use Corridor is developed. From here, an open drain within the road reserve will convey flows to join 'tributary 7'. Figure 18 presents the conceptual design and modelling results for this interim stormwater management system.

ABN Group: Doley Rd, Byford - Local Water Management Strategy
Figure 14: Small event stormwater management system



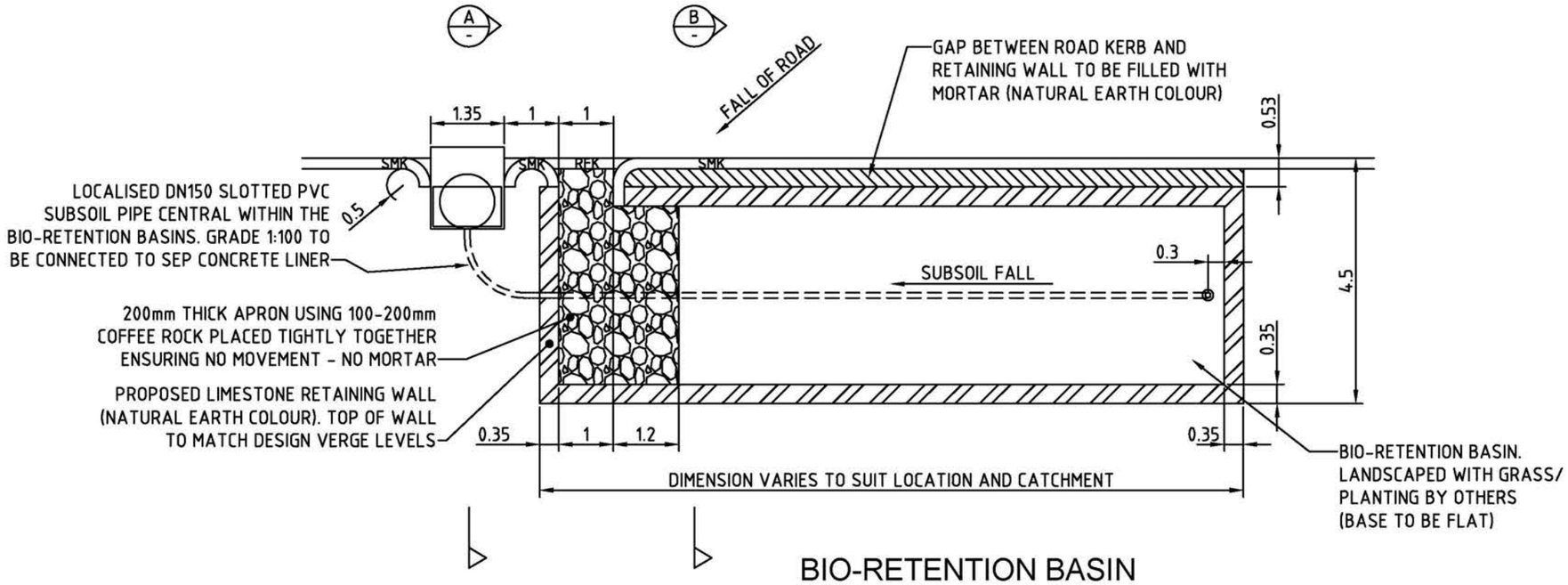
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Data source: Landgate, ABN Group, DoP. Created by: BM. Projection: MGA: zone 50.

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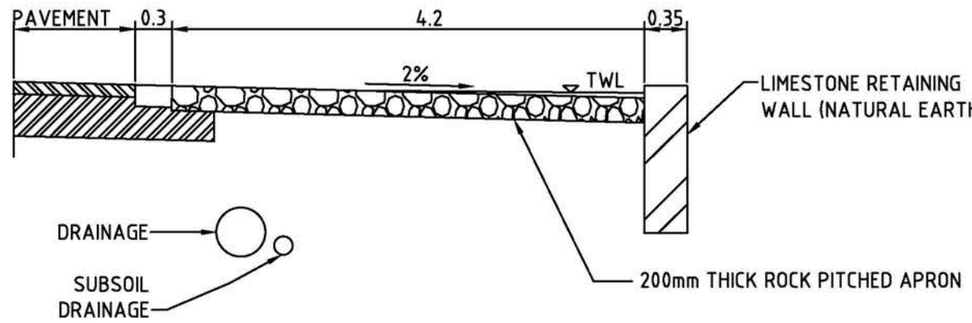
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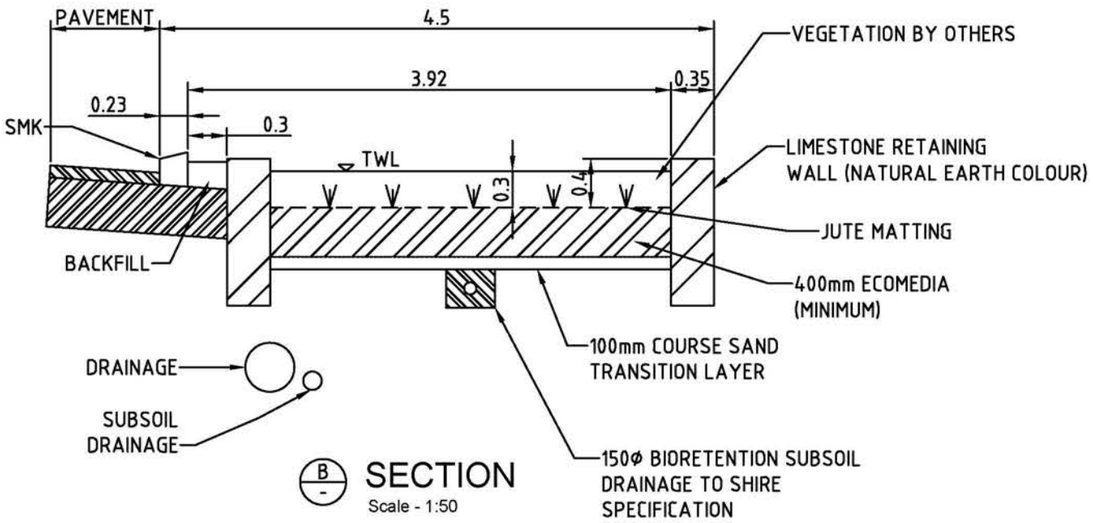
BIO-RETENTION BASIN

Scale - 1:100



A SECTION

Scale - 1:50



B SECTION

Scale - 1:50

Typical Detail
BIO-RETENTION BASIN

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ISSUE	DATE	DESIGN	CHECK
B	08 DEC 2015	BM	HB

DATA SOURCES

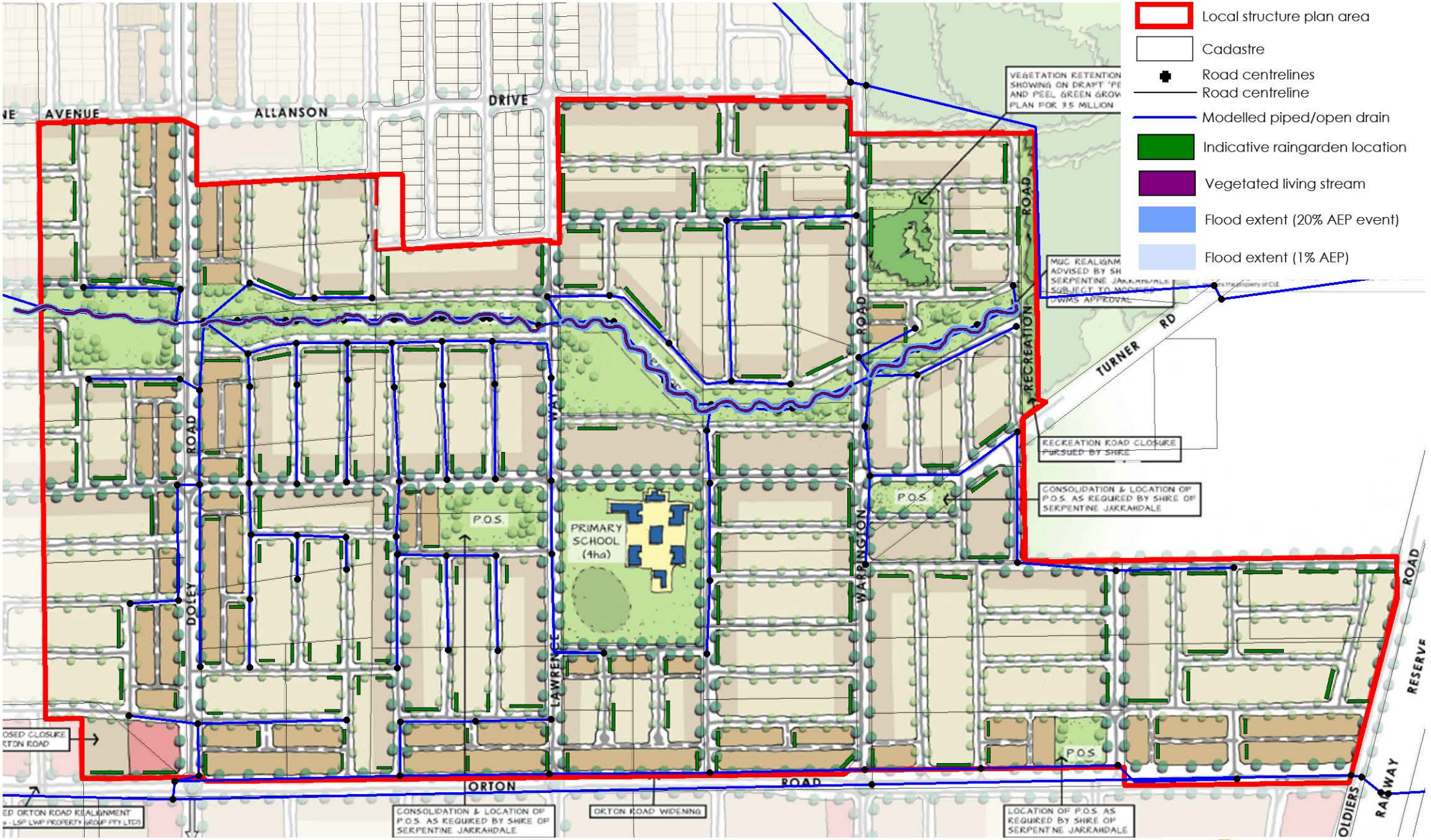
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ABN Group: Doley Rd, Byford - Local Water Management Strategy
Figure 16: Minor event (20% AEP) stormwater management system



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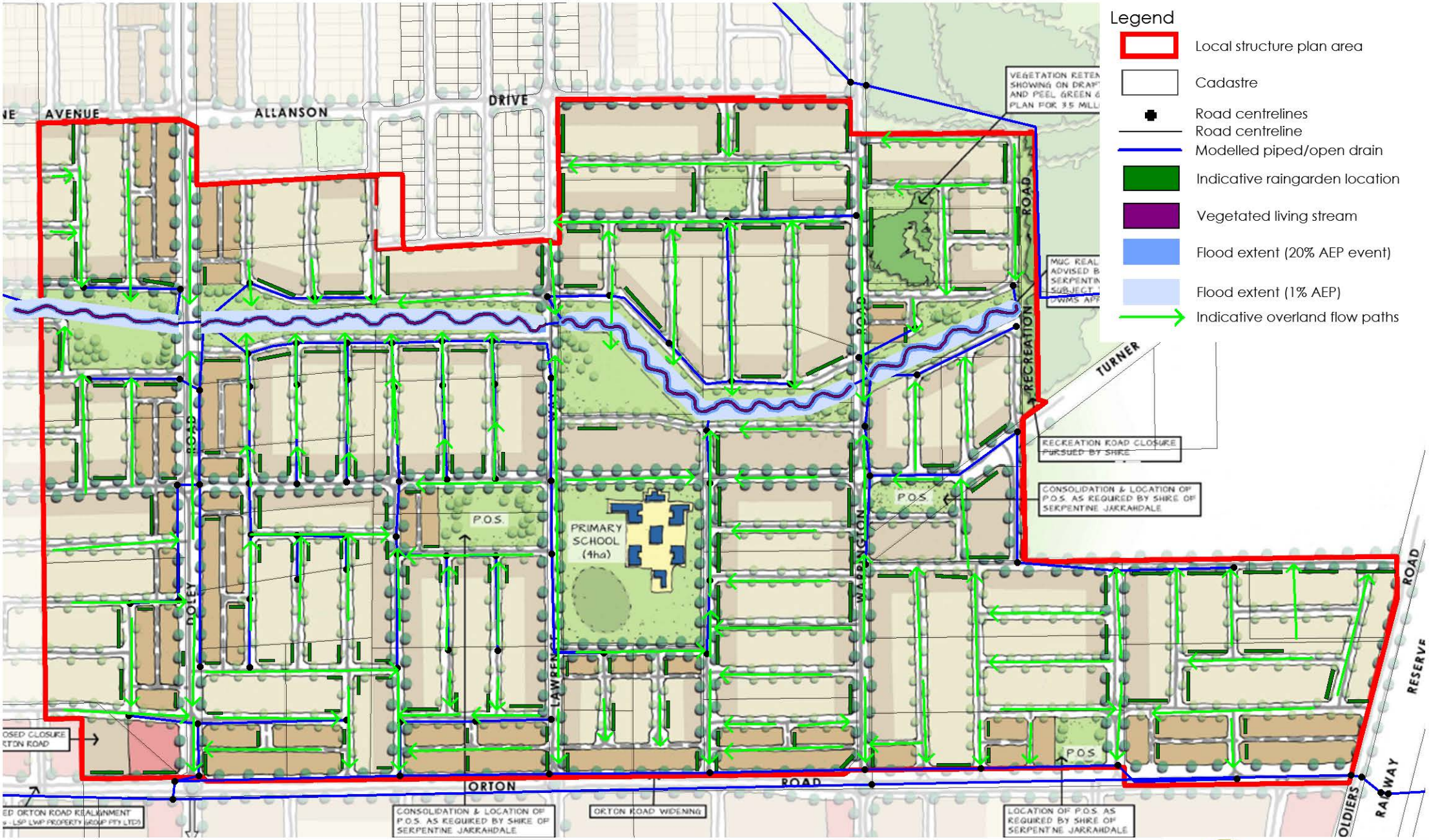
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ABN Group: Doley Rd, Byford - Local Water Management Strategy
Figure 17: Major event (1% AEP) stormwater management system



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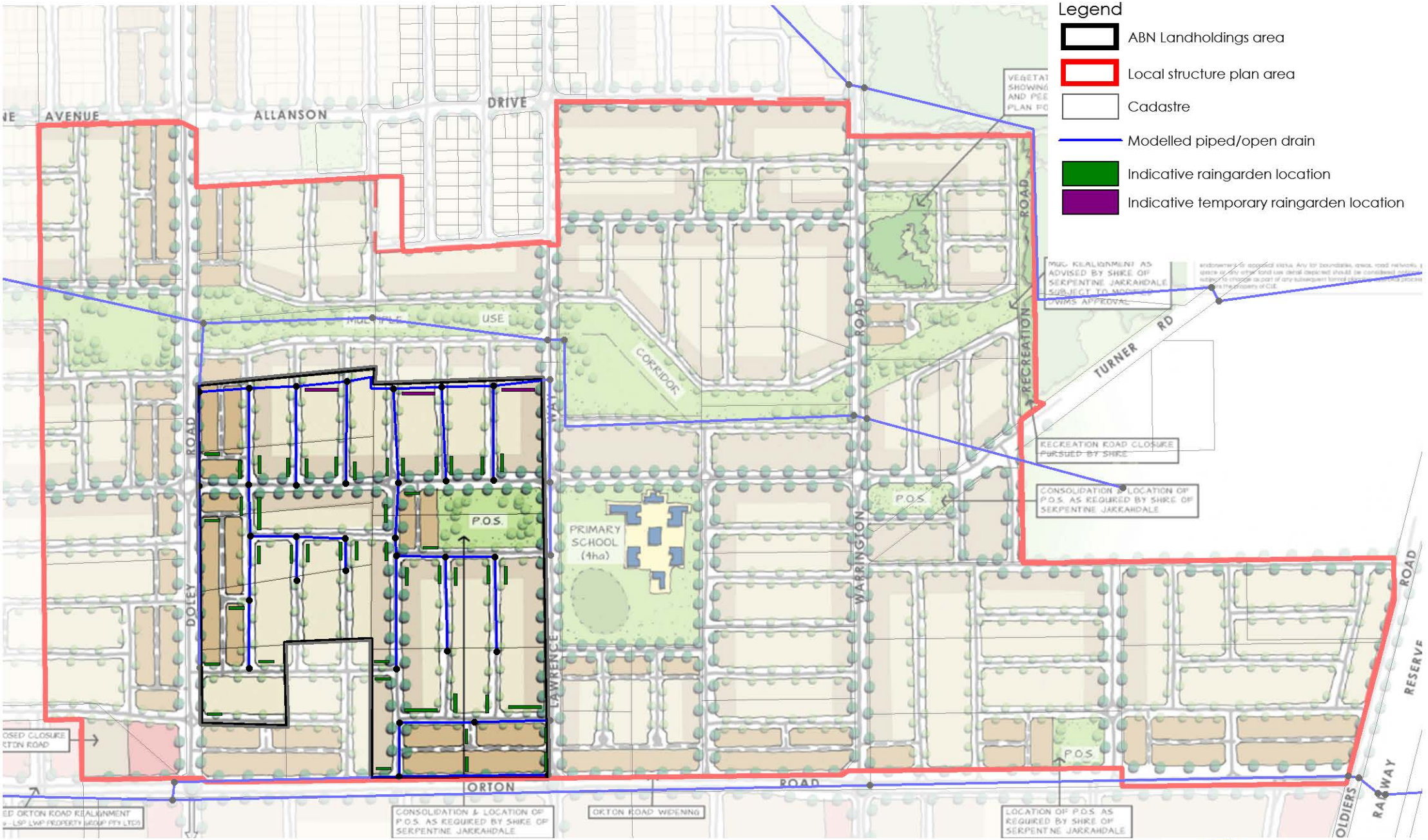
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ABN Group: Doley Rd, Byford - Local Water Management Strategy
Figure 18: Interim stormwater management system



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Data source: Landgate, ABN Group, DoP. Created by: BM. Projection: MGA: zone 50.

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4.3 Groundwater management

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.

Key design criteria:

- Controlled groundwater level (inverts of subsoil drains) will be the maximum recorded groundwater level or the natural surface whichever is the lower.
- The bio-retention system and drainage inverts are set at or above controlled groundwater level although existing inverts below the level may remain.
- Subsurface drainage must be designed with free-draining outlets.

4.3.1 Groundwater modelling and design

While the Byford Townsite Drainage and Water Management Plan (developed by the Department of Water in 2008) has previously been utilised to define required minimum separation distance between groundwater and finished lot levels for developments in Byford, this local water management strategy proposes to use the new IPWEA specification; *Separation distances for groundwater controlled urban development*.

A 1-dimensional groundwater model was constructed for a typical cross section through back to back residential lots with subsoil drains located in adjacent road verges. The model includes the following characteristics and assumptions:

- Raingardens are provided in the verge to retain and infiltrate the first 15 mm of rainfall from the road reserve.
- Soakwells are provided in the front setback of lots to retain and infiltrate the first 15 mm of rainfall from roof's and driveways.
- Subsoil drains are located at the natural surface level and in-situ soils are assumed to be impervious.
- Imported sand fill used to create the finished surface for the development has a hydraulic conductivity of 5 m/day.
- The modelled cross section is presented in Figure 25.
- Zero recharge is experienced directly beneath impervious surfaces but the first 15 mm of rainfall from these areas is redirected to adjacent cells modelled as containing raingardens or soakwells.
- Recharge from soakwells is assumed to be 100%.
- Recharge from raingardens is assumed to be 90%.
- 30 years of future wet climate rainfall obtained from the Department of Water was run through the model to enable generation of annual exceedance probability (AEP) heights for the phreatic surface between subsoil drains.

Modelling demonstrates that the 50% AEP phreatic surface reaches the following heights above the subsoil drain invert (Controlled Groundwater Level) at various locations of interest:

- 0.7 m in backyards (furthest point from the subsoil drain)
- 0.6 m in front setbacks (beneath soakwells)
- 0.5 m in verges (beneath raingardens)

Figure 26 presents the complete modelled time-series results at key locations within the cross section demonstrating that the minimum recommended 300 mm separation from the 50% AEP phreatic surface level to the base of raingardens can be achieved with provision of just 700mm of sand beneath the base of the raingarden over the underlying clay surface. Allowing 300 mm detention depth for the raingardens results in a total requirement of 1.0m of sand over clay.

Details of groundwater modelling undertaken are presented in in Appendix 6.

4.4 Water quality management

Site specific targets have been proposed for estuarine catchments of the Swan Coastal Plain as a part of background work undertaken by the Department of Water during the development of the UNDO water quality modelling tool. The targets were developed based on consideration of the sensitivity of the receiving water body and the proximity of the development site. Applying this approach, the Doley/Warrington precinct would lie outside of the suggested 'proximity zones' of the estuarine portion (>1000 m) of the downstream waterways and the Cardup Brook conservation category wetland (>500 m). This would indicate that the following targets could be applied:

- 3.6 kg/ha/yr of Nitrogen
- 0.2 kg/ha/yr of Phosphorous

4.4.1 Water quality modelling and design

UNDO (Urban Nutrient Decision Outcomes) is a simple empirical decision support model with a flexible framework that evaluates nutrient reduction decisions for new urban developments on the Swan Coastal Plain. It has been developed by the Department of Water to provide urban development proponents with an easy to use tool for assessment by local and state government authorities.

An UNDO model has been developed for the site with two sub-regions identified (1: Residential & POS and 2: Road reserve & commercial). These sub-regions have been defined as recommended by the type of drainage strategy proposed for each. Residential and public open space areas are assumed to be served by on-site soakage with subsoil drainage but no piped connection to stormwater drainage. Commercial areas and road reserves are provided with piped stormwater drainage.

Results of UNDO modelling, in the form of a report which is generated by the software containing details of all assumptions and inputs, are provided in Appendix 7.

The outcomes of UNDO modelling indicate that on-site retention of the first 15 mm of rainfall within soakwells on lots and raingardens in streets will provide discharge loads of

- 1.94 kg/year/hectare of total nitrogen
- 0.18 kg/year/hectare of total phosphorous

These loads are within recommended targets for developments within estuarine catchments of the Swan Coastal Plain that have been developed for a discussion paper as a part of supporting information for the UNDO modelling tool by the Department of Water. The recommended target export loads for areas outside the proximity zone (>2000 m from the estuarine portion of the river) are 3.6 kg/ha/yr of Nitrogen and 0.20 kg/ha/yr of Phosphorous.

It is noted that groundwater quality data reported for the site and surrounds suggests the presence of high levels of legacy nutrients within the soils and local groundwater. The introduction of subsoil drainage to control groundwater has the potential to mobilise these legacy nutrients.

To manage the risk of legacy nutrient mobilisation and prevent any potential impacts to threatened ecological communities in the Brickwood Reserve from lowering of groundwater levels, it is proposed that the controlled groundwater level will be set at no more than 300 mm below natural surface. This will allow for the removal of 300 mm of topsoil prior to compaction, grading and laying of subsoil drains in a layer of clean imported fill as discussed in section 4.3. This strategy will minimise the export of in-situ groundwater predominantly draining newly infiltrated stormwater from above.

4.5 Management of disease vectors and nuisance insects

The presence of permanent or seasonal water bodies close to residential areas provides the potential for Mosquitos and Chironomid Midges to become a nuisance to the resident population.

This strategy does not propose to construct any new permanent or semi-permanent water bodies. However, the construction of above ground water quality treatment systems is proposed. These systems will need to be designed to minimise detention times throughout the year.

This strategy also proposes to construct new surface drainage and retain and restore natural watercourses in the strategy area. New surface drainage systems will be designed to minimise standing water and natural water courses will be rehabilitated to provide healthy functioning ecosystems that will support natural predators to assist in controlling populations of nuisance insects.

Additionally, there are constructed and natural water courses and water bodies in surrounding land where there is potential for mosquitoes and midges to breed. This strategy cannot influence the design or management of water systems in surrounding land areas but is required to recognise their presence and propose strategies that can assist with managing their potential impacts on the developing land and future community.

Physical, chemical and biological control methods can be used to manage mosquito populations. Methods which are likely to be employed (and their order of priority) include:

Physical

Engineering and Landscape design and construction will aim not to create any new permanent or semi-permanent water bodies. There will be no standing water bodies within stage 8.

Biological

Improved water quality is a key way that nuisance insects can be managed by minimising nutrient loads and thereby reducing potential for algal blooms and through encouraging and sustaining healthy populations of predator species including fish and dragonflies. Subsoil drainage flows and minor event stormwater discharges will pass through water quality treatment areas prior to entering permanent or semi-permanent water bodies.

Chemical

Should Mosquitos and Chironomid Midges become a nuisance, pesticides (larvicides and/or adulticides) will be used as required to kill mosquito larvae in breeding sites.

4.6 Dieback management

The risk of spreading dieback (*Phytophthora cinnamomi*) has been considered as part of the design of the stormwater management system, to reduce the potential for spreading the disease from Brickwood Reserve.

Figure 19 presents local hydrological information associated with the Brickwood Reserve at its boundary adjacent to the strategy area.

A drain exists along the eastern side of the Recreation Road reserve which is an unmade road along the boundary of Brickwood Reserve. This drain conveys runoff from the Brickwood Reserve to the north to join the watercourse identified as "Tributary 6" in the *Byford Townsite DWMP* (DoW 2008) and *The Glades LWMS* (JDA 2009). This tributary does not enter the strategy area although a small portion of the strategy area, to the east of Warrington Road drains into it.

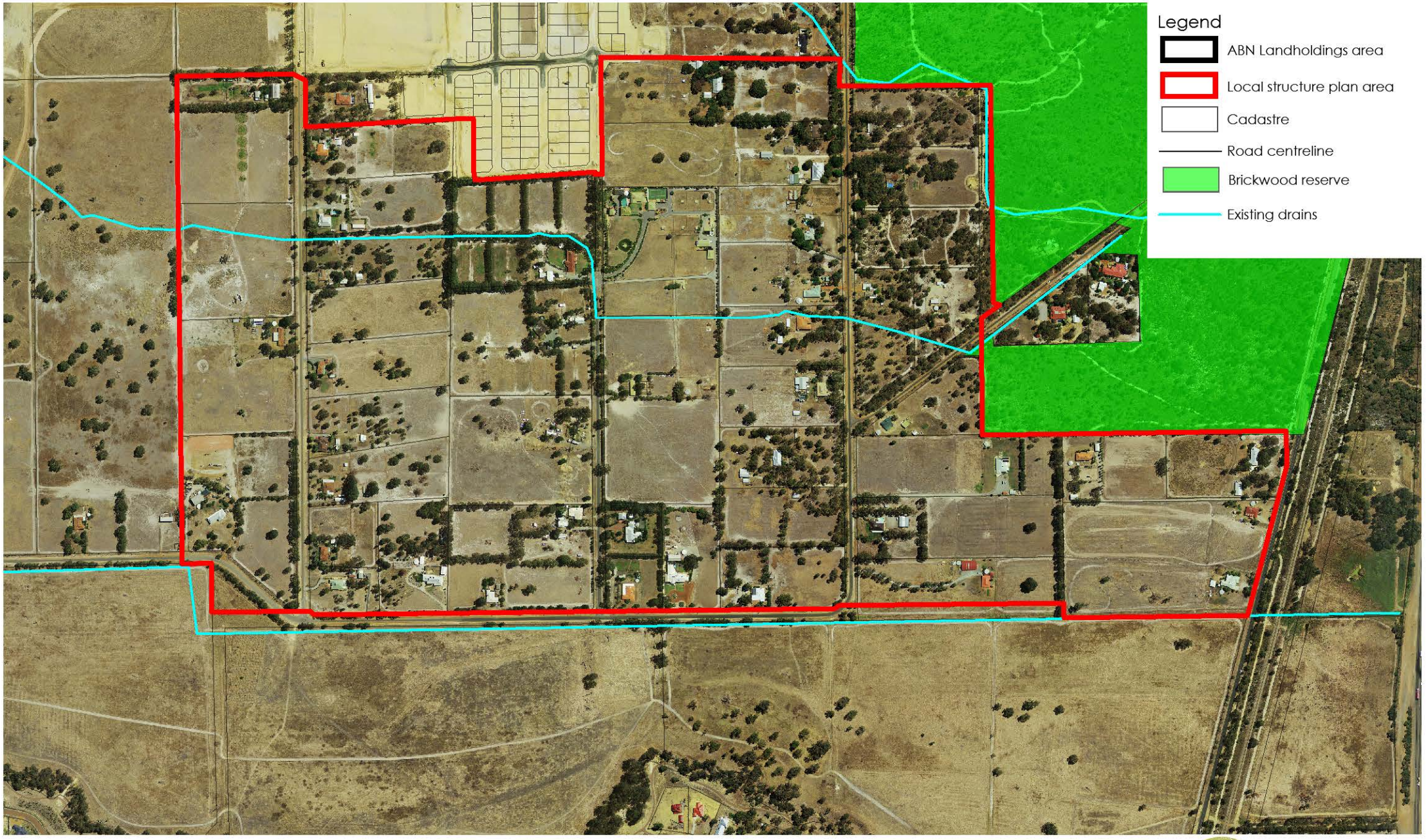
The future development of this land and creation of Recreation Road has the potential to provide more frequent surface water discharges from dieback affected areas in the Reserve into the downstream environment. For this reason, future development in this area should avoid disturbance of the existing drain if possible. Construction of a new drainage system to serve the new road and the portion of the Tributary 6 catchment within the strategy area is proposed to avoid contamination of the system and downstream watercourse.

There is a second drain along the southern side of the Turner Road reserve. This drain conveys runoff from the southern portion of the Brickwood Reserve to the west to join the watercourse identified as "Tributary 7" in the *Byford Townsite DWMP* (DoW 2008) and *The Glades LWMS* (JDA 2009). This tributary enters the strategy area and is contained within the central multiple use corridor. No developing land drains into this drain.

The future development of land downstream of Brickwood Reserve is not expected to increase the frequency of discharge from dieback affected areas within the Reserve. This is because the strategy area is entirely downstream of any discharge from the Reserve and there are no works proposed within Turner Road or its reserve upstream of the Brickwood Reserve boundary.

ABN Group: Doley Rd, Byford - Local Water Management Strategy

Figure 19: Brickwood Bushland Reserve hydrology and proposed dieback management area



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Data source: Landgate, ABN Group, DoP. Created by: BM. Projection: MGA: zone 50.

Scale 1: 8,000 at A4

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5 IMPLEMENTATION

5.1 Pre-development monitoring

It is considered that there is very little value in additional groundwater level monitoring prior to construction. Previous observations of groundwater at the strategy area correlate well to district scale modelling undertaken by the Department of Water and suggest that groundwater level coincides with the natural surface throughout the strategy area. The close correlation of both modelled and monitored data gives no indication that more detail is warranted.

In addition to the previously collected groundwater quality data it is proposed to undertake quarterly snapshot sampling at the two existing bores located within the strategy area which will be reported in a subsequent Urban Water Management Plan. This data, in conjunction with data previously collected in support of The Glades LWMS will be used to develop appropriate trigger values for assessment of post-development water quality.

5.2 Post-development monitoring

A post-development monitoring program will be designed in cooperation with Serpentine-Jarrahdale Shire and the Department of Water, and in accordance with the Department of Water's *Water monitoring guidelines for better urban water management strategies and plans* (2012). The monitoring program will be outlined in full in a subsequent UWMP and should include the following as a minimum:

Surface water

Surface water monitoring sites should be selected to address the key objectives of site specific post-development monitoring. Monitoring should include:

- 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.

Surface water sampling should be undertaken during August to October to capture peak winter baseflows, and 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)
- Ammonium (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 site specific post-development monitoring. Monitoring should include both levels and 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);
- Ammonium (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).

Post-development monitoring will be undertaken for a period of three (3) years. Commencement will be scheduled to include at least one (1) year following completion of the majority (80%) of development. The results of post-development monitoring will be reported to Serpentine-Jarrahdale Shire and the Department of Water on an annual basis, in a manner acceptable to each.

5.3 Delivery

Key tasks, roles and responsibilities relating to delivery of urban water management objectives are outlined in Table 8.

Table 9: summary of roles and responsibilities

Task	Responsibility	Planning stage
Potable water supply planning and connection to main distribution network	Water Corporation	Subdivision (UWMP)
Design of water distribution networks	Landowner/ developer	Subdivision (UWMP)
Water and wastewater planning and connection to main distribution networks	Water Corporation	Subdivision (UWMP)

Task	Responsibility	Planning stage
Design of wastewater reticulation networks	Landowner/ developer	Subdivision (UWMP)
Design of drainage networks including design of water quality treatment areas	Landowner/ developer	Subdivision (UWMP)
Development of detailed Landscaping plan incorporating stormwater management strategies	Landowner/ developer	Subdivision (UWMP)
Obtain bed and banks permit	Landowner/ developer	Subdivision (UWMP)
Obtain groundwater allocation licenses	Landowner/ developer	Subdivision (UWMP)
Confirmation of ongoing management and maintenance requirements and agreement with Shire for handover of responsibilities	Landowner/ developer/ Shire of Serpentine-Jarrahdale	Subdivision (UWMP)
Confirmation of post-development water quality monitoring program (including bore locations) and reporting	Landowner/ developer	Subdivision (UWMP)

APPENDIX 1 – LWMS CHECKLIST

Local water management strategy Item	Deliverable	☑	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements & requirements for BMPs and critical control points	☑	
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		☑	
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	☑ ☑	
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable)	Landscape Plan	☑	
Design criteria			
Agreed design objectives		☑	
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	☑	
Geotechnical - topography, soils including acid sulphate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	
Environmental - areas of significant vegetation, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	☑	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	☑	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	☑	
Water sustainability initiatives			
Water supply & efficiency measures – private and public open spaces		☑	
Fit-for-purpose strategy and agreed actions. If non-potable supply, support with water balance		☑	
Wastewater management		☑	
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and100 year detentions storage areas	major event Plan Long section of critical points	☑ ☑	
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	minor event Plan	☑	

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

APPENDIX 2 – GEOTECHNICAL REPORT

APPENDIX 3 – WATER BALANCE MODELLING REPORT

APPENDIX 4 – WATER DEMANDS ANALYSIS

APPENDIX 5 – STORMWATER MODELLING DETAILS

Introduction and background

Stormwater modelling undertaken to support the preparation of the Doley/Warrington precinct structure plan was guided by the following key design criteria:

- Peak discharge and flood levels are not to exceed the figures provided in the DWMP at key locations post-development
- Flood storage is to be provided in the Multiple Use Corridor (MUC) and along the current waterway alignment
- The first 15 mm of rainfall from lots is to be infiltrated on site
- The first 15 mm of rainfall from roads is to be treated on site using bio-retention structures and infiltrated in the road reserve
- Swales to be provided where possible within road reserves (typically where the reserve is larger than 20m)
- The minor drainage system to be designed to convey runoff generated from the 20% AEP (5yr ARI) rainfall event.

Hydrological and hydraulic modelling was conducted using InfoWorks ICM. InfoWorks utilises a number of rainfall runoff generation methodologies and routs excess runoff through a proposed drainage system.

Hydrological modelling

Three land use scenarios were modelled during the study. The scenarios included:

- Existing land use (existing)
- ABN landholdings 'interim development' scenario
- Ultimate development in the Doley/Warrington precinct

The existing scenario modelled catchments and loss parameters replicate the parameters utilised in the Byford Townsite DWMP.

For the interim development scenario, a detailed storm water drainage model was constructed for the area covered by the ABN land holdings. The modelling was also used to size a piped drainage network for the development site. This model was nested within the existing scenario model.

Ultimate development scenario modelling was conducted to understand peak flow and flood levels at key locations post ultimate development of the entire Doley/Warrington precinct. This model also included the ABN land holding development scenario model embedded within the overall structure plan area model.

Land use parameterisation

Land use categories and surface type parameters used in modelling are presented in Table 9. The first flush (15mm) rainfall will be captured at the lot and be infiltrated to the groundwater aquifer. The first flush was modelled as an initial loss.

Table 10: Modelled surface types

Runoff surface type	Initial loss (mm)	Runoff coefficient
Pervious surfaces:		
Upper forest	0	0.2
Rural pasture(Slow Infiltration)	10	4mm/hr infiltration
Urban Pervious (Slow Infiltration)	10	4mm/hr infiltration
Garden Pervious	10	0.2
Public open space	10	0.6
Verge	10	0.8
Impervious surfaces		
Existing Impervious	1.5	1.0
Constructed Impervious	15	1.0
Roof	15	1.0
Hardstand/paving	15	0.7
Road	15	1.0

Subcatchment delineation

Subcatchments for each of the development scenarios were delineated with consideration of the following factors:

- Site topography,
- Local Structure Plan layouts,
- Previous studies,
- Existing watercourse alignment,
- Existing drainage structures, and
- Proposed road layouts.

Catchments for the existing case scenario were largely adopted from the Byford Townsite DWMP with some minor modifications and corrections.

For the interim and ultimate development scenarios the DWMP subcatchments were removed from the areas covered by the Local Structure Plan and replaced with detailed catchments taking into consideration the proposed lot layout, roads, POS and drainage layout. For areas of the Local Structure Plan in ABN ownership an increased level of detail was possible.

Catchment delineation for each of the modelled scenarios is presented in Figure 20, Figure 21 and Figure 22.



Figure 20: Model layout - existing system

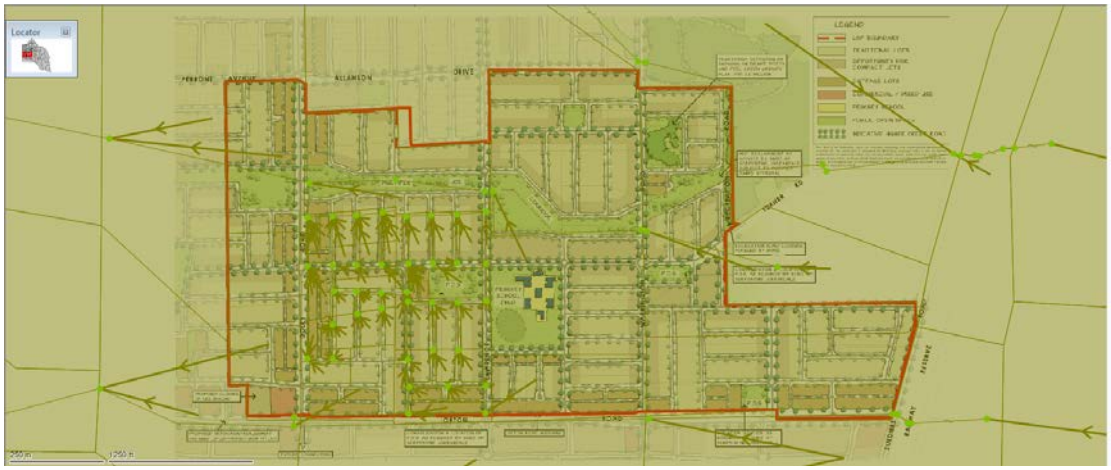


Figure 21: Model layout – interim development

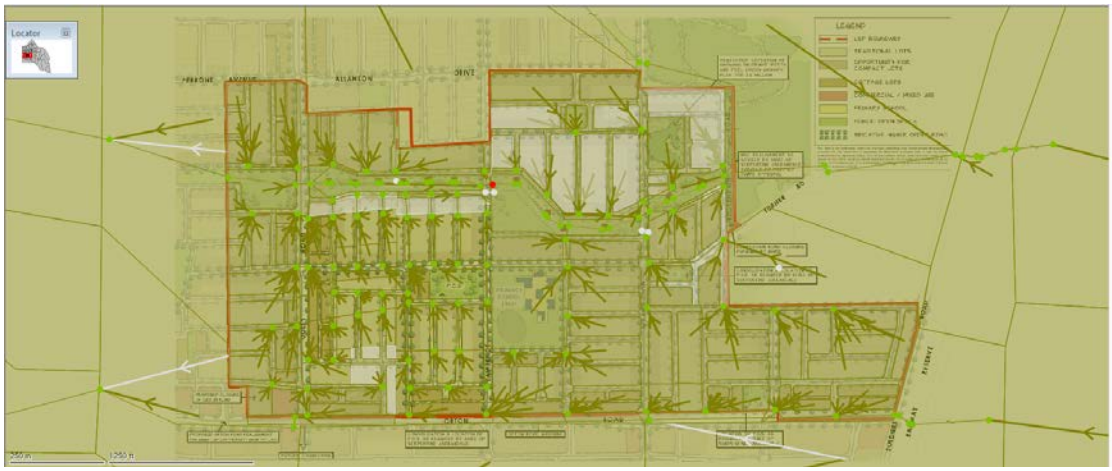


Figure 22: Model layout - ultimate system

Hydraulic modelling

The runoff excess generated from each catchment was routed through existing and proposed hydraulic structures towards the catchment outlet using InfoWorks ICM.

Bioretention systems, piped drainage and roadside or median swales will be provided to drain runoff towards the catchment outlet.

The existing 'tributary 7' watercourse will be rehabilitated and restored to form a living stream embedded within the Multiple Use Corridor (MUC). Riffles will be constructed to assist with the management of erosive velocities during flood events and stormwater quality during low flows.

Detailed drainage system layouts for each of the modelled scenarios are presented in Figure 20, Figure 21 and Figure 22.

Details of proposed structures

It is proposed that the first 15mm of rainfall will be captured an infiltrated in lots. Similarly, the first 15 mm of rainfall from road reserves will also be captured for treatment in roadside bioretention systems. A combination of open and piped stormwater drainage is proposed to convey runoff generated from the 20% AEP (5yr ARI) storm event including roadside or median swales along Orton, Warrington and Doley Roads.

Flow attenuation will be provided in the MUC and current watercourse. Permeable riffles will be provided allow slow conveyance of baseflows and minor storms whilst allowing for the free flow of more significant events. The storage provided by riffles will assist with provision of detention capacity during major storm events. Cross sections of proposed channels are provided in the following figures.

Interim development

The interim development solution proposes to construct an open cut-off drain along the northern boundary of the ABN landholdings to capture discharges from each of the north-south streets. This drain conveys flows towards an area of public open space adjacent to Doley Road where it joins the MUC via an existing drain in the Doley road reserve.

Lots along this boundary will be retained for this purpose until development proceeds in the remainder of the structure plan area.

Model results

Each of the three modelled scenarios was run with the 1% AEP (100yr ARI) and 20% AEP (5yr ARI) storm events with a range of durations to obtain a worst cast (critical) duration for both top water level and peak flow at each location.

Two key locations from the Byford Townsite DWMP are of interest; termed 7c1 located upstream of Doley Road at Tributary 7 and Location 8c located at the Junction of Orton and Doley Road. These locations, at the downstream boundary of the structure plan area enable a direct comparison of the modelled scenarios. A summary of results from the model runs are provided in Table 10.

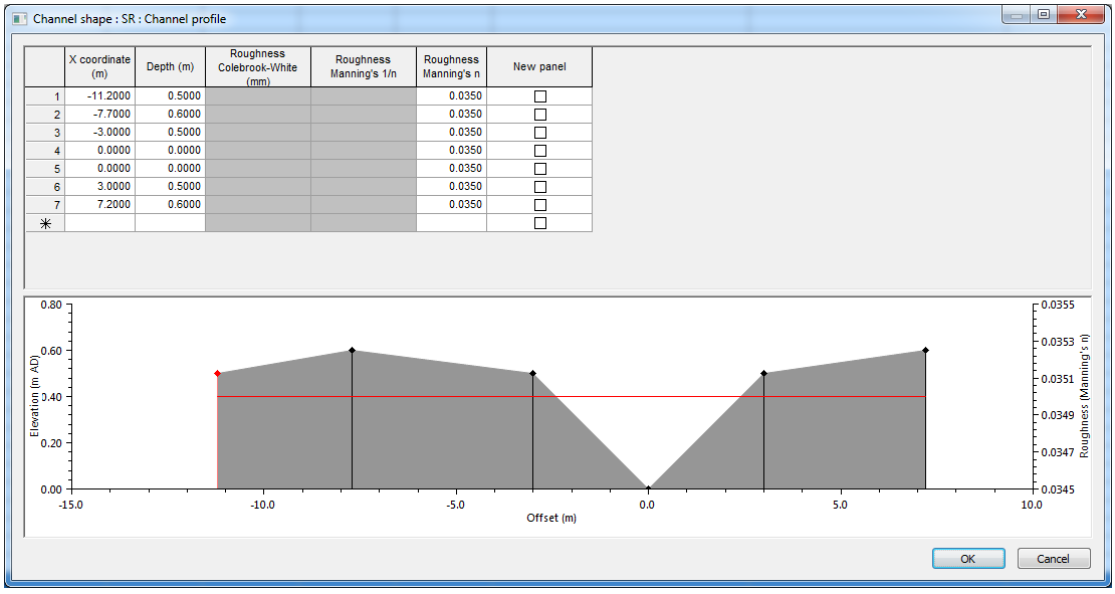


Figure 23: Swale cross section on arterial roads

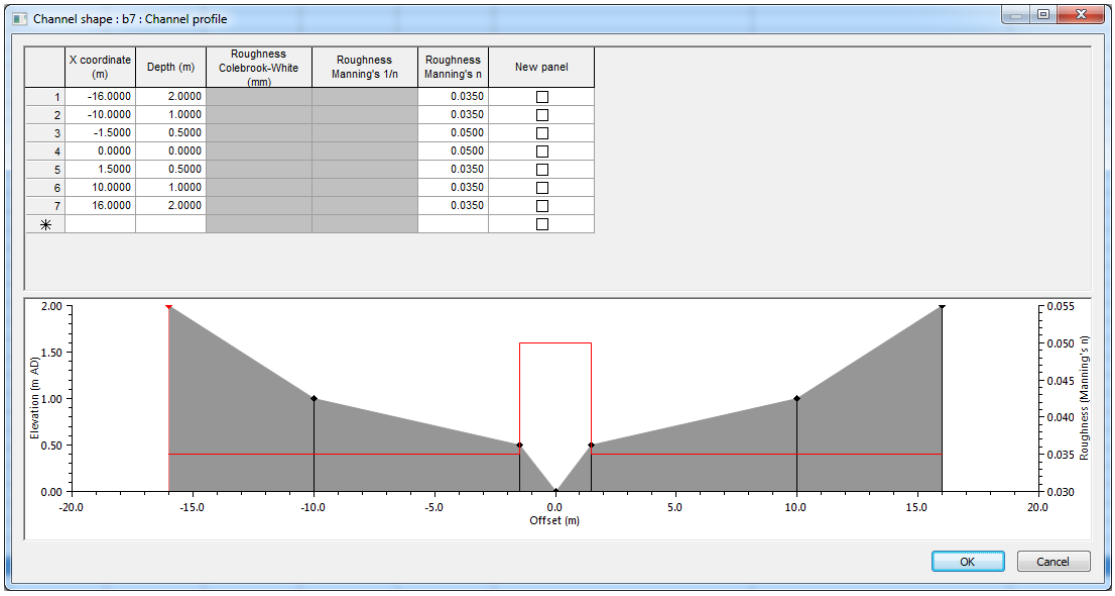


Figure 24: MUC channel cross section

Table 11: Peak flow and flood levels at key locations

Event	1% AEP						20% AEP					
	Existing (DWMP)		Interim		Ultimate		Existing (DWMP)		Interim		Ultimate	
Location	Q	TWL	Q	TWL	Q	TWL	Q	TWL	Q	TWL	Q	TWL
7C1	4.46	37.2	2.55	36.1	2.46	36.8	1.87	37.1	1.55	36.1	1.11	36.6
8C	9.28	39.4	7.40	39.3	4.49	39.2	3.51	39.3	2.34	39.2	1.43	39.2

Note: All flows are expressed as m3/s and all top water levels are expressed as mAHD

LONGITUDINAL SECTIONS

Interim development scenario, Multiple Use Corridor



20% AEP:

1% AEP:

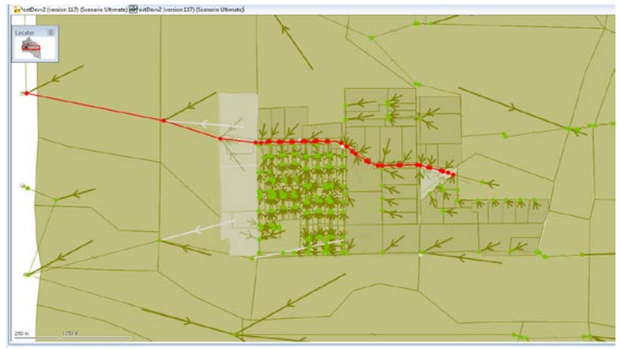
Interim development scenario, Doley Road Drain



20% AEP:

1% AEP:

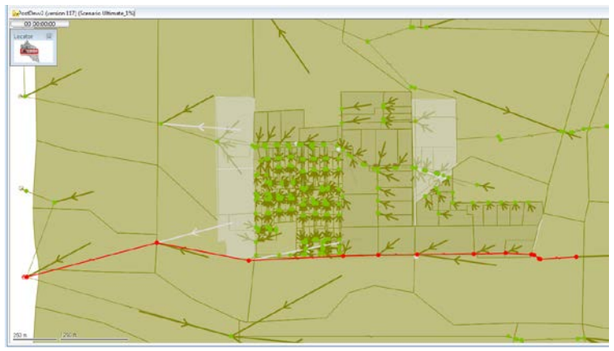
Ultimate development scenario, Multiple Use Corridor



20% AEP:

1% AEP:

Ultimate development scenario, Doley Road Drain



20% AEP:

1% AEP:

APPENDIX 6 – GROUNDWATER MODELLING RESULTS

Groundwater modelling was undertaken using Essential Environmental's Shallow Aquifer Management Model (SammEE). The model allows consideration of groundwater levels in a developing area to facilitate the development of earthworks and subsoil drainage strategies.

A 1-dimensional groundwater model was constructed using SammEE for a typical cross section through back to back residential lots with subsoil drains located in adjacent road verges. The model includes the following characteristics and assumptions:

- Raingardens are provided in the verge to retain and infiltrate the first 15 mm of rainfall from the road reserve.
- Soakwells are provided in the front setback of lots to retain and infiltrate the first 15 mm of rainfall from roof's and driveways.
- Subsoil drains are located at the natural surface level and in-situ soils are assumed to be impervious
- Imported sand fill used to create the finished surface for the development has a hydraulic conductivity of 5 m/day
- The modelled cross section is presented in Figure 25
- Zero recharge is experienced directly beneath impervious surfaces but the first 15 mm of rainfall from these areas is redirected to adjacent cells modelled as containing raingardens or soakwells.
- Recharge from soakwells is assumed to be 100%
- Recharge from raingardens is assumed to be 90%
- 30 years of future wet climate rainfall obtained from the Department of Water was run through the model to enable generation of annual exceedance probability (AEP) heights for the phreatic surface between subsoil drains

Modelling demonstrates that the 50% AEP phreatic surface reaches the following heights above the subsoil drain invert (Controlled Groundwater Level) at various locations of interest:

- 0.7 m in backyards (furthest point from the subsoil drain)
- 0.6 m in front setbacks (beneath soakwells)
- 0.6 m in verges (beneath raingardens)

Figure 25 shows the modelled cross section as it appears within the model interface with locations of key items labelled to assist with interpretation.

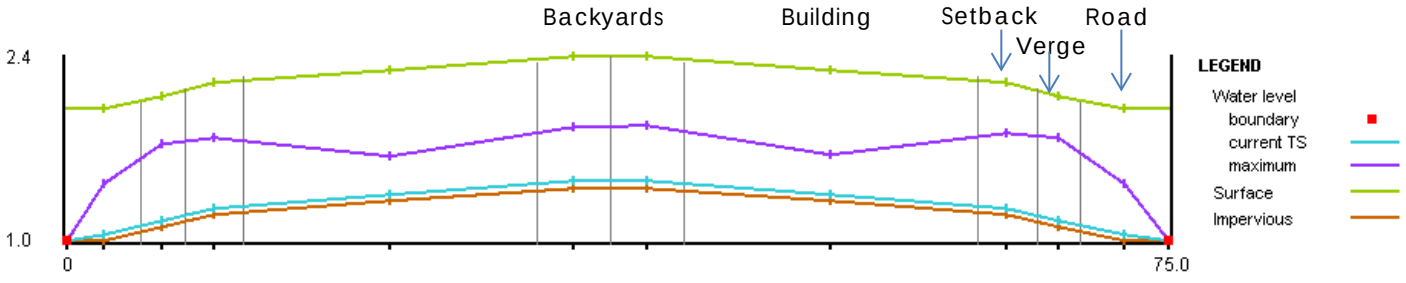


Figure 25: SammEE modelled cross section

Table 11 presents the modelled maximum groundwater level (phreatic surface) at key locations within the cross-section and the resulting 30 year maximum and 50% AEP levels.

Figure 26presents the complete modelled time-series results at key locations within the cross section demonstrating that the minimum recommended 300 mm separation from the 50% AEP phreatic surface level to the base of raingardens can be achieved with provision of just 700mm of sand beneath the base of the raingarden over the underlying clay surface. Allowing 300 mm detention depth for the raingardens results in a total requirement of 1.0m of sand over clay.

Table 12: Groundwater model results – Annual maxima at key locations

Modelled year	Max of Backyard	Max of Soakwell	Max of Verge
2016	1.68	1.53	1.45
2017	1.64	1.53	1.46
2018	1.80	1.66	1.64
2019	1.87	1.82	1.78
2020	1.79	1.56	1.48
2021	1.72	1.55	1.49
2022	1.78	1.57	1.51
2023	1.75	1.58	1.49
2024	1.67	1.56	1.46
2025	1.76	1.59	1.50
2026	1.66	1.58	1.50
2027	1.67	1.58	1.52
2028	1.81	1.64	1.55
2029	1.78	1.64	1.63
2030	1.76	1.67	1.63
2031	1.73	1.52	1.45
2032	1.78	1.55	1.48
2033	1.79	1.60	1.55
2034	1.66	1.55	1.48
2035	1.73	1.55	1.47
2036	1.71	1.72	1.73
2037	1.72	1.60	1.53
2038	1.80	1.58	1.52
2039	1.71	1.58	1.50
2040	1.71	1.55	1.47
2041	1.77	1.64	1.57
2042	1.83	1.58	1.50
2043	1.81	1.60	1.51
2044	1.65	1.57	1.48
2045	1.72	1.56	1.49
30 year max	**1.87**	**1.82**	**1.78**
50% AEP	1.7	1.6	1.5
Filled surface level	2.4	2.2	2.1
Separation achieved	**0.7**	**0.6**	**0.6**

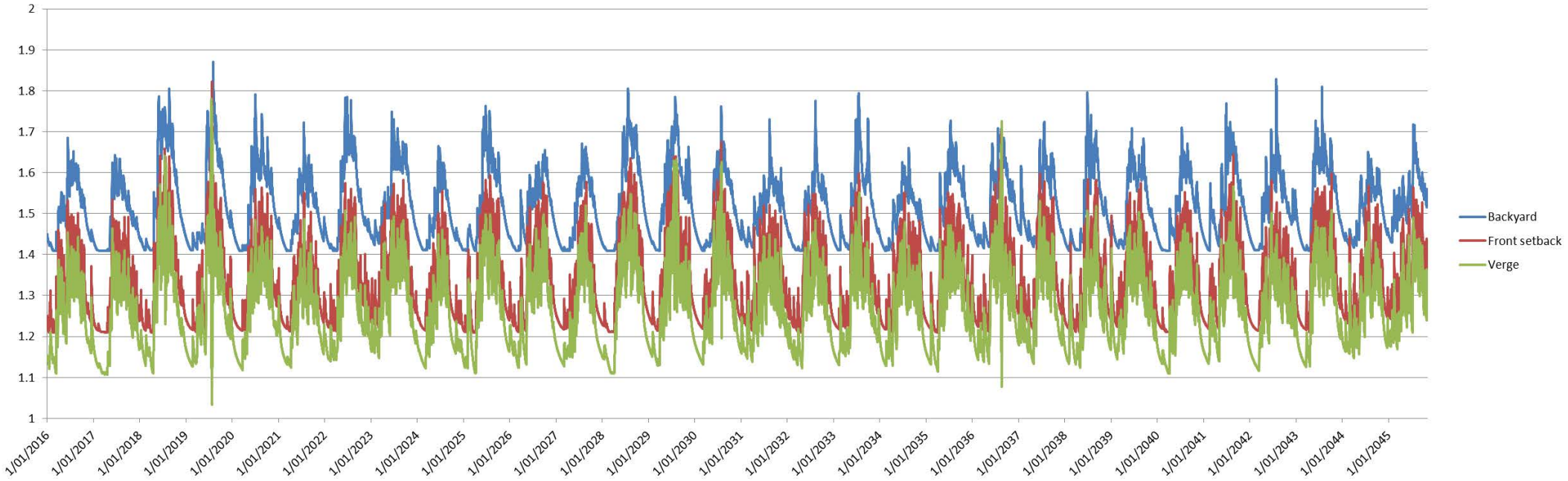


Figure 26: SammEE model results – 30 year future climate model results showing groundwater level traces at key locations

APPENDIX 7 – UNDO WATER QUALITY MODELLING REPORT

APPENDIX 8 – LANDSCAPE PLANS

Client: ABN Group

Report	Version	Prepared by	Reviewed by	Submitted to Client	
				Copies	Date
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Essential Environmental
land & water solutions
622 Newcastle St Leederville 6007
p: 08 9328 4663 | f: 08 6316 1431
e: info@essentialenvironmental.com.au
www.essentialenvironmental.com.au

APPENDIX 6

Retail Needs Assessment

Doley-Warrington Road Precinct, Byford

Retail Needs Assessment

December 2015

Prepared by:

RPS AUSTRALIA EAST PTY LTD

38 Station Street
Subiaco WA 6008

T: +61 8 9211 1111
E: tim.connoley@rpsgroup.com.au

Client Manager: Tim Connoley
Report Number: PR130257 -1
Version / Date: Final

Prepared for:

ABN GROUP

131 Hasler Road
Osborne Park WA 6017

T: +61 8 9526 1167
E: j.cordina@abngroup.com.au
W: www.abngroup.com.au

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1.0 Introduction

1.1 Background and Purpose

The Doley-Warrington Road Precinct is located in southern Byford. Adjacent to The Glades, this site is planned to accommodate approximately 1,900 lots over the next 15-20 years.

As part of the structure planning process for the Doley-Warrington Road Precinct, RPS has been engaged to assess the viability of a local centre/s within the subject area.

1.2 Report Structure

The report is comprised of the following key sections:

- **Site Characteristics** – an assessment of the local characteristics of the site, the existing competitive environment and the urban development outlook;
- **Trade Area Profile** – an assessment and overview of the socio-economic and retail expenditure characteristics of the subject site's trade catchment;
- **Market Viability** – an analysis of the market viability of the proposed floorspace and suitability of nominated sites; and
- **Development Recommendations** – a summary of the findings on the general viability of the proposed retail sites and development recommendations.

2.0 Site Characteristics

This section has explored the local characteristics of the Doley-Warrington Road Precinct and the retail and urban development environment which it is located within.

2.1 Byford

The Doley Warrington Road Precinct is located in southern Byford. Byford is the major town in the Shire of Serpentine Jarrahdale. It is located 45km from the Perth CBD and forms the northern part of the Peel region.

As one of Perth's most affordable suburbs for housing, Byford is home to numerous housing developments which are expected to continue to support significant population growth over the next two decades. Byford's population is forecast to grow at an annual rate of 4.1%, increasing the population by over 132% to 30,636 residents by 2036.

Byford is located approximately 5.5km north of Mundijong, which is expected to see growth in the order of 15,000 residents over the next two decades. The north of Byford includes many expanding urban areas, including the Wungong Urban Water Area which is expected to deliver more than 40,000 homes.

To the west of Byford, the area is largely rural urban and is not planned to accommodate urban development according to the draft South Metro Peel Sub-Regional Framework. Kwinana and Rockingham, approximately 20km west of Byford, provide significant local employment for the largely blue-collar workforce in Byford.

2.2 Doley-Warrington Road Precinct

The Doley-Warrington Road Precinct covers numerous land holdings in southern Byford. RPS has assessed the area from a retail viability context to inform the subsequent analysis.

2.2.1 Precinct Access

Access is an important determinant of the potential trade area of a retail centre. A well located site is generally able to attract a greater share of passing traffic, with poor location decisions difficult and expensive to overcome.

RPS has undertaken an overview of the local transport context for the site. The key findings are summarised below.

- **Orton Road Realignment and Extension**: Orton Road is planned to be extended to the east to connect with Soldiers Road and ultimately the South Western Highway. It is also planned to be realigned to the immediate west of Doley Road to the future Tonkin Highway extension. This will be an important link to Kwinana-Rockingham area and provide the opportunity for increased tertiary trade.
- **Public transport provision**: There is limited existing and planned public transport directly to the subject site. There however expected to be the provision of a bus route along Orton Road and to the future primary school from 2020 onwards.
- **Physical barriers**: Natural and infrastructure barriers that ease or impede travel will influence the relative access of a particular location to a range of locations, and subsequently improve the attraction of one activity over another, especially to residents in more distant catchments. The main physical barrier for the subject site is the current lack of road access to the urban area east of South Western Highway. This will require the construction of an additional rail crossing and is therefore considered a medium to long-term prospect. Additionally, there are no plans to connect local roads through to areas south of Byford (besides existing Soldiers Road and future Tonkin Highway) which will limit north-south movements through the subject site.

It is important to note that travel time is a more important consideration than physical distance when considering the extent of the catchment area. From a travel time perspective, the subject site currently provides sub-five minute access to central Byford shopping options and the urban areas of Cardup. The subject site is also within a two-three minute drive to the planned The Glades Village neighbourhood centre.

On completion of the extension of Orton Road to Soldiers Road, the subject site would be expected to provide easier access to the growing areas in north Mundijong, the proposed light industrial area east of Cardup and central Byford.

Overall, the analysis of site access reveals that any proposed retail in the short term will need to cater to a local catchment, with limited tertiary trade expected until Orton Road is extended. Once the extension is complete, there is an opportunity for convenience retail along the south-eastern edge of the precinct (i.e. corner of Orton Road and Soldiers Road) to capture local spending from Cardup and south-eastern Byford and commuter traffic from Mundijong. Local retail provision further west along Orton Road will be limited to a local catchment and tertiary trade from south-eastern Byford (though this is a longer-term prospect given the need for a rail crossing).

2.2.2 Urban Development

RPS has explored the current and future residential development within the wider area of the subject site. The key developments of relevance to the subject have been summarised below.

- **Doley-Warrington Road Precinct**: The Precinct is currently undeveloped, with several homes on larger lots scattered throughout. It is currently undergoing a structure planning process which has identified the potential for 1,917 lots or approximately 5,900 residents. Development within the Precinct is expected to occur from mid-2017 at a rate of 120 lots per annum, on average. Development is likely to extend from the northern and western edges of the development given the existing infrastructure and urban development in these areas.
- **The Glades at Byford**: The Glades is planned to accommodate more than 10,000 residents across 3,500 lots. The estate encompasses the areas to the immediate north, west and south of the subject site. Development to date has extended from Abernethy Road southward, with remaining development primarily to the west and south of the subject site in the order of 1,500-1,600 lots. The development expected to occur within The Glades over the next decade will provide a key catchment for any future convenience retail within the Doley-Warrington Road Precinct.
- **Byford West Private Estate**: East of The Glades, Byford West Private Estate is planned for 374 lots. Approximately two-thirds of the development has been sold to date. Proposed neighbourhood nodes have progressed as residential lots.
- **Byford Town Centre**: The town centre development is planned for medium density development ranging from R30 to R60 on the periphery of the town centre for grouped housing and aged accommodation and low density development to the west of the town centre (maximum R15) interfacing with the Trotting Complex. This plan expects to accommodate 2,500 residents at build-out.
- **The Brook at Byford**: This Cedar Woods development, located south-east of the town centre has approximately 200-250 lots remaining.
- **Byford on the Scarp**: Located to the east of the South Western Highway, the final residential stages of this development are progressing and expected to include another 50-60 lots.

There is limited urban development further north of Abernethy Road. Redgum Brook is nearing final stages in this development along Thomas Road. Byford Central, between Thomas Road and Larsen Road, has only a handful of sites available. Adjacent to Byford Central, Briggs Road is expected to accommodate approximately 200 dwellings.

Further south of the subject site, there is considerable development planned in Mundijong. The Whitby Precinct in northern Mundijong has the potential to provide tertiary trade along Soldiers Road. This precinct is planned to accommodate 3,750 lots and a future District Centre (2025+).

The developments noted above will include a range of community, civic and commercial land uses to cater for the expanding population. The key community, civic and commercial land uses near the subject site have been summarised below (the key competing retail/commercial land uses have been explored in section below).

- **Future Primary School Site (Doley-Warrington Road Precinct)**: The Byford Structure Plan identified the need for primary school site within the Precinct. The site is unlikely to be developed prior to 2020.
- **Future Primary School Site (The Glades)**: A future Byford South West Primary School is planned to open in 2017/18. The primary school site is located to the immediate north-west of the Doley-Warrington Road Precinct.
- **Orton Road Mixed Business Area**: A planned mixed business area along Orton Road, west of Doley Road, has subsequently been progressed as a mixed use zone in the Byford Main Precinct Structure Plan. The structure plan is currently being amended though it is our understanding that the mixed use zone will remain.

Overall, the urban development analysis reveals that there is considerable development planned near and within the Doley-Warrington Road Precinct, including approximately 1,900 lots in the subject site, 1,500-1,600 lots in The Glades (primarily to west and south of the subject area) and 150 lots within the Byford West Private Estate.

The future primary school site is expected to cater to local residents and will therefore not generate notable additional expenditure for any retail within the subject area. Meanwhile, the planned mixed business area is now expected to be developed as a mixed use zone (primarily residential) which will support increased local expenditure in the catchment.

2.2.3 Retail Competition Assessment

The distribution of centres plays a key role in consumer's retail shopping behaviour and subsequent contribution to the delineation of trade areas by determining how far residents need to travel to access goods and services. RPS has explored existing and planned retail provision within this section.

There is limited existing competing retail across Byford. The only convenience and traditional retail provision is within central Byford. The intersection of the South Western Highway and Abernethy Road accommodates several restaurant/take-away premises, fruiterer, butcher, an IGA supermarket, chemist as well as another grocery and liquor store. Given recent growth in the area, current tenancies are trading above average.

There are however numerous planned retail centres throughout Byford. The key planned retail sites in relation to the Doley-Warrington Road Precinct have been summarised in the table below.

Table 1 Planned Retail/Commercial Centres

Name	Description	Status
Byford Town Centre	The new town centre, approximately 3km north-east of the Doley Warrington Road Precinct adjacent to the existing central Byford retail, is initially planned to include 5,631sqm of retail NLA, comprising of a Coles (4,024sqm), speciality stores (1,027sqm), cafe/restaurant facilities (380sqm), a gymnasium (350sqm), medical Centre (301sqm) and a liquor store (200sqm). Planning has also progressed for a Farmer Jacks Supermarket with a NLA of 2,276sqm.	**Coles Centre**: Earth works are underway and the development is expected to be complete in early 2018. **Farmer Jacks**: Planned for completion Sep 2017.

Name	Description	Status
	The IGA on 865 South Western Hwy has been granted approval for a 560sqm addition. In the longer term, there is provision for retail floorspace of between 9,000sqm and 15,500sqm which could accommodate two full-line supermarkets, a limited line supermarket, specialty stores and convenience retail.	**IGA expansion**: Planned for 2016.
Cardup Business Park	The 194ha trapeze within the boundaries of Robertson Rd, Norman Street, South Western Hwy, and Cardup Siding Rd, approximately 4.7km east of the Doley-Warrington Road Precinct, is proposed to become a light industrial business park and include a variety of warehouses, factories, and shops.	The development is not expected to occur until post-2018.
Whitby District Centre	The precinct lays approximately 6.7km south of the Doley-Warrington Road Precinct and is proposed to contain 22,500sqm NLA. The area is proposed to include a discount department store, two supermarkets, and 70-90 specialty stores	Unlikely to proceed prior to 2025.
The Glades Village	The centre is immediately north-west of the Doley-Warrington Road Precinct and proposed to contain 7,000sqm NLA, with retail floorspace currently capped at 4,500sqm NLA and non-retail commercial floorspace capped at 2,500sqm NLA.	The cafe/restaurant component has commenced development, as is estimated to be completed in June 2016. A future Woolworths is likely to be developed post-2020.

Numerous 'neighbourhood nodes' were identified in the Byford Structure Plan however many of these have subsequently progressed as residential and/or community uses such as a day care centre. There are planned neighbourhood nodes within the undeveloped portion of The Glades which may provide a local retail mix however it is our understanding that these are progressing as residential and mixed use sites.

3.0 Trade Area Profile

This section defines a catchment for convenience retail provision at the subject site and examines the future socio-economic and retail expenditure characteristics of the trade area. This section also provides an estimate of the amount and type of retail floorspace that the trade area can support over the next two decades.

3.1 Trade Area Definition

3.1.1 What is a Trade Area?

A current or proposed centre will have a trade area which shows where the centre will draw most of its trade. Whilst trade areas can be drawn for a variety of land uses, the main purpose for trade area analysis is to derive the retail floorspace potential for a specific site.

Trade area analysis can also be used to understand the likely impact of a development or expansion on surrounding competitive retail floorspace both inside and surrounding the trade area.

Trade areas are usually divided into primary and secondary catchments:

- **Primary catchment**: Depending on the scale of the centre, the primary catchment will typically draw between 60% and 75% of the total trade for the centre. Market shares of resident retail spending levels within this area are higher than in the secondary catchment as residents will typically frequent centres that are closer to their home base. The primary catchment is the most important area to consider in terms of the demographics, future sales growth and marketing strategies for the subject centre. The spatial distance of primary catchments differ based on a range of factors including centre size and location.
- **Secondary catchments**: Between 10% and 25% of the centre's trade will typically be drawn from the secondary catchment. This area will generally have a higher degree of competitive choice for the resident population and there are also a higher degree of factors which lead to these residents making the choice of which centre to frequent. The secondary catchment will generally not reach beyond 10km of the subject site, but it may extend further in lower density areas and where there are less competitive centres.

Centres may also receive trade from tertiary 'beyond' trade. This can include trade from other areas outside the catchment, including passing vehicle trade, the nearby working and tourism population and co-located uses such as sporting ovals and community facilities.

3.1.2 Defining the Trade Area

Trade areas can vary significantly based on a range of factors including centre size, role, competition, travel times including an understanding of future infrastructure (new roads and public transport) which may make it easier to travel to the site, as well as physical and manmade barriers (parklands, rivers, railway lines) which may make it harder to access the site. Future residential areas should also be considered in a catchment analysis.

For this analysis, the trade area at the subject site has been defined based on an assumption that the proposed retail will be convenience in nature. We have also taken the following into account the following key considerations analysed in the previous sections:

- **Size and composition of proposed development** – the convenience nature of the proposed floorspace suggests that the site will trade to a predominantly local catchment;
- **Physical characteristics** – the main physical barriers are the current lack of an east road connection to Soldiers Road and the limited road connections to Cardup rural residential areas;

- **Access and travel patterns** – Orton Road, Doley Road, Turner Road and Warrington Road are considered the main traffic routes to the subject site;
- **Local competition** – the major existing completion is central Byford which currently acts as a regional and local convenience centre and the major planned centre which will detract from trade in the catchment will be The Glades Village which is planned to offer retail options; and
- **Development trends** – future urban growth is limited within rural residential areas outside of Byford, though there is considerable growth in excess of 3,500 lots planned for southern and western Byford.

3.1.3 Development Trade Area

Based on the above considerations, RPS identified three catchments. These are illustrated in the figure below.

- **Primary Catchment**: The primary trade area is broadly defined by the urban areas which are located within a three to four minute drive from the subject site, including future urban areas to within Byford.
- **Secondary Catchment**: The secondary trade area extends to the rural residential areas to the west, south and east of the subject site. There is expected to be limited trade from urban areas north of Abernethy Road given the existing retail provision, future Byford Town Centre and lack of key north-south roads. There is also unlikely to be significant trade generating from Mundijong unless retail was located along Soldiers Road and/or the mixed business zone developed into a regional commercial area.

The catchment regions have been based on ABS Statistical Area 1 boundaries which are the smallest areas for which statistical data required for a retail report is provided and therefore represent the most detailed and accurate method in explaining the retail market within a small area. It is important to note that the site is expected to also generate 'tertiary trade' due to worker movements past the site and the future school use. This is subsequently explored in more detail.

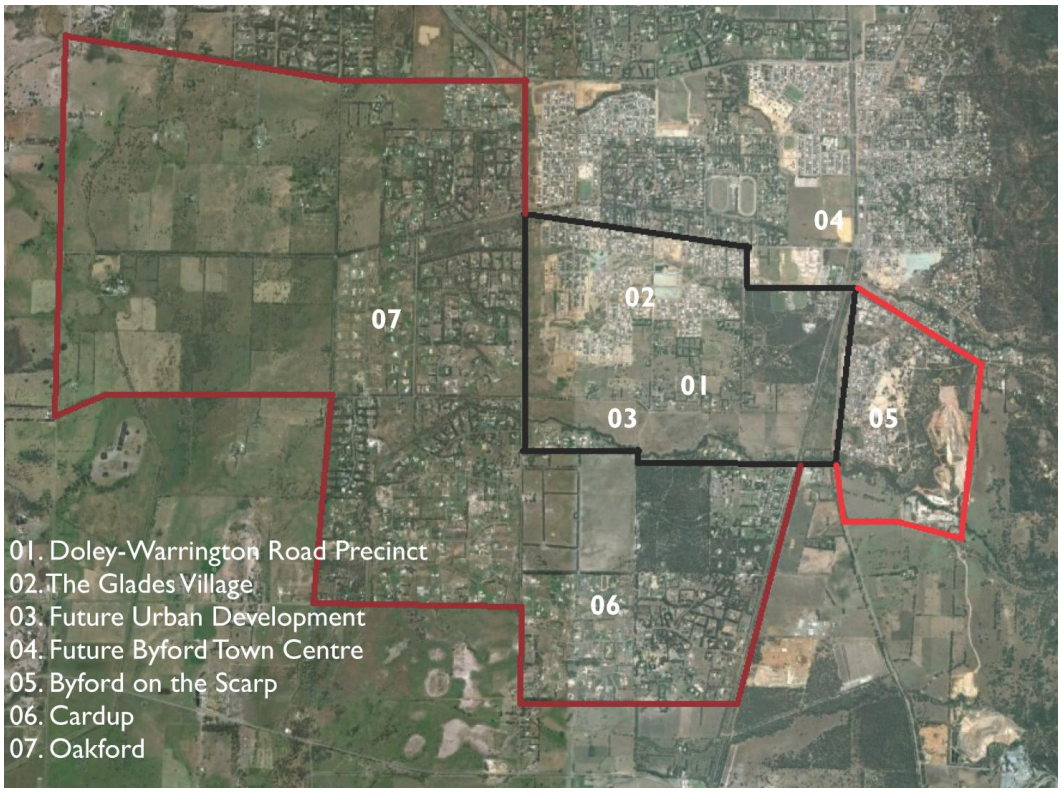


Figure 1 Subject Site Catchment Map

3.2 Catchment Socio-Economic Profile

3.2.1 Population Forecast

The resident population of the trade area increased considerably over the last decade, with growth of more than 1,000 residents within the primary trade area. The population growth rate is expected to decline over the next five years, in line with declines across Perth, but will remain considerable at 5.7% per annum. The slowing growth rate is largely due to limited growth within the secondary catchments. For instance, the primary catchment's population is still expected to grow at an average annual rate of 12.7% between 2016 and 2021.

In the medium-term, the growth rate in the primary catchment is expected to moderately increase and by 2036 there is expected to be more than 17,000 residents in the trade area, up from approximately 4,500 (this is equivalent to 4,100 lots).

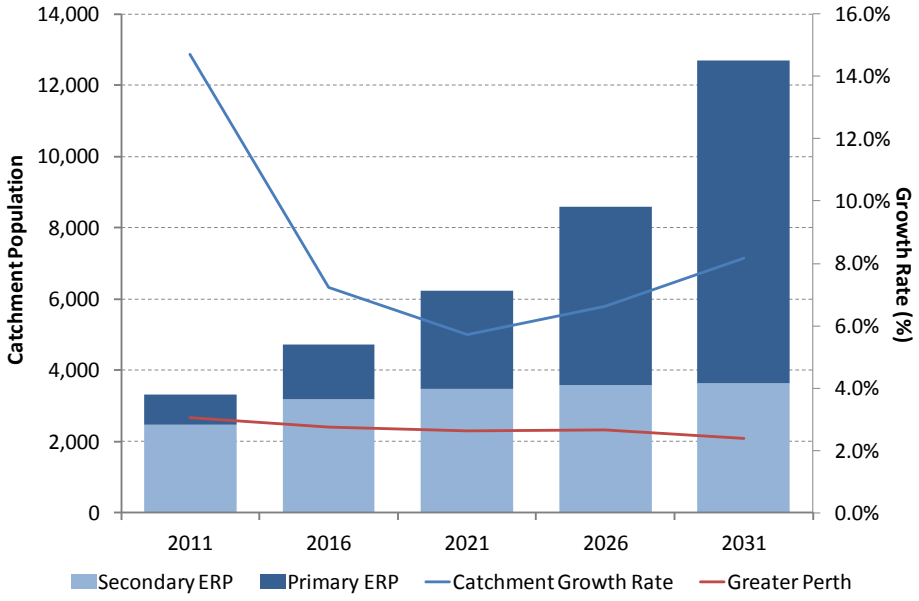


Figure 2 Historical and Forecast Population Growth, Catchment Area[1]

3.2.2 Socio-Economic Characteristics

RPS explored the characteristics of the resident population of the primary and secondary catchment areas compared with the benchmark regions of Metropolitan Perth and Western Australia. Whilst the core focus of the report is to explore the viability of proposed retail floorspace on the subject site, it is vitally important to understand demographic factors which outline important factors relating to this development.

A summary of the socio-economic characteristics of the trade area compared to Greater Perth, regional Western Australia and the whole of WA is illustrated in the table over the page[2].

[1] ABS (2015) Estimated Resident Population by SA1 (unpublished), Australian Bureau of Statistics, Canberra; Population projections generated by RPS demographers, based on urban development zoning and trends and Profile id forecasts
[2] ABS (2012) Census of Population and Housing, 2011, Australian Bureau of Statistics, Canberra

Table 2 Socio-Economic Profile, 2011

	Primary Catchment	Secondary Catchment	Greater Perth	Regional WA	WA
Med. weekly h/hold income	$1,766	$2,048	$1,459	$1,253	$1,415
Med. annual h/hold income	$91,832	$106,470	$75,868	$65,156	$73,580
Var. from Greater Perth benchmark	21.0%	40.3%	0.0%	-14.1%	-3.0%
Avg. household size	3.1	3.2	2.5	2.5	2.5
Avg. persons per bedroom	1.0	1.1	1.1	1.1	1.1
Housing Payments					
Med. weekly loan repayment	$520	$595	$462	$375	$450
Med. weekly rent repayment	$406	$313	$320	$180	$300
Loan to income ratio	29.4%	29.1%	31.6%	30.0%	31.8%
Rent to income ratio	23.0%	15.3%	21.9%	14.4%	21.2%
Housing status (% of households)					
Owned outright	16.0%	16.0%	30.0%	31.3%	30.2%
Being purchased	63.1%	74.5%	40.7%	31.3%	38.7%
Renter	20.9%	9.5%	28.2%	36.4%	29.9%
Other	0.0%	0.0%	1.2%	1.1%	1.1%
Age distribution (% of population)					
Aged 0-14	25.5%	26.4%	19.2%	21.3%	19.7%
Aged 15-24	14.7%	13.7%	14.3%	11.8%	13.7%
Aged 25-34	15.4%	11.0%	14.7%	13.7%	14.5%
Aged 35-44	13.7%	19.9%	14.5%	15.0%	14.7%
Aged 45-54	8.8%	15.3%	13.6%	14.7%	13.9%
Aged 55-64	8.4%	9.3%	11.2%	11.9%	11.4%
Aged 65+	13.6%	4.4%	12.5%	11.5%	12.3%
Med. Age	**31.0**	**32.5**	**36.0**	**37.0**	**36.0**
Dwelling Type					
Separate house	93.1%	89.5%	71.1%	69.4%	70.7%
Semi-detached and townhouse	0.0%	0.0%	10.7%	4.7%	9.3%
Flat, unit, apartment	0.0%	0.0%	8.2%	3.0%	7.0%
Other dwelling	0.0%	0.0%	0.4%	2.3%	0.8%
Not stated	0.0%	0.0%	0.0%	0.2%	0.1%
Total Occupied Private Dwellings	**93.1%**	**89.5%**	**90.4%**	**79.5%**	**87.9%**
Unoccupied Private Dwellings	6.9%	10.5%	9.6%	20.5%	12.1%
Total Private Dwellings	**246**	**854**	**693,327**	**210,163**	**903,487**
Motor Vehicles Per Dwelling					
No vehicle	0.0%	1.6%	6.3%	6.1%	6.3%
1 vehicle	20.3%	9.4%	34.1%	31.5%	33.5%
2 vehicles	51.5%	48.4%	39.8%	38.8%	39.6%
3+ vehicles	28.2%	40.6%	19.8%	23.6%	20.6%
Average vehicle number	**2.22**	**2.50**	**1.81**	**1.90**	**1.83**

This analysis identified where the trade area is significantly different from wider benchmark regions and explored how this impacts on retail floorspace need. Key findings from the assessment included:

- **High incomes:** The primary and secondary catchments were home to higher income residents, with the median household income 21.0% and 40.3% higher than the Perth median, respectively. Whilst high incomes in the more affordable area may seem counterintuitive, it is generally the case that new urban areas have high wages given low unemployment and the working age profile of home buyers.
- **Young and maturing families**: The majority of households in the trade area are larger than the Perth average and a reflection of the housing stock and buyer demographic of young and maturing families. Retail spending is therefore more heavily skewed towards bulky goods and department stores.
- **High care ownership**: Residents in the trade area are much more likely to own more than two vehicles. Households are therefore more inclined to drive to retail centres which can impact on the viability of small convenience retail centres and requires higher car parking provision.

3.3 Retail Expenditure Profile

RPS has derived retail expenditure using MarketInfo 2012, the latest version available[3]. MarketInfo is an independently formulated model and is used by the majority of retail economists in understanding the retail floorspace needs of an area. This model estimates an area's propensity to spend on retail goods based on a range of socio-economic characteristics.

Across Greater Perth, each person generally spends around $13,800 on retail goods per annum[4]. As noted in the figure below, residents in the secondary catchments spent higher amounts on retail goods than the Perth average given the secondary catchments include a large portion of high income earning families on rural residential lots. Whilst the primary catchment includes households with high incomes, discretionary income is considered to be lower than the Perth average, with key fixed expenses such mortgage payments.

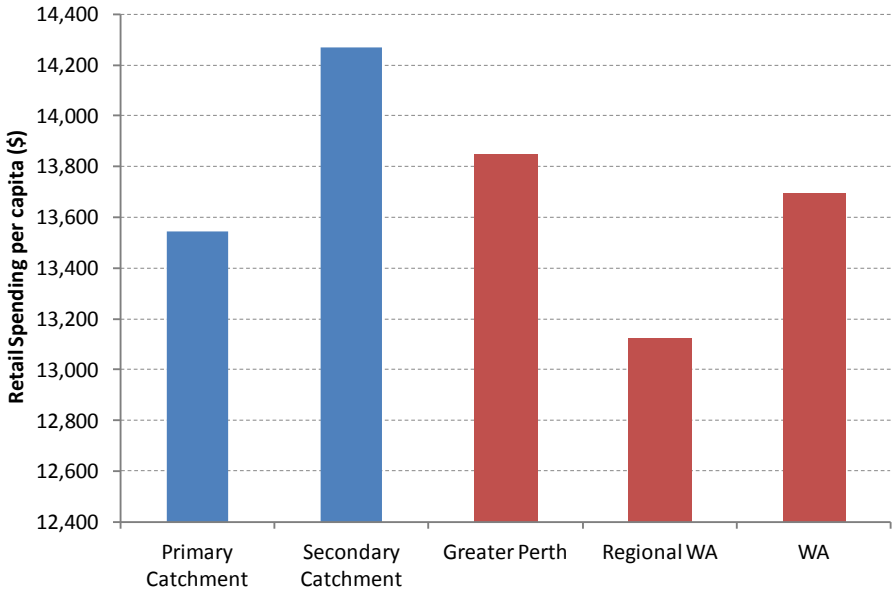


Figure 3 Retail Spending by Area, 2015

[3] Market Data Systems (2013) MarketInfo 2012, Market Data Systems, Brisbane
[4] Excludes motor vehicle and fuel expenditure

The above per capita retail spending has been broken down further into the levels of spending at retail centres by major store type. Key findings are illustrated in the figure below.

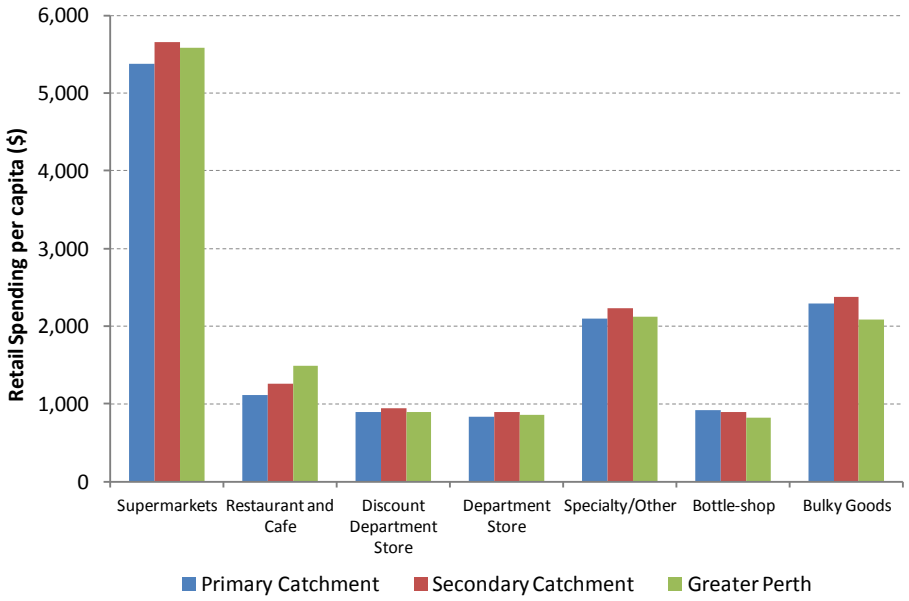


Figure 4 Retail Spending by Store Type, 2015

3.4 Retail Floorspace Demand

3.4.1 Approach

Retail demand is a product of the number of people in a location and the amount they each spend on retail goods and service. The total retail expenditure pool of a location (the total amount of money spent by residents and households) is estimated by applying expenditure rates per person to current and future population forecasts. This is then converted to floorspace demand through the application of sales densities. This process is illustrated in the figure below.

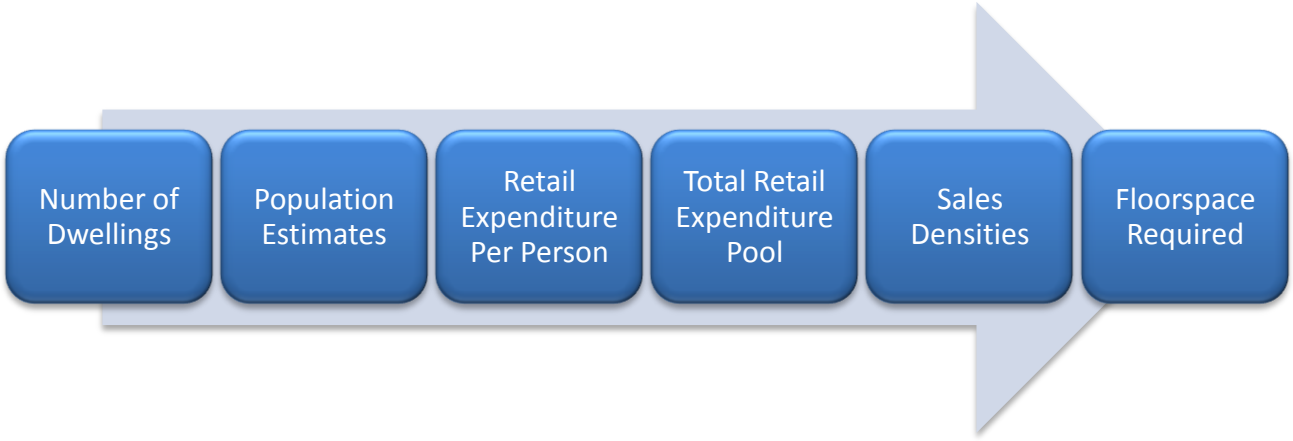


Figure 5 Retail Expenditure Pool and Floorspace Need

3.4.2 Retail Expenditure Projections

It is important to note that the retail market is not immune to structural changes that are occurring in the economy and society. The retail sector in Australia is being tested by numerous factors, including, but not limited to:

- Changing consumers – consumers are altering their trading patterns, with higher levels of spending devoted to experiential items such as sporting events, concerts, restaurants and cafes.
- Online trading – online trading is increasing much faster than traditional 'bricks and mortar' stores, though there is still a strong preference to frequent stores as online retail expenditure accounts for only 6.5% of retail expenditure. Additionally, retail outlets are devoting more resources to accommodating both online and in-store customers.
- Regulatory changes – WA is playing catch up to more mature retail markets, with trading law changes activating centres for longer hours.

In order to consider the changing patterns in the retail sector, RPS has applied current growth rates by expenditure category and population projections to arrive at the total spending profile of the catchment residents. The growth in expenditure categories is based on real growth rates derived from Deloitte Access Economics forecasts[5].

Over the next 10 years, retail spending for trade area residents is expected to increase by an average of 7.3% per annum to more than $300 million, with much higher growth within the primary catchment. This reflects a combination of population-based and real expenditure per capita growth.

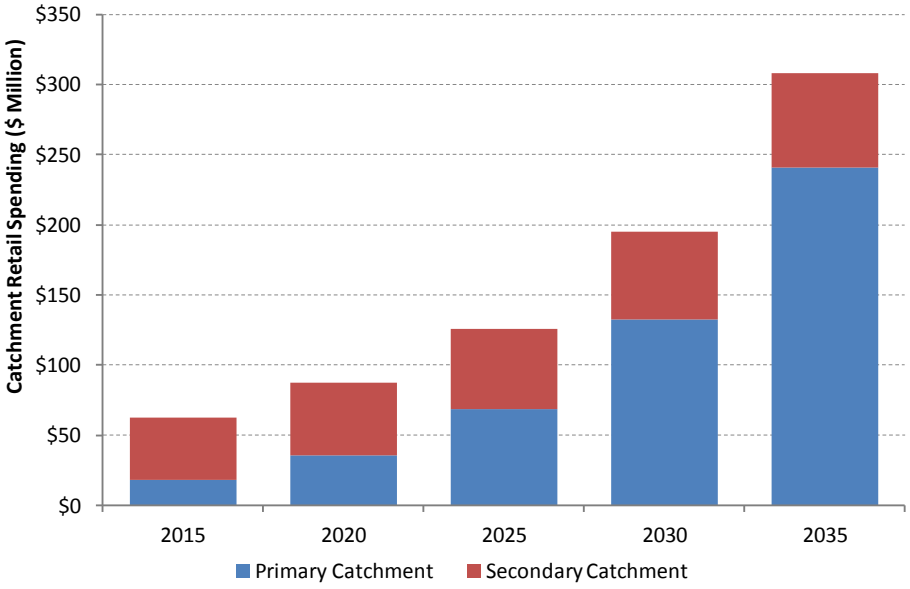


Figure 6 Retail Spending Growth, Trade Area

[5] Deloitte (2014) Retail Forecasts, 2014, Deloitte Access Economics, Melbourne

3.4.3 Catchment Floorspace Requirements

RPS has applied sales densities to each retail category to estimate how the retail spending of residents in the catchment translates into demand for retail floorspace need. Sales densities are the dollar sales per square metre of Gross Floor Area (GFA) required to sustainably operate that floorspace in the catchment. For example, an average supermarket would need $6,500 of sales per square metre per annum to continue to operate that space at a commercially viable level. This is a broad average, with some supermarkets in inner metropolitan markets requiring $7,500 of sales per square metre per annum to operate viably. Industry standard sales densities by retail category for the subject site are outlined in the figure below.

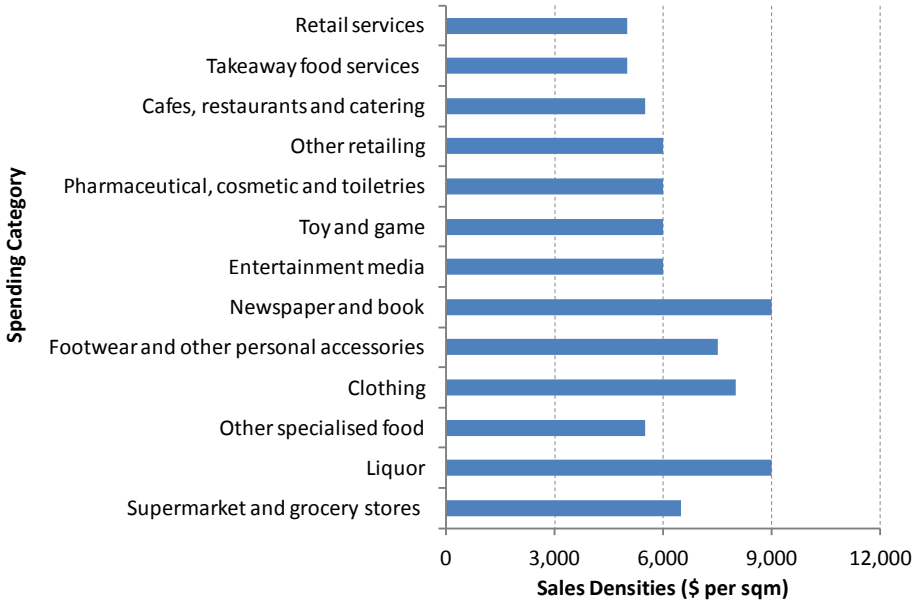


Figure 7 Retail Sales Densities by Spending Category, 2015

These densities were applied to the projected expenditure volumes to find the estimated floorspace demand for retail property. This analysis has been summarised below.

Table 3 Convenience Retail Floorspace Demand, 2015 to 2035

	Supermarket and grocery stores	Liquor	Other specialised food	Clothing	Footwear and other personal accessories	Newspaper and book	Entertainment media	Toy and game	Pharmaceutical, cosmetic and toiletries	Other retailing	Cafes, restaurants and catering	Takeaway food services	Retail services	Motor vehicle and fuel retailing	Medical and health
2015	2,881	563	280	561	491	91	158	118	215	619	770	780	514	3,249	1,590
2020	4,078	805	399	758	654	123	218	170	287	863	1,074	1,110	711	4,440	2,249
2025	5,980	1,192	587	1,061	904	172	312	251	398	1,246	1,556	1,637	1,018	6,294	3,297
2030	9,383	1,886	925	1,589	1,339	257	479	395	593	1,921	2,413	2,580	1,561	9,551	5,170
2035	15,023	3,039	1,485	2,431	2,031	392	748	631	907	3,017	3,831	4,146	2,440	14,825	8,275
Floorspace need growth (sqm per annum)															
2015-2025	310	63	31	50	41	8	15	13	18	63	79	86	50	304	171
2025-2035	904	185	90	137	113	22	44	38	51	177	228	251	142	853	498
Floorspace need growth (%)															
2013 - 2023	108.0%	112.5%	110.0%	89.5%	84.4%	88.8%	98.5%	113.8%	85.4%	101.7%	102.3%	110.5%	98.6%	93.9%	107.7%
2023 - 2033	147.0%	151.1%	148.8%	125.2%	120.3%	124.5%	135.6%	148.6%	122.7%	138.5%	141.6%	149.3%	135.7%	131.3%	146.8%

This represents the total amount of retail floorspace that the expenditure of the trade area residents can support. However, this demand will not be met entirely from centres within the trade area. Consumers travel

across cities and regions to different retail centres for different reasons, including convenience, size and extent of offering and built form quality. This level of unmet demand and leakage was therefore explored in the following section.

3.4.4 Retail Supply Gap

Based on the above analysis, RPS has examined the current and future expected market gap within the catchment area.

Building on the summary in Section 2.2.3, the following table describes our estimates of future retail provision of relevance at various dates over the next two decades. This analysis suggests that there is currently a high level of retail expenditure leakage to larger shopping centres and retail strips (e.g. Armadale Shopping City).

Table 4 Convenience Retail Floorspace

Square Metres	2015	2020	2025	2030
Central Byford	3,120	3,560	3,560	3,560
Farmer Jacks	-	2,276	2,276	2,276
Byford Town Centre	-	5,631	5,631	8,900
The Glades Village	-	2,100	4,500	4,500
Total Competing Convenience Retail Supply	**3,120**	**13,567**	**15,967**	**19,236**
Trade Area Supply Share	1,255	6,512	9,261	12,503
Total Trade Area Demand	6,307	8,861	12,904	20,108
Market Gap	**5,052**	**2,349**	**3,643**	**7,605**

Overall, the analysis indicates that several large developments are planned to be completed over the next five years and capture much of the market gap for convenience retail. There is however a notional gap which is expected to increase strongly from 2025 onwards. It is not however appropriate for the subject site or indeed any development within the trade area to capture this entire market gap. Neighbouring developments already likely capture much of the unmet demand and therefore a large development could have adverse impacts on retail activity at these developments. RPS has therefore explored the potential for the subject site in Section 4.0.

4.0 Market Viability

This section analyses the market viability of retail floorspace within the Doley-Warrington Road Precinct and assesses the potential tenancy and floorplate mix.

4.1 Development Potential

RPS applied the results of the trade area analysis to the subject site in order to assess whether convenience retail floorspace is appropriate and commercially viable.

4.1.1 Trade Area Market Share Potential

To determine the level of retail floorspace that can be sustained at the subject area, RPS has applied retail category-specific market shares to the retail floorspace demand projected for the trade area. Market share assumptions are outlined in the following table.

Table 5 Market Shares

Market Shares	Primary Catchment	Secondary Catchment[6]
Supermarket and grocery stores	20.0%	10.0%
Liquor	20.0%	10.0%
Other specialised food	20.0%	10.0%
Clothing	5.0%	3.0%
Footwear and other personal accessories	5.0%	3.0%
Newspaper and book	10.0%	5.0%
Entertainment media	10.0%	5.0%
Toy and game	5.0%	3.0%
Pharmaceutical, cosmetic and toiletries	10.0%	5.0%
Other retailing	10.0%	5.0%
Cafes, restaurants and catering	15.0%	8.0%
Takeaway food services	15.0%	8.0%
Retail services	10.0%	5.0%
Medical and health	15.0%	8.0%

Based on the role and function of the centre and the competitive supply from nearby centres, it is expected that the centre is able to capture only small market shares of the total trade area spend. The remaining expenditure is expected to be captured by existing and larger centres outside the trade area.

[6] Additionally, we have assumed that the east Byford secondary catchment market shares will not increase until post the Orton Road extension.

4.1.2 Tertiary Trade Potential

A portion of the trade at the subject site will come from areas outside the catchment. This can include:

- Residents who live outside of the catchment and pass the centre infrequently;
- Tourists that stay in or pass through the catchment; and
- Workers located in the catchment.

Generally, tertiary (beyond trade) spending will make up at least 10% of the turnover of a local centre. Centres located on busy roads and in tourist locations however achieve higher levels of tertiary spending. Additionally, the co-location of regional attractions will encourage a greater level of tertiary spending.

Analysing the expected tertiary trade proportion is however not a straightforward task. Signage, parking, ease of access and brand reputation are just some of the key determinants of tertiary trade attraction. Based on tertiary trade levels at similarly located convenience retail centres located within urban areas, along local roads, RPS has applied a tertiary trade proportion of 10%. A centre located along Soldiers Road would attract a larger portion.

4.1.3 Supportable Retail Floorspace

The market shares and tertiary trade proportions were applied to the total catchment floorspace demand to arrive at the site-specific retail floorspace potential. This floorspace potential is likely to vary depending on the tenancy mix, however, it is broadly representative of the likely levels that would be sustainable at the subject site.

It should be noted that the supportable retail floorspace is only one cosideration. There are other important considerations that complement this analysis (which will be considered during a development application process), including:

- Role of centre in State and local strategies;
- Market leasing conditions;
- Retail shop demand for tenancy sizes and building floorplates;
- Impact on neighbouring centres; and
- Economic and community benefits.

RPS estimates that a convenience retail centre could support around 1,500sqm of retail shop floorspace by 2025. This includes 990sqm of supermarket floorspace, 250sqm for cafe and takeaway shops and 280sqm for specialty/other stores. Thereafter, a larger centre is modelled to be viable however there is the potential that competing centres are expanded or developed that would impact on market shares. It is therefore considered appropriate to plan for the viable floorspace at 2025 but allow for a moderate expansion.

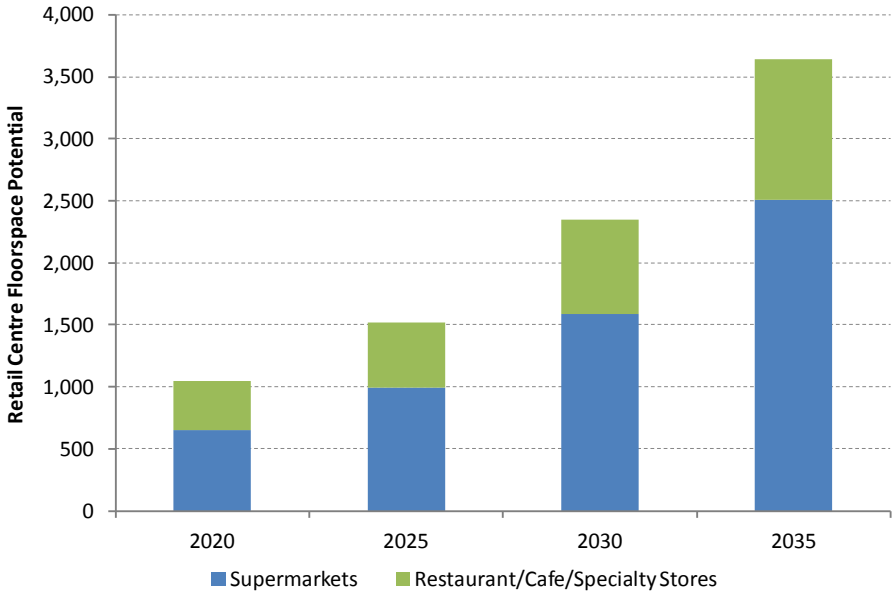


Figure 8 Centre Floorspace Potential

4.2 Preliminary Floorplate and Tenancy Assessment

The composition and scale of the identified retail floorspace is an important component of any floorspace viability assessment. Based on the above analysis, a centre with the following retail floorspace attributes is viable by 2025.

Table 6 Viable Retail Floorspace, 2025

Category	NLA (sqm)
Supermarket and grocery stores	990
Café/Restaurant	250
Specialty	280

A small shopping centre equivalent to an IGA is considered the most likely anchor tenant within a retail centre at the subject area. IGA is typically accommodated within floorplates of 500-1,200sqm. Given the proximity to competing centres, a floorplate of 700sqm-800sqm is considered likely.

The degree of specialty store and café/restaurant provision is commensurate to the ability of co-located uses to attract pedestrian patronage. In the case of convenience retail centres, the greater patronage of co-located supermarkets, the greater the supportable provision of other retail stores. Stores equivalent to 80sqm on average are likely to be suitable and include tenancies such as a bakery/café, take-away food, newsagency and limited personnel services (e.g. hairdresser)[7].

In addition to above, there is a recognised need for medical/health floorspace (and potentially a day care or community use) which may be accommodated for within the Doley-Warrington Road Precinct (in the order of 325sqm at a market share of 15%). There is currently expected to be limited competing supply expected in the area.

[7] Specialty stores average 90-100m2 of gross leasable area, though some are as small as 55-60m2.

4.3 Potential Parking Needs

Typically, parking needs are determined based on some attribute of land use, typically size or number of employees. These rates can be somewhat arbitrary as the exact use of the property may not be known, or it changes over time, the hours of operation of uses vary and peak and average rates can differ greatly. These standard rates are however the best approximation of parking demand available and provide a good starting point.

The State Government's Activity Centre policy recommends a minimum of 4-5 parking bays per 100m^2 of shops. There are however a number of determinants of car parking need which should be considered, including:

- Size and nature of the centre – parking requirements typically reduce as centre sizes increase given that larger centres are associated with having a greater diversity of land use which requires parking at different times at different rates;
- Urban character and socio-economics – the prevalence of higher car ownership corresponds to greater demand for car trips;
- Public transport availability – the lack of alternative forms of transport;
- Availability of other parking – street and curb parking;
- Operating hours –local centres typically operate from 8am to 9pm on weekdays and more restricted hours on weekends;
- Parking restrictions – generally a convenience retail centre development would provide free, time restricted parking; and
- Land use combinations – the combination of other uses that leads to overlapping parking demand influences the degree of parking demand.

The proposed development at the subject area is for a convenience shopping centre which is a considerable trip generator in the urban environment. Convenience centres are generally associated with the twice weekly shopping. These centres are also home to several food retailers which drives car usage as well. It is therefore considered that 4-5 bays would not be sufficient for the retail/commercial component of the development.

Newly developed centres have become more nuanced when considering parking provision requirements. An average of 6.6 bays per 100m^2 has been observed at comparable developments across Perth. This level of provision is considered more appropriate for a development within the subject area.

4.4 Site Requirements

From a location perspective, the centre is best-placed to be located along a moderately busy route such as Orton Road, with a north-south connection bordering the site. A site equivalent to approximately 0.5ha would suffice the needs of a centre of this size.

Co-location is an important factor to consider, with the centre benefiting from co-location with the mixed use area west of Doley Road. There is also expected to be urban development at this western portion at an earlier point than the eastern edge of the subject area which would support the viability of the centre.

Furthermore, RPS has recommended that one site be planned to accommodate this centre given fragmenting the centre across an intersection or road would result in minor tenancies unable to capture passing pedestrian traffic despite their proximity. There are also issues surrounding the decline in amenity of small dispersed centres as they are more likely to have fragmented ownership which can lead to a longer

term decline in the level of maintenance and amenity of the centre. While one owner may wish to maintain their tenancy, surrounding tenancies that are not maintained leads to a longer run decline in the viability of maintenance for all tenancies.

5.0 Development Recommendations

5.1 Key Findings

The Doley-Warrington Road Precinct is considered somewhat constrained by limited road access and any retail provision in the short to medium term is therefore expected to cater to a primarily local catchment. There is unlikely to be significant tertiary trade until Orton Road is extended and re-aligned and even when this progresses there is expected to be limited north-south tertiary trade to support trade levels.

There is considerable urban development planned within the subject site and the nearby The Glades development which will support a substantial increase in retail expenditure over the next two decades. Additionally, the planned mixed business area now appears likely to develop into mixed use – predominantly residential. However, in line with this growth there is a planned neighbourhood centre (The Glades Village) and substantial plans at the future Byford Town Centre.

We have analysed the likely growth in competing retail centres above and this analysis identified a key need for local retail in the trade area. Additionally, it was identified that there are no small-scale retail developments planned in southern Byford. There is therefore a potential opportunity for a small-scale retail centre for the nearby 10,000 residents expected to move to the area over the coming decades.

An analysis of the potential scale and timing of a retail centre within the Doley-Warrington Road Precinct revealed that a convenience retail centre could support around 1,500sqm of retail shop floorspace by 2025. Thereafter, a larger centre is modelled to be viable however there is the potential that competing centres are expanded or developed that would impact on market shares. It is therefore considered appropriate to plan for the viable floorspace at 2025 but allow for a moderate expansion.

5.2 Recommendations

The analysis has revealed that the Doley-Warrington Road Precinct could support a small retail centre which is likely anchored by a supermarket such as IGA in the order of 800sqm. It is also recommended that there is provision for approximately four specialty tenancies in the order of 320sqm and medical/health uses in the order of 325sqm. Parking equivalent to 95 bays (6.6 bays per 100sqm) is considered appropriate.

Table 7 Recommended Floorspace Provisions

Category	NLA (sqm)
Supermarket and grocery stores	800
Café/Restaurant/Specialty	320
Medical/Health	325
TOTAL	**1,445**

From a location perspective, the centre is best-placed to be located along a moderately busy route such as Orton Road, with a north-south connection bordering the site. It will also benefit from co-location with the mixed use area west of Doley Road given urban development at this western portion at an earlier point than the eastern edge of the subject area. Furthermore, the subject site should be planned across one 0.5ha site given fragmenting the centre across an intersection or road would be a barrier to viability and lead to a longer term decline in the level of maintenance and amenity of the centre.

APPENDIX 7

Engineering Servicing Report

pritchard francis

Level 1
430 Roberts Road
PO Box 2150
Subiaco WA 6904

Telephone: (08) 9382 5111
Facsimile: (08) 9382 5199
admin@pfeng.com.au

15-251

Engineering Servicing Report

for

ABN Group

on

Lots on Orton Road, Lawrence Way and Doley Rd, Byford

Revision	Description	Date
0	For Lodgement	14-Dec-15

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3	Infrastructure	5
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Appendix Two	*Galt Geotechnics Desktop Study, 2015*
Appendix Three	*Byford Townsite Drainage And Water Management Plan, September 2008*
Appendix Four	*Water Corporation Sewer Long Term Planning, 2015*
Appendix Five	*Water Corporation Water Planning, November 2015*
Appendix Six	*Water Corporation Maps, 2015*
Appendix Seven	*ATCO Maps, 2015*
Appendix Eight	*Western Power Maps, 2015*

1 Introduction

On behalf of ABN Developments, Pritchard Francis has prepared the following report to provide strategic engineering advice on the serviceability of the proposed Local Structure Plan (LSP) area adjacent Orton Rd in Byford.

The potential development area is located within the Shire of Serpentine Jarrahdale, and is bounded to the south by Orton Road, to the west by the urban development front approaching from Shackleton Terrace, the east by Lots off Warrington Road and the north by Perrone Ave, Lawrence Way and Partridge Bend. It also covers an extension from the corner of Warrington and Orton Roads through to Soldiers Rd, including land of Turner Rd. All lots within the area shown in Figure 1 are considered.



Figure 1 - Site Overview

This report is compiled using information obtained from relevant service providers, Dial Before You Dig and preliminary site investigation.

2 Site Conditions

2.1 Geology

The Perth 1:50,000 Geological maps show primarily sandy clay conditions across the site (Figure 2).

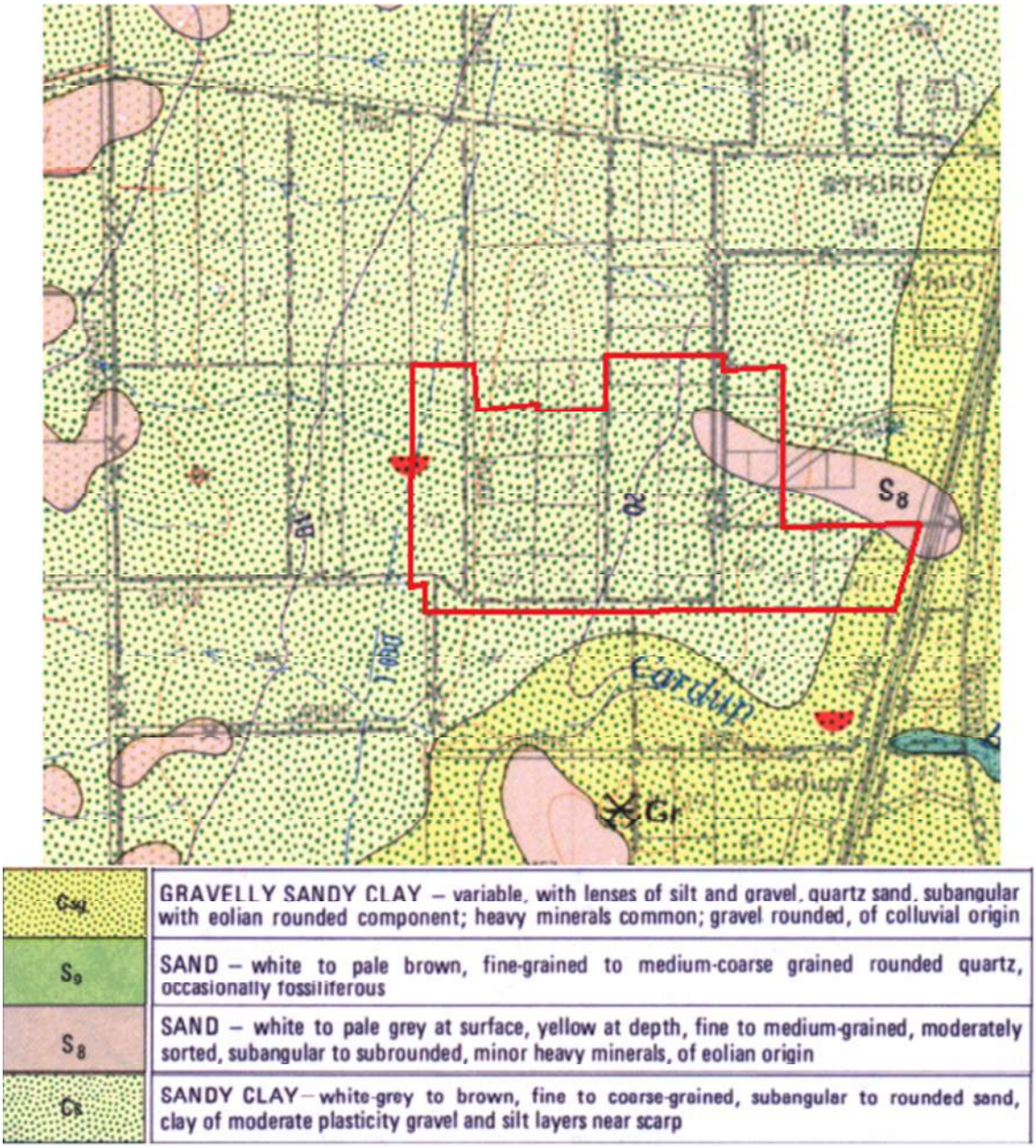


Figure 2 - 1:50,000 Geological Mapping Excerpt

Geotechnical advice received from Galt Geotechnics on 11 September 2015 (Appendix One) suggests that the majority of the site is overlain by 0.4-1.3m of sand underlain by clayey sands transitioning to sandy clays at about 2m depth.

Acid Sulphate Soils (ASS) are shown in Department of Environment mapping to be of moderate to low risk in the top 3 m within the areas indicated as Sandy Clay. Further investigation by an environmental consultant

will be required to determine the extent of ASS present within the development and create a management plan for this development as required.

2.2 Topography

The Landgate contours (Figure 3) shows the site generally falls east to west, from a maximum of RL55 to RL35. This gives a roughly 1% grade fall across the site, tending towards to North West.

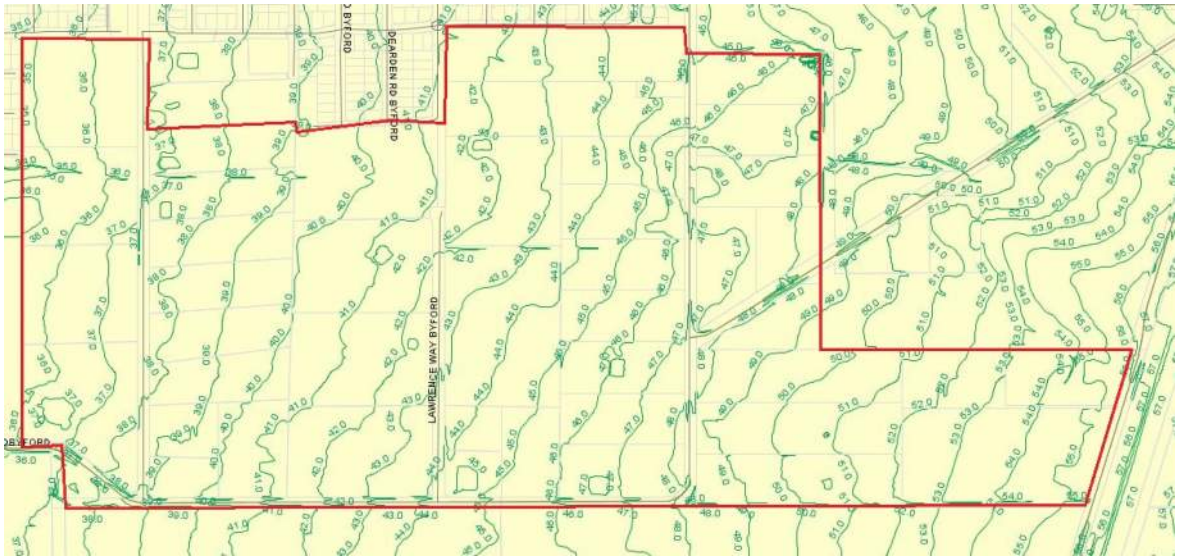


Figure 3 - Landgate Contours for site area

More recent survey undertaken by MNG Group of the area between Doley and Lawrence roads have shown that the Landgate contours are broadly correct. Additional survey should be conducted on the interfaces to neighbouring lots to ensure the overall drainage and sewer system function correctly.

2.3 Groundwater Levels

The Perth Groundwater Atlas May 2003 groundwater levels do not cover this area, however very close to the west in similar ground conditions they appears to show levels approximately 2m below the surface, with historical maximums close to 1m or less groundwater depth.

Geotechnical advice received from Galt Geotechnics (Appendix One and Appendix Two) suggests groundwater data shows it is likely that water is 2 to 3m under the surface levels, however the 3m excavations conducted during this investigation found no groundwater despite being conducted in September (normally a time of peak groundwater levels). The preliminary report suggests that perched groundwater may become apparent during very wet periods.

Depending on the amount of fill applied to the site it is unlikely that shallow common services or stormwater infrastructure would require any dewatering, although deeper services such as sewer may require dewatering.

2.4 Earthworks/Retaining

The approximate 1% fall across the majority of the site should minimise the amount of retaining required throughout the development.

The Galt reports (Appendix One and Appendix Two) suggest a classification of A can be applied where overlying sand is at 1.8m or Class S where sand fill is between 0.7m and 1.8m depth. Existing sand depths reported from preliminary geotechnical investigations (Appendix One) show class S as being achievable with moderate import fill amounts. The reports identify a clay layer underneath the overlying sand, which may require some grading to reduce the risk of trapped low points.

Final earthworks levels will depend on flood levels as well as invert levels of the proposed Multi Use Corridor (MUC) in the north west, which will provide drainage for the area. This will be outlined in the Local Water Management Strategy (LWMS) for the area.

2.5 Other Constraints

There are no Aboriginal or other heritage sites visible within the site boundary in Landgate information. There are also no contaminated sites listed within the area.

The site and surrounding developing sites are part of Armadale Plasuplain, a mutli-use wetland. Any additional constraints arising from this will be detailed in the LWMS.

3 Infrastructure

3.1 Stormwater Drainage

The Byford Town site Drainage and Water Management Plan (Appendix Three) shows the site area being split into two drainage catchments, with the southern catchment discharging toward Orton Rd and the northern catchment to a trapezoidal drain that follows along the northern boundary of the site. The fall in levels on the site tends toward the north west and thus it is expected that the overland flow path will primarily lead toward the north. Further detailed modelling of the catchment will be undertaken to confirm the appropriate location of the catchment boundary.

Lot connections would normally be expected to connect to a main drainage system leading to these drains. Although in areas where sand cover is significant it may be possible to use soakwells. The overall drainage system will designed in line with the LWMS developed for the structure plan site, which requires a minor system containing a 5 year ARI storm event with major events leading to the MUC.

For the area specific to ABN's landholdings, the intent is for a temporary swale system to constructed on the north side of the area to handle major stormwater events until the final configuring involving the MUC is developed. Stormwater from major events will discharge to the Doley Rd swales to allow stormwater to enter the existing main drainage system.

The Byford Water Management plan also indicates expected flood levels in the area. Based on the northern catchment, the Doley Rd 100yr flood level is ~35.5mAHD. The development of the MUC as per the LWMS may change some details and thus this will be the guiding constraint in relation to flood levels.

3.2 Sewerage Reticulation

The majority of the area currently has no existing sewer reticulation, as shown by Water Corporation mapping in Appendix Six.

Water Corporation Planning (Appendix Three) shows that the site lies mostly within catchments feeding to a pump station to the North West. This is split into multiple catchments east to west, centred primarily around a proposed common line on Orton Rd which goes through to Soldiers Rd. These extensions are not currently part of Water Corporations' 5 year plan for works so will likely require developer funding.

The northern ~30% of the site feeds into existing catchments in developments to the north and the levels appear to be favourable for simple connection to existing stubs.

3.3 Water Reticulation

The majority of the area currently has no existing water reticulation, as shown by Water Corporation mapping in Appendix Six.

Planning and correspondence from the Water Corporation (Appendix Five) shows that the Water Corporation planning for the area has allowed for the installation of a 250P main along Orton Rd, turning north onto Doley Rd. This would connect the perimeter of the structure plan area to the mains on Soldiers Rd, although due to the general available of water services to the north these may be more likely to be utilised alone in the early stages of development.

3.4 Gas

Medium pressure 100PVC gas lines exists on Doley, Lawrence, Orton, Warrington and Turner Roads, and would be expected to be able to provide for connection points to the development.

ATCO mapping acquired from Dial Before You Dig is included in Appendix Six.

3.5 Electrical

The area is currently served by an overhead, primarily HV power network on all roads within the area, originating from the Byford Zone Substation off Thomas Road. It is expected that these would require undergrounding to satisfy Western Power conditions.

Western Power's Network Capacity Mapping Tool shows a reasonably small amount of available capacity in currently in the area (<5MVA within 3-4 years) however as any development would be staged this could be limited to a smaller yearly increase in demand that would be considered by Western Power as normal network growth. Similar stage sizes in the area have not tripped any requirements for upgrade.

It is not expected that extension of HV feeder cables into the development areas would be required, and beyond that only normal electrical reticulation would be required. In the event a feeder extension is required, approximately 2.5km of feeder plus an additional breaker at the substation would have to be budgeted for.

Western Power mapping acquired from Dial Before You Dig is included in Appendix Eight.

3.6 Communications

Telstra mapping shows that all lots in the development area are currently served. Due to the large number of lots to be installed in the area, it is expected than an application for NBN connection to the development would be made. NBN connected developments exist both to the north west of the site as well as closer to the Byford town site to the east, and as such connection is likely possible with a low to moderate contribution to backhaul costs.

4 Conclusion

On behalf of ABN Developments, Pritchard Francis has assessed the serviceability of the proposed LSP area and it is considered that the proposed area is serviceable for the planning provided.

The site is considered in Water Corporation planning and preliminary correspondence with Water Corporation revealed no special difficulty in servicing the development area. More detailed information will require a submission to Water Corporation.

It is expected that both power and communications infrastructure in the area will be sufficient to allow connection of a staged development without major upgrade works, and this is supported by the current developments in the area.

Stormwater disposal is expected to primarily through lot connection pits, with discharge toward the main drains in the Byford area. The quantity of storage and discharge rate will be assessed in the LWMS.

Based on the items assessed in this report, Pritchard Francis believes that the proposed development area is capable of being serviced with all essential services.

Appendices

Appendix One	*Galt Geotechnics Preliminary Report, 2015*
Appendix Two	*Galt Geotechnics Desktop Study, 2015*
Appendix Three	*Byford Townsite Drainage And Water Management Plan, September 2008*
Appendix Four	*Water Corporation Sewer Long Term Planning, 2015*
Appendix Five	*Water Corporation Water Planning, November 2015*
Appendix Six	*Water Corporation Maps, 2015*
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Appendix Eight	*Western Power Maps, 2015*

Appendix One Galt Geotechnics Geotechnical Report for ABN, 2015

Report on

GEOTECHNICAL STUDY
PROPOSED RESIDENTIAL SUBDIVISION
VARIOUS LOTS
LAWRENCE WAY, DOLEY & ORTON ROADS
BYFORD

Submitted to:

Alcock Brown Neaves (ABN) Group
Ground Floor
131 Hasler Road
OSBORNE PARK WA 6017

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6 014
T: +61 (8) 6272-0200
F: +61 (8) 9285-8444

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APPENDIX A: SITE PHOTOGRAPHS

APPENDIX B: BOREHOLE REPORTS

APPENDIX C: DYNAMIC CONE PENETROMETER TEST RESULTS

APPENDIX D: PERMEABILITY TEST RESULTS

APPENDIX E: LABORATORY TEST RESULTS

APPENDIX F: UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

1. INTRODUCTION

This report presents the outcomes of Galt Geotechnics Pty Ltd's (Galt's) due-diligence level geotechnical study to support a local structure plan application for the proposed residential subdivision of the various lots along Lawrence Way, Doley Road and Orton Road in Byford ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

The investigation was requested by Jeremy Cordina of ABN Group and authorised in an email dated 1 September 2015.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the supplied information, the proposed development comprises 8 lots, covering a total plan area of approximately 31.9 ha. We understand that the following lots are to be included:

- Lot 1347 Orton Road
- Lots 27 & 43 Lawrence Way
- Lots 130, 133, 145, 155 & 202 Doley Road

Lots 54 & 64 Lawrence Way were originally included in the initial investigation works, however were subsequently removed from the scope of work. The test results within these lots have been included within this report for completeness.

Publicly available contour mapping indicates that the site surface levels varying from about RL 37 m AHD along Doley Road in the west of the site, sloping up to around RL 44 m AHD along Lawrence Way in the south east of the site.

All of the lots have been predominantly cleared of vegetation, with localised mature trees present mainly along the lot boundaries, although scattered large trees and bushes are also present in the center of most lots. All of the lots, with the exception of Lot 130 Doley Road, have existing residential dwellings occupying part of the lot. Several of the lots are presently being used for livestock (horses), with fencing sub-dividing the properties to form smaller paddocks.

It is understood that the proposed development will comprise the subdivision of the site into several hundred residential lots and the construction of new access roads. Due to the preliminary nature of the project, no details regarding the proposed final site levels, layout of lots or access roads are known at this stage.

It is expected that the new residential structures will be single or double storey brick masonry and founded on shallow footings, with ground-bearing slabs. We understand that the target site classification is likely to be either 'Class A' or 'Class S' in accordance with AS2870-2011.

3. PROJECT OBJECTIVES

The objectives of the study were to:

- broadly assess subsurface soil and groundwater conditions across the site;
- provide a preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings";
- provide recommendations for the site to improve the site classification to "Class A" or "Class S" if applicable;
- recommend likely appropriate site preparation procedures including compaction criteria;
- assess the permeability of the soils at the site for potential on-site disposal of stormwater by infiltration; and
- provide a preliminary subgrade California bearing ratio (CBR) value for pavement thickness design by others.

4. FIELDWORK

Fieldwork was carried out on 3, 4 and 24 September 2015 and comprised:

- drilling of machine-augered boreholes at 30 locations, extending to a depth of between 2 m and 3 m (for assessment of general conditions across the site);
- testing with a dynamic cone penetrometer adjacent to the boreholes, extending to depths of between 0.5 m and 0.9 m;
- drilling of machine-augered boreholes at a further 14 locations (BH31 to BH44), extending to a depth of up to 2.0 m (for delineation of sand thickness);
- infiltration tests using the 'inverse auger hole' technique at 3 locations (P01 to P03), at depths of between 0.44 m to 0.52 m below ground;
- installation of ground water monitoring wells at 3 locations (MW01 to MW03) to depths of between 1.8 m and 2.4 m; and
- measurement of groundwater levels in the installed monitoring wells.

General

A geotechnical engineer from Galt located the test positions, supervised the drilling, logged the materials encountered in the boreholes, conducted the infiltration and penetrometer testing, and collected samples for inspection and laboratory testing.

The test locations are shown on Figure 1, Site and Location Plan. Photographs of the site are presented in Appendix A, Site Photographs. Summary details of the boreholes are presented in Table A1: Summary of Tests, at the end of text.

Boreholes

Geotechnical boreholes were drilled with an Eziprobe utility mounted drill rig using solid auger drilling techniques. Borehole reports are presented in Appendix B, Borehole Reports along with a method of soil description and a list of explanatory notes and abbreviations used in the reports. A photograph of the spoil recovered from each borehole is included with selected borehole reports.

Dynamic Cone Penetrometer Testing

Dynamic cone penetrometer (DCP) tests were carried out adjacent to boreholes to depths of between 0.5 m and 0.9 m. Results of the DCP testing are presented in Appendix C, Penetrometer Test Results. The tests were conducted in accordance with test method AS 1289 6.3.2.

Permeability Testing

Permeability testing was carried out at three locations (P01 to P03) using the method described by Cocks[1]. The results of the permeability testing are presented in Appendix D, Permeability Test Results and summarised in Table 1: Summary of Permeability Test Results.

[1] Cocks, G (2007), "Disposal of Stormwater Runoff by Soakage in Perth Western Australia", Journal and News of the Australian Geomechanics Society, Volume 42 No. 3, pp 101-114

Table 1: Summary of Permeability Test Results

Test Location	Description	Pipe Embedment (m)	Minimum Unsaturated Permeability, k (m/day)		
			Test 1	Test 2	Test 3
P01/BH06	SAND	0.44	3.6	3.1	3.0
P02/BH15	SAND	0.47	1.6	0.6	0.6
P03/BH28	SAND	0.52	1.5	1.4	0.9

Note: 1. The minimum permeabilities shown were recorded throughout the entire duration of the tests, with pressure head varying between about 0.5 m and 0.28 m.

Groundwater Monitoring Wells

Three groundwater monitoring wells (MW01 to MW03) were installed across the site. The wells comprised 50 mm PVC standpipes extending to depths of between 2.0 m and 2.4 m with the entire length of pipe slotted. Gravel pack was placed in the annulus between the borehole wall and standpipe.

Groundwater well details and groundwater levels measured during installation (3 September 2015) are summarised in Table 2: Summary of Monitoring Well Information. Groundwater levels within the monitoring wells were not monitored post-installation, however these wells remain in place for future monitoring.

Table 2: Summary of Monitoring Well Information

Borehole/Monitoring Well	Depth of Well (m)	Depth to Groundwater (m)
		Installation 3 September 2015
MW01/BH02	2.4	GNE
MW02/BH16	1.8	GNE
MW03/BH22	2.4	GNE

Note: GNE – groundwater not encountered

5. LABORATORY TESTING

Laboratory testing was undertaken by Mining and Civil Geotest Pty Ltd in their NATA accredited laboratory on recovered samples of the clayey fill across parts of the site. The testing comprised determination of:

- particle size distribution on 5 samples; and
- Atterberg limits and linear shrinkage on 5 samples; and
- shrink-swell index on 3 samples.

Laboratory test results along with the test methods followed are presented in Appendix E and are summarised in Table 3: Summary of Laboratory Test Results.

Table 3: Summary of Laboratory Test Results

Test Location	Sample Depth (m)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	LS (%)	I_{ss}
BH02	2.0 – 3.0	3	39	58	57	23	34	14.5	N/A
BH06	0.6 – 0.8	24	48	28	37	16	21	9.5	1.2
BH14	0.7 – 1.0	15	47	38	42	19	23	11	1.5
BH17	1.0 – 1.3	7	47	46	47	20	27	13	0.7
BH22	2.2 – 3.0	2	44	54	57	20	37	14.5	N/A

NOTES: LL: Liquid Limit PL: Plastic Limit PI: Plasticity Index
LS: Linear Shrinkage I_{ss}: Instability Index

6. SITE CONDITIONS

6.1 Geology

The Armdale sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is underlain by Sandy Clay, described as *SANDY CLAY – white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity, gravel and silt layers near scarp.* This is generally in accordance with our experience in the area of the site.

The findings of our investigation are generally in accordance with the geological mapping; however, a thin layer of surficial clayey fill was encountered covering parts of the site.

6.2 Subsurface Conditions

Based on the materials encountered within the boreholes, the subsurface conditions are generally consistent across the site. The typical soil profile may be described as follows:

- SAND (SP), fine to medium grained, sub-angular to sub-rounded, trace organics in top 0.1 m, trace non-plastic fines, with some fines at depth, moist, generally medium dense to dense, from the surface extending to depths of between 0.4 m and 1.3 m; overlying
- Clayey SAND (SC), fine to medium grained, sub-angular to sub-rounded, red-orange, medium plasticity fines, dry to moist, stiff to hard, extending from the base of the sand layer to between 1.2 m and 2.5 m; overlying
- Sandy CLAY (CL) / CLAY, medium to high plasticity, red/orange, sand is fine grained, sub-rounded to sub-angular, dry to moist, stiff to hard, extending to the maximum depth of investigation of 3.0 m.

Figure 2 shows the thickness of sand overlying the clayey soils at the test locations (as well as interpolated sand thicknesses across the site). This includes allowance for a nominal 100 mm topsoil strip.

6.3 Groundwater

The Perth Groundwater Atlas (1997) shows the maximum groundwater level be around RL 32 m to RL 33 m AHD at the western boundary of the site. This is within about 2 m to 3 m of the current ground surface.

Groundwater was not encountered in any of the boreholes or standpipes during the field investigation (late winter). A perched groundwater table over clayey soils is expected at wetter times of the year.

7. GEOTECHNICAL ASSESSMENT

7.1 Site Classification

We consider that the site is geotechnically capable of supporting the proposed residential subdivision.

We have assessed the site in accordance with AS 2870-2011 "Residential Slabs and Footings" which defines the site classes as such in Table 4: Summary of Site Classifications AS 2870-2011 (only relevant site classes shown).

Table 4: Summary of Site Classifications AS 2870-2011

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock site with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	Up to 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm

We consider that in its current state the following site classifications apply:

- "Class A" where the overlying sand thickness is greater than 1.8 m;
- "Class S" where the overlying sand thickness is between 0.3 m and 1.8 m;
- "Class M" where the overlying sand thickness is between 0.0 m and 0.3 m.

The site preparation measures outlined in Section 7.2 must be followed to achieve the site classification noted above.

Figure 2 presents the relevant sand thickness at each test location (excluding topsoil, assumed to be 100 mm thick). Contouring of the sand thickness profile is also shown on Figure 2, however this has only been undertaken for the western and central lots where additional testing was undertaken. Based on the existing thickness of sand cover across the site, a site classification of "Class S" is considered applicable for the site.

We understand that optimisation of the site classification may be required as part of the development. We consider that the following site classifications would be applicable:

- "Class S-4" with a characteristic surface movement of up to 20 mm where the overlying sand thickness is between 0.3 m and 1.0 m; and
- "Class S-2" with a characteristic surface movement of up to 10 mm where the overlying sand thickness is between 1.0 m and 1.8 m.

We note that subdivision of 'Class S' is not incorporated in the code, but is a practice adopted by some structural engineering consultants in Perth in order to optimise 'Class S' footing designs.

In order to achieve a "Class S-2" classification across the site, up to 0.7 m of sand fill would be required across localised areas of the development site (although generally less, and in some areas no fill is required). We envisage that this material could be sourced from areas of the site where the thickness of the sand overlying the clay is greater than 1.0 m, or alternatively as imported sand fill.

Improvement of the site to "Class A" may be possible with importation and placement of sand fill to produce a total sand thickness of at least 1.8 m overlying clayey soils. This would require importation, placement and compaction of up to about 1.5 m of sand fill across localised areas of the development site (although generally less).

7.2 Site Preparation

The site preparation measures outlined below are aimed at improvement of the site in preparation for construction of the structures including on-ground slabs, shallow footings, retaining walls and pavements.

- Demolish/remove the existing buildings, fences and pavements (including removal of all footings, sewerage tanks and soakwell) and dispose of off-site.
- Remove all topsoil and vegetation from the site, including grubbing out of roots. A topsoil strip of 100 mm may be assumed, however the topsoil strip must be deep enough to remove all roots. Grubbing out of tree roots will be required where trees are removed. Localised remediation may be required for areas where large trees are removed and the soil is disturbed to a depth of greater than 1 m.
- Compact ground surface to achieve the level of compaction specified in Section 7.3 to a minimum depth of 0.9 m below surface. **Note:** Where there is more than 1 m of bulk fill to be placed over the in-situ sand, the depth of compaction can be reduced to 0.45 m.
- Where fill is required to raise site surface levels, approved fill must be used (refer to Section 7.4), placed and compacted in layers of no greater than 300 mm loose thickness.

We note that general disturbance of the clayey soils at the site is not likely to be needed, however if excavation of the clayey soils is required (i.e. services, etc), care should be taken to not mix the overlying sand and underlying clayey soils, so that the sand can be re-used as approved fill.

7.3 Compaction

7.3.1 Granular Soils

Approved granular fill must be compacted using suitable compaction equipment to achieve a dry density ratio (DDR) of at least 95% MMDD (maximum modified dry density) as determined in accordance with AS 1289 5.2.1 at a moisture content within 2% of optimum moisture content (OMC).

Granular fill must be placed in horizontal layers of not greater than 300 mm loose thickness. Each layer must be compacted by suitable compaction equipment (such as a self-propelled vibrating rollers or large (>800 kg) plate compactor), and carefully controlled to ensure even compaction over the full area and depth of each layer.

Where clean sand (<5% gravel, <5% fines) is used as fill, a Perth sand penetrometer (PSP) may be used for compaction control in accordance with AS 1289.6.3.3. The following minimum blow counts may be assumed to correspond to a DDR of 95% MMDD:

- 0-150 mm: SET
- 150-450 mm: 8
- 450-750 mm: 10
- 750-1050 mm: 12 (or 750-900 mm: 6).

Where the above blow counts cannot be achieved, a site-specific PSP correlation should be carried out to determine the PSP blow count correlating to a DDR of 95% MMDD. The correlation must:

- be done on site;
- use the nuclear density gauge (NDG) to determine density at a minimum of 5 points with varying density to a depth of 300 mm below surface;
- use a calibrated PSP to determine the PSP blow count from 150 mm to 450 mm at each of the NDG test points; and
- be plotted on a chart of PSP blow count vs DDR.

If gravel is used as fill, compaction testing must be done using a nuclear density gauge (NDG) in accordance with AS 1289.5.8.1.

7.3.2 Clayey Soils

The *in situ* clayey soils must be compacted using suitable compaction equipment to a minimum dry density ratio of 95% SMDD (standard maximum dry density) as determined in accordance with AS 1289.5.1.1. Compaction control is not required except where in situ soils are disturbed or clay fill is required.

The *in situ* clayey soils will require careful moisture conditioning so that the moisture content of the material is between optimum moisture content (OMC) and 2% wet of OMC at the time of placement and compaction. We note that compaction to specification 95% SMDD can be difficult to achieve for the clayey in situ material when not appropriately moisture conditioned.

A nuclear density gauge should be used for compaction control of clayey soils in accordance with AS 1289.5.8.1.

The clayey soils on the site will drain poorly when inundated during the wetter times of the year and result in saturated conditions that may inhibit compaction of the soil. To reduce the risk associated with this, we recommend that earthworks are carried out during the summer months when perched water is expected to be limited and not within 1-2 weeks following heavy rainfall.

If difficulties are encountered during compaction due to water, further advice should be sought from us.

7.3.3 Compaction Testing

After compaction, verify that the required level of compaction has been achieved within any fill and to minimum depth of 0.9 m below foundations.

- on each lift of fill at the rate of 1 test per 500 m^3;
- at each spread footing location (unless footings are in clayey soil);
- at 7.5 m centres below on-ground slabs;
- at 15 m centres along retaining walls (foundations and backfill, where present); and
- at 10 m centres on pavements subgrades (on the road centreline or on a grid below car parks/hardstanding).

7.4 Approved Fill

Imported granular fill must comply with the material requirements as stated in AS 3798-2007, “Guidelines on Earthworks for Commercial and Residential Developments”.

Generally, the *in-situ* sand is considered suitable for re-use as inert structural fill. Sand close to the interface with the underlying clayey soil (within 0.3 m) is not recommended for reuse as structural fill due to the elevated fines content (up to about 12%).

We do not consider the in-situ clayey soil is suitable for re-use as structural fill.

Any organic-rich sand (including the nominal 100 mm topsoil strip) or sand containing significant proportions of fines (material less than 0.075 mm in size) must not be used as fill without further treatment.

We expect that sandy topsoil can be suitably blended with clean sand to produce a permeable structural fill, once organics are removed (by screening). This usually requires:

- Drying-out of topsoil (typically by undertaking topsoil strip during late summer, or by stockpiling for several months).
- Screening using a vibrating screen plant (50 mm screen deck or smaller is typically appropriate).
- Blending either mechanically (using scrapers, graders, etc) or through the screen, usually at a rate of 1 to 2 parts clean sand to 1 part screened topsoil.

Where doubt exists, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials. We must comment on specific topsoil blending regimes once a design permeability has been established for the site.

7.5 Stormwater Disposal

The results of the infiltration tests carried out at four locations are included in Appendix D, Permeability Test Results. The minimum measured permeabilities are between 0.6 m/day (P02) and 3.0 m/day (P01).

We consider that the *in-situ* sands and sand fill at the site are not currently suitable for the disposal of stormwater by infiltration by means of soakwells. We consider that at least 1.5 m total sand thickness is required above clayey soils (noting that around the bottom 0.3 m of sand is tending to become clayier across most of the site). This thickness of sand is not currently available, but may possibly be present if a sufficient amount of imported sand is brought to the site. If this is done, we recommend a design value of permeability (k) not greater than 1 m/day for the sand fill to allow for the variability in materials and reduced permeability as a consequence of:

- densification of sand during site preparation works;
- natural variation in sands; and
- clogging of the sand around soakwells and soakage basins over time with fines.

The imported sand fill may have a higher permeability, however we cannot comment at this stage until a specific fill source is proposed.

The underlying *in-situ* clayey soil has a relatively high fines content, and is therefore likely to have a very low permeability. Soakwells may also have a reduced permeability during the wetter times of the year if a perch groundwater table is present over the clayey soils.

Soak wells should be placed outside a line of 1V:2H extending below the edge of the nearest footing, subject to local council regulations. Discharge from soak wells has been known to promote densification of loose sandy soils, leading to settlements of footings and slabs. Soak wells should be carefully wrapped with geotextile to prevent migration of sand and fines into the soak well.

If the sand thickness of the site is kept relatively low (i.e. <1.5 m), we do not recommend the use of soakwells and we consider that lot connections will be required.

7.6 Pavement Design

Where the pavement subgrades comprise of at least 0.5 m of *in-situ* sand or sand backfill over the clayey soils and the site preparation measures outline in Section 7.2 have been completed, pavement thickness design may be undertaken assuming a subgrade California bearing ratio, CBR of 10%.

Where the pavement is underlain by less than 0.5 m of sand or by a clayey subgrade, a revised CBR value should be assumed.

8. CLOSURE

We draw your attention to Appendix F of this report, Understanding your Geotechnical Engineering Report. The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimise risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

GALT GEOTECHNICS PTY LTD





Owen Woodland CPEng

Geotechnical Engineer

Paul Woodroof CPEng

Geotechnical Engineer

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Tables

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2/39 Flynn St, WEMBLEY WA 6014

ABN: 64 625 054 729

Table A1: Summary of Tests

Test Names	Test Depth (m)	Thickness of Surficial Sand Layer (m)[1]	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH01	2.0	0.9	GNE[2]	Target depth	Sand, overlying Clayey SAND; overlying Sandy CLAY
BH02	3.0	0.8	GNE	Target depth	
BH03	2.0	1.2	GNE	Target depth	
BH04	0.7	0.5	GNE	Refusal	
BH05	2.0	0.7	GNE	Target depth	
BH06	2.1	0.6	GNE	Target depth	
BH07	2.0	0.4	GNE	Target depth	
BH08	2.0	0.9	GNE	Target depth	
BH09	3.0	1.2	GNE	Target depth	Sand, overlying Gravelly SAND, overlying Clayey SAND; overlying Sandy CLAY
BH10	2.0	1.3	GNE	Target depth	Sand, overlying Clayey SAND; overlying Sandy CLAY
BH11	3.0	0.9	GNE	Target depth	
BH12	2.0	0.8	GNE	Target depth	
BH13	3.0	0.7	GNE	Target depth	
BH14	2.0	0.7	GNE	Target depth	
BH15	2.0	0.7	GNE	Target depth	
BH16	3.0	0.6	GNE	Target depth	
BH17	2.0	0.6	GNE	Target depth	
BH18	1.7	1.0	GNE	Refusal	
BH19	1.6	1.1	GNE	Refusal	
BH20	1.7	1.3	GNE	Refusal	
BH21	2.0	0.9	GNE	Target depth	
BH22	3.0	0.7	GNE	Target depth	
BH23	2.0	1.0	GNE	Target depth	
BH24	2.0	0.8	GNE	Target depth	
BH25	1.6	1.0	GNE	Refusal	
BH26	2.0	1.0	GNE	Target depth	
BH27	2.0	0.7	GNE	Target depth	
BH28	2.0	1.1	GNE	Target depth	
BH29	2.0	1.1	GNE	Target depth	
BH30	3.0	0.7	GNE	Target depth	
BH31	1.0	0.6	GNE	Target depth	Sand, overlying Clayey SAND
BH32	1.0	0.6	GNE	Target depth	
BH33	1.4	1.0	GNE	Target depth	
BH34	1.2	1.0	GNE	Target depth	

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ABN: 64 625 054 729

Test Names	Test Depth (m)	Thickness of Surficial Sand Layer (m)[1]	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
BH35	1.2	0.7	GNE	Target depth	Sand, overlying Clayey SAND
BH36	1.0	0.6	GNE	Target depth	
BH37	2.0	1.3	GNE	Target depth	
BH38	1.0	0.7	GNE	Target depth	
BH39	1.2	0.4	GNE	Target depth	
BH40	1.2	0.8	GNE	Target depth	
BH41	1.2	0.7	GNE	Target depth	
BH42	1.3	1.1	GNE	Target depth	
BH43	1.3	1.0	GNE	Target depth	
BH44	1.3	1.0	GNE	Target depth	

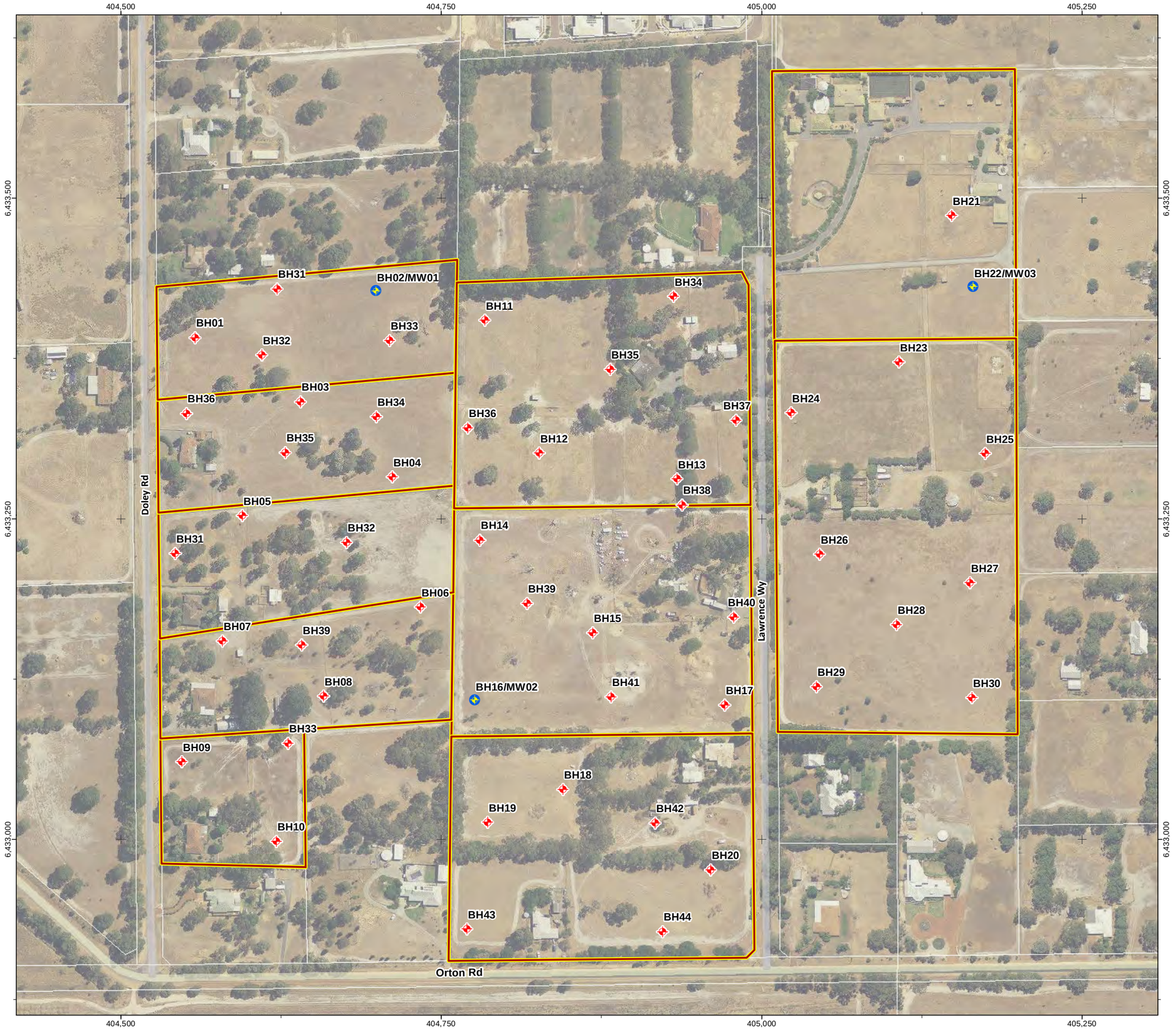
Notes
1. Thickness of surficial sand layer includes topsoil which is approximately 100 mm thick
2. GNE – groundwater not encountered

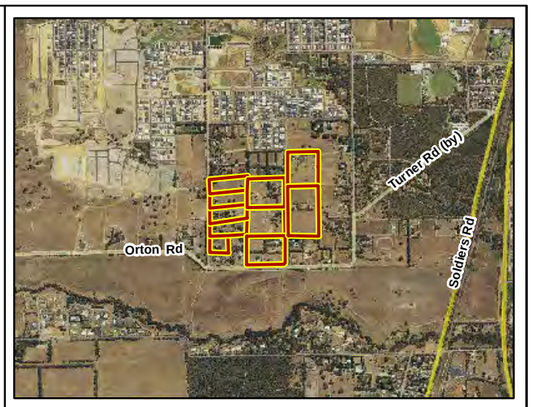
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Figures

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ABN: 64 625 054 729





Legend

- Site Boundary
- Borehole
- Borehole / Groundwater Monitoring Well

N

0 40 80 120 160 200
Meters



SCALE	1:3,000	(A3)
DRAWN	DAC	
DATE DRAWN	7/10/2015	
CHECKED	PCW	
DATE CHECKED	7/10/2015	
PROJECTION	GDA 1994 MGA Zone 50	

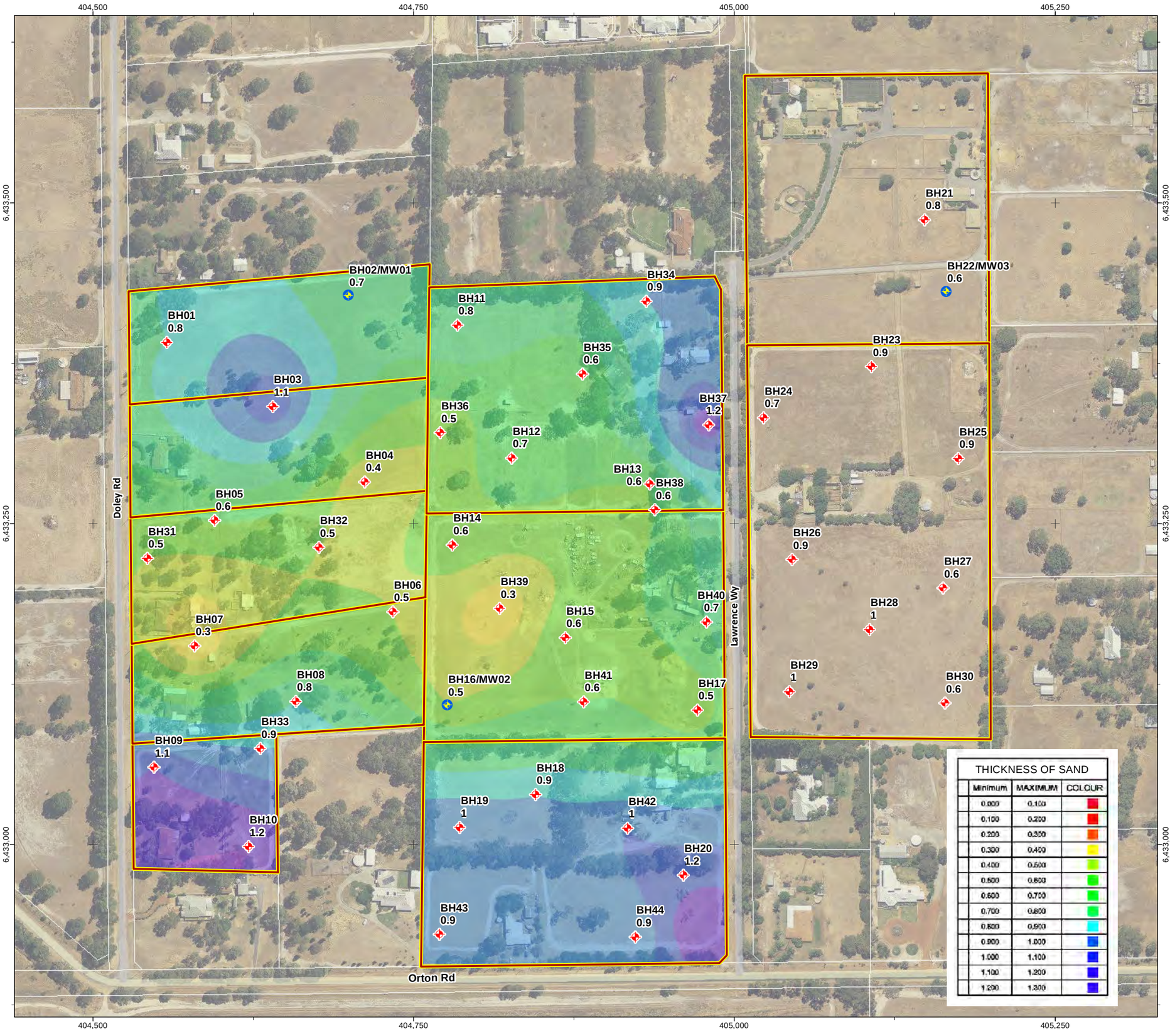
Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Fax : +61 (0)8 9285 8444
Address : U2, 39 Flynn Street, Wembley, WA, 6014

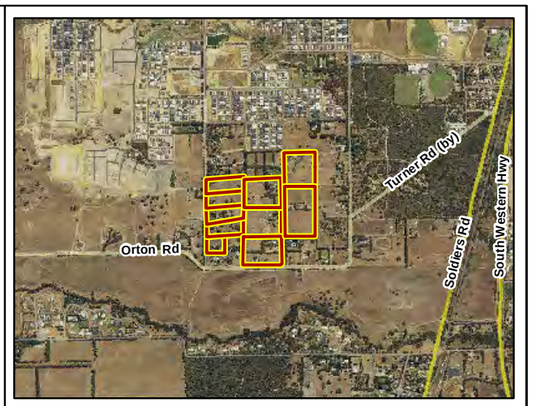
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CLIENT	**ABN GROUP**
PROJECT	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION	VARIOUS LOTS ALONG LAWRENCE WAY, DOLEY AND ORTON ROAD, BYFORD
TITLE	SITE & LOCATION PLAN

Job No	Fig No	Rev
J1501201	FIGURE 1	**A**

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Legend

- Site Boundary

Test Locations

- Borehole
- Borehole / Groundwater Monitoring Well

N

0 40 80 120 160 200
Meters



SCALE	1:3,000	(A3)
DRAWN	DAC	
DATE DRAWN	7/10/2015	
CHECKED	PCW	
DATE CHECKED	7/10/2015	
PROJECTION	GDA 1994 MGA Zone 50	

Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Fax : +61 (0)8 9285 8444
Address : U2, 39 Flynn Street, Wembley, WA, 6014

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CLIENT	**ABN GROUP**
PROJECT	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION	VARIOUS LOTS ALONG LAWRENCE WAY, DOLEY AND ORTON ROAD, BYFORD
TITLE	THICKNESS OF SAND OVERLYING CLAYEY SOILS

Job No	Fig No	Rev
J1501201	FIGURE 2	**A**

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Appendix A: Site Photographs

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ABN: 64 625 054 729



Photograph 1: At BH09 facing east



Photograph 2: At BH15 facing west



Photograph 3: At BH17 facing north



Photograph 4: At BH23 facing west



Photograph 5: At BH28 facing south



Photograph 6: Drilling at BH16

Appendix B: Borehole Reports

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 64 625 054 729

BOREHOLE: BH01

Job Number:	J1501201	**Easting:**	404558 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433391 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
									SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, with some fines		L - MD	
			0.5							Grey-red			
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity, approximately 40% fines	M	VSt	
			1.5						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained			
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:28 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH02

Job Number:	J1501201	**Easting:**	404699 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433428 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
										SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines			
			0.5						SP	With some fines	M	L - MD	
			1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)		VSt	
	H		1.5							Sandy CLAY: medium to high plasticity, red-orange, sand is fine to coarse grained, sub-angular			
			2.0		B(BH02-01)				CI-CH		D	H	
			2.5										
			3.0							Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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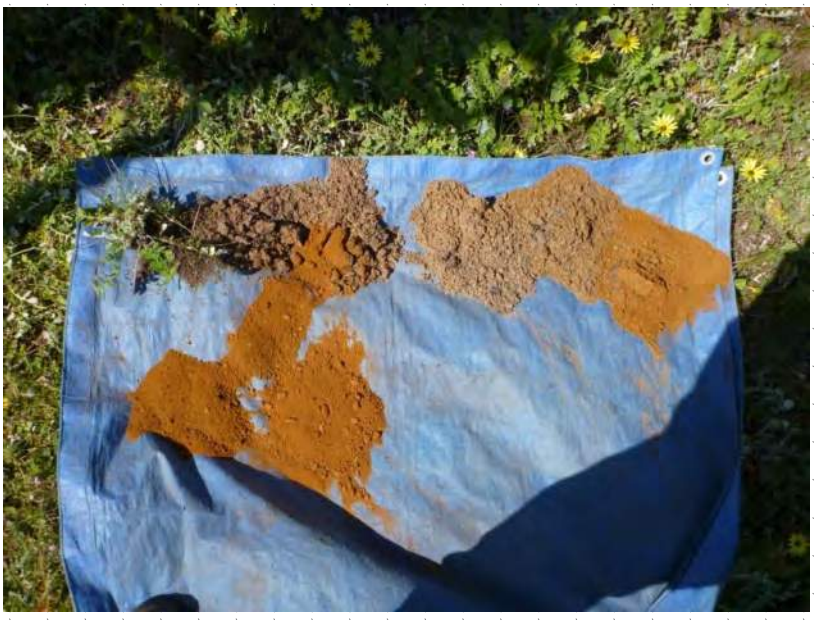
BOREHOLE: BH03

Sheet 1 OF 1

Job Number:	J1501201	**Easting:**	404640 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433341 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey-red, trace fines	M	L - MD	
			1.0							With some fines		MD	
			1.5						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity		VSt	
			2.0						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular			
			2.5							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:28 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH04

Job Number:	J1501201	**Easting:**	404712 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433283 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, dark grey			
									SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey-red, with some fines	M	L - MD	
	H		0.5						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)	D	H	
			1.0							Hole terminated at 0.70 m Target depth Groundwater not encountered			
			1.5										
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH05

Job Number:	J1501201	**Easting:**	404609 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433250 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, with some fines	M	L - MD	
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity, with some silt (approximately 40% fines)	D	VSt - H	
			1.5						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular			
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH06

Job Number:	J1501201	**Easting:**	404722 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433200 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)	M	L - MD	
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey			
	H		1.0		B(BH06-01)				SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, red-orange, clay is medium plasticity (approximately 30% fines), with some gravel		VSt - H	
			1.5		B(BH06-02)				CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine to medium grained, sub-angular to sub-rounded			
			2.0										
			2.5							Hole terminated at 2.10 m Target depth Groundwater not encountered			
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH07

Job Number:	J1501201	**Easting:**	404579 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433155 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, dark grey			
									SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey-red, with some fines		L - MD	
			0.5							Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)			
	H		1.0						SC		M	VSt	
			1.5										
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH08

Job Number:	J1501201	**Easting:**	404728 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433100 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, dark grey			
										SAND: fine to medium grained, sub-angular to sub-rounded, grey			
			0.5						SP	Grey-red, trace clay		L - MD	
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 30% fines)	M	VSt	
			1.5		B(BH08-01)				CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine to medium grained, sub-angular to sub-rounded			
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH09

Job Number:	J1501201	**Easting:**	404547 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433060 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, grey-brown	M	L - MD	
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey			
			1.0						SP	Gravelly SAND: fine to coarse grained, sub-angular to sub-rounded, red-orange, gravel is fine to medium grained, sub-angular, with some fines			
	F		1.5						SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, red-orange, clay is medium plasticity, with some silt (approximately 40% fines)		St - VSt	
			2.0										
			2.5						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine to medium grained, sub-angular to sub-rounded			
			3.0							Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH10

Job Number:	J1501201	**Easting:**	404621 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6432999 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, black-grey			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey		L - MD	
			1.0							Sand is fine to coarse grained, yellow-grey	M		
			1.5						SC	Clayey SAND: fine to medium grained, sub-angular to sub-rounded, red-orange, clay is high plasticity, approximately 30% fines		VSt	
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH11

Job Number:	J1501201	**Easting:**	404784 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433405 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, dark grey			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey With some fines		L - MD	
	H		1.0		B(BH11-01)				SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)	M	VSt	
			2.0						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-rounded			
			3.0							Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH12

Job Number:	J1501201	**Easting:**	404839 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433296 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, black-grey			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey		L - MD	
										Grey-red, trace clay			
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity, approximately 40% fines	M	VSt	
			1.5						CI-CH	Sandy CLAY: medium plasticity, red-orange, sand is fine grained, sub-rounded			
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH13

Sheet 1 OF 1

Job Number:	J1501201	**Easting:**	404961 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433287 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, black-grey			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey-red, with some fines		L - MD	
			1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)	M		
	H		2.0						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular to sub-rounded		VSt	
			3.0							Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH14

Job Number:	J1501201	**Easting:**	404780 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433234 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, dark grey			
									SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey		VD - MD	
			0.5							With some fines		MD	
	F				B(BH14-01)				SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, 30-40% medium plasticity fines	M	VSt	
	H		1.0										
			1.5										
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH15

Sheet 1 OF 1

Job Number:	J1501201	**Easting:**	404868 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433161 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, black-grey			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey Grey-red, with some fines		L - MD	
	F		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity, approximately 40% fines	M	VSt	
			1.5										
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH16

Job Number:	J1501201	**Easting:**	404776 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433109 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey-orange, trace fines	M	L - MD	
			0.5										
	F		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)		VSt	
			1.5										
	H		2.0							Dark red-orange			
			2.5										
			3.0							Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH17

Job Number:	J1501201	**Easting:**	404971 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433105 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium grained, sub-angular to sub-rounded, black-grey			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey-orange		L - MD	
			1.0		B(BH17-01)				SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 45% fines)	M	VSt	
			1.5							Approximately 50% fines			
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH18

Job Number:	J1501201	**Easting:**	404845 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433039 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines		L - MD	
										Grey-red, with some fines	M		
	F		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)		H	
			1.5										
			2.0							Hole terminated at 1.70 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH19

Job Number:	J1501201	**Easting:**	404771 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6432958 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
									SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines		L - MD	
			0.5										
	F		1.0							Grey-red, with some fines	M	MD	
									SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)		VSt - H	
	H		1.5										
										Hole terminated at 1.60 m Refusal on hard stratum Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH20

Job Number:	J1501201	**Easting:**	404968 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6432935 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines	M	L - MD	
			0.5							Grey-red, with some fines			
	F		1.0										
	H		1.5						SC	Clayey SAND: fine to medium grained, sub-angular, red/orange, clay is medium plasticity	D	H	
			2.0							Hole terminated at 1.70 m Refusal on hard stratum Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH21

Job Number:	J1501201	**Easting:**	405092 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433514 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
										SAND: fine to medium grained, sub-angular to sub-rounded, grey mottled red-orange, with some fines		L - MD	
			0.5						SP			MD	
	H		1.0						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular	M	VSt	
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH22

Job Number:	J1501201	**Easting:**	405165 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433431 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey-red, with some fines	M	L - MD	
			1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)			
	H		1.5										
			2.0		B(BH22-01)				CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular	D	VSt - H	
			2.5										
			3.0							Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH23

Job Number:	J1501201	**Easting:**	405107 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433372 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey			
										With some fines	M	L - MD	
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity, with some silt (approximately 40% fines)			
			1.5						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular	D	VSt - H	
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH24

Job Number:	J1501201	**Easting:**	405023 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433333 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL)			
									SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, with some fines	M	MD	
			0.5							Grey-red			
	F		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)			
	H		1.5						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular	D	VSt	
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH25

Job Number:	J1501201	**Easting:**	405175 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433301 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium medium grained, sub-angular to sub-rounded, dark grey			
										SAND: fine to medium grained, sub-angular to sub-rounded, grey			
			0.5						SP	Trace fines	M	L - MD	
										With some fines			
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity, approximately 40% fines		VSt - H	
			1.5						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular	D	H	
										Hole terminated at 1.60 m Refusal on hard Sandy CLAY Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH26

Job Number:	J1501201	**Easting:**	405045 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433222 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium medium grained, sub-angular to sub-rounded, dark grey, trace organics			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey		L - MD	
										Grey-red, with some fines	M	D	
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)		VSt - H	
			1.5						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular	D	H	
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH27

Job Number:	J1501201	**Easting:**	405163 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433200 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA	E		0.0						SP	SAND (TOPSOIL): fine to medium medium grained, sub-angular to sub-rounded, dark grey, trace organics			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey Grey-red, trace clay		L - MD	
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)	M	VSt - H	
			1.5						CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular		H	
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH28

Job Number:	J1501201	**Easting:**	405105 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433168 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium medium grained, sub-angular to sub-rounded, dark grey, trace organics			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey		L - MD	
			1.0							Grey-red, with some fines	M		
	H		1.5		B(BH28-01)				SC	Clayey SAND: fine to medium grained, sub-angular, red-brown, clay is medium plasticity (approximately 40% fines)		VSt	
									CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular			
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH29

Job Number:	J1501201	**Easting:**	405043 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433119 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium medium grained, sub-angular to sub-rounded, dark grey, trace organics			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey	M	L - MD	
			1.0							With some fines			
	H		1.5						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)			
									CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular	D	VSt	
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH30

Job Number:	J1501201	**Easting:**	405164 m	**Contractor:**	Galt	**Date:**	04/09/2015
Client:	ABN Group	**Northing:**	6433110 m	**Drill Rig:**	Eziprobe	**Logged:**	EY
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	E		0.0						SP	SAND (TOPSOIL): fine to medium medium grained, sub-angular to sub-rounded, black-grey, trace organics			
			0.5						SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey Grey-red, with some fines		L - MD	
	H		1.0						SC	Clayey SAND: fine to medium grained, sub-angular, red-orange, clay is medium plasticity (approximately 40% fines)	M	VSt	
			1.5		B(BH30-01)				CI-CH	Sandy CLAY: medium to high plasticity, red-orange, sand is fine grained, sub-angular	D	H	
			2.0										
			2.5										
			3.0							Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH31

Job Number:	J1501201	**Easting:**	404542 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433223 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets, trace low plasticity fines			Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							Becoming brown	M		
									SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 30% medium plasticity fines, trace fine grained gravel			
			1.0							Hole terminated at 1.00 m Target depth Groundwater not encountered			
			1.5										
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH32

Job Number:	J1501201	**Easting:**	404676 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433232 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace rootlets, trace fines	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							Pale grey-brown			
									SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 20-30% medium plasticity fines, trace fine to medium grained gravel			
			1.0							Hole terminated at 1.00 m Target depth Groundwater not encountered			
			1.5										
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH33

Job Number:	J1501201	**Easting:**	404630 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433075 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace fine to medium grained gravel	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							Pale grey-brown			
			1.0						SC	Mottled orange, trace fine to medium grained gravel, trace medium plasticity fines Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 20-30% medium plasticity fines, trace fine to medium grained gravel			
			1.5							Hole terminated at 1.40 m Target depth Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH34

Job Number:	J1501201	**Easting:**	404931 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433424 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, brown-grey, trace rootlets, trace fines	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							Pale brown, no rootlets			
			1.0						SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange mottled grey, 20-30% medium plasticity fines			
										Hole terminated at 1.20 m Target depth Groundwater not encountered			
			1.5										
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH35

Job Number:	J1501201	**Easting:**	404882 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433367 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-brown, trace organics, trace rootlets, trace low plasticity fines	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5										
			1.0						SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 25-30% medium plasticity fines, trace fine to medium grained gravel			
			1.5							Hole terminated at 1.20 m Target depth Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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BOREHOLE: BH36

Job Number:	J1501201	**Easting:**	404771 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433321 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, trace rootlets, trace fines	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5						SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, 15-20% high plasticity fines			
			1.0							Hole terminated at 1.00 m Target depth Groundwater not encountered			
			1.5										
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH37

Job Number:	J1501201	**Easting:**	404980 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433327 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, brown becoming pale brown, trace rootlets, trace medium plasticity fines, trace fine to medium grained gravel			Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5										
			1.0							Becoming orange-brown, with some fine to medium grained gravel	M		
			1.5						SP-SC	Gravelly SAND/Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 20% fine to medium grained gravel, 10-15% medium plasticity fines			
			2.0							Hole terminated at 2.00 m Target depth Groundwater not encountered			
			2.5										
			3.0										
			3.5										

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP.GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH38

Job Number:	J1501201	**Easting:**	404938 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433261 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey, trace fines			Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							With some (10%) medium plasticity fines, increasing fines content with depth	M		
									SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 20-30% medium plasticity fines, trace fine to medium grained gravel			
			1.0							Hole terminated at 1.00 m Target depth Groundwater not encountered			
			1.5										
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP.GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH39

Job Number:	J1501201	**Easting:**	404817 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433184 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-cream, trace rootlets, trace organics, trace fines	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5						SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, 15-20% medium plasticity fines			
			1.0							Orange-brown, trace fine to medium grained gravel, 30-40% medium plasticity fines			
			1.5							Hole terminated at 1.20 m Target depth Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH40

Job Number:	J1501201	**Easting:**	404978 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433174 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey-brown, trace rootlets, trace organics, trace fines	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5										
			1.0						SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 20-30% medium plasticity fines, trace gravel			
			1.5							Hole terminated at 1.20 m Target depth Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP.GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH41

Job Number:	J1501201	**Easting:**	404882 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433111 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, trace rootlets, trace organics	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							Mottled orange, no rootlets			
			1.0						SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 20-40% medium plasticity fines, trace fine to medium grained gravel			
			1.5							Hole terminated at 1.20 m Target depth Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH42

Job Number:	J1501201	**Easting:**	404917 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6433013 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, trace rootlets, trace organics, trace fines	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							Pale grey-brown mottled orange, increasing fines content			
			1.0						SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-brown, 30% high plasticity fines, trace fine to medium grained gravel			
			1.5							Hole terminated at 1.30 m Target depth Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP.GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH43

Job Number:	J1501201	**Easting:**	404770 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6432930 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey mottled dark grey, trace rootlets	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							Pale grey-brown, trace fines			
			1.0							Increasing fines content, mottled orange			
									SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange-grey, 20-30% medium plasticity fines, trace fine to medium grained gravel			
			1.5							Hole terminated at 1.30 m Target depth Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP.GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH44

Job Number:	J1501201	**Easting:**	404923 m	**Contractor:**	Galt	**Date:**	24/09/2015
Client:	ABN Group	**Northing:**	6432928 m	**Drill Rig:**	Eziprobe	**Logged:**	SC
Project:	Due Diligence Level Study	**Datum:**	MGA94 Zone 50	**Inclination:**	-90°	**Checked Date:**	06/10/2015
Location:	Various Lots, Lawrence Way, Doley & Orton Rd, Byford					**Checked By:**	PCW

Drilling					Sampling			Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
MA			0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, trace rootlets, trace organics	M		Holes drilled to assess sand thickness only. Drilling resistance and soil density/consistency not observed.
			0.5							Pale grey-brown, trace fine to medium grained gravel			
			1.0						SC	Clayey SAND: fine to coarse grained, sub-angular to sub-rounded, orange mottled grey, 30% medium plasticity fines, trace fine to medium grained gravel			
			1.5							Hole terminated at 1.30 m Target depth Groundwater not encountered			
			2.0										
			2.5										
			3.0										
			3.5										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 - TEMP GLB Log GG_EXCAVATION J1501201.GPJ <<DrawingFile>> 09/10/2015 12:29 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

Appendix C: Dynamic Cone Penetrometer Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 64 625 054 729

DYNAMIC CONE PENETROMETER RECORD SHEET

AS 1298.6.3.2

Client: ABN Group **Job No:** J1501201

Project: Proposed Residential Development **Date:** 03/09/2015 & 04/09/2015

Location: Lawrence Way, Doley Rd and Orton Rd, Byford **Engineer:** EY

Test No:	DCP01	DCP02	DCP03	DCP04	DCP05	DCP06	DCP07	DCP08
Location:	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	-	-	-	-	-	-	-	-
100-200	2	3	2	4	2	2	3	2
200-300	2	2	2	4	3	2	4	2
300-400	3	2	3	4	5	4	3	5
400-500	5	6	5	18	12	11	10	15+
500-600	11	20+	13		15+	20+	15+	
600-700	10		26					
700-800	17							
800-900								

Test No:	DCP09	DCP10	DCP11	DCP12	DCP13	DCP14	DCP15	DCP16
Location:	BH09	BH10	BH11	BH12	BH13	BH14	BH15	BH16
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	-	-	-	-	-	-	-	-
100-200	3	2	2	2	3	2	3	2
200-300	5	2	2	3	3	2	3	3
300-400	3	3	2	2	3	3	3	2
400-500	10+	3	2	11	5	3	5	18
500-600		2	5	19	19	6	16	20+
600-700		2	11	20+	20+	7R	19	
700-800		4	20+					
800-900		11						
900-1000								

Test No:	DCP17	DCP18	DCP19	DCP20	DCP21	DCP22	DCP23	DCP24
Location:	BH17	BH18	BH19	BH20	BH21	BH22	BH23	BH24
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	-	-	-	-	-	-	-	-
100-200	2	2	1	3	2	2	2	3
200-300	2	2	2	3	3	3	3	5
300-400	5	3	2	2	5	6	3	3
400-500	17	3	2	3	16	22	4	3
500-600	20+	9	3	5	20		20+	11
600-700		20+	5	10				16
700-800			6	14				
800-900			11	12				
900-1000								

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2 R: Refusal

DYNAMIC CONE PENETROMETER RECORD SHEET

AS 1298.6.3.2

Client: ABN Group **Job No:** J1501201

Project: Proposed Residential Development **Date:** 03/09/2015 & 04/09/2015

Location: Lawrence Way, Doley Rd and Orton Rd, Byford **Engineer:** EY

Test No:	DCP25	DCP26	DCP27	DCP28	DCP29	DCP30		
Location:	BH25	BH26	BH27	BH28	BH29	BH30		
Depth (mm)	**N^{o} of Penetrometer Blows per 100 mm Depth Interval**							
0-100	-	-	-	-	-	-		
100-200	6	2	3	2	2	2		
200-300	3	2	3	3	3	1		
300-400	4	3	7	3	4	3		
400-500	5	5	15+	5	4	7		
500-600	4	10		6	5	15		
600-700	7	15+		9	5	11		
700-800	15+			11	11	13		
800-900				13	13	13		

Test No:								
Location:								
Depth (mm)	**N^{o} of Penetrometer Blows per 100 mm Depth Interval**							
0-100								
100-200								
200-300								
300-400								
400-500								
500-600								
600-700								
700-800								
800-900								
900-1000								

Test No:								
Location:								
Depth (mm)	**N^{o} of Penetrometer Blows per 100 mm Depth Interval**							
0-100								
100-200								
200-300								
300-400								
400-500								
500-600								
600-700								
700-800								
800-900								
900-1000								

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2 R: Refusal

Appendix D: Permeability Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 64 625 054 729

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1501201
Client:	ABN Group
Site:	Various Lots
Location:	Byford
Calc by:	EY
BH Name:	P01/BH06
Test Depth:	0.44 m

Spreadsheet author:	ORW	17-Oct-09

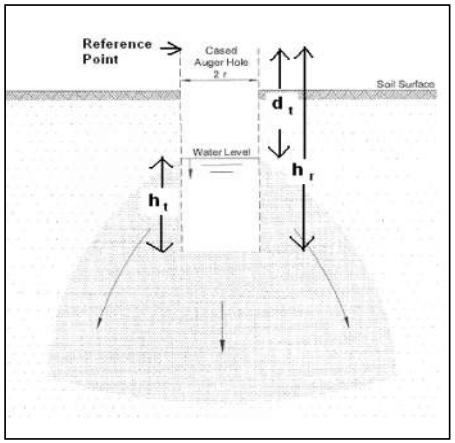
$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.64	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

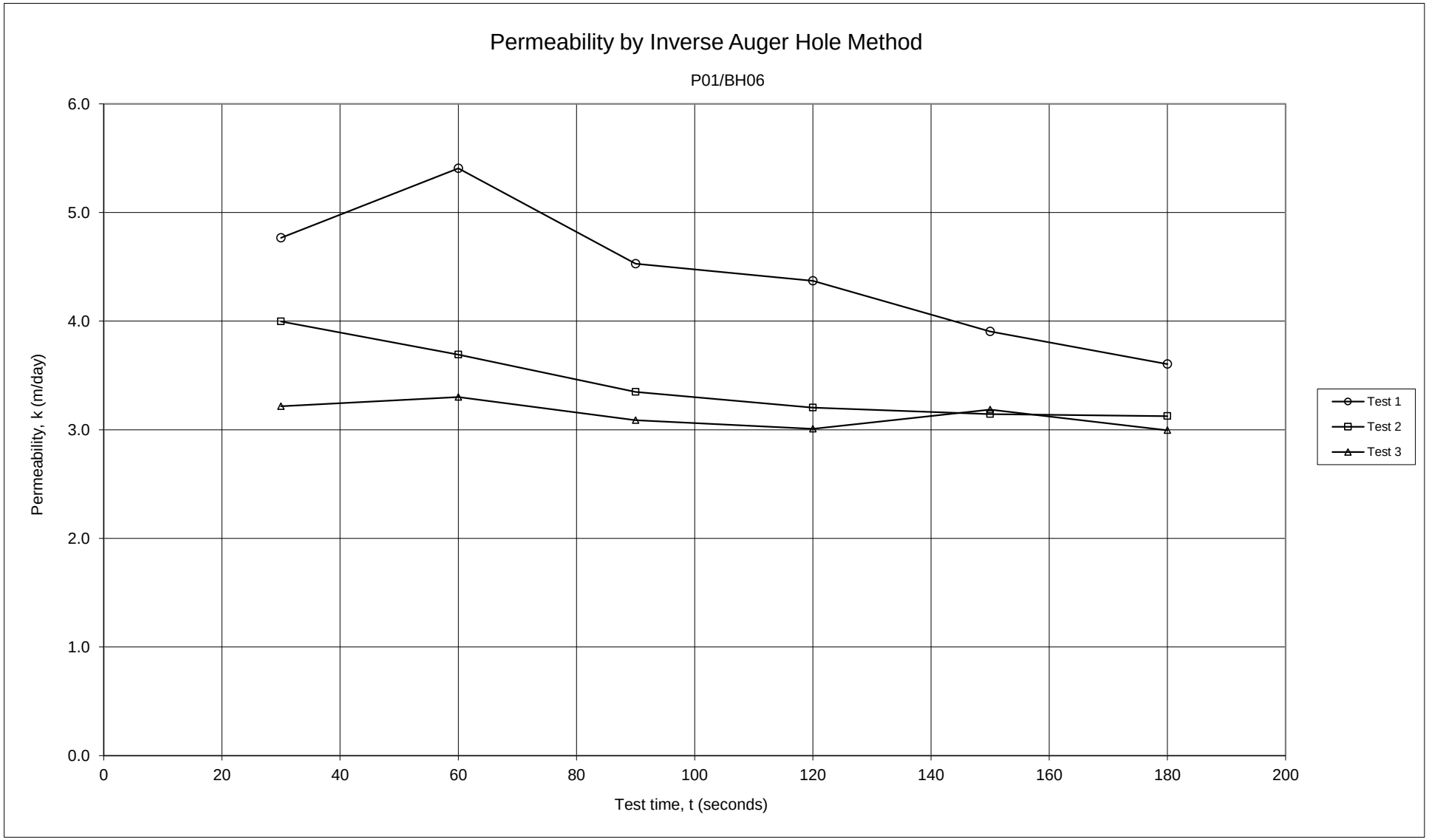
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.24	0.4		
30	0.27	0.37	5.5E-05	4.8
60	0.305	0.335	6.3E-05	5.4
90	0.32	0.32	5.2E-05	4.5
120	0.34	0.3	5.1E-05	4.4
150	0.35	0.29	4.5E-05	3.9
180	0.36	0.28	4.2E-05	3.6
		AVERAGE	5.1E-05	4.4

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.245	0.395		
30	0.27	0.37	4.6E-05	4.0
60	0.29	0.35	4.3E-05	3.7
90	0.305	0.335	3.9E-05	3.3
120	0.32	0.32	3.7E-05	3.2
150	0.335	0.305	3.6E-05	3.1
180	0.35	0.29	3.6E-05	3.1
		AVERAGE	4.0E-05	3.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.25	0.39		
30	0.27	0.37	3.7E-05	3.2
60	0.29	0.35	3.8E-05	3.3
90	0.305	0.335	3.6E-05	3.1
120	0.32	0.32	3.5E-05	3.0
150	0.34	0.3	3.7E-05	3.2
180	0.35	0.29	3.5E-05	3.0
		AVERAGE	3.6E-05	3.1


Permeability by Inverse Auger Hole Method
P01/BH06
Permeability, k (m/day)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

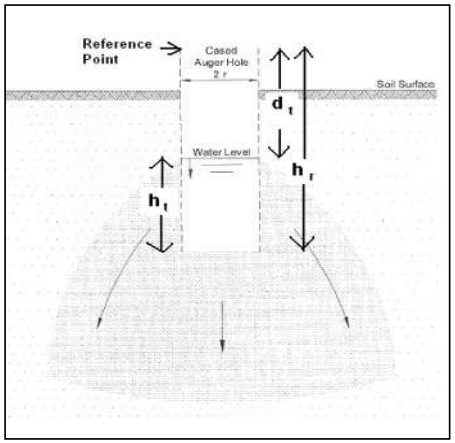
Galt Geotechnics

Job No:	J1501201
Client:	ABN Group
Site:	Various Lots
Location:	Byford
Calc by:	EY
BH Name:	P02/BH15
Test Depth:	0.47 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.6	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

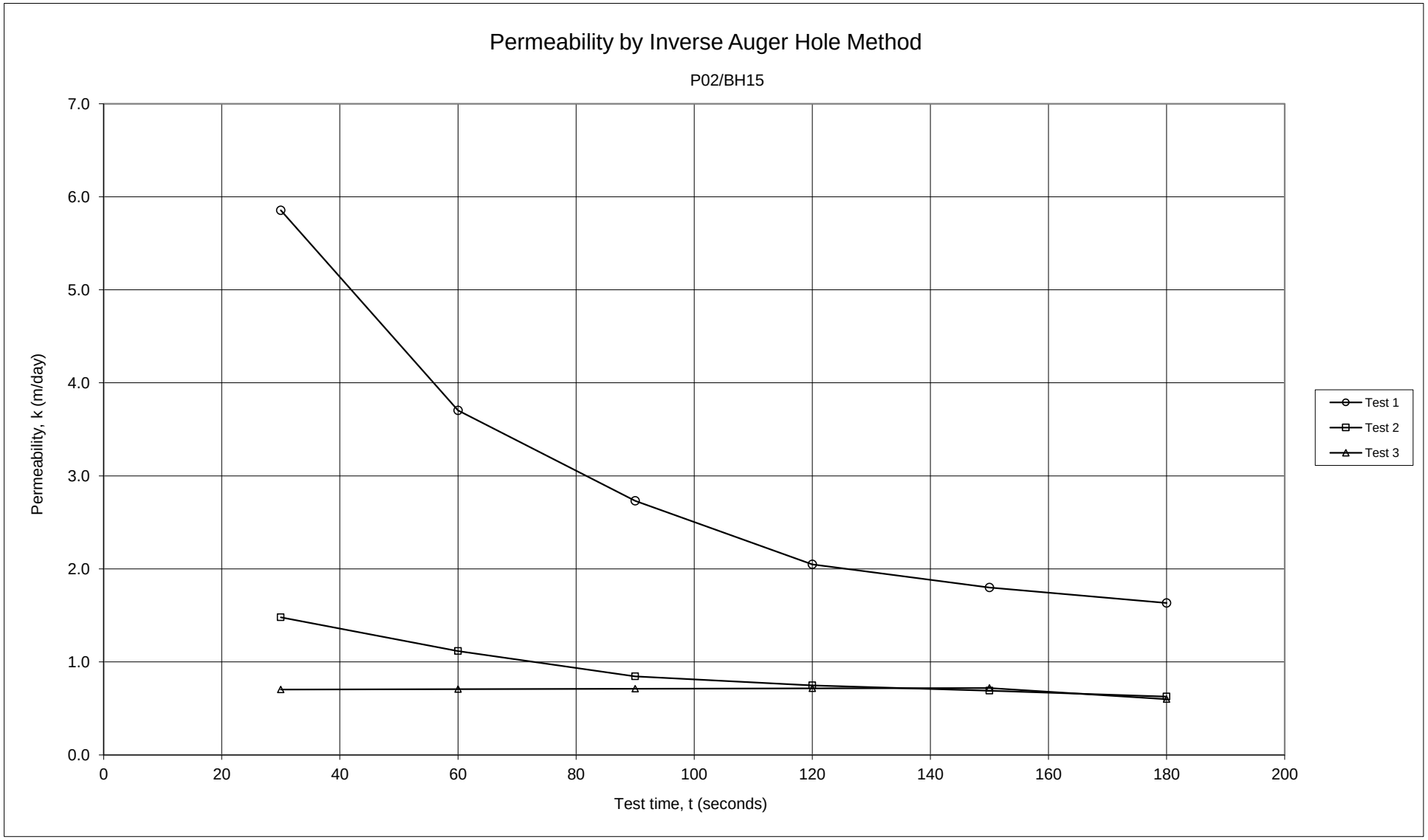
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.16	0.44		
30	0.2	0.4	6.8E-05	5.9
60	0.21	0.39	4.3E-05	3.7
90	0.215	0.385	3.2E-05	2.7
120	0.215	0.385	2.4E-05	2.0
150	0.22	0.38	2.1E-05	1.8
180	0.225	0.375	1.9E-05	1.6
		AVERAGE	3.4E-05	3.0

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.18	0.42		
30	0.19	0.41	1.7E-05	1.5
60	0.195	0.405	1.3E-05	1.1
90	0.197	0.403	9.8E-06	0.8
120	0.2	0.4	8.7E-06	0.7
150	0.203	0.397	8.0E-06	0.7
180	0.205	0.395	7.3E-06	0.6
		AVERAGE	1.1E-05	0.9

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.16	0.44		
30	0.165	0.435	8.1E-06	0.7
60	0.17	0.43	8.2E-06	0.7
90	0.175	0.425	8.2E-06	0.7
120	0.18	0.42	8.3E-06	0.7
150	0.185	0.415	8.3E-06	0.7
180	0.185	0.415	6.9E-06	0.6
		AVERAGE	8.0E-06	0.7


Permeability by Inverse Auger Hole Method
P02/BH15
Permeability, k (m/day)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1501201
Client:	ABN Group
Site:	Various Lots
Location:	Byford
Calc by:	EY
BH Name:	P03/BH28
Test Depth:	0.52 m

Spreadsheet author:	ORW	17-Oct-09

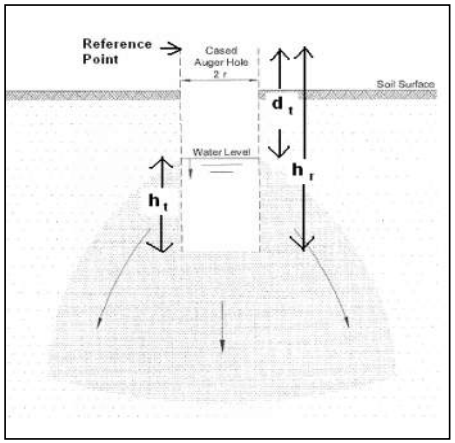
$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.62	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

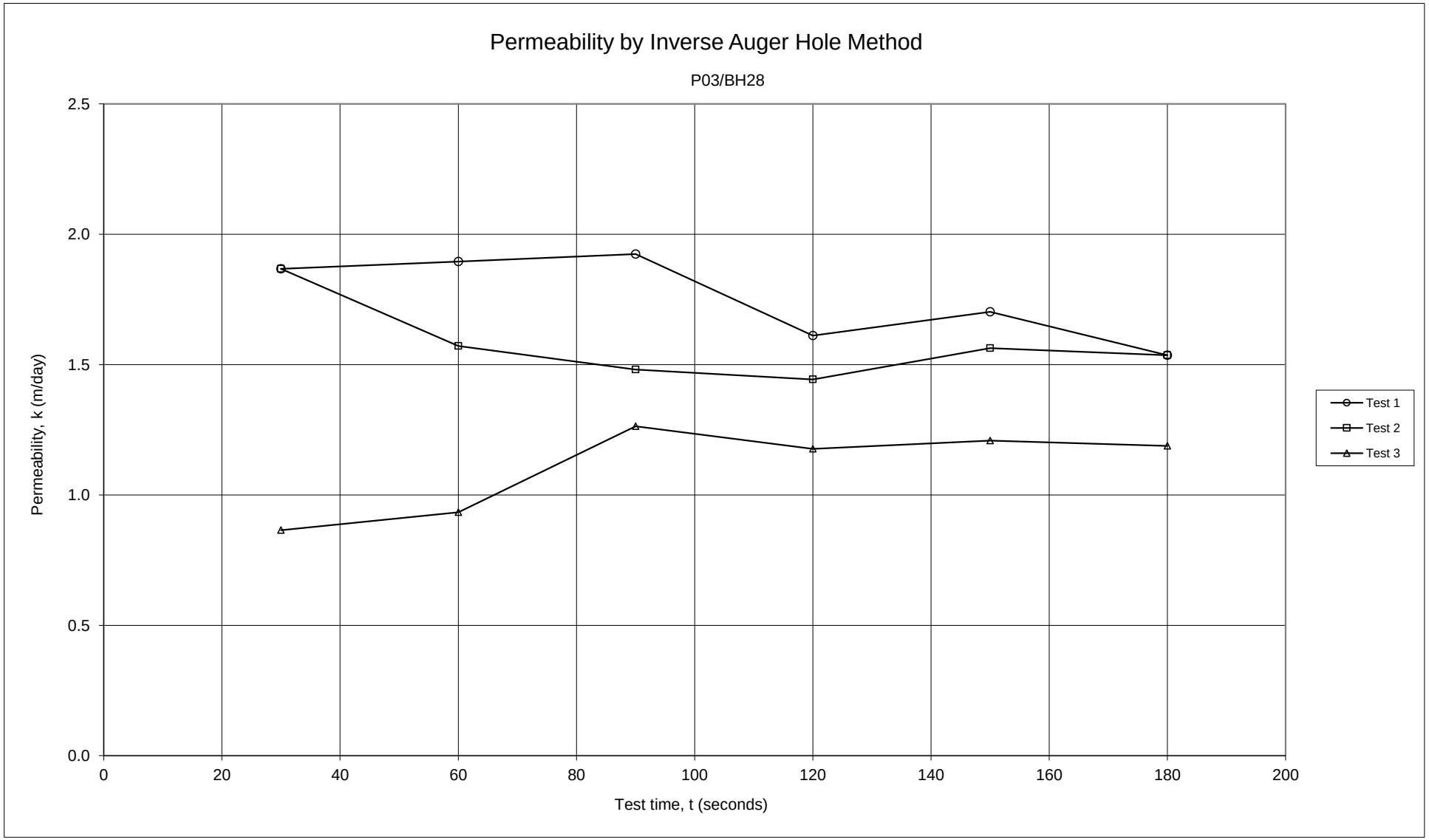
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.115	0.505		
30	0.13	0.49	2.2E-05	1.9
60	0.145	0.475	2.2E-05	1.9
90	0.16	0.46	2.2E-05	1.9
120	0.165	0.455	1.9E-05	1.6
150	0.18	0.44	2.0E-05	1.7
180	0.185	0.435	1.8E-05	1.5
		AVERAGE	2.0E-05	1.8

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.115	0.505		
30	0.13	0.49	2.2E-05	1.9
60	0.14	0.48	1.8E-05	1.6
90	0.15	0.47	1.7E-05	1.5
120	0.16	0.46	1.7E-05	1.4
150	0.175	0.445	1.8E-05	1.6
180	0.185	0.435	1.8E-05	1.5
		AVERAGE	1.8E-05	1.6

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.115	0.505		
30	0.122	0.498	1.0E-05	0.9
60	0.13	0.49	1.1E-05	0.9
90	0.145	0.475	1.5E-05	1.3
120	0.152	0.468	1.4E-05	1.2
150	0.162	0.458	1.4E-05	1.2
180	0.17	0.45	1.4E-05	1.2
		AVERAGE	1.3E-05	1.1


Permeability by Inverse Auger Hole Method
P03/BH28
Permeability, k (m/day)
2.5
2.0
1.5
1.0
0.5
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Appendix E: Laboratory Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 64 625 054 729

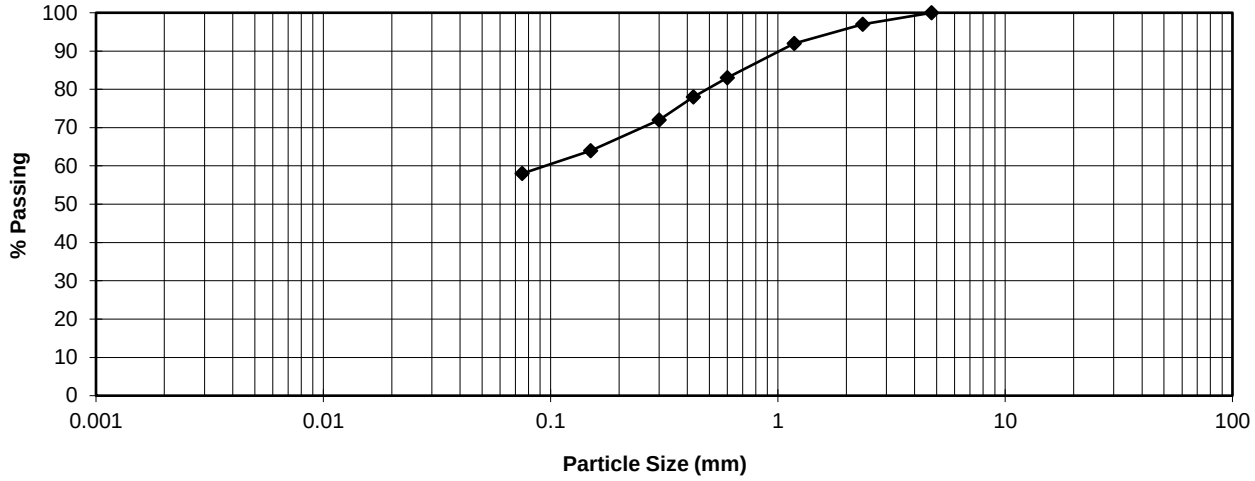
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/6384
Sample No:	P15/6384
Issue Date:	17 September 2015

Client: Galt Geotechnics (J1501201)
Project: Proposed Residential Development
Location: Various Lots, Byford

Sample location: BH02-1
Sample Depth (m): 2.0 - 3.0



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	97
1.18	92
0.600	83
0.425	78
0.300	72
0.150	64
0.075	58

Plasticity index tests
AS 1289

Liquid limit 3.1.1	57	%
Plastic limit 3.2.1	23	%
Plasticity index 3.3.1	34	%
Linear shrinkage 3.4.1	14.5	%

Cracked ☐

Curled ☑

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Matthew van Herk
AS PSDPI May 2009

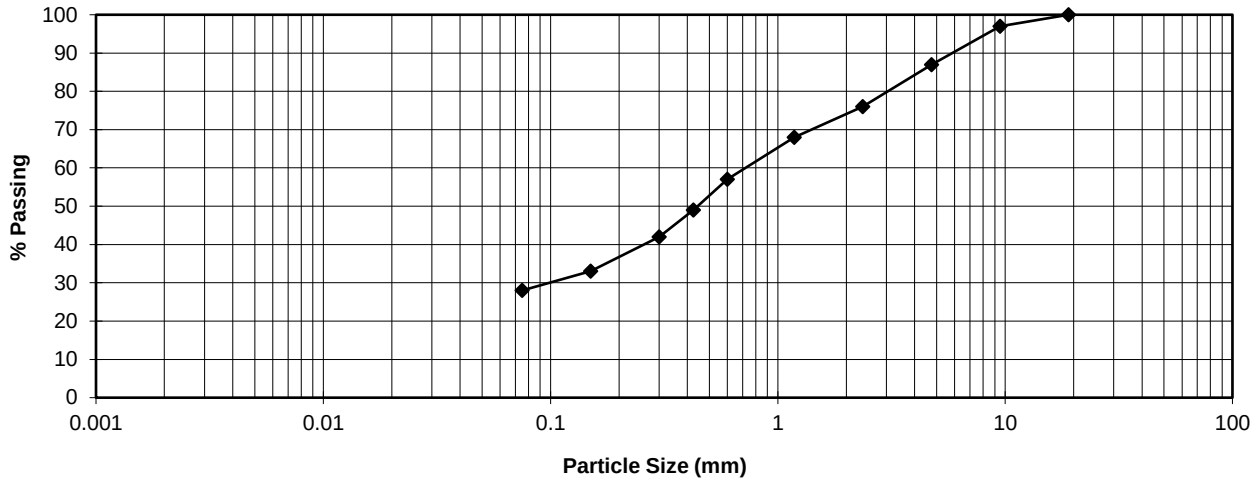
Particle Size Distribution & Plasticity Index tests

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Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/6385
Sample No:	P15/6385
Issue Date:	17 September 2015

Client: Galt Geotechnics (J1501201)
Project: Proposed Residential Development
Location: Various Lots, Byford

Sample location: BH06-1
Sample Depth (m): 0.6 - 0.8



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	97
4.75	87
2.36	76
1.18	68
0.600	57
0.425	49
0.300	42
0.150	33
0.075	28

Plasticity index tests
AS 1289

Liquid limit 3.1.1	37	%
Plastic limit 3.2.1	16	%
Plasticity index 3.3.1	21	%
Linear shrinkage 3.4.1	9.5	%
Cracked	☐	
Curled	☑	

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Matthew van Herk
AS PSDPI May 2009

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Ph (08) 9414 8022 Fax (08) 9414 8011
Email matt@mcgeotest.com.au
Unit 1/1 Pusey Road, JANDAKOT WA 6164

Determination of the Shrinkage Index of a Soil
Shrink Swell Index
AS 1289.7.1.1

		Job No:	60083
		Report No:	60083-P15/6385
		Date of issue:	17-Sep-2015
Client:	Galt Geotechnics (J1501201)	Date tested:	10-Sep-2015
Project:	Proposed Residential Development	Tested by:	P. Shettigar
Location:	Various Lots, Byford	Checked:	S. Davies
Sample:	BH06 (0.6m - 0.8m)	Sample No:	P15/6385

Sample details

Sample description : Yellow Gravelly Clay

Sample Type : 63 mm Ø tube sample

Swell Specimen		Shrinkage Specimen	
Dry Density - Initial (t/m$^{3)}$	1.88	Moisture Content Initial (%)	14.9
Moisture Content - Initial (%)	14.9	Length/Diameter Ratio	1.7
Moisture Content - Final (%)	15.5	Extent of Crumbling	Nil
Overburden Pressure (kPa)	3	Extent of Cracking	Nil
Significant Inert Inclusions (%)	5		

Shrink-Swell Index

I_{ss} = **1.2** % Vertical strain per pF change in Total suction

Tested as received

Approved Signature

Matthew van Herk

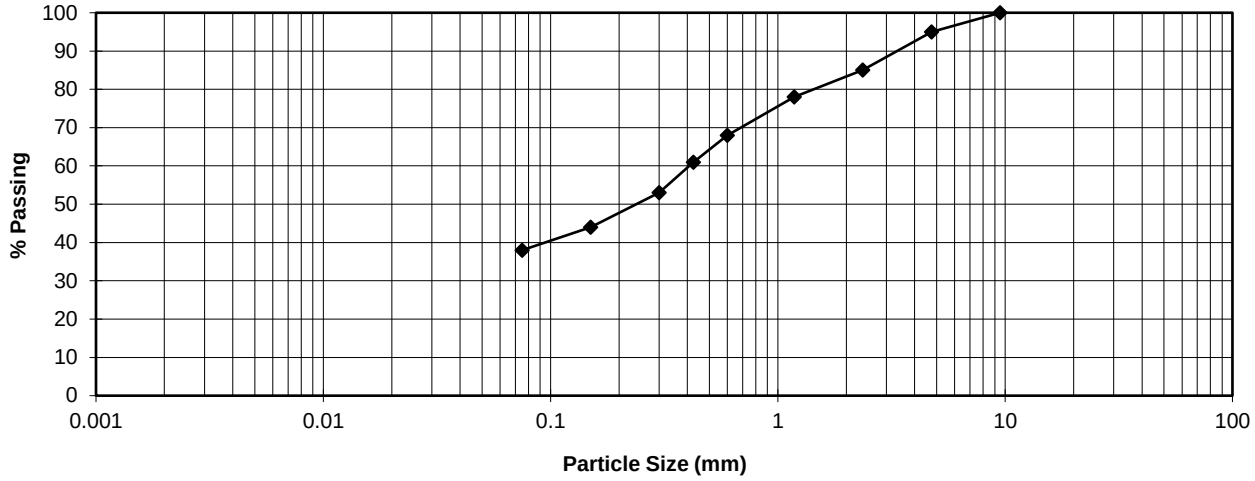
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/6386
Sample No:	P15/6386
Issue Date:	17 September 2015

Client: Galt Geotechnics (J1501201)
Project: Proposed Residential Development
Location: Various Lots, Byford

Sample location: BH14-1
Sample Depth (m): 0.7 - 1.0



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	95
2.36	85
1.18	78
0.600	68
0.425	61
0.300	53
0.150	44
0.075	38

Plasticity index tests
AS 1289

Liquid limit 3.1.1	42	%
Plastic limit 3.2.1	19	%
Plasticity index 3.3.1	23	%
Linear shrinkage 3.4.1	11.0	%

Cracked ☐

Curled ☑

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Matthew van Herk
AS PSDPI May 2009

Mining & Civil Geotest Pty Ltd

Ph (08) 9414 8022 Fax (08) 9414 8011
Email matt@mcgeotest.com.au
Unit 1/1 Pusey Road, JANDAKOT WA 6164

Determination of the Shrinkage Index of a Soil
Shrink Swell Index
AS 1289.7.1.1

		Job No:	60083
		Report No:	60083-P15/6386
		Date of issue:	17-Sep-2015
Client:	Galt Geotechnics (J1501201)	Date tested:	10-Sep-2015
Project:	Proposed Residential Development	Tested by:	P. Shettigar
Location:	Various Lots, Byford	Checked:	S. Davies
Sample:	BH 14 (0.7m - 1.0m)	Sample No:	P15/6386

Sample details

Sample description : Yellow/Orange Clay

Sample Type : 63 mm Ø tube sample

Swell Specimen		Shrinkage Specimen	
Dry Density - Initial (t/m^3)	1.51	Moisture Content Initial (%)	17.3
Moisture Content - Initial (%)	17.3	Length/Diameter Ratio	1.5
Moisture Content - Final (%)	18.1	Extent of Crumbling	Nil
Overburden Pressure (kPa)	3	Extent of Cracking	Nil
Significant Inert Inclusions (%)	2		

Shrink-Swell Index

I_{ss} = **1.5** % Vertical strain per pF change in Total suction

Tested as received

Approved Signature

Matthew van Herk

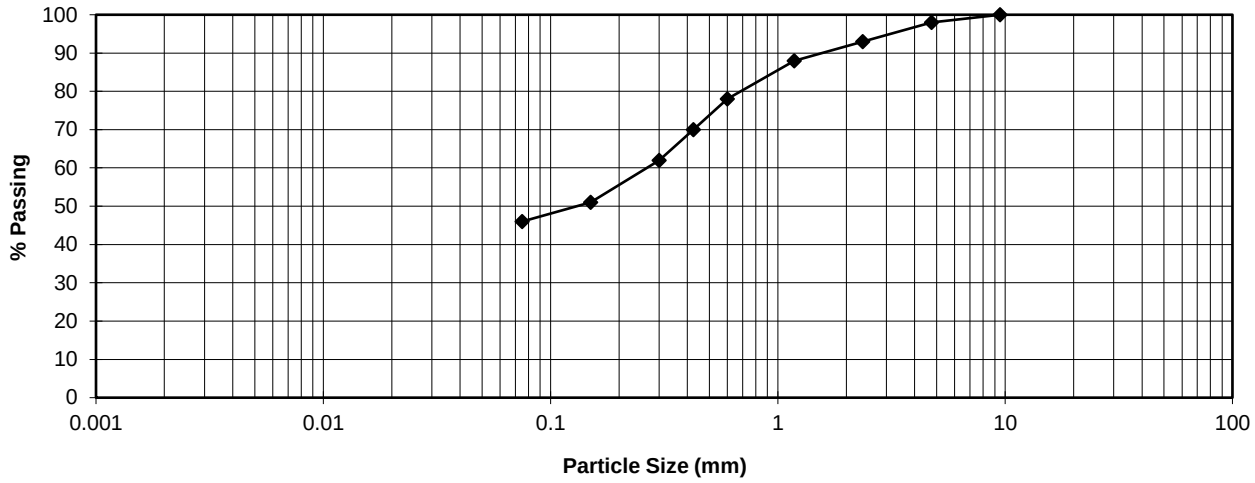
Particle Size Distribution & Plasticity Index tests

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Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/6387
Sample No:	P15/6387
Issue Date:	17 September 2015

Client: Galt Geotechnics (J1501201)
Project: Proposed Residential Development
Location: Various Lots, Byford

Sample location: BH17-1
Sample Depth (m): 1.0 - 1.3



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	98
2.36	93
1.18	88
0.600	78
0.425	70
0.300	62
0.150	51
0.075	46

Plasticity index tests

AS 1289		
Liquid limit 3.1.1	47	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	27	%
Linear shrinkage 3.4.1	13.0	%
Cracked	☐	
Curled	☑	

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Matthew van Herk
AS PSDPI May 2009

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Ph (08) 9414 8022 Fax (08) 9414 8011
Email matt@mcgeotest.com.au
Unit 1/1 Pusey Road, JANDAKOT WA 6164

Determination of the Shrinkage Index of a Soil
Shrink Swell Index
AS 1289.7.1.1

		Job No:	60083
		Report No:	60083-P15/6387
		Date of issue:	17-Sep-2015
Client:	Galt Geotechnics (J1501201)	Date tested:	10-Sep-2015
Project:	Proposed Residential Development	Tested by:	P. Shettigar
Location:	Various Lots, Byford	Checked:	S. Davies
Sample:	BH 17 (1.0m 1.3m)	Sample No:	P15/6387

Sample details

Sample description : Yellow Clay

Sample Type : 63 mm Ø tube sample

Swell Specimen		Shrinkage Specimen	
Dry Density - Initial (t/m$^{3)}$	1.63	Moisture Content Initial (%)	17.2
Moisture Content - Initial (%)	17.2	Length/Diameter Ratio	1.8
Moisture Content - Final (%)	18.3	Extent of Crumbling	Nil
Overburden Pressure (kPa)	3	Extent of Cracking	Nil
Significant Inert Inclusions (%)	2		

Shrink-Swell Index

I_{ss} = **0.7** % Vertical strain per pF change in Total suction

Tested as received

Approved Signature

Matthew van Herk

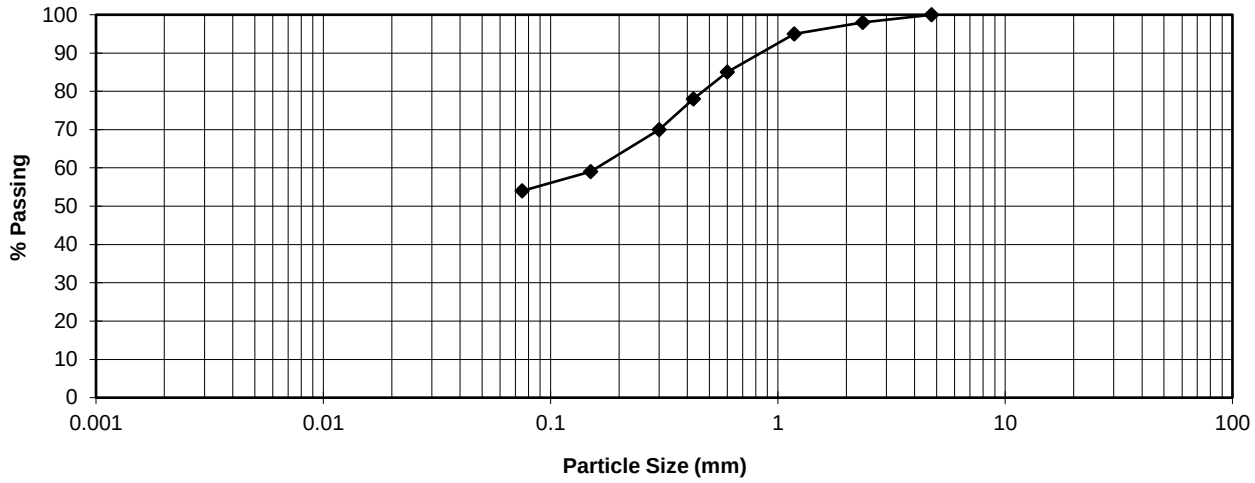
Particle Size Distribution & Plasticity Index tests

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Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P15/6388
Sample No:	P15/6388
Issue Date:	17 September 2015

Client: Galt Geotechnics (J1501201)
Project: Proposed Residential Development
Location: Various Lots, Byford

Sample location: BH22-1
Sample Depth (m): 2.2 - 3.0



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	98
1.18	95
0.600	85
0.425	78
0.300	70
0.150	59
0.075	54

Plasticity index tests
AS 1289

Liquid limit 3.1.1	57	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	37	%
Linear shrinkage 3.4.1	14.5	%

Cracked ☐

Curled ☑

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Matthew van Herk
AS PSDPI May 2009

Appendix F: Understanding Your Geotechnical Engineering Report

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2/39 Flynn St, WEMBLEY WA 6014
ABN: 64 625 054 729

UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

GALT FORM PMP11 Rev1

1. EXPECTATIONS OF A GEOTECHNICAL ENGINEERING REPORT

This document has been prepared to clarify what is and is not provided in your geotechnical report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with geotechnical conditions.

Geotechnical engineering is a less exact science than other engineering disciplines. We include this information to help you understand where our responsibilities as geotechnical engineers begin and end, to help the client recognise his responsibilities and risks. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of geotechnical problems and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following :

- The project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this geotechnical report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your geotechnical engineering report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the design team and by being able to review work produced by other members of the design team which relies on geotechnical information provided in our report.

3. GEOTECHNICAL ENGINEERING LOGS

Our reports often include logs of intrusive and non-intrusive geotechnical investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party as a consequence of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The geotechnical recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including as a result of anthropogenic events (such as construction on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

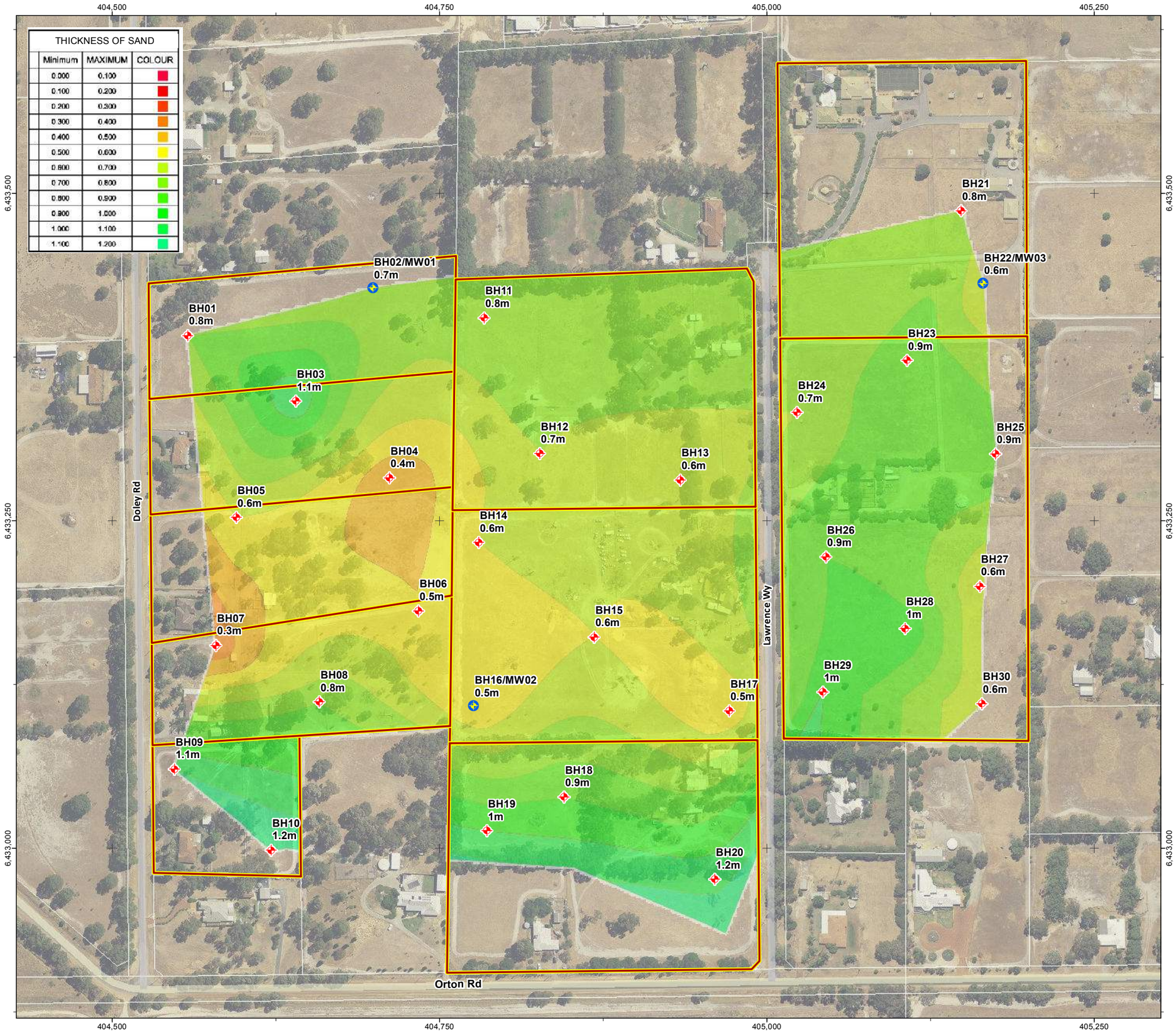
6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

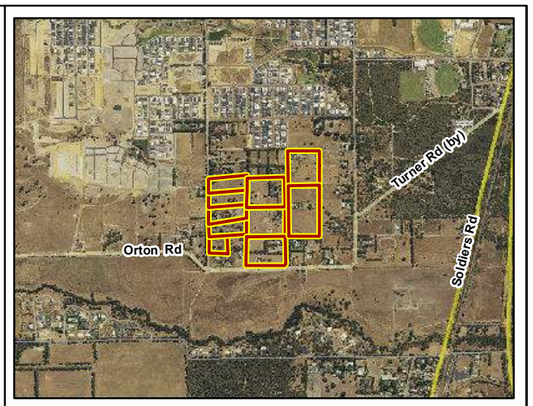
Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use engineering judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from engineering judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not included. The investigation techniques used by us in developing our report differ from those for an environmental investigation. Our report was not prepared with environmental considerations in mind and it is the client's responsibility to satisfy himself that environmental considerations have been taken into account for the site. If you require guidance on how to proceed on evaluating environmental risk at the site, we can provide further information and contacts.





Legend

- Site Boundary
- Borehole
- Borehole / Groundwater Monitoring Well

N

0 40 80 120 160 200
Meters



SCALE	1:2,946 (A3)
DRAWN	DAC
DATE DRAWN	11/09/2015
CHECKED	–
DATE CHECKED	–
PROJECTION	GDA 1994 MGA Zone 50

Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Fax : +61 (0)8 9285 8444
Address : U2, 39 Flynn Street, Wembley, WA, 6014

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CLIENT	ABN GROUP
PROJECT	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION	VARIOUS LOTS ALONG LAWRENCE WAY, DOLEY AND ORTON ROAD, BYFORD
TITLE	THICKNESS OF SAND CONTOURS
Job No	J1501201
Fig No	FIGURE 2
Rev	A

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Appendix Two Galt Geotechnics Desktop Study for the LSP Area, 2015

Report on

DESKTOP GEOTECHNICAL STUDY
PROPOSED RESIDENTIAL SUBDIVISION
BYFORD

Submitted to:

Alcock Brown Neaves (ABN) Group
Ground Floor
131 Hasler Road
OSBORNE PARK WA 6017

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6 014
T: +61 (8) 6272-0200
F: +61 (8) 9285-8444

J1501201 003 R Rev1

12 November 2015

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1. Introduction 1

2. Site Description and Proposed Development 1

3. Project Objectives 2

4. Site Conditions 2

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FIGURE 1: SITE & LOCATION PLAN

FIGURE 2: GEOLOGY

FIGURE 3: GROUNDWATER CONTOURS

APPENDICES

APPENDIX A: UNDERSTANDING YOUR REPORT

1. INTRODUCTION

This report presents the outcomes of Galt Geotechnics Pty Ltd's (Galt's) desktop geotechnical study for the proposed residential subdivision of the various lots along Warrington Road, Soldier Road, Lawrence Way, Doley Road and Orton Road in Byford ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

The desktop study was requested by Jeremy Cordina of ABN Group and authorised in an email dated 23 October 2015.

No intrusive investigation was undertaken across the majority of the site as part of this desktop study. All information provided herein is therefore subject to confirmation based on intrusive testing of the remaining area (other than the existing advice for several of the lots which were previously investigated, J1501201 001 R Rev0).

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the supplied information, the proposed development comprises 42 existing lots, covering a total plan area of approximately 114 ha (approximately 120 ha including the roads and reserves). A summary of the lot numbers and details is included in the attached Table A1 – Proposed Residential Development Lot Details, which is located at the end of the text of this report. The location of the lots to the surrounding area is shown on Figure 1, Site and Location Plan.

Publicly available contour mapping indicates that the site surface levels vary from about RL 36 m AHD along the western edge of the proposed development of the site, sloping up to around RL 57 m AHD along Soldiers Road in the east of the site.

All of the lots have been predominantly cleared of vegetation, with localised mature trees present mainly along the lot boundaries, although scattered large trees and bushes are also present in the center of most lots. Most of the lots also have existing residential dwellings occupying part of the lot. Several of the lots are also presently being used for livestock (horses), with fencing sub-dividing the properties to form smaller paddocks.

It is understood that the proposed development will comprise the subdivision of the site into several hundred residential lots and the construction of new access roads. Due to the preliminary nature of the project, no details regarding the proposed final site levels, layout of lots or access roads are known at this stage.

It is expected that the new residential structures will be single or double storey brick masonry and founded on shallow footings, with ground-bearing slabs. We understand that the target site classification is likely to be either 'Class A' or 'Class S' in accordance with AS2870-2011.

We have previously undertaken a due diligence investigation for several of the lots within the proposed development, including:

- Lot 1347 Orton Road
- 27, 43, 54 & Lot 64 Lawrence Way
- 133, 145, 155 & Lots 130 and 202 Doley Road

We note that 54 and Lot 64 Lawrence Way were originally included in the initial investigation works, however were subsequently removed from the scope of work. The findings of our previous investigation were presented in our report, J1501201 001 R Rev0, dated 9 October 2015.

3. PROJECT OBJECTIVES

The objectives of the desktop study were to:

- broadly assess subsurface soil and groundwater conditions across the sites, based on publicly available information and our experience in this area;
- provide a preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings" and advise on possible measures to improve the site classification to Class S or A;
- advise on likely site preparation procedures including compaction criteria;
- advise on the likely permeability of the soils for potential on-site disposal of stormwater by infiltration; and
- advise on the likely subgrade California bearing ratio (CBR) value for pavement thickness design by others.

4. SITE CONDITIONS

4.1 Geology and Expected Ground Conditions

The Armdale sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is predominantly underlain by Sandy Clay, described as

- *SANDY CLAY – white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity, gravel and silt layers near scarp.*

In the east of the site, there are two isolated areas of SAND and Gravelly Sandy CLAY. These are described as follows:

- *SAND – white to pale grey at surface, yellow at depth, fine to medium grained, moderately sorted, sub-angular to sub-rounded; and*
- *Gravelly Sandy CLAY - variable, with lenses of silt and gravel, quartz sand, subangular with eolian rounded component, heavy minerals common, gravel rounded of colluvial origin*.

An overview of the regional geology is included as Figure 2 – Indicative Geotechnical Aspects.

Based our experience in the area and the results of our previous investigation, we anticipate that most of the site will be underlain by a variably thick layer of sand, overlying Clayey SAND / Sandy CLAY. Based on the geological mapping the north east corner of the site is likely to have a thicker layer of sand overlying clayey soils, whereas the south east corner is likely to have a thinner layer of sand (potentially clayey soils at the surface).

4.2 Groundwater

The Perth Groundwater Atlas (1997) does not extend to the site, however the noted historical maximum groundwater level is around RL 34 m AHD in close proximity to the western boundary of the development. This is within about 2 m of the current ground surface.

A perched groundwater table over clayey soils is expected at wetter times of the year.

Groundwater was not encountered in any of the boreholes or standpipes (maximum depth of 3 m) during the previous field investigation of several of the lots (conducted late winter).

5. GEOTECHNICAL ASSESSMENT

5.1 Site Classification

We consider that the site is likely to be geotechnically capable of supporting the proposed residential subdivision.

We have assessed a preliminary site classification in accordance with AS 2870-2011 "Residential Slabs and Footings". Based on the findings from the previous investigation, we consider the following preliminary site classifications are likely to be applicable:

- "Class A" where the overlying sand thickness is greater than 1.8 m;
- "Class S" where the overlying sand thickness is between 0.3 m and 1.8 m;
- "Class M" where the overlying sand thickness is between 0.0 m and 0.3 m.

The findings of the previous investigation (part of the development area) found between 0.3 m and 1.2 m of sand over the clayey soils. Based on this we consider that a preliminary site classification of 'Class S' is likely to be applicable for most of the site.

A site classification of "Class M" may be applicable in the south east of the site where a thinner cover of sand is expected over the clayey soils.

Site classifications will be highly dependent on the sand cover at the site and the reactivity of the underlying clayey soils, which can only be confirmed with intrusive geotechnical studies.

Where at least 1.8 m of inert sand is encountered over clayey soils (potentially in the north east of the site) a site classification of "Class A" will be applicable. Improvement of the site classification to 'Class A' in other areas of the site is also possible with importation and placement of sand fill to produce a total sand thickness of at least 1.8 m overlying clayey soils.

The preliminary site preparation measures outlined in Section 5.2 must be followed to achieve the site classification noted above.

Confirmation of the applicable site classification for the different areas of the site must be undertaken as part of an intrusive investigation.

5.2 Site Preparation

The preliminary site preparation measures outlined below are aimed at improvement of the site in preparation for construction of the structures including on-ground slabs, shallow footings, retaining walls and pavements.

- Demolish/remove the existing buildings, fences and pavements (including removal of all footings, sewerage tanks and soakwell) and dispose of off-site.
- Remove all topsoil and vegetation from the site, including grubbing out of roots. A topsoil strip of 100 mm may be assumed, however the topsoil strip must be deep enough to remove all roots. Grubbing out of tree roots will be required where trees are removed. Localised remediation may be required for areas where large trees are removed and the soil is disturbed to a depth of greater than 1 m.
- Compact ground surface to achieve the achieve a minimum dry density ratio (DDR) of at least 95% maximum modified dry density (granular soils) or 95% standard maximum dry density (clayey soils) to a minimum depth of 0.9 m below surface. **Note:** Where there is more than 1 m of bulk fill to be placed over the in-situ sand, the depth of compaction can be reduced to 0.45 m.

- Where fill is required to raise site surface levels, use approved granular fill, placed and compacted in layers of no greater than 300 mm loose thickness.

We note that general disturbance of the clayey soils at the site is not likely to be needed, however if excavation of the clayey soils is required (i.e. services, etc), care should be taken to not mix the overlying sand and underlying clayey soils, so that the sand can be re-used as approved fill.

Special attention may need to be given to:

- areas where large trees are removed;
- remediation and backfilling of former farm dams (including removal of any embankments back down to natural ground and trimming of soft soil at the base);
- any former landfill areas (if present), noting that they may not be evident until earthworks take place.

5.3 Stormwater Disposal

We consider that the *in-situ* sands at the site are unlikely to be suitable for the disposal of stormwater by infiltration by means of soakwells, due to the shallow thickness of sand overlying clayey soils expected over most of the site. Disposal may be possible in the north east of the site where the sand thickness is expected to be greater, however this will also depend on the maximum groundwater levels in this area (which we are not aware of at this stage).

Typically, we consider that at least 1.5 m total sand thickness is required above clayey soils to facilitate the use of soakwells (noting that around the clay interface that the overlying sand tending to become clayier). To achieve this, imported sand is likely to be required for raising surface levels. Subsoil drainage would also be recommended in this instance to drain infiltrated water away from houses and roads.

If the sand thickness of the site is kept relatively low (i.e. <1.5 m), we consider that lot connections will be required.

Testing conducted as part of the previous investigation indicated that the permeability of the in-situ sand ranged between 0.6 m/day and 3.0 m/day.

If raising of the site levels was undertaken to facilitate stormwater disposal, we recommend a preliminary design value of permeability (k) not greater than 1 m/day for the in-situ sand to allow for the variability in materials and reduced permeability as a consequence of:

- densification of sand during site preparation works;
- natural variation in sands; and
- clogging of the sand around soakwells and soakage basins over time with fines.

Imported sand fill may have a higher permeability, however we cannot comment at this stage until a specific fill source is proposed.

The underlying *in-situ* clayey soil has a relatively high fines content, and is therefore likely to have a very low permeability. Soakwells may also have a reduced permeability during the wetter times of the year if a perch groundwater table is present over the clayey soils.

Soak wells should be placed outside a line of 1V:2H extending below the edge of the nearest footing, subject to local council regulations. Discharge from soak wells has been known to promote densification of loose sandy soils, leading to settlements of footings and slabs. Soak wells should be carefully wrapped with geotextile to prevent migration of sand and fines into the soak well.

5.4 Pavement Design

Where the pavement subgrades comprise of at least 0.5 m of *in-situ* sand or sand backfill over the clayey soils and the site preparation measures outline in Section 5.2 have been completed, pavement thickness design may be undertaken assuming a subgrade California bearing ratio, CBR of 10%.

Where the pavement is underlain by less than 0.5 m of sand or by a clayey subgrade, a revised CBR value should be assumed.

6. FURTHER INVESTIGATION

6.1 Scope

We understand that a local structure plan application is required to enable re-zoning of the existing lots to a purpose other than its current rural zoning. At a high level, we consider that the site is geotechnically adequate for the proposed target use. For detailed design (and almost certainly to support a development application), investigation is required to confirm that the land is capable of supporting such development and to identify likely constraints to such development. Based on this, we consider that the objectives of detailed due diligence study are to:

- Assess the subsurface soil and groundwater conditions across the site, with an emphasis on:
  - thickness and density of existing sand cover over clayey soils
  - depth to groundwater;
  - presence of filling within the site (if at all); and
  - presence of shallow rock or cemented soils.
- provide a preliminary site classification(s) in accordance with AS 2870-2011 “Residential Slabs and Footings”;
- provide recommendations for the site to improve the site classification to “Class A” or “Class S” if applicable;
- recommend likely appropriate site preparation procedures including compaction criteria;
- assess the permeability of the soils at the site for potential on-site disposal of stormwater by infiltration; and
- provide a subgrade California bearing ratio (CBR) value for pavement thickness design by others.

We consider that accurate characterisation of the clayey soils and the thickness of overlying sand (if at all) is likely to be critical for confirming the viability of the proposed residential development. Characterisation of the clayey soils will be necessary for assessing the required thickness of natural sand or imported granular fill required over the different areas of the site, in order to achieve at least a “Class S” classification (understood to be the minimum required site classification). As such, a scope of work and testing program which focuses on the characterisation of the in-situ clayey soils will be required. We can provide a proposal for this if required.

7. CLOSURE

As previously discussed, the preliminary findings and recommendations presented in this report must be confirmed through intrusive investigation prior to detailed design.

We draw your attention to Appendix A of this report, Understanding your Report. The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimise risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

GALT GEOTECHNICS PTY LTD





Owen Woodland CPEng

Geotechnical Engineer

Paul Woodroof CPEng

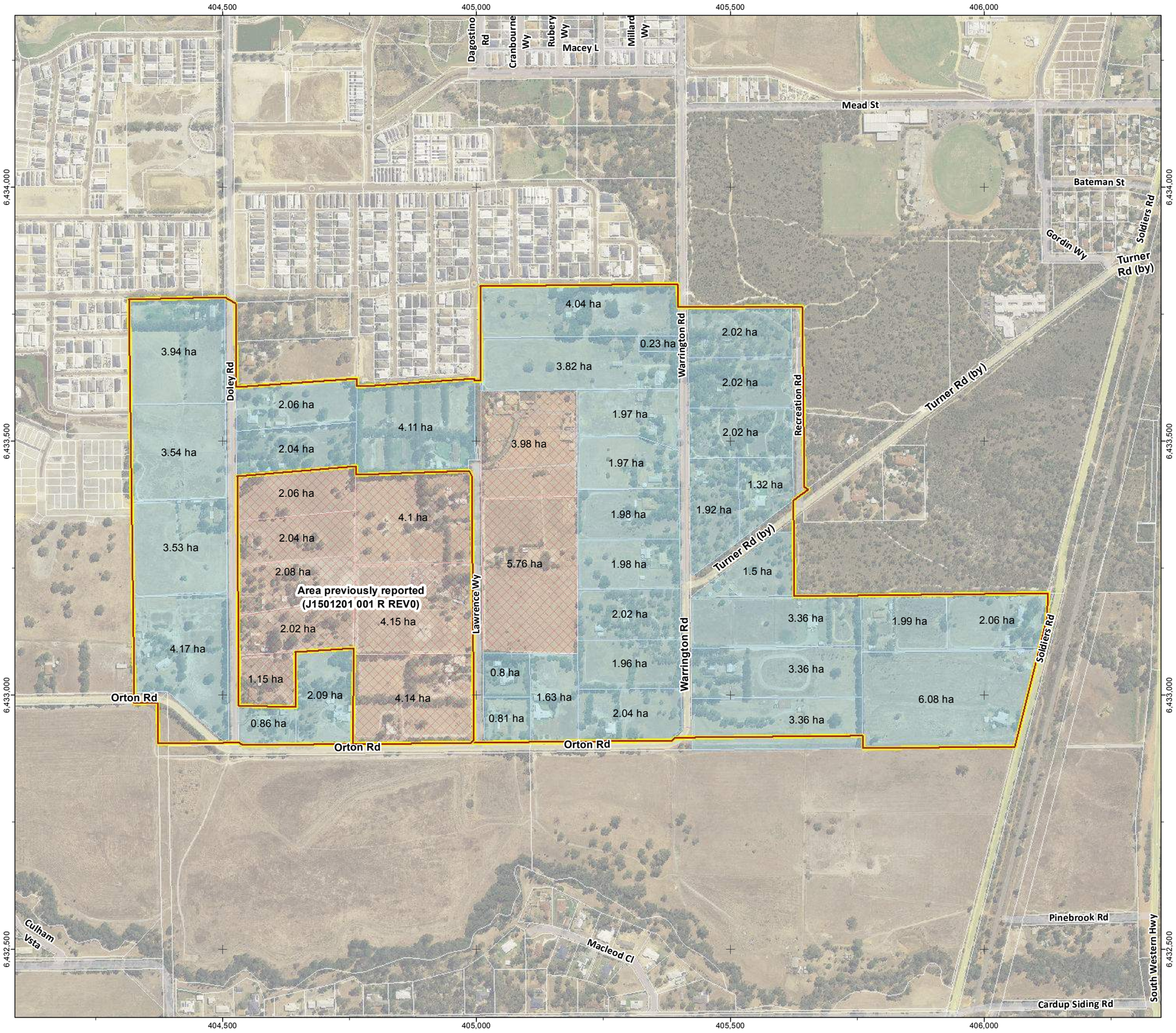
Geotechnical Engineer

\\GALT-SBS2011\Data\Jobs\2015\J1501201 - ABN Group DD SI Byford\03 Correspondence\J1501201 003 R Rev1.docx

Figures

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 64 625 054 729





Legend

- Site Boundary
- AREA PREVIOUSLY INVESTIGATED
- AREA OF DESKTOP STUDY

N

0 120 240 360 480 600
Meters



SCALE	1:7,500	(A3)
DRAWN	DAC	
DATE DRAWN	9/11/2015	
CHECKED	PCW	
DATE CHECKED	9/11/2015	
PROJECTION	GDA 1994 MGA Zone 50	

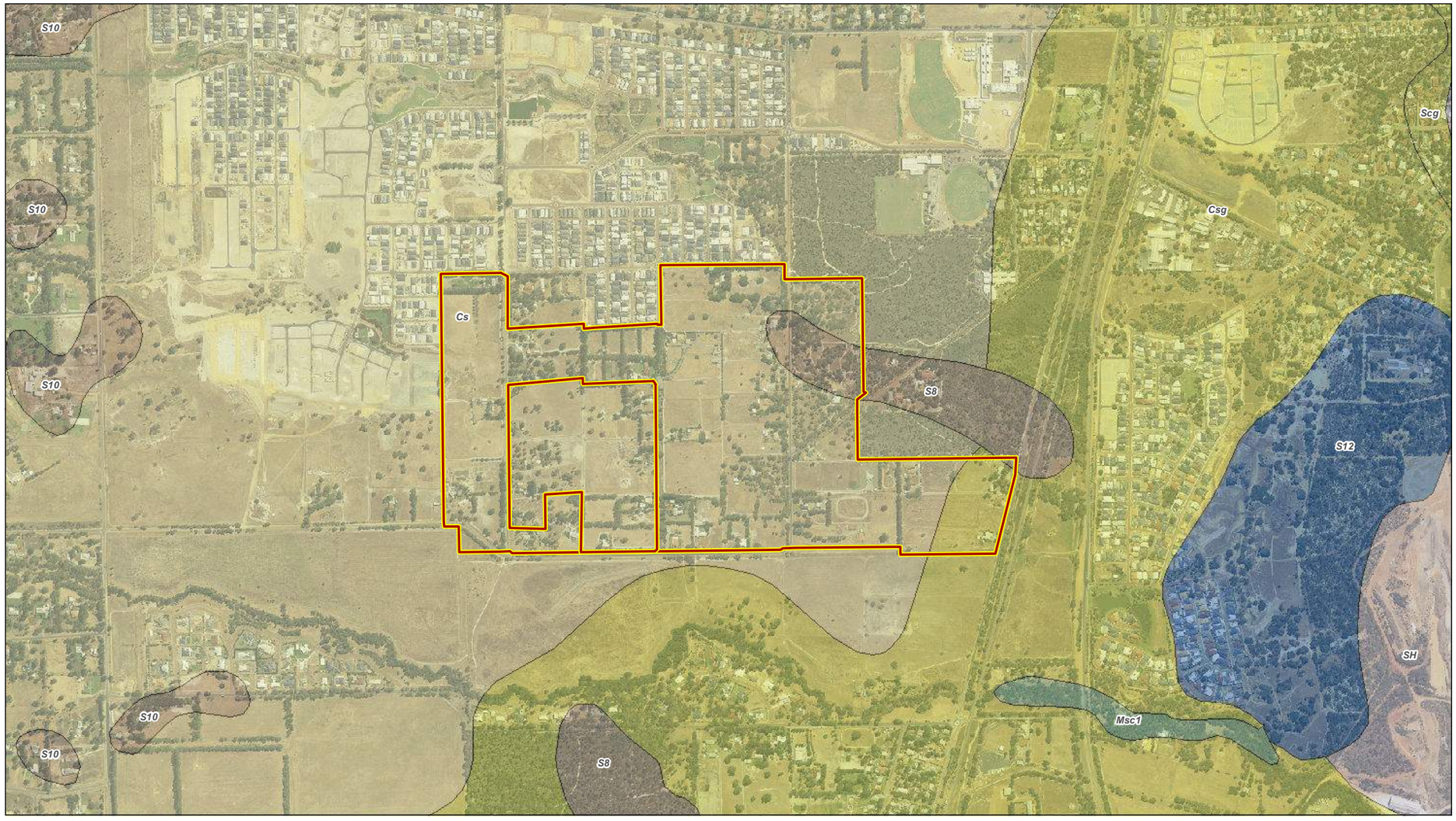
Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Fax : +61 (0)8 9285 8444
Address : U2, 39 Flynn Street, Wembley, WA, 6014

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CLIENT	**ABN GROUP**
PROJECT	PROPOSED RESIDENTIAL DEVELOPMENT
LOCATION	ORTON ROAD BYFORD
TITLE	SITE & LOCATION PLAN

Job No	Fig No	Rev
J1501201	FIGURE 1	**A**

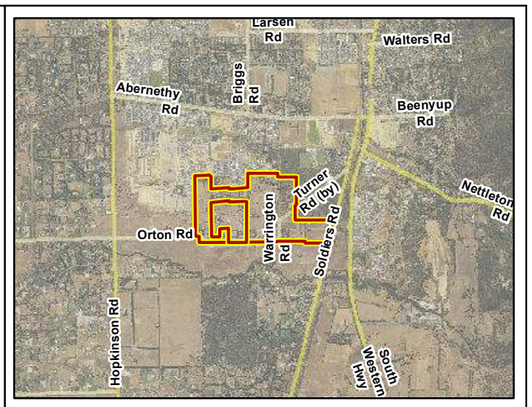
O:\Jobs\2015\J1501201 - ABN Group DD SI Byford\09 GIS\04 MXD\J1501201-004.mxd (DamonClark) 9/11/2015 5:04:19 PM



GEOLOGY MAP

ARMADALE:20331	CODE, NARRATIVE
Cs	Cs: SANDY CLAY - white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp
Csg	Csg: GRAVELLY SANDY CLAY - variable, with lenses of silt and gravel, quartz sand, subangular with eolian rounded component; heavy minerals common; gravel rounded, of colluvial origin
Msc1	Msc1: CLAYEY SANDY SILT - pale brown, angular to rounded sand, low cohesion, of alluvial origin
S10	S10: SAND - as S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin
S12	S12: SAND - structureless, yellow, fine-grained, subangular and medium to coarse-grained subrounded to rounded quartz, feldspar and heavy minerals common, minor silt and clay, of colluvial origin
S8	S8: SAND - white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin
SH	SH: SHALE - brown-green to black, silty, thinly bedded with interbeds of siltstone and fine-grained sandstone
Scg	Scg: GRAVELLY CLAYEY SAND - decomposed bedrock, gravel rock fragments, angular quartz/feldspar sand, clay minerals may flocculate to silt/sand size, of colluvial origin

GEOLOGY MAP LEGEND



Legend

Site Boundary

N

0 240 480 720 960 1200

Meters



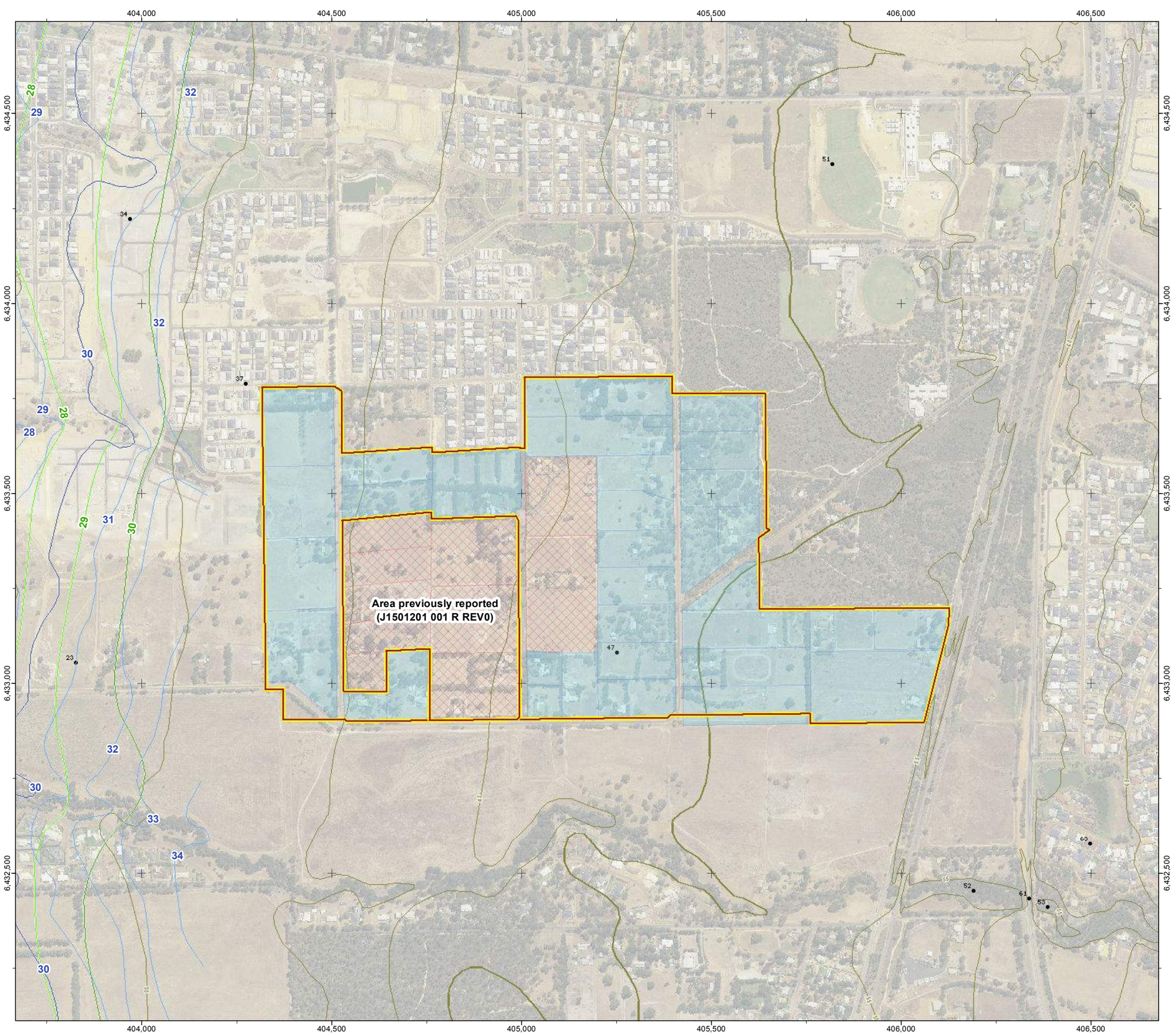
SCALE	1:15,000	(A3)
DRAWN	DAC	
DATE DRAWN	9/11/2015	
CHECKED	PCW	
DATE CHECKED	9/11/2015	
PROJECTION	GDA 1994 MGA Zone 50	

Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Fax : +61 (0)8 9285 8444
Address : U2, 39 Flynn Street, Wembley, WA, 6014

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CLIENT	**ABN GROUP**
PROJECT	PROPOSED RESIDENTIAL DEVELOPMENT
LOCATION	ORTON ROAD BYFORD
TITLE	GEOLOGY

Job No	Fig No	Rev
J1501201	FIGURE 2	**A**





Legend

- Site Boundary
- AREA PREVIOUSLY INVESTIGATED
- AREA OF DESKTOP STUDY

Ground Water Contours (m AHD)

Maximum

- 5
- 1

Minimum

- 5
- 1

N

0 160 320 480 640 800
Meters



SCALE	1:10,000	(A3)
DRAWN	DAC	
DATE DRAWN	9/11/2015	
CHECKED	PCW	
DATE CHECKED	9/11/2015	
PROJECTION	GDA 1994 MGA Zone 50	

Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Fax : +61 (0)8 9285 8444
Address : U2, 39 Flynn Street, Wembley, WA, 6014

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CLIENT	**ABN GROUP**
PROJECT	PROPOSED RESIDENTIAL DEVELOPMENT
LOCATION	ORTON ROAD BYFORD
TITLE	GROUNDWATER CONTOURS

Job No	Fig No	Rev
J1501201	FIGURE 3	**A**

Tables

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2/39 Flynn St, WEMBLEY WA 6014

ABN: 64 625 054 729

Table A1: Proposed Residential Development Lot Details

Location	Area (ha)	Comments
Lot 32 Doley Road	3.5431	
88 Doley Road	3.9404	
109 Doley Road	2.0618	
119 Doley Road	2.0447	
128 Doley Road	3.5370	
Lot 130 Doley Road	2.0631	Previously Investigated (J1501201 001 R Rev0)
133 Doley Road	2.0445	
145 Doley Road	2.0850	
155 Doley Road	2.0228	
Lot 201 Doley Road	0.8626	
Lot 202 Doley Road	1.1512	Previously Investigated (J1501201 001 R Rev0)
1299 Orton Road	4.1716	
1339 Orton Road	2.0934	
1347 Orton Road	4.1410	Previously Investigated (J1501201 001 R Rev0)
1367 Orton Road	0.8107	
1379 Orton Road	1.6303	
1387 Orton Road	2.0410	
27 Lawrence Way	4.1543	Previously Investigated (J1501201 001 R Rev0)
43 Lawrence Way	4.1038	
54 Lawrence Way	3.9773	
55 Lawrence Way	4.1071	
Lot 64 Lawrence Way	5.7686	Previously Investigated (J1501201 001 R Rev0)
Lot 136 Lawrence Way	0.8004	
Lot 21 Warrington Road	1.9615	
Lot 45 Warrington Road	2.0236	
78 Warrington Road	4.0789	

Location	Area (ha)	Comments
83 Warrington Road	2.0238	
84 Warrington Road	3.8185	
91 Warrington Road	2.0237	
106 Warrington Road	1.9691	
110 Warrington Road	1.9658	
111 Warrington Road	1.9291	
116 Warrington Road	1.9788	
124 Warrington Road	1.9806	
142 Warrington Road	2.0240	
143Warrington Road	3.3659	
147Warrington Road	3.3662	
155 Warrington Road	3.3662	
84 Turner Road	1.3247	
97 Turner Road	1.5010	
140 Soldiers Road	2.0636	
150 Soldiers Road	1.9883	
154 Soldiers Road	6.0685	
Total	**113.9775**	

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ABN: 64 625 054 729

Appendix A: Understanding Your Report

www.galtgeo.com.au
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ABN: 64 625 054 729

UNDERSTANDING YOUR REPORT

GALT FORM PMP11 Rev2

1. EXPECTATIONS OF THE REPORT

This document has been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

3. SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.

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Appendix Three Byford Townsite Drainage And Water Management Plan, September 2008



Byford townsite drainage and water management plan

Looking after all our water needs

Department of Water

DWMP1

September 2008

Department of Water
168 St Georges Terrace
Perth Western Australia 6000
Telephone +61 8 6364 7600
Facsimile +61 8 6364 7601
www.water.wa.gov.au

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September 2008

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Summary

This *Drainage and water management plan* forms a key part of the Department of Water's urban drainage initiative. The focus of this initiative is the preparation of drainage and water management plans to help address water issues in proposed development areas.

The *Drainage and water management plan* presents the Department of Water's guidance for the Serpentine Jarrahdale Shire, the Western Australian Planning Commission, land developers and other state agencies about water management issues to help development proceed within the Byford Townsite area.

The *Drainage and water management plan* also assists in integrating land and water planning as required by *State planning policy 2.9* and outlined in *Better urban water management* (in preparation for the Department for Planning and Infrastructure, Department of Water, Western Australian Local Government Association and Department of Environment, Water, Heritage and the Arts by Essential Environmental Services, 2008).

All water management strategies, local structure plans, local planning scheme amendments and subdivision plans prepared for areas of proposed new development must demonstrate compliance with the strategies, objectives and design criteria detailed in this document.

A summary plan and checklist for developers has been developed and included with this document.

A regional scale controlled groundwater level is established and advice for developers and stakeholders for the management of groundwater quantity and quality within the Byford townsite area is given.

Section 9 – implementation presents monitoring requirements for local water management strategies and an Implementation action plan.

1 Introduction

The Byford structure plan was approved in 2005 by the Serpentine Jarrahdale Shire and the Western Australian Planning Commission. The structure plan provides a guide to subdivision and development/redevelopment of the townsite and surrounding rural residential development.

The *Byford urban stormwater management strategy* was adopted by the Serpentine Jarrahdale Shire in 2003. The strategy set out guidelines for water-sensitive urban design. It was simplified to form the *Byford urban stormwater management strategy developer guidelines* in 2005. This *Drainage and water management plan supersedes* the *Byford urban stormwater management strategy* and *Byford urban stormwater management strategy developer guidelines.*

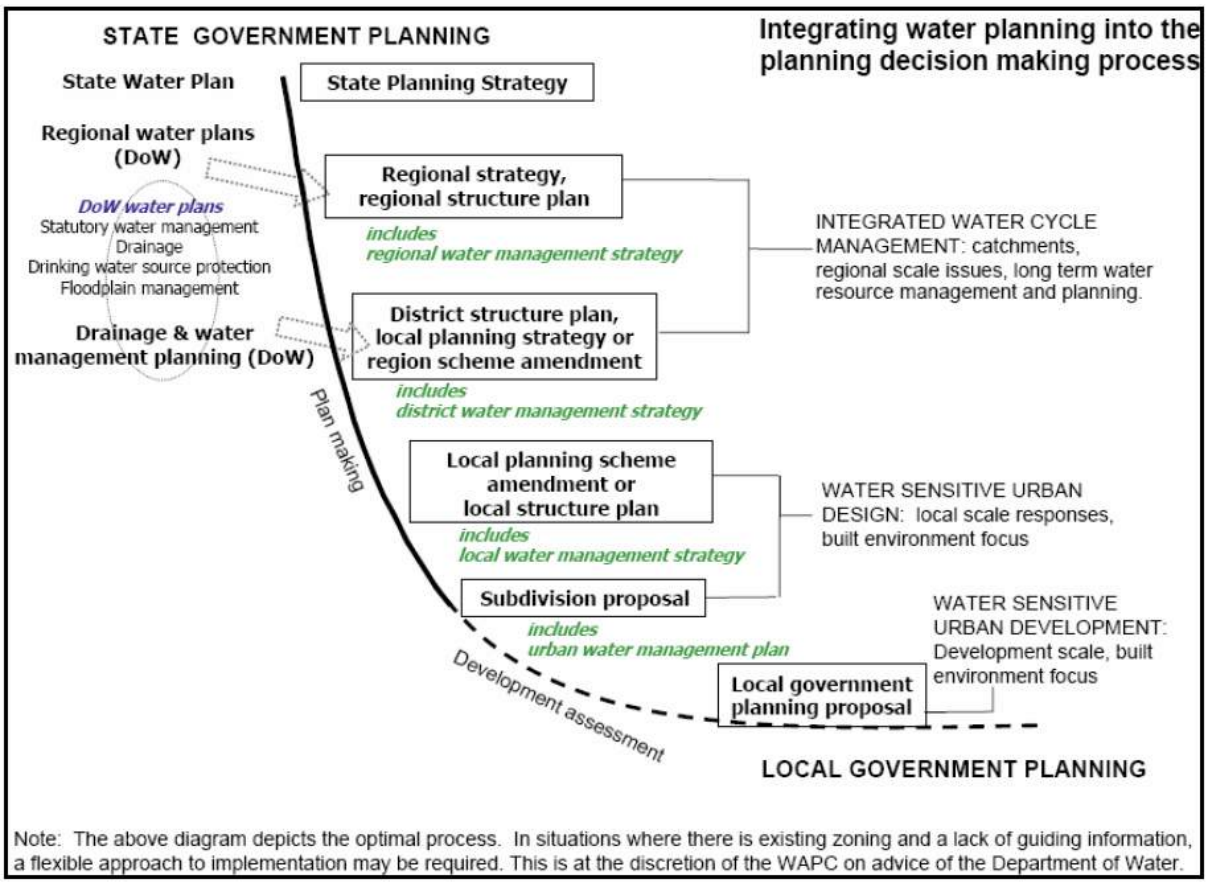
Total water cycle management, also referred to as integrated water cycle management, 'recognises that water supply, stormwater and sewage services are interrelated components of catchment systems and therefore must be dealt with using a holistic water management approach that reflects the principles of ecological sustainability' (Department of Water 2004, *Stormwater management manual for Western Australia*, Ch. 2, p. 14).

The scope of the *Drainage and water management p*lan 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 sulphate 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 *Drainage and water management plan* within the state government planning framework is defined in *Better urban water management* (prepared for the Department of Planning and Infrastructure, Department of Water, Western Australian Local Government Association and Department of Environment, Water, Heritage and the Arts by Essential Environmental Services, in press) and outlined in Figure 1-1 below.

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



This document presents the proposed arterial drainage scheme for the Byford townsite in accordance with the responsibilities for drainage planning assigned to the Department of Water by the state government.

1.1 Planning background

In addition to *Better urban water management,* the *Drainage and water management plan* uses the following documents to define its key principles and objectives:

- *Liveable Neighbourhoods - edition 4*
- *State Planning Policy no. 2.9: Water resources*
- *Byford townsite detailed area plan* (Statewest Surveying & Planning, Chris Antill Planning & Urban Design, McDowall Affleck, Thompson Partners and Landform Research, 2005)
- *Byford structure plan* (Taylor Burrell Barnett, 2005)

1.2 Previous studies

A number of key investigations have been undertaken in the Byford locality. It is the aim of this *Drainage and water management plan* to incorporate information from all of these studies and present design criteria and management strategies.

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.

Local-scale groundwater modelling has recently been completed by CyMod Systems (2007) for the Department of Water 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) for the Department of Water. 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.

The study area has been assessed for acid sulphate soil risk, the results of which are presented in the *Western Australian Planning Commission planning bulletin No. 64 'acid sulphate soils'* (2003).

Environmental water requirements of groundwater dependent-ecosystems have not yet been published for this area.

1.3 Summary plan and checklist

Figure ES1 provides an overview of the arterial drainage scheme that is proposed for the Byford townsite area and which forms a major part of this *Drainage and water management plan*, addressing stormwater quantity management. In addition, recommendations and key design criteria for stormwater quality management are detailed.

Water Conservation

- Consumption target for water of 100 kL/person/yr including not more than 40-60 kL/person/yr scheme water;
- Meeting 5 Star Plus provisions for all new dwellings;
- The use of native plants is to be promoted, with native species constituting a minimum of 30-35% of total POS area;
- The use of on-site rainwater tanks is to be promoted, to achieve water consumption targets whilst also having the ability to fully or partially meet on site stormwater retention requirements.

Floodways

- Development outside of the Floodway should ensure finished floor levels at a minimum of 0.5 m above the 100 year flood level;
- The existing cross sectional area of waterways must be maintained. Restoration of waterways is essential and in some cases channel realignments and channel profile modifications may be carried out, provided it is demonstrated that the predevelopment cross-sectional area has been preserved subject to approval.

Roads

- Defined major arterial roads should remain passable in the 100 year ARI event;
- Minor roads should remain passable in the 5 year ARI event;
- Emergency evacuation areas defined at least 2.0 m above 100 year ARI event level.
- Water Quality treatment systems and Water Sensitive Urban Design structures must be designed in accordance with the Stormwater Management Manual for Western Australia (DoW, 2007) and Australian Runoff Quality (Engineers Australia, 2006).

Water Quality Design Targets

Water quality management BMPs to acheive design targets:

- Vegetated bioretention systems sized at 2% of the constructed impervious area they receive runoff from

OR

- to achieve:
  - At least 80% reduction of total suspended solids;
  - At least 60% reduction of total phosphorus;
  - At least 45% reduction of total nitrogen;
  - At least 70% reduction of gross pollutants

Approval Process

Proponents shall develop and present the strategies for water quantity and quality management in the Local Water Management Strategy and Urban Water Management Plans to support the 'Planning Approvals' required for the development to proceed.

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

It is strongly recommended that proponents meet with the local authority to discuss proposed surface and groundwater management strategies and to gain further guidance on site-specific requirements of the local authority prior to the completion of any LWMS or UWMP.

Groundwater Management

- The bio-retention system, subsurface drainag and drainage inverts are set at or above CGL although existing drainage inverts below CGL may remain;
- Subsurface drainage must be designed with free-draining outlets;
- Where development may discharge pollutants from the shallow groundwater to receiving environments, the following interim targets will be adopted:
  - As compared with a development that does not actively manage water quality, achieve:
    - at least 60% reduction of total phosphorous;
    - at least 45% reduction of total nitrogen.
- Discharge to water dependent ecosystems must be in accordance with the requirements of the Department of Environment and Conservation.

Fill

- The clean fill imported onto the site is to incorporate a band of material that will reduce phosphorus export via soil leaching, whilst also meeting soil permeability and soil compaction criteria specified by the Local Government Authority
- The development should ensure finished lot levels at a minimum of 0.8 m above the phreatic line;
- Where a perched water table exists or the predicted MGL is at or within 1.2 m of natural ground level, the importation of clean fill and/or the provision of sub surface drainage will be required.

Monitoring

- Monitoring programs needs to commence 2 years prior to proposed development
- Monitoring sampling should follow Australian Standards AS/NZ 5667 Water quality sampling guidelines and a NATA accredited laboratory is required for testing.
- The extent and density of groundwater monitoring bore network should spatially represent hydrogeology. The surface water monitoring sites should capture the sites inflows and outflows, detention or retention storages inflows and outflows and water dependent ecosystems.
- If treatment measure is infiltration, then both filtered and unfiltered samples of total nutrient concentrates should be measured.

Risk

- Monitoring program to include a contingency action plan with associated trigger values.
- The LWMS should include an assessment of risks associated with failure of infrastructure, climate change, maintenance and other future circumstances.

Purpose of the Local Water Management Strategy

A key component of a local structure plan is a LWMS, which describes the strategy to meet total water cycle management and is consistent with the District Water Management Plan. A LWMS must provide sufficient detail that the proposed water management system is appropriately sized and designed as proof of concept. It must also illustrate that sufficient land has been set aside to implement the strategy.

Stormwater Attenuation

- The 1 year 1 hour ARI event shall be detained at source.
- The post-development critical 1 year ARI peak flow and volume and the 100 year ARI peak flow shall be consistent with pre-development flows at:
  - the discharge points of all subdivisions into waterways;
  - the discharge points from the Structure Plan area (Hopkinson Road);
  - the discharge points of each subcatchment.
- Finished lot levels at minimum of 0.5m above 100-year ARI flood levels

Flows from developed areas must be attenuated, in accordance with this table, which protects the regional system, in flood detention/storage areas incorporated into POS within the subdivision and located outside defined floodways.

Local Drainage – Subcatchment Planning Criteria

Subcatchment ID	Area (ha)	Peak discharge Flow (m^3/s)		Detention Volume (m^3)	
		5 year	100 year	5 year	100 year
10C	24.7	0.4	1.4	2800	5800
3C	68.1	0.4	3.5	9000	20100
3D1	65.1	0.8	3.3	8100	15000
3D2	49.0	0.5	2.3	6200	12900
3D3	12.8	0.3	0.8	1800	3400
3D4	11.4	0.3	0.7	1500	3000
5B	40.3	0.6	1.4	5100	12400
3B3	24.6	0.4	0.9	3100	7500
5E	21.2	0.4	1.3	1800	4400
5F	6.3	0.2	0.4	500	1300
5G	108.9	3.5	9.4	5400	13700
6B	26.9	0.6	1.8	3300	5800
6C	19.8	0.4	1.4	2400	4800
6D1	77.2	0.7	2.8	8000	20200
6F	17.8	0.4	0.6	1900	4700
6D2	16.0	0.3	0.8	2000	3500
6E	20.9	0.4	1.4	2200	4900
7A	57.1	0.6	2.1	6700	15700
7B	46.4	0.7	2.3	5600	10600
7C	29.2	0.6	1.9	2700	6000
7C1	40.8	0.6	1.9	5300	10400
7D	34.0	0.5	1.7	3300	8100
8A	19.0	0.3	0.5	2100	6000
8B	43.1	0.6	1	4700	13600
8C	55.6	0.4	1.4	8400	19200
8D	47.8	0.4	2.6	6600	13300
9B	37.1	0.6	2.1	1700	5800
9C	85.4	1.2	5.3	5300	12800
9D	22.6	0.5	1.4	1000	3100
3B1	31.2	0.5	1.3	5400	8200
3B2	55.2	0.7	2.6	9500	14200

Regional Drainage – Flows, Levels and Floodway Widths at Critical Locations

Location	Peak Flows (m^3/s)		Peak Levels (m AHD)		Indicative Floodway Width (m)
Number and Description	5 Year ARI	100 Year ARI	5 Year ARI	100 Year ARI	100 Year ARI
1. Oaklands drain d/s George Road (north)	5.5	10.2	53.2	53.5	40
2. Oaklands drain d/s George Road (south)	2.4	10.7	51.8	52.0	40
3. Oaklands drain d/s Evans Road	10.7	34.5	44.3	44.6	32
4. Oaklands drain d/s Briggs Road	11.0	30.3	32.7	32.9	70
5. Oaklands drain at Thomas Road and Masters Road	9.5	25.7	30.9	31.1	50
6. Oaklands drain d/s Malarkey Road	20.8	59.3	29.8	30.2	50
7. Oaklands drain at Hopkinson Road	15.7	48.9	26.4	26.9	60
8. Beenyup Brook d/s South Western Hwy	8.1	31.2	58.5	58.7	40
9. u/s end piped section of Beenyup Brook d/s Abernethy Road	2.8	3.1	56.5	56.6	-
10. u/s end swale from Beenyup Brook to Oaklands drain	5.2	16.1	56.5	56.6	10
11. u/s end swale down Abernethy Rd from Beenyup Brook to Trib 6	0.0	11.5	56.3	56.8	10
12. Overland flow down Warrington Road	0.0	1.3	44.5	45.4	10
13. Overland flow down Doley Road	0.0	2.7	34.5	35.5	10
14. Beenyup Brook at Hopkinson Road	8.1	9.6	26.0	26.3	40
15. Tributary 6 u/s Briggs Road (Extn)	1.4	3.4	41.6	41.7	40
16. Tributary 6 at Hopkinson Road	1.6	6.7	27.6	27.7	50
17. Tributary 7 at Hopkinson Road	2.0	5.1	27.1	27.2	50
18. Cardup Brook d/s South Western Hwy	5.8	23.5	55.1	57.1	70
19. Cardup Brook at Hopkinson Road	9.4	33.2	27.6	27.9	50

1:12,500 at A1

0 100 200 400 600 800 1,000

Metres

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

N

LEGEND

- Byford Drainage and Water Management Plan Area - GHD - 20070625
- Modelled Subcatchment - GHD - 20070823
- Cadastre - DLI - 20061201
- Critical Flow and Level Locations - GHD - 20080718

Drains - GHD - 20080131

- Main Waterway (Restored)
- Modelled Overland Flowpath
- Modelled Swale Drain
- Modelled Piped Drain

- 100 Year ARI Floodways (Not to be developed or obstructed in any way) - GHD - 20080215
- 5m Contours - GHD - 20080718

Byford Drainage & Water Management Plan
Summary Plan & Checklist

Job Number 6122524
Revision 1
Date 17 Sept 2008

Figure ES1

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

Local water management strategy, checklist for developers

The checklist provides a summary of items to be addressed by developers in the preparation of local water management strategies for assessment by the Serpentine Jarrahdale Shire when an application for a local structure plan is lodged.

The checklist must be completed and signed by a suitably qualified professional and submitted to council together with the local water management strategy.

Applicant:……

Name of structure plan:……

Version of structure plan: ……

Contact: ……

Address: ……

Telephone number:……Email: ……

Authorised Signature: ……

Date: ……

	Item	**Submission**		**Assessment**	
		Document ref. 1	**Comments2**	**Compliance**	**Comment**
1.0	Introduction				
1.1	Drainage and water management principles and design objectives for this structure plan				
1.2	Planning background (subject land)				
1.3	Previous studies (related to drainage and water)				
2.0	Proposed development				
2.1	Key elements of structure plan				
2.2	Previous land use and potential sources of contamination				
2.3	Finished lot levels – (determined by greater of 100 year flood protection criteria or minimum separation of building foundations to MGL or CGL)				
2.4	Assessment of risk undertaken				
3.0	Existing site characteristics				
3.1	Topography and landform identified				
3.2	Environmental geology of the site identified (including soil types, ASS and PASS)				
3.3	Soil hydraulic conductivity and infiltration capacity of the site identified				
3.4	Groundwater levels, flows and quality of the site mapped (include identification and monitoring of any local or regional groundwater bores)				
3.5	Surface water flows and quality of the site identified (include flow monitoring of existing drainage)				
3.6	Environmental assets and water-dependent ecosystems mapped				
3.7	Indigenous sites identified				
3.8	Existing infrastructure and constraints to design identified (include management strategies for any identified constraints)				
3.9	Site water balance pre-development and post-development identified				
3.10	Water sustainability Initiatives				
4.0	Stormwater management				
4.1	Pre- and post-development hydrology (1 year, 5 year and 100 year ARI events)				
4.2	1 year ARI event managed for ecological protection in accordance with *Drainage and water management plan* section 6.2				
4.3	5 year ARI event managed for serviceability in accordance with *Drainage and water management plan* section 6.2				
4.4	100 year ARI event managed for flood protection in accordance with *Drainage and water management plan* section 6.2 (include flow paths and emergency				

[1] Identify the section in the local structure plan in which this item has been addressed. It is possible that some items are not applicable and if this is the case, please put an explanation in the comments section.

[2] Please make comments as to the applicability of this criterion.

	access routes and fully identify flood plain and protection measures)				
4.5	Finished lot levels at minimum of 0.5m above 100-year ARI flood levels.				
4.6	POS credits identified				
4.7	Water quality management BMPs to achieve design targets: Vegetated bioretention systems sized at 2% of the constructed impervious area they receive runoff from OR to achieve: at least 80% reduction of total suspended solids at least 60% reduction of total phosphorus at least 45% reduction of total nitrogen at least 70% reduction of gross pollutants				
5.0	Groundwater management				
5.1	Groundwater level management strategy				
5.2	Bio-retention system, subsurface drainage and drainage inverts				
5.3	Subsurface drainage design				
5.4	Groundwater management strategies to achieve: at least 60% reduction of total P at least 45% reduction of total N				
5.5	Discharge to water-dependent ecosystems				
5.6	Specifications for imported fill (where proposed)				
5.7	Finished lot levels at a minimum of 0.8 m above the phreatic line				
6.0	Monitoring				
6.1	Monitoring programs commenced 2 years prior to proposed development				
6.2	Monitoring/sampling to follow Australian Standards				
6.3	Monitoring/sampling locations				
6.4	Water quality parameters to be monitored (refer to section 9.5 of *Drainage and water management plan*				
6.5	Monitoring program to include a contingency action plan to manage risk				
7.0	Implementation				
7.1	Commitments				
7.2	Maintenance schedules				
7.3	Roles and responsibilities (for pre-development, during construction and all periods post-development)				
7.4	Funding				
7.5	Review				

2 Pre-development environment

Documents referred to for background information include:

- *Byford urban stormwater management strategy developer guidelines* (Parsons Brinkerhoff 2005)
- *Byford floodplain management strategy* (SKM, 2007)
- *Byford townsite detailed area plan* (Statewest et al. 2005)
- *Framework for developing the Jandakot water resources management strategy* (Parsons Brinkerhoff B 2004)
- *Planning bulletin No. 64* (Western Australian Planning Commission 2003)
- *Swan coastal geomorphic wetland mapping*

2.1 Study area

The study area of the *Drainage and water management plan* is the Byford townsite and surrounding locality as covered by the 2005 Byford structure plan).



The Byford town centre is located approximately 35 km south-east of the Perth CBD, within the Serpentine Jarrahdale Shire.

The *Byford structure plan* site is approximately 1500 ha 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. Although the Byford Trotting Centre and surrounding rural residential area were excluded from the 2005 *Byford structure plan*, they will be included in this *Drainage and water management plan*.

The existing catchment land use is predominantly rural or rural residential, with the majority of rural land consisting of open grassland. The urban areas, which contain a mix of urban residential, commercial, light industrial, community and public open space, are currently concentrated between the South Western Highway and the lower foothills of the Darling Range.

The site location plan is presented in Figure A-1.

2.2 Geotechnical information

The topography of the Byford locality 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) (Figure A-2).

2.3 Soils

There are three primary soil types across the study area (Figure A-2). The soil types are:

- Ridge Hill colluvium from the Yogannup formation – highly variable layers of gravelly to sandy clay with lenses of silt and gravel
- Guildford clay – lenses of sandy clay, clayey sand, iron-rich cemented sand and sand. Low horizontal conductivity and very low vertical conductivity
- Bassendean sand – 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.

Acid sulphate soils

The Western Australian Planning Commission's *Planning Bulletin No. 64 (2003),* which is based upon a review of existing geomorphological, geological and hydrological information, indicates that the soils in the Byford area to the west of the South Western Highway consist of moderate to low risk of actual acid sulphate soils or potential acid sulphate soils occurring generally at greater than 3 m depth.

Low to no risk of actual acid sulphate soils or potential acid sulphate soils occurring generally at greater than 3 m depth can be found to the east of the South Western Highway in the Byford area (Figure A-3).

The risk of acid sulphate 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.

2.4 Environmental assets and water-dependent ecosystems

Environmental assets and water-dependent ecosystems are presented in Figure A-4.

The Department of Environment and Conservation's *Swan coastal geomorphic wetland mapping* indicates there are wetlands classified as conservation category and resource enhancement within the Brickwood Reserve in the south-eastern section of the study area. Conservation category wetland classification also applies to the area of land between the South Western Highway and rail line north of Cardup Brook and along Cardup Brook to the east of the South Western Highway. These

wetlands are under the protection of the *Revised draft environmental protection policy wetlands* (EPA, 2004) with high conservation and environmental values.

Brickwood Reserve also contains remnant vegetation that is considered highly significant. The reserve is listed as Bush Forever site 321 and contains at least five priority taxa and three declared rare flora species (Statewest 2005), as well as eucalyptus woodland.

The northern portion of the remnant vegetation between the rail line and South Western Highway north of Cardup Brook is currently proposed to be listed as Bush Forever site 350.

Cardup nature reserve, which lies just outside the southern boundary of the study area, is classified as Bush Forever sites 271 and 352 and contains at least four priority taxa.

The two old shale quarries at the base of the scarp carry permanent water and have some conservation value, but are not now listed as wetlands under the *EPP policy* (Statewest et al. 2005).

2.5 Social considerations

The Department of Indigenous Affairs has previously identified several sites of indigenous significance in the Byford townsite study area. These sites are mostly concentrated around the Cardup Brook and its floodplain, but also other smaller sites around the catchment.

The locations of these sites are identified in Figure A-4 and have been considered in developing this report. 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.

2.6 Surface water

A number of small creeks drain across the site from the scarp, including Oaklands Drain, Beenyup Brook and Cardup Brook. The most ecologically significant of these is Cardup Brook. The brook touches the southern edge of the study area. Beenyup Brook drains through the central south and two small creek lines drain across the northern parts. Each of these creeks is highly incised and the bottoms of these creeks are usually a few metres below the surrounding land surface.


Oaklands Drain (GHD,2006)

Beenyup and Cardup Brooks have linkages to the west through constructed drains and discharge to the Birrega main drain. These watercourses eventually discharge to the Serpentine River system, which links to the Peel-Harvey Estuary.

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.

Virtually the whole study area is designated as multiple use wetlands, with several areas designated resource enhancement or conservation category. The most significant of these wetlands lie within the Brickwood Reserve and along the course of the Cardup Brook (Figure A-4). A further conservation category is located downstream of the study area on the Beenyup Brook.

Surface water quality

Limited surface water quality data is available within the study area. The S*napshot 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 located 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 of the 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.

The *Draft water quality improvement plan for the rivers and estuary of the Peel-Harvey System* (2007) has considered further the water quality of the Serpentine, Harvey and Murray catchments. Specifically this plan states objectives for total phosphorous and indicates the percentage reduction required in each subcatchment to achieve the objectives. Recommendations from the plan have been incorporated into the water quality management strategies presented in section 6.3.

2.7 Groundwater

Groundwater flows

Geotechnical and groundwater investigations have been undertaken by Parsons-Brinkerhoff as part of the *Byford urban stormwater management strategy* and separately by the Water Corporation. Results from field measurements indicate that groundwater levels are typically 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 100 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.

Local scale groundwater modelling has also been completed by CyMod Systems (2007) for the Department of Water to assess any impacts from variations in climate or planned development in the study area.

The groundwater model was run for three scenarios: no development under average rainfall conditions (current climate); proposed development under average conditions;

and proposed development under wet rainfall conditions. Dry conditions were not selected as a post-development groundwater model.

Further information regarding the selection of pre- and post-development model scenarios and the construction and calibration of the groundwater model may be gained by requesting a copy of the *Groundwater modelling report* (CyMod Systems, 2007) from the Department of Water.

The study suggests that historical groundwater levels may be used as a basis for groundwater design objectives, given the overall downward trend in groundwater levels after 1995 due to the combination of abstraction of groundwater from bores and decreased rainfall.

There is only one long-term monitoring bore within the study area (T170, AWRC site No - 61410153), which is situated close to the intersection of Thomas Road and Hopkinson Road/Tonkin Highway (Figure A-5). The long-term maximum groundwater level at this location is 26.8 m Australian height datum, which correlates well to the *Perth groundwater atlas* 27 m maximum groundwater level contour that passes within 70 m of the bore's location. However, because the groundwater atlas coverage extends less than a kilometre into the study area and the CyMod model has not been used to analyse a pre-development wet scenario, maximum groundwater level cannot be presented at this time.

In order to provide recommendations for fill requirements appropriate to protection of infrastructure against likely maximum groundwater levels, further groundwater measurement, modelling or investigation must be carried out by developers to determine maximum groundwater levels over the proposed development site.

Groundwater quality

There is very limited groundwater quality data available for the study area. 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).

3 Proposed development

3.1 Key elements of the structure plan

The *Byford structure plan* (Taylor Burrell Barnett, 2005) (Figure A-7) outlines the Serpentine Jarrahdale Shire's proposed plan for future subdivision and development/ redevelopment of the townsite and the surrounding rural residential area. The plan will have an impact on the surface water management strategy for the study area, as it will define on a district-scale the areas available for surface drainage infrastructure and corridors. There is flexibility within the plan on the types of best management practices that may be used for surface and groundwater quantity and quality management.

The *Byford structure plan* excludes the Byford Trotting Complex and surrounding rural residential areas that are not intended to be developed within the next 20 years.

The plan proposes substantial development of low-lying, rural floodplain areas. Much of the proposed development is residential (R2.5 to R60) and rural residential with a number of schools and pockets of mixed commercial and town centre.

Drainage corridors and proposed drainage basin locations have been included in the plan in accordance with the *Byford urban stormwater management strategy* (PB, 2003).

Since 2004, residential subdivisions in the *Byford structure plan* area have commenced. These developments have involved some minor clearing of trees and very extensive amounts of filling.

A particular concern, raised by the *Byford floodplain management study* (SKM, 2007), and confirmed by hydrologic and hydraulic modelling carried out as a part of this study, is that the main proposed town centre site is situated in an area at substantial risk of flooding. The *Byford structure plan* currently indicates that drainage through this area will be piped (there are no indicated drainage corridors) with an indicative overland flow path down Abernethy Road. However, the plan does include a public open space corridor between the railway line to the east and the trotting complex to the west and it may be possible to incorporate a waterway into this corridor subject to detailed engineering design at the local structure plan stage.

Future local structure plans, accompanied by local water management strategies, must address this issue. They must incorporate appropriate drainage corridors and infrastructure for the Beenyup Brook at this location as well as making provision for overland flood routing between the Beenyup Brook, Abernethy Road and the most southerly branch of the Oaklands drain as outlined in Section 6.2 of this report.

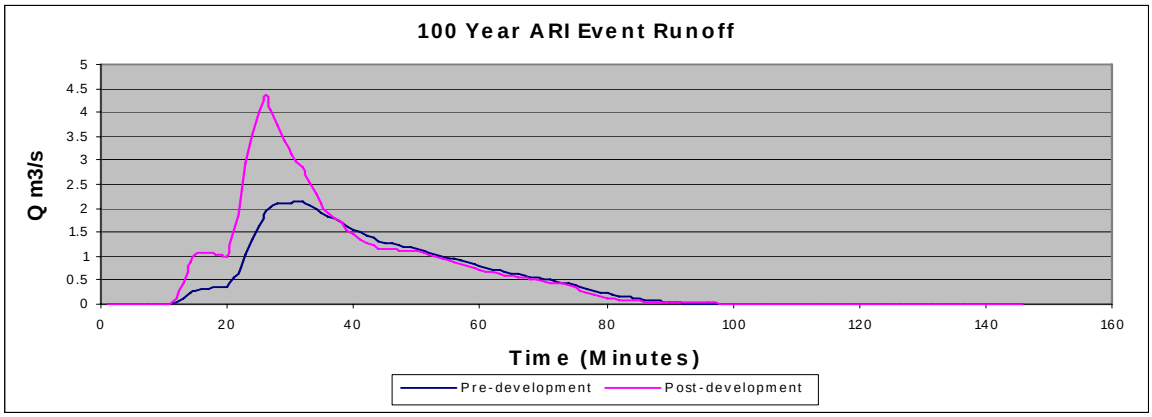
4 Protection of environmental assets

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

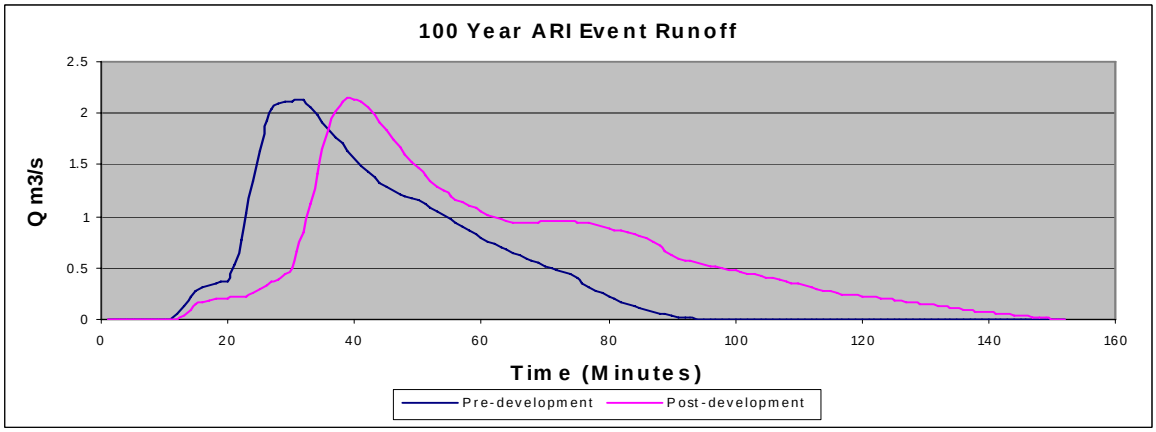
Changes in land use from rural to urban may lead to local increases in peak flows and volumes of runoff due to increases in impervious area (Figure 4.1 below). Large increases in peak flows and volumes have the potential to adversely impact on receiving environments by causing erosion and increasing the period of inundation of vegetation.

Figure 4-1 Typical pre- and post-development runoff hydrograph comparison.



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 4.2 below). 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 4-2 Typical pre- and post-development runoff hydrograph comparison, with compensated post-development flows.



Virtually the whole study area is designated as multiple use wetlands, with several areas designated resource enhancement wetlands or conservation category. The

most significant of these wetlands lie within the Brickwood Reserve and along the course of the Cardup Brook (Figure A-4). The Brickwood Reserve is upstream of the proposed development area and as such, no significant impact is anticipated. The preservation of the pre-development hydraulic grade line along the Cardup Brook will ensure that the potential for development impacts to this area will be minimised.

A further conservation category is located downstream of the study area on the Beenyup Brook. It is anticipated that the maintenance of pre-development peak flow rates at the downstream end of the study area, using the Hopkinson Road culverts as a critical control point, will ensure that there is no impact on this wetland.

Development will result in the loss of significant areas of multiple use wetlands. The addition of imported fill and subsurface drainage will control groundwater levels and soil wetness and therefore reduce the extent of inundated areas. 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.

Manage and restore watercourses and wetlands

There are wetlands classified as conservation category and resource enhancement wetlands within the Brickwood Reserve in the south-eastern section of the study area (Figure A-4). The Environmental Protection Agency requires all conservation categories to be protected and managed for conservation purposes. The agency also recommends the consideration of existing watercourses and inclusion of requirements for restoration, revegetation and reservation of an appropriate corridor width. Various guidelines are available for all aspects of wetland and watercourse protection and restoration and are published by the Department of Water and Department of Environment and Conservation.

Assess and manage impacts on native flora and fauna

There are a number of declared rare and priority flora species within the study area, with one species shown (CALM 2003). 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.

Assess and manage impacts on sites of indigenous significance

As discussed in section 2.5 of this report, the Department of Indigenous Affairs has identified several sites of indigenous significance 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.

5 Urban water use

The key objectives for urban water use are to:

- ensure the efficient use of all water resources in the newly-developing urban form and aim to achieve highest value use of fit-for-purpose water
- 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 supply

The State Government has identified demand reduction and efficient use of potable water as a priority. The *State water plan* (Government of Western Australia 2007) sets household consumption targets of less than 100 kilolitres per person per year (kL/person/year for consumers within Perth and not more than 40 to 60 kL/person/yr of scheme water.

Gardens (private and public) and public open space areas need to be waterwise in design to minimise irrigation requirements. Low water requirement plants should be predominantly used and turf areas should be kept to a minimum.

Tools

5 star plus: water use in houses code–stage 1

5 star plus is based around two new codes: the *Energy use in houses code* and the *Water use in houses code* The *Water use in houses code* has two stages; stage 1 apples to new homes approved for construction after 1 September 2007. The implementation date for stage 2 is yet to be determined (Department of Housing and Works 2007).



Water Efficiency Labelling and Standards Example Label, 2008.

5.2 Fit-for-purpose use water



Recycled water tap, GHD, 2006.

Fit-for-purpose water is often used in applications outside buildings, commonly for maintenance of public open space and passive and active recreation areas. Traditionally demand has been met by groundwater resources.

Development pressure and the drying climate have influenced the need for smarter urban form design and use of water in the urban landscape. Various programs are in place to build in water conservation and efficiency measures for public facilities and space.

The *State water recycling strategy* (Department of Premier and Cabinet and Department of Water 2008) identifies opportunities for new housing developments in Western Australia to access a variety of alternative water supplies. Innovative alternative water supply projects will come to the fore in a time when traditional water

sources reach maximum allocation limits. Assessment of risk, cost-benefit and practicality of these projects will be critical to the success of alternative water supply proposals.

Tools

H2Options (Water Corporation 2008) – a seven-step guide for developers to maximise water efficiency in the Perth metropolitan area. More information can be found at www.watercorporation.com.au/P/publications_alternative_water_supply.cfm

Water conservation/efficiency plans– – the State water recycling strategy (Department of Premier and Cabinet and Department of Water 2008) introduced the concept of water users developing and implementing water conservation/efficiency plans as part of the water licensing process undertaken by the Department of Water and integrating water use efficiency measures into water users' daily operations.

Water conservation/efficiency plans s enable licensees to obtain a thorough knowledge of their water use and then provide details of a water efficiency implementation program to achieve improved water use efficiency.

International council for local environmental issues (ICLEI) water campaign™ – a collaborative program (of which the State Government is a partner) to build the capacity of local government to reduce water consumption and improve local water quality. More information about this program can be found at <www.iclei.org>.

Other documents that may provide guidance are:

- *Interim position statement: constructed lakes* (Department of Water 2007)
- *Interim position statement: third pipe (community bores*) (Department of Water in press)
- *Structural controls, stormwater management manual for Western Australia* (Department of Environment and Swan River Trust 2007).

6 Stormwater management strategy

The key objectives for surface water management are:

- protection of wetlands and waterways from the impacts of urban runoff
- protection of infrastructure and assets from flooding and inundation

6.1 Floodplain management

Recommendations for floodplain management are presented in the *Floodplain management strategy* (SKM, 2007). This study developed two-dimensional modelling of the Byford catchment and resulted in the identification of floodway and flood fringe areas. The proposed *Floodplain management plan* includes structural and non-structural measures for flood mitigation focussed on managing potential flooding impacts on the site and to the immediate neighbouring land and drainage infrastructure.


Oaklands Drain
GHD, 2007

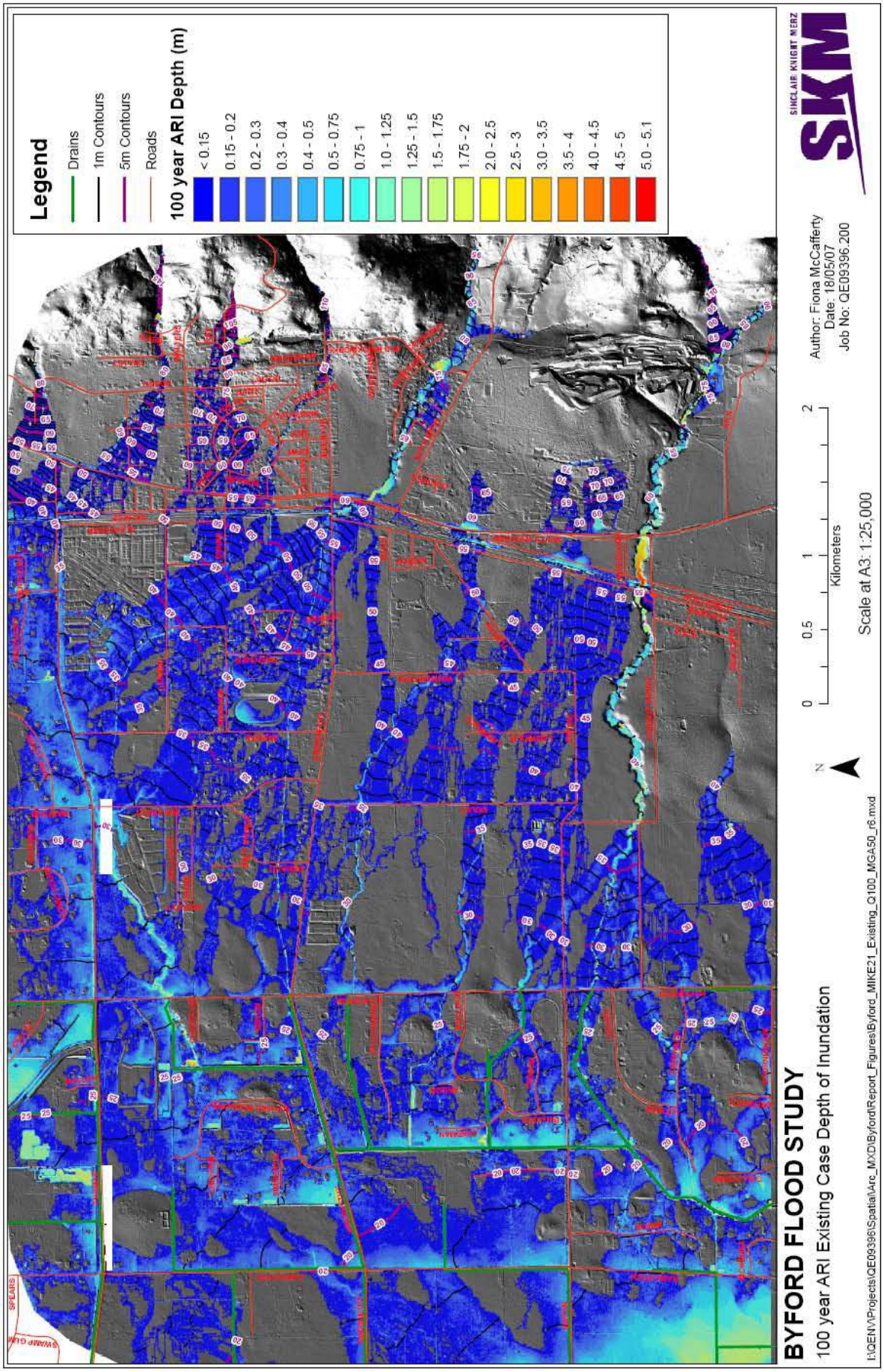
Flood mitigation measures

Flood mitigation measures are focussed on correct planning for appropriate land use in the structure plan areas and setting aside the land required for floodplain inundation depths. Existing and developed scenarios were presented within the *Floodplain management strategy* (SKM, 2007) and the 100-year *existing case depth of inundation* is reproduced in Figure 6-1 below. The 'developed' case includes raised ground levels within subdivisions but no other modifications, such as waterway realignments or new or modified road crossings and so has not been reproduced in this report.

Planning measures recommended by the *Flood plain management strategy* are:

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

Figure 6-1 100 Year ARI existing case depth of inundation (SKM, 2007)



- The design of the new urban areas should incorporate current best practice in water-sensitive urban design to mitigate the impacts of urbanisation in the catchments on regional water quantity and quality.
- The proposed town centre in the structure plan was found by the *Floodplain management strategy,* to be located in an area of existing high or extreme flood hazard. *Drainage and water management plan* modelling indicates that this risk is manageable and a strategy for addressing the flood risk for the proposed town centre is presented in Section 6.2 of this plan.
- Waterways within the structure plan area should be constructed to manage the flooding from the 100-year annual recurrence interval flood event within their channels and floodplains without allowing flooding from the upstream catchment to enter adjacent residential areas.
- New drainage corridors should be designed with consideration of the current practice in water-sensitive urban design by incorporating water quality management controls and riparian vegetation to allow the drainage paths to recover to a more natural state once the agricultural pressures are removed.

A key recommendation within the *Flood management study* (SKM, 2007) was that emergency management planning should be undertaken to identify evacuation routes access for critical emergency services, as well as ensuring that locations are identified for temporary shelter that have sufficient floor level flood clearance.

6.2 Surface water quantity management

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 objectives

- For the critical one-year annual recurrence interval event, the post-development discharge volume and peak flow rates shall be maintained relative to pre-development conditions in all parts of the catchment. Where there are identified impacts on significant ecosystems, desirable environmental flows and/or hydrological cycles shall be maintained or restored as outlined in this report and approved by the Department of Water.
- The catchment runoff shall be managed for all annual recurrence interval events up to and including the 100-year event within the development area to pre-

development peak flow rates. Pre-development critical five and 100-year annual recurrence interval event peak flow rates are specified in Table 6.1 of this report.

- Water-sensitive urban design and best management practices promoting on-site retention of events up to the one–year annual recurrence interval form the basis of the surface water quantity management strategy for minor events.
- The critical five and 100-year annual recurrence interval peak surface water flow rates shall be managed at the downstream end of the development area (Hopkinson Road) to pre-development peak flow rates to minimise the impacts on downstream rural areas to the west of Hopkinson Road.

Manage surface water flows from major events to protect infrastructure and assets

Hydrologic and hydraulic modelling of the study area using InfoWorks CS has determined indicative subcatchment scale peak discharge flows and volumes, detention volumes required to manage surface water flows from major events and hydraulic grade lines within the main waterways.

Detention volumes required to meet the specified five and 100-year annual recurrence interval peak flows are presented in Table 6.1 of this report.

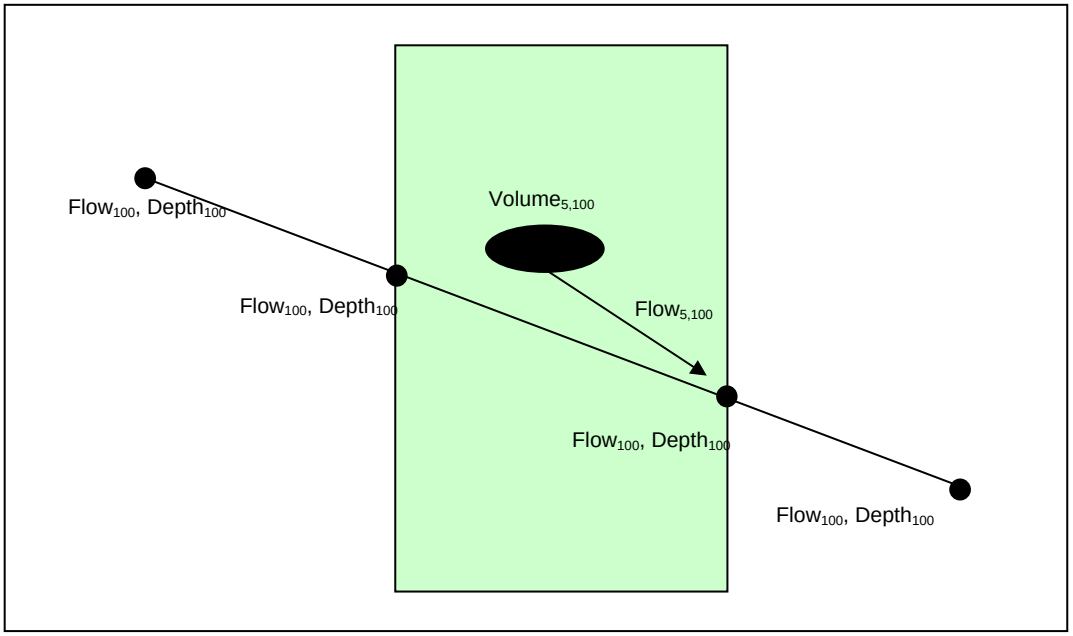
Figure A-8 in Appendix C and Table 6-1 below present the proposed surface water management strategy for Byford townsite. Indicative 100-year annual recurrence interval flood levels, overland flow paths, subcatchment delineation (Figure A-8), and discharge flows and detention volumes (Table 6-1), are provided 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. Longitudinal sections (Figures C-10a-p) of each main watercourse are provided to assist with the design of subdivisional drainage and may be used to accurately determine flows and levels as the waterways pass specific locations that are not necessarily indicated in Figure A-8.

For each subcatchment, the critical five and 100-year annual recurrence interval event pre-development discharge flow rates are presented in Table 6.1 along with an indicative post-development storage volume required to maintain that flow rate. The five-year year event is recommended by the Department of Water as the appropriate event for assessing the serviceability of local drainage, while flow paths and storage areas for the 100-year annual recurrence interval event should be provided for flood management purposes in accordance with the *Australian rainfall and runoff* (IEA,2001) concept of a minor/major drainage system.

It is important to note that the *Drainage and water management plan* model assumes that the one year one hour annual recurrence interval event (from allotments and also from the road network) is retained at source, so this volume is not included in the indicative flood detention volumes provided in table 6.1. Flows from the road network in a one-year annual recurrence interval event should be retained (or detained for the duration of the one-year event) within the road reserve network in a manner that mitigates pollutant export.

Discharge flow rates quoted in Table 6.1 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 indicated by Figure 6.2 below.

Figure 6-2 Schematic presentation of information provided for subcatchments and main waterways



For each modelled node (Figure 6.2) along the main waterways, the critical 100-year annual recurrence interval event hydraulic grade line with associated peak flow rates is presented on longitudinal sections (Figures C-10a-p).

Where a proposed development forms a part of one or more of the subcatchments presented in Figure A-8, the storage volume to be provided by that development should be calculated based on the subcatchment surface area as a percentage of the total subcatchment surface area.

Where there is an inconsistency between the drainage planning criteria presented in this report (Table 6-1) and a previous approval, then the previous approval, and associated developers' obligations, should prevail. However, in a case where greater detention volumes are required by this report (Table 6-1) than those previously approved, an assessment will need to be made of the impact on public and private amenity for the determining event and a judgement made on whether remedial work is required. The issue of who has responsibility for investigation and any remedial work need to be discussed and determined.

Waterway dimensions and alignments as originally developed in the *Byford urban stormwater management strategy* have been retained where possible. Typical cross-sections are presented in Figure A-9. A summary of peak flows, levels and indicative floodway widths at critical locations (Figure A-8) is presented in table 6.2 below.

Table 6-1 Subcatchment drainage planning criteria – ultimate development

Subcatchment ID	Area	Peak discharge flow (m^3/s)		Detention volume (m^3)	
Subdivisional storage basins	(ha)	5 year	100 year	5 year	100 year
10C	24.7	0.4	1.4	2800	5800
3C	68.1	0.4	3.5	9000	20100
3D1	65.1	0.8	3.3	8100	15000
3D2	49.0	0.5	2.3	6200	12900
3D3	12.8	0.3	0.8	1800	3400
3D4	11.4	0.3	0.7	1500	3000
5B	40.3	0.6	1.4	5100	12400
3B3	24.6	0.4	0.9	3100	7500
5E	21.2	0.4	1.3	1800	4400
5F	6.3	0.2	0.4	500	1300
5G	108.9	3.5	9.4	5400	13700
6B	26.9	0.6	1.8	3300	5800
6C	19.8	0.4	1.4	2400	4800
6D1	77.2	0.7	2.8	8000	20200
6F	17.8	0.4	0.6	1900	4700
6D2	16.0	0.3	0.8	2000	3500
6E	20.9	0.4	1.4	2200	4900
7A	57.1	0.6	2.1	6700	15700
7B	46.4	0.7	2.3	5600	10600
7C	29.2	0.6	1.9	2700	6000
7C1	40.8	0.6	1.9	5300	10400
7D	34.0	0.5	1.7	3300	8100
8A	19.0	0.3	0.5	2100	6000
8B	43.1	0.6	1	4700	13600
8C	55.6	0.4	1.4	8400	19200
8D	47.8	0.4	2.6	6600	13300
9B	37.1	0.6	2.1	1700	5800
9C	85.4	1.2	5.3	5300	12800
9D	22.6	0.5	1.4	1000	3100
3B1	31.2	0.5	1.3	5400	8200
3B2	55.2	0.7	2.6	9500	14200

Table 6-2 Flows, levels and floodway widths at critical locations

Location	Peak flows (m^3/s)		Peak levels (m AHD)		Indicative floodway width (m)
Number (Fig. A-8) and description	5 Year ARI	100 Year ARI	5 Year ARI	100 Year ARI	100 Year ARI
1. Oaklands drain d/s George Road (north)	5.5	10.2	53.2	53.5	40
2. Oaklands drain d/s George Road (south)	2.4	10.7	51.8	52.0	40
3. Oaklands drain d/s Evans Road	10.7	34.5	44.3	44.6	32
4. Oaklands drain d/s Briggs Road	11.0	30.2	32.7	32.9	70
5. Oaklands drain at Thomas Road and Masters Road	9.5	25.7	30.9	31.1	50
6. Oaklands drain d/s Malarkey Road	20.8	59.3	29.8	30.2	50
7. Oaklands drain at Hopkinson Road	15.7	48.9	26.4	26.9	60
8. Beenyup Brook d/s South Western Hwy	8.1	31.2	58.5	58.7	40
9. u/s end piped Beenyup Brook d/s Abernethy Road	2.8	3.1	56.5	56.6	-
10. u/s end swale from Beenyup Brook to Oaklands drain	5.2	16.1	56.5	56.6	10
11. u/s end swale down Abernethy Rd from Beenyup Brook to Trib 6	0.0	11.5	56.3	56.8	10
12. overland flow down Warrington Road	0.0	1.3	44.5	45.4	10
13. overland flow down Doley Road	0.0	2.7	34.5	35.5	10
14. Beenyup Brook at Hopkinson Road	8.1	9.6	26.0	26.3	40
15. Tributary 6 u/s Briggs Road (Extn)	1.4	3.4	41.6	41.7	40
16. Tributary 6 at Hopkinson Road	1.6	6.7	27.6	27.7	50
17. Tributary 7 at Hopkinson Road	2.0	5.1	27.1	27.2	50
18. Cardup Brook d/s South Western Hwy	5.8	23.5	55.1	57.1	70
19. Cardup Brook at Hopkinson Road	9.4	33.2	27.6	27.9	50

Notes:

- Flows at Hopkinson Road in the 100 year ARI event provided in this table include flow overtopping the road and are therefore greater than those shown on the longitudinal sections (Figure A-10).

A regional flood management strategy has been developed to address the flood risk at the town centre. The strategy is presented in Figure A-8 and Table 6.2 above and includes the construction of a new high-level overflow into a swale drain along the length of Abernethy Road, as well as provision of an overland flow path or swale connecting Beenyup Brook with Oaklands drain and a piped section of Beenyup Brook.

The location and design of this infrastructure are conceptual only and may be modified to suit local design requirements.

Funding for the design and construction of regional flood management measures will need to be provided via a developer contribution scheme. Details of this scheme are being developed by the Serpentine Jarrahdale Shire and the Western Australian Planning Commission.

There will be some flooding of the road surface in Warrington and Doley Roads. Modelling indicates that the product of depths and velocities on these road surfaces will not exceed 0.4 m^2/s as recommended in *Australian rainfall and runoff* (IEA, 2001) to prevent pedestrians being swept along.

6.3 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.



Oaklands drain

GHD, 2007

To minimise the average annual load of pollutants discharged by stormwater management systems into receiving environments, appropriate site-specific targets will be developed and adopted as indicated by the *Draft water quality improvement plan for the rivers and estuary of the Peel-Harvey system, Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992* (Government of Western Australia) and other investigations underway.

The *Water quality improvement plan* has been developed to address catchment management measures and control actions relating to phosphorus, but does not specify site-specific design criteria. Until the outcomes of other investigations are known, and site-specific targets have been developed, interim targets will be adopted and are presented in section 6.4 of this *Drainage and water management plan*.

The water quality objectives of the plan are:

Median loadings of total phosphorus to estuarine waters should be less than 75 tonnes per annum in an average year with;

- the median load of total phosphorus flowing in the estuary from the Serpentine River being less than 21 tonnes

Water qualities in streams in winter are to meet mean concentrations of 0.1 mg/L TP at current mean flows.

In the Upper Serpentine catchment, the plan found that winter concentrations were in

the range 0.1-0.2 mg/l and total winter loads were in the range 15-20 tonnes.

The draft *Water quality improvement plan* specifies that reductions of 30-40 per cent for load and concentration are required in the upper Serpentine catchment to meet its objectives and recommends the following best management practices for urban areas:

Table 6-3 Recommended best management practices

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

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

The *Water quality improvement plan* has been developed to address catchment management measures and control actions relating only to phosphorus loads to the waterways. The Environmental Protection Authority recognises that there are other problems within the Peel-Harvey system. These include the nitrogen concentrations in estuarine waters; estuarine and riverine habitat loss; acid soil drainage; and bacteria concentrations – animal and human effluent. All of these problems require action.

Further investigations are already underway on these issues and will become components of a catchment management plan, as required in the 1989 environmental conditions, subsequently amended in 1991 and 1993 (Environmental Protection Authority, 2003).

Water quality treatment systems and water-sensitive urban design structures to meet these objectives must be designed, implemented and managed in accordance with the *Stormwater management manual for Western Australia* (Department of Water, 2007) and *Australian runoff quality* (Engineers Australia, 2006).

6.4 Key design criteria

Surface water quantity

- The one-year one-hour annual recurrence interval event shall be detained at source for the duration of the event through the use of retention (soakage) or storage devices. Refer to Chapter 9 of the *Stormwater management manual for Western Australia* (Department of Water, 2007) for devices suited to the soil types for this catchment. The manual contains guidance for the appropriate design of retention and detention systems.
- The post-development critical one-year annual recurrence interval peak flow and volume and the 100-year annual recurrence interval peak flow shall be consistent with pre-development flows at:
    - the discharge points of all subdivisions into waterways
    - the discharge points from the structure plan area (Hopkinson Road)
    - the discharge points of each subcatchment
- Flows from developed areas must be attenuated, in accordance with Table 6-1 in flood detention/storage areas incorporated into public open space within the subdivision and located outside defined floodways(Figure A-8);

- Post-development flows for all annual recurrence interval events must be discharged at flow rates that are consistent with pre-development flow rates for those same events.
- Floodways are defined on Figure A-8 and contain the regional 100-year annual recurrence interval event flow. Floodways may not be developed or obstructed in any way and are entirely separate from the storage volumes presented in Table 6.1.
- Developments outside the floodway should ensure finished floor levels at a minimum of 0.5 m above the 100 year flood level.
- The existing cross-sectional area of waterways must be maintained. Restoration of waterways is essential and 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 the beds and banks of waterways under the *Rights in Water and Irrigation Act 1914.*
- Public open space and retention basins should operate as dry basins with a minimum clearance of 0.3 m between the controlled groundwater level and the invert of the basin. Wet basins are not recommended by the Department of Water and are unlikely to be approved by the Serpentine Jarrahdale Shire.
- Defined major arterial roads should remain passable in the 100-year annual recurrence interval 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 five- year annual recurrence interval event.
- Emergency evacuation areas should be defined at least 2.0 m above the 100-year annual recurrence interval event level.
- Water quality treatment systems and water-sensitive urban design structures must be designed in accordance with the *Stormwater management manual for Western Australia* (Department of Water 2007) and *Australian runoff quality* (Engineers Australia 2006).

Surface water quality

The Department of Water is currently developing water quality targets that will be finalised in 2008. In the interim, designs may be based on the methodology established in the *Stormwater management manual for Western Australia* (Department of Water 2007).

Targets are to be achieved through adopting a treatment train approach including:

- non-structural measures to reduce applied nutrient loads
- on-site retention of one-year one-hour annual recurrence interval events

- bioretention structures/systems, (also referred to as ‘rain gardens’) to be sized at two per cent of connected impervious areas

If it is proposed to use a computer stormwater modelling tool to assess a proposed water quality management strategy, the following design targets are recommended:

As compared with a development that does not actively manage water quality, developments must achieve:

- at least 80 per cent reduction of total suspended solids
- at least 60 per cent reduction of total phosphorus
- at least 45 per cent reduction of total nitrogen
- at least 70 per cent reduction of gross pollutants

Proponents shall develop and present the strategies for water quantity and quality management in the local water management strategy and urban water management plans to support the planning approvals required for the development to proceed.

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

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

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

Controlled groundwater level

Controlled groundwater level is a groundwater level endorsed by the Department of Water. Sub-surface drainage may not be installed below the controlled groundwater level.

The actual level selected will vary according to availability of data and/or modelling results. Commonly, when a modelling approach is used, the rainfall record for a year with close to average rainfall for the current climate is run and the winter maximum groundwater level for this scenario becomes the controlled groundwater level. Alternatively, where a historical groundwater record is available, the average of recorded maxima for a selected period of record that is representative of the current climate may be chosen.

Maximum groundwater level

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

Developments will be required to make the development surface level 1.2 m above the maximum groundwater level, if subsurface drainage is not installed.

Phreatic line

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

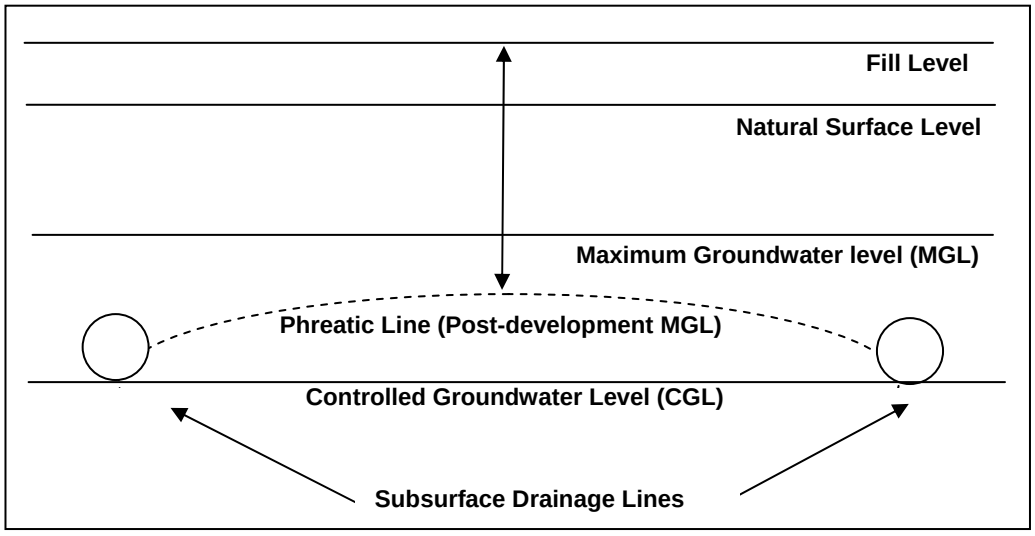
When subsurface drainage is installed the phreatic line becomes the level from which building floor level clearance to groundwater is measured.

Meeting the groundwater clearance and subsurface drainage criteria

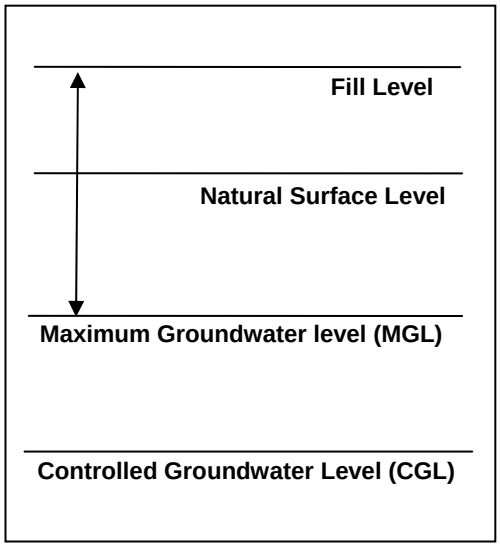
Examples of different ways in which the groundwater clearance and subsurface drainage criteria may be met under different conditions are presented below.

Case 1: The natural surface is less than 1.2 m above maximum groundwater level. Subsurface drainage is installed at controlled groundwater level to control the maximum groundwater level. However, because the natural surface is less than 1.2

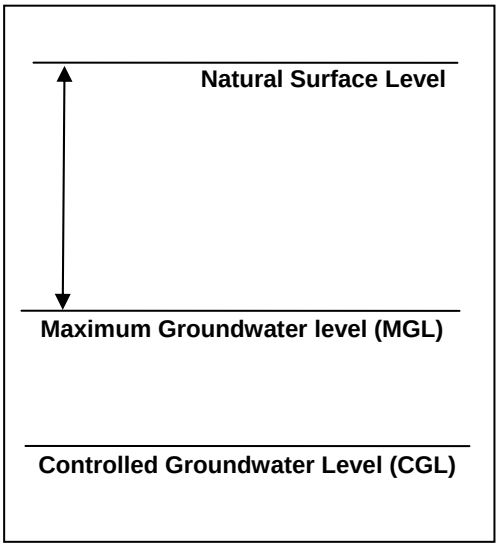
m above the resultant phreatic line, some additional fill has also been provided to meet the minimum clearance requirement.



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



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



7.2 Groundwater quantity management

Manage groundwater levels to protect infrastructure and assets

To protect housing from flooding and damage from groundwater, the predicted maximum groundwater level must be determined, through modelling and/or measurement. Where this information is not available, local studies shall be undertaken and endorsed by the Department of Water. Where the predicted maximum groundwater level is at or within 1.2 m of the surface the importation of clean fill and/or the provision of sub surface, drainage will be required to ensure that

adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub-surface drainage will need to be placed at a Department of Water/Department of Environment and Conservation approved controlled groundwater level.

Groundwater modelling (CyMod Systems, 2007) included three scenarios – no development under average rainfall conditions (current climate) and proposed development under both average and wet rainfall conditions. Dry conditions were not selected as a post-development groundwater model.

Further information regarding the selection of pre- and post-development model scenarios and the construction and calibration of the groundwater model may be gained by requesting a copy of the *Groundwater modelling report* (CyMod Systems, 2007) from the Department of Water.

The district scale predicted maximum groundwater level has not been defined at this time for the study area. Localised perching that is common within this catchment cannot be accurately represented by district scale modelling and must be considered when determining the local scale predicted maximum groundwater level, which is important for the protection of urban infrastructure.

The district scale controlled groundwater level adopted for the study area and presented in Figure A-5 is the pre-development average rainfall scenario as modelled by CyMod Systems (2007).

Further investigations will be required to determine local scale predicted maximum groundwater level for individual developments to determine whether subsurface drainage is required for protection of urban infrastructure. This drainage should always be located at or above the district scale controlled groundwater level as presented in Figure A-5.

Maintain groundwater regimes for the protection of groundwater-dependent ecosystems

To ensure protection of groundwater dependent ecosystems, local studies to model and/or measure groundwater levels and refine the district scale controlled groundwater level shall be undertaken and endorsed by the Department of Water.

It has been identified that localised perching of groundwater is quite extensive within the development area. Where there is a groundwater-dependent ecosystem that is reliant on this seasonal perched groundwater, it will be necessary to maintain this regime. Investigations to derive a local scale controlled groundwater level shall be undertaken and endorsed by the Department of Water.

Local controlled groundwater levels must be developed with consideration of ecological water requirements for groundwater-dependent ecosystems, such as wetlands. Determination of ecological water requirements of groundwater-dependent ecosystems is outlined in the *Urban development and determination of ecological water requirements of groundwater-dependent ecosystems* (Department of Water, in preparation).

Once the ecological water requirements have been determined, controlled groundwater levels can then be finalised in accordance with the requirements of the *Decision process for stormwater management in WA* (Department of Environment and Swan River Trust, 2005). Controlled groundwater levels should always aim to meet ecological water requirements. However, if ecological water requirements cannot be met, the likely impacts on the groundwater-dependent ecosystems values should be outlined.

Any proposals to control the seasonal or long-term maximum groundwater levels through a controlled groundwater level approach should demonstrate through adequate field investigations, to the satisfaction of the Department of Water, how any local and regional impacts are to be managed.

Manage the shallow aquifer to protect the value of groundwater resources

Groundwater in the area is currently used for domestic and commercial purposes and is potentially an important source of water for new development in the area.

Groundwater modelling (CyMod Systems, 2007) has indicated that unmanaged future bore usage will result in long-term lowering of groundwater levels. Results for both of the proposed development scenarios predict decreases in groundwater levels when compared to the pre-development case. These results indicate that the level of bore usage assumed for the purposes of groundwater modelling cannot be supported. The post-development wet rainfall sequence scenario predicts groundwater levels of 0.40 m higher than those predicted for the average rainfall scenario, although they are still lower than those in the pre-development scenario.

In addition, the introduction of subsurface drainage may result in reduced aquifer recharge as a result of the loss of seasonal perching and its slow subsidence.

If groundwater abstraction is to be supported for new development in the area, a water balance should be prepared as a part of a local water management strategy to identify the potential long-term impacts. Ongoing monitoring and control will be essential.

7.3 Groundwater quality management

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

Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the (sub) catchment in which the development is located.

Water sensitive urban design and best management practices must not only promote infiltration to aid in prevention of possible local flooding from increased runoff due to urbanisation; but they must also treat the water prior to its discharge to waterways, wetlands and to groundwater. This is particularly important given the high variability in phosphorus retention capacity of the soils in the study area and the anticipated increase in nutrient load due to urbanisation.

Where subsoil drainage is installed for groundwater level or soil moisture control, a 'treatment system' (swale/bioretention etc) at each subsoil drain outlet point will be required. The *Stormwater management manual for Western Australia* (Department of Water 2004-07) contains guidance for the design of subsoil drainage, appropriate to calculated flow rates.

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 Environment and Conservation.

Contaminated sites must be managed in accordance with the *Contaminated Sites Act 2003*.

7.4 Key design criteria

- Where a perched water table exists or the predicted maximum groundwater level is at or within 1.2 m of the natural ground level, the importation of clean fill and/or the provision of sub-surface drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub-surface drainage will need to be placed at or above the approved controlled groundwater level.
- The bio-retention system and drainage inverts are set at or above controlled groundwater level although existing inverts below the level may remain.
- Subsurface drainage is to be installed at or above controlled groundwater level.
- Subsurface drainage must be designed with free-draining outlets.
- Development should ensure finished lot levels at a minimum of 0.8 m above the phreatic line.
- The clean fill imported onto the site is to incorporate a band of material that will reduce phosphorus export via soil leaching, whilst also meeting soil permeability and soil compaction criteria specified by the local government authority.
- Where development is associated with any new or existing waterway or open drain that intersects the shallow water table, and that may discharge pollutants from the shallow groundwater to receiving environments, the following interim targets will be adopted until such time as appropriate site-specific targets are developed:

As compared with a development that does not actively manage water quality, the following should be achieved:

- at least 60 per cent reduction of total phosphorous
- at least 45 per cent reduction of total nitrogen

Where development is associated with an ecosystem that is dependent on a particular hydrologic regime for survival, the water quality discharged to the

groundwater must be in accordance with the requirements of the Department of Environment and Conservation.

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

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

8 Commitment to best management practice

In order to meet the design criteria of reductions in total phosphorus, total nitrogen, total suspended solids and gross pollutants as compared to developments in which water treatment is not undertaken, it is necessary to use a combination of best management practice strategies.

In addition, best management practice strategies reduce risks of flooding on housing and infrastructure while maximising the potential for stormwater to be treated as a resource.

The existing *Byford structure plan* (Figure A-7) includes realignment of some multiple use corridors away from existing natural drainage features and alignments. It is the recommendation of this study that the *Byford structure plan* should be amended to rectify this anomaly and include the drainage corridors presented in Figure A-8 of this *Drainage and water management plan.*

The hierarchy of best management practice principles is as follows:

implement controls at or near the source to prevent pollutants entering the system and/or treat stormwater

- install in-transit measures to treat stormwater and mitigate pollutants that have entered the conveyance system
- implement end-of-pipe controls to treat stormwater, addressing any remaining pollutants prior to discharging to receiving environments

Structural and non-structural best management practice strategies must be used in combination to achieve the required stormwater treatment outcomes.

Recommended best management practices in increasing order of scale include:

- residential lot scale:
    - 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
- Commercial lot scale:
    - on-site detention and/or retention
    - water-wise and nutrient-wise landscaping
    - maximised permeable surfaces



Rainwater tank, GHD, 2007

  - porous pavements
  - amended topsoils
  - landscaped infiltration structures
  - hydrocarbon management and sediment traps
  - rainwater tanks for harvesting, detention and re-use
- Street scale:
  - infiltration measures
  - sediment traps
  - porous pavements (car parking)
  - conveyance bioretention systems



Biofiltration pocket
GHD, 2007

- Estate scale:
  - retention/detention (including water quality treatment) areas integrated within public open space, in accordance with the objectives and requirements of Elements 4 (Public parkland) and 5 (Urban water management) of *Liveable Neighbourhoods Edition 4*(In preparation)
  - use of imported fill material with a high phosphorous retention capability
  - retention of existing waterways and restoration of a pre-development ecology and channel morphology in new and existing waterways
  - non-structural best management practices such as interpretive signage, garden education programs, publishing a water-sensitive urban design web-page for the estate and inviting residents to engage with existing community catchment groups
- Area scale:
  - non-structural best management practices such as public education campaigns, support of local community catchment groups, installation of interpretive signage and web pages and the adoption of appropriate planning principles including local laws for on-site detention and retention

The above practices may be limited by several factors, including: local soil and hydrological conditions, the depth and type of fill imported, public safety and public health standards, design life/reliability requirements, maintenance/management costs, legal authority and streetscape aesthetics. Advice should be sought from the local authority on the practices most appropriate for adoption within the Byford townsite.

9 Implementation

9.1 Requirements for following stages

State planning policy 2.9: water resources (Government of WA, 2006) requires that planning should contribute to the protection and wise management of water resources through local and regional planning strategies, structure plans, schemes, subdivisions, strata subdivisions and development applications. *Better urban water ,management* (in preparation for the Department of Planning and Infrastructure, Department of Water, Western Australian Local Government Authority and Department of Environment, Water, Heritage and the Arts by Essential Environmental Services, 2008 provides guidance on implementation of *State planning policy 2.9.* It identifies the requirements for water management strategies and plans that must be developed to accompany the land use planning and approvals process in the *Drainage and water management plan* area at each stage of the planning process

In summary, all local structure planning should incorporate a local water management strategy consistent with the strategies and objectives of this *Drainage and water management plan*. Subsequent subdivision applications should be accompanied by an urban water management plan where required by the Department of Water and Serpentine Jarrahdale Shire, and/or should be consistent with any approved local water management strategy and with the strategies and objectives of this *Drainage and water management plan.* Guidelines for local water management strategies and urban water management plans are in preparation by the Department of Water. In the interim the Department of Water regional office can be contacted for guidance on the requirements of these documents. Developers are encouraged to contact the Department of Water and Serpentine Jarrahdale Shire early in the planning process to discuss specific water management requirements for proposals

It is recommended that the *Byford structure plan* (Figure A-7) be modified to reflect the recommendations of this *Drainage and water management plan* and to remove reference to the *Byford urban stormwater management strategy* (SJ Shire 2003). Furthermore, it is recommended that the *Shire of Serpentine Jarrahdale town planning scheme No. 2* be amended to remove reference to the *Byford stormwater management strategy.*

9.2 Review of Drainage and water management plan

It is intended that the *Drainage and water management plan* be reviewed within ten years or earlier if deemed necessary until development has occurred consistent with the Byford structure plan.

The review should be undertaken by the Department of Water, with agreement from the Environmental Protection Authority, Western Australian Planning Commission, Serpentine Jarrahdale Shire and the Water Corporation. The review should cover, but not be limited to the following:

- assessment of impacts of development
- design objectives
- requirements for local water management strategies and urban water management plans
- cost-recovery mechanisms

9.3 Monitoring strategy

A groundwater and surface water monitoring program should be designed as part of the local water management strategy to assess the hydrological impacts of the proposed development and to establish a contingency action plan with associated trigger values for specified parameters.

The baseline monitoring program should be conducted for at least three years prior to development to characterise the sites hydrology and hydrogeology. However in some cases it may be acceptable to provide 18 months of pre-development monitoring with a minimum of two winters where the monitored hydrology and hydrogeology is considered suitably reflective of the long-term environment, and approval has been given by the Department of Water. The results of the baseline monitoring strategy should be presented in the final local water management strategy.

The post-development monitoring program should be tailored to the development, quantifying the development's impact on surfaces water quality, surface water flows, groundwater levels seasonal fluctuation and quality.

The monitoring results can then provide:

- pre-development baseline data
- post-development comparison to target design objectives and criteria
- a trigger for contingency action, as per the contingency plan
- an interim internal assessment tool of the monitoring programme

All monitoring results should be provided to the Department of Water in an agreed format. A report on these results is not usually required; however where a trigger for contingency action has been reached, it will be necessary to report on the action taken.

Standards

Monitoring sampling should follow Australian Standards AS/NZ 5667 series of *Water quality sampling* guidance notes and a National Association of Testing Authorities accredited laboratory is required to perform water quality testing.

Monitoring network

The groundwater monitoring bore network's extent and density should spatially represent the hydrogeology of the local area, to the satisfaction of the local government and Department of Water.

Surface water monitoring sites should capture inflows and outflows for the whole site, all detention or retention storages, and any water dependent ecosystems.

Monitoring parameters

Monitoring of groundwater levels should be initially on a monthly basis to establish water level fluctuations. Surface water monitoring requirements are site-specific and must meet the regulatory bodies' recommendations.

Samples should be analysed for at least the following water quality parameters:

- *in-situ* pH, electrical conductivity and temperature
- heavy metals - arsenic, cadmium, chromium, copper, lead, nickel, zinc, mercury
- total suspended solids
- total nitrogen and total kjeldahl nitrogen
- ammonia (NH4)
- nitrate and nitrite (NO_x)
- total phosphorus (TP)
- orthophosphate (PO_4^{3-})



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

- total titratable acidity and total alkalinity
- major anions (chloride, bromide and sulphate)
- major cations (calcium, magnesium, sodium and potassium)
- iron and aluminium

The effective management of urban stormwater quality typically focuses on the treatment of frequent, low-intensity stormwater events. These small but frequent flows account for the majority of nutrient loads and represent the best opportunity for water quality improvement.

The process of infiltration filters the stormwater and is effective in the removal of particulate nutrients. Dissolved nutrients cannot be filtered and are therefore more difficult to treat. Urban runoff is a combination of dissolved and particulate nutrients.

If the treatment measure is infiltration, then filtered and unfiltered samples of total nutrient concentrations should be measured to quantify the proportion of dissolved and particulate nutrients generated within the development site, and the method recorded.

A summary of an example monitoring program is presented in Table 9-1 below. The format and frequency of post-development reporting should be proposed within the local water management strategy and approved by the local government and Department of Water. Where a trigger for contingency action, as specified in the

local water management strategy is reached, it will be necessary to report on the action taken.

Table 9-1 Monitoring programme summary

	Sites	Frequency	Parameters
Surface water	Developments inflow and outflow locations Detention storages inflow and outflow Water bodies	Site specific	-Flows -Water levels
		Monthly grab samples while flowing, to be reviewed after the first year of monitoring	-**In-situ** pH, EC and temperature. -**Unfiltered sample**: pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals -**Filtered sample**: nitrate/nitrite and PO4,
Groundwater	Network of monitoring bores providing a suitable spatial representation of the study area.	Monthly	Water level
		Quarterly (typically Jan, Apr, July, Oct)	-**In-situ** pH, EC and temperature. -**Unfiltered sample**: pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals -**Filtered sample**: nitrate/nitrite and PO4

A summary of monitoring requirements and responsibilities is provided in Table 9-2.

Table 9-2 Assessment requirements of development proposals - monitoring

Responsible Agency	Timing	Monitoring Requirement
Developers	Period of 3 years pre-development (minimum of 18 months with at least 2 winters with approval of DoW)	Monitor key criteria for maintenance of hydrologic regimes, buffers and ecological corridors/linkages of environmental assets Monitor local superficial aquifer groundwater levels Monitor flow and water quality (including nutrients, TSS, and gross pollutants) at regular intervals (monthly) Monitor peak flows (snapshots) within developments and wetlands
	Period of 3 years post-development, including at least 1 year following completion of the majority (80%) of developments	Monitor key criteria for maintenance of hydrologic regimes, buffers and ecological corridors/linkages of environmental assets Monitor local superficial aquifer groundwater levels Monitor flow and water quality (including nutrients, TSS, and gross pollutants) at regular intervals (monthly) Monitor peak flows (snapshots) within developments and wetlands Monitor behavioural patterns with respect to non-structural measures for water quality management Monitor performance of new drainage systems
DoW	Ongoing	Monitor efficacy of water conservation measures and achievement of water consumption targets Monitor regional surface water flows and quality Monitor confined aquifer groundwater levels and regional superficial aquifer groundwater levels and quality Monitor groundwater abstraction in the DSP area Monitor surface water quality and flows at strategic locations in main drains and waterways Monitor structural BMPs for efficacy with advice from the BMP technical reference group Monitor performance of new drainage systems across catchments and property boundaries
SJ Shire – with funding from developer contributions scheme	From 3 years post-development	Monitor key criteria for maintenance of hydrologic regimes, buffers and ecological corridors/linkages of environmental assets Monitor local superficial aquifer groundwater levels Monitor water quality and flows within developments and wetlands Monitor behavioural patterns with respect to non-structural measures for water quality management
DEC	Ongoing	Evaluate health of significant environmental assets

9.4 Action plan

Table 9-3 presents the key actions necessary to implement the proposed *Drainage and water management plan*, identifying the responsible agency and proposed time for completion. SJ Shire refers to Serpentine-Jarrahdale Shire.

Table 9-3 Actions and responsibilities for implementation of the Drainage and water management plan

Strategy	Action	Lead agency	Timing
Protection of environmental assets			
Minimise changes to hydrology to prevent impacts on watercourses and wetlands	Establish a process for ongoing evaluation of the impacts of development on significant environmental assets and review of the strategy	DEC	As part of the planning process
	Identify land required for protection of environmental assets and to allow for the management of their hydrologic regimes	DEC	As part of the planning process
	Incorporate environmental assets as a key part of community planning	DPI and SJ Shire	Through assessment of planning proposals
Manage and restore watercourses and wetlands	Determine post development hydrology for the Cardup and Beenyup Brooks	DoW	Through assessment of LWMS/UWMP
	Develop management plans for the Cardup and Beenyup Brooks consistent with the post development hydrology	SJ Shire	Commencing immediately & ongoing
Assess and manage impacts on native flora and fauna	Provide appropriate buffers and ecological corridors/linkages in local structure plans	WAPC and SJ Shire	Through assessment of planning proposals
	Establish responsibilities for ongoing management of natural areas	DEC and SJ Shire	As part of the planning process
	Undertake more detailed fauna assessments at the local structure plan stage, including details of management measures to deal with issues such as habitat protection, fauna relocation and non-native animal control	WAPC and SJ Shire	Through assessment of planning proposals
Assess and manage impacts on sites of indigenous significance	Undertake more detailed assessments at the local structure plan stage, including details of management measures as required	Developers in consultation with DIA and SJ Shire	Through local structure planning
Surface water management			
Minimise changes in hydrology to prevent impacts on receiving environments	Ensure development complies with the stormwater design objectives for flooding and ecological protection	DoW	Through assessment of LWMS/UWMP
Manage surface water flows from major events to protect infrastructure and assets	Ensure development in the DSP area complies with the stormwater design criteria for flood management in this *Drainage and water management plan*	SJ Shire	Through assessment of LWMS/UWMP
	Secure land that might be required for arterial drainage in the Byford townsite catchment	WAPC and SJ Shire	Through local structure planning

Strategy	Action	Lead agency	Timing
	Design and construct regional flood management infrastructure	SJ Shire with funding from developer contribution scheme	Through local structure planning
Apply the principles of water sensitive urban design	Seek opportunities to include environmental and social objectives in planning of stormwater management, such as incorporation of multiple use corridors to provide habitat values and opportunities for recreation	SJ Shire	Through assessment of local structure plans
	Retain existing natural waterways and drainage lines in the design of stormwater management systems for urban development – requires modification of existing BSP	SJ Shire	Through modification of BSP and assessment of LWMS/UWMP
Adopt nutrient load reduction design objectives for stormwater runoff	Ensure development in the DSP area complies with the design objectives for stormwater quality	SJ Shire	Through assessment of LWMS/UWMP
Groundwater management			
Manage groundwater levels to protect infrastructure and assets	Monitor superficial aquifer groundwater levels pre- and post-development at the local scale	Developers' data to be passed by SJ Shire to DoW for collation	3 years each pre- and post-development
	Monitor confined aquifer groundwater levels and regional superficial aquifer groundwater levels	DoW	Commencing immediately and ongoing
	Investigate potential changes to local water balance and implications for groundwater rise	DoW	Through assessment of LWMS/UWMP
	Manage groundwater levels within ranges reported in this *Drainage and water management plan* via a combination of subsoil drainage at local CGLs, imported fill and groundwater abstraction as appropriate for management of groundwater rise, and via recharge mechanisms for falling groundwater levels	Developers for 3 years post-development, after that time responsibility of SJ Shire	Commencing immediately and ongoing
Maintain groundwater regimes for groundwater dependent ecosystems	Review developers' investigations of local groundwater regime to establish local groundwater management criteria near GDEs	DoW	Through assessment of LWMS/UWMP
Protect the value of groundwater resources	Prepare a groundwater allocation plan for the DSP area	DoW	Commencing immediately and ongoing
Adopt nutrient load reduction design objectives for discharges to groundwater	Ensure development in the DSP area complies with the design objectives for groundwater quality	DoW	Through assessment of LWMS/UWMP
Monitoring and implementation			
Adopt an adaptive management approach	Monitor water quality and flows pre- and post-development, within developments and at strategic locations in waterways This includes both regular (monthly) sampling for flow and water quality and targeted peak flow during storm events Locations to include key outlets to waterways	At the local scale: developers then SJ Shire, data to be passed to DoW for collation At the regional scale (sub-catchment outlets): DoW	3 years pre- and post-development, then ongoing

Strategy	Action	Lead agency	Timing
	Collate and analyse monitoring data to establish baseline water quality data throughout DSP area	Developer to pass data to DoW, DoW to collate and organise data, CSIRO's real-time data collection system to support the data analysis	Commencing immediately and ongoing
	Assess behavioural patterns with respect to non-structural measures and the effectiveness of non-structural measures, using a method such as community-based social marketing	Developer to implement with guidance from local government, local government to take over responsibility 3 years post-development	Ongoing
	Determine efficacy of structural BMPs, provide feedback to developers and allow for alteration of practices if necessary	DoW and local government with advice from the BMP technical reference group	Ongoing
	Engage the research community in the process of evaluation and feedback	DoW with advice from the BMP technical reference group	Ongoing
Water Conservation			
Adopt drinking water consumption target	Ensure that residential development complies with the water conservation design objectives	DoW	Through assessment of LWMS/UWMP
	Ensure scheme water substitution does not lead to an overall increase in water consumption	DoW	Through assessment of LWMS/UWMP
Ensure that non-potable water supply systems deliver a net benefit to the community	The impact of a non-potable water supply system on the local water balance must be assessed as part of the local water management strategy	DoW	Through assessment of LWMS/UWMP
	The design of a non-potable water supply system must be subject to a sustainability assessment as part of the local water management strategy to determine the net benefit or cost of the scheme	DoW	Through assessment of LWMS/UWMP
Ensure that non-potable water supply systems are designed as part of an integrated water supply	Non-potable water supply systems must be designed in conjunction with potable water supply systems, to ensure that fire-fighting requirements can be met from one or both of the systems and that both systems are designed for efficiency (e.g. minimising pipe sizes and pumping requirements where possible)	DoW	Through assessment of LWMS/UWMP
	Reach agreement between the developer, SJ Shire and licensed service provider (e.g. Water Corporation) on the design, operation and management of a non-potable water supply system, including arrangements for use in public open space and appropriate level of water quality, to ensure that all water demands are met appropriately	DoW	Through assessment of LWMS/UWMP

10 Figures

Figure A-1 Location plan

Figure A-2 Topography and geology

Figure A-3 Acid sulphate soil risk

Figure A-4 Environmental assets and water-dependent ecosystems

Figure A-5 Controlled groundwater level

Figure A-6 Existing infrastructure

Figure A-7 Byford structure plan

Figure A-8 Stormwater strategy

Figure A-9 Typical cross-sections

Figure A-10 Longitudinal sections

404000 406000 408000

6436000 6434000 6432000

BYFORD
6122

Shire of Serpentine - Jarrahdale

City Shire of

LEGEND

Byford Drainage and Water Management Plan Area (GHD, 20070601)

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BACKGROUND TAKEN FROM STREETSMART STREETEXPRESS 2007 EDITION.
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SCALE

200 0 200 400 600 m

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LOCALITY MAP



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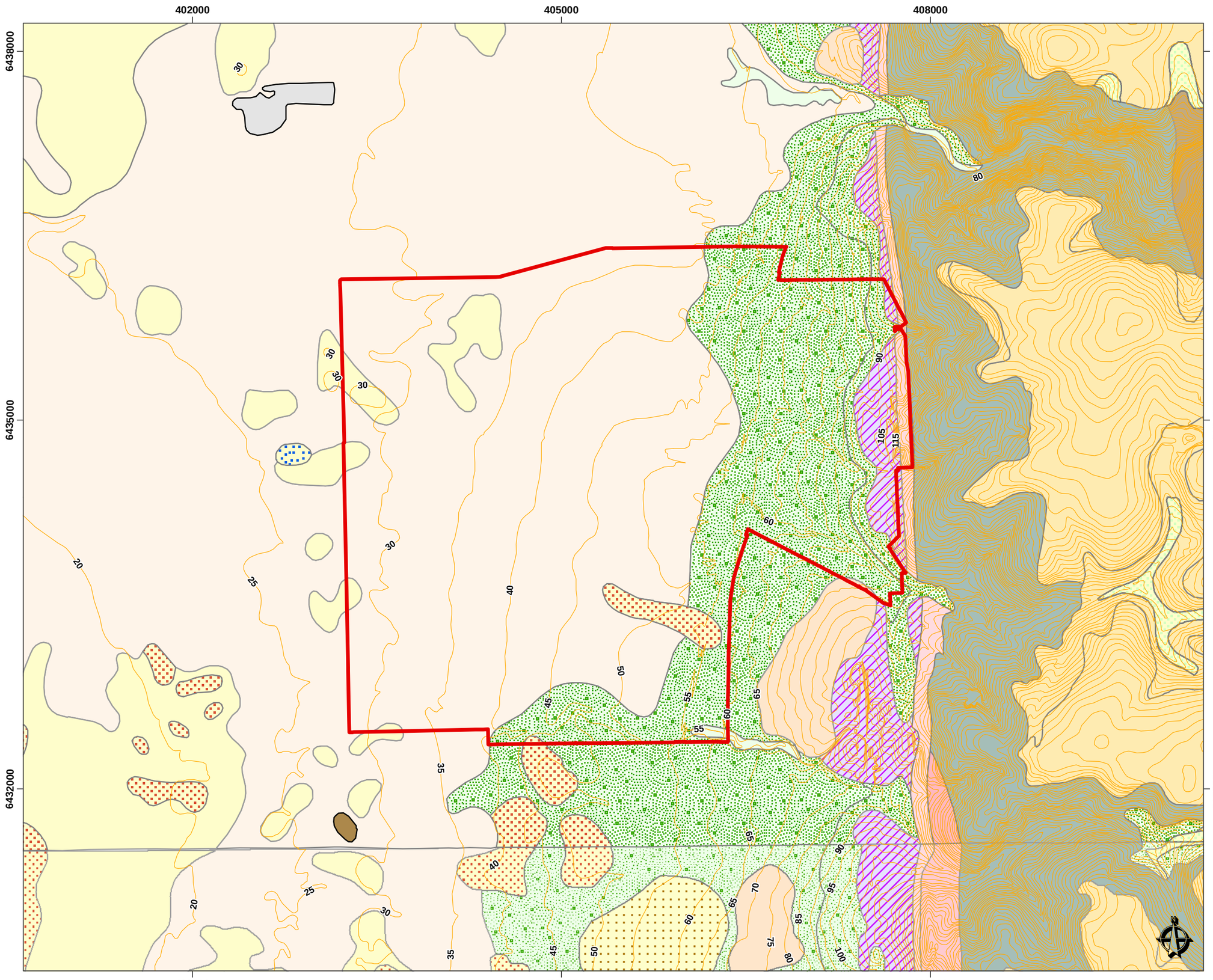
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BYFORD TOWNSITE - DRAINAGE & WATER MANAGEMENT PLAN

Figure A-1
Location Map



LEGEND

Byford Drainage and Water Management Plan Area (GHD, 20070601)

5m Contours (GHD, 20080718)

Armadale & Serpentine 1:50,000 Geology (Geological Survey of WA, 19860101)

- Qpw — Sand: white to pale brown, fine-grained to medium-coarse grained rounded quartz
- Qa — Alluvium and minor colluvium
- Qpo — Colluvium, soil and undifferentiated sand
- Qpb — Bassendean Sand: quartz sand (fixed dunes)
- Qpb/Qa — Bassendean sand over alluvium and minor colluvium
- Qpa — Guildford Formation: alluvium (clay, loam, sand, gravel) variably lateritized and podsolized
- Qpr — Yoganup Formation: leached and ferruginised beach sand, conglomerate and dunes
- Qc — Gravelly Sandy Clay
- Qha — Sandy Silty Clay - pale brown
- Czl — Laterite- chiefly massive, but includes overlying pisolithic gravel and laterized sand
- Pa — Armadale Shale - brown green to black, silty thinly bedded with interbeds of siltstone & fine-grained sandstone
- Age, Agr, Agp — Granite: fine to course-grained mesocratic rocks, of granite granodiorite and adamellite composition, even-grained or porphyritic
- Am — Migmatite - banded and nebulitic
- An — Gneiss - fine to medium-grained mesocratic gneiss, planar gneissic fabric, occasional fine mesocratic rocks representing sheared dolerites
- Ironstone — Red-brown, grading from coffee rock through vuggy and pisolitic to massive, of alluvial origin
- SS2 — Sandstone - basal conglomerate and silty
- Made ground

For more information, see Perth Metropolitan Region 1:50,000 Environmental and Urban Geology Series map sheets for Armadale and Serpentine

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BYFORD TOWNSITE - DRAINAGE & WATER MANAGEMENT PLAN

Figure A-2
Topography & Geology

402000 404000 406000 408000 410000

6438000 6436000 6434000 6432000

TONKIN HWY
THOMAS RD
HOPKINSON RD
ABERNETHY RD
BEENYUP RD
NETTLETON RD
ORTON RD
CARDUP SIDING RD
SOLDIERS RD
SOUTH WESTERN HWY
GOSSAGE RD

LEGEND

Byford Drainage and Water Management Plan Area (GHD, 20070601)

Cadastre (DLI, 20061201)

Acid Sulfate Soil Risk Map, Swan Coastal Plain (DEC, 20060807)

- High to moderate ASS disturbance risk (<3m from surface)
- Moderate to low ASS disturbance risk (<3m from surface)
- No known ASS disturbance risk (<3m from surface)

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SCALE

325 0 325 650 975 m

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Figure A-3
Acid Sulfate Soil Risk Map

402000 404000 406000 408000 410000

6438000 6436000 6434000 6432000

TONKIN HWY
THOMAS RD
MALARKEY RD
BRIGGS RD
LARSEN RD
ALEXANDER RD
GEORGE ST
HOPKINSON RD
ABERNETHY RD
BEENYUP RD
DOLEY RD
WARRINGTON RD
NETTLETON RD
SOUTH WESTERN HWY
ORTON RD
CARDUP SIDING RD

Brickwood Reserve

65
266
449
321
350
351
352
271

LEGEND

- Byford Drainage and Water Management Plan Area (GHD, 20070601)
- Road Centreline (DLI, 2007)
- Bush Forever Sites (DPI, 2000)
- Threatened Ecological Communities Buffer (CALM, 200702)
- Aboriginal Heritage Sites (DIA, 200712)

Geomorphic Wetlands (DEC, 200706)

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed
- Not Applicable

Declared Rare & Priority Species (DEC, 200706)

- (R) Declared Rare Flora - Extant Taxa
- Priority 1 - Poorly Known Taxa
- Priority 2 - Poorly Known Taxa
- Priority 3 - Poorly Known Taxa
- Priority 4 - Rare Taxa

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300 0 300 600 900 m

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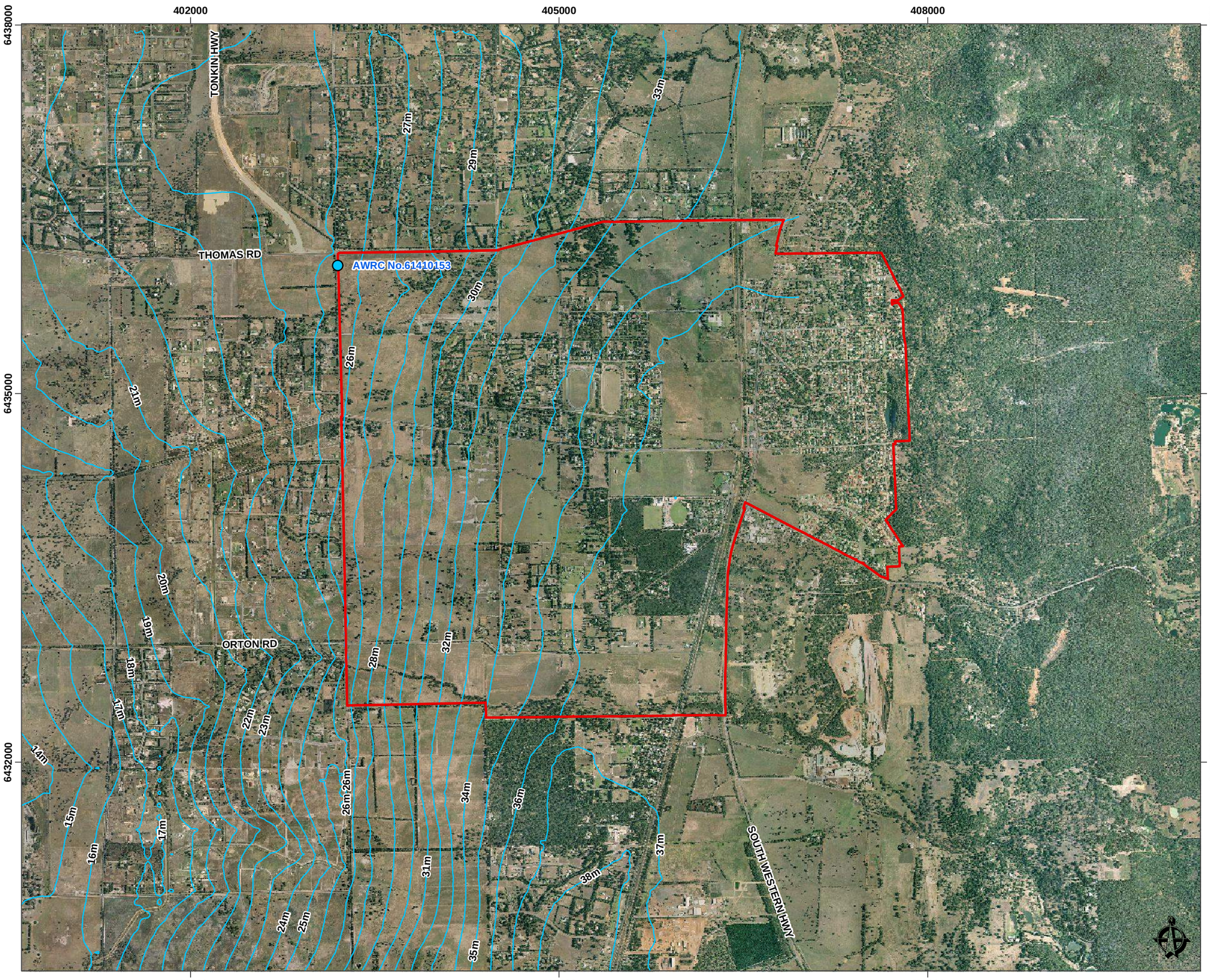
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BYFORD TOWNSITE -
DRAINAGE & WATER MANAGEMENT PLAN

Figure A-4
Environmental and Social Considerations



LEGEND

- Byford Drainage and Water Management Plan Area (GHD, 20070601)
- AWRC No.61410153
- Modelled Maximum Groundwater Level (Current Climate) 1 m Contour*

* Interpolated from data published in CyMod Report "Local Scale Groundwater Modelling for Assess Effects of Climatic Variations and Planned Development", May 2007

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BYFORD TOWNSITE -
DRAINAGE & WATER MANAGEMENT PLAN

Figure A-5
Controlled Groundwater Level

404000 406000 408000

6436000

6434000

6432000

TONKIN HWY
THOMAS RD
MALARKEY RD
BRIGGS RD
LARSEN RD
ALEXANDER RD
GEORGE ST
HOPKINSON RD
ABERNETHY RD
BEENYUP RD
DOLEY RD
WARRINGTON RD
TURNER RD
SOUTH WESTERN HWY
NETTLETON RD
ORTON RD
CARDUP SIDING RD
BARGE DR

LEGEND

- Byford Drainage and Water Management Plan Area (GHD, 20070601)

Water Corporation Infrastructure

- Water Pumping Installation Location
- Water Main
- Drain
- Sewer (Rising Main)
- Sewer (Gravity Pipe)

Local Authority Infrastructure

- Drain
- Natural Stream

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NOTE THAT POSITIONAL ERRORS CAN BE > 5M IN SOME AREAS
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SCALE

200 0 200 400 600 m

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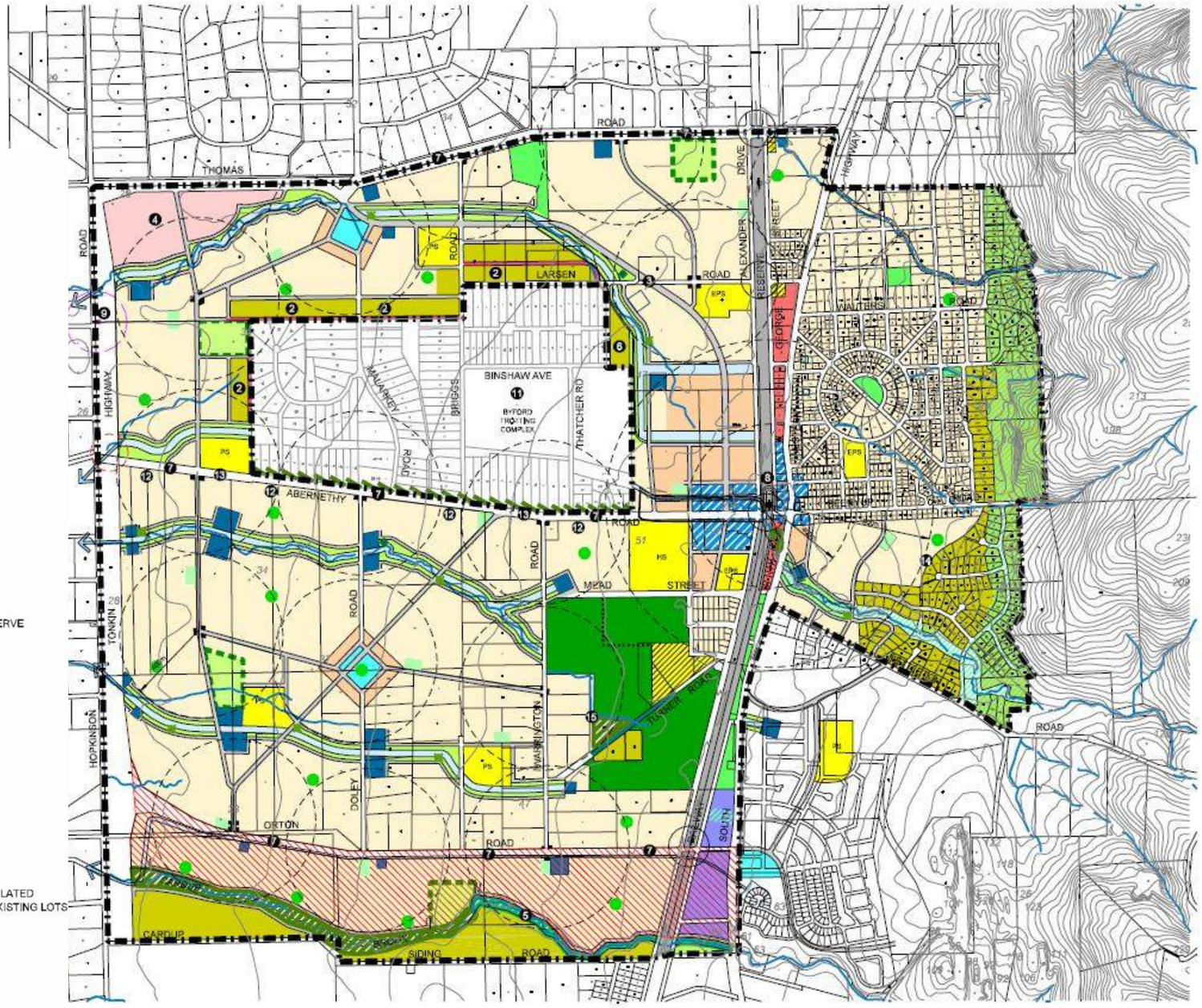
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BYFORD TOWNSITE - DRAINAGE & WATER MANAGEMENT PLAN

Figure A-6
Existing Infrastructure

LEGEND

- STRUCTURE PLAN AREA
- RURAL RESIDENTIAL
- RESIDENTIAL (R2.5 - 5)
- RESIDENTIAL (R20)
- RESIDENTIAL (R30-60)
- TOWN CENTRE
- NEIGHBOURHOOD CENTRE
- HIGHWAY COMMERCIAL
- NEIGHBOURHOOD NODE
- SCHOOLS
  EPS - Existing Primary School
  PS - Primary School
  HS - High School
- MIXED BUSINESS
- MULTIPLE USE CORRIDOR (MUC)
- WATERWAY
- DRAINAGE BASIN INDICATIVE LOCATION
- FUTURE ROADS
- EXISTING MRS REGIONAL PARKS AND RECREATION RESERVE
- EXISTING LOCAL PUBLIC OPEN SPACE
- PROPOSED LOCAL PARK (Approx.3000m²)
- PROPOSED LOCAL PARK WITHIN MUC
- PROPOSED NEIGHBOURHOOD PARK (Approx. 4000m²)
- PROPOSED NEIGHBOURHOOD PARK WITHIN MUC
- DISTRICT RECREATION (Approx. 4ha)
- CONSERVATION
- FORESHORE RESERVE
- PUBLIC PURPOSES
- BUFFER BETWEEN TROTTING COMPLEX EQUESTRIAN RELATED ACTIVITIES AND RESIDENTIAL AREA INCLUDED WITHIN EXISTING LOTS
- AREA OF LANDSCAPE SENSITIVITY
- DRAINAGE DIRECTION FLOW
- UNCONSTRUCTED ROAD / BRIDLE PATH
- TURNER ROAD - POSSIBLE CLOSURE SUBJECT TO FURTHER INVESTIGATION BY COUNCIL
- RAILWAY CROSSINGS
- POSSIBLE FUTURE GRADE SEPERATED CROSSING
- POSSIBLE FUTURE RAILWAY STATION
- LAND SUBJECT TO FURTHER STUDY, REGARD TO BE GIVEN TO THE PREFERRED ALIGNMENT OF THE TONKIN HIGHWAY PRIMARY REGIONAL ROAD RESERVATION



SUBJECT TO REVISIONS

BYFORD STRUCTURE PLAN (Taylor, Burrell, Barnett, 2005)

LEGEND

Byford Structure Plan
(Taylor Burrell Barnett, 2005)

NOT TO SCALE

LOCALITY MAP



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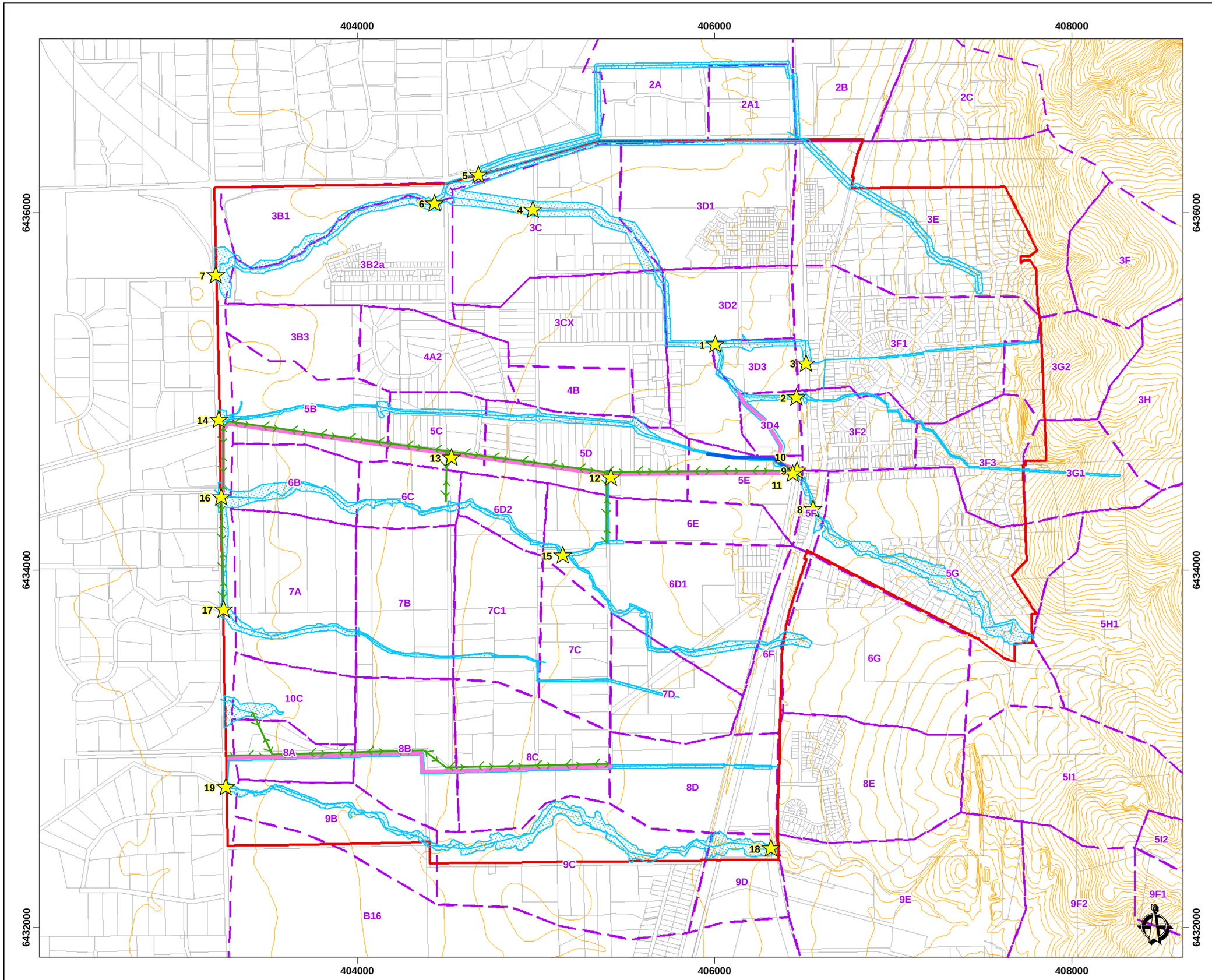
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BYFORD TOWNSITE -
DRAINAGE & WATER MANAGEMENT PLAN

Figure A-7
Byford Structure Plan



LEGEND

- Byford Drainage and Water Management Plan Area (GHD, 20070625)
- Modelled Subcatchment (GHD, 20070823)
- Cadastre (DLI, 20061201)
- 100 Year ARI Floodways (GHD, 20080215)
- 5m Contours (GHD, 20080718)
- Critical Flow and Level Locations (GHD, 20080718)

Drains (GHD, 20080131)

- Main Waterway (Restored)
- Modelled Overland Flowpath
- Modelled Swale Drain
- Modelled Piped Drain

MAP UNITS PROJECTED IN MGA ZONE 50
NOTE THAT POSITIONAL ERRORS CAN BE > 5M IN SOME AREAS.

SCALE

200 0 200 400 600 m

1:20,000 at A3

LOCALITY MAP



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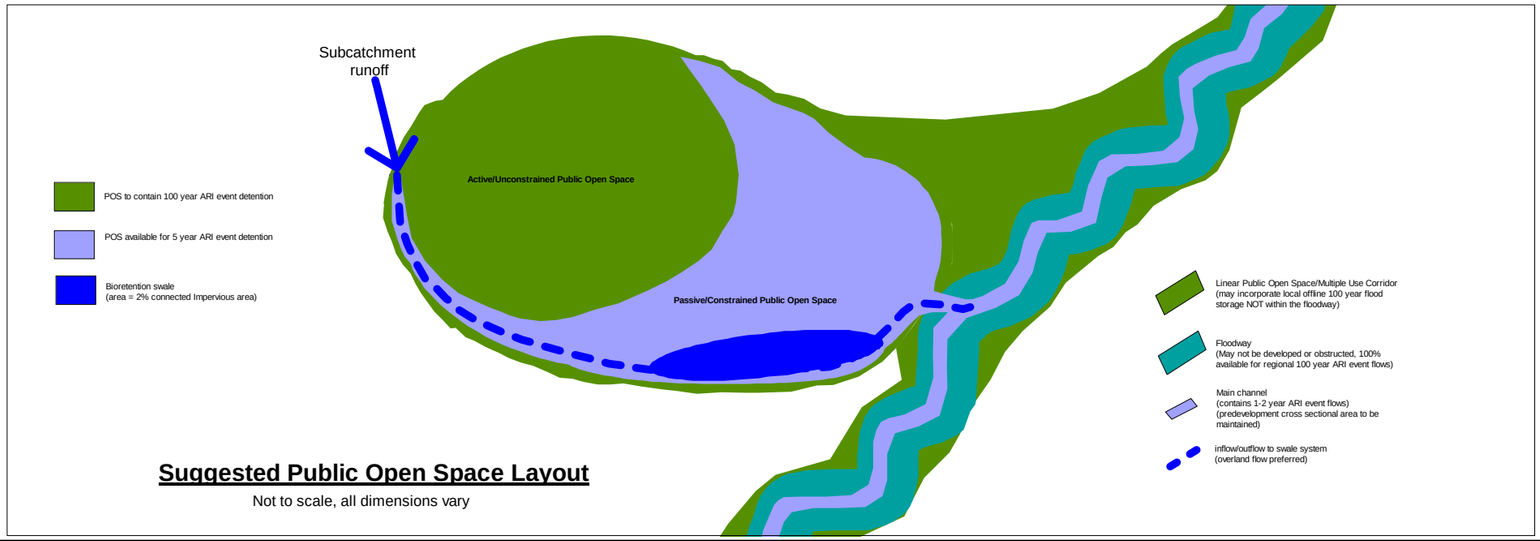
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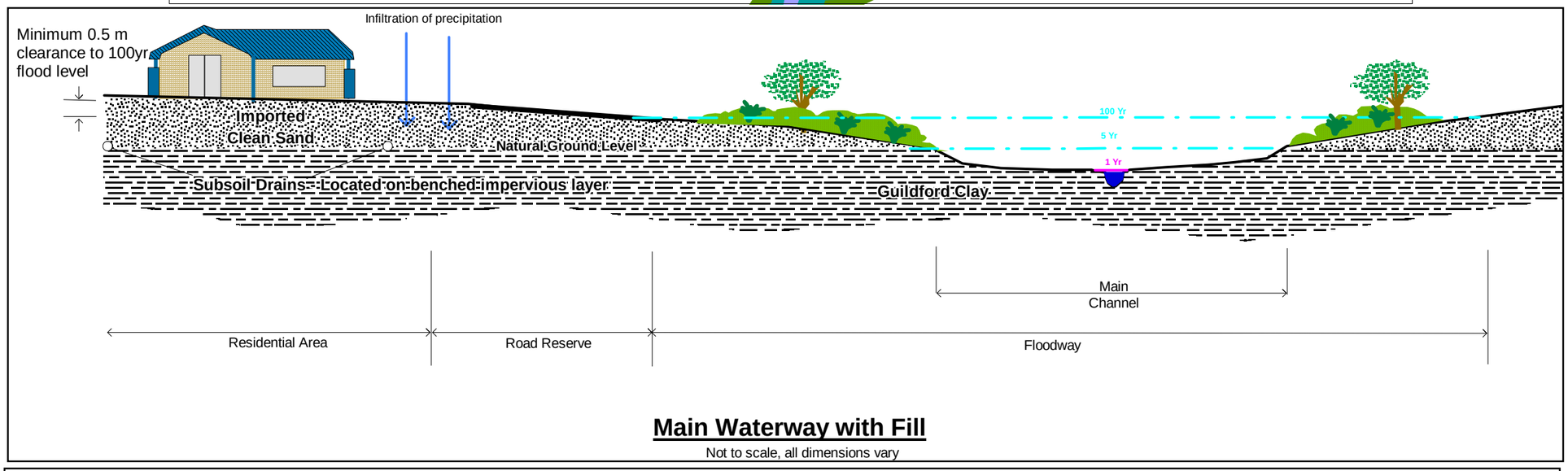
BYFORD TOWNSITE - DRAINAGE & WATER MANAGEMENT PLAN

Figure A-8
Stormwater Strategy



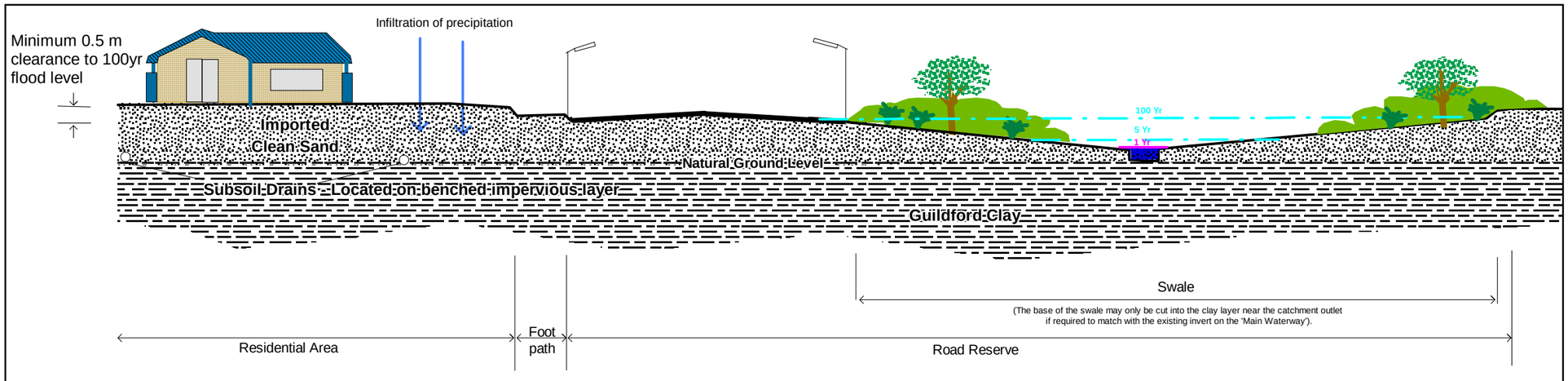
Suggested Public Open Space Layout

Not to scale, all dimensions vary



Main Waterway with Fill

Not to scale, all dimensions vary



Major Swale in Road Reserve with Fill

Not to scale, all dimensions vary

LEGEND

SCALE

Not to scale

LOCALITY MAP



South West WA

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CREATED BY	CHECKED	APPROVED
HB	DH	

HORIZONTAL DATUM:	GDA94	**PROJECTION:**	MGA ZONE 50
HEIGHT DATUM:	m AHD	**METADATA RECORDED:**	100%

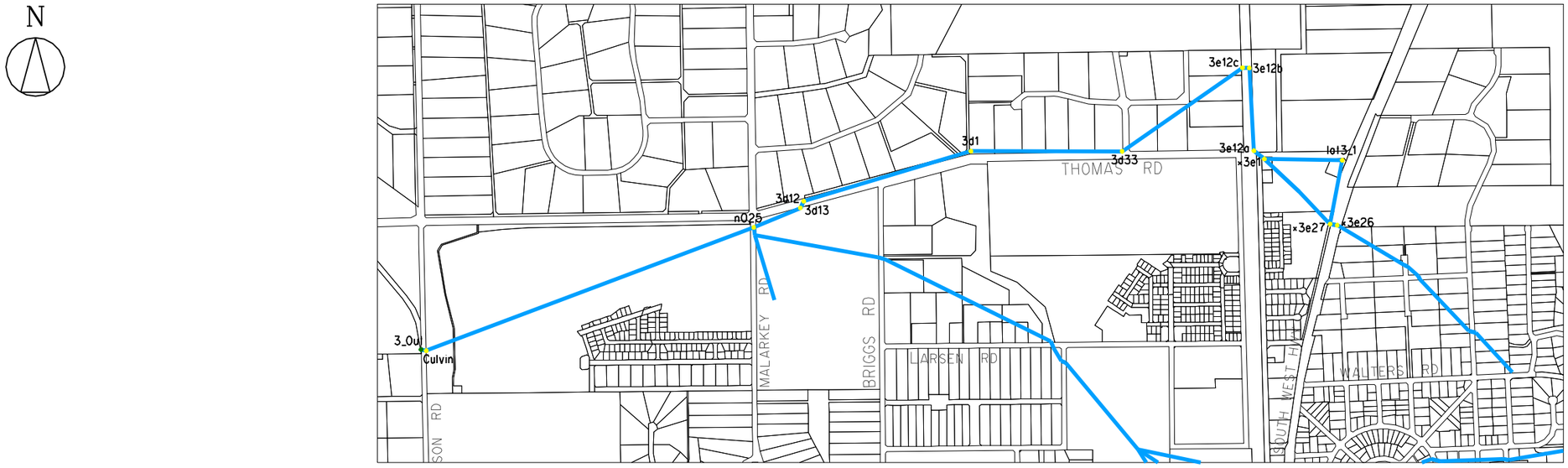
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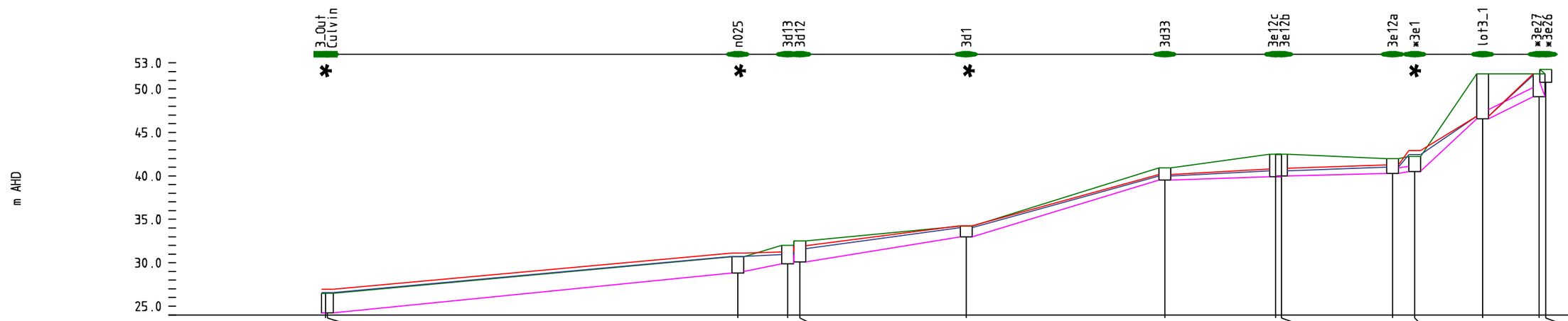
Department of Water, Government of Western Australia — GHD CLIENTS PEOPLE PERFORMANCE

BYFORD TOWNSITE - DRAINAGE & WATER MANAGEMENT PLAN

Figure A-9
Proposed Drain Cross sections

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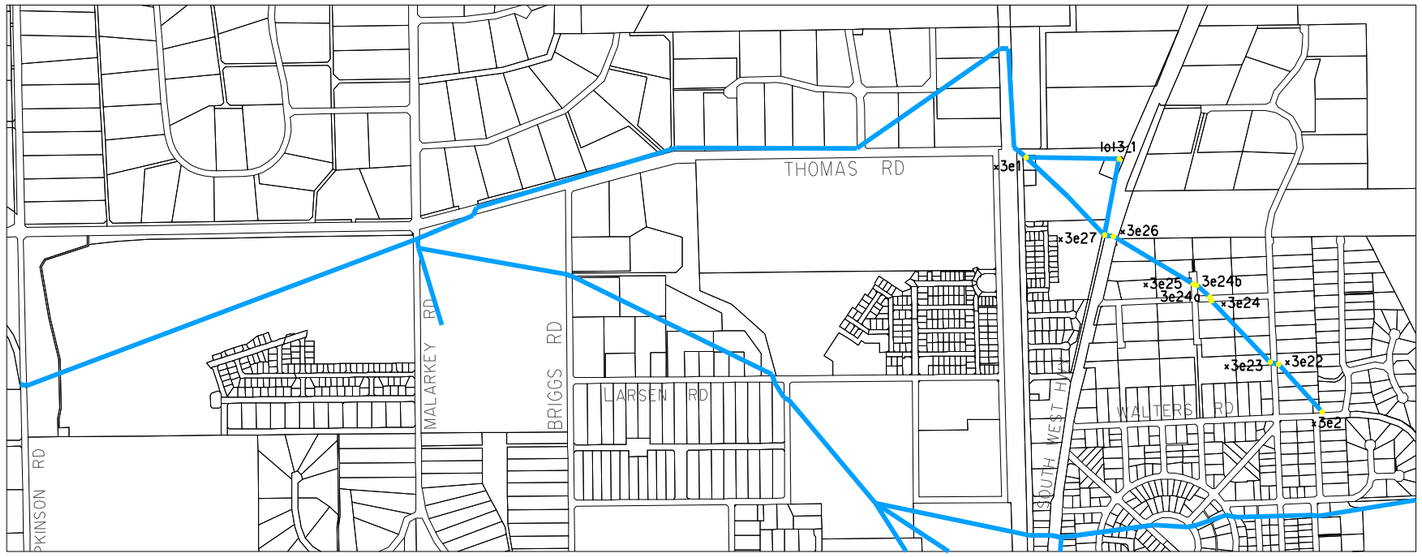


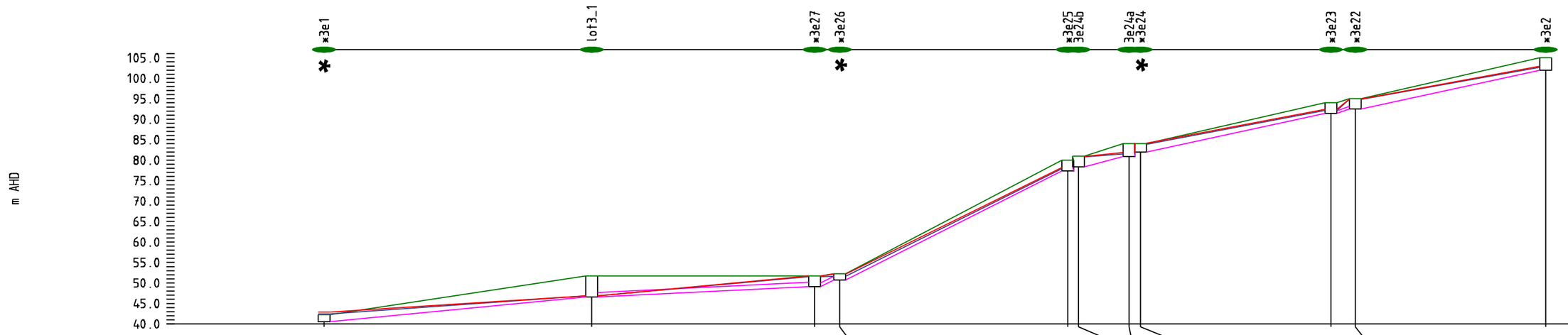


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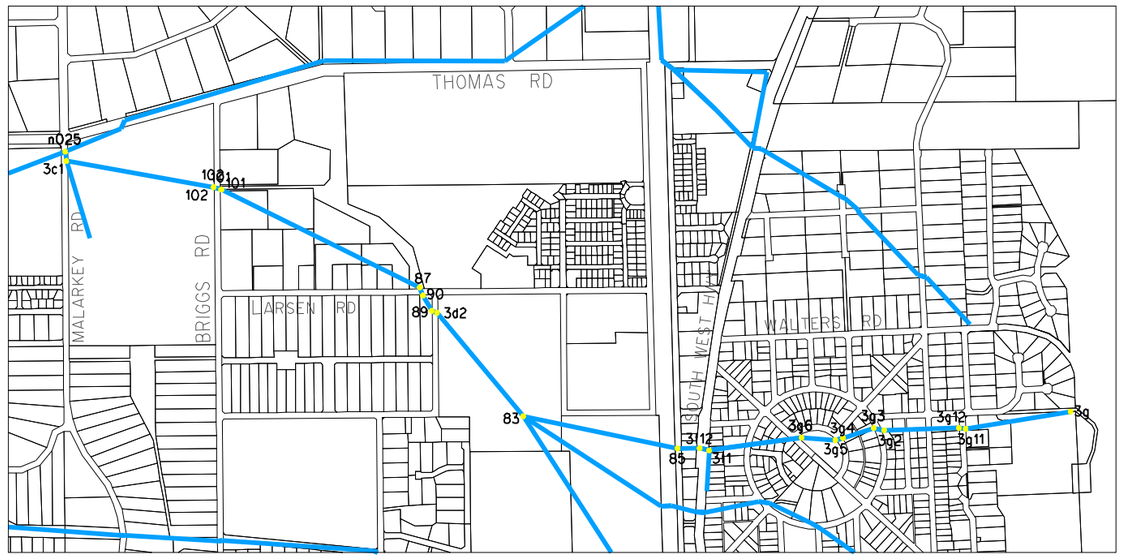


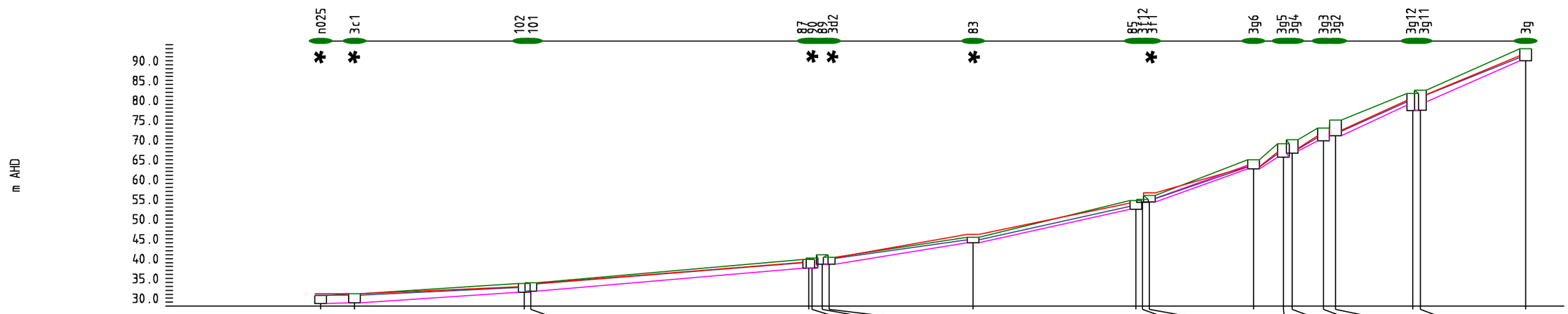


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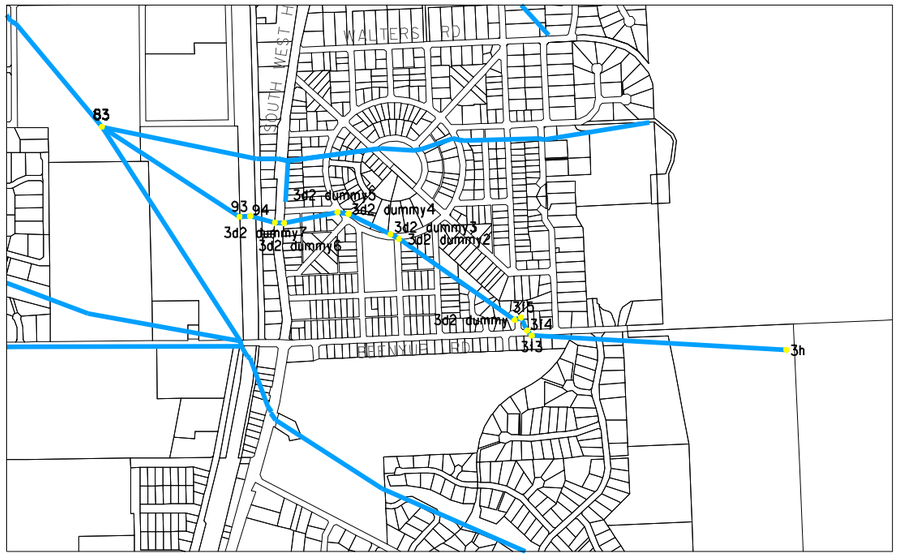


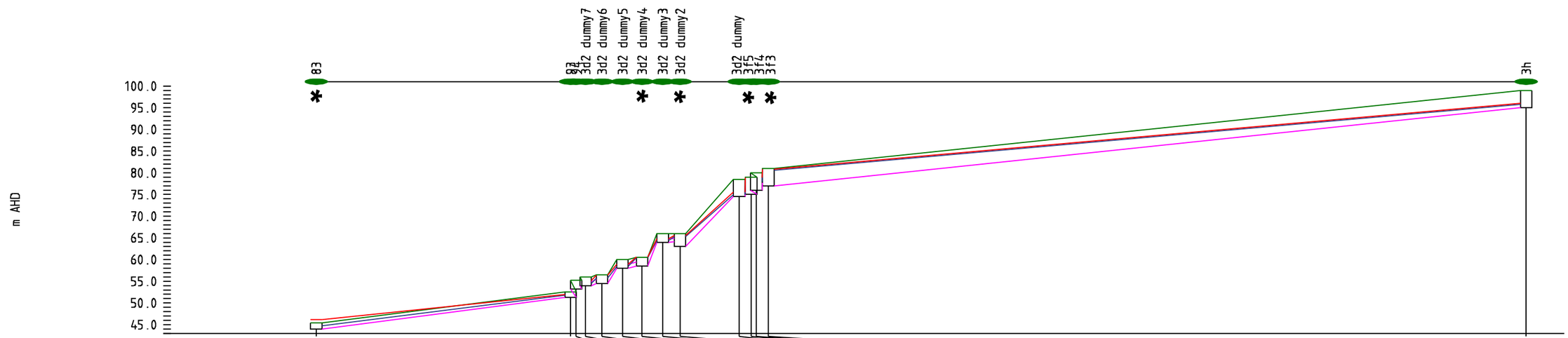


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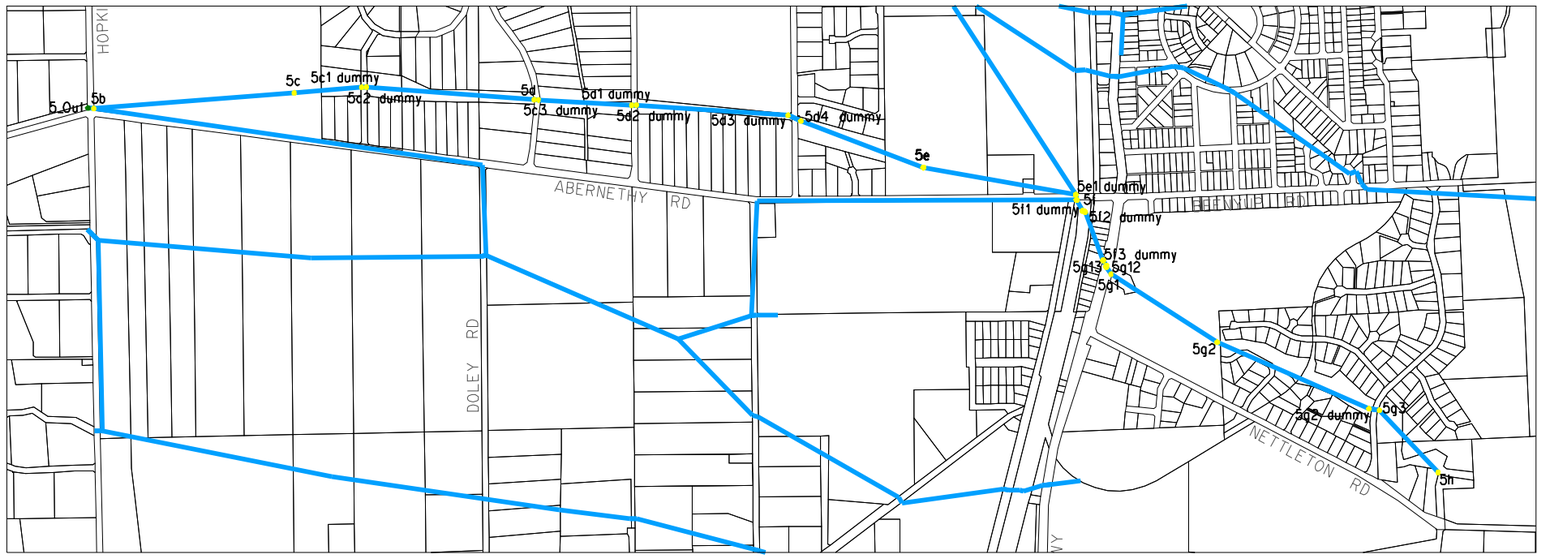


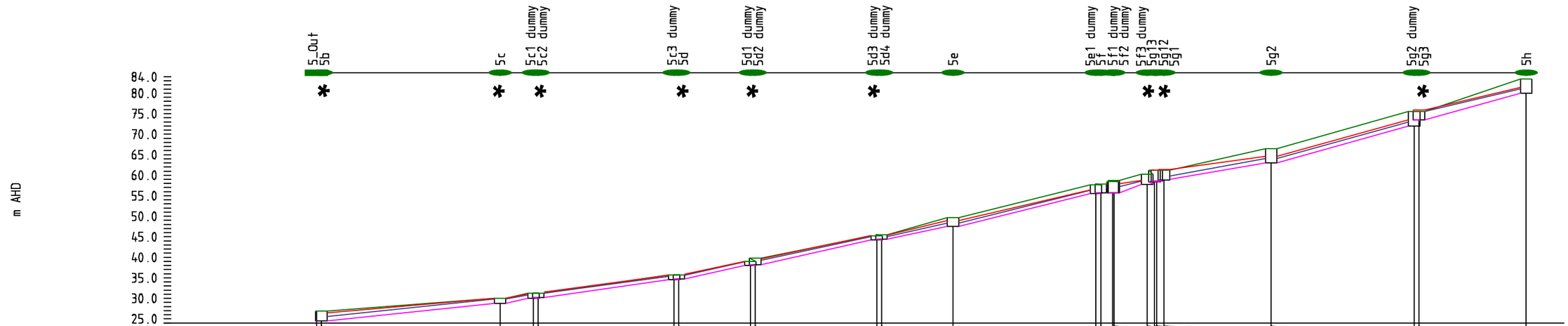


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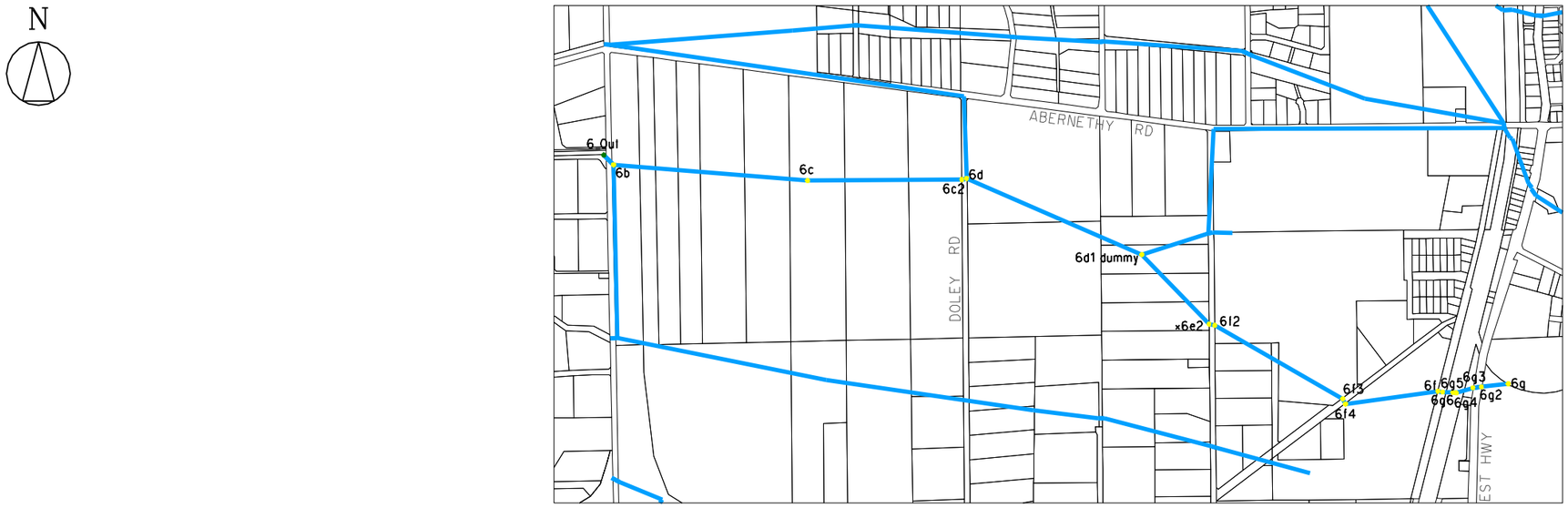
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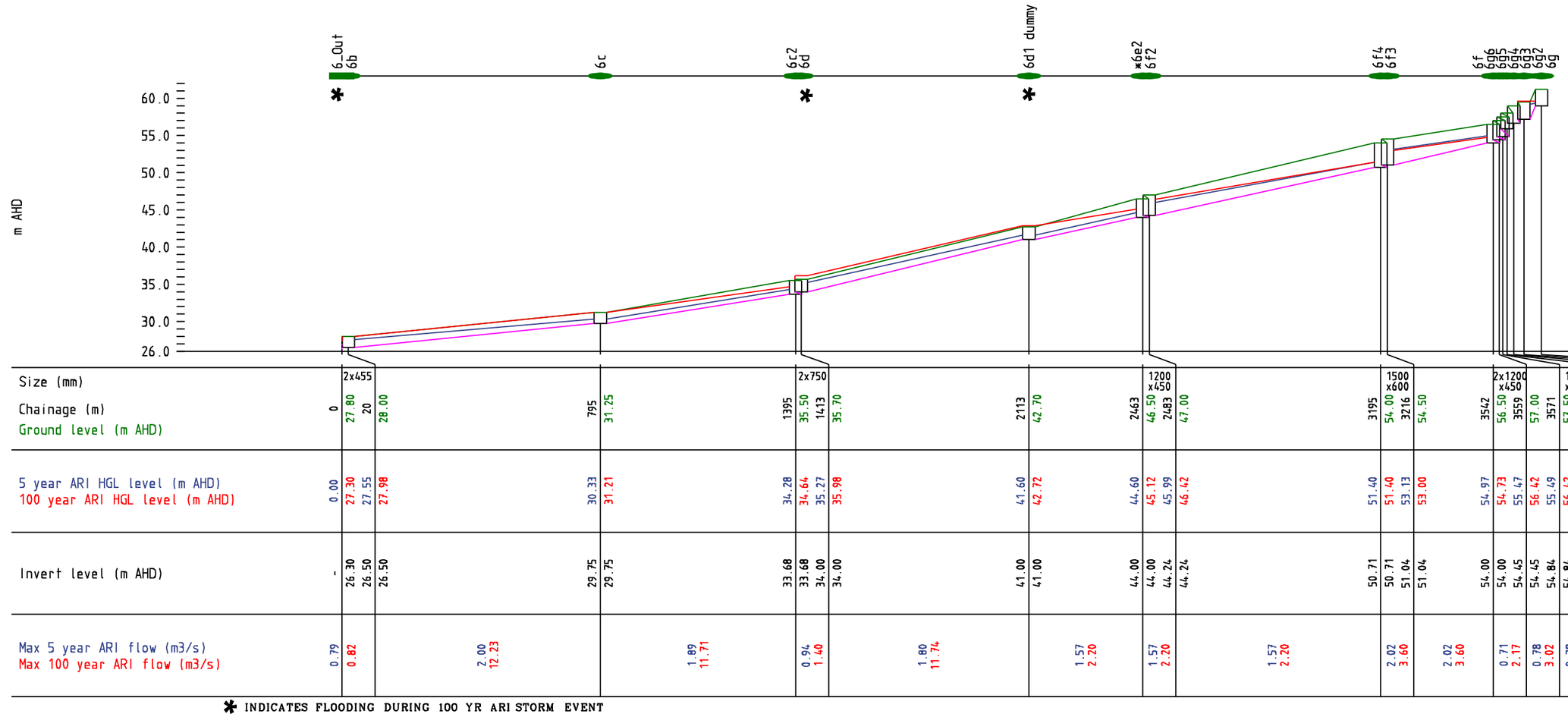




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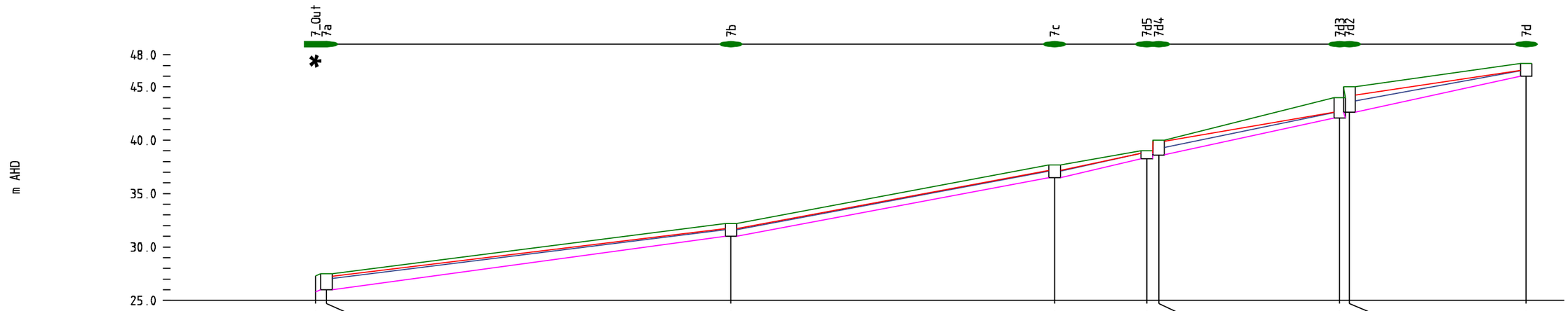


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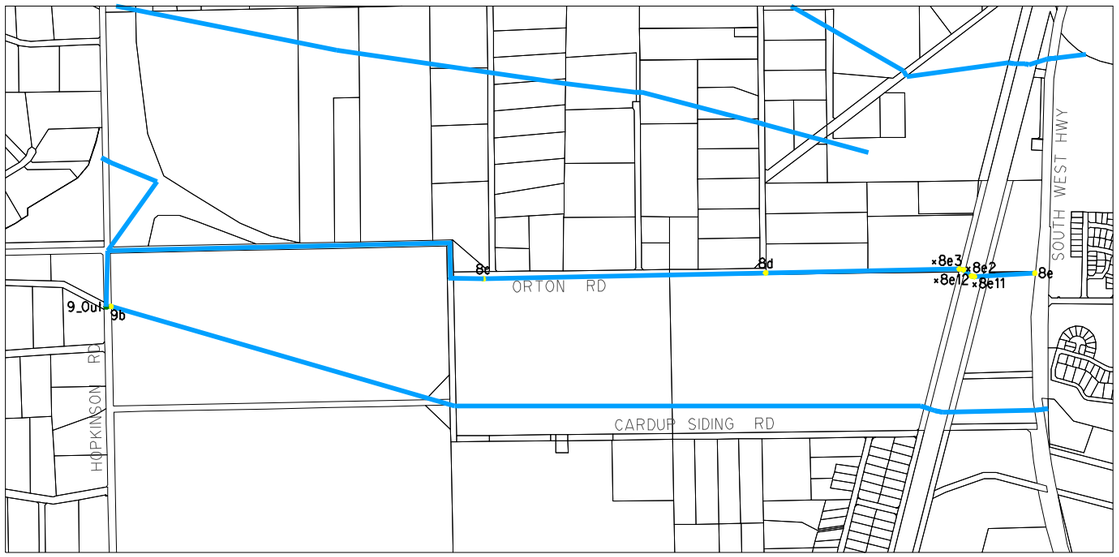


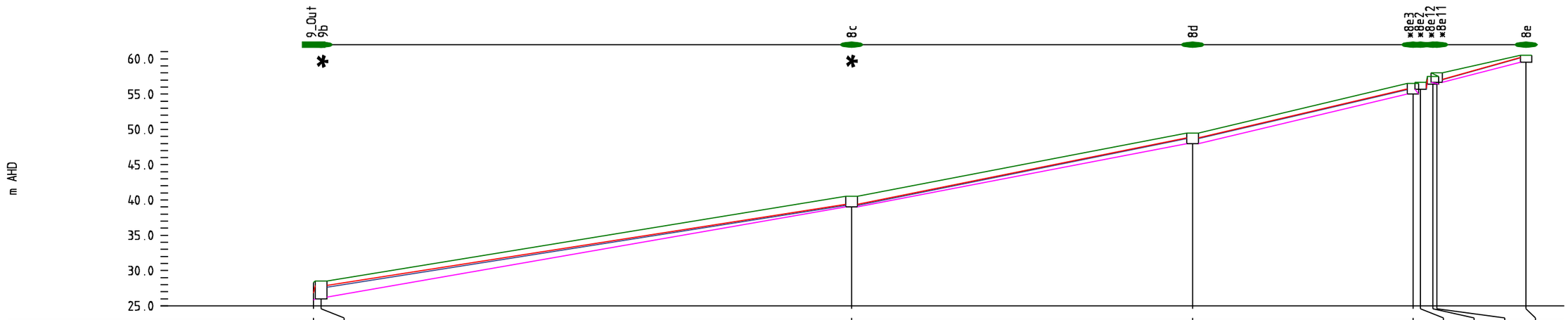


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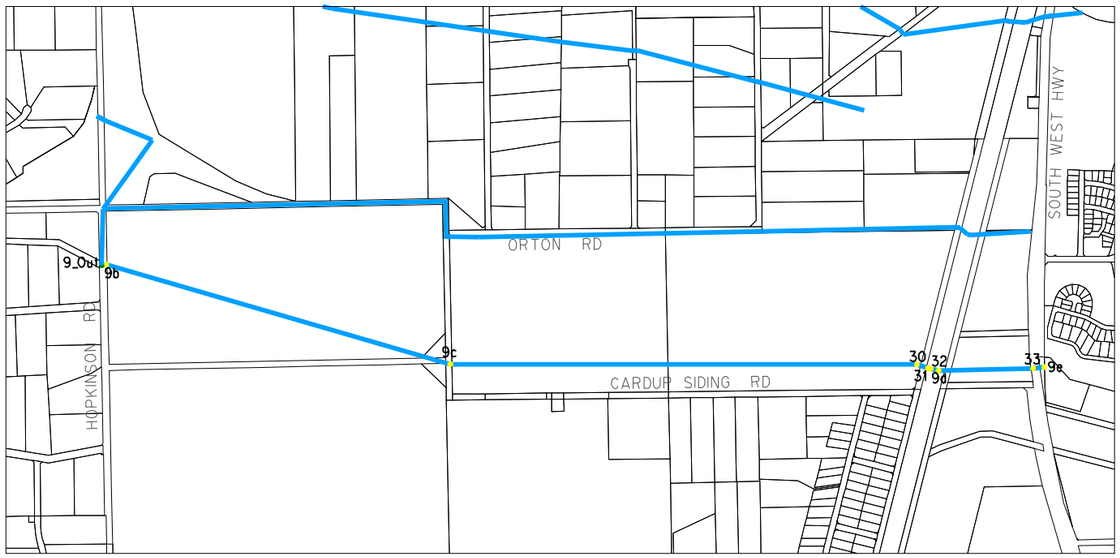


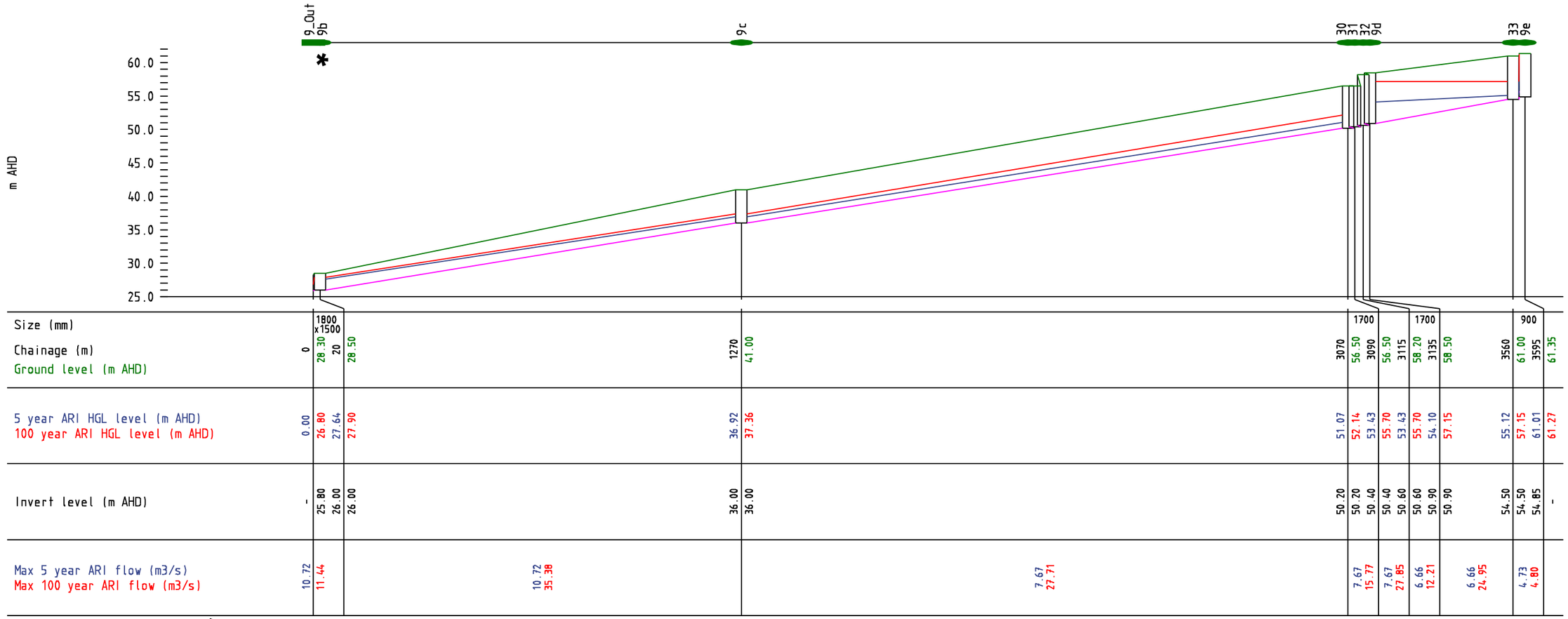


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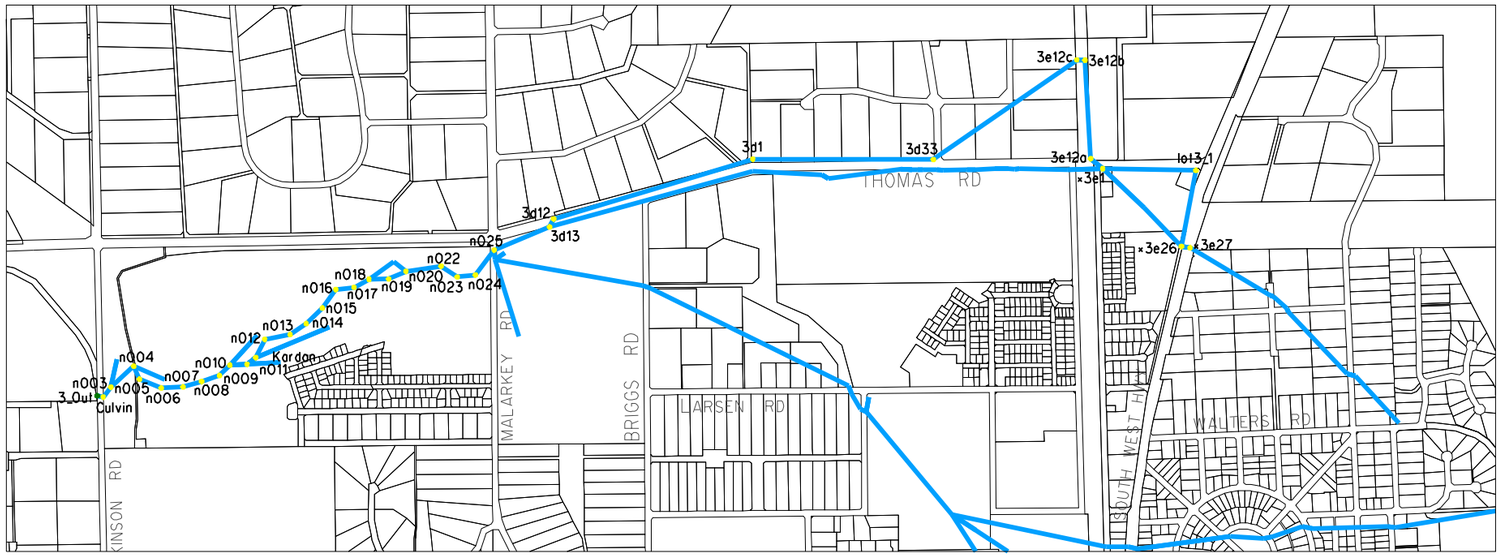


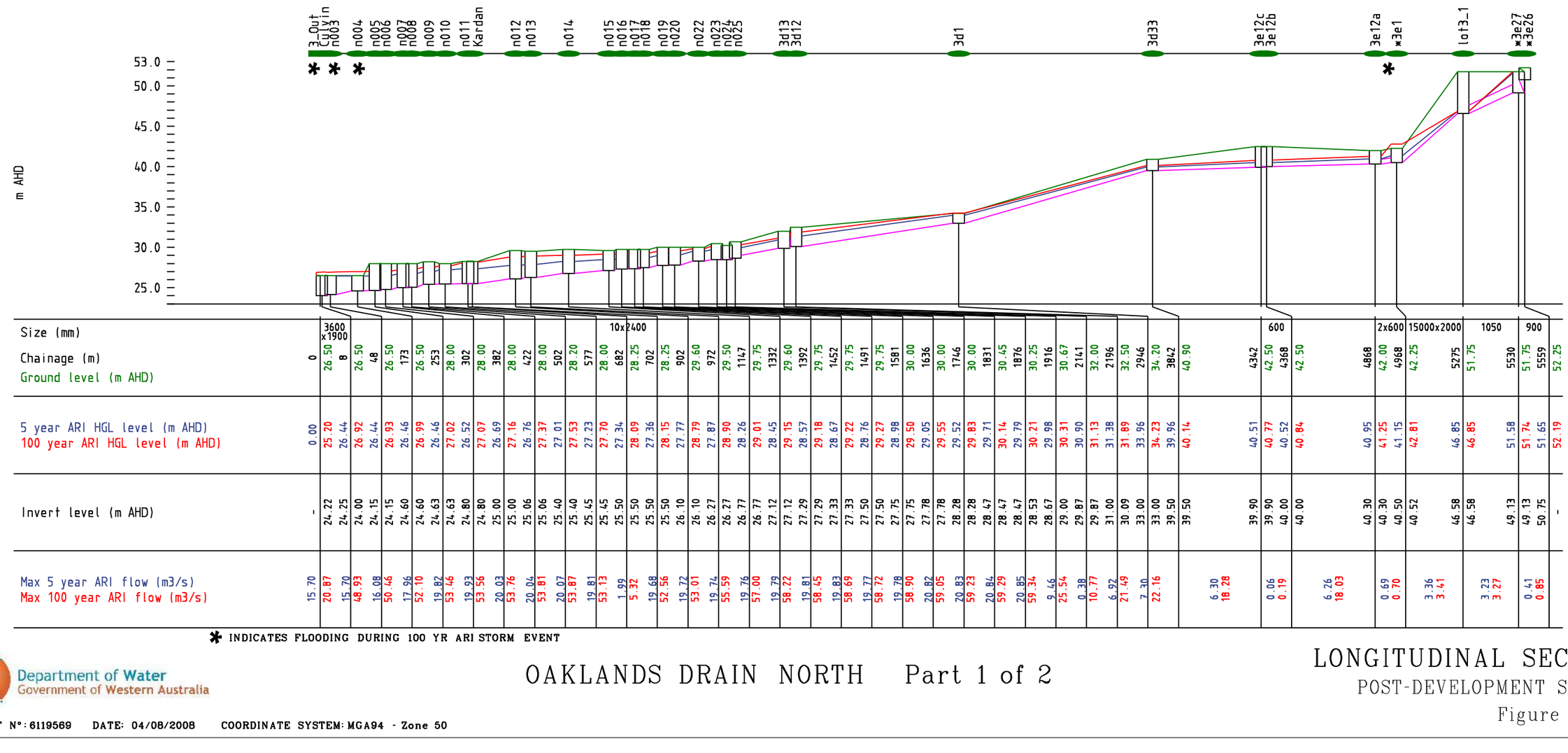


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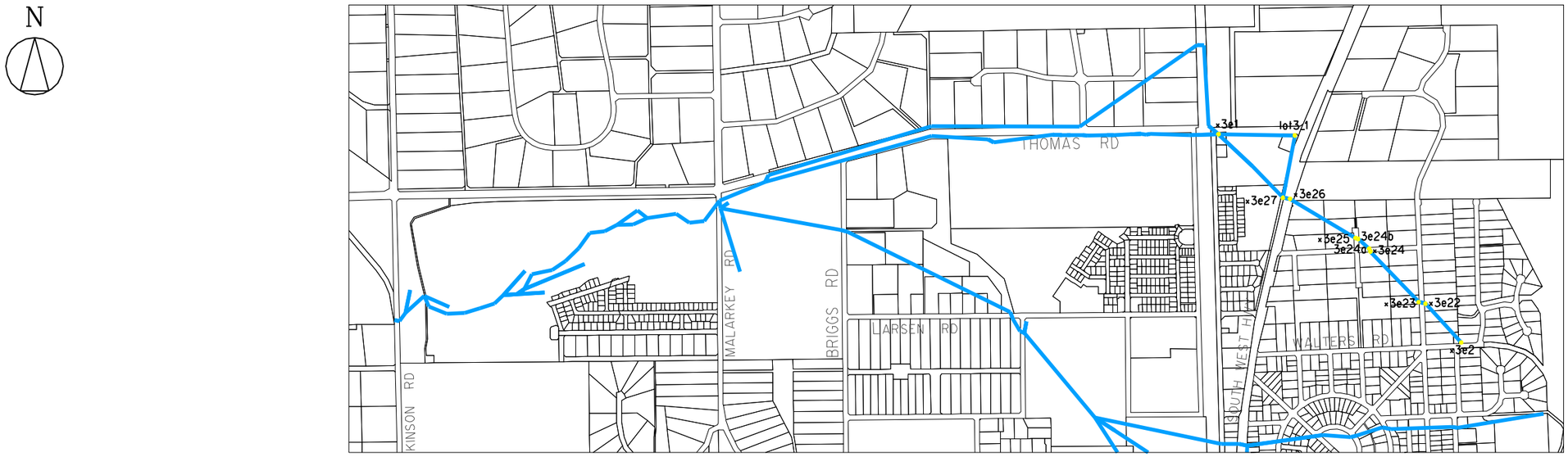


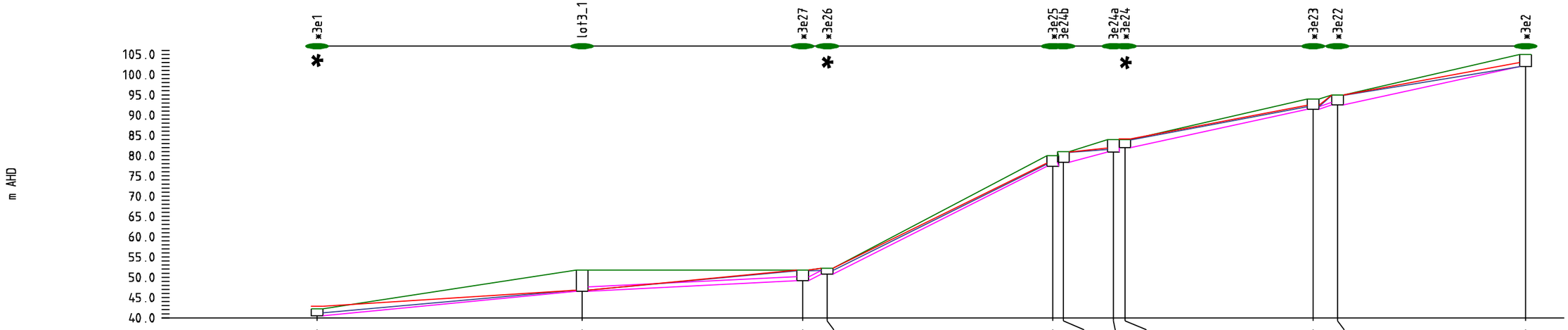




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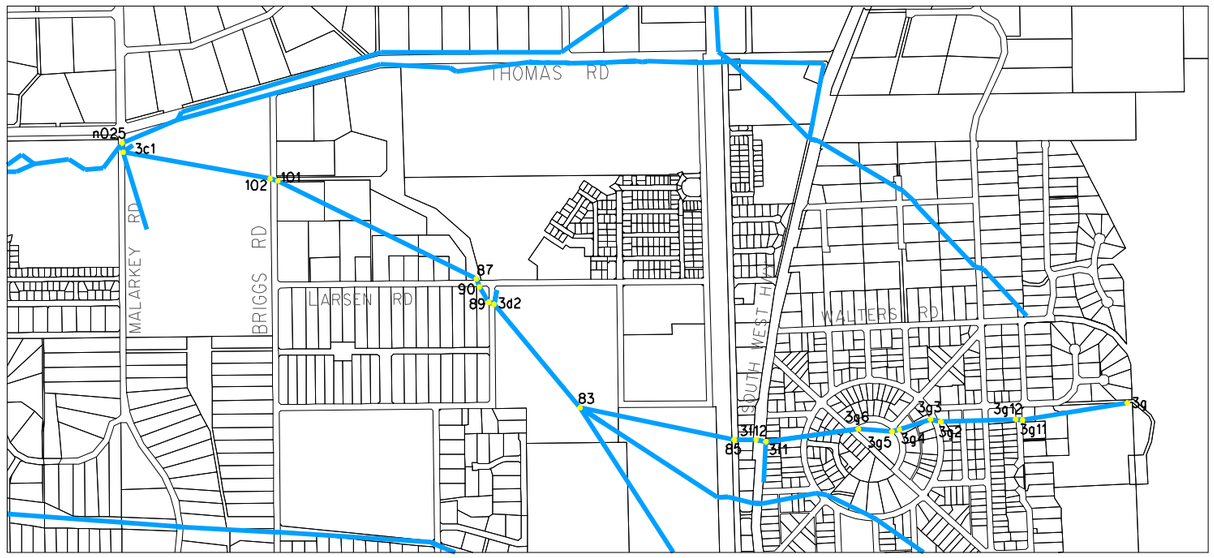


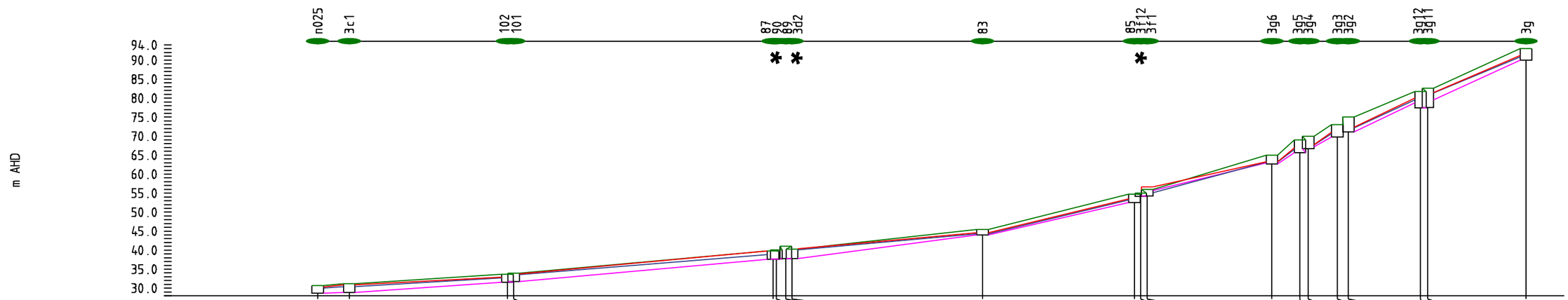


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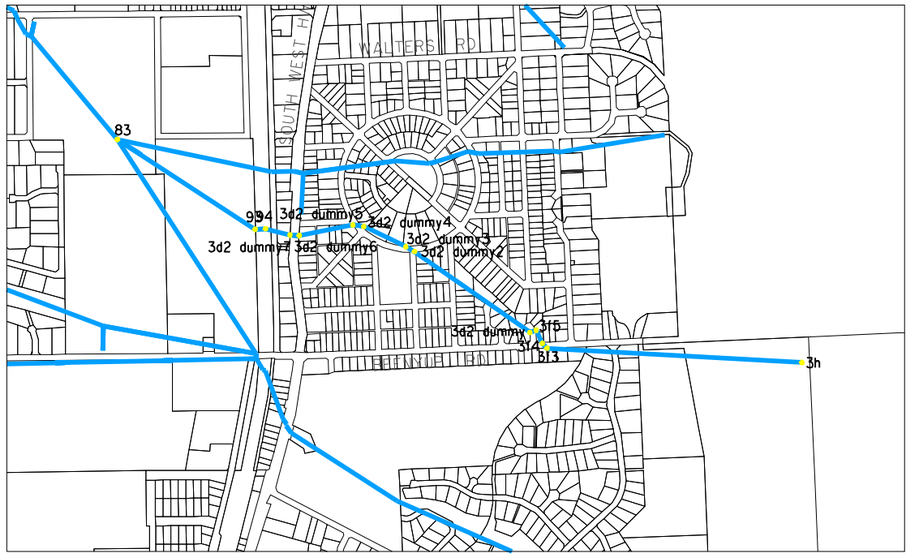


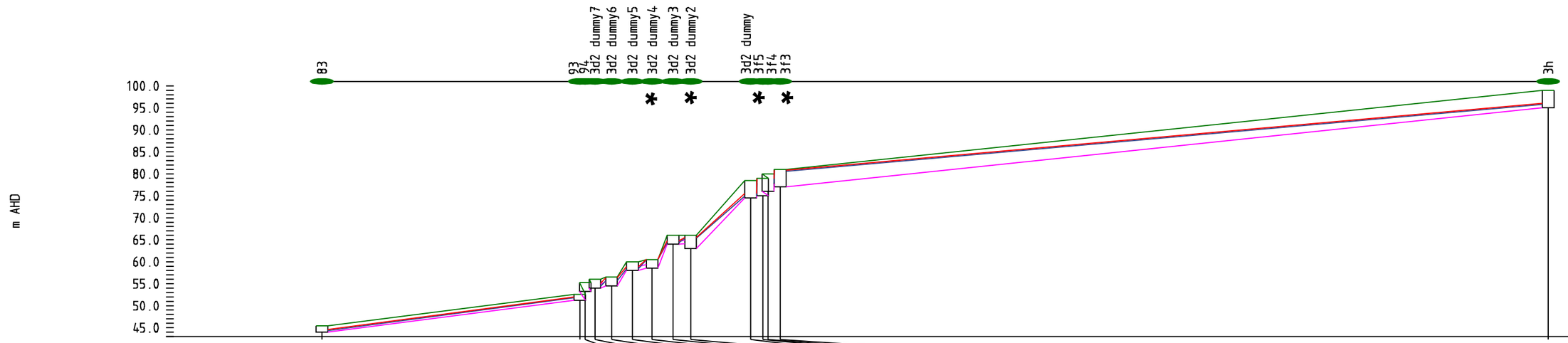


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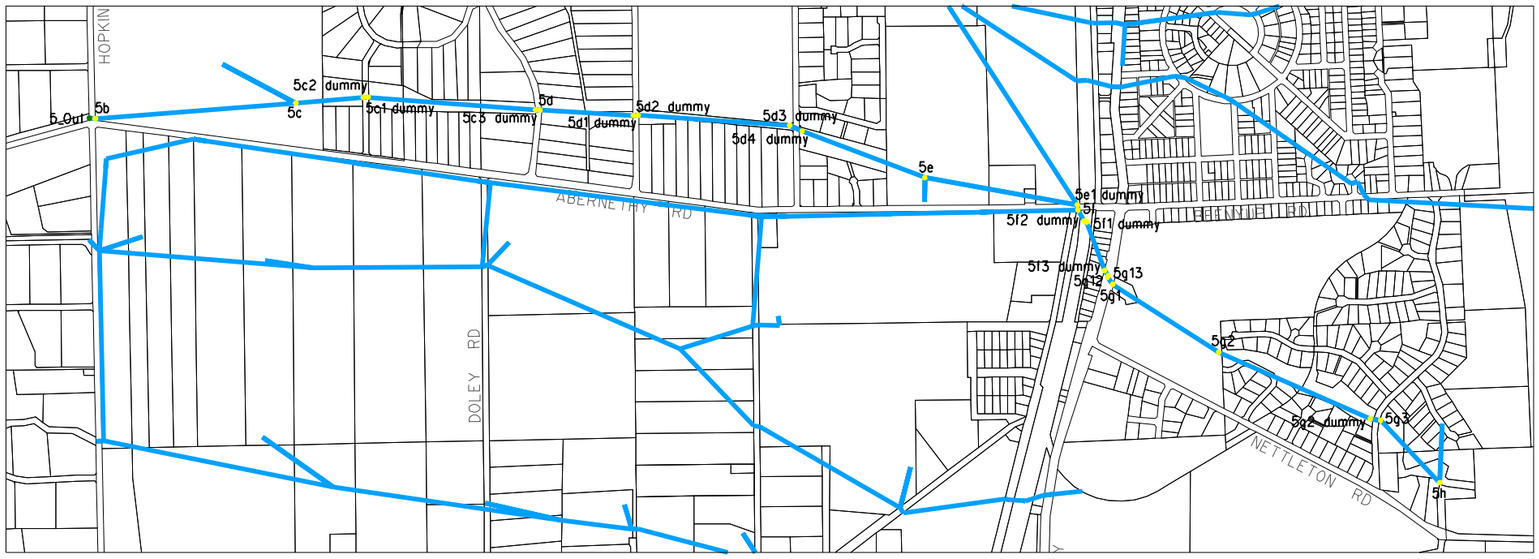


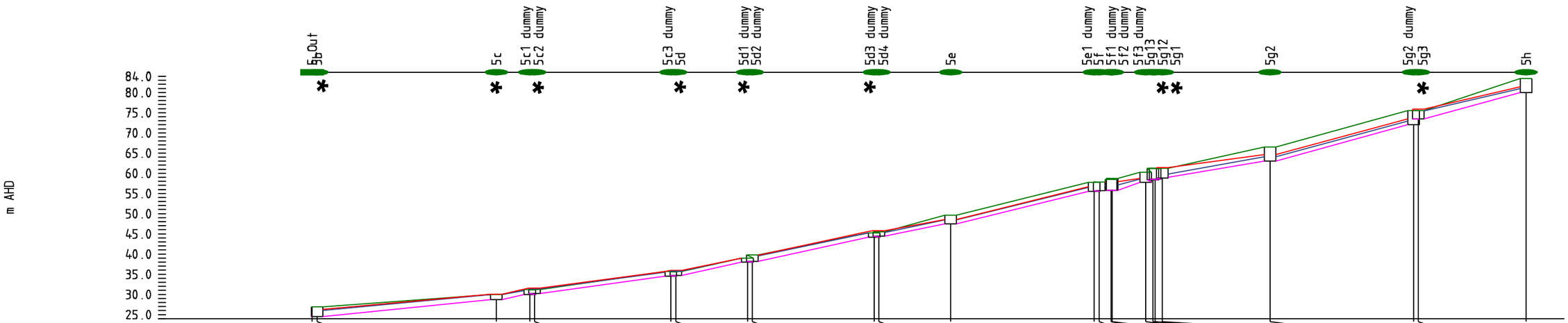


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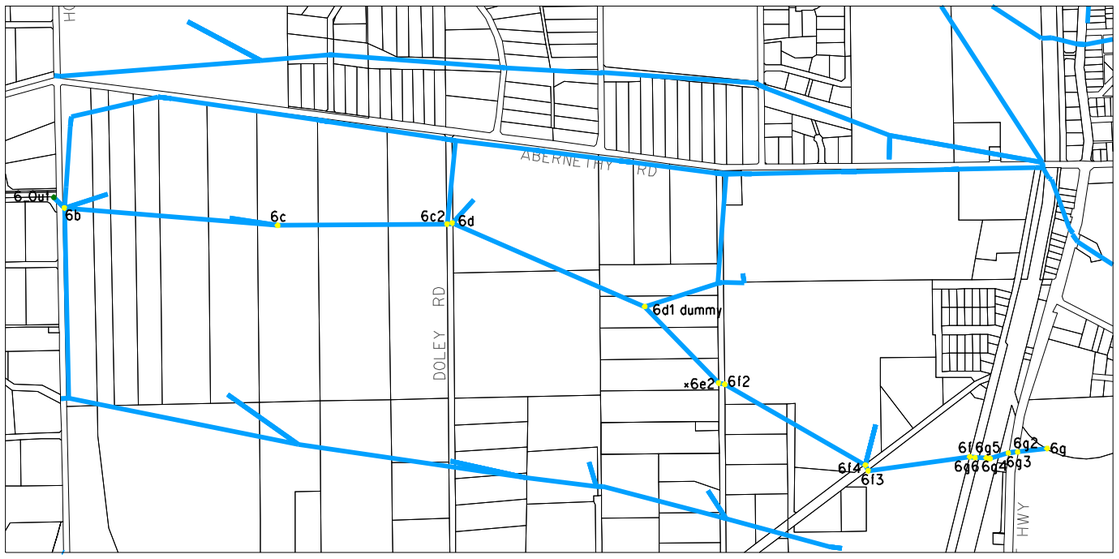


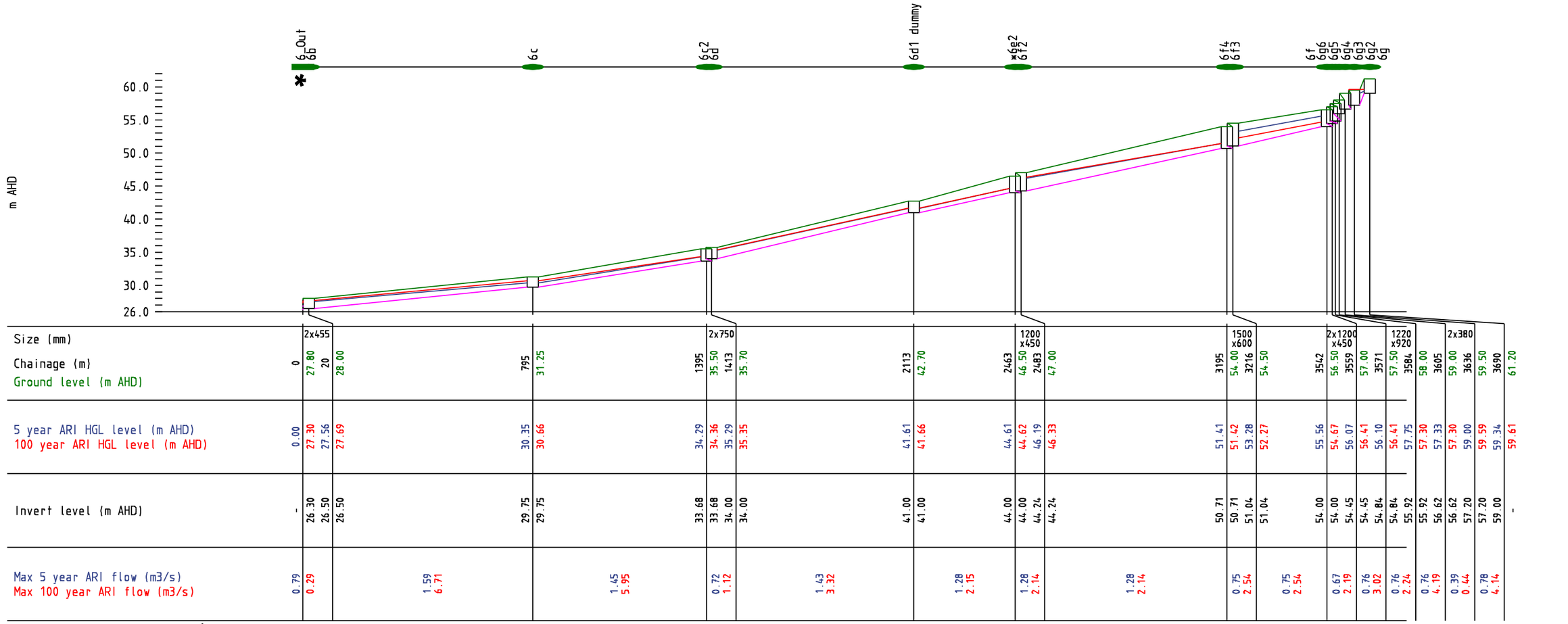


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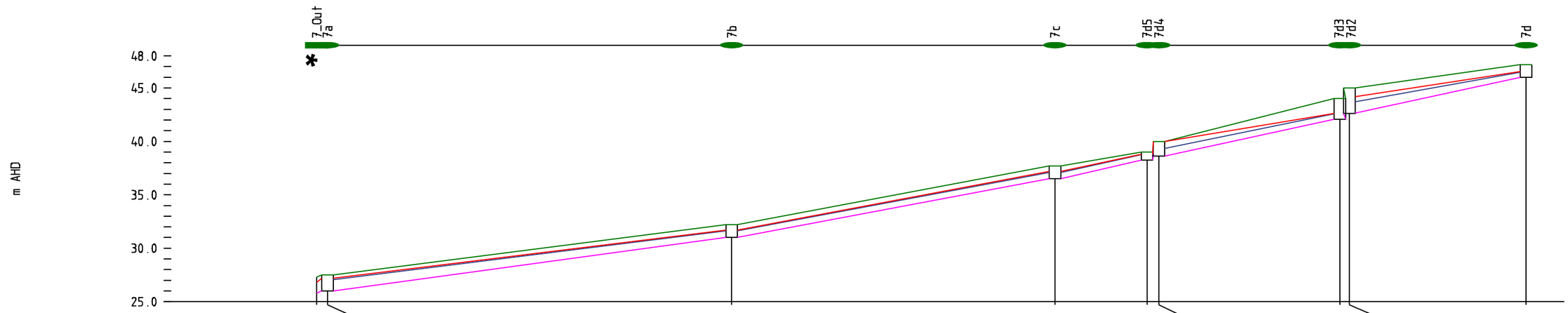


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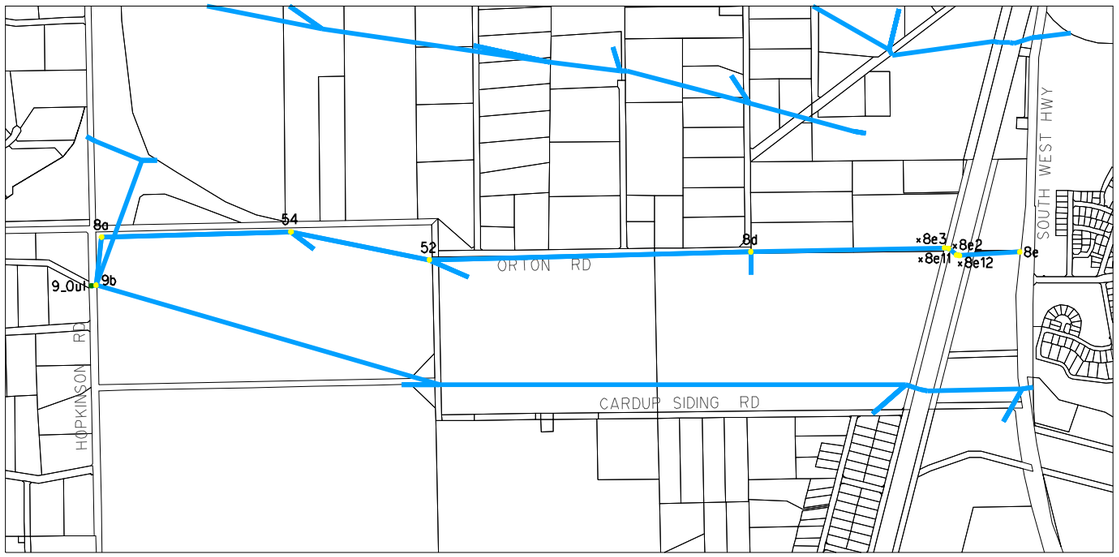


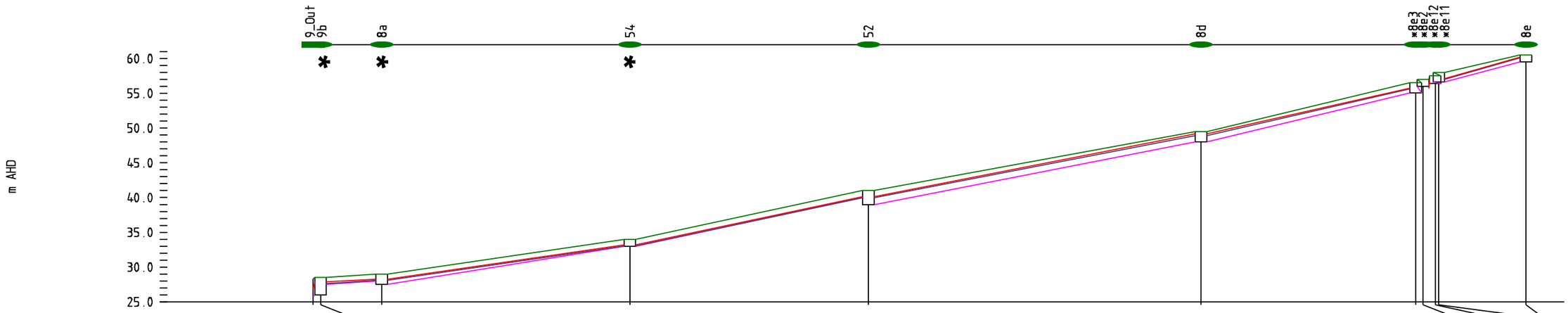


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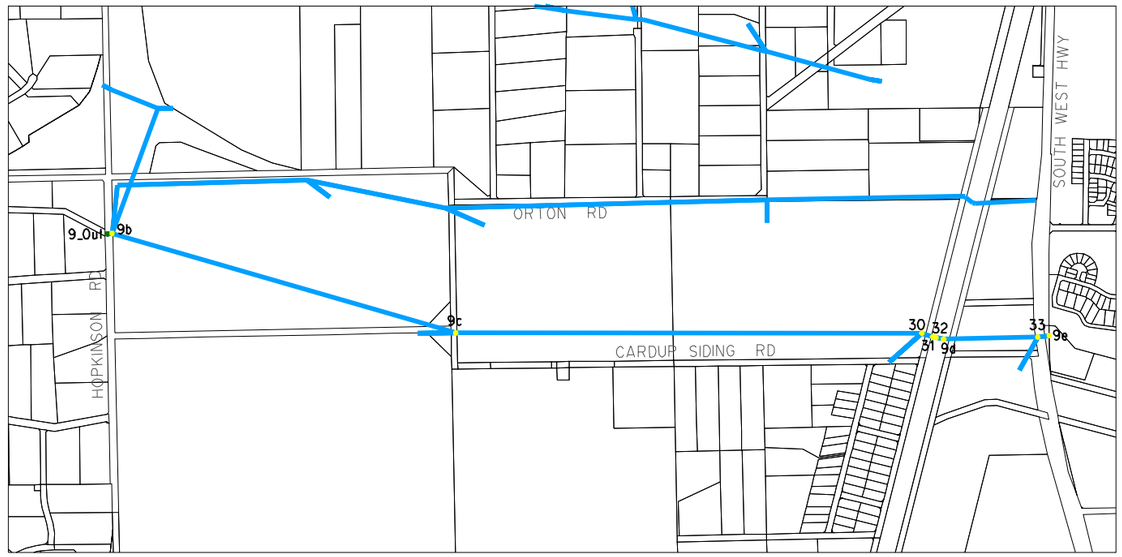


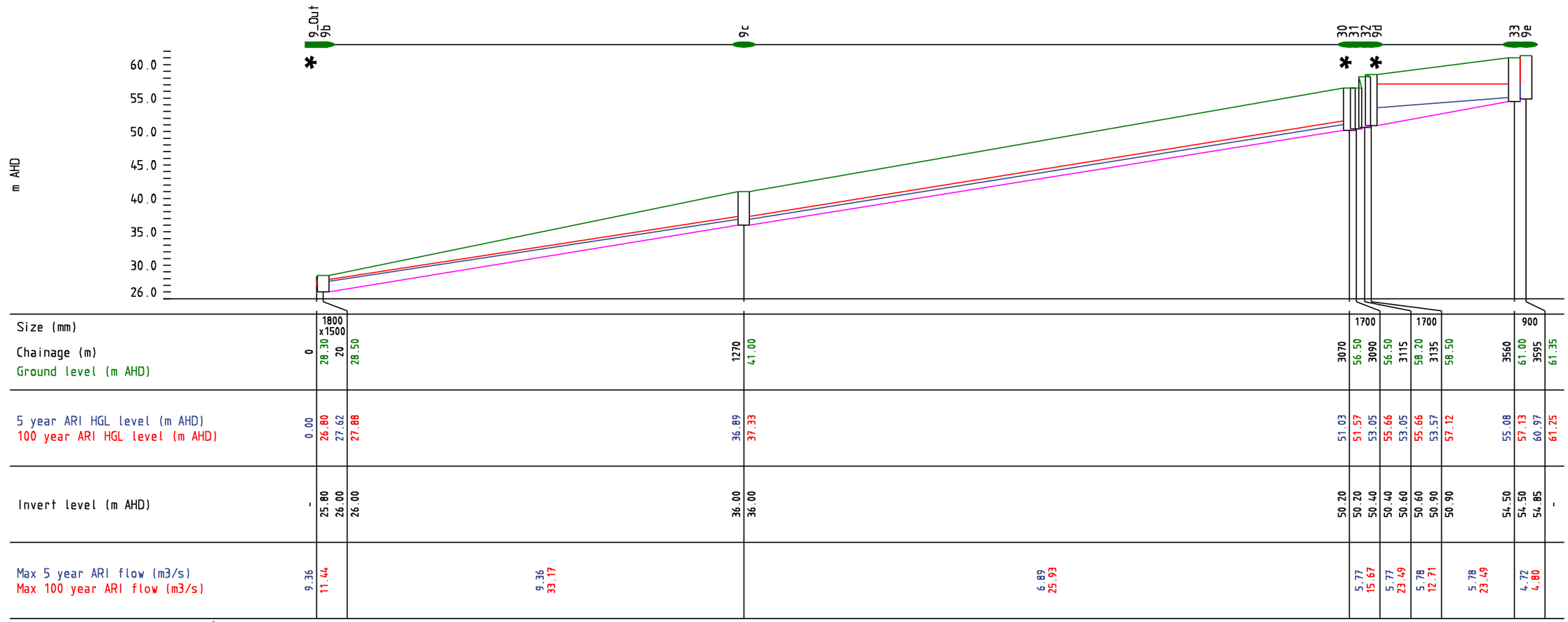


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Appendices

Appendix A – Stormwater modelling in InfoWorks CS

A.1 Hydraulic modelling in InfoWorks CS
A.2 Initial modelling assumptions
A.3 Surface runoff parameters
A.4 Hydrologic model validation
A.5 Hydraulic model validation
A.6 Modified parameterisation
A.7 Historic rainfall event – February 1992

A.1 Hydraulic modelling in InfoWorks CS

InfoWorks CS 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).

Mannings roughness coefficients applied to the conduits are summarised in Table A.1.

Table A.1 Culverts roughness coefficients (Mannings 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

Local detention basins were sized according to the principles outlined in Chapter 6. The numerical model is run for pre-development land use to determine maximum discharge from each subcatchment for critical one, five and 100-year annual recurrence interval rainfall events. The peak discharges of the subcatchments are to be maintained in the post-development scenario.

The detention storage size is tested by running critical one, five and 100-year annual recurrence interval rainfall events for the post-development scenario. The peak discharge from the detention basin should not exceed the pre-development level and the storage volume should be fully utilised. If the storage volume is inadequate, the basin is resized to achieve required volume utilisation, discharge out of the basin and the shape of the hydrograph.

Groundwater levels in drains and basins were modelled by the application of inflows directly into the drain. Groundwater levels and 100-year annual recurrence interval event flood levels were used to determine indicative fill requirements and the invert of the detention basin.

A.2 Initial modelling assumptions

The following assumptions used for modelling of the Byford townsite:

- Peak winter groundwater levels (controlled groundwater levels) applied as starting water levels in basins and as baseflows in drains.
- Annual recurrence interval year 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 and losses) adopted from the *Byford floodplain management strategy* (SKM, 2007).

A.3 Surface runoff parameters

Recorded stream flow information was not available for the Byford catchments to enable calibration of the loss parameters adopted within runoff routing models of the catchments. When deciding on the appropriate loss parameters applicable to the Byford catchments, the Department of Water considered:

- adopted parameters for calibrated runoff routing models of nearby similar catchments
- incorporation of antecedent flow from the catchment (baseflow)
- adopted parameters during modelling for other major infrastructure projects on the Swan Coastal Plain
- catchment soil characteristics
- vegetation coverage
- future expansion of Tonkin Highway
- uncertainty in design rainfall depths and temporal patterns
- uncertainty due to the impact of climate change
- uncertainty in upper catchment land use/vegetation coverage into the future

The F*loodplain management strategy* adopted runoff coefficients of 10 mm initial loss and 50 per cent continuing proportional loss for the upper catchments and 10 mm initial loss and 4 mm/hr continuing loss on the flatter heavy soils downstream of South Western Highway.

The InfoWorks CS model of Byford townsite uses 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. 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 (Table A-2).

The land use of the existing catchments was adopted from the *SKM flood management strategy. The distinct structure plan* (Table A-3) provided the land use breakdown for the ultimate development. The percentage of surface types for individual catchments was calculated from the existing land use and district structure plan; the results are summarised in Table A-4 (pre-development scenario) and Table A-5 (post-development scenario).

Design rainfall events for the 1h, 3h, 6h, 12h, 24h, 48h and 72h durations were run for 1y, 5y and 100y ARI.

Table A.2 InfoWorks model runoff area properties

Land use	surface roughness (Mannings 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 0.5 - 100y (calib.) 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 A.3 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%

Notes:

- 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 A.4 InfoWorks model catchment properties for pre-development scenario

Subcatchment ID	Total area (ha)	Vector slope (%)	Catchment width (m)	% Impervious
10C	24.672	1.4	280.2	0
2A	95.713	1.5	552.0	3.049
2A1	20.593	2.0	256.0	29.798
2B	79.625	4.1	503.4	1.517
2C	44.476	11.8	376.3	1.538

Subcatchment ID	Total area (ha)	Vector slope (%)	Catchment width (m)	% Impervious
3B1	29.222	1.8	305.0	0
3B2	54.433	1.8	416.3	0
3B3	24.668	1.8	280.2	0
3C	68.105	1.4	465.6	0
3CX	56.251	2.0	423.1	47.952
3D1	65.070	3.4	455.1	0
3D2	49.011	2.1	395.0	0
3D3	12.820	2.1	202.0	0
3D4	11.409	2.5	190.6	0
3E	136.379	10.8	658.9	42.016
3F	45.228	26.3	379.4	0
3F1	80.810	5.6	507.2	53.968
3F2	27.055	3.8	293.5	60.000
3F3	31.540	13.0	316.8	47.969
3G1	30.298	24.6	310.6	0
3G2	33.347	24.3	325.8	0
3H	109.757	16.4	591.1	0
4A2	34.352	1.8	330.7	54.023
4B	16.631	2.0	230.1	5.988
5B	40.298	1.6	358.2	1.467
5C	22.714	1.7	268.9	26.840
5D	47.859	2.0	390.3	24.008
5E	21.189	2.1	259.7	0
5F	6.314	3.8	141.8	0
5G	108.901	8.1	588.8	24.022
5H1	182.568	17.1	762.3	0
5H2	108.331	13.2	587.2	0
5I1	74.415	17.1	486.7	0
5I2	13.563	19.8	207.8	0
5J	268.448	8.8	924.4	0
5K	163.319	11.0	721.0	0
5L	246.591	5.4	886.0	0
5M	188.239	5.8	774.1	0
6B	26.896	1.8	292.6	0
6C	19.783	1.9	250.9	0
6D1	77.237	2.1	495.8	0
6D2	16.049	1.5	226.0	0
6E	20.920	1.8	258.1	0
6F	17.800	3.6	238.0	0
6G	74.373	4.3	486.6	0
7A	57.144	1.2	426.5	0
7B	46.436	1.4	384.5	0
7C	29.203	1.8	304.9	0
7C1	40.756	1.3	360.2	0
7D	34.041	1.9	329.2	0
8A	18.977	1.3	245.8	0
8B	43.128	1.5	370.5	0
8C	55.552	1.5	420.5	0

Subcatchment ID	Total area (ha)	Vector slope (%)	Catchment width (m)	% Impervious
8D	47.806	1.9	390.1	0
8E	65.206	6.6	455.6	0
9B	37.144	2.0	343.9	0
9C	85.439	3.9	521.5	6.007
9D	22.645	4.0	268.5	0
9E	113.147	9.5	600.1	0
9F1	22.219	27.0	265.9	0
9F2	101.466	21.1	568.3	0
9G	355.666	15.7	1064.0	0
9H	463.327	10.4	1214.4	0
9I	232.132	5.7	859.6	0
B16	224.573	2.0	845.5	0

Table A.5 InfoWorks model catchment properties for post-development scenario

Subcatchment ID	Total area (ha)	Vector slope (%)	Catchment width (m)	% Impervious
10C	24.672	1.4	280.2	38.486
2A	95.713	1.5	552.0	3.049
2A1	20.593	2.0	256.0	29.798
2B	79.625	4.1	503.4	1.517
2C	44.476	11.8	376.3	1.538
3B1	29.222	1.8	305.0	28.681
3B2a	10.392	1.8	180.8	31.570
3B2b	15.680	1.8	201.5	28.800
3B2c	30.907	1.8	290.2	21.370
3B3	24.668	1.8	280.2	47.952
3C	68.105	1.4	465.6	38.265
3CX	56.251	2.0	423.1	26.702
3D1	65.070	3.4	455.1	33.162
3D2	49.011	2.1	395.0	27.361
3D3	12.820	2.1	202.0	42.016
3D4	11.409	2.5	190.6	53.968
3E	136.379	10.8	658.9	60.000
3F	45.228	26.3	379.4	0
3F1	80.810	5.6	507.2	47.969
3F2	27.055	3.8	293.5	0
3F3	31.540	13.0	316.8	0
3G1	30.298	24.6	310.6	26.976
3G2	33.347	24.3	325.8	36.151
3H	109.757	16.4	591.1	0
4A2	34.352	1.8	330.7	54.023
4B	16.631	2.0	230.1	5.988
5B	40.298	1.6	358.2	34.950
5C	22.714	1.7	268.9	31.609
5D	47.859	2.0	390.3	20.449
5E	21.189	2.1	259.7	35.969
5F	6.314	3.8	141.8	28.798
5G	108.901	8.1	588.8	31.791
5H1	182.568	17.1	762.3	0

Subcatchment ID	Total area (ha)	Vector slope (%)	Catchment width (m)	% Impervious
5H2	108.331	13.2	587.2	0
5I1	74.415	17.1	486.7	0
5I2	13.563	19.8	207.8	0
5J	268.448	8.8	924.4	0
5K	163.319	11.0	721.0	0
5L	246.591	5.4	886.0	0
5M	188.239	5.8	774.1	0
6B	26.896	1.8	292.6	15.110
6C	19.783	1.9	250.9	29.278
6D1	77.237	2.1	495.8	39.315
6D2	16.049	1.5	226.0	5.331
6E	20.920	1.8	258.1	0
6F	17.800	3.6	238.0	33.378
6G	74.373	4.3	486.6	40.158
7A	57.144	1.2	426.5	39.404
7B	46.436	1.4	384.5	40.196
7C	29.203	1.8	304.9	24.176
7C1	40.756	1.3	360.2	23.179
7D	34.041	1.9	329.2	39.852
8A	18.977	1.3	245.8	37.906
8B	43.128	1.5	370.5	42.541
8C	55.552	1.5	420.5	1.765
8D	47.806	1.9	390.1	4.672
8E	65.206	6.6	455.6	11.069
9B	37.144	2.0	343.9	4.190
9C	85.439	3.9	521.5	15.879
9D	22.645	4.0	268.5	4.190
9E	113.147	9.5	600.1	0
9F1	22.219	27.0	265.9	0
9F2	101.466	21.1	568.3	0
9G	355.666	15.7	1064.0	0
9H	463.327	10.4	1214.4	0
9I	232.132	5.7	859.6	0
B16	224.573	2.0	845.5	0

A.4 Hydrologic model validation

Peak and total pre-development catchment runoff generated by the InfoWorks model was compared to peak and total catchment output from the RAFTS model used in the SKM floodplain management study.

In general, the fit is good, though at high flows the peak flows generated by InfoWorks are somewhat smaller than those generated by RAFTS. Figure 1 shows the peak outputs of each model plotted against each other (the 1:1 line is provided for comparison, Figure 2) for the critical 6 hour 100-year event.

A comparison of total generated runoff volume has also been carried out for the six-hour 100-year annual recurrence interval event and shows a good calibration

between the RAFTS and InfoWorks models. The results are presented in Figure 3 below.

Figure 1 Hydrologic model validation – peak flow: 6h 100y

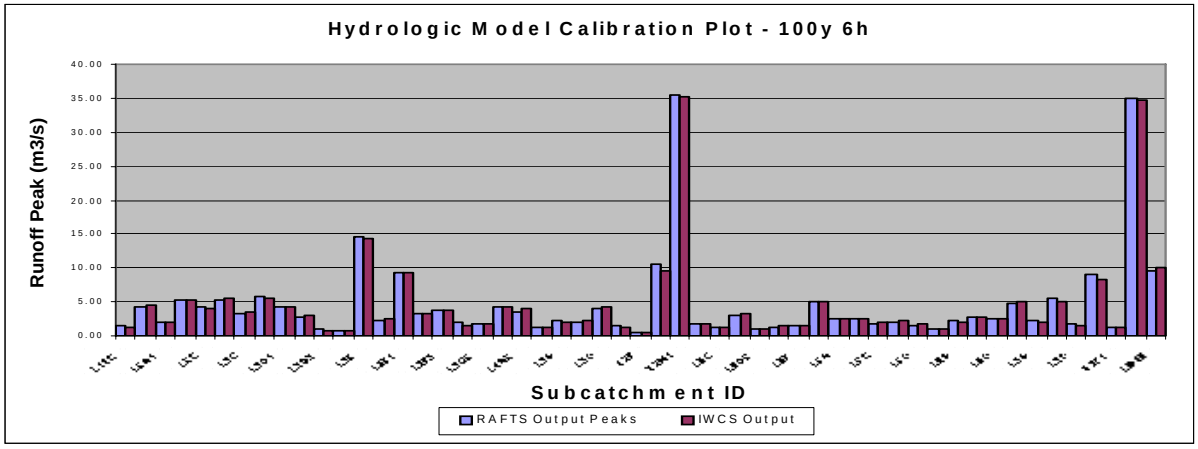


Figure 2 Hydrologic model validation – peak flow: 6h 100y

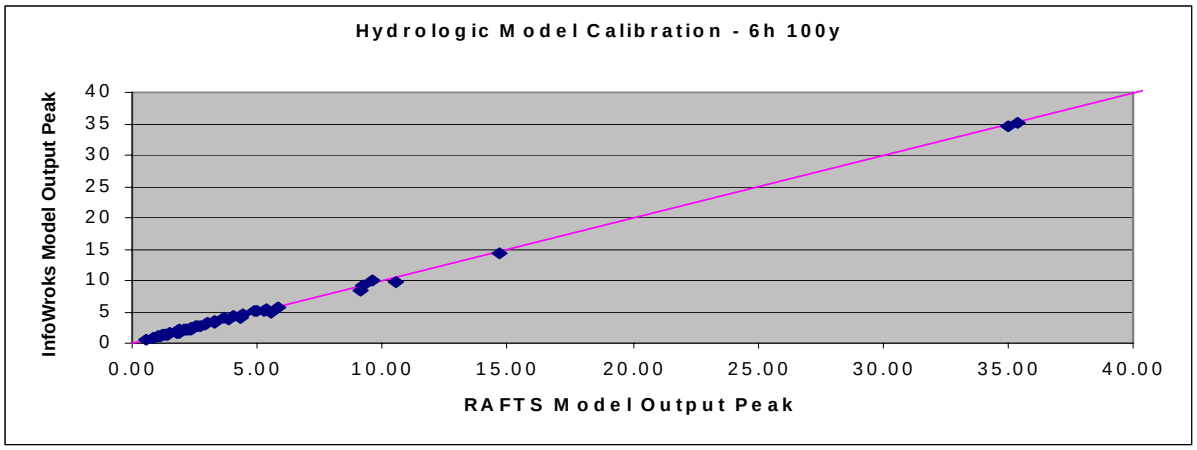
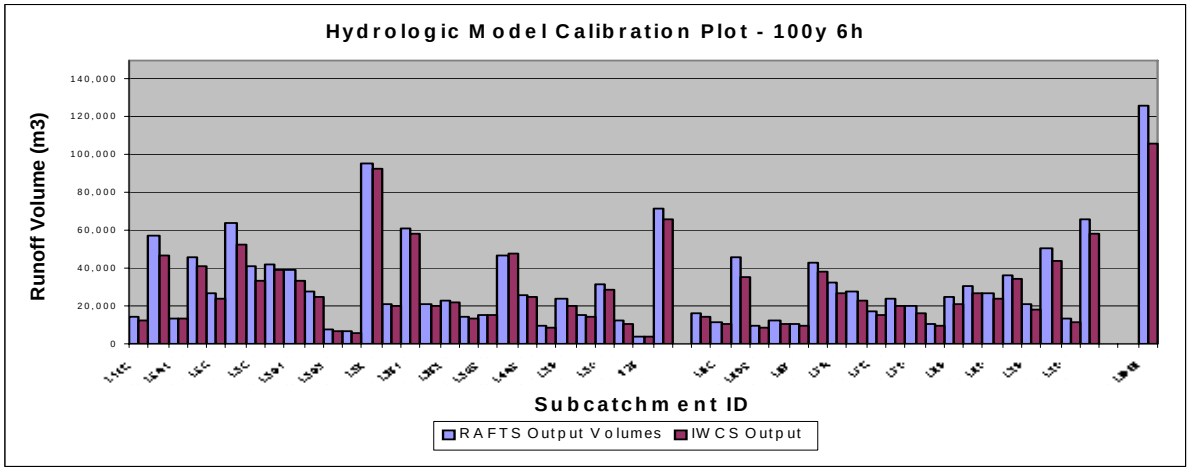


Figure 3 Hydrologic model validation – total volume: 6h 100y



A.5 Hydraulic model validation

Peak pre-development flows generated by the InfoWorks model at various critical locations within the major waterways were compared to peak flows reported in the *Floodplain management study* (SKM, 2007) and are presented in Table A-6 below.

In general the InfoWorks model flows compare well to those generated by the flood model (SKM, 2007).

Table A-6 Pre-development peak flow comparison between SKM flood study and Drainage and water management plan InfoWorks CS Model

Location	10 Year ARI Peak Flows (m^3/s)		100 Year ARI Peak Flows (m^3/s)	
	Flood Study	DWMP model	Flood Study	DWMP model
Oaklands drain at Hopkinson Road	30.0	32.9	53.0	50.4
WC drain downstream of catchment 5B	5.2	6.1	9.4	9.9
WC drain downstream of catchment 6B	3.3	1.9	8.0	8.1
WC drain downstream of catchment 7A	5.0	2.9	10.0	9.7
Cardup Brook at Hopkinson Road	19.0	18.8	56.0	55.3

Table A-7 presents the significant hydraulic structures that have been included within the InfoWorks model of the Byford townsite catchment.

Table A-7 Modelled hydraulic structures

Location		Shape	Diameter/ width (mm)	Height (mm)	Invert level (m AHD)	Number of barrels
X	Y					
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
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

Location X	Location Y	Shape	Diameter/ width (mm)	Height (mm)	Invert level (m AHD)	Number of barrels
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

A.6 Modified parameterisation

The original 100 -year annual recurrence interval event upper catchment runoff parameter of 0.5 (or 50% continuing proportional loss) developed for the *Floodplain management strategy* included allowances for the following uncertainties:

- uncertainty in design rainfall depths and temporal patterns
- uncertainty due to the impact of climate change
- uncertainty in upper catchment landuse / vegetation coverage into the future

These allowances provided a conservative analysis of potential flood risk for the catchment. However, it is appropriate to reduce this allowance for design purposes, and so for the design scenarios presented in the main text of this report the Department of Water have adopted runoff coefficients of:

- 10 mm initial loss and 60 per cent continuing proportional loss for the upper catchments
- 10 mm initial loss and 4 mm/hr continuing loss on the flatter heavy soils downstream of the South Western Highway

These adopted parameters are not expected to account for the full extent of the uncertainties in estimating the 100-year annual recurrence interval flow for the catchments but are considered appropriate for providing an adequate level of flood protection to the new residential areas. Table A-8 below presents the results of this modification.

Table A-8 Pre-development peak flow comparison between parameters

Location	100 Year ARI Peak Flows (m^3/s)	
	Design parameter – 60% continuing loss	Calibration parameter – 50% continuing loss
Oaklands drain at Hopkinson Road	49.5	50.4
WC drain downstream of catchment 5B	9.7	9.9
WC drain downstream of catchment 6B	7.2	8.1
WC drain downstream of catchment 7A	9.0	9.7
Cardup Brook at Hopkinson Road	43.8	55.3

A.7 Historic rainfall event – February 1992

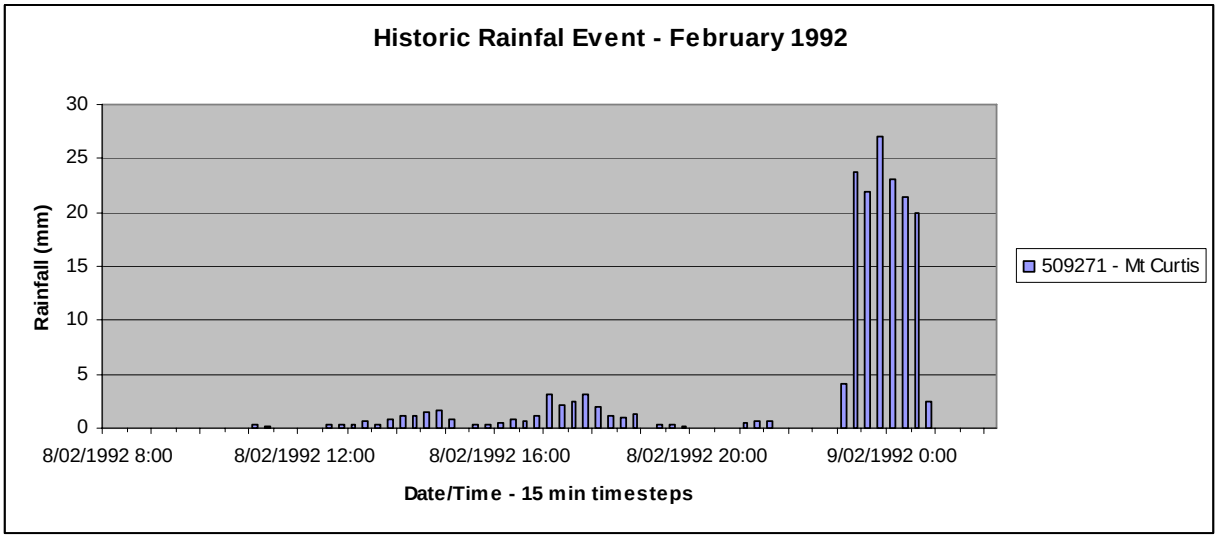
Historic rainfall records were available at two locations close to the study area for the significant historic rainfall event that occurred in February 1992. Although no flow or level data exist for any of the waterways within the catchment, it is known that whilst widespread flooding occurred elsewhere on the Swan Coastal Plain, there was no recorded flooding within the study area as a result of this event.

In order to examine the performance of the model in simulating this event, the initial losses of the catchment were increased to 100 mm to allow for the summer conditions within the catchment. The 1992 rainfall event, as recorded at Mt Curtis (see Figure 4) was then run with the InfoWorks model.

The results of this scenario show that while there was some flooding predicted at the inlets to several culverts at road and rail crossings throughout the catchment, the flooding was short-lived (one to two hours) and occurred during and immediately following the most intense part of the event (between midnight and 2 am). The nature of this predicted flooding is such that it would be unlikely to cause any significant disruption to traffic and would not have endangered any dwellings.

It is considered sufficiently unlikely that the type and extent of flooding predicted by the model for this event would be reported, so that the model can be considered to not be significantly over-predicting flooding in the catchment.

Figure 4 Historic rainfall event – February 1992



List of shortened forms

ADS	Arterial drainage scheme
AHD	Australian height datum
ARI	Annual recurrence interval
BFS	Bush Forever site
CCW	Conservation category wetland
CGL	Controlled groundwater level
DEC	Department of Environment and Conservation
DoW	Department of Water
DPI	Department of Planning and Infrastructure
DRF	Declared rare flora
DSP	District structure plan
DWMP	Drainage and water management plan
DWMS	District water management strategy
EWR	Environmental water requirement
GDE	Groundwater-dependent ecosystem
HGL	Hydraulic grade line
LWMS	Local water management strategy
MUW	Multiple use wetland
PWSA	Public water supply area
REW	Resource enhancement wetland
SJ Shire	Serpentine Jarrahdale Shire
TEC	Threatened ecological community
ToK	Town of Kwinana
TN	Total nitrogen

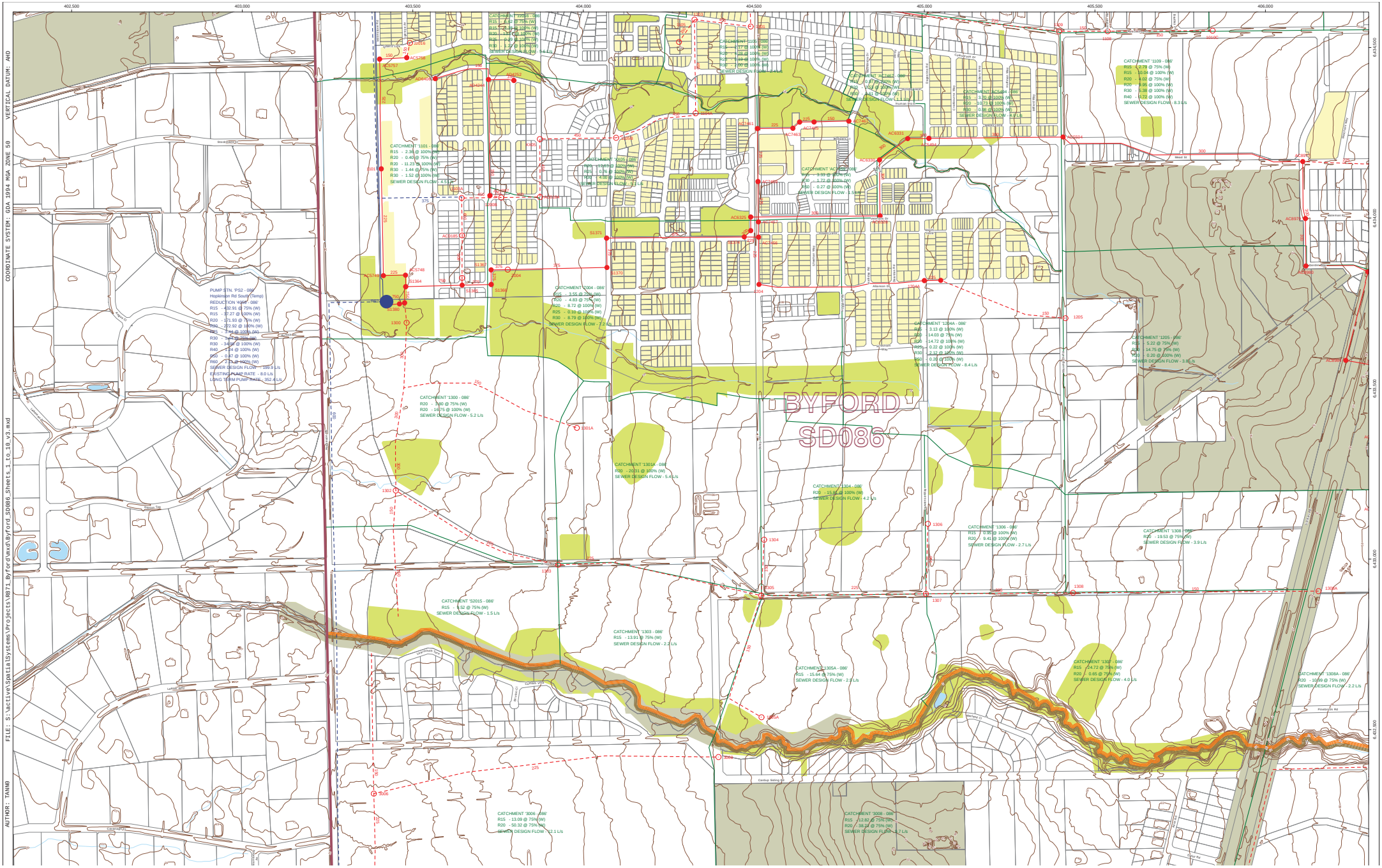
TP	Total phosphorous
TWG	Technical working group
TWL	Top water level
UWMP	Urban water management plan
UWPCA	Underground water protection control area
WAPC	Western Australian Planning Commission
WDE	Water-dependent ecosystem

References

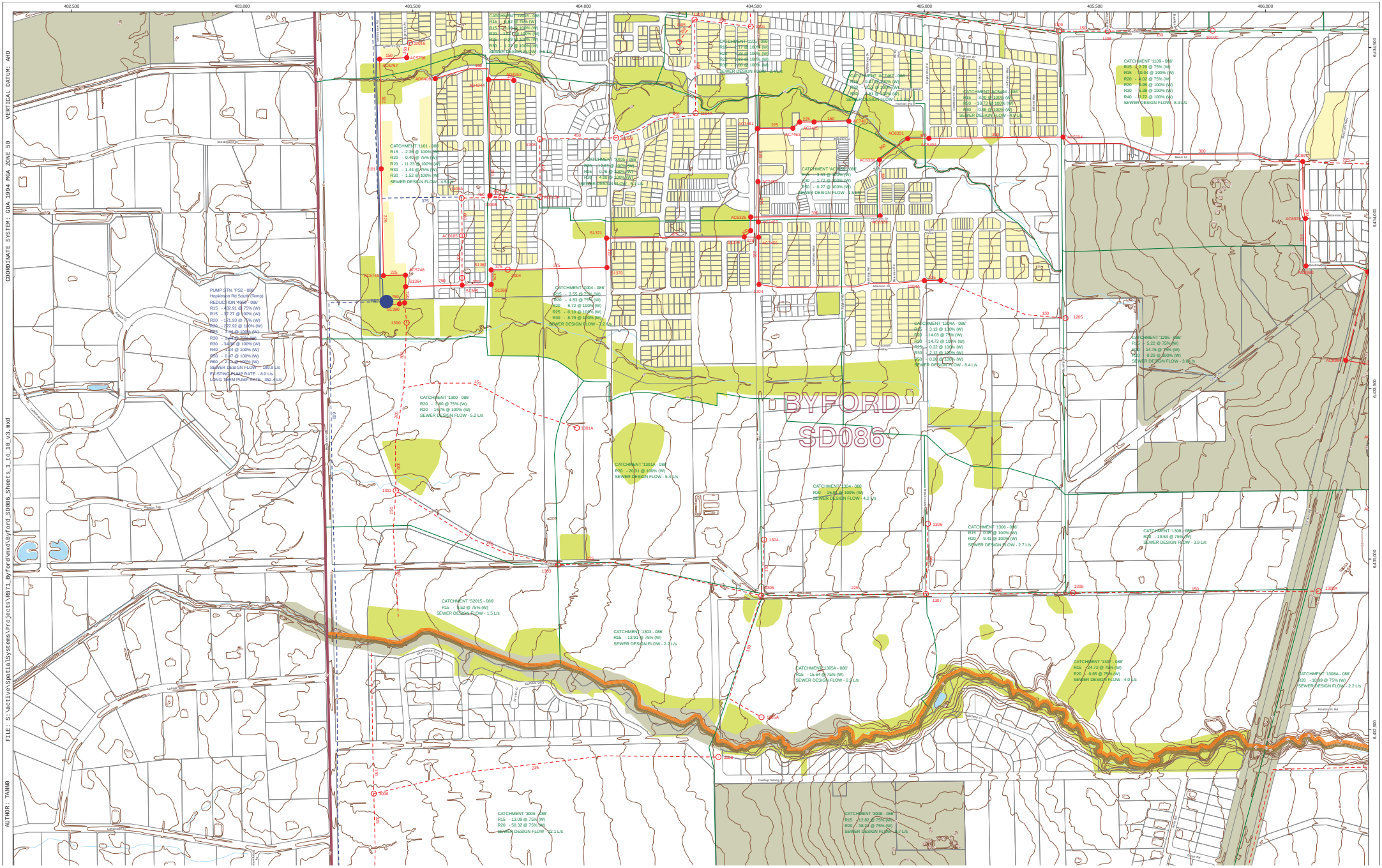
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Appendix Four Water Corporation Sewer Long Term Planning, 2015


BYFORD
SD086
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COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
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AUTHOR: TANM0

Appendix Four Water Corporation Sewer Long Term Planning, 2015


BYFORD
SD086
VERTICAL DATUM: AHD
COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
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AUTHOR: TANM0

Appendix Five Water Corporation Water Planning, November 2015

Adrian Stefan

From: Simon Ridgewell <Simon.Ridgewell@watercorporation.com.au>
Sent: Friday, 6 November 2015 8:43 AM
To: Adrian Stefan
Cc: Rick Harrison; Kevin Purcher
Subject: Orton Road Byford - Water Planning
Attachments: 201511060824.pdf

Good Morning Adrian,

We have discussed the planning further amongst the team, and have come up with a compromise plan, based on what Development Services Branch believe is likely to happen in the area. A DN 250 will be sufficient in place of a distribution and DN 200 combination. Please find attached, the updated planning:

Should you have any questions regarding the updated plan, please don't hesitate to contact me.

Best Regards

Simon Ridgewell
Water Supply Reticulation Planner
Development Services Branch
Assets Planning
Water Corporation
T: (08) 9420 2775
629 Newcastle Street, Leederville, WA 6007
PO Box 100, Leederville, WA 6902
www.watercorporation.com.au

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Perrone Ave

Allanson Dve

Cristonia Tce

Doley Rd

Doley Rd

Orton Rd

Future Distribution

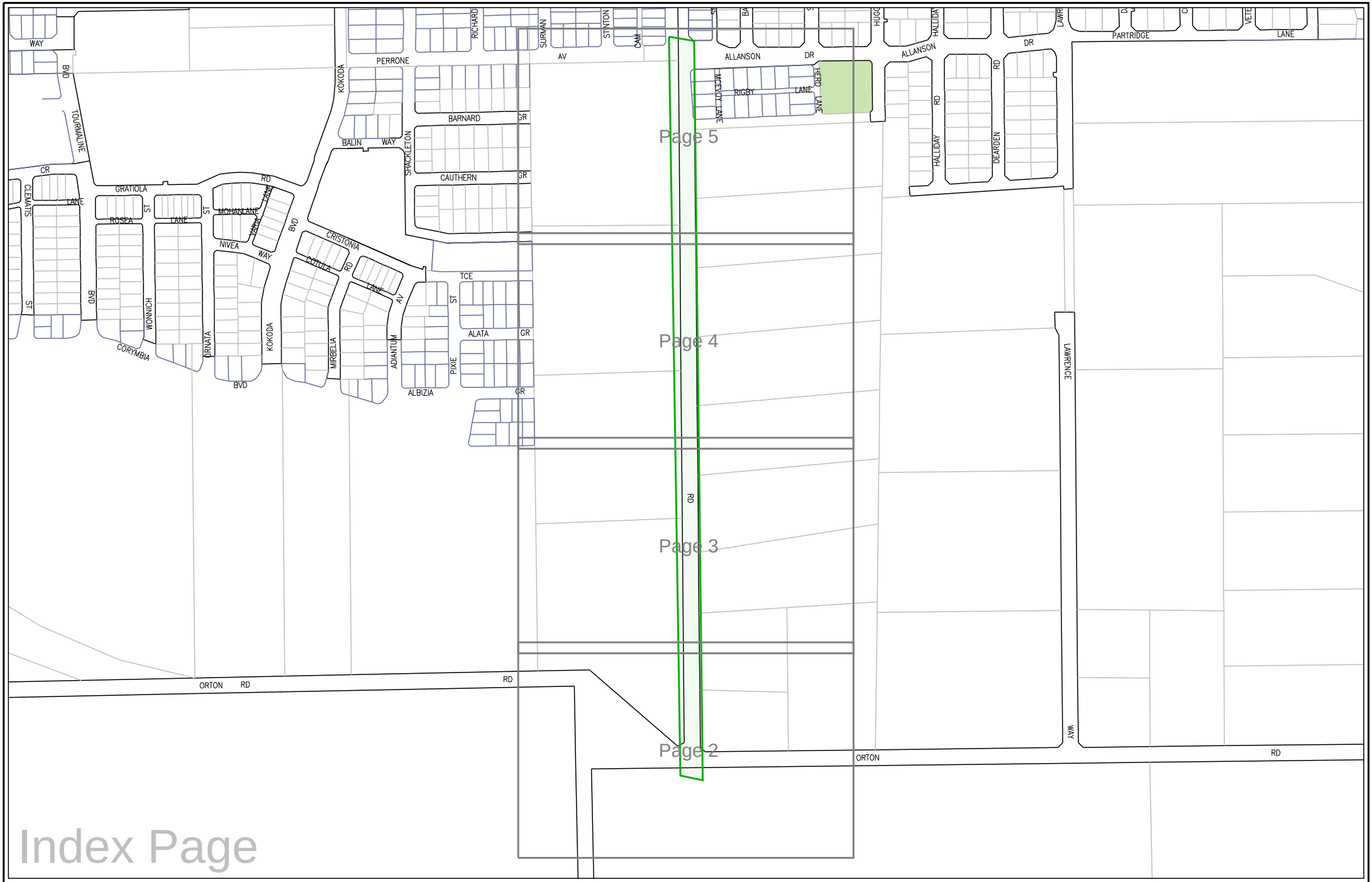
Orton Rd

Existing/Proposed Distribution
Existing/Proposed DN 250
Existing/Proposed DN 200
Existing/Proposed DN 150
Existing/Proposed DN 100

Note: All mains not indicated are to be DN 100 or smaller

6/11/15.

Appendix Six Water Corporation Maps, 2015



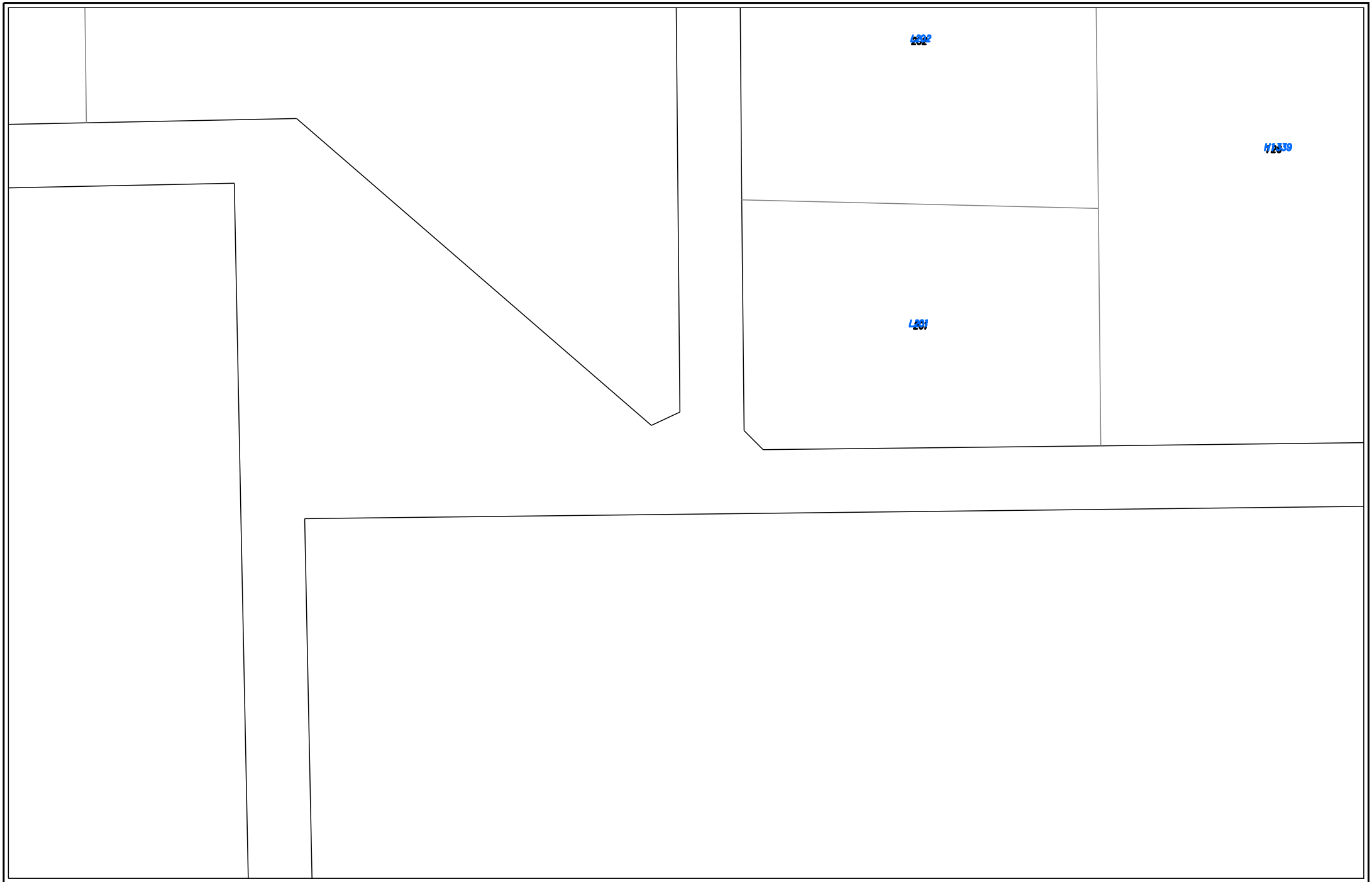
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Print Date: 04/08/2015 Page: 1 of 5

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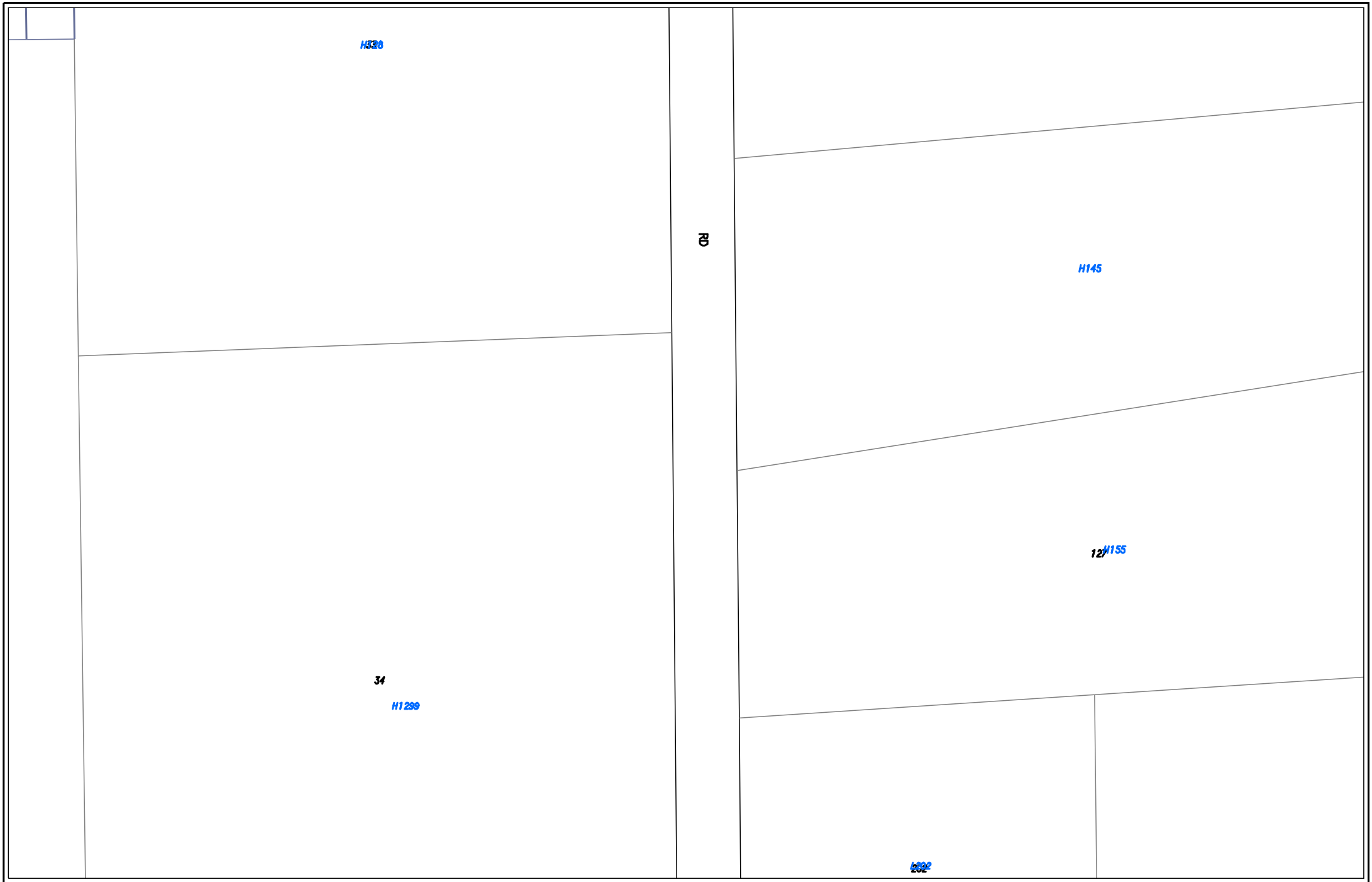
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Water

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WATER CORPORATION

Scale: 1:1500 Centre Point: 115.987°, -32.234°

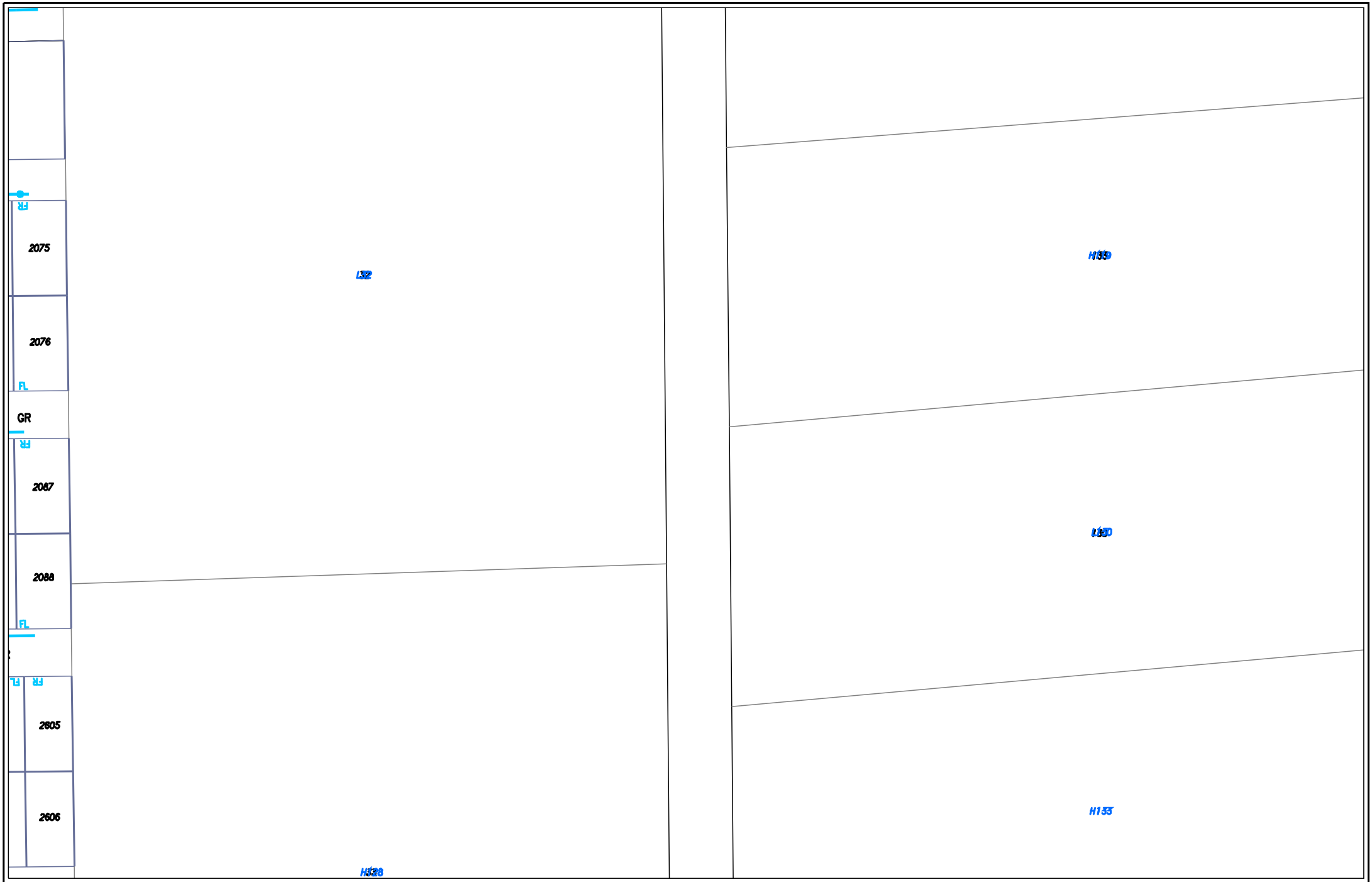
Sequence No: 47078759

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Water

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Scale: 1:1500 Centre Point: 115.987°, -32.232°

Sequence No: 47078759

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Water

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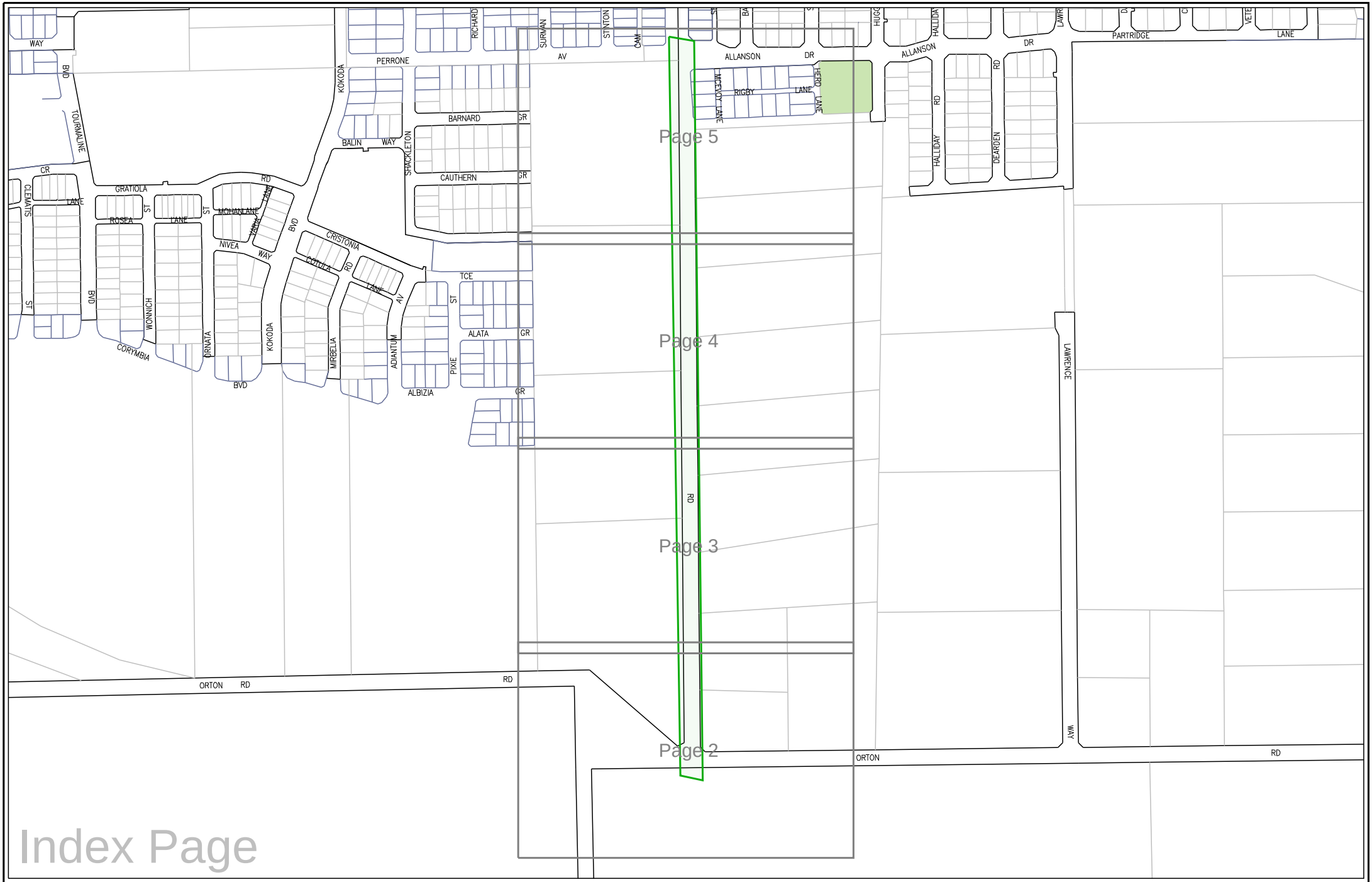
Scale: 1:1500 Centre Point: 115.987°, -32.229°

Sequence No: 47078759

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WATER CORPORATION

Scale: 1:6064

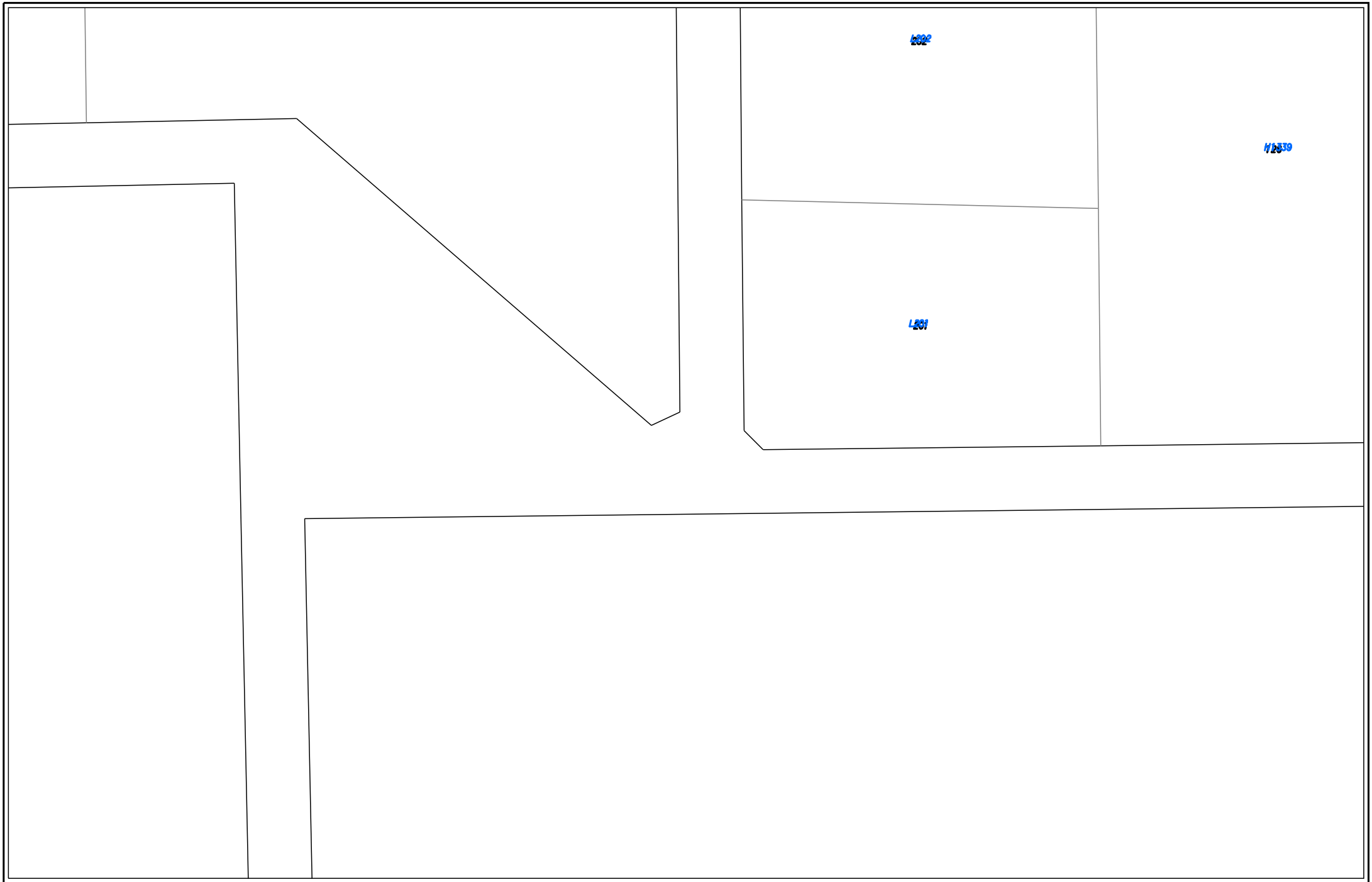
Sequence No: **47078759**

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Sewer

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Scale: 1:1500 Centre Point: 115.987°, -32.236°

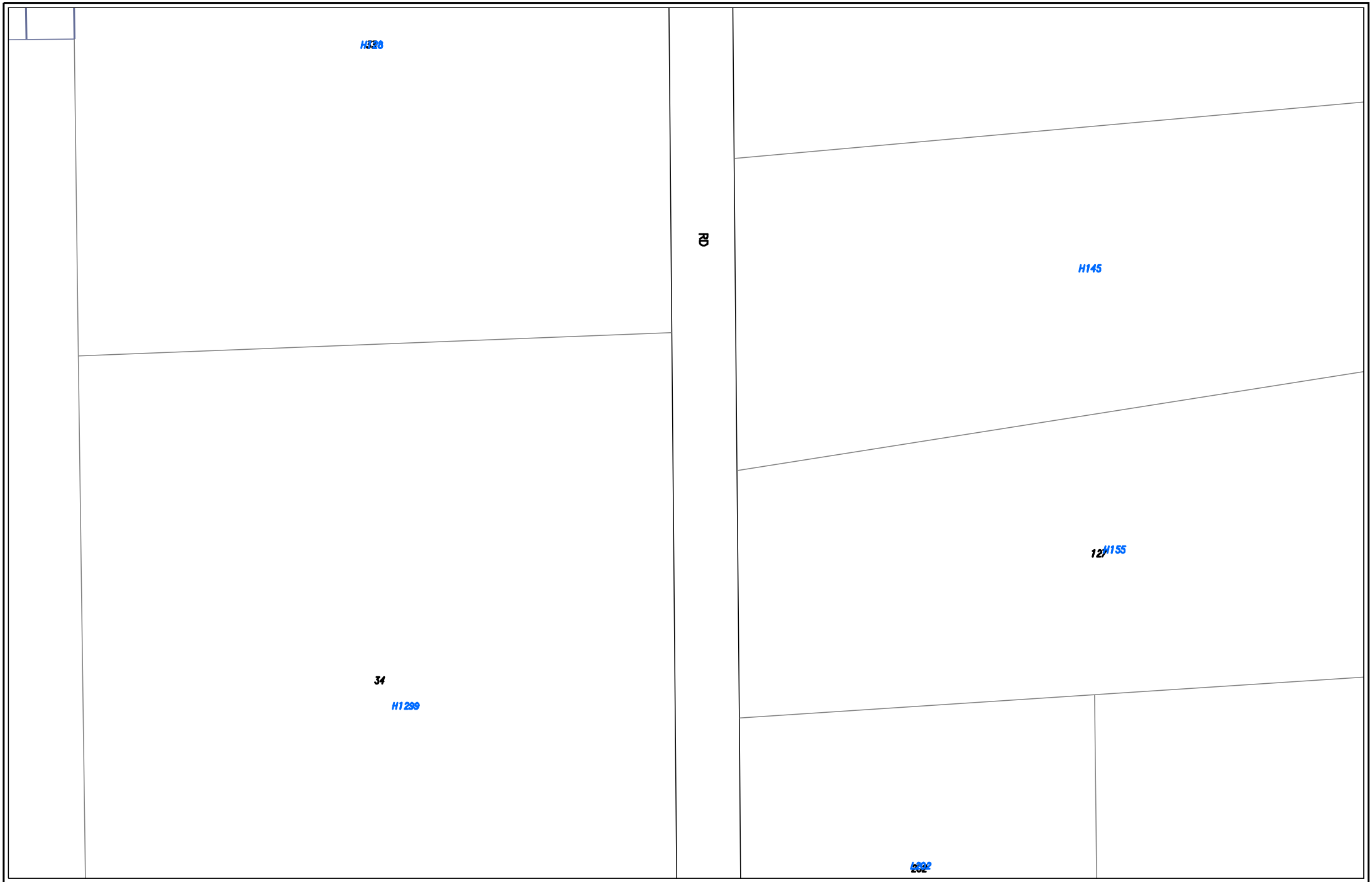
Sequence No: 47078759

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Sewer

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WATER CORPORATION

Scale: 1:1500 Centre Point: 115.987°, -32.234°

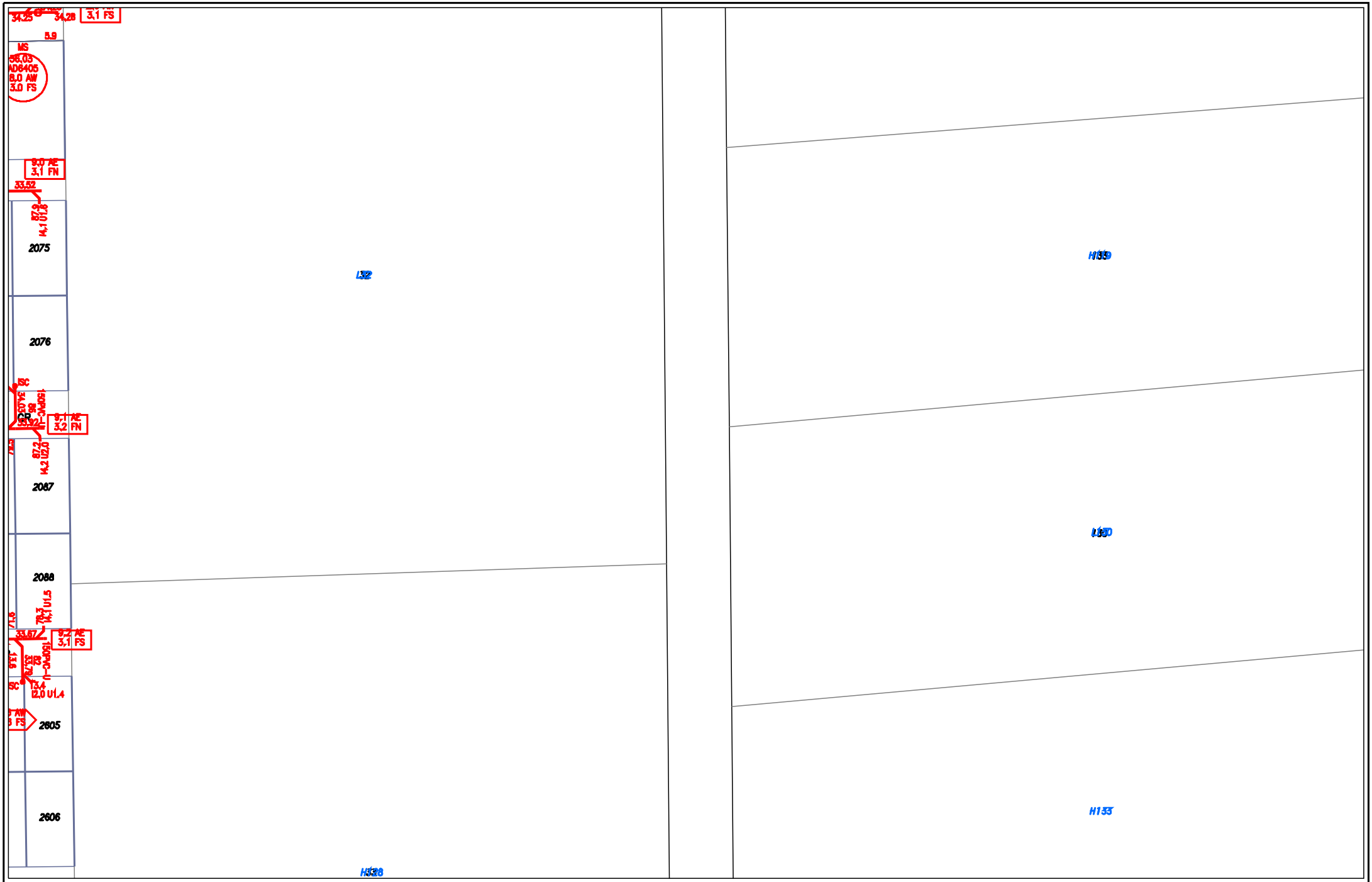
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WATER CORPORATION

Scale: 1:1500 Centre Point: 115.987°, -32.232°

Sequence No: 47078759

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WATER CORPORATION
UNDERGROUND ASSET DETAILS

ABN 28 003 434 917
629 Newcastle Street
Leederville, WA, 6007
PO Box 100
Leederville, WA, 6902
www.watercorporation.com.au
(08) 9424 8115

Requestor details

Mr Adrian Stefan
Pritchard Francis
PO Box 2150
Subiaco WA 6008

Phone: 0893825111
Mobile: Not Supplied
Fax: Not Supplied
Email: adrian.s@pfeng.com.au

Sequence No: **47078813**
DBYD Job No: 9499220
Enquiry Date: 04/08/2015
Issue Date: 04/08/2015

Requested location details



Address Doley Road
Byford WA 6122
GPS X Coordinate
GPS Y Coordinate
Map Ref 556B4,556B5

Note: The response for this enquiry has been interpreted from details in the picture location only.

Water Corporation asset impact

NO PIPELINES FOUND
No underground pipes were identified. However be aware that pipes may still exist in your work area.
NOTE: For best results use the polygon function to define your work area. Point and line requests only generate a limited search of the surrounding area.

Important

1. Plans show approximate location only – verify location by potholing before using powered machinery.
2. Please read all information and attachments.
3. All documents must be kept together and retained on site by the work team.
4. This information is valid for 30 days from date of issue.

WATER CORPORATION
UNDERGROUND ASSET DETAILS

ABN 28 003 434 917
629 Newcastle Street
Leederville, WA, 6007
PO Box 100
Leederville, WA, 6902
www.watercorporation.com.au
(08) 9424 8115

Requestor details

Mr Adrian Stefan
Pritchard Francis
PO Box 2150
Subiaco WA 6008

Phone: 0893825111
Mobile: Not Supplied
Fax: Not Supplied
Email: adrian.s@pfeng.com.au

Sequence No: **47078825**
DBYD Job No: 9499223
Enquiry Date: 04/08/2015
Issue Date: 04/08/2015

Requested location details



Address Doley Road
Byford WA 6122
GPS X Coordinate
GPS Y Coordinate
Map Ref 556A5,556B5

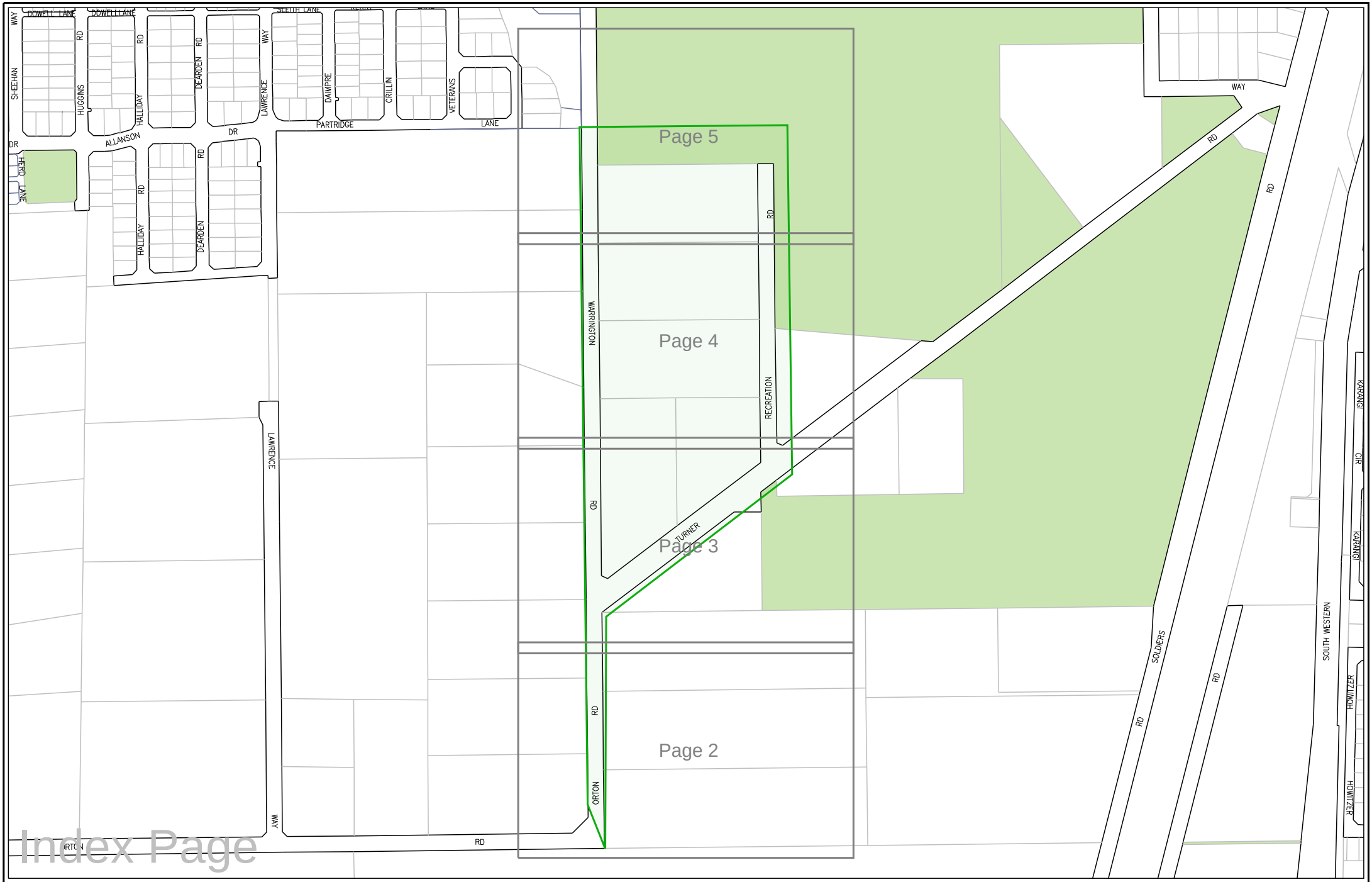
Note: The response for this enquiry has been interpreted from details in the picture location only.

Water Corporation asset impact

NO PIPELINES FOUND
No underground pipes were identified. However be aware that pipes may still exist in your work area.
NOTE: For best results use the polygon function to define your work area. Point and line requests only generate a limited search of the surrounding area.

Important

1. Plans show approximate location only – verify location by potholing before using powered machinery.
2. Please read all information and attachments.
3. All documents must be kept together and retained on site by the work team.
4. This information is valid for 30 days from date of issue.



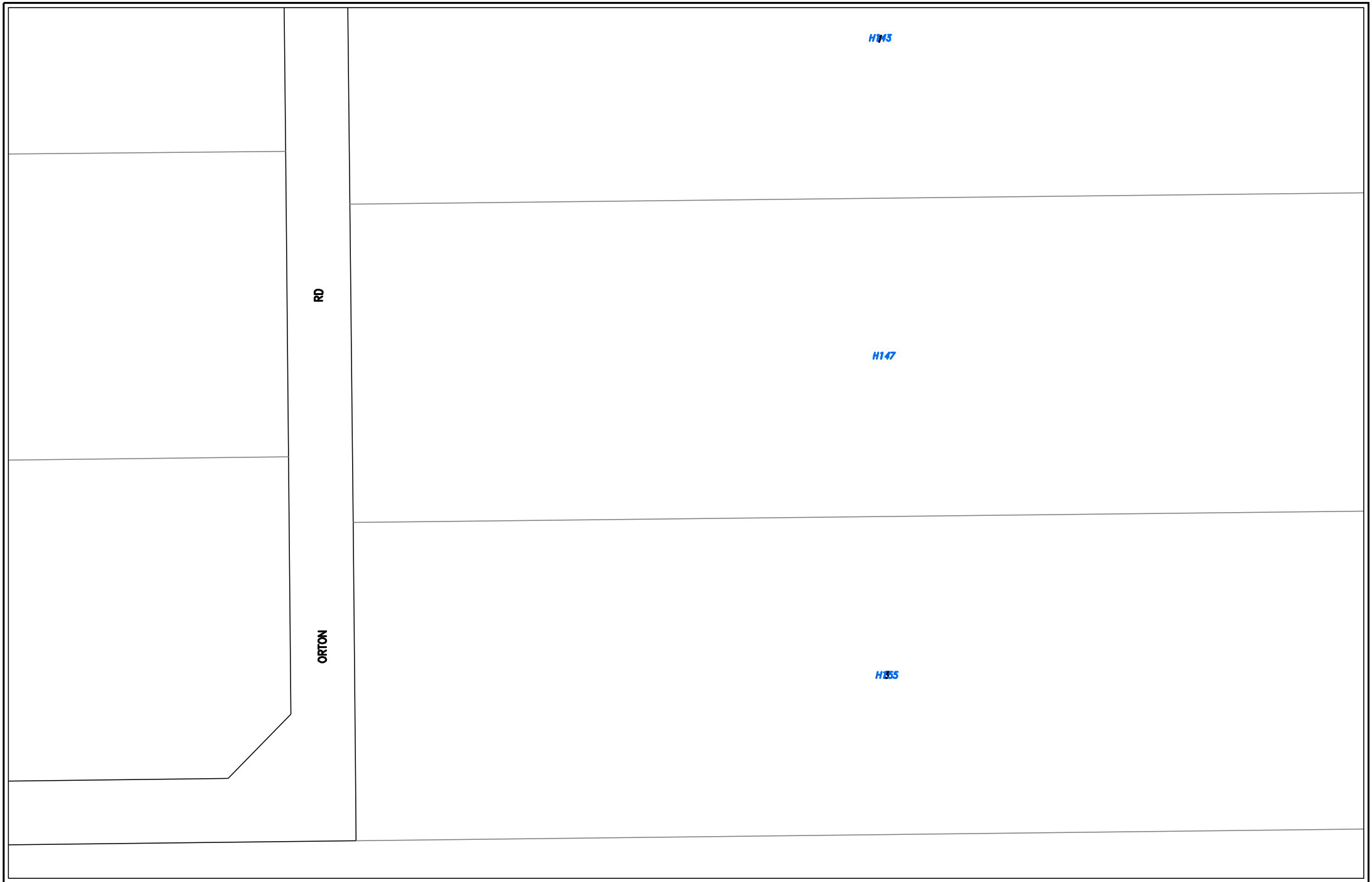
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Sequence No: **49239625**

Print Date: 19/11/2015 Page: 1 of 5

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WATER CORPORATION

Scale: 1:1500 Centre Point: 115.997°, -32.236°

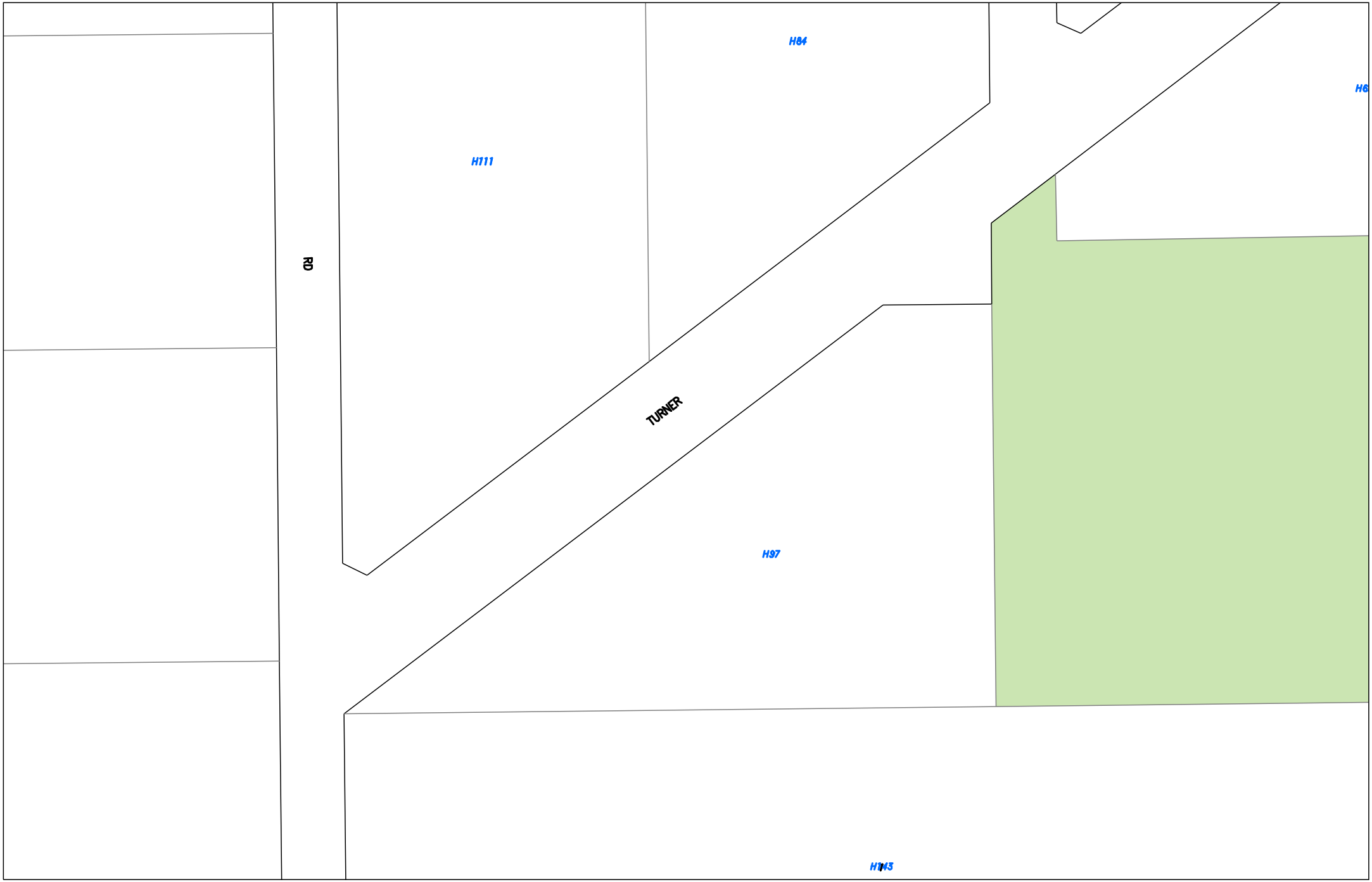
Sequence No: 49239625

Print Date: 19/11/2015 Page: 2 of 5

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WATER CORPORATION

Scale: 1:1500 Centre Point: 115.997°, -32.233°

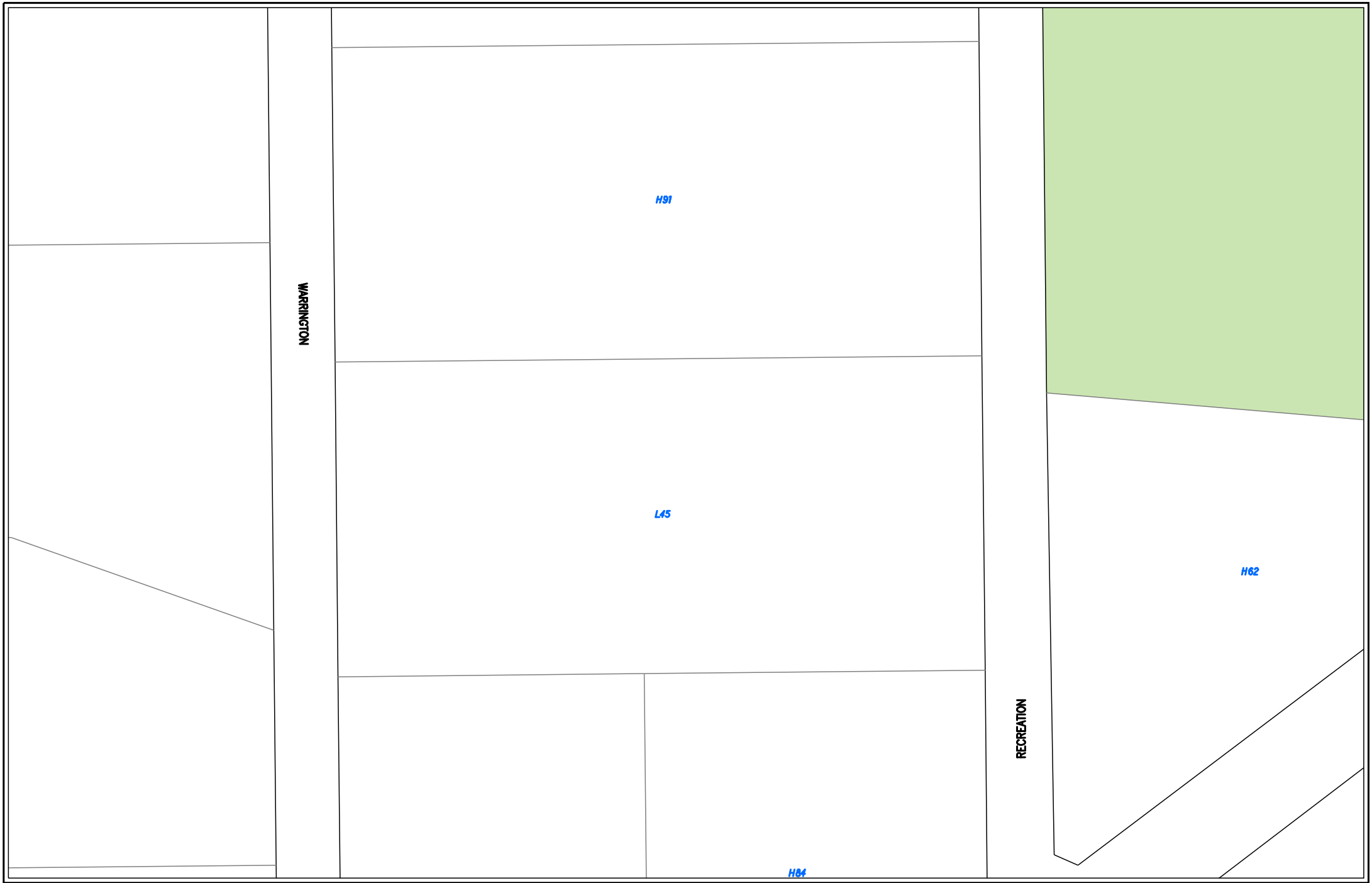
Sequence No: 49239625

Print Date: 19/11/2015 Page: 3 of 5

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Sewer

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WATER CORPORATION

Scale: 1:1500 Centre Point: 115.997°, -32.231°

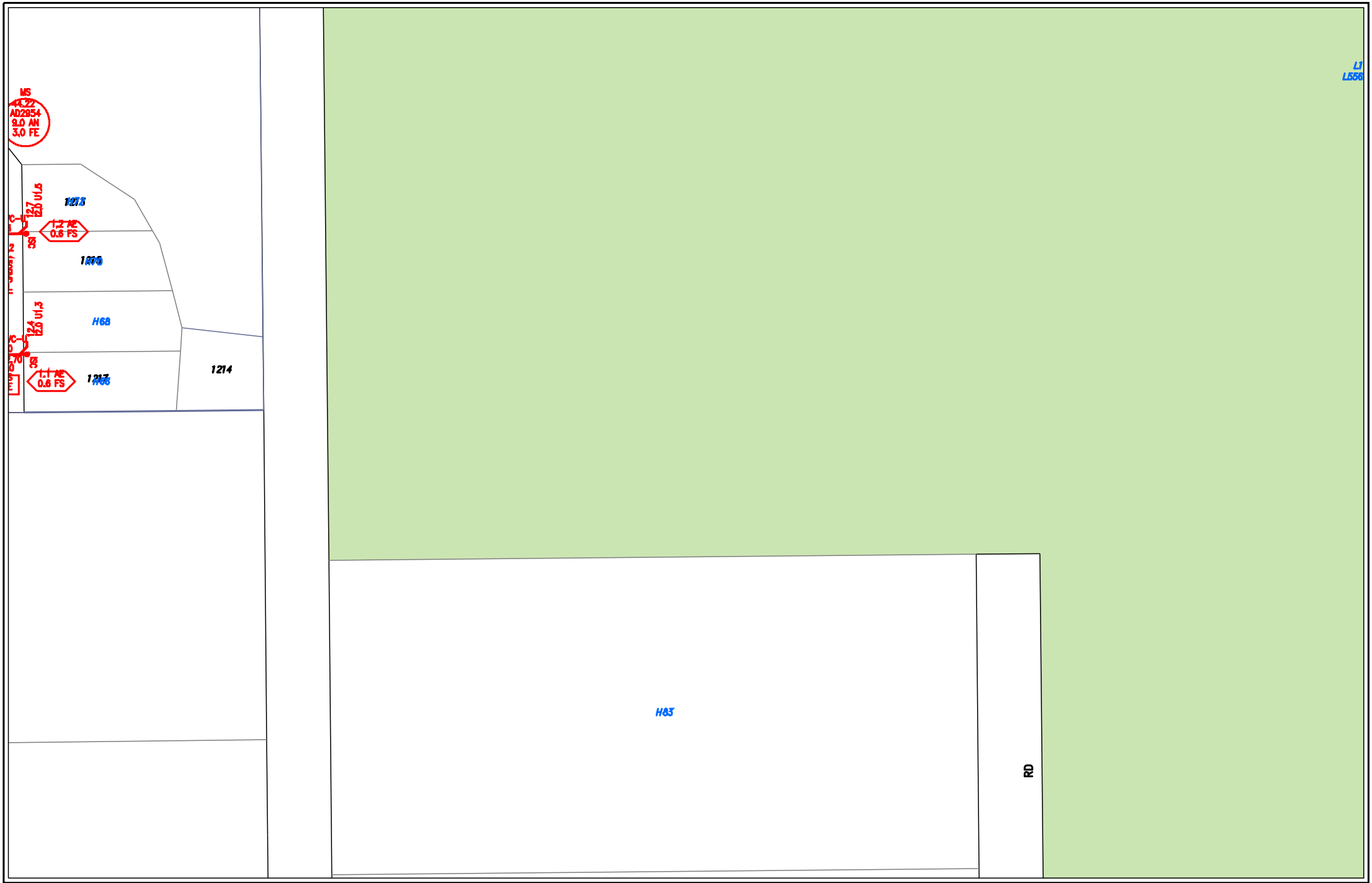
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Print Date: 19/11/2015 Page: 4 of 5

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WATER CORPORATION

Scale: 1:1500 Centre Point: 115.997°, -32.228°

Sequence No: 49239625

Print Date: 19/11/2015 Page: 5 of 5

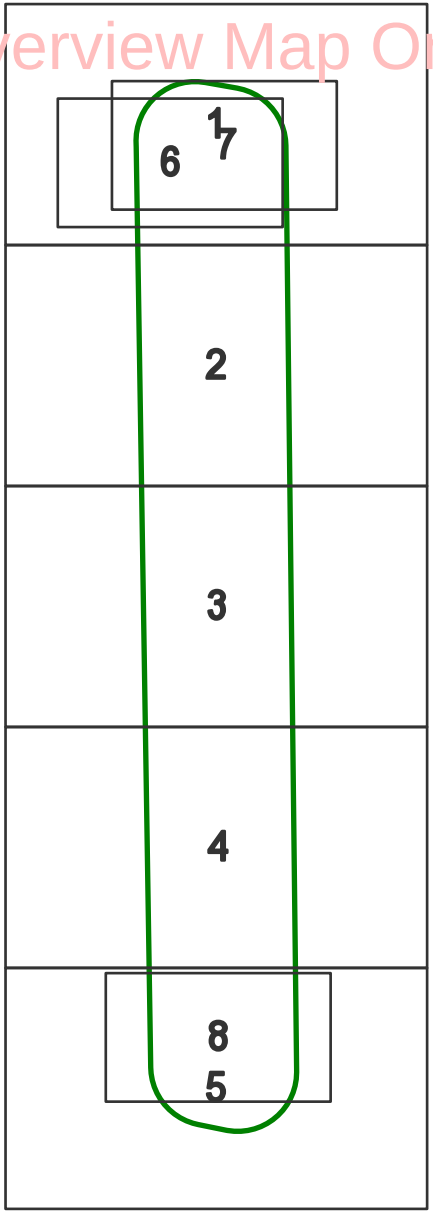
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Appendix Seven ATCO Maps, 2015

Overview Map Only



Sequence No: 47078758
Job No: 9499209
Map Tile:
Date: 4/08/2015
Scale: 1:7687
Location: Orton Road, Byford 6122

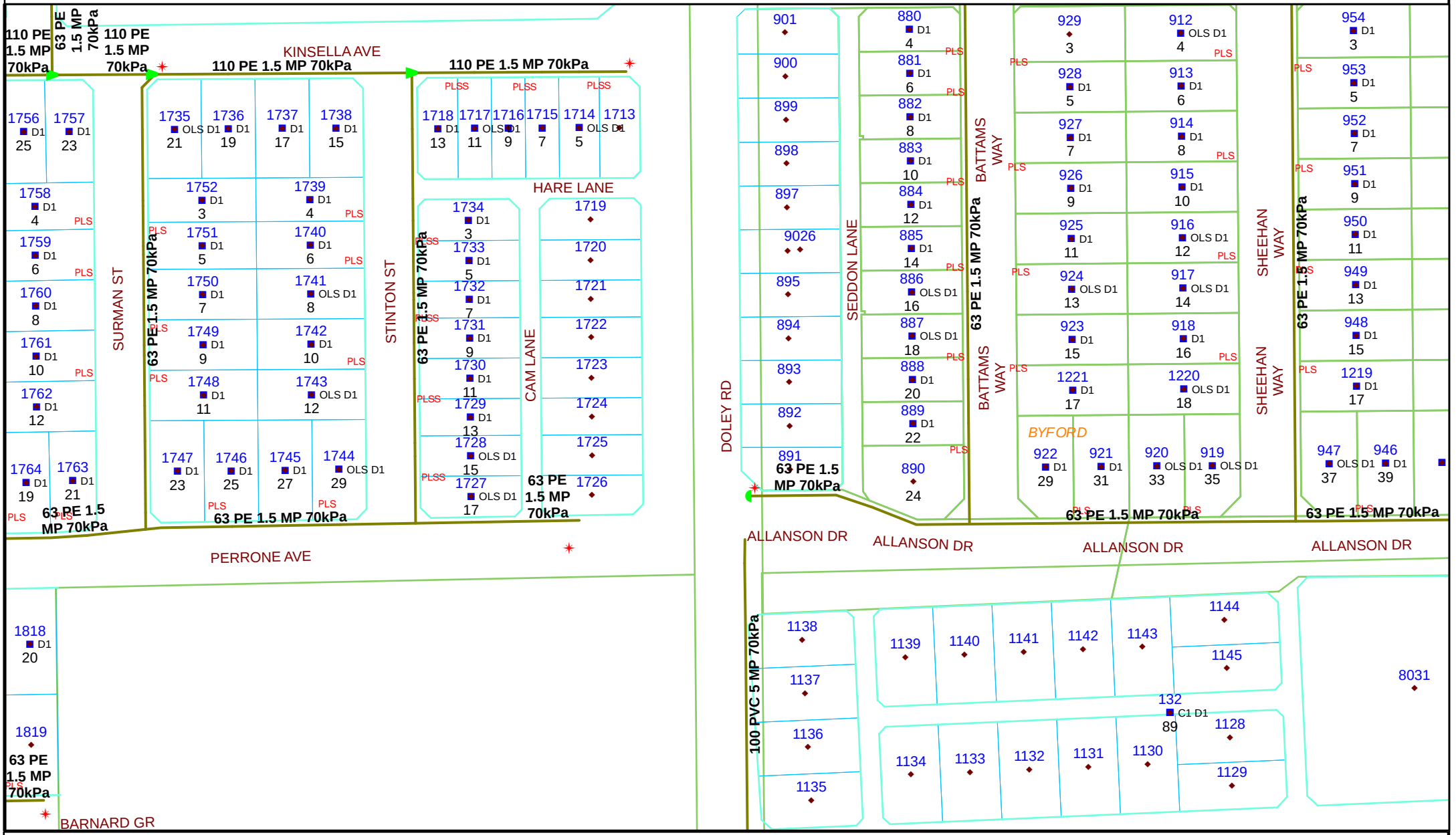
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Sequence No: 47078758 | Map Tile: 1 | Scale: 1:1500

Job No: 9499209 | Date: 4/08/2015 | Location: Orton Road, Byford 6122

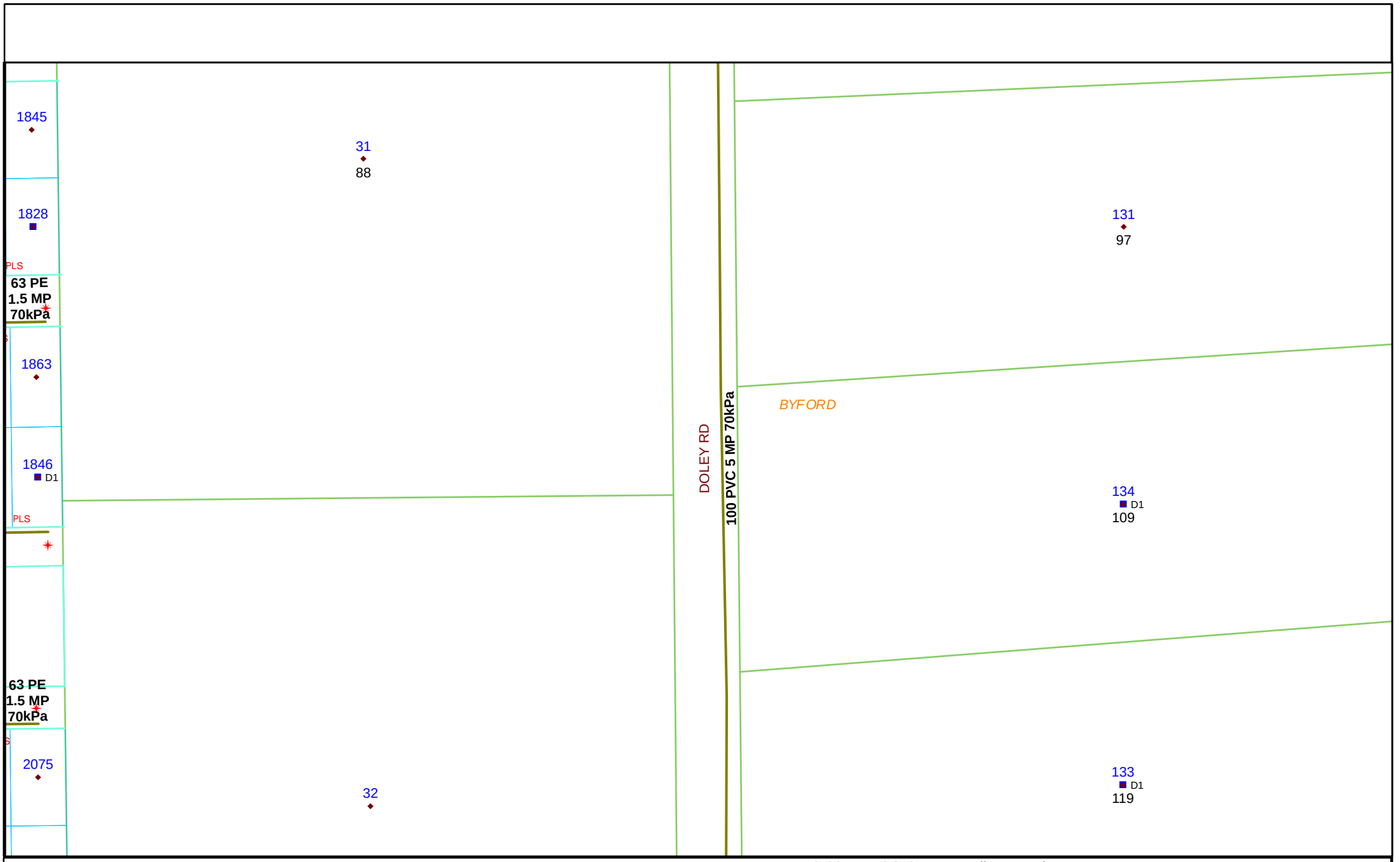
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Sequence No: 47078758 | Map Tile: 2 | Scale: 1:1500

Job No: 9499209 | Date: 4/08/2015 | Location: Orton Road, Byford 6122

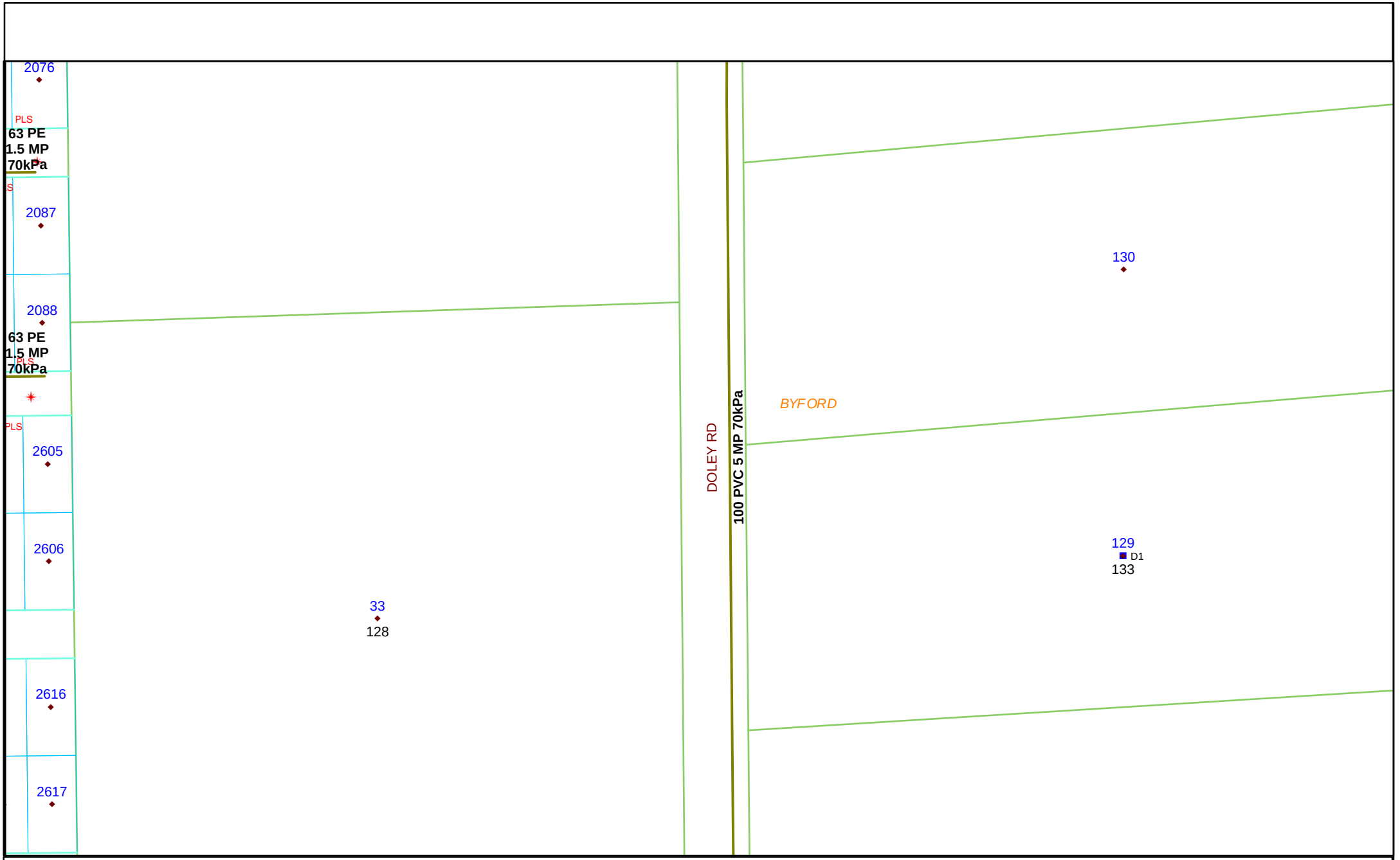
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Sequence No: 47078758 | Map Tile: 3 | Scale: 1:1500

Job No: 9499209 | Date: 4/08/2015 | Location: Orton Road, Byford 6122

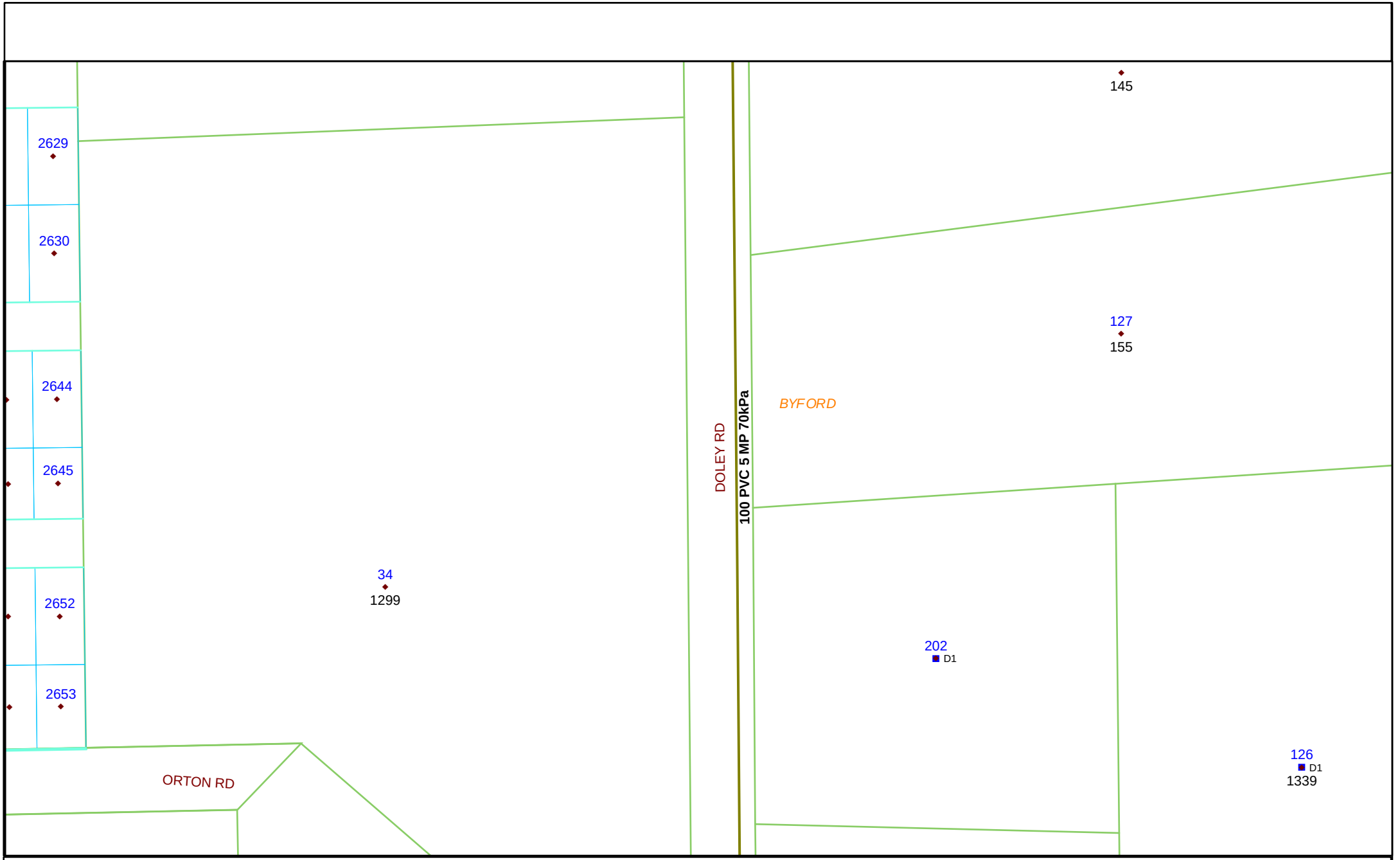
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Sequence No: 47078758 | Map Tile: 4 | Scale: 1:1500

Job No: 9499209 | Date: 4/08/2015 | Location: Orton Road, Byford 6122

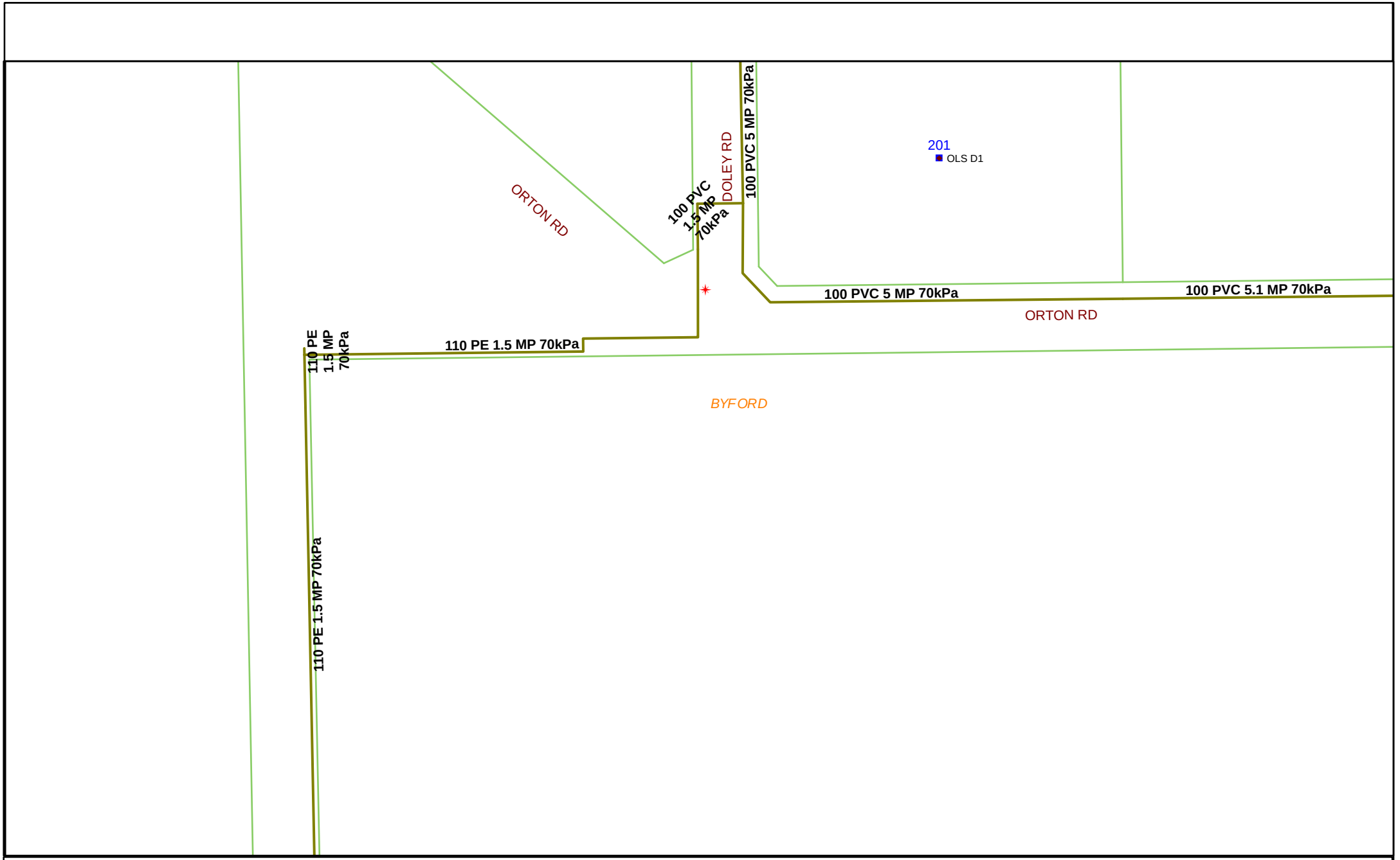
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Sequence No: 47078758 | Map Tile: 5 | Scale: 1:1500

Job No: 9499209 | Date: 4/08/2015 | Location: Orton Road, Byford 6122

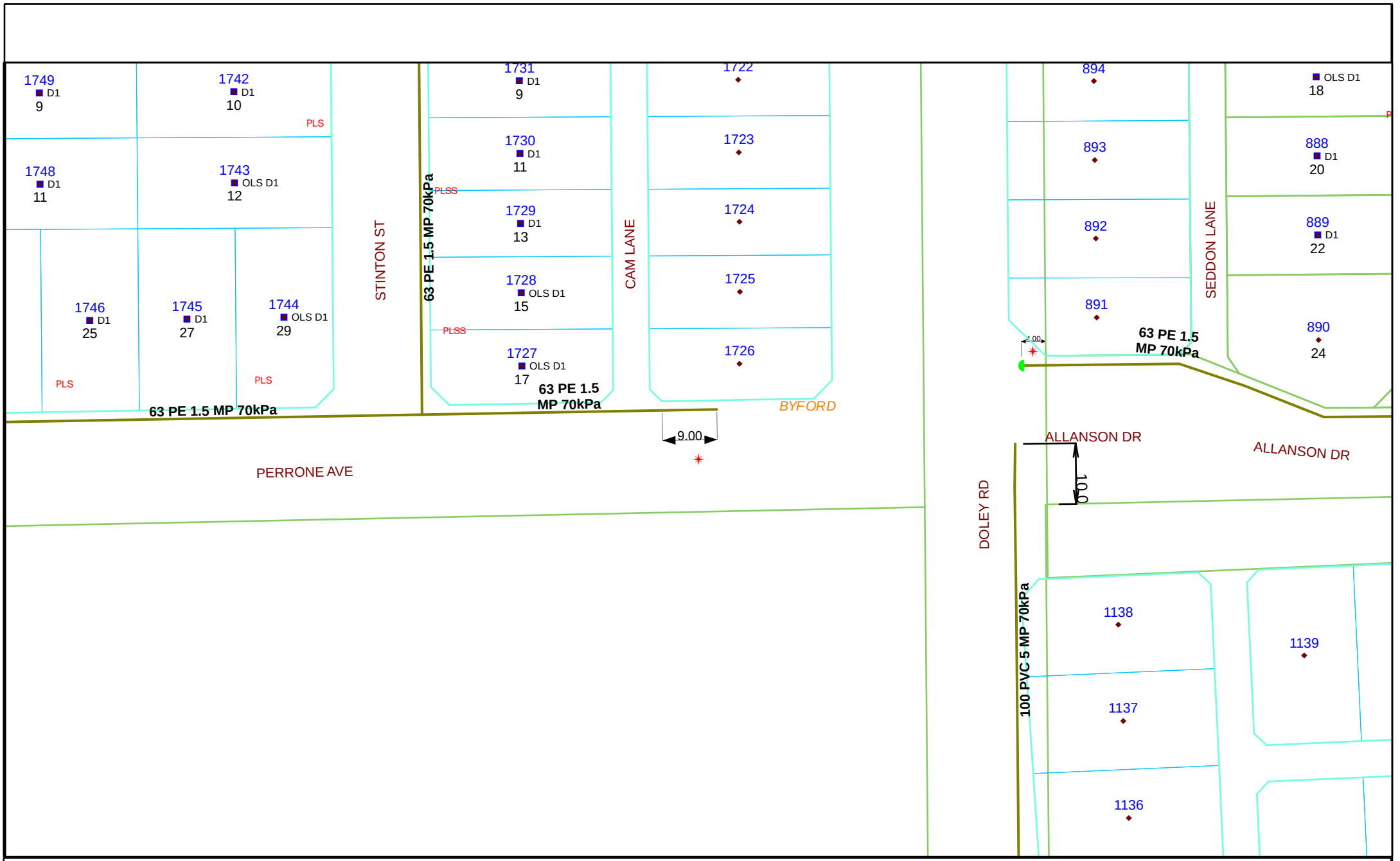
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Sequence No: 47078758 Map Tile: 6 Scale: 1:800

Job No: 9499209 Date: 4/08/2015 Location: Orton Road, Byford 6122

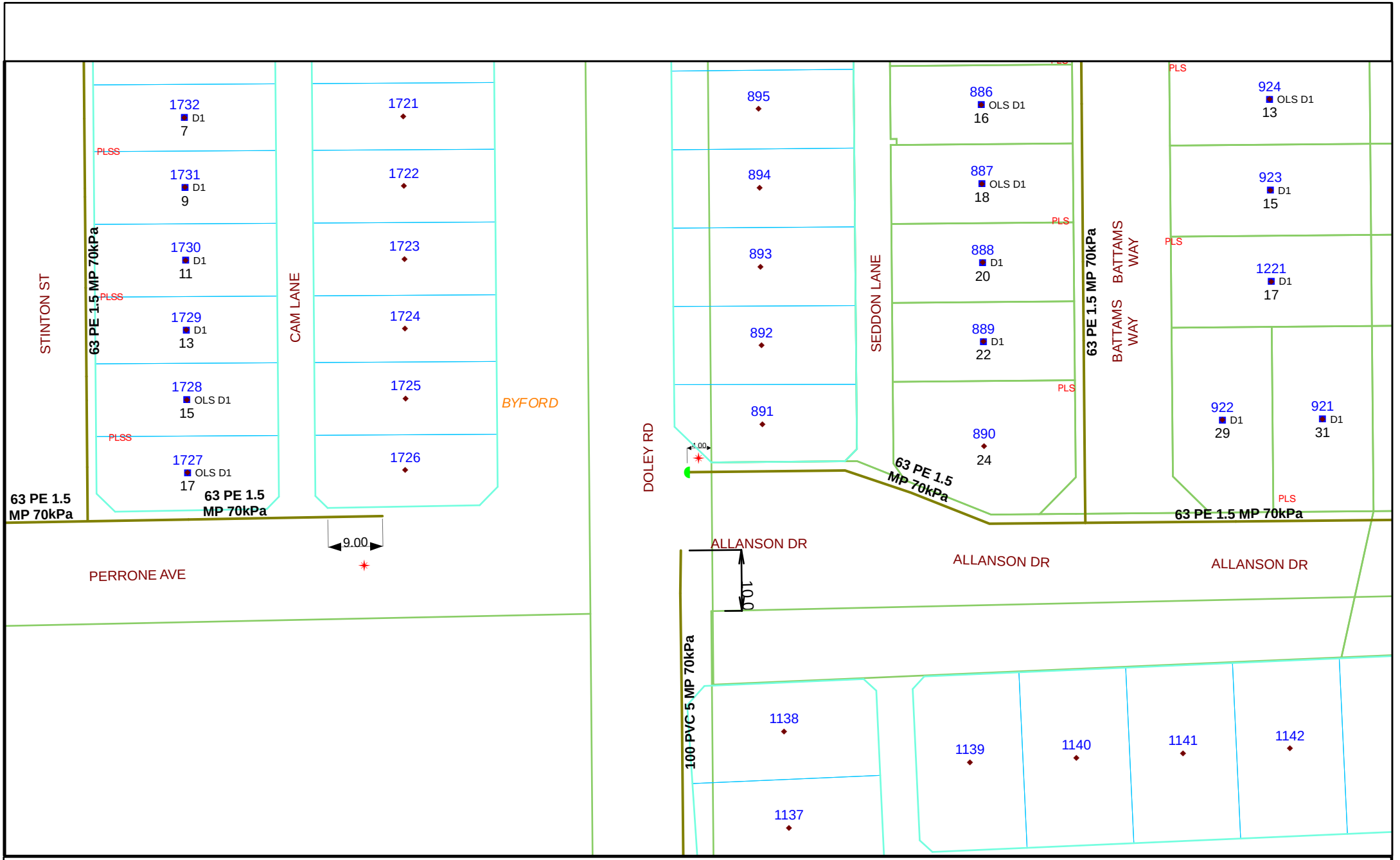
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Sequence No: 47078758 Map Tile: 7 Scale: 1:800

Job No: 9499209 Date: 4/08/2015 Location: Orton Road, Byford 6122

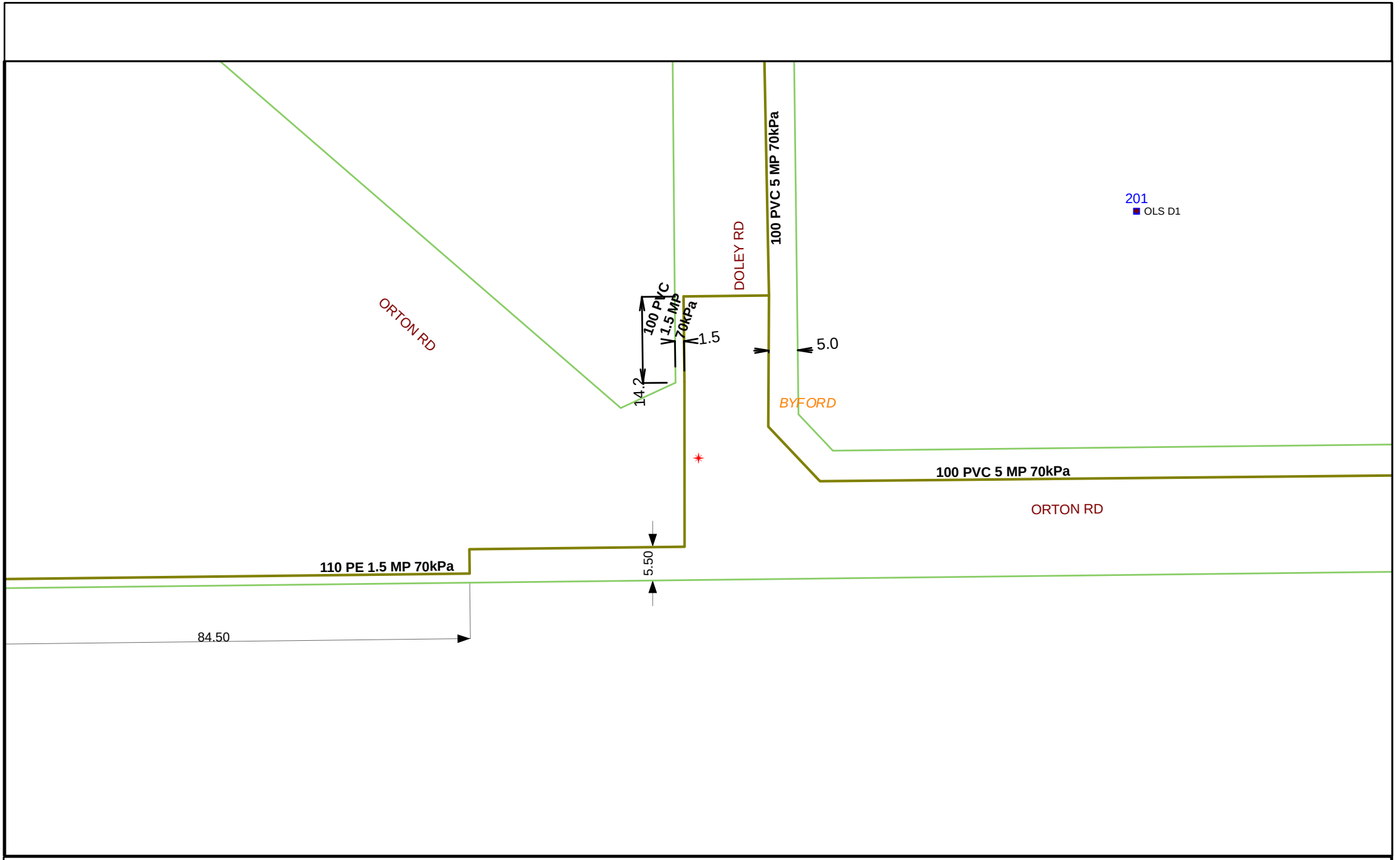
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Sequence No: 47078758 | Map Tile: 8 | Scale: 1:800

Job No: 9499209 | Date: 4/08/2015 | Location: Orton Road, Byford 6122

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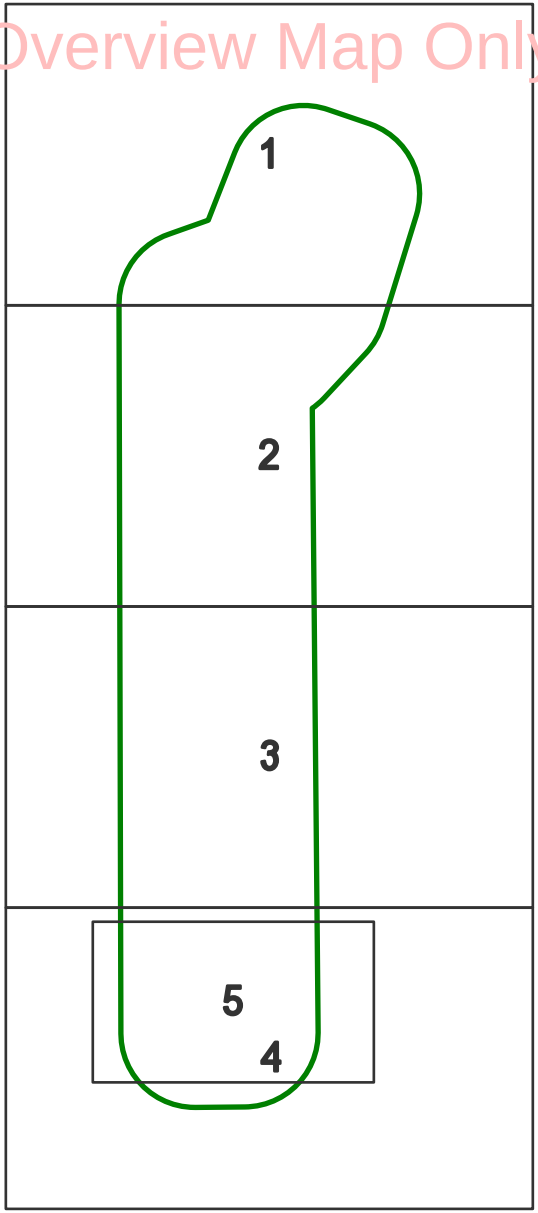
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Overview Map Only



Sequence No: 47078812
Job No: 9499220
Map Tile:
Date:4/08/2015
Scale: 1:6150
Location: Doley Road, Byford 6122

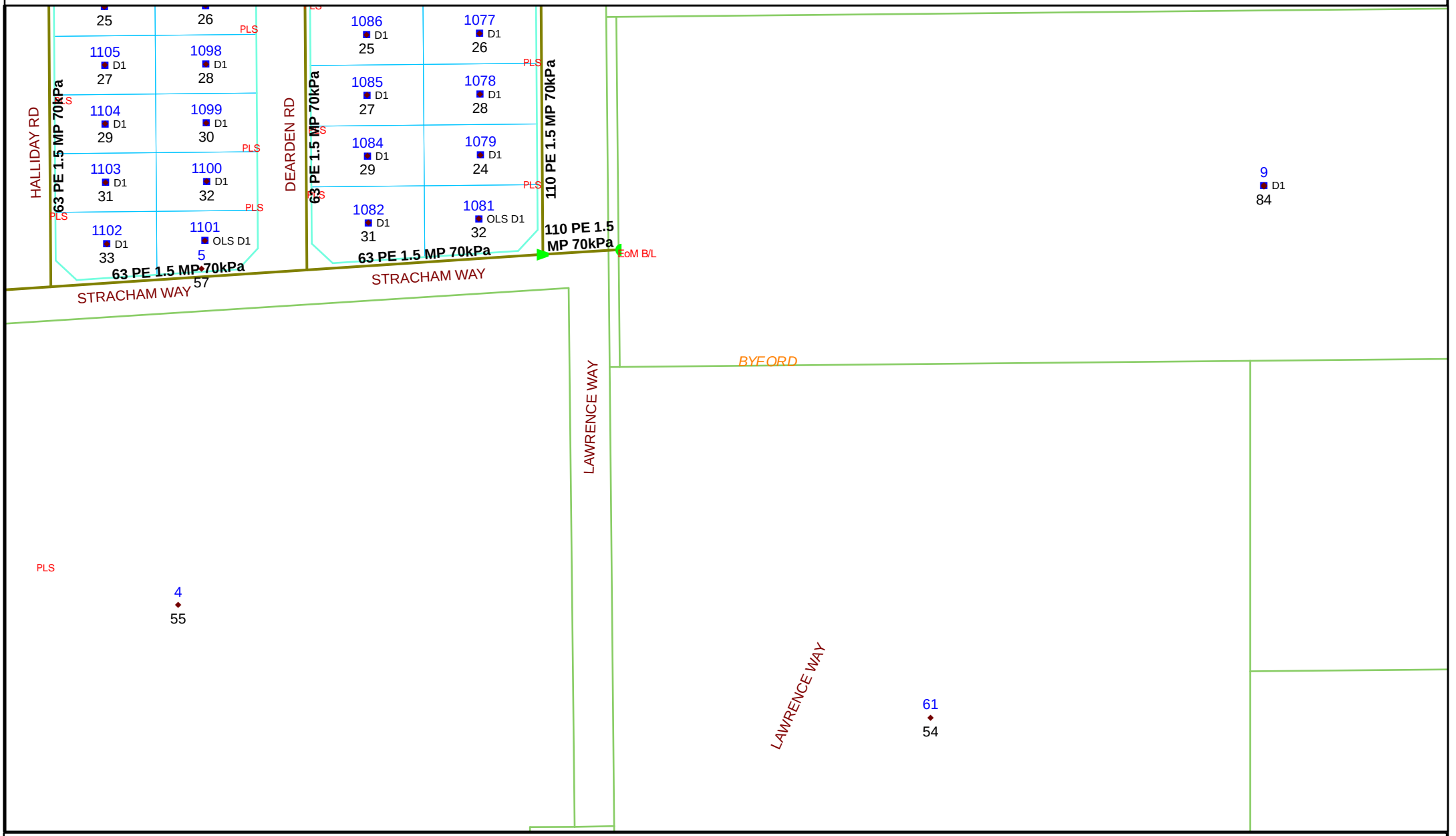
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Sequence No: 47078812 | Map Tile: 1 | Scale: 1:1500

Job No: 9499220 | Date: 4/08/2015 | Location: Doley Road, Byford 6122

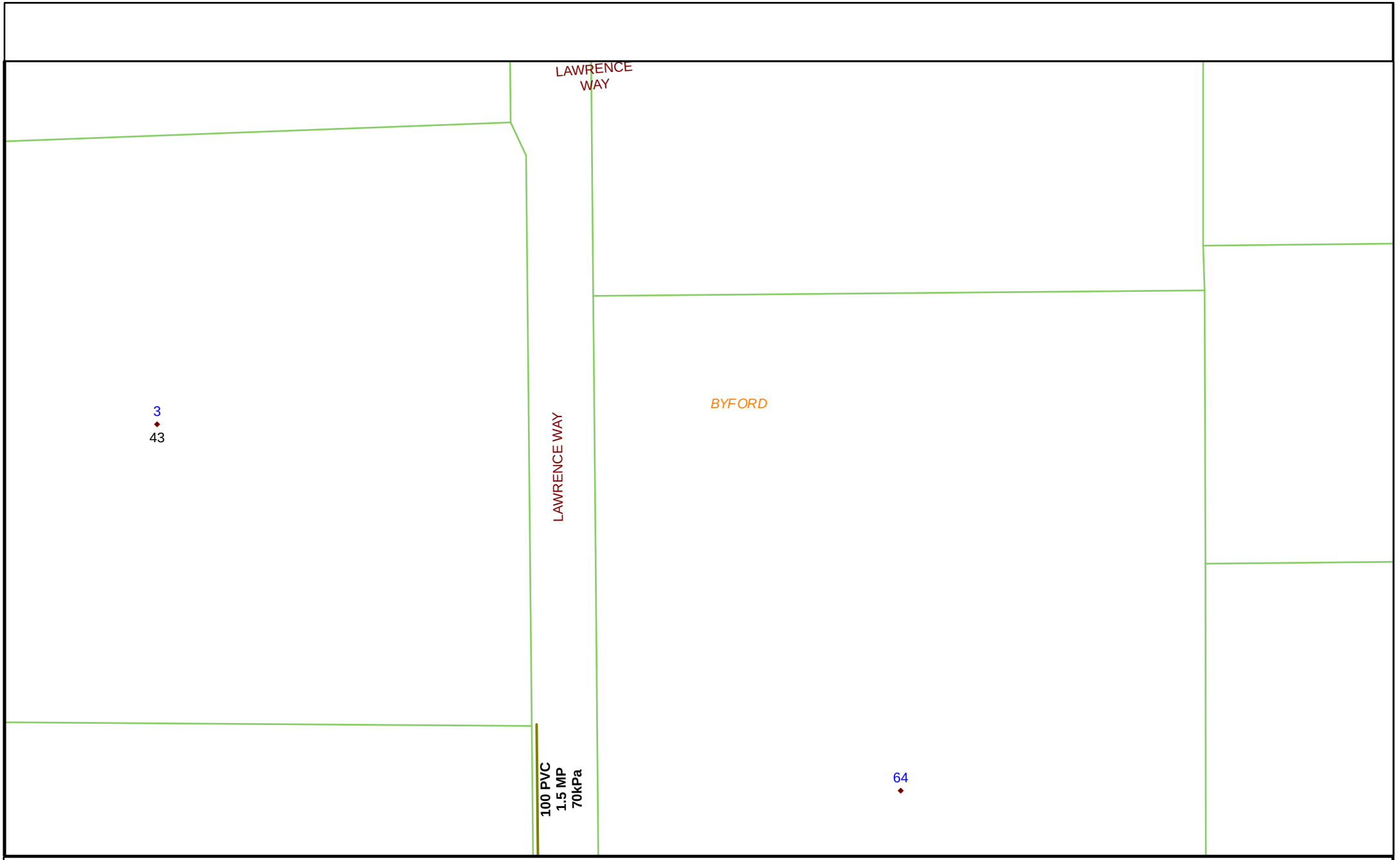
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Sequence No: 47078812 Map Tile: 2 Scale: 1:1500

Job No: 9499220 Date: 4/08/2015 Location: Doley Road, Byford 6122

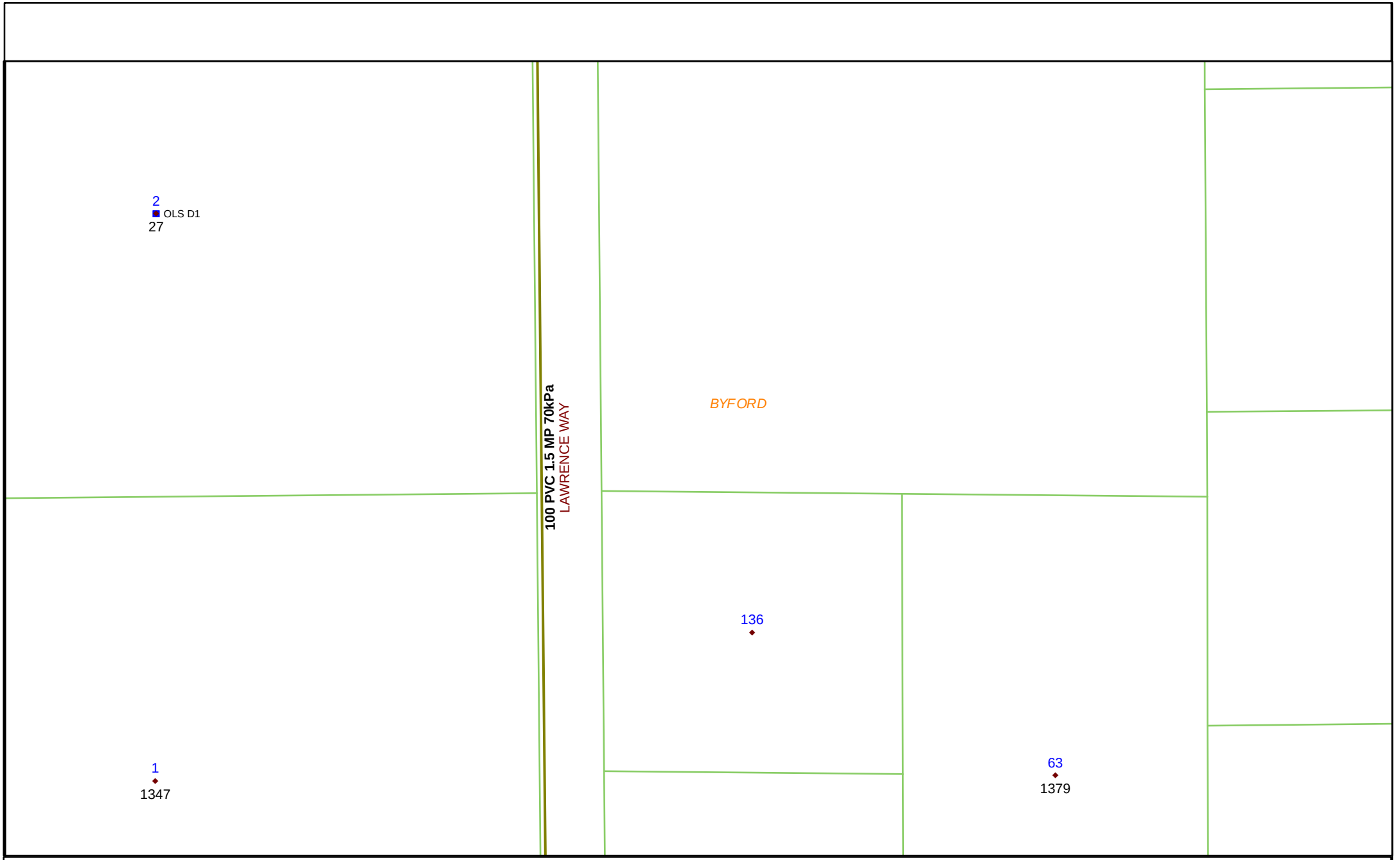
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Sequence No: 47078812 Map Tile: 3 Scale: 1:1500

Job No: 9499220 Date: 4/08/2015 Location: Doley Road, Byford 6122

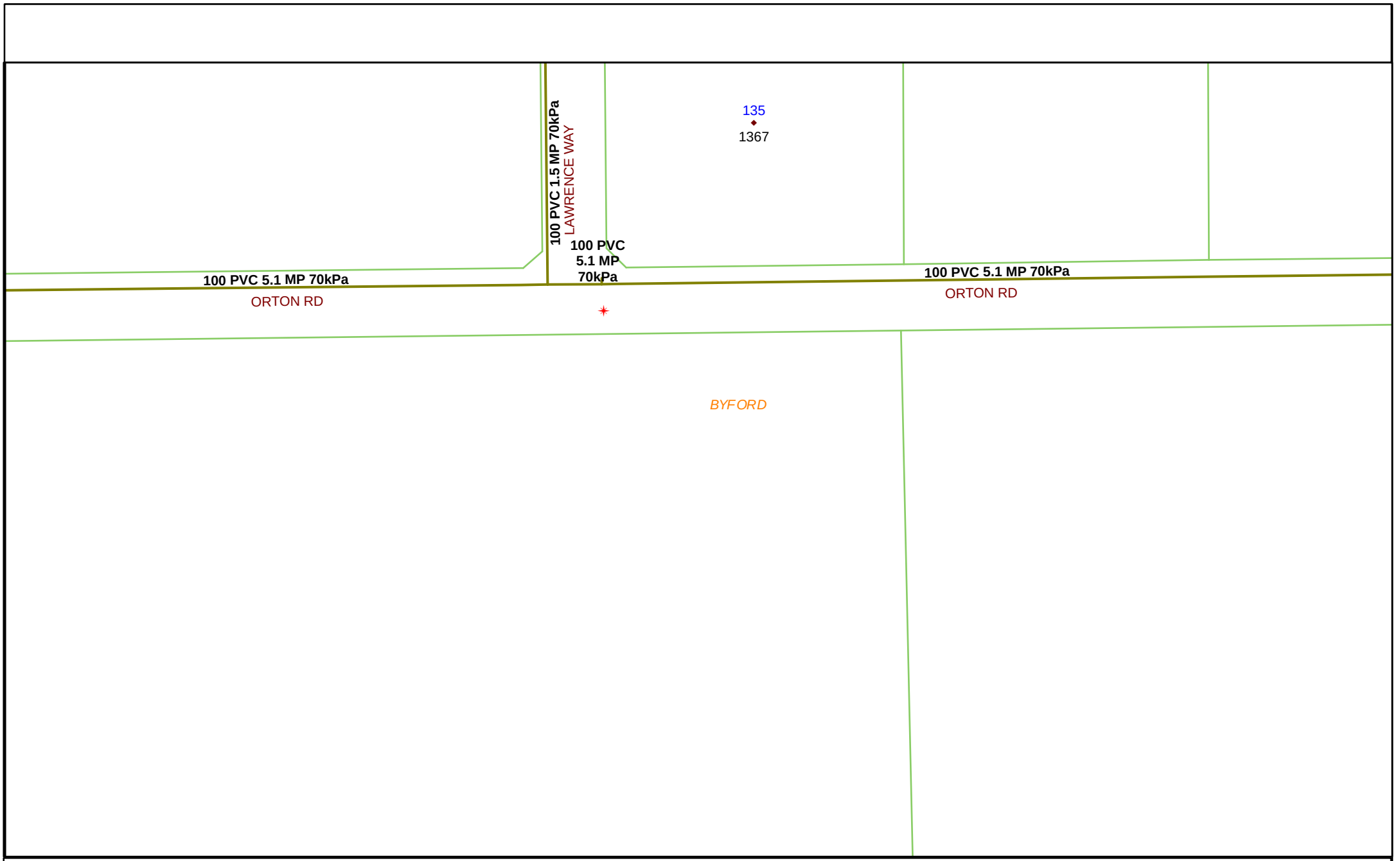
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Sequence No: 47078812 Map Tile: 4 Scale: 1:1500

Job No: 9499220 Date: 4/08/2015 Location: Doley Road, Byford 6122

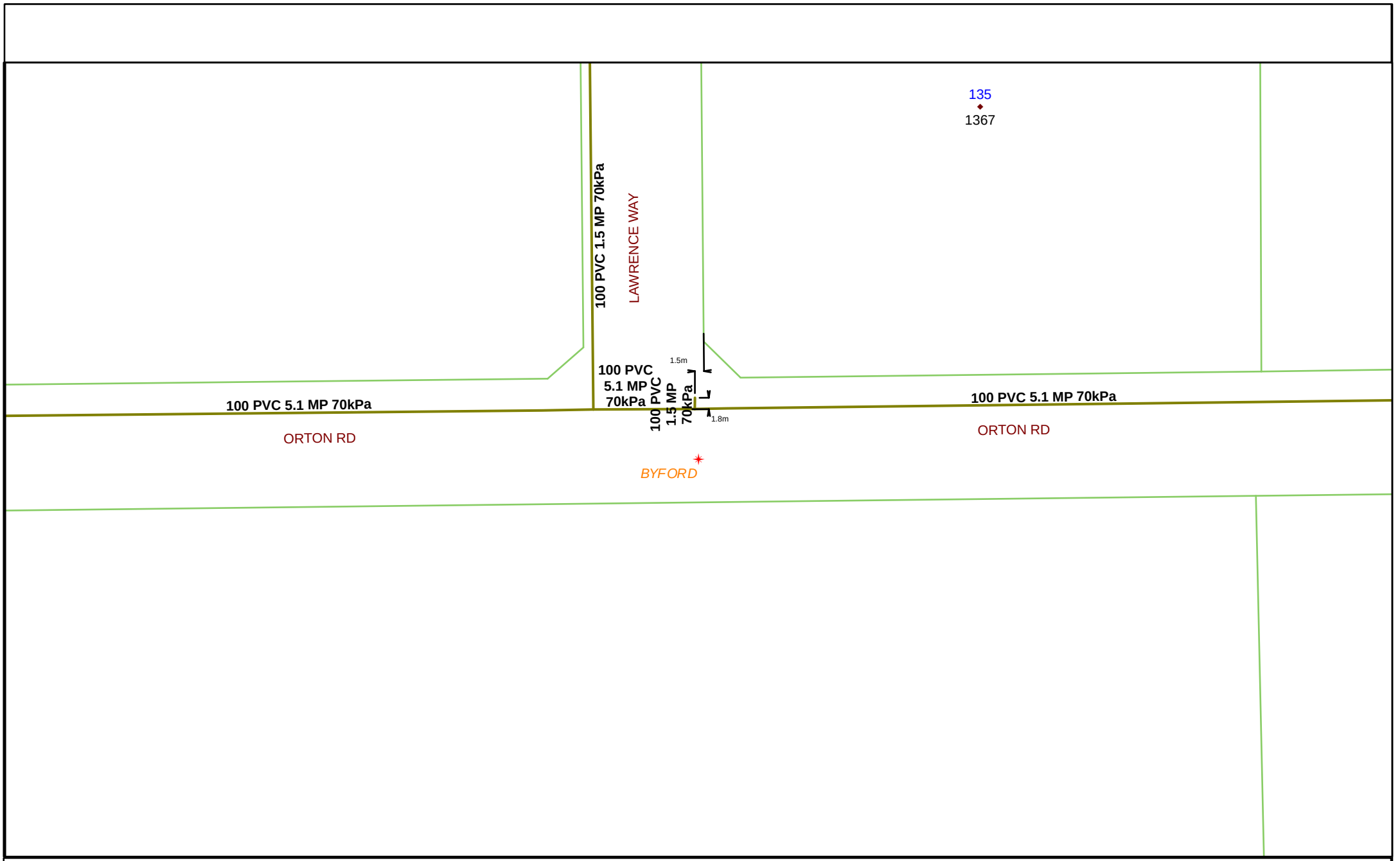
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Sequence No: 47078812 Map Tile: 5 Scale: 1:800

Job No: 9499220 Date: 4/08/2015 Location: Doley Road, Byford 6122

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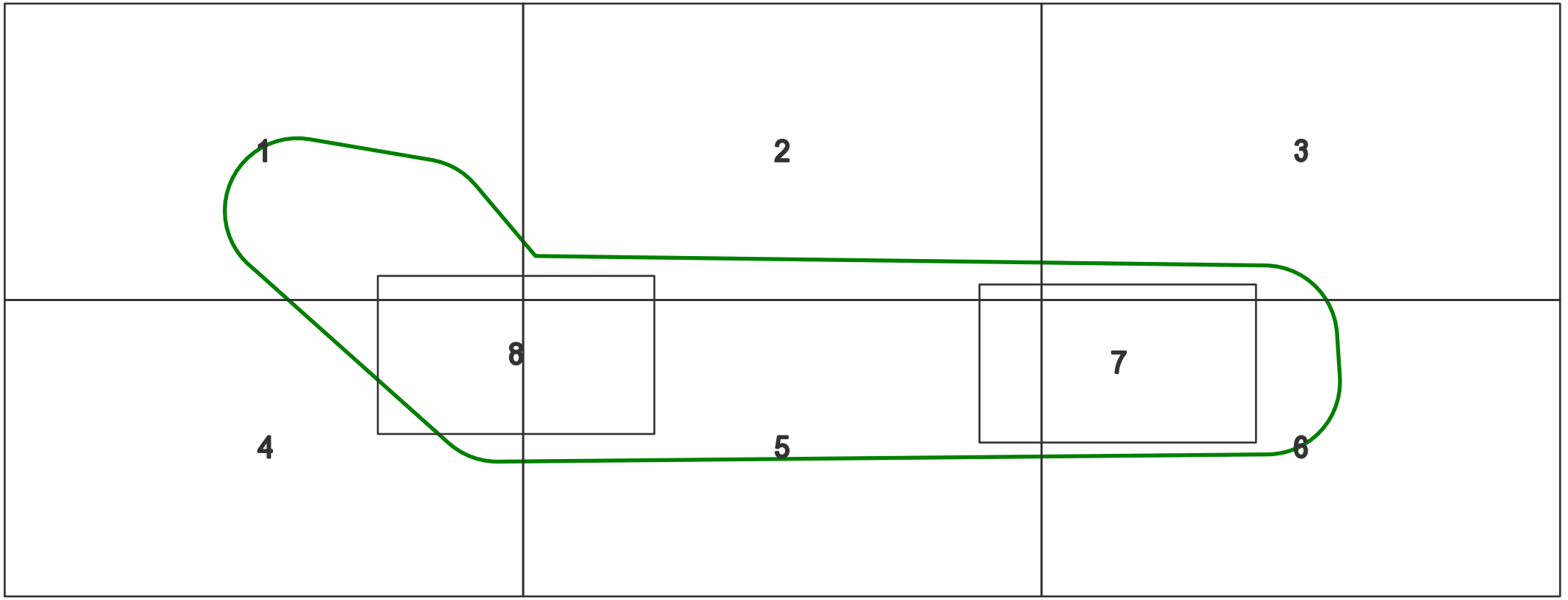
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Overview Map Only



Sequence No: 47078824 Map Tile: Scale: 1:4612

Job No: 9499223 Date:4/08/2015 Location: Doley Road, Byford 6122

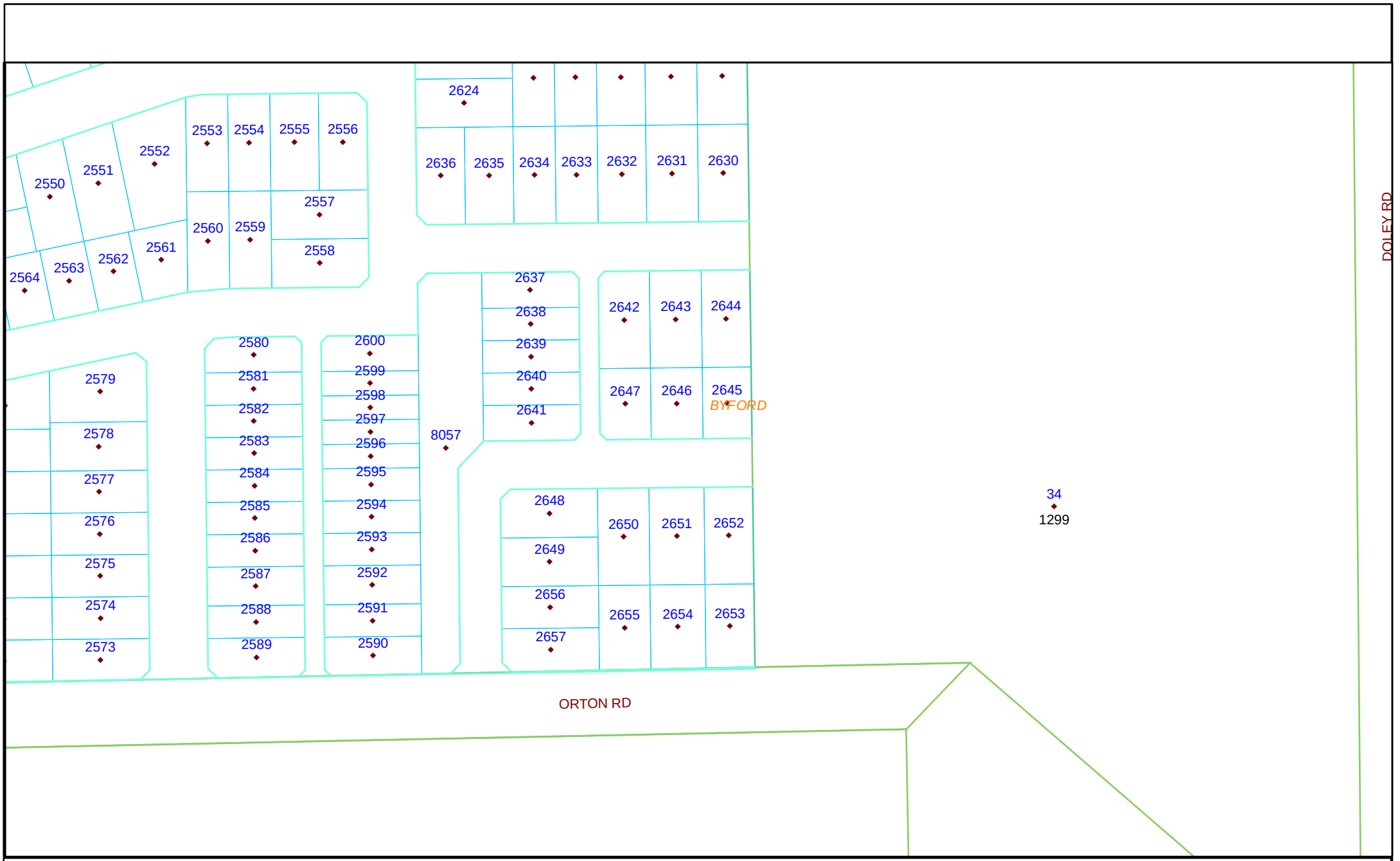
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Sequence No: 47078824 Map Tile: 1 Scale: 1:1500

Job No: 9499223 Date: 4/08/2015 Location: Doley Road, Byford 6122

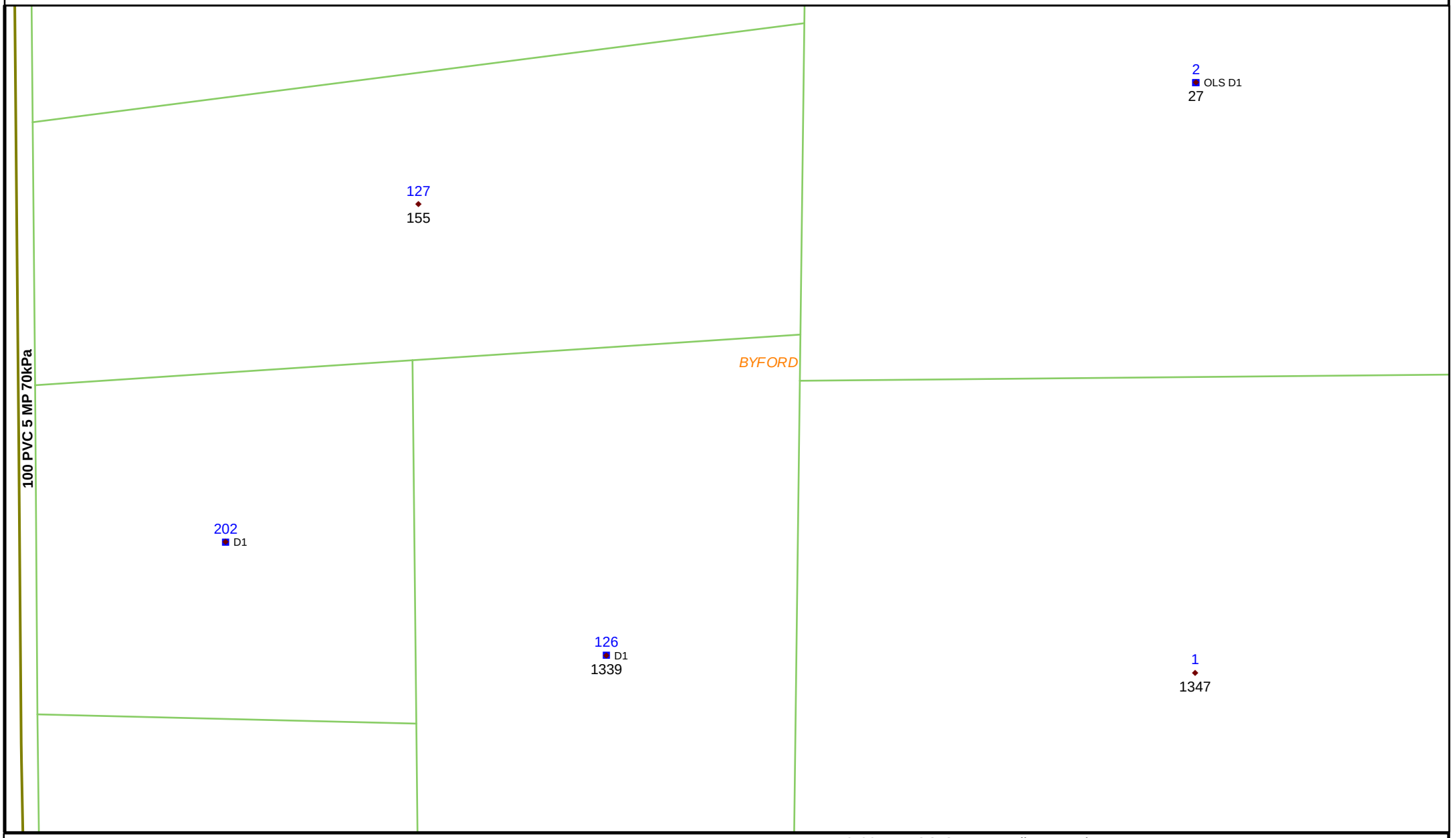
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Sequence No: 47078824 | Map Tile: 2 | Scale: 1:1500

Job No: 9499223 | Date: 4/08/2015 | Location: Doley Road, Byford 6122

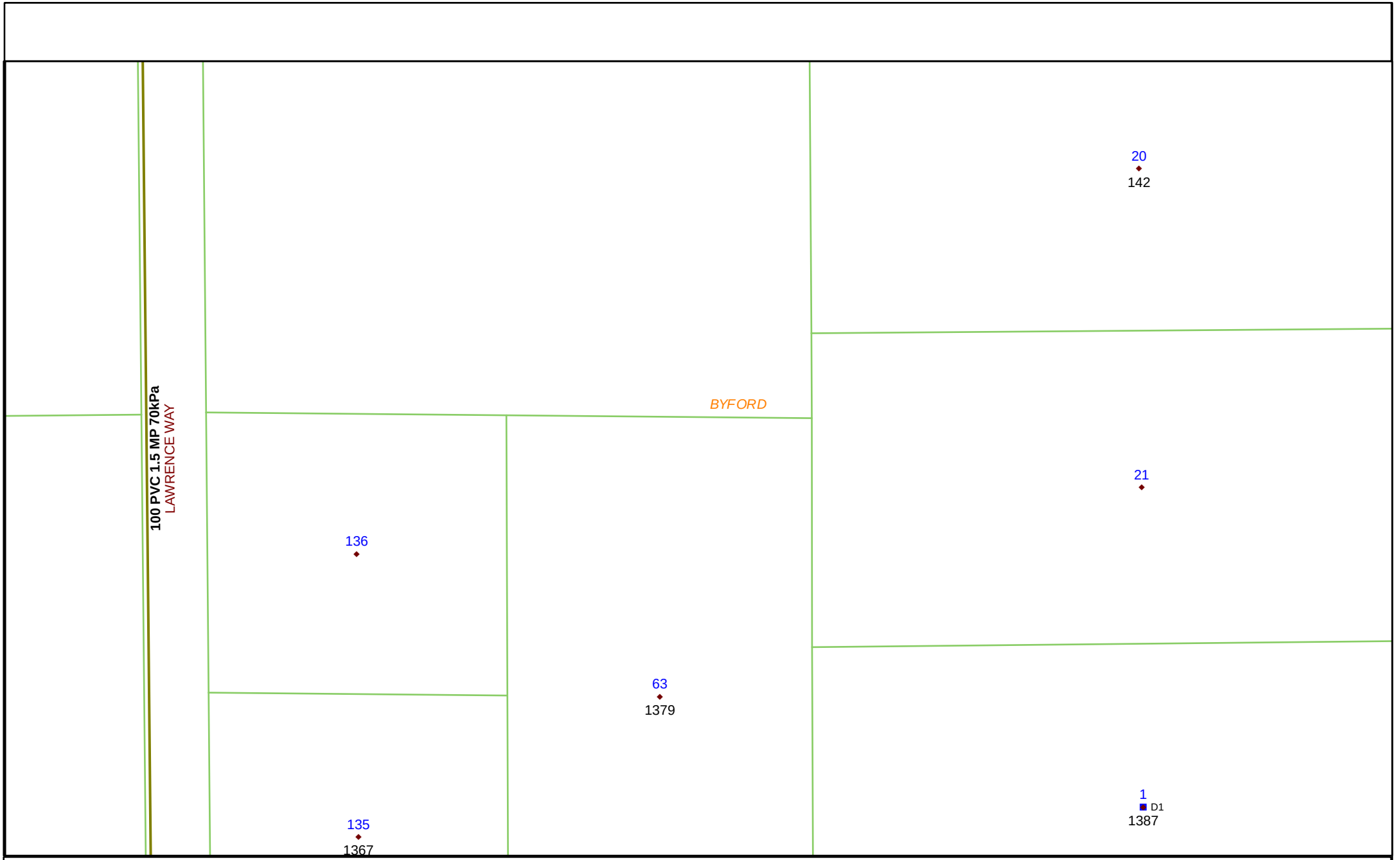
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Sequence No: 47078824 Map Tile: 3 Scale: 1:1500

Job No: 9499223 Date: 4/08/2015 Location: Doley Road, Byford 6122

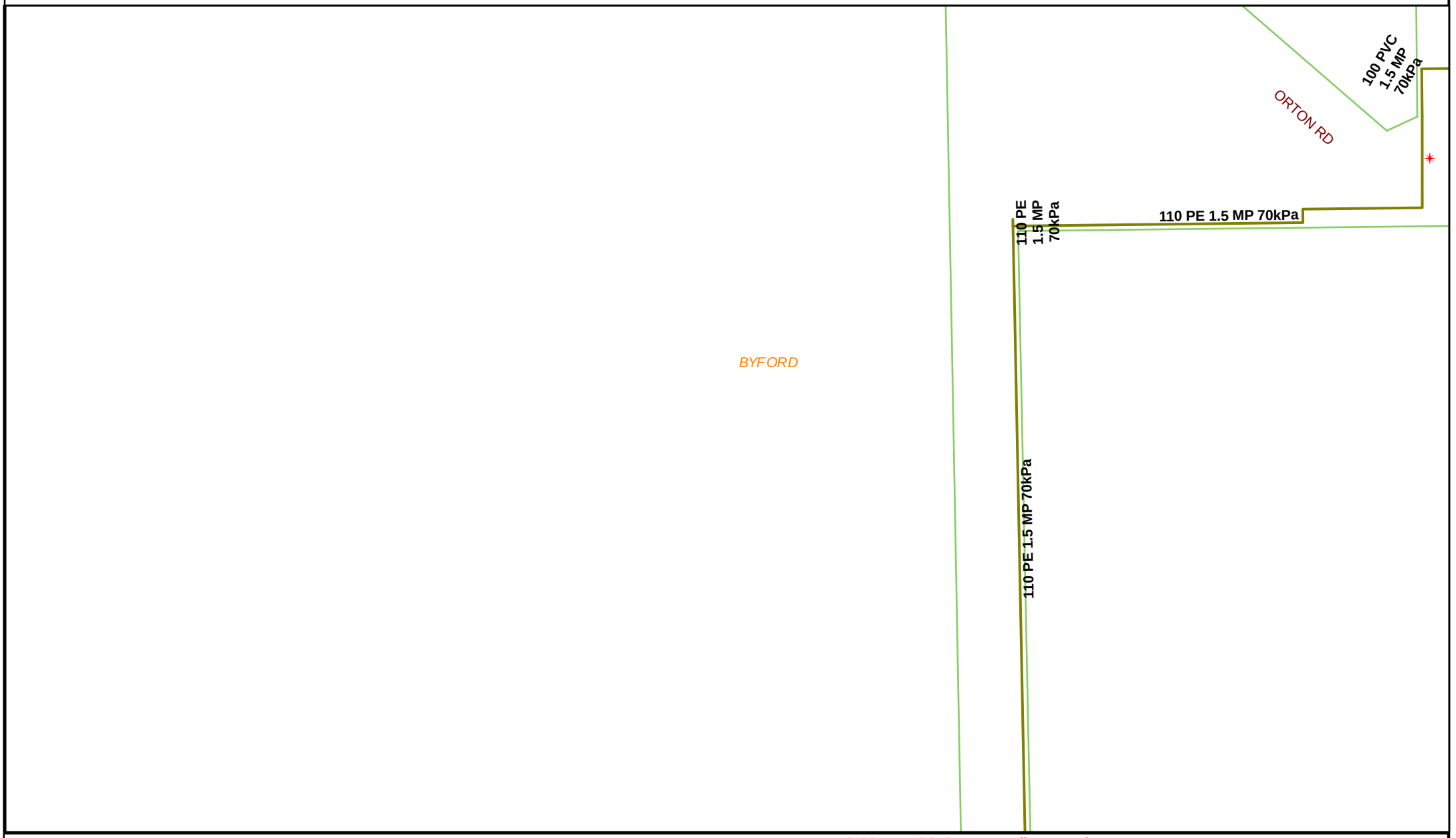
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Sequence No: 47078824 | Map Tile: 4 | Scale: 1:1500

Job No: 9499223 | Date: 4/08/2015 | Location: Doley Road, Byford 6122

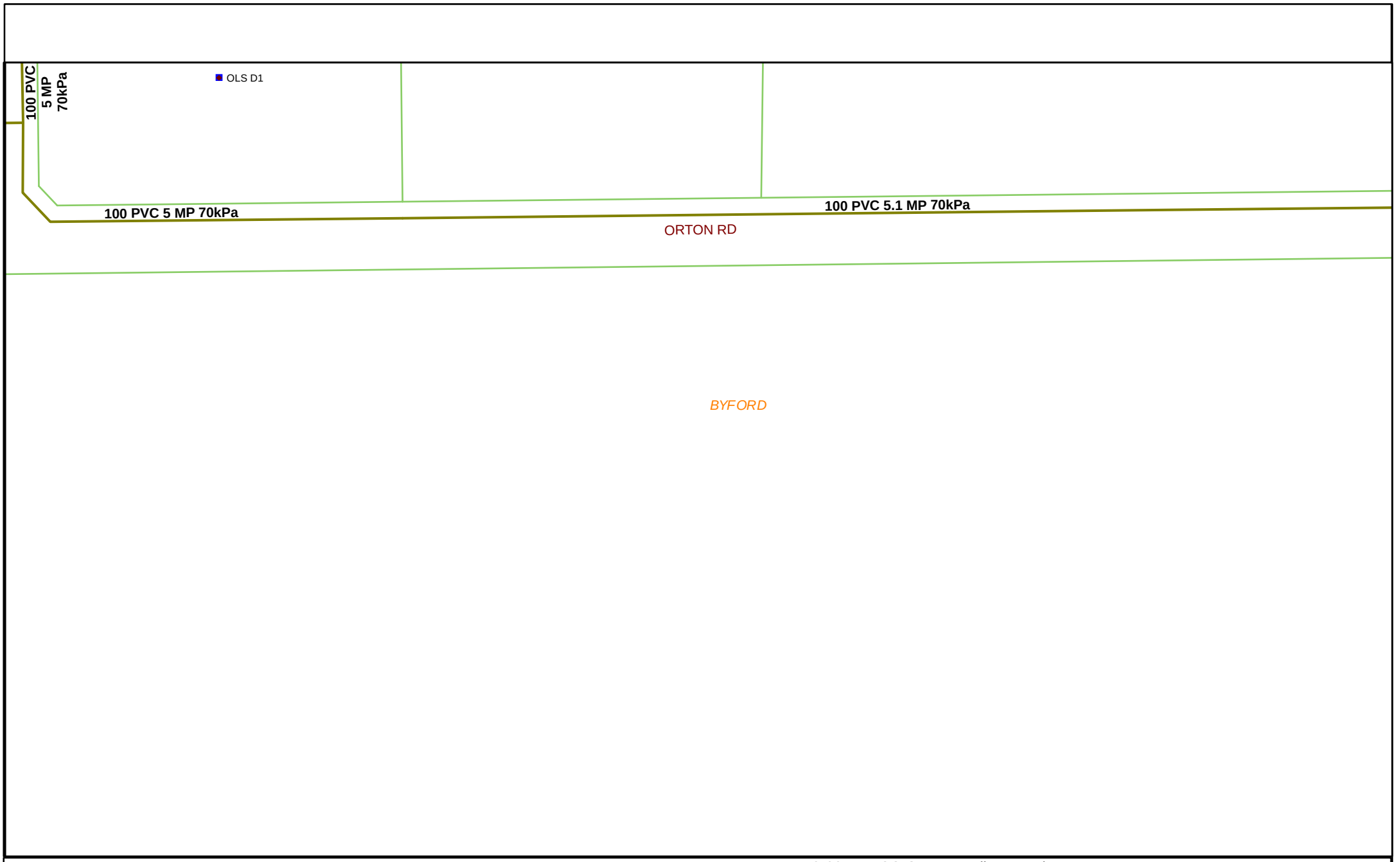
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Sequence No: 47078824 Map Tile: 5 Scale: 1:1500

Job No: 9499223 Date: 4/08/2015 Location: Doley Road, Byford 6122

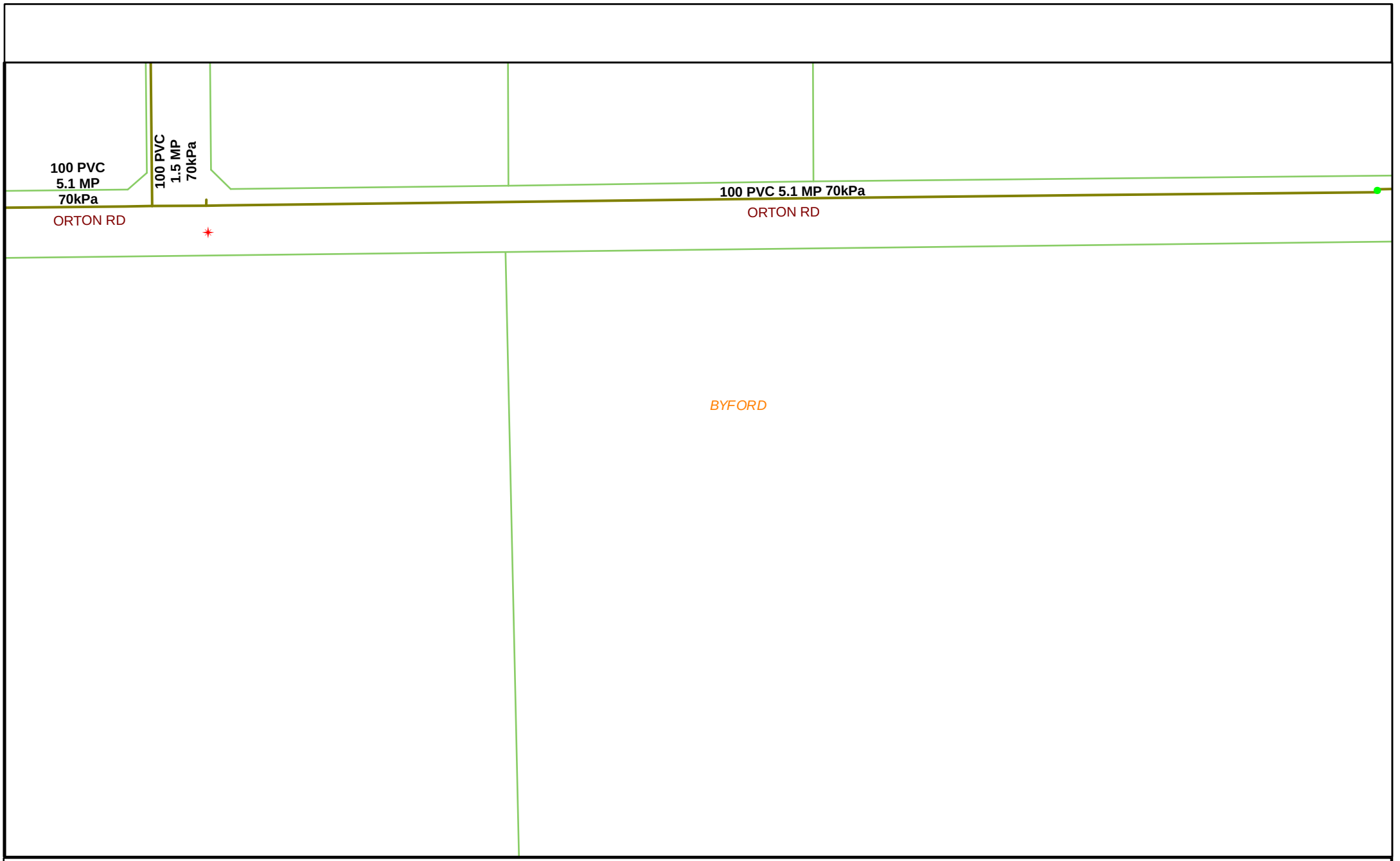
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Sequence No: 47078824 Map Tile: 6 Scale: 1:1500

Job No: 9499223 Date: 4/08/2015 Location: Doley Road, Byford 6122

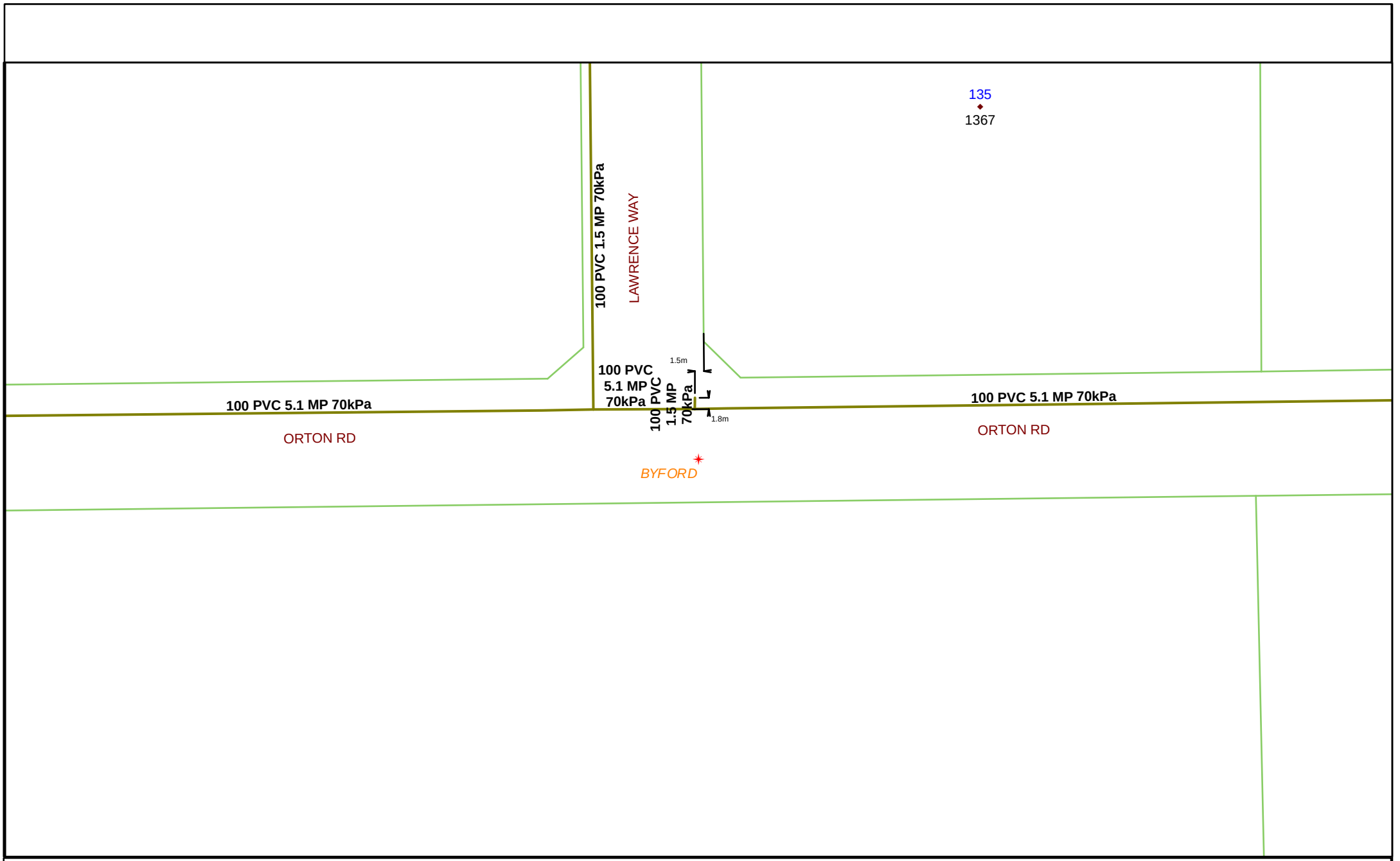
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Sequence No: 47078824 Map Tile: 7 Scale: 1:800

Job No: 9499223 Date: 4/08/2015 Location: Doley Road, Byford 6122

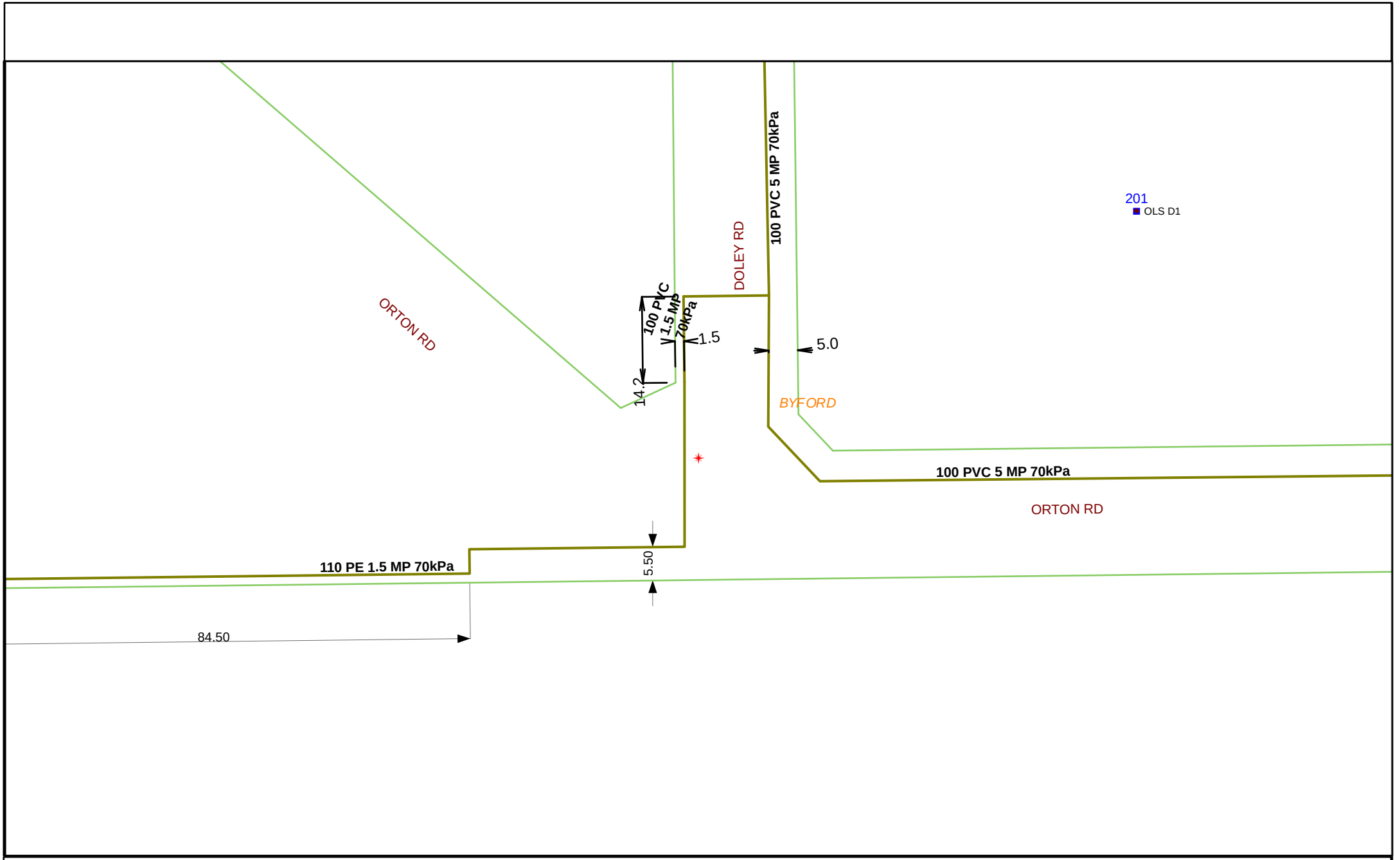
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Sequence No: 47078824 | Map Tile: 8 | Scale: 1:800

Job No: 9499223 | Date: 4/08/2015 | Location: Doley Road, Byford 6122

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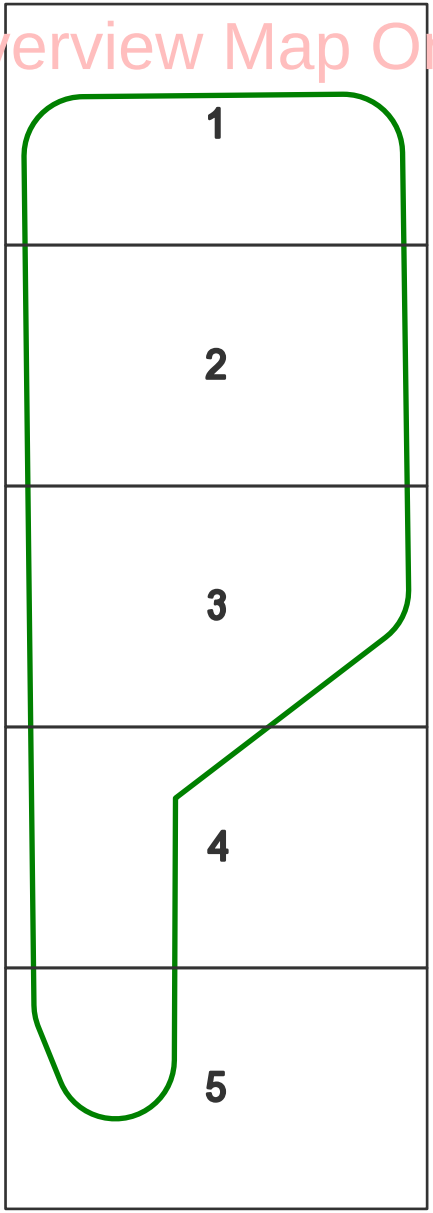
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Overview Map Only



Sequence No: 49239623 | Map Tile: | Scale: 1:7687

Job No: 9951652 | Date:19/11/2015 | Location: Warrington Road, Byford 6122

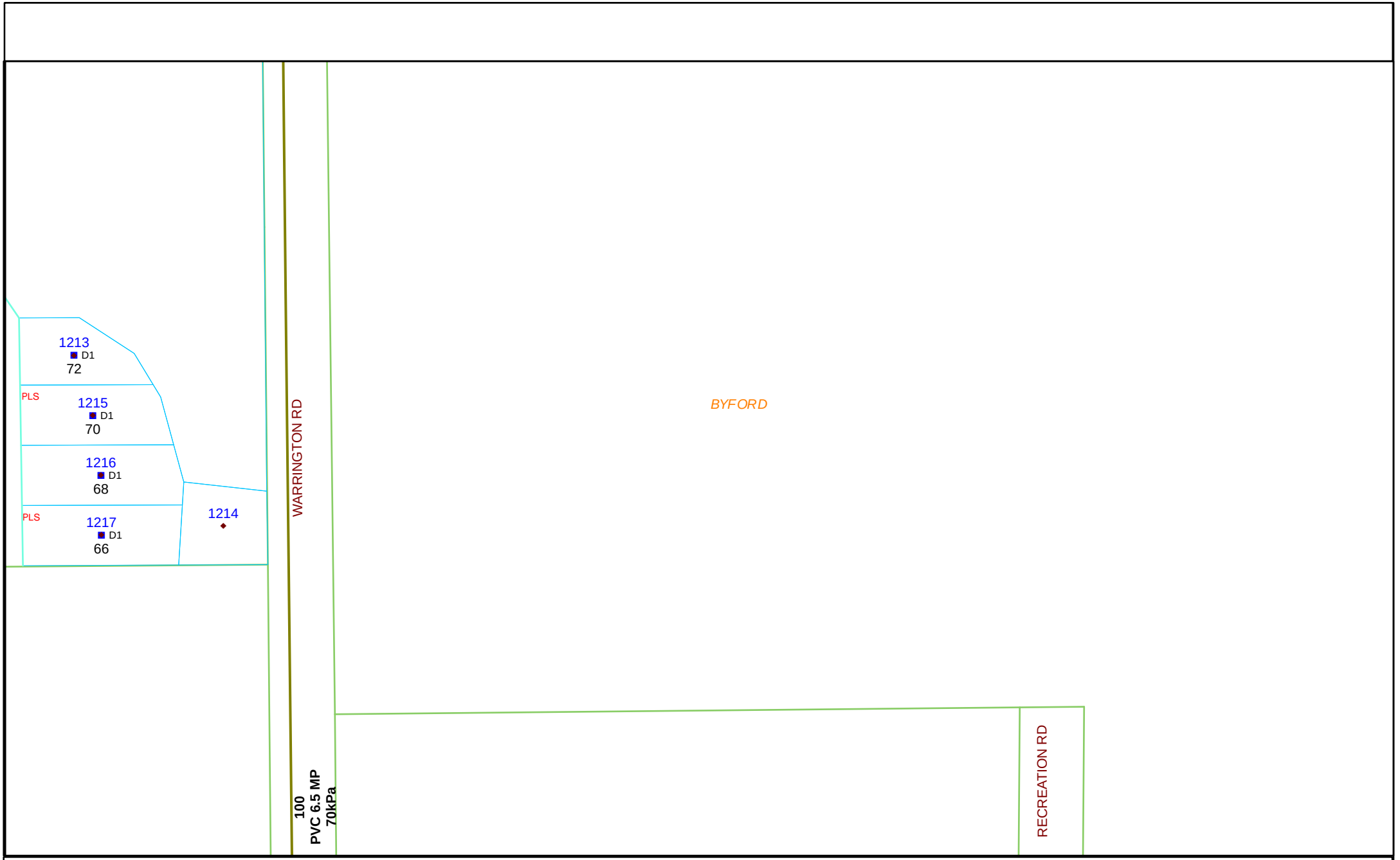
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Sequence No: 49239623 Map Tile: 1 Scale: 1:1500

Job No: 9951652 Date:19/11/2015 Location: Warrington Road, Byford 6122

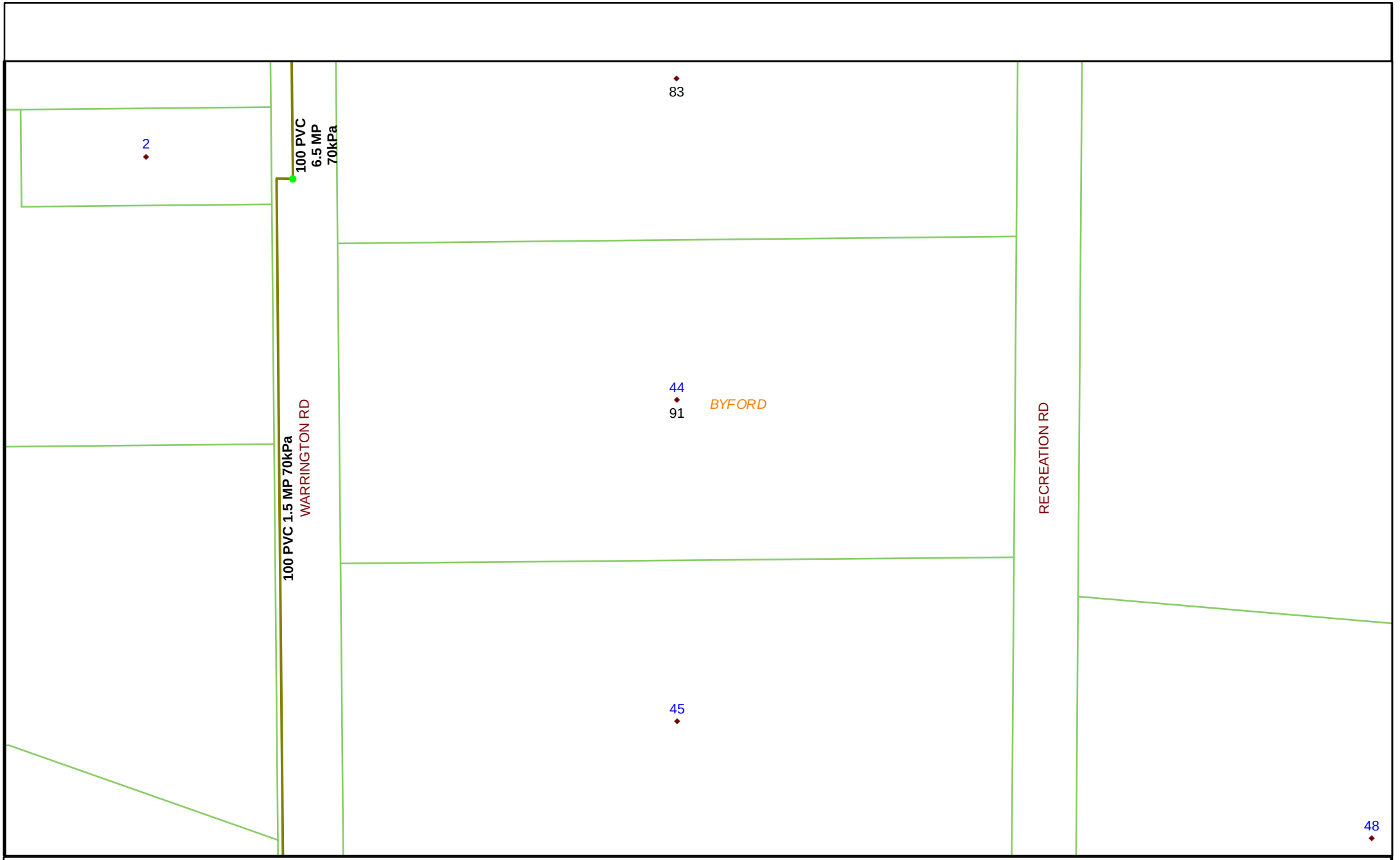
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Sequence No: 49239623 Map Tile: 2 Scale: 1:1500

Job No: 9951652 Date:19/11/2015 Location: Warrington Road, Byford 6122

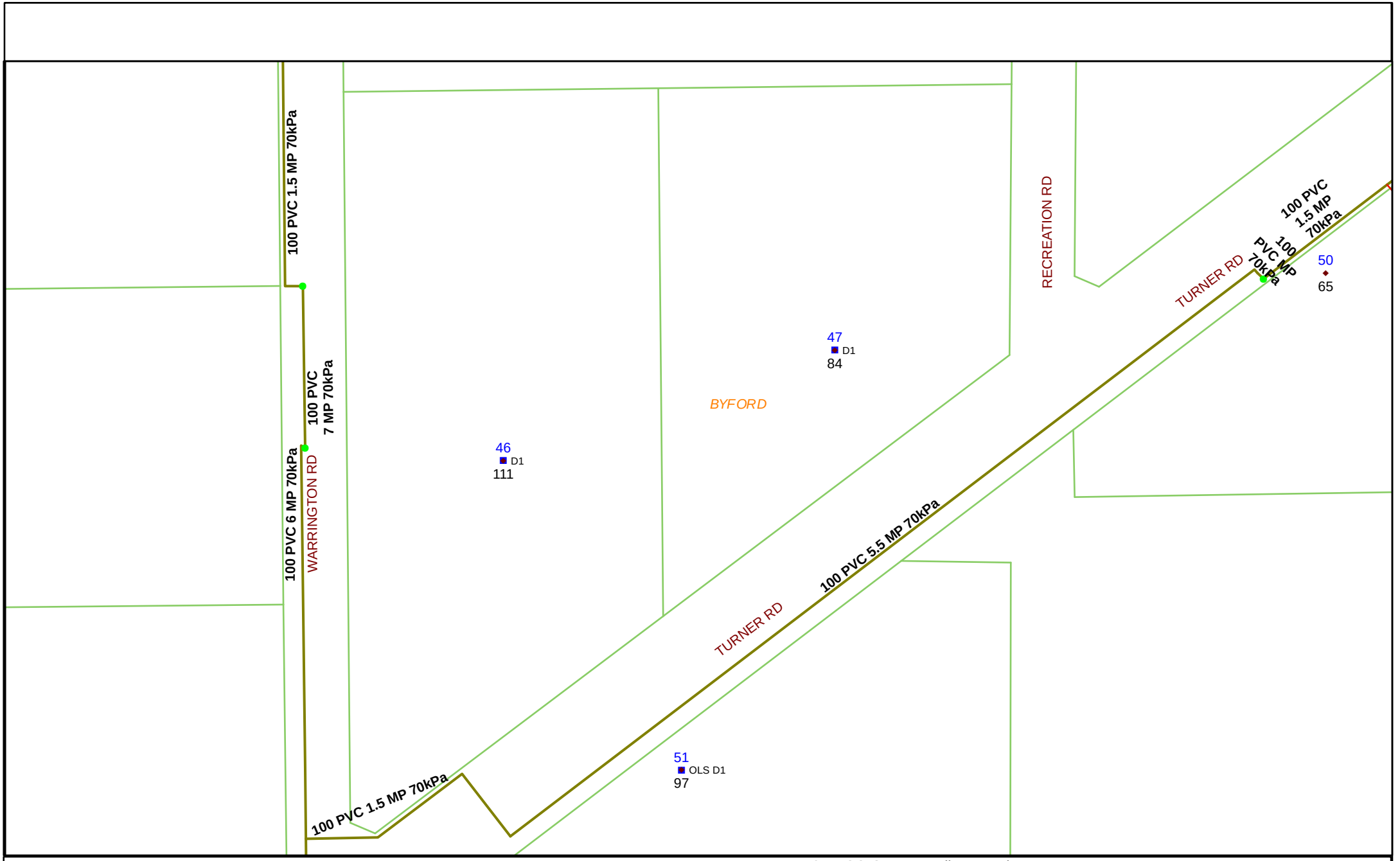
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Sequence No: 49239623 Map Tile: 3 Scale: 1:1500

Job No: 9951652 Date:19/11/2015 Location: Warrington Road, Byford 6122

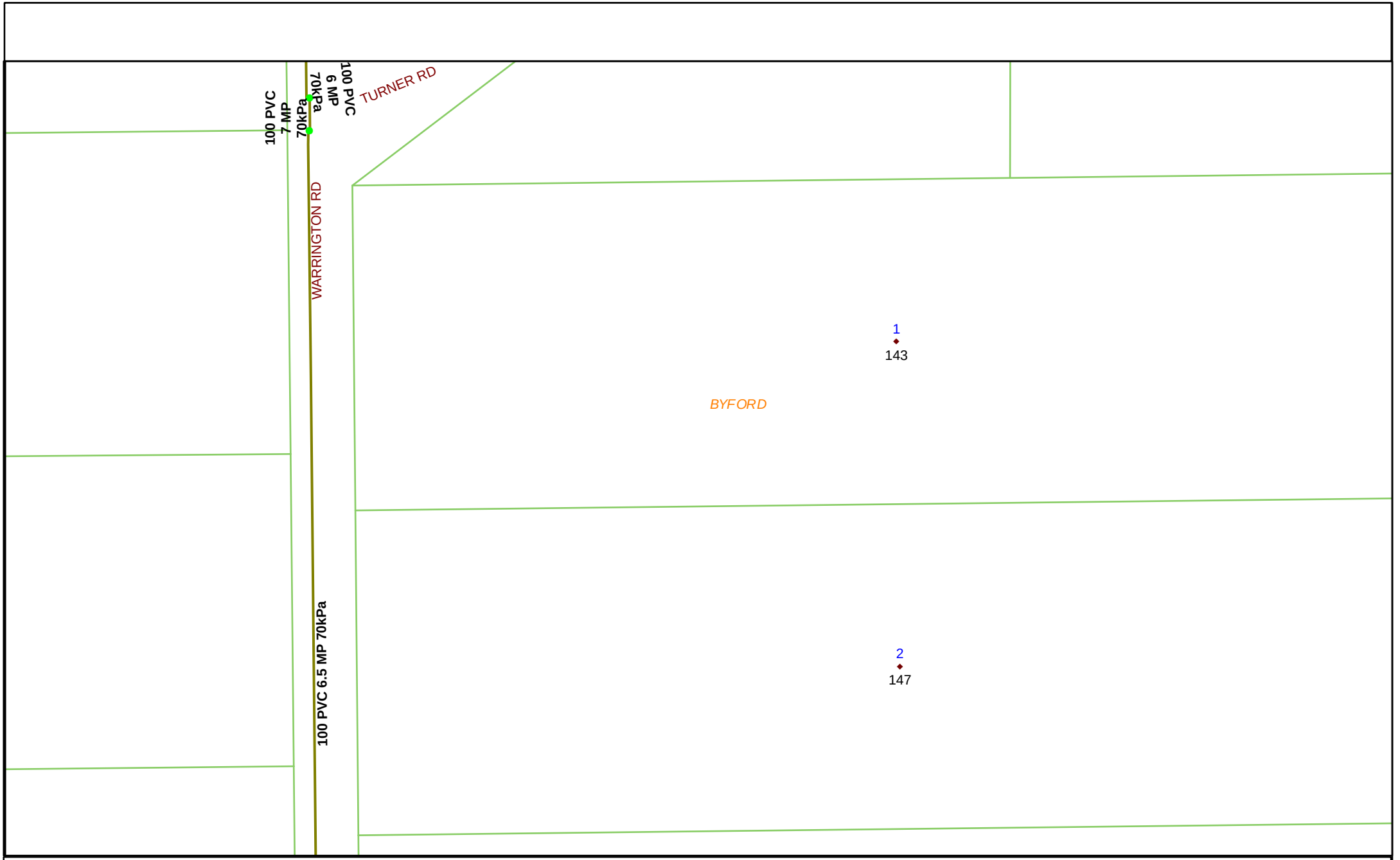
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Sequence No: 49239623 Map Tile: 4 Scale: 1:1500

Job No: 9951652 Date:19/11/2015 Location: Warrington Road, Byford 6122

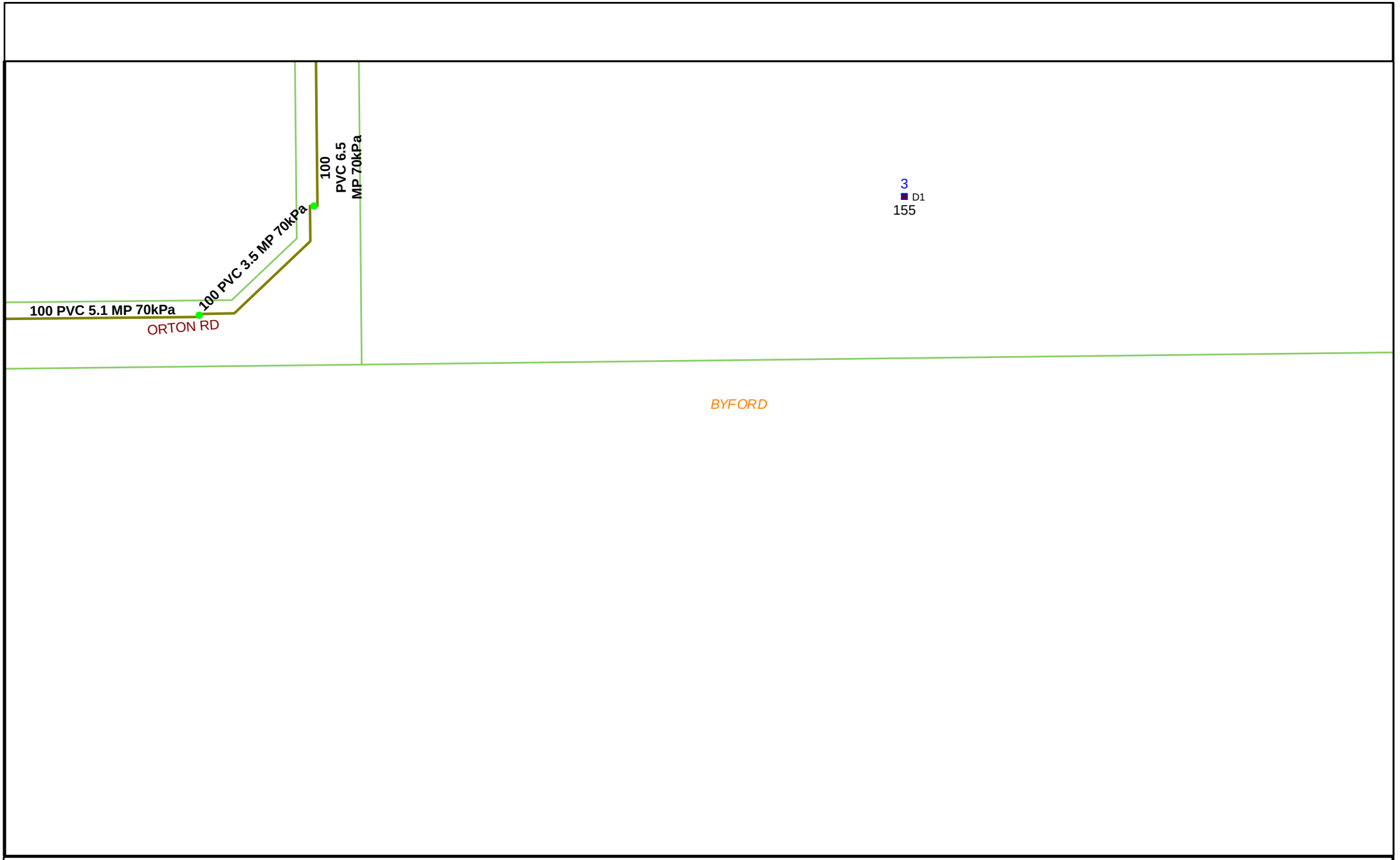
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Sequence No: 49239623 Map Tile: 5 Scale: 1:1500

Job No: 9951652 Date:19/11/2015 Location: Warrington Road, Byford 6122

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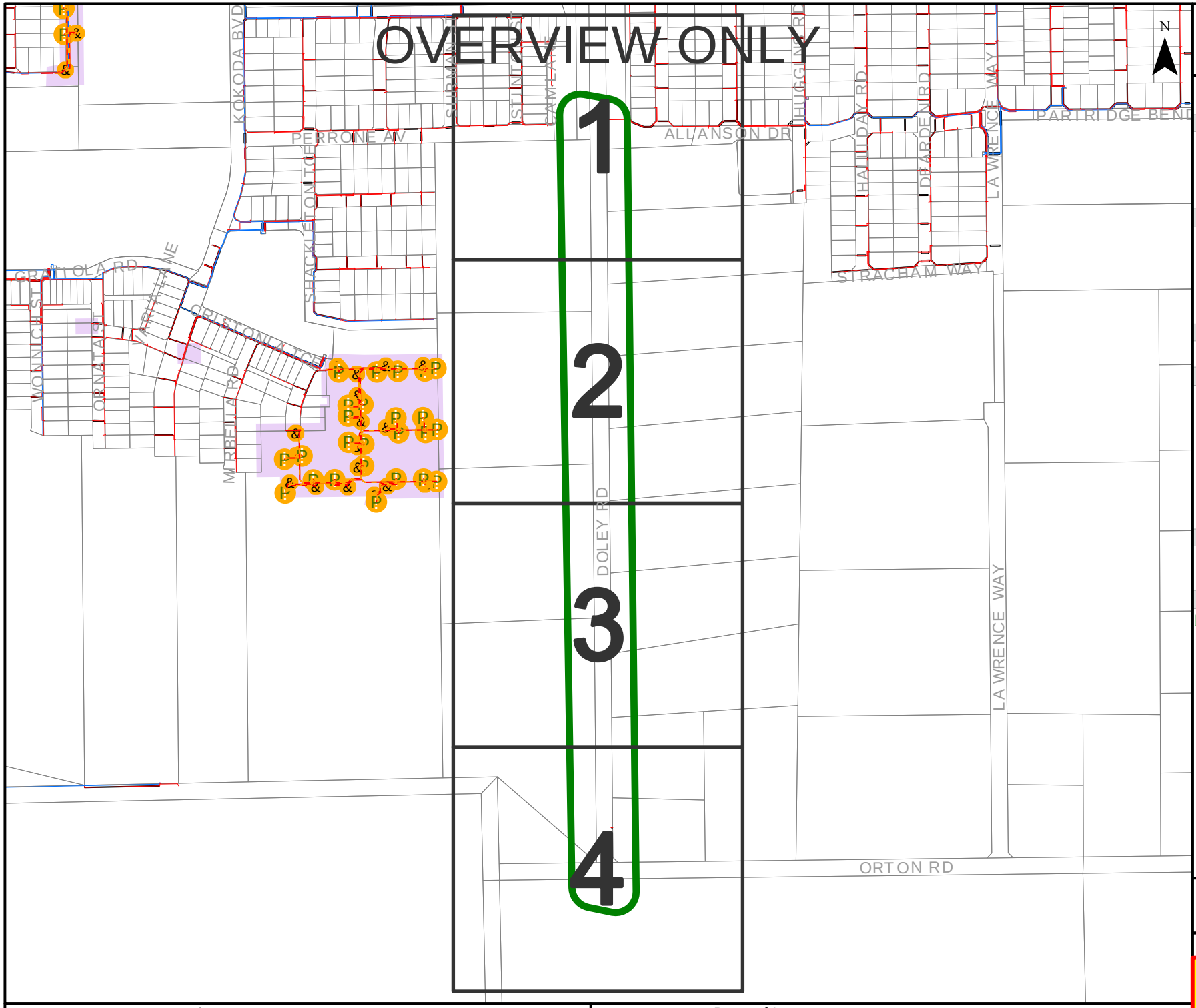
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Appendix Eight Western Power Maps, 2015



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UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Hand exposure via pothole method is MANDATORY.

Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

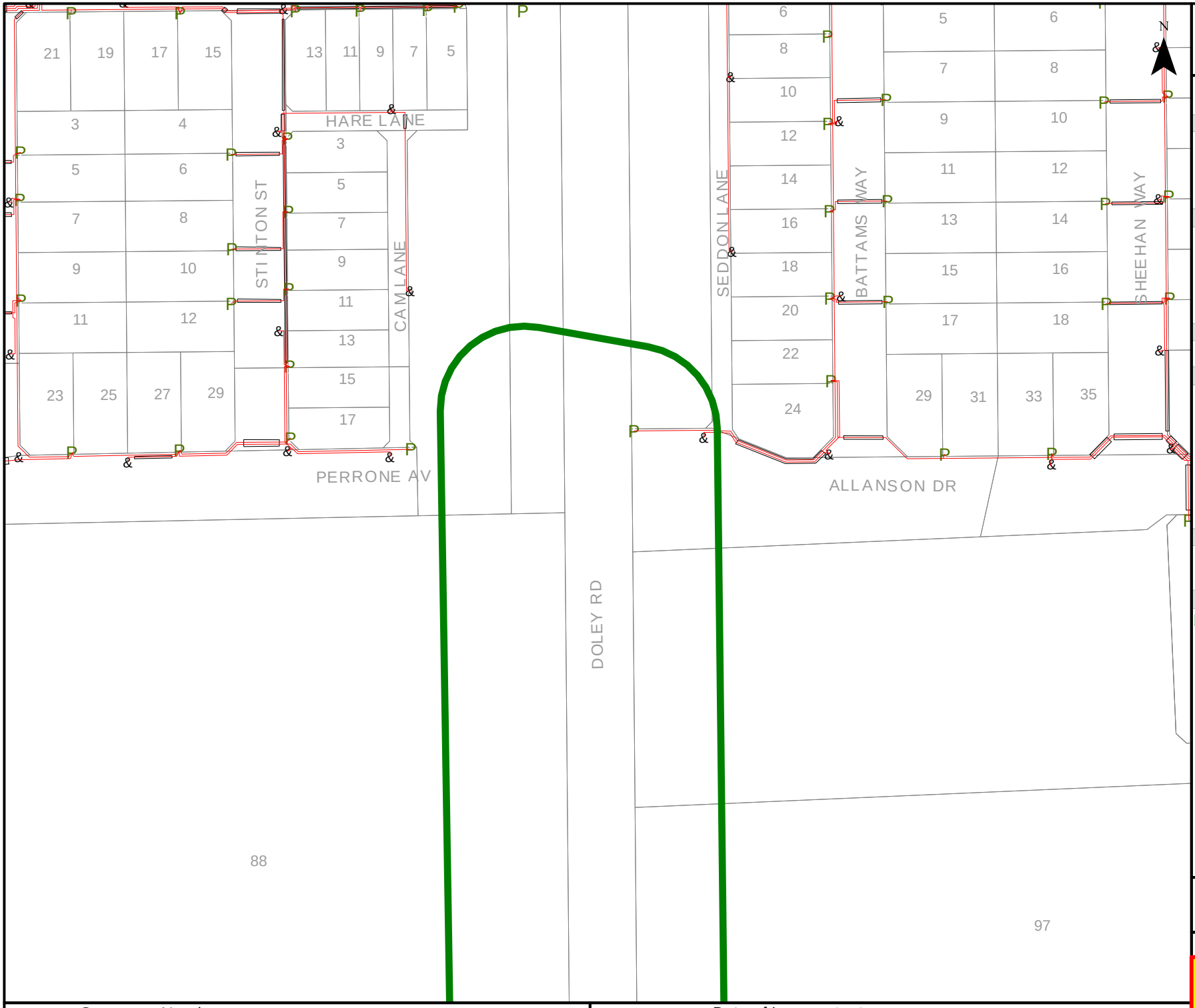
Information valid for 30 days from date of issue

A4	Scale : 1:6150

WARNING! Look out for overhead power lines

Sequence Number: 47078756

Date of Issue: 4/08/2015



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UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

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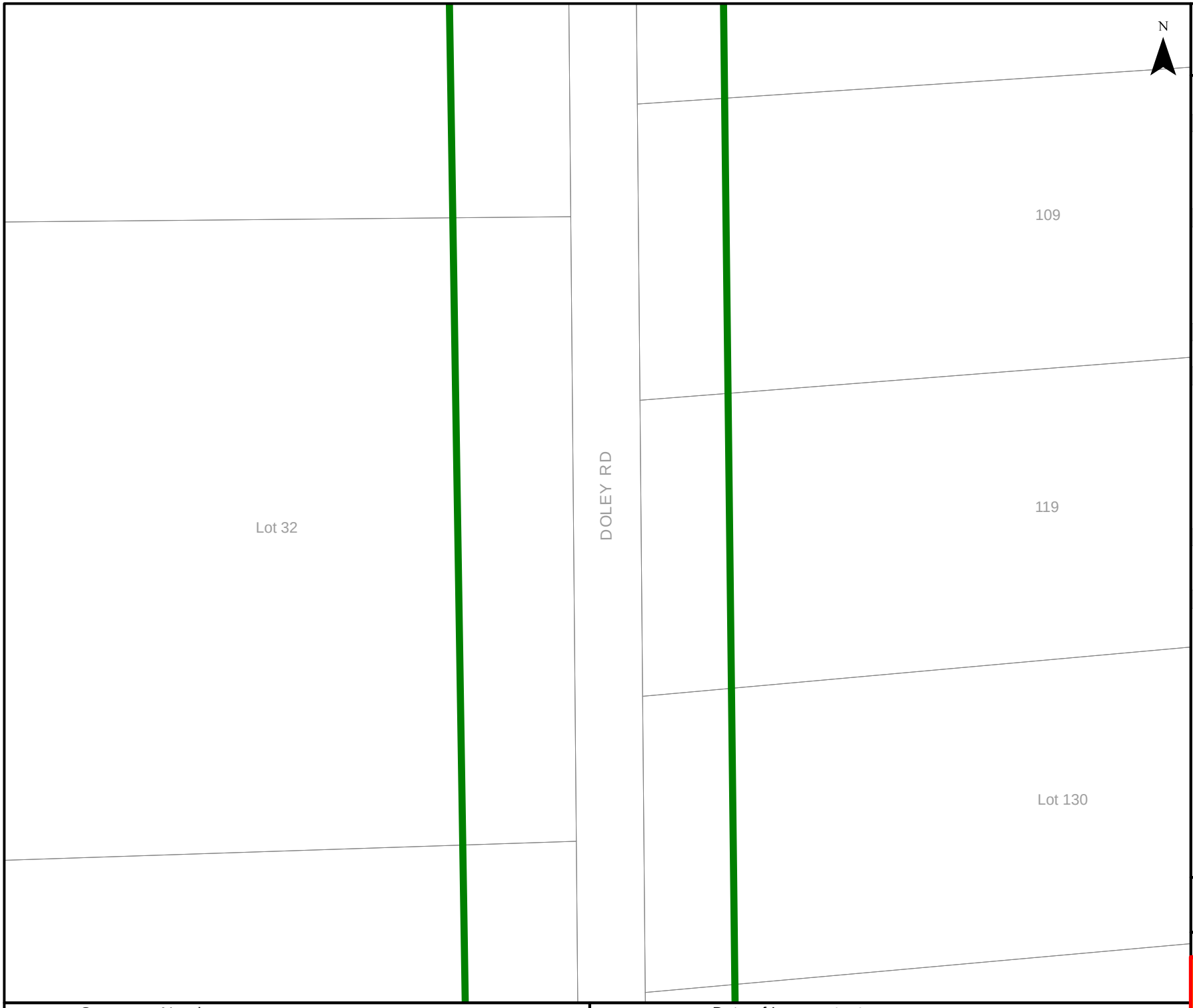
Information valid for 30 days from date of issue

A4 | Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 47078756

Date of Issue: 4/08/2015



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UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
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- Ring Main Unit
- LV Distribution Frame

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- LV Termination

Proposed Construction Assets

- Design Area *
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- Low Voltage Underground Cable
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- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

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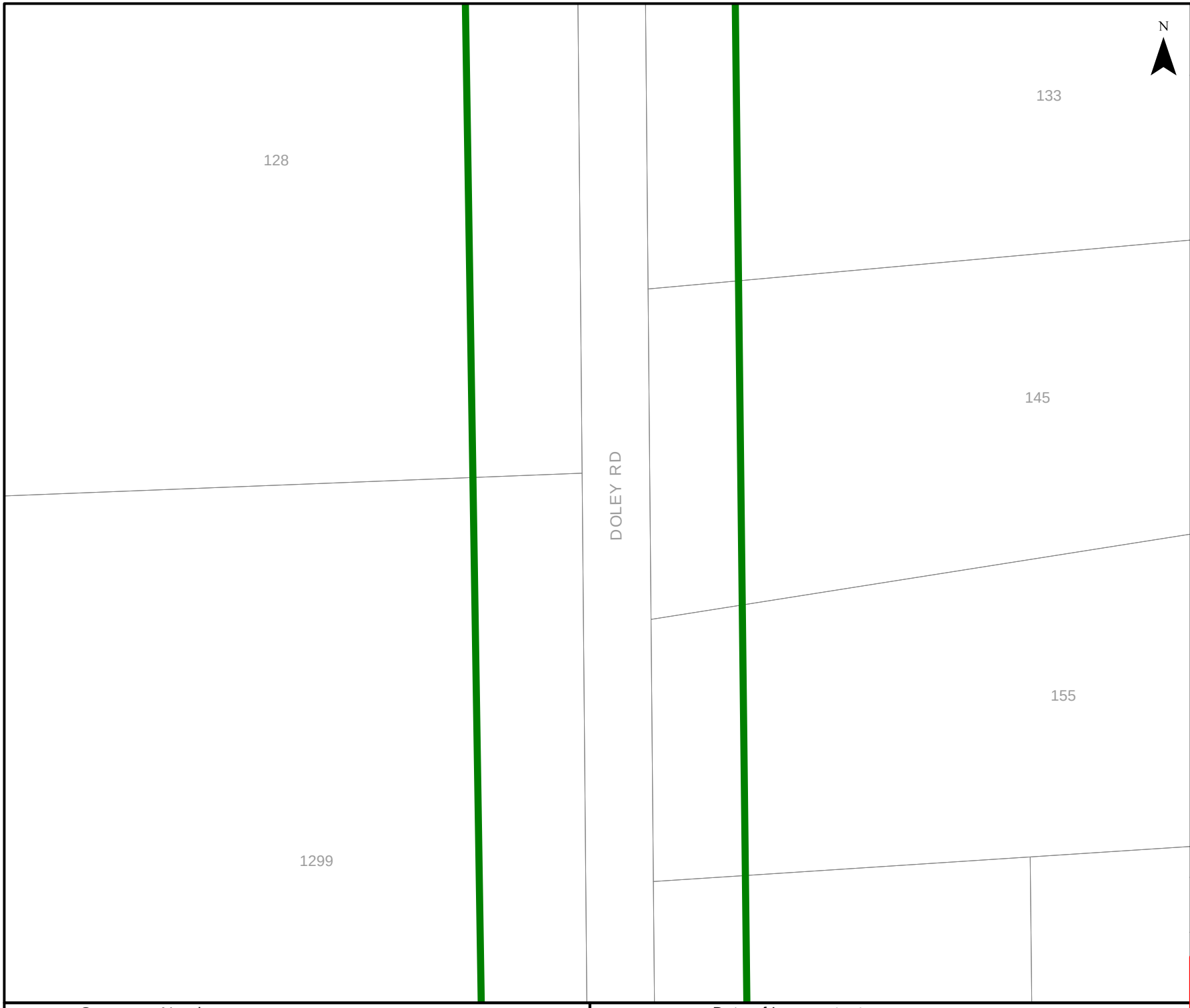
Information valid for 30 days from date of issue

A4	Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 47078756

Date of Issue: 4/08/2015



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UNDERGROUND LEGEND

Structures

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- Metal Pole
- Transformer Site
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- Ring Main Unit
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- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

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- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
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- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

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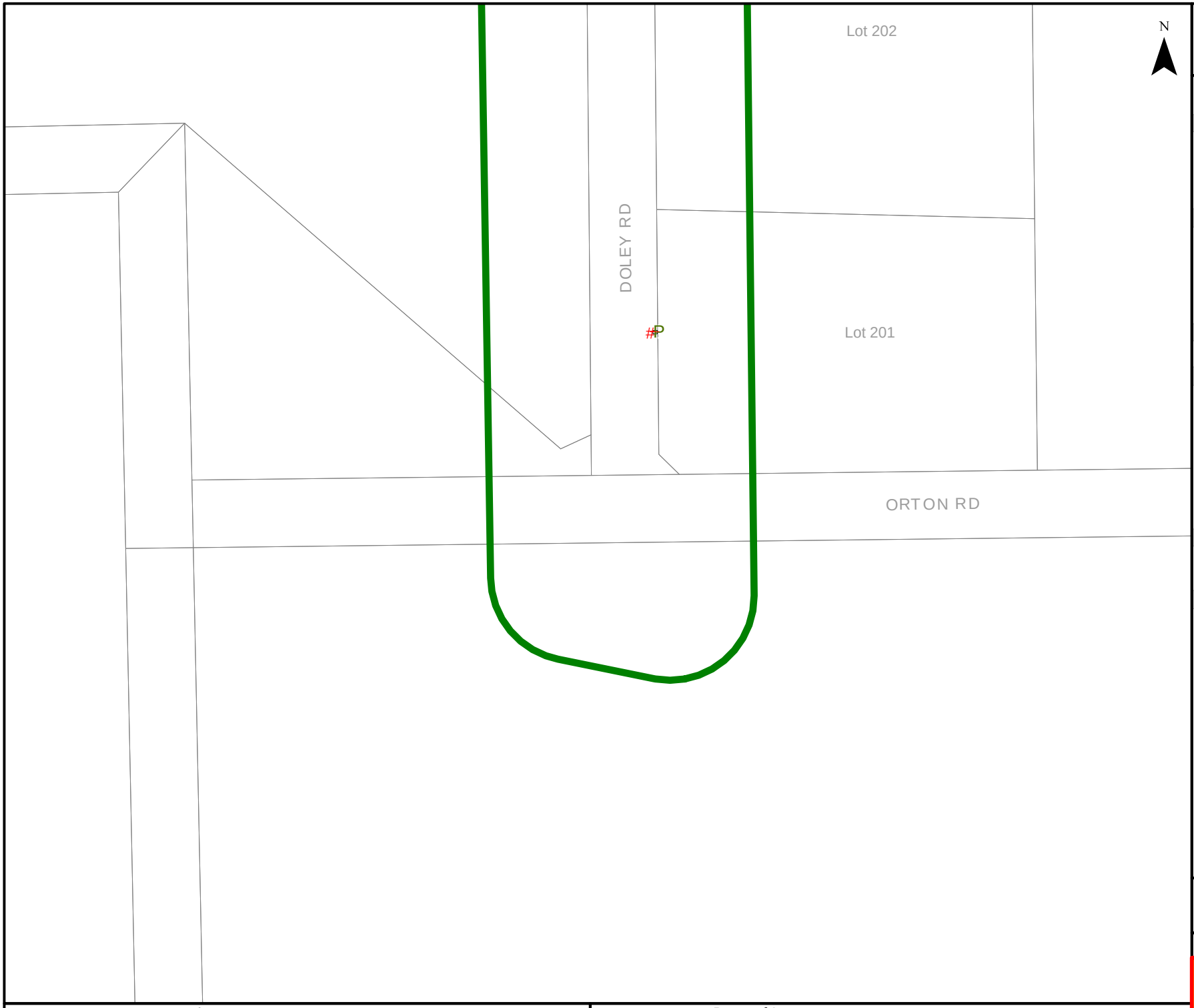
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A4	Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 47078756

Date of Issue: 4/08/2015



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UNDERGROUND LEGEND

Structures

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- Metal Pole
- Transformer Site
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- LV Distribution Frame

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Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

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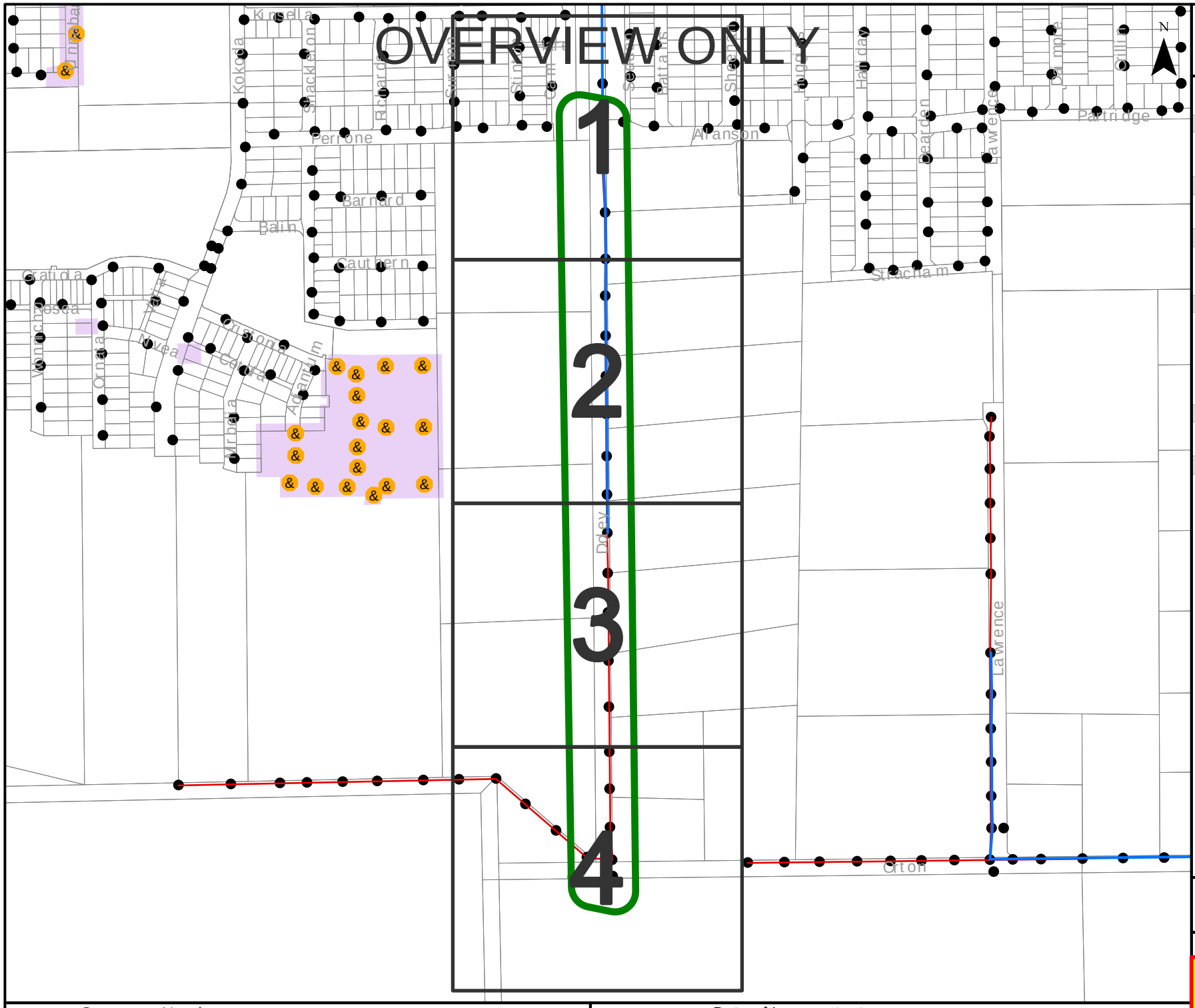
Information valid for 30 days from date of issue

A4	Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 47078756

Date of Issue: 4/08/2015



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OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Check that you have enough clearance from the DANGER ZONES near overhead powerlines.

Telephone Support: 1300 769 345
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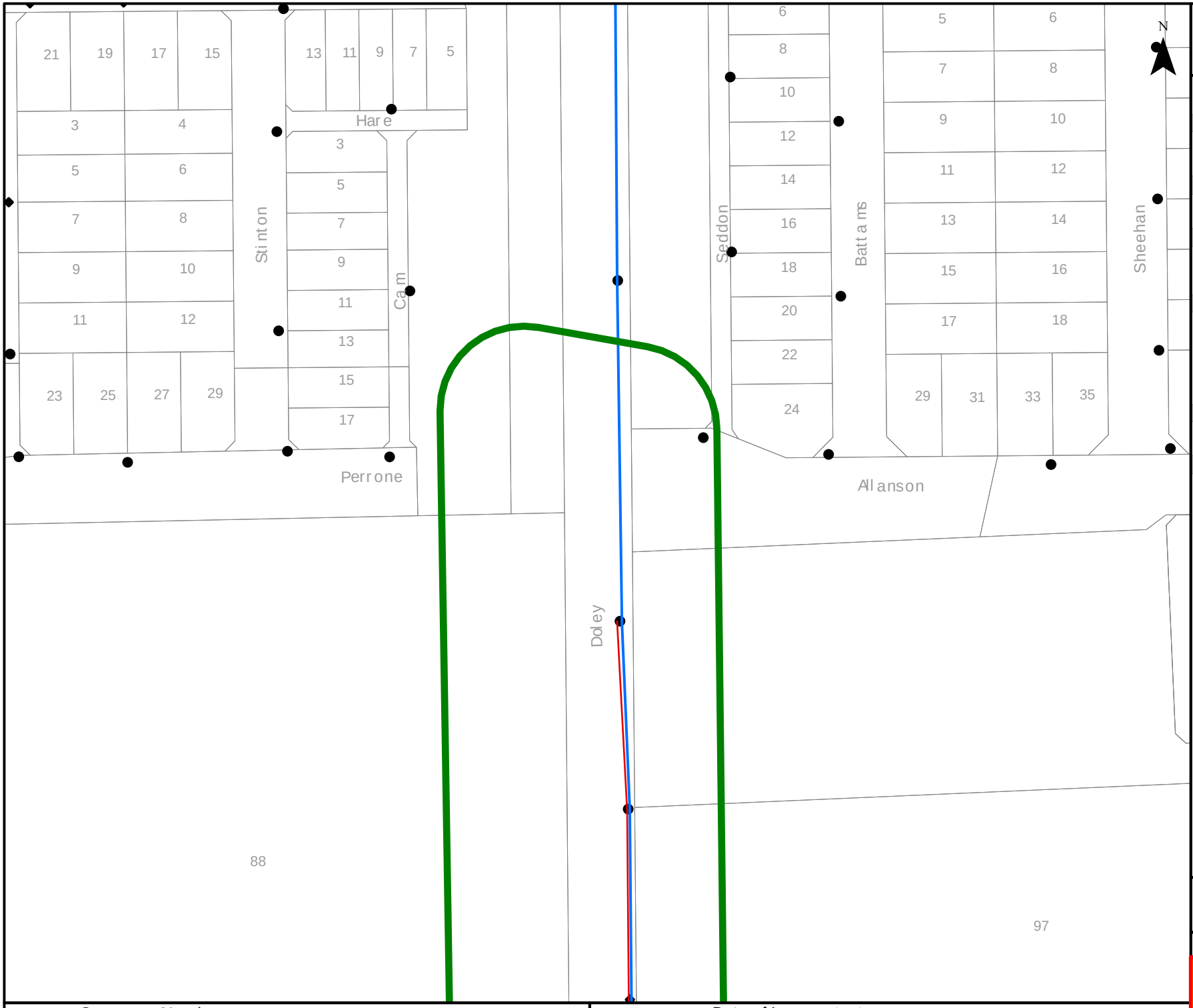
Information valid for 30 days from date of issue

A4	Scale : 1:6150

WARNING! Look out for overhead power lines

Sequence Number: 47078756

Date of Issue: 4/08/2015



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OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

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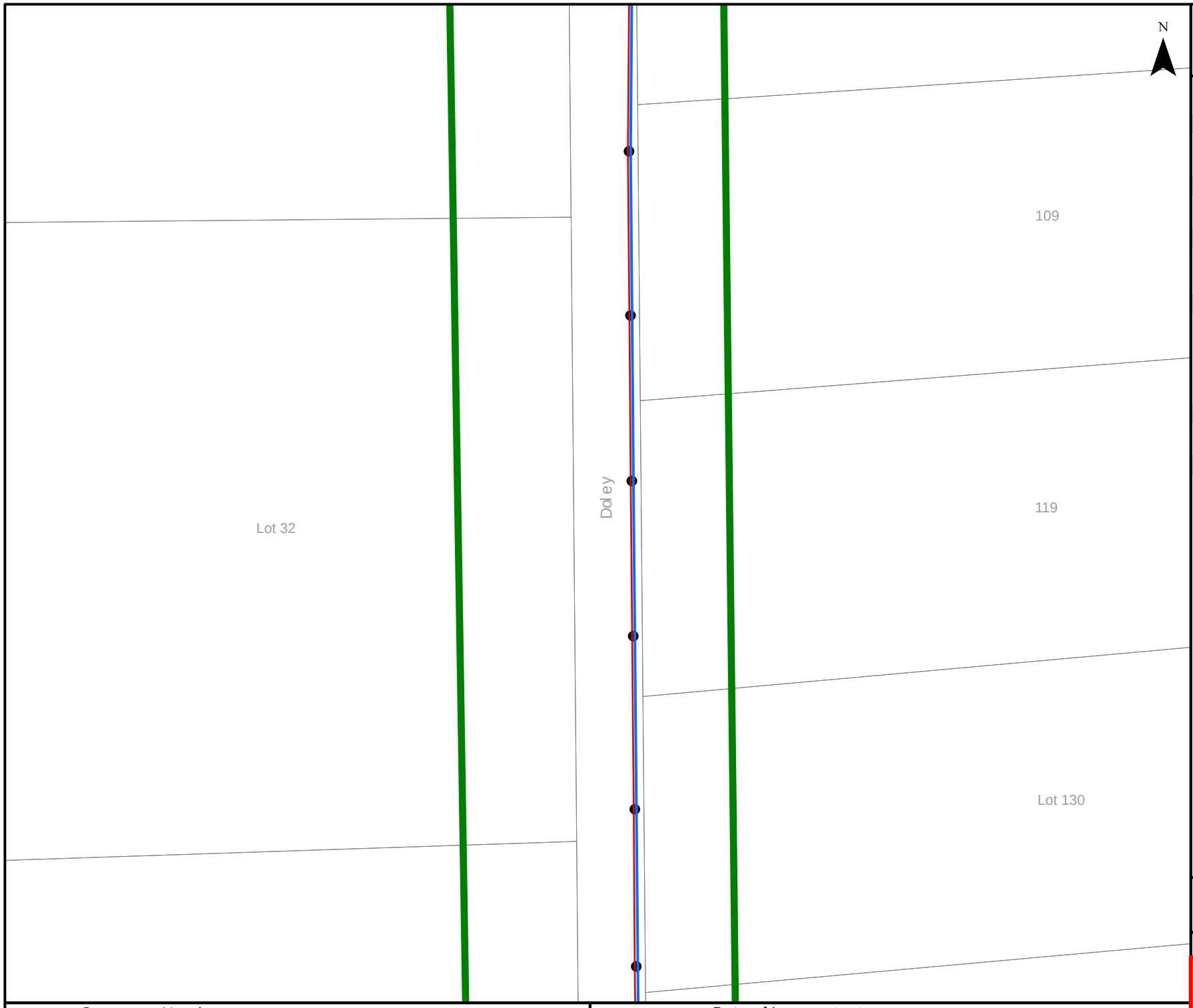
Information valid for 30 days from date of issue

A4	Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 47078756

Date of Issue: 4/08/2015



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OVERHEAD LEGEND

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Communications Assets

- Overhead Pilot Cable

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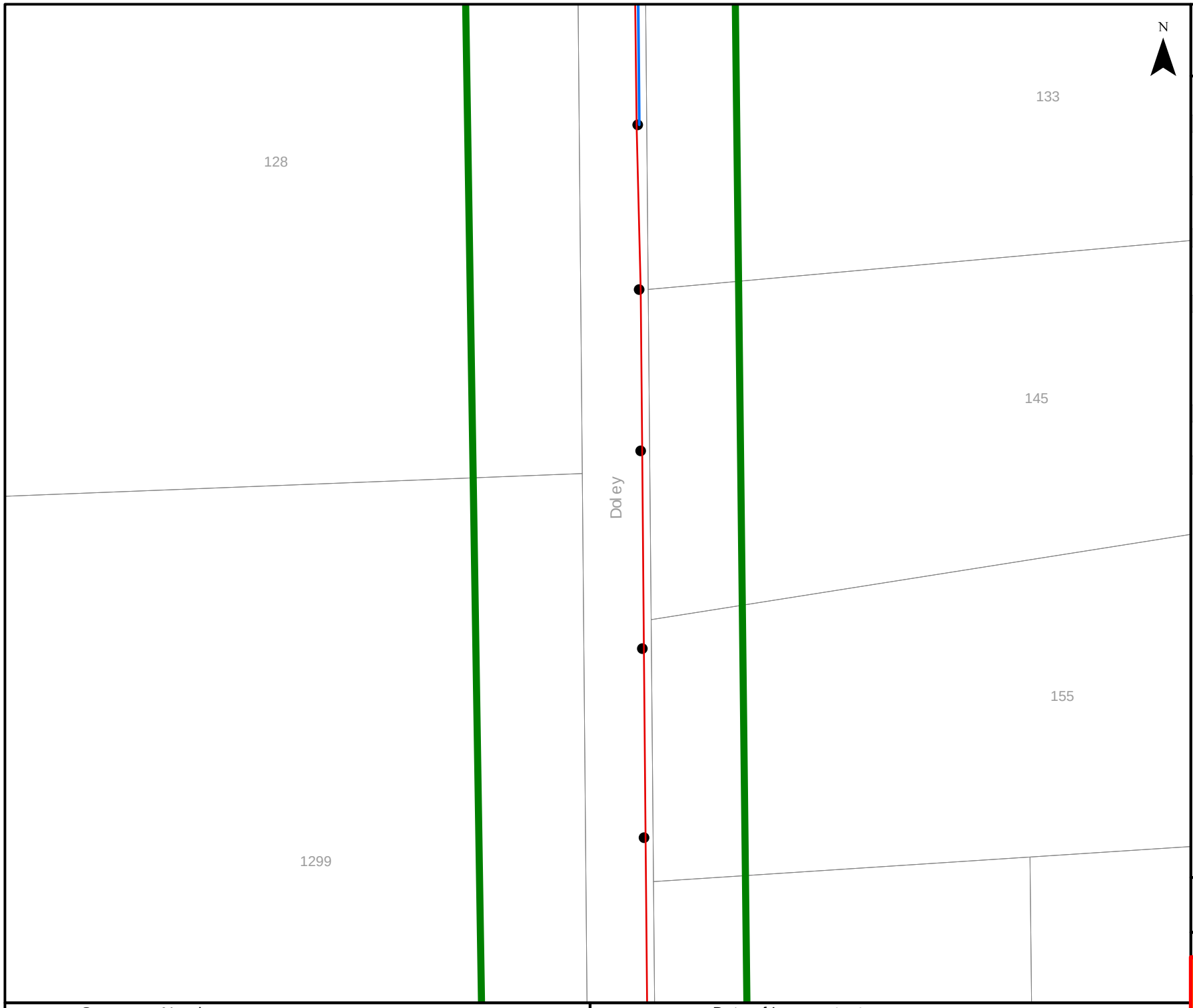
Information valid for 30 days from date of issue

A4 | Scale : 1:1500

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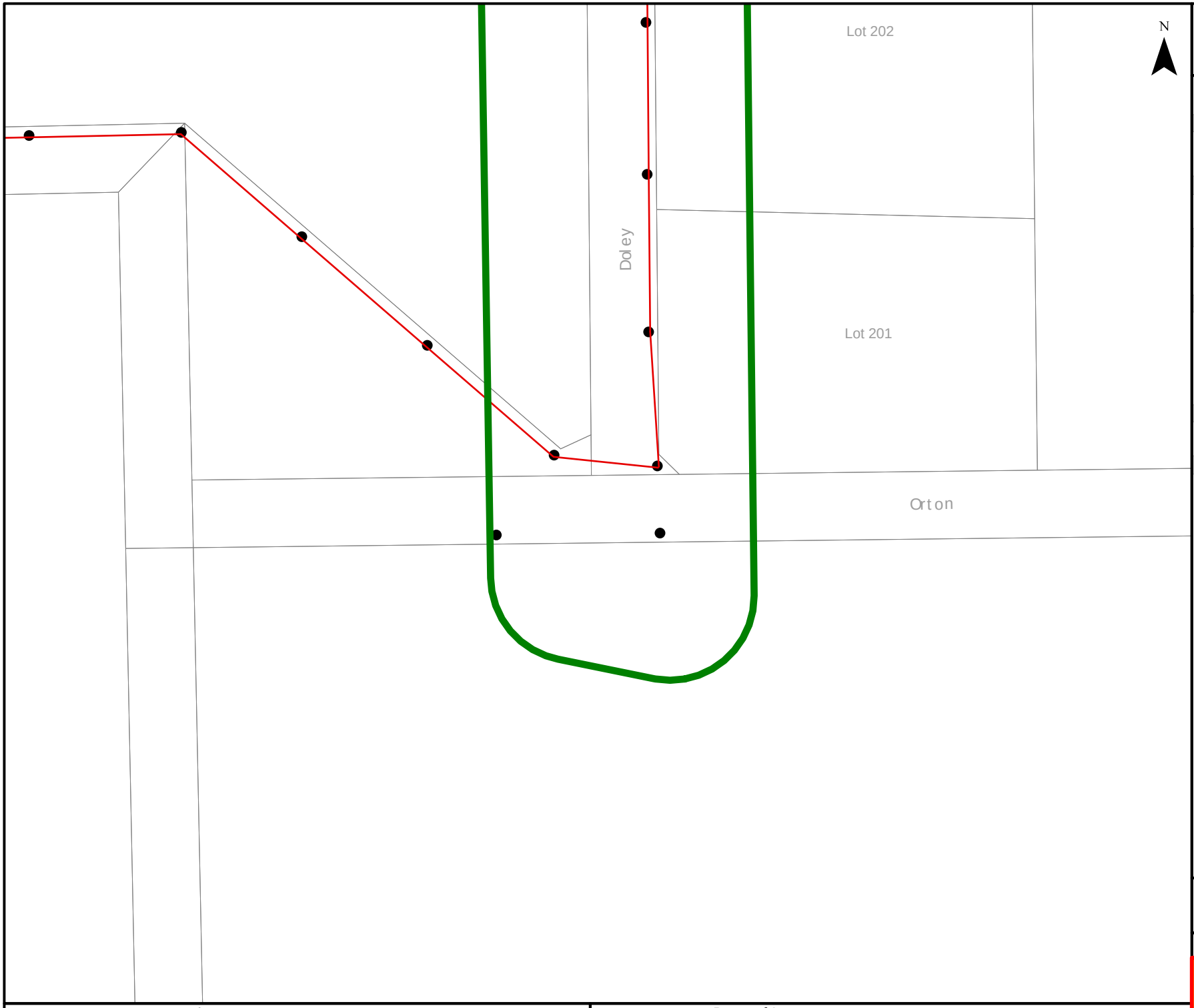
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OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Check that you have enough clearance from the DANGER ZONES near overhead powerlines.

Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

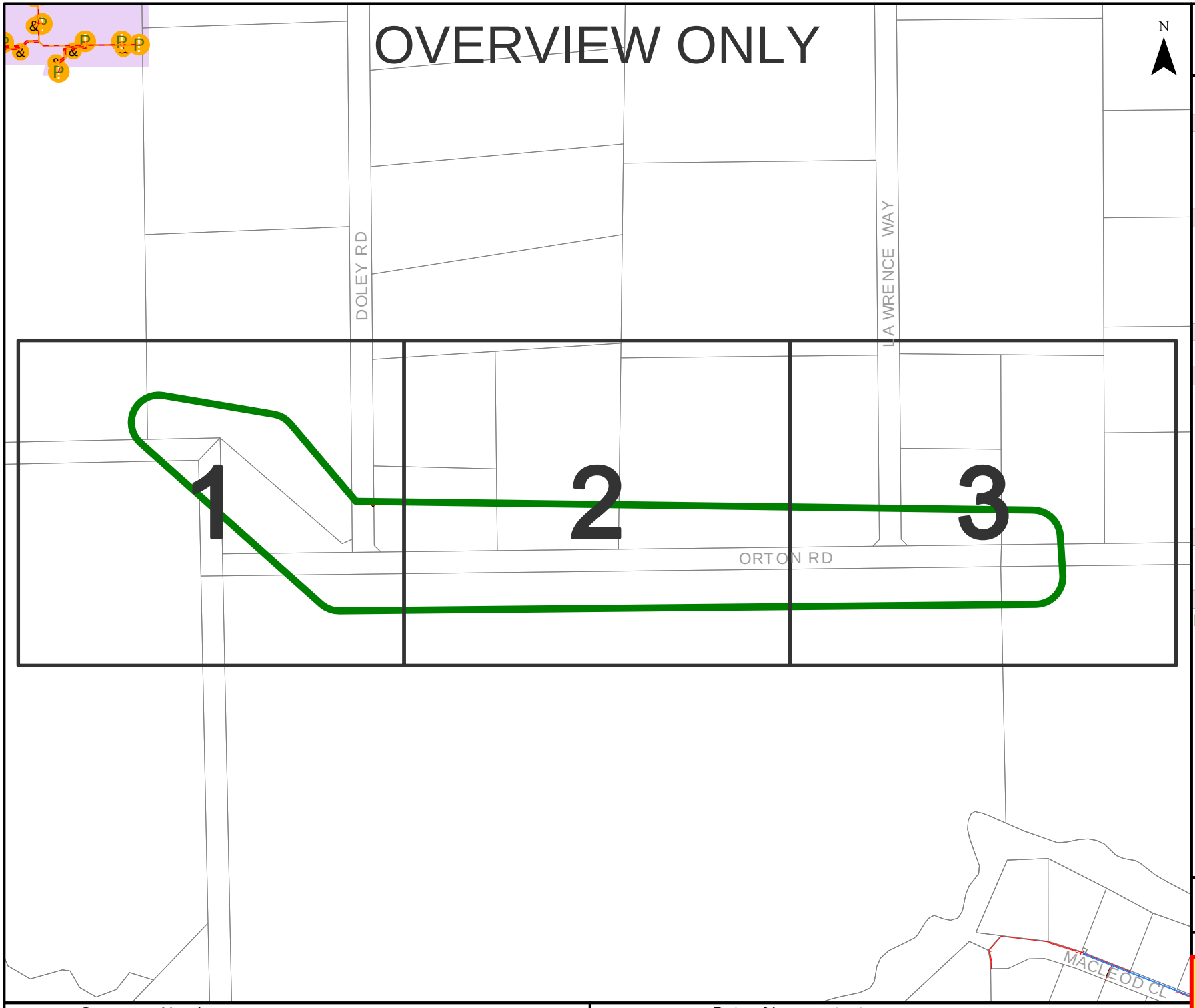
Information valid for 30 days from date of issue

A4	Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 47078756

Date of Issue: 4/08/2015



westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

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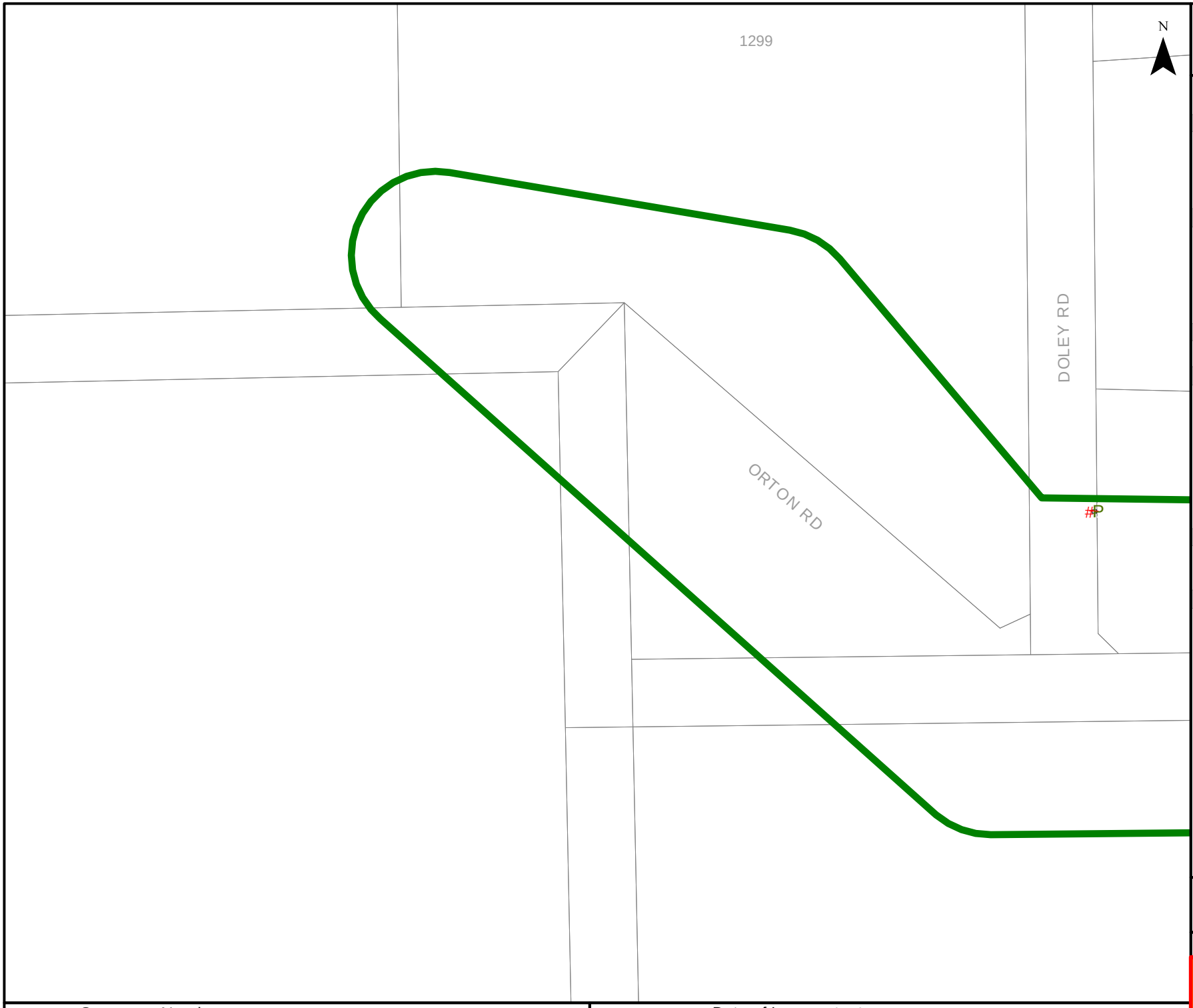
Information valid for 30 days from date of issue

A4	Scale : 1:4612

WARNING! Look out for overhead power lines

Sequence Number: 47078822

Date of Issue: 4/08/2015



westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

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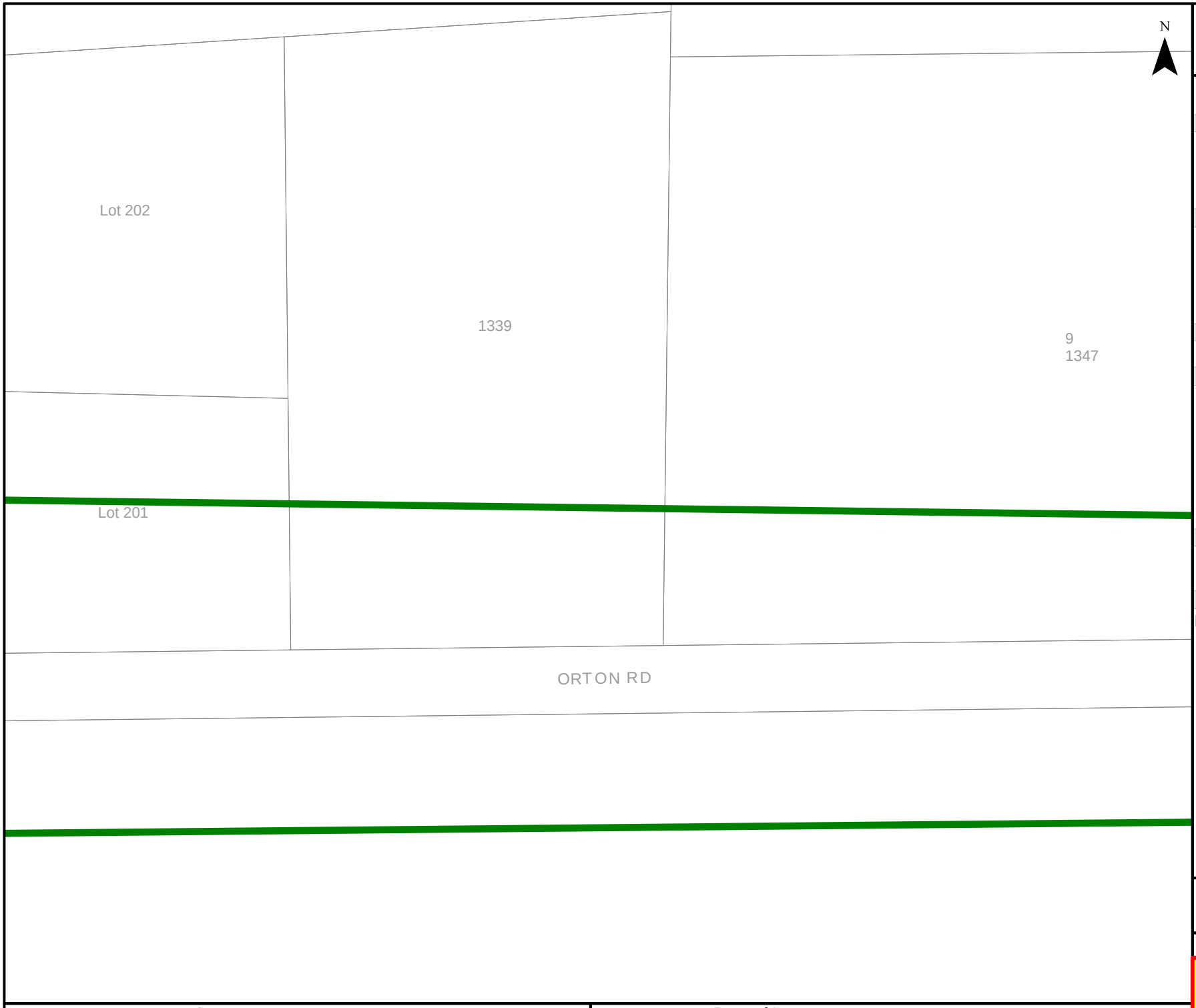
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A4	Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 47078822

Date of Issue: 4/08/2015



westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
- Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- HV Termination
- LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- Pillar
- Transformer site
- HV Termination
- LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

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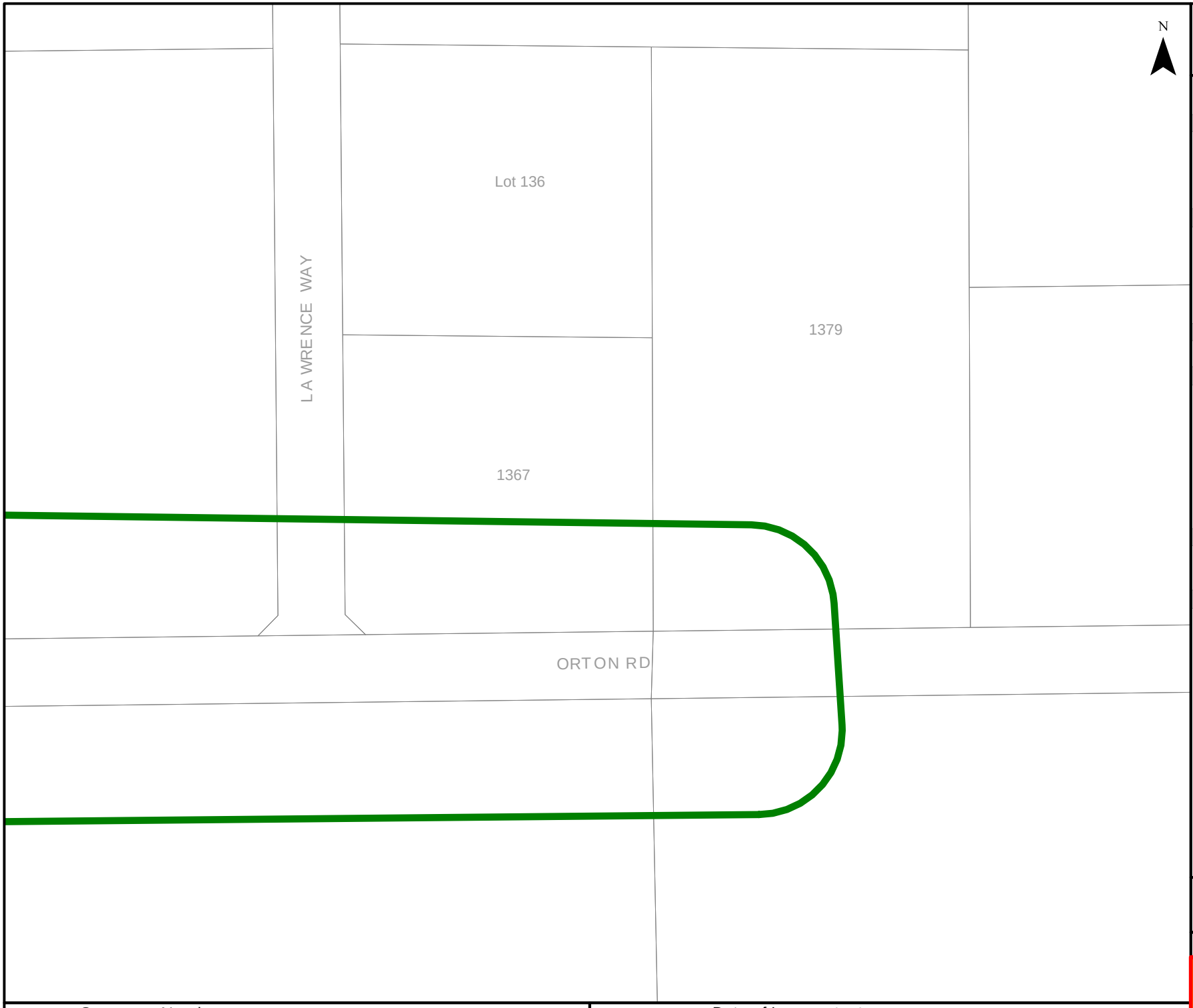
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A4	Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 47078822	Date of Issue: 4/08/2015



westernpower

UNDERGROUND LEGEND

Structures

- Pillar
- Metal Pole
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- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
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- Design Area *
- High Voltage Underground Cable
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State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

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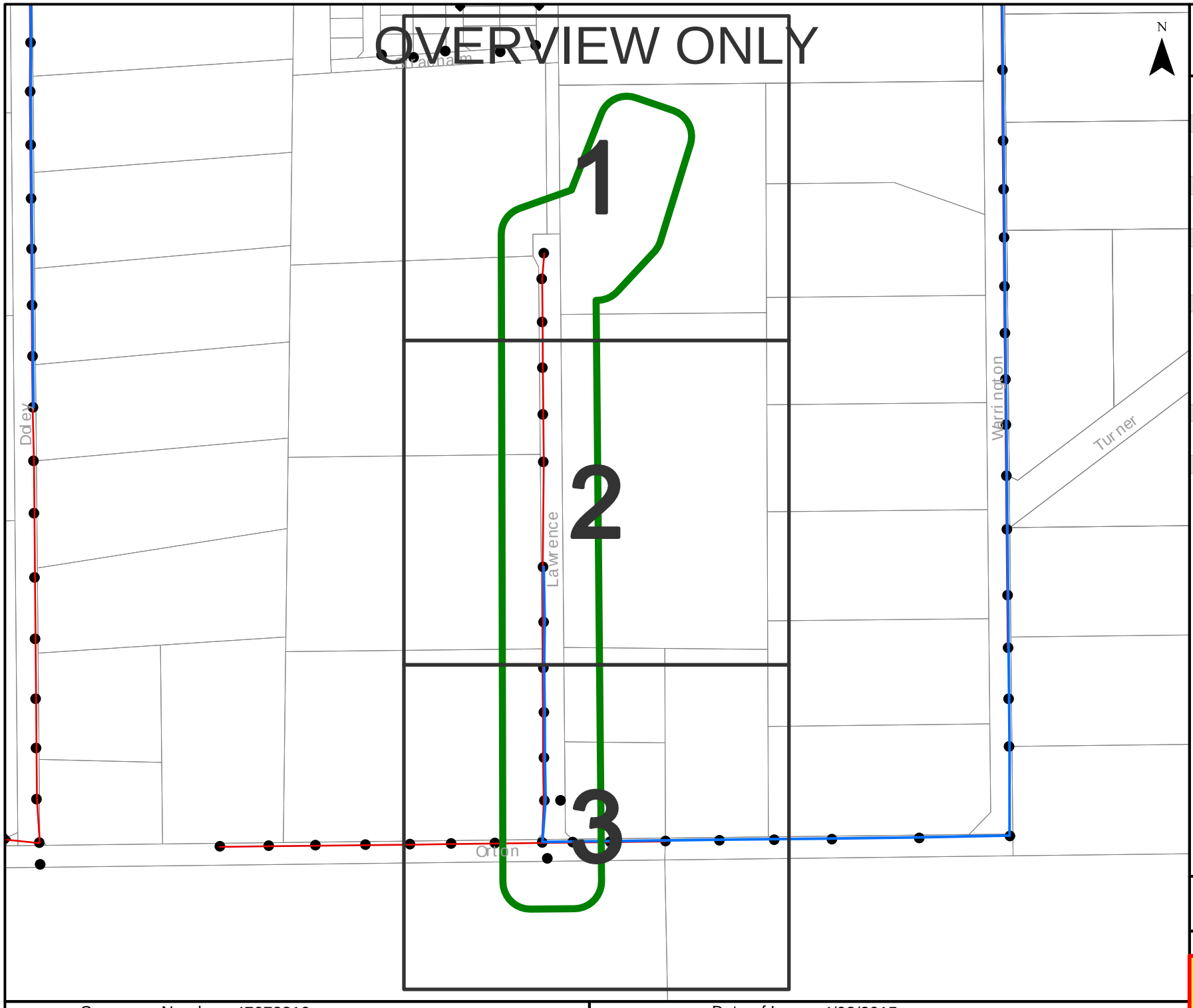
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WARNING! Look out for overhead power lines

Sequence Number: 47078822

Date of Issue: 4/08/2015



westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

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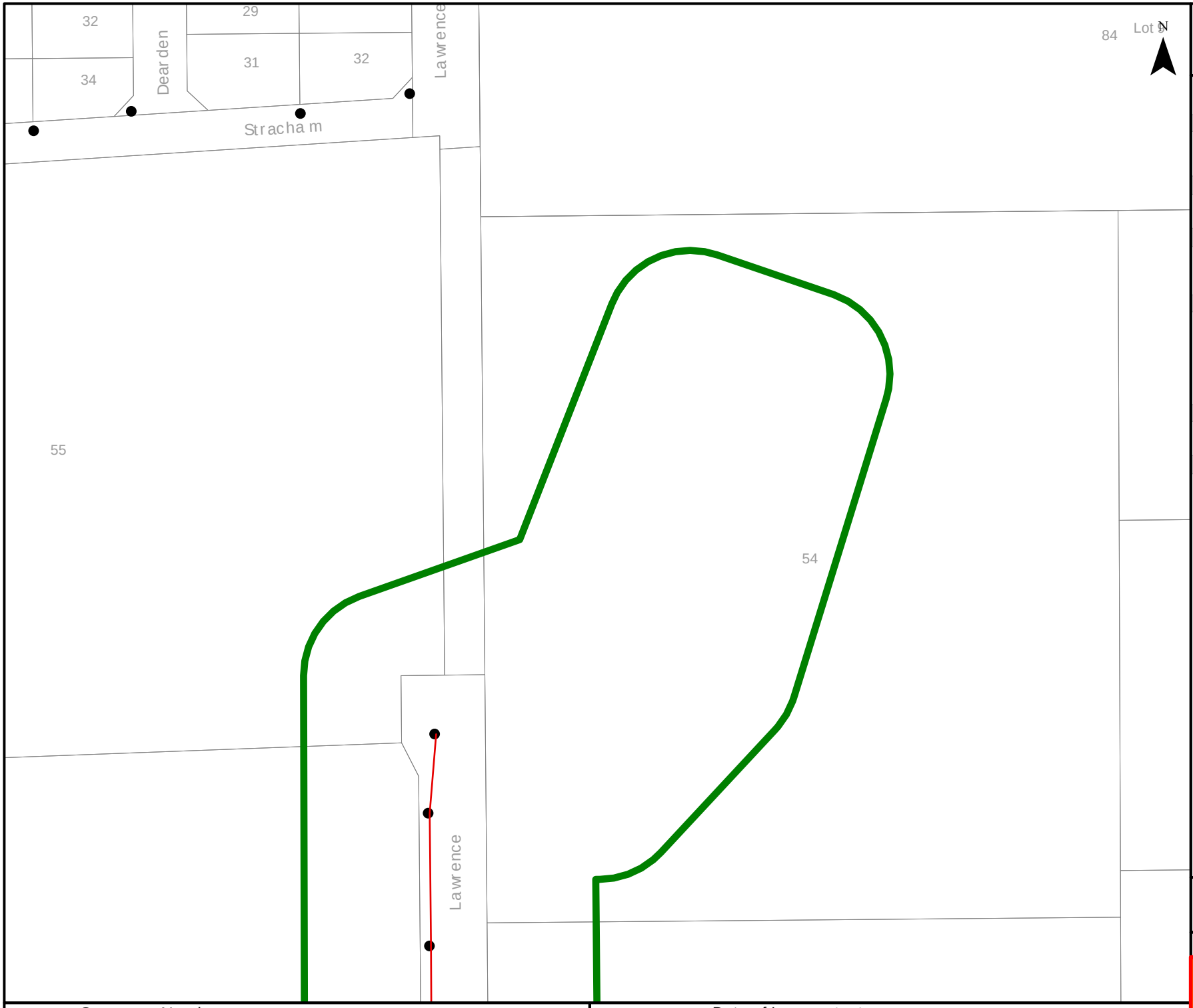
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A4	Scale : 1:4612

WARNING! Look out for overhead power lines

Sequence Number: 47078810

Date of Issue: 4/08/2015



westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

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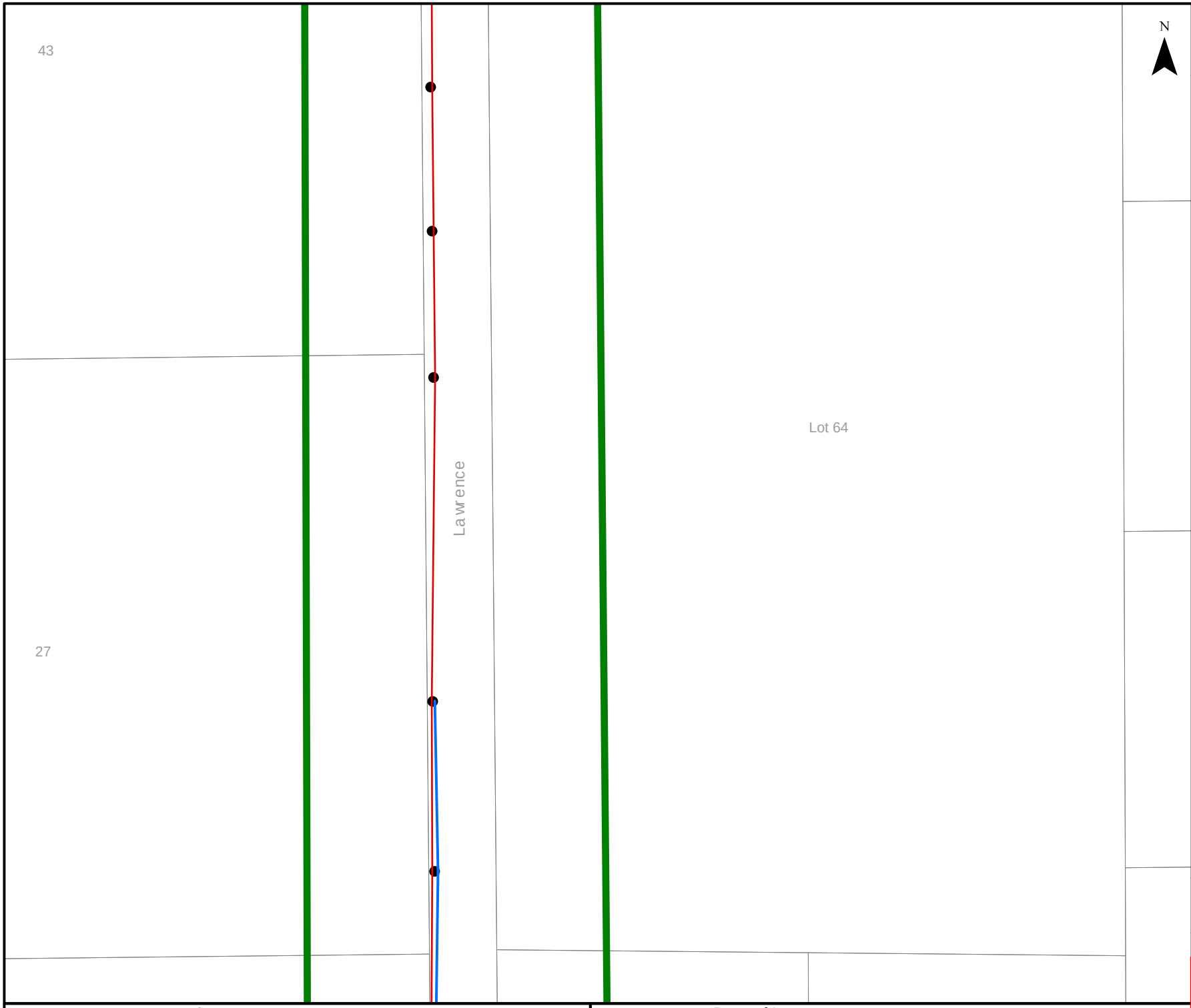
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Date of Issue: 4/08/2015



westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
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- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

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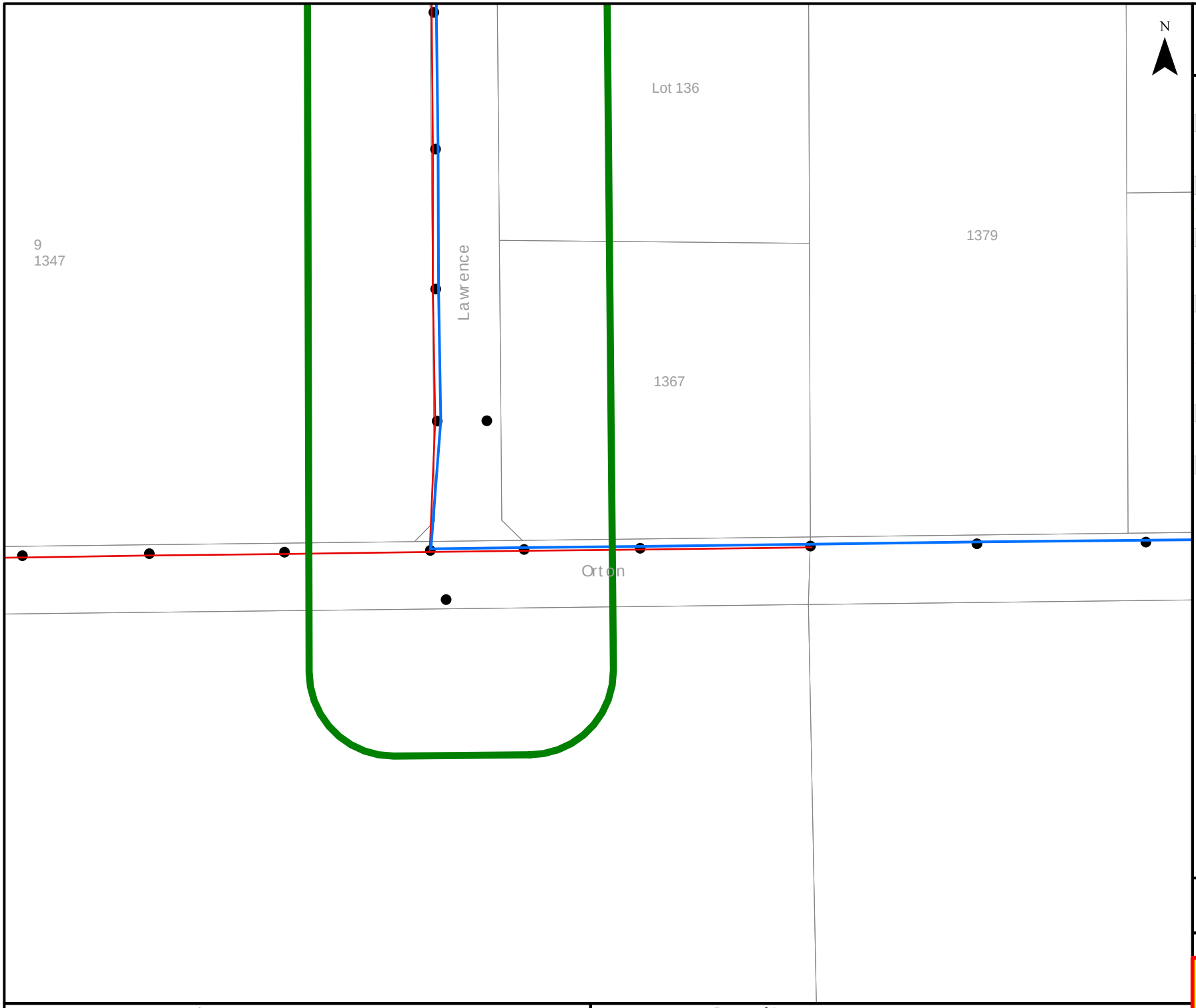
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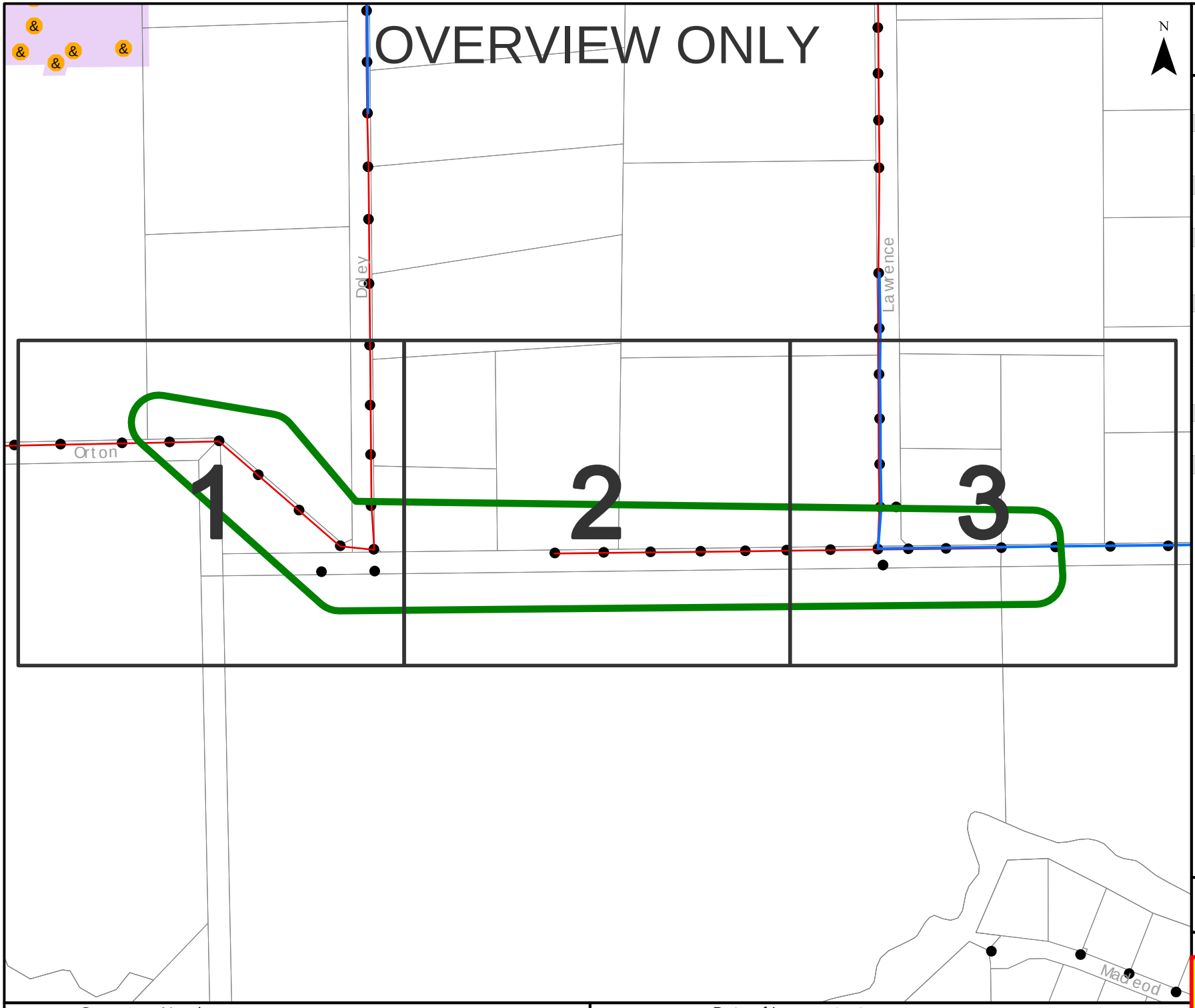
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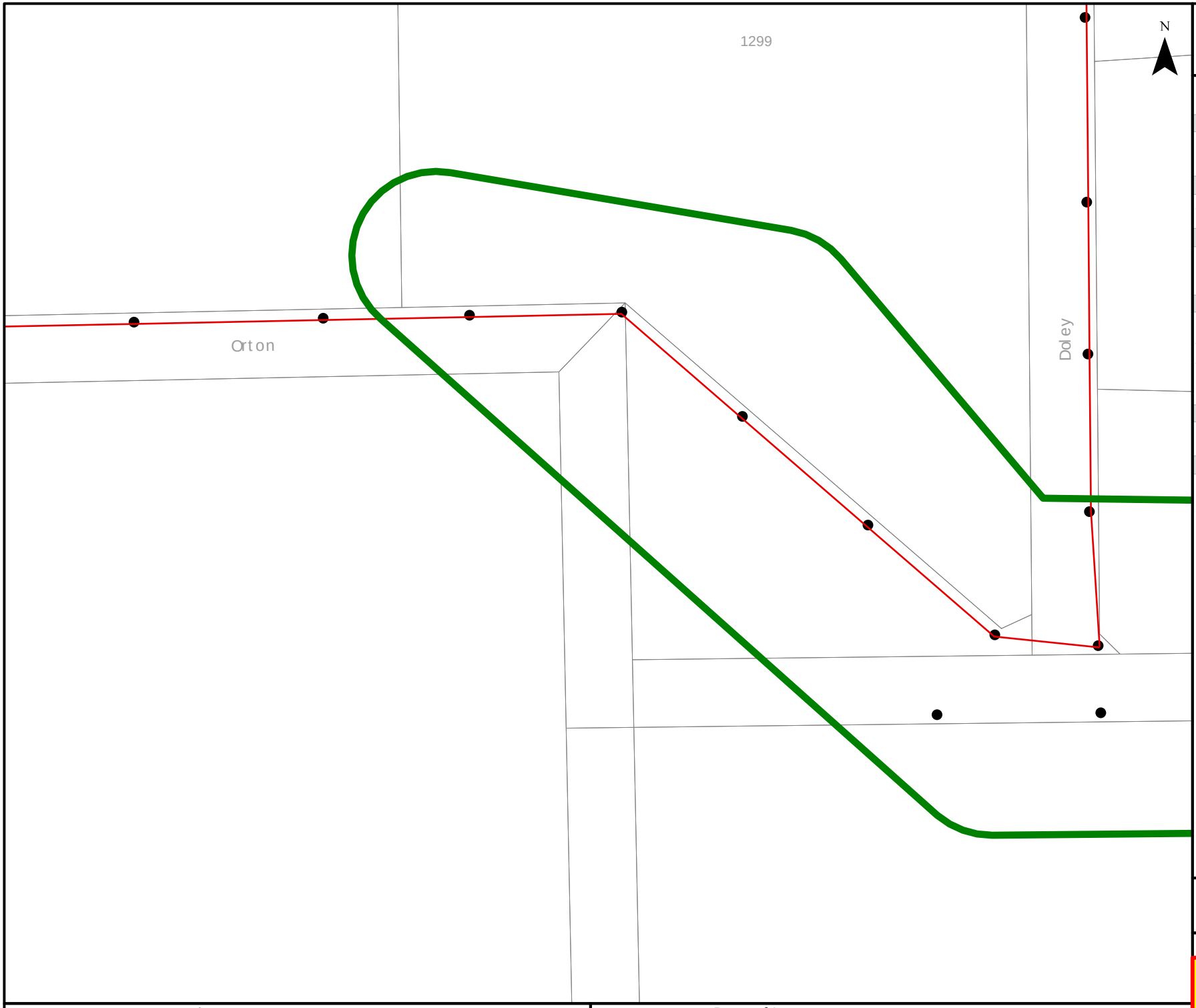
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A4	Scale : 1:4612

WARNING! Look out for overhead power lines

Sequence Number: 47078822

Date of Issue: 4/08/2015



westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
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Proposed Construction Assets

- Design Area *
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Communications Assets

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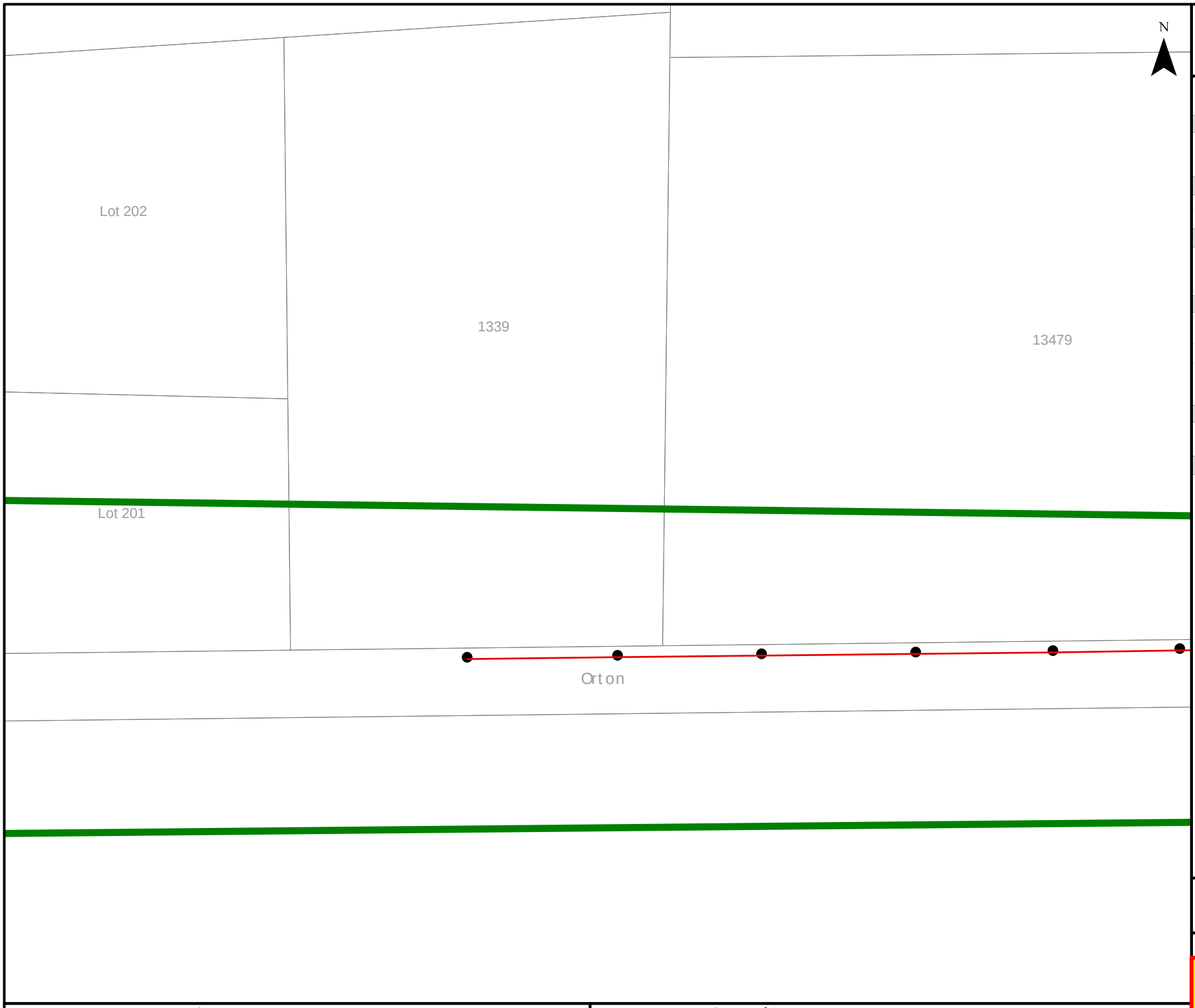
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A4	Scale : 1:1500

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westernpower

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- Overhead Pilot Cable

Feature

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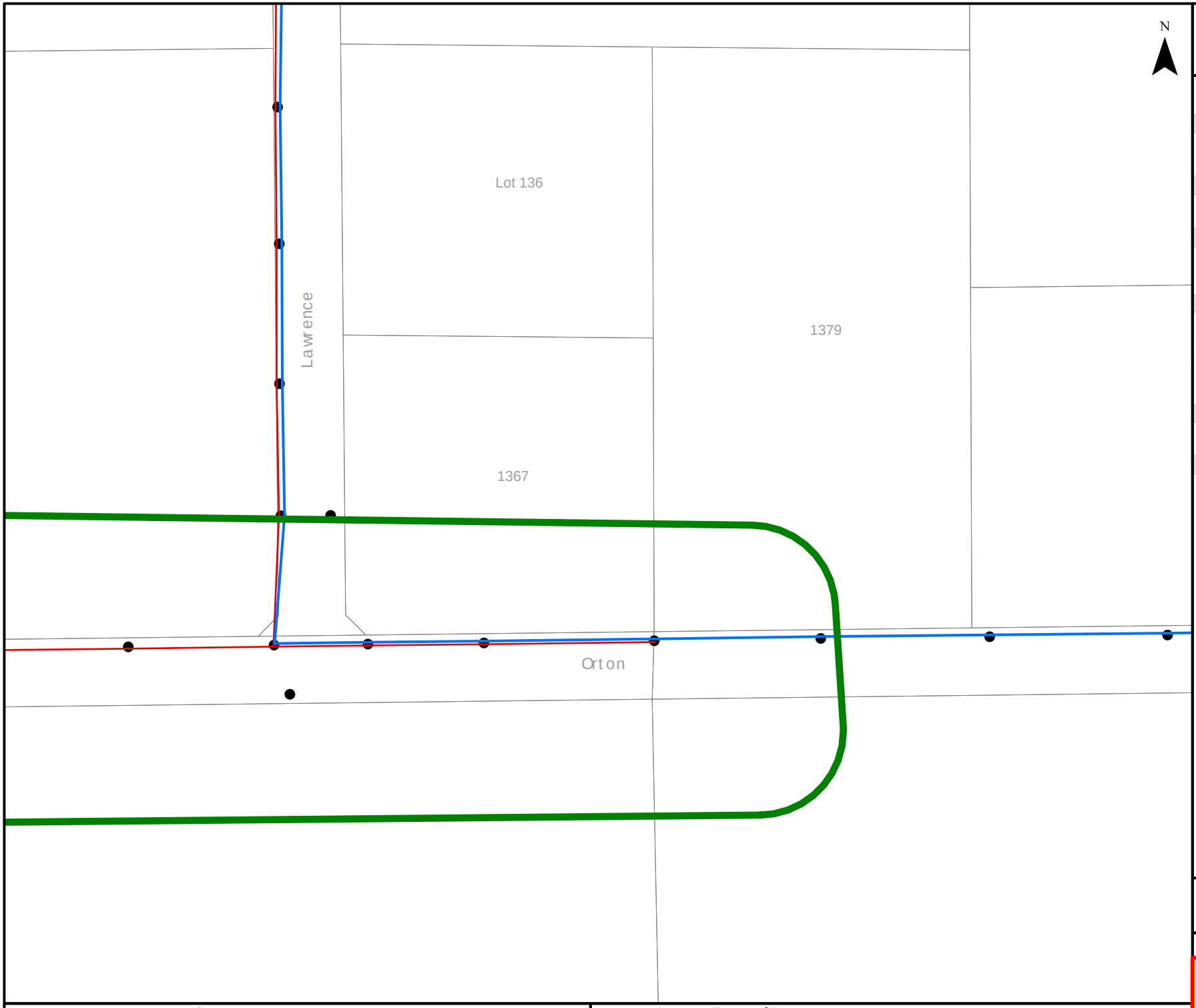
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westernpower

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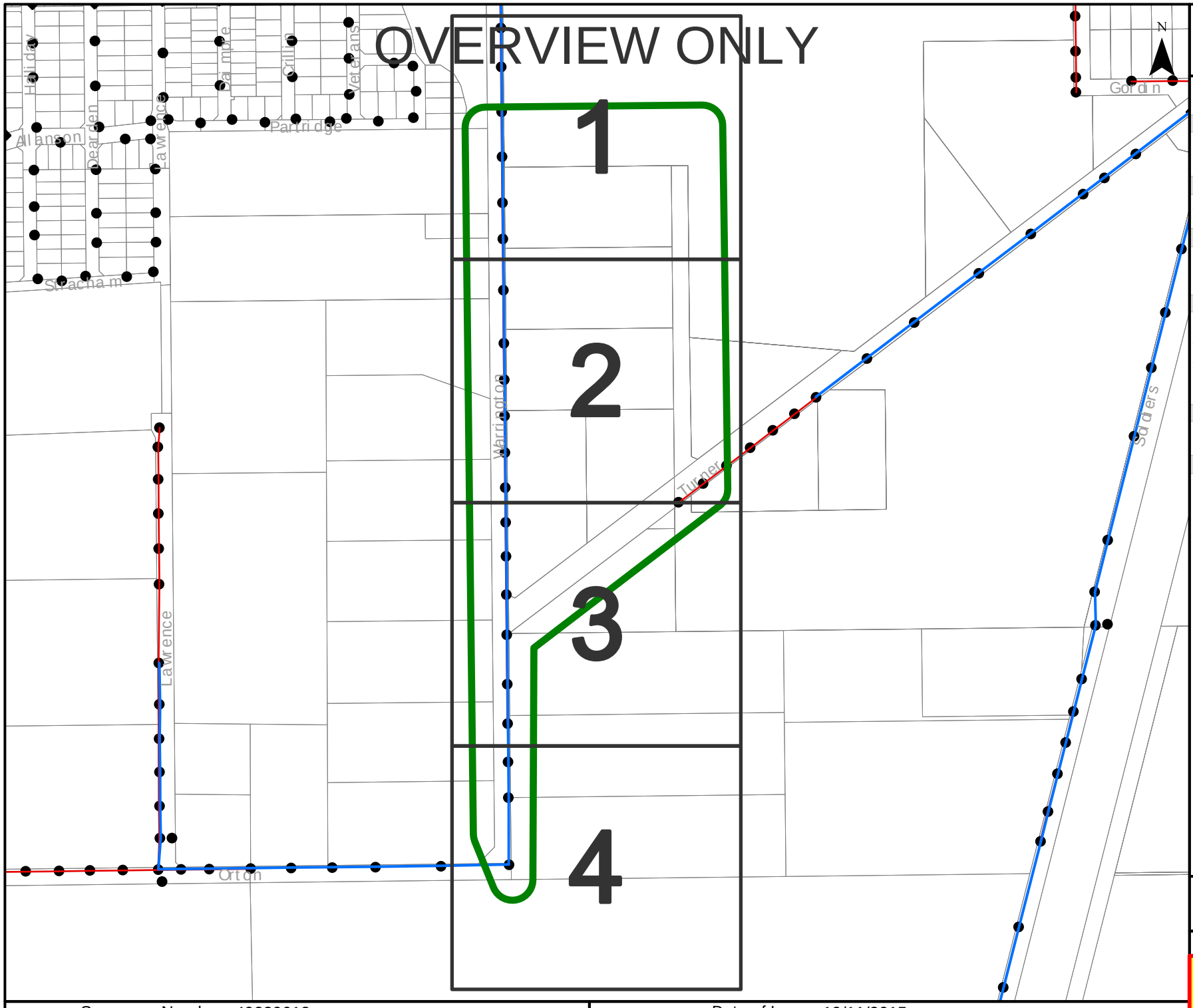
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westernpower

OVERHEAD LEGEND

Structures

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- Transmission Poles

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- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

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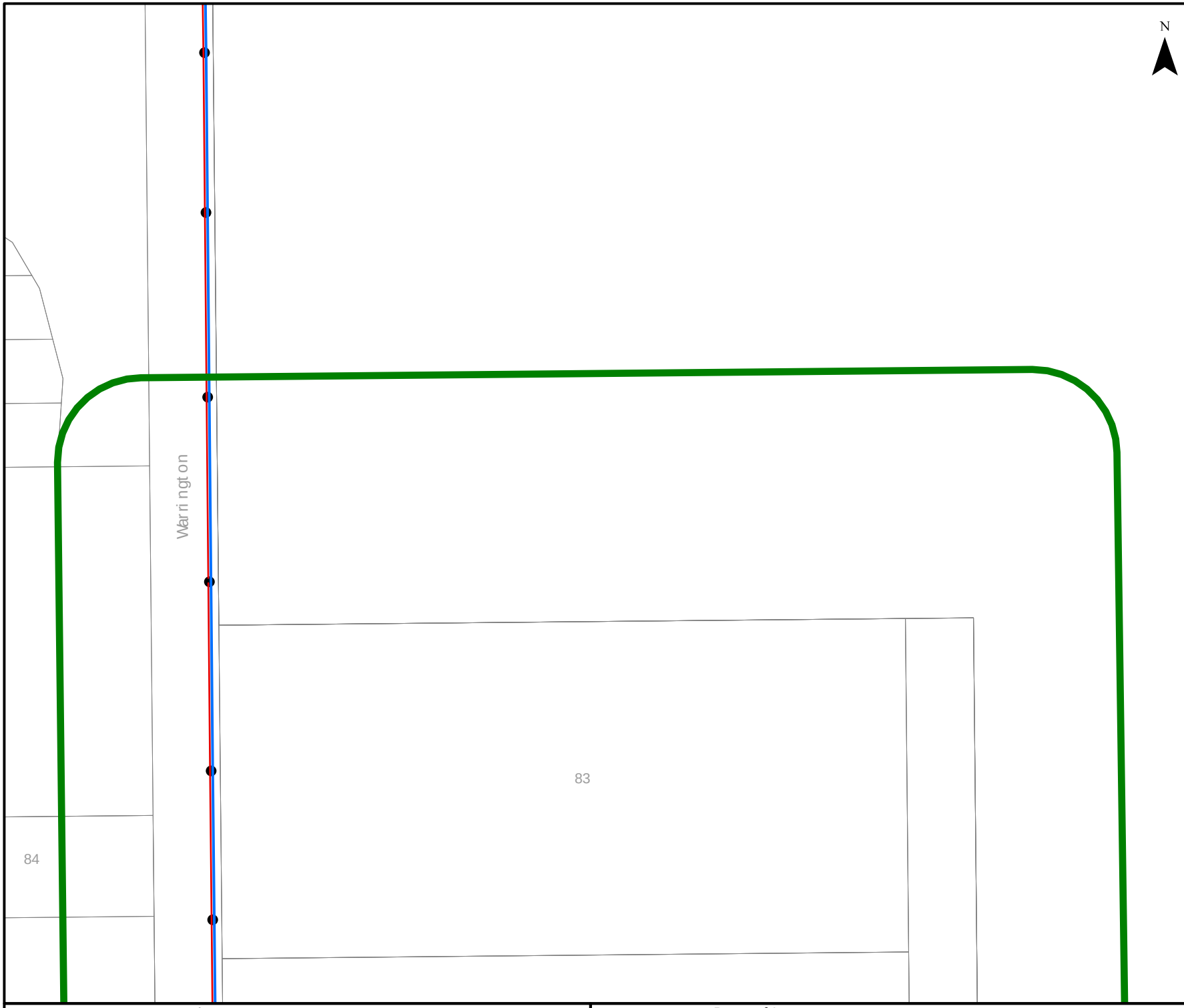
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WARNING! Look out for overhead power lines

Sequence Number: 49239618

Date of Issue: 19/11/2015



westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

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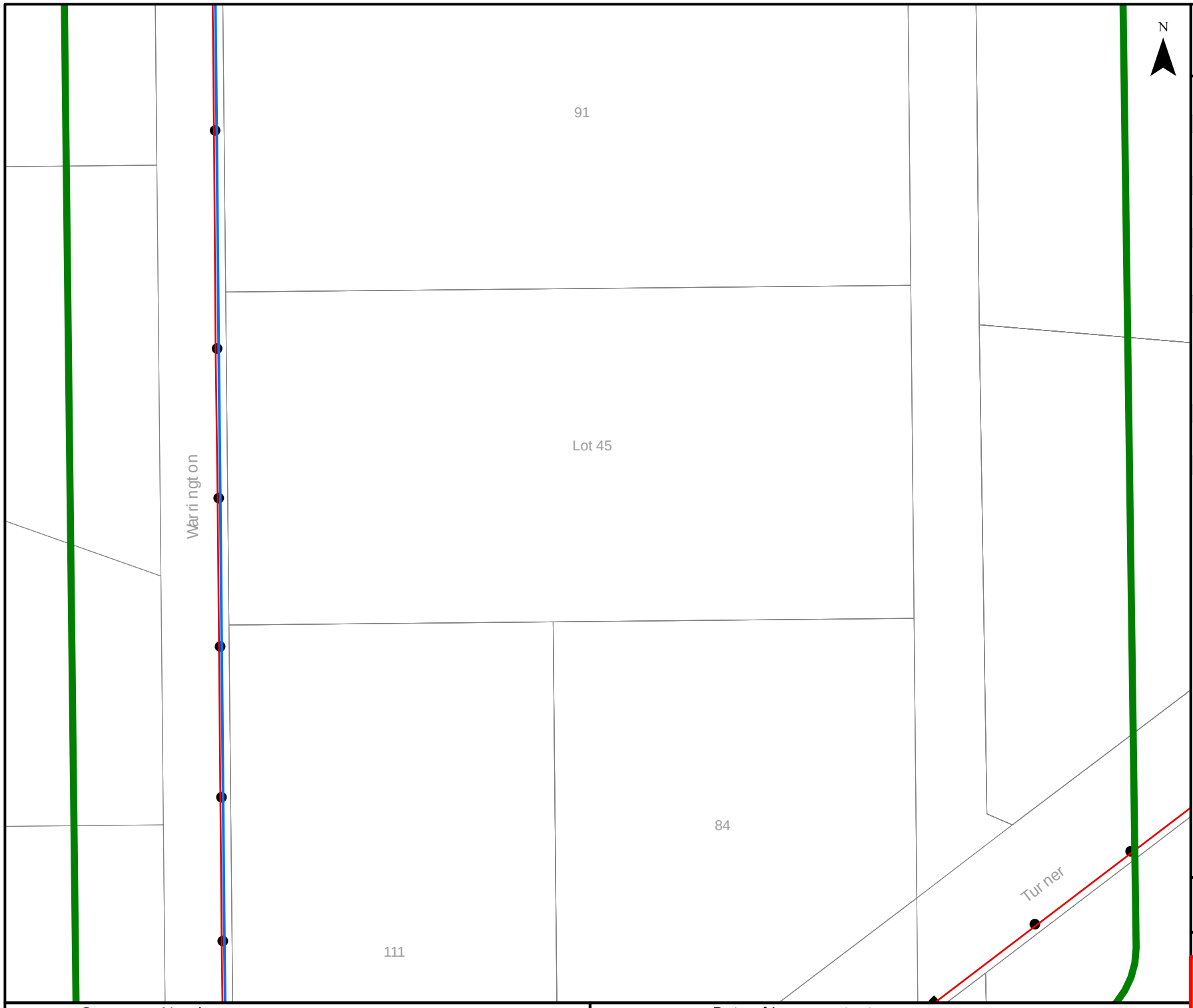
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A4	Scale : 1:1500

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Date of Issue: 19/11/2015



westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

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Proposed Construction Assets

- Design Area *
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- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

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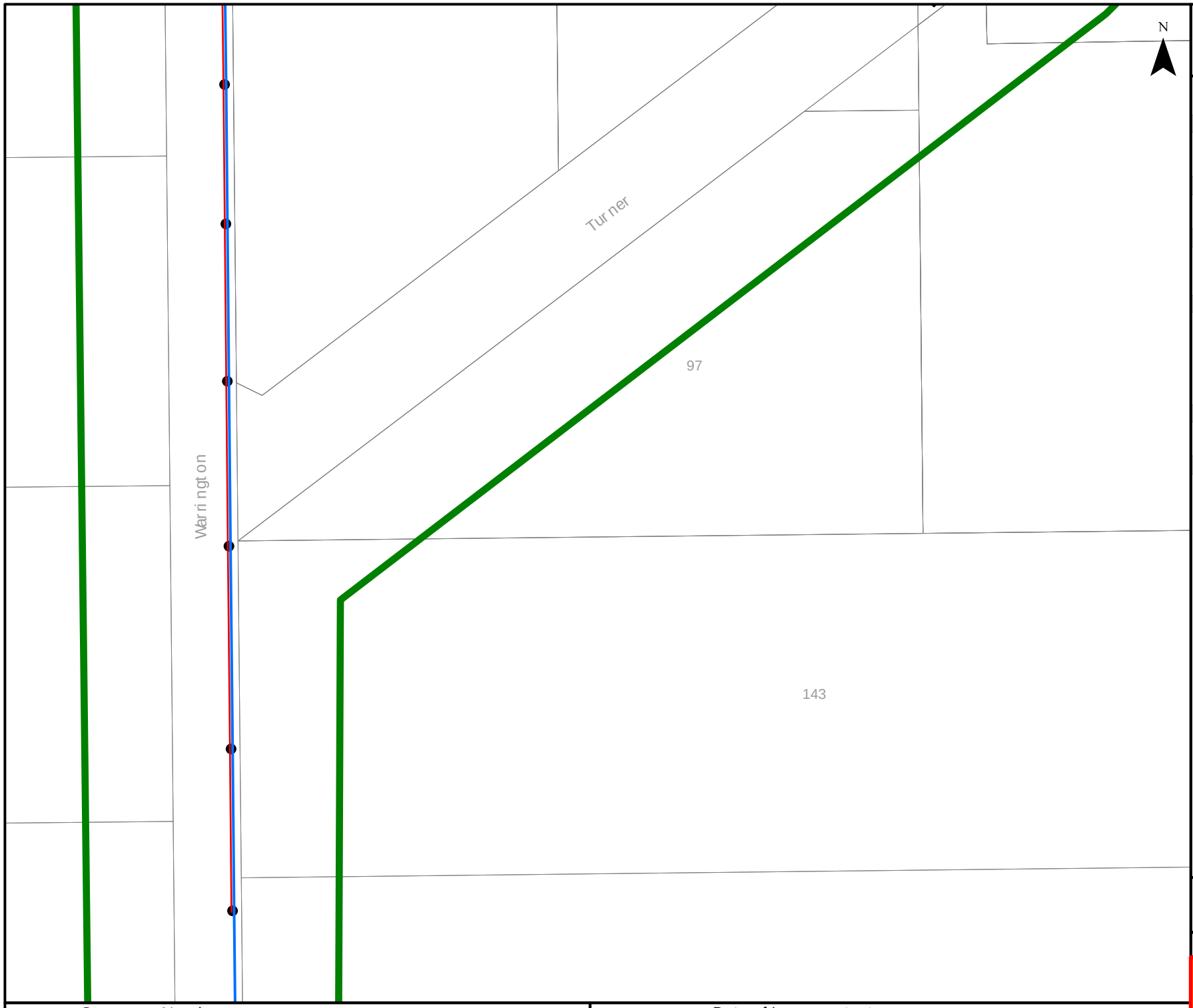
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westernpower

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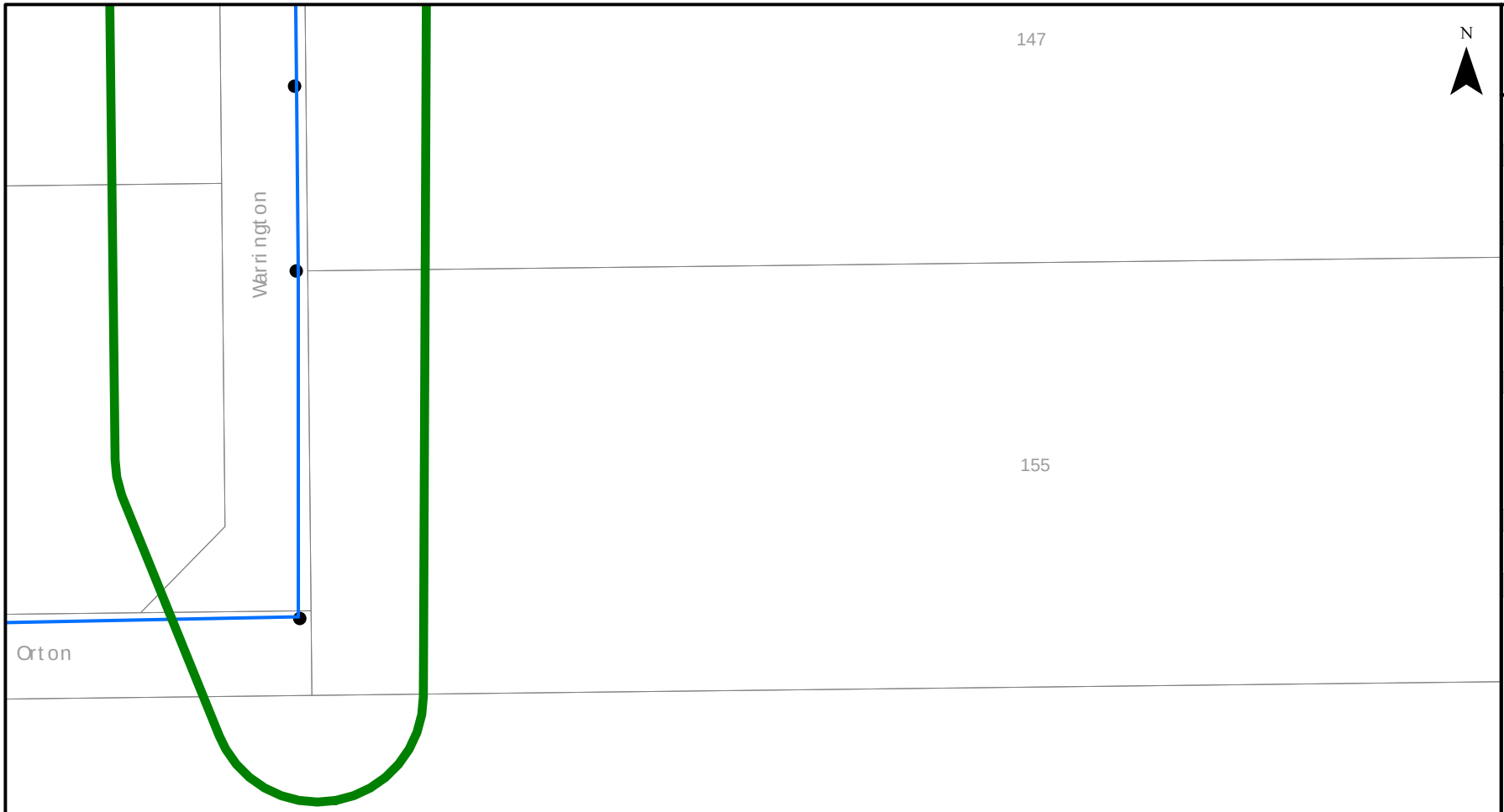
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westernpower

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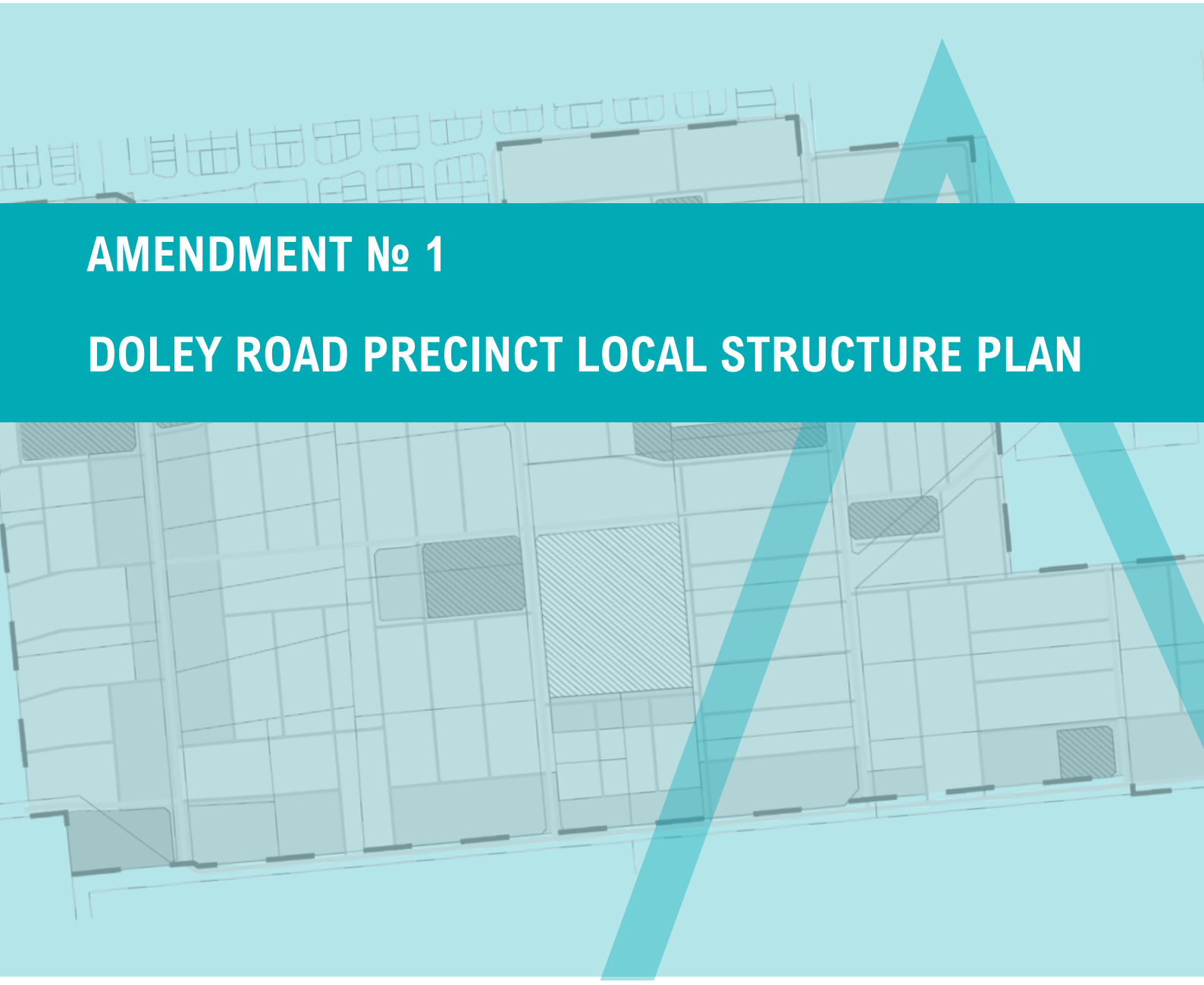
Sequence Number: 49239618	Date of Issue: 19/11/2015

APPENDIX 8

Amendment 1 documentation

AMENDMENT № 1

DOLEY ROAD PRECINCT LOCAL STRUCTURE PLAN



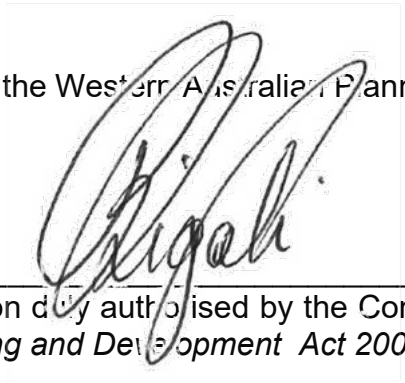
URBANISTA

TOWN PLANNING

IT IS CERTIFIED THAT AMENDMENT NO. 1 TO THE DOLEY ROAD PRECINCT STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

15 MARCH 2022

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.

TABLE OF AMENDMENTS

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

Amendment Number	Summary of the Amendment	Amendment type (minor / major)	Date approved by Western Australian Planning Commission
—	Original Structure Plan as approved by the WAPC	—	17 July 2017
1	Minor changes to LSP in area bound by Lawrence Way, Warrington Road, Allanson Drive, and Orton Road.	Minor	14 March 2022

TABLE OF DENSITY PLANS

Each time a density plan is approved, the plan is to be recorded in the table of density plans at the front of the structure plan.

Density Plan No.	Location of density plan	Total area of density plan application	Date endorsed by Western Australian Planning Commission

LEGEND

ZONES

- Residential R25-R40
- Residential R40-R60
- Residential R60
- Mixed Use R80

LOCAL RESERVES

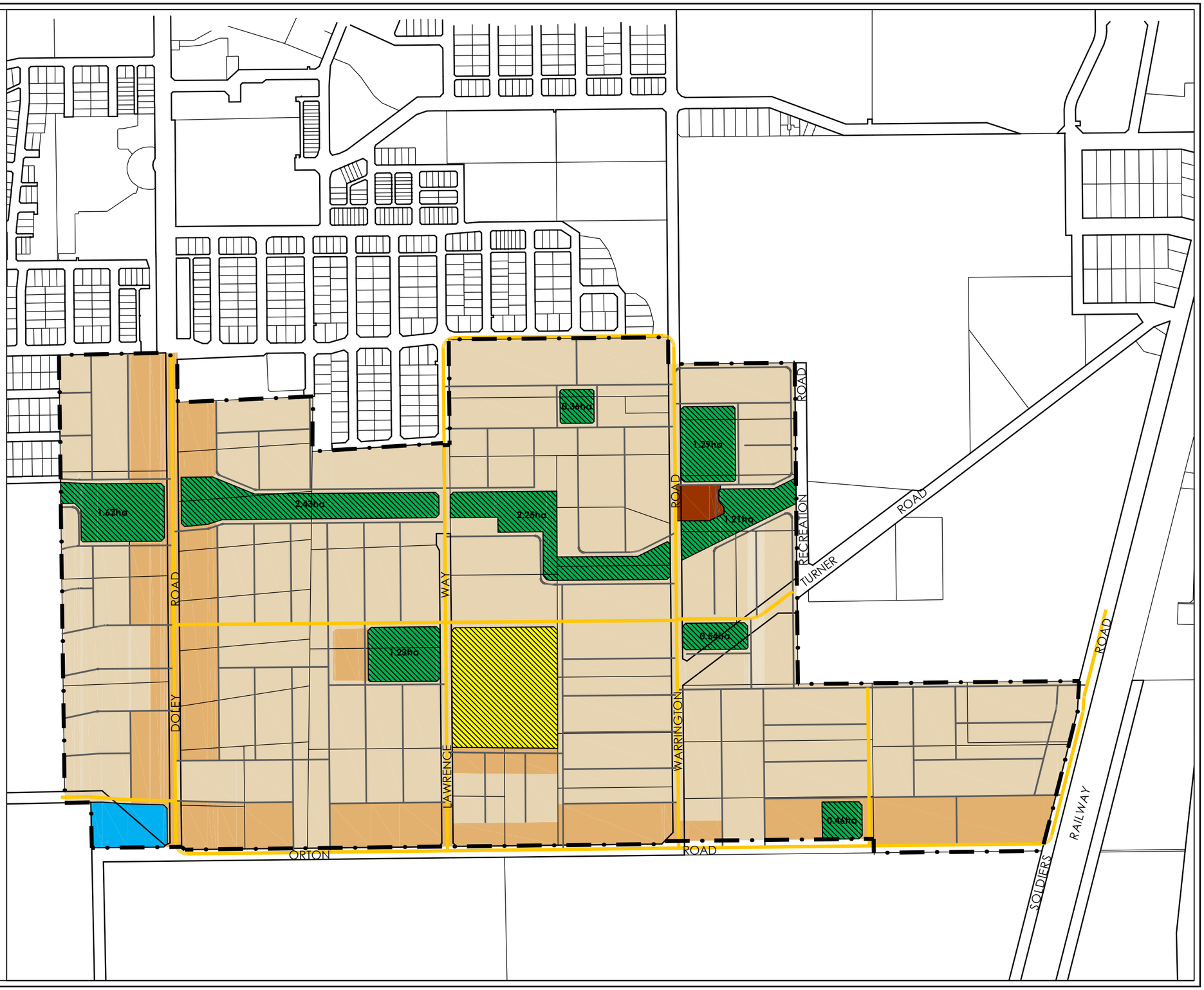
- Public Open Space
- Public and Community Purposes

OTHER

- Structure Plan Boundary
- Neighbourhood Connector
- Access Street

NOTES

1. Public Open Space areas are indicative only and subject to further detail design and drainage considerations.
2. All access streets are indicative only and are subject to refinement as part of the detailed subdivision process.
3. Orton Road, a future Other Regional Road, is to be widened from 20 metres to 32 metres (6 metres to be ceded by landholdings north and south of the road).
4. Soldiers Road, a future Other Regional Road, is to be widened from 20 metres to 30 metres (10 metres to be ceded by landholdings abutting Soldiers Road).
5. Land is required to accommodate a roundabout at the intersection of Orton and Soldiers Road. The land to be ceded and the design of the roundabout is to be to the satisfaction of the Shire on advice from the Department of Planning.
6. Direct access to Soldiers Road is not permitted and an internal road will be required between residential lots and Soldiers Road to provide appropriate access and frontage. Double storey, rear-loaded and dual frontage lots are not permitted in this location due to interface and noise attenuation objectives.



LOCAL STRUCTURE PLAN MAP

0 50 100 150 200 250 300 350 400 500m

SCALE 1:7000 @ A3

DOLEY ROAD PRECINCT
AMENDMENT No. 1

@urbanistaplanning
Tel: (08) 6444 9171
admin@urbanistaplanning.com.au
www.urbanistaplanning.com.au
Level 1, 231 Bulwer St,
Perth, WA 6000 Australia
Urbanista Town Planning
ABN: 47 6209 657 098
MGA94
& AHD

URBANISTA
TOWN PLANNING

EXECUTIVE SUMMARY

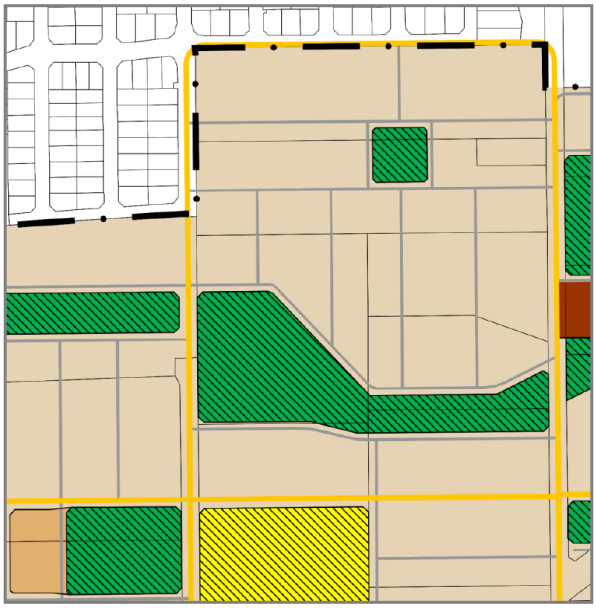
The *Doley Road Precinct Local Structure Plan* was prepared to guide the built form outcome of the Local Structure Plan (LSP) area in the western part of the Byford townsite as it transitions from rural small holdings to medium and higher density residential housing. The LSP area covers a total area of approximately 120.5 hectares, originally comprising 47 freehold lots located along and to the north of Orton Road, Byford, within the Shire of Serpentine-Jarrahdale.

The Doley Road Precinct Local Structure Plan—prepared by CLE Town Planning + Design—was endorsed by the Western Australian Planning Commission (WAPC) on 17 July 2017 for a standard period of ten years. The purpose of a LSP is to guide the subdivision and subsequent development of land.

This "minor" LSP amendment (Amendment No. 1) for the Doley Road Precinct Local Structure Plan has been prepared to reconfigure indicative development outcome of residential and Public Open Space (POS) land at and around 55 Lawrence Way (Lot 61 on D61334). The LSP amendment is considered to be "minor" as, it is consistent with the objectives and purpose of the original endorsed LSP, and in accordance with WAPC's 2015 *Structure Plan Framework*, the LSP amendment:

> …does not *materially alter the purpose and intent of the structure plan, …change the intended lot / dwelling yield by more than 10 per cent or adversely impact upon the amenity of adjoining landowners and occupiers, restrict the use and development of adjoining land, or significantly impact on infrastructure provision or impact upon the environment.*

The changes are summarised in Table 1, which show a change in POS (of with further discussion provided within this report. A comparison between the former Doley Road Precinct LSP map and the Amendment No. 1 map is shown in the image below and Appendix 1.



Current Doley Road Precinct LSP Map Extract
(as at 1 February 2020)



Doley Road Precinct LSP Amendment No. 1
(map extract showing area subject to amendment)

This amendment takes into account the statutory and strategic planning framework applicable to the subject site, and is supported by a comprehensive assessment and review of the development principles and assessments as they relate to environmental, engineering and servicing, transport impact and bushfire risk management issues.

Table 1—Land Use Summary

Item	Description	LSP Reference
Total area covered by the LSP	120.5ha	Part 2 — 1.2
• Residential • Commercial • Road Reserves • Parks and Recreation • Public Purpose	68.2 hectares 1.0 hectare 35.7 hectares 11.2 hectares 4.0 hectares	Part 2 — 3.1
Calculated using street type designations in Figure 19, Liveable Neighbourhoods, and other sources.		
Total estimated lots yield	1,900–2,200 lots	Part 2 — 3.3.1
Estimated number of dwellings	1,900–2,200 dwellings	
Dwellings (as per Perth & Peel@3.5 million) Dwellings (as per Liveable Neighbourhoods)	16.4 dwellings / gross hectare 28.2 dwellings / site hectare	
Estimated Population	~5,390 people (+40) @ 2.8 people / household	
Number of Primary Schools	1 (4.0 ha)	Part 2 — 3.8
Number of High Schools	0	—
Estimated commercial floorspace	1,500sqm	Part 2 — 3.7
Public Open Space	11.241ha (total POS) 11.014ha (unrestricted POS) 0.227 (restricted POS)	Table 2, Part 2 — 3.3.

Table 2—Land Use Schedule

Gross Site Area	**120.5ha**
Less	
• Primary School Site	4.0ha
• Commercial Centre	1.04ha
• Orton Road widening	0.43ha
Sub-Total	5.47ha
Nett Site Area	**115.03ha**
Deductions (Small Stormwater Events area (first 15mm of rainfall)) *SEE NOTE 1*	
• POS 1	0.056ha
• POS 2	0.138ha
• POS 5	0.153ha
• POS 7	0.047ha
Sub-Total	0.394ha
Gross Subdivisible Area	**114.64ha**
Public Open Space Contribution (derived from the 2017 LSP)	
• *At least 10% Public Open Space*	*11.465ha*
Comprising of: • *at least 80% unrestricted POS* • *up to 20% restricted POS*	 *9.172ha* *2.293ha*
Total Public Open Space Proposed	**11.241ha (9.81%)**
Unrestricted POS	
• POS 1 (Gross Area 1.62ha)	1.533ha
• POS 2 (Gross Area 2.43ha)	2.213ha
• POS 3 (Gross Area 1.23ha)	1.230ha
• POS 4 (Gross Area 0.36ha)	0.360ha
• POS 5 (Gross Area 2.34ha) (Subject of Amendment No. 1)	2.251ha
• POS 6 (Gross Area 1.29ha)	1.290ha
• POS 7 (Gross Area 1.21ha)	1.137ha
• POS 8 (Gross Area 0.54ha)	0.540ha
• POS 9 (Gross Area 0.46ha)	0.460ha
Sub-Total	**11.014ha**
Restricted POS (1:5 ARI Rainfall Events area (excluding Small Stormwater Events area)) *SEE NOTE 2*	
• POS 1	0.032ha
• POS 2	0.079ha
• POS 5	0.089ha
• POS 7	0.027ha
Sub-Total	**0.227ha**

Notes

1) Areas subject to inundation from the Small Stormwater Event (first 15mm of rainfall) are not included as restricted or unrestricted open space and are a deduction from the nett site area.

2) Areas for the detention of stormwater for a small stormwater event up to the 1:5 ARI are treated as restricted open space up to 20%.

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Part

1 Implementation Section

1. STRUCTURE PLAN AREA

This Local Structure Plan (LSP) applies to the land identified in the approved Doley Road Local Structure Plan map in Byford, comprising of approximately 120.5ha of land.

Refer to Local Structure Plan Map.

2. OPERATION

This structure plan commences operation on the date it is approved by the Western Australian Planning Commission. The structure plan is valid for a period of ten years from such time, unless otherwise specified. The Doley Road Precinct LSP was originally approved on 17 July 2017.

3. STAGING

Development staging should follow an orderly sequence and should not exceed the extension of essential service infrastructure or constructed road access. Basic essential infrastructure including roads and utilities are to be provided prior to the release of land for residential or other development. An indicative staging plan is provided in Figure 22.

4. SUBDIVISION & DEVELOPMENT REQUIREMENTS

4.1 LAND USE ZONING

The land use zoning of LSP area is shown on the Local Structure Plan Map.

These land use zoning classifications have been prepared to guide the future subdivision and development of the land. Land Use permissibility (zoning table) is to be consistent with the Shire's current gazetted Local Planning Scheme. Land use permissibility within the Structure Plan area shall be in accordance with the corresponding zone or reserve under the Scheme, or as otherwise outlined in this Structure Plan. Further details of land use composition are provided in Table 1—Land Use Summary.

4.2 R-CODE DENSITY

The density coding within the structure plan area consists of residential codings that provide a mix of medium density development. The proposed density codings remain as per the original endorsed structure plan and are R25-40, R40-60, R60 and R80. The code ranges allow for a responsive and flexible approach to development to suit market demand and allow for the built form to reflect the character of the area as the LSP area is built out over the next ten years.

The Structure Plan Map defines the broad residential density ranges that apply to specific areas within the Structure Plan area. Lot specific residential densities, within the defined residential ranges, are to be subsequently assigned in accordance within a Residential Code Plan approved by the WAPC.

Residential Code Plan

A Residential Code Plan is to be submitted at the time of subdivision to the WAPC and shall be consistent with the Structure Plan, and the Residential Density Ranges and locational criteria contained in Clause 5.2.3.

The Residential Code Plan is to include a summary of the proposed dwelling yield of the subdivision. Approval of the Residential Code Plan shall be undertaken at the time of determination of the subdivision application by the WAPC. The approved Residential Density Code Plan shall then form part of the Structure Plan and shall be used for the determination of future development applications.

Variations to the Residential Code Plan will require further approval of the WAPC, with a revised Residential Code Plan submitted generally consistent with the approved plan of subdivision issued by the WAPC. The revised Residential Code Plan shall be consistent with Residential Density ranges identified on Structure Plan Map and the locational criteria explained below.

Residential Code Plans are not required if the WAPC considers that the subdivision is for one or more of the following:

i. The amalgamation of lots;
ii. Consolidation of land for "superlot" purposes to facilitate land assembly for future development;
iii. The purposes of facilitating the provision of access, services or infrastructure; or
iv. Land which by virtue of its zoning or reservation under the Structure Plan cannot be developed for residential purposes.

Locational Requirements

The allocation of residential densities shall be in accordance with the following locational criteria:

a) The R25 density code shall apply as the base code to all 'Residential' zoned lots, with the exception of those lots coded R40 or R60 as set out below.
b) The R40 density code may apply to all 'Residential' zoned lots where one or more of the following applies:
    i. The lot is located on a street corner or at the end of a street block; or
    ii. Considered to be in an area of high amenity including within 400m of a commercial centre / neighbourhood node, around public open space, primary school and adjacent to major public transport routes.
c) The R60 density code may apply to 'Residential' zoned lots that meet one or more of the criteria set out in (b) above or where the lot measures 900m² or greater

4.3 PUBLIC OPEN SPACE

Public open space is to generally be provided in accordance with Table 2 – Land Use Table and Plans 1 (Structure Plan Map).

As a condition of subdivision of Lot 61 Lawrence Way, Byford, the subdivider will be required to make payment to the Shire of Serpentine Jarrahdale for the sum equivalent to 700m^2, being that portion of the land that would otherwise be provided as open space prior to Amendment 1 of the SP.

4.4 ROAD TREATMENTS

The road reserves should include the installation of street trees and landscaping, parallel street parking bays, dual-use paths, shared-paths, stormwater retention and infiltration systems, and street lighting to the satisfaction of the Shire and their adopted policies and planning framework. The width of and number of crossovers shall be kept to a functional minimum in accordance with the R-Codes and the Shire's adopted Local Planning Policies, to minimise the extent of hard surface, and reduce vehicle conflict.

Further information is provided below, and within the figures and technical appendices which guide, inform, and accompany this report—including the consultant traffic engineer's report.

a. Orton Road, a future Other Regional Road, is to be widened from 20 metres to 32 metres (6 metres to be ceded by landholdings north and south of the road).

b. Soldiers Road, a future Other Regional Road, is to be widened from 20 metres to 30 metres (10 metres to be ceded by landholdings abutting Soldiers Road).

c. Land is required to accommodate a roundabout at the intersection of Orton and Soldiers Road. The land to be ceded and the design of the roundabout is to be to the satisfaction of the Shire on advice from the Department of Planning.

d. Direct access to Soldiers Road is not permitted and an internal road will be required between residential lots and Soldiers Road to provide appropriate access and frontage. Double storey, rear-loaded and dual frontage lots are not permitted in this location due to interface and noise attenuation objectives.

e. Notwithstanding the Shire's endorsed LSP Map, intersections to Orton Road shall be:

    i. restricted and rationalised where possible in accordance Development Control Policy 1.4 and Liveable Neighbourhoods,

    ii. reduced from six to three intersections between Warrington and Soldiers Roads, and

    iii. left-in-left-out only at the intersection with Road 82 unless a roundabout is coordinated with the LSP area south of Orton Road (whichever is preferred by the Shire).

f. Direct lot access is not permitted to lots abutting Orton Road and Doley Road and rear laneway arrangements shall be provided.

g. The construction of Recreation Road is not supported due to BF 321 and TECs. Closure of Recreation Road is recommended and its management and restoration is expected to be outlined and ensured within the Draft Brickwood Reserve Management Plan (authored by the Shire of Serpentine-Jarrahdale) currently being assessed by the Department of Planning.

h. Road paving is not permitted to straddle lot boundaries unless a subdivision application is received that is signed by all landowners.

i. The lots fronting the proposed road which straddles Lot 50 (No. 124) Warrington Road and Lot 20 (No. 142 Warrington Road) will not be supported for creation (via subdivision) until such time as the entire road is created/constructed".

j. The land subject of the "Mixed Use" classification shall not be created or developed until such time as the Orton Road realignment is finalised.

4.5 NOISE ATTENUATION

Noise attenuation treatments as per the recommendations outlined in the Lloyd George Acoustics Storer Acoustic Assessment dated 17 June 2016 including notifications on title, and quiet house design within Local Development Plans, but excluding the construction of a noise wall, shall be implemented as conditions of subdivision approval for any lots adjacent to Soldiers Road unless an updated and more accurate Acoustic Assessment is provided with, and approved for, any future subdivision application for the lots in closest proximity of the railway.

4.6 DEVELOPMENT STANDARDS

Development of land within the subject site is to be consistent with TPS No. 2.

4.7 NOTIFICATIONS ON TITLES

Where an application proposes to create lots with include land with a bushfire attack level of 12.5 or above, the following notification on the certificate(s) of title of the proposed lot(s) may be required:

This land is within a bushfire prone area as designated by an order made by the Fire and Emergency Services Commissioner and is/may be subject to a bushfire management plan. Additional planning and building requirements may apply to development on this land.

Other standard conditions may be incorporated on the certificates(s) of title as appropriate.

5. LOCAL DEVELOPMENT PLANS

The preparation of a Local Development Plan in accordance with clause 5.18.5 of the TPS No. 2 may be required by the Western Australian Planning Commission (WAPC), on the advice of the Shire of Serpentine-Jarrahdale, as a condition of subdivision approval where deemed necessary to address specific site considerations for development where proposed lots or parcels:

- Abutting POS reservations; or
- Are subject to the development performance standards of State Planning Policy 3.7 Planning in Bushfire Prone Areas, and have a demonstratable bush fire risk; or
- At the discretion of the developer there are additional development considerations or site constraints that need to be addressed through a LDP to enable coordinated development of the site.

Notwithstanding, the WAPC or local government may require the preparation of a LDP in accordance with Part 6, Schedule 2 (Regulation 47) of the *Planning and Development (Local Planning Schemes) Regulations 2015* (W.A.).

The LDP shall demonstrate an additional level of detail to specify how development will achieve the objectives and development standards outlined in the previous section and other planning framework considerations. A LDP shall not vary the proposed land use permissibility or residential density, as detailed in the structure plan.

Local Development Plan Information Required

A LDP should draw on this Local Structure Plan to guide its preparation and shall consider other LDPs prepared and approved prior within this LSP area.

LDPs shall demonstrate a coordinated approach to development, and where possible a single LDP should encompass multiple contiguous development sites or lots, as opposed to individual sites and lots.

6. OTHER REQUIREMENTS

6.1 CONDITIONS OF SUBDIVISIONAL APPROVAL

The following technical reports / strategies are to be prepared and submitted as a condition of subdivision approval (where applicable):

- Urban Water Management Plan;
- Bushfire Management Plan (BAL Assessment); and
- Acid Sulphate Soils Management Plan.

6.2 BUSHFIRE MANAGEMENT

This Local Structure Plan is supported by a Bushfire Management Plan (Appendices 3 and 6.2). Regardless of whether the land has been formally designated as bushfire prone, any building to be erected on land identified as falling within 100 metres of a bushfire hazard is designated as bushfire prone land and shall comply with the requirements of Australian Standard 3959 under the Building Code of Australia. Stage / subdivision applications will need to provide bushfire assessment documentation and relevant (self-contained) treatments at each subsequent level of planning in accordance with State Planning Policy 3.7—Planning in Bushfire Prone Areas.

6.3 DEVELOPMENT CONTRIBUTIONS

The Local Structure Plan is subject to the Byford Development Contribution Scheme pursuant to the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2.

Part

2 Explanatory Section

1. PLANNING BACKGROUND

1.1 INTRODUCTION AND PURPOSE

Part Two of this Local Structure Plan comprises an explanatory report that outlines site details, the applicable planning framework, site conditions and constraints and the design rationale for the structure plan. Part Two should be read in conjunction with the Local Structure Plan Map and any figures and appendices as they relate.

The purpose of the LSP is to guide the subdivision and subsequent development of the LSP area in the western part of Byford's townsite. This LSP has been prepared in accordance with the requirements for Development Areas under Part 5.4 of the Shire's Town Planning Scheme No. 2 (TPS No. 2) the "deemed provisions" of the *Planning and Development (Local Planning Schemes) Regulations 2015* (W.A.).

The Doley Road Precinct Local Structure Plan was endorsed by the Western Australian Planning Commission on 17 July 2017. In the time since, portions of the LSP area have been developed, generally west and south of the subject site. Based on the information presented in the LSP, the estimated post-development dwelling yield was for 1,875–1,975 dwellings, which has increased to 1,890–1,990 dwellings in Amendment No. 1 over the 120.5ha structure plan are (refer to Table 1—Land Use Summary). The LSP is lodged in accordance with Clause 5.18.1 of TPS2 where a structure plan is required prior to subdivision or development within a Development Zone.

1.2 LAND DESCRIPTION

The following section provides a brief summary of the location, land use and ownership within the LSP area.

1.2.1 Location

The LSP area is in the Shire of Serpentine-Jarrahdale, approximately 30km south-east of the Perth CBD, 9km south-west of the Armadale Town Centre and 2km south-west of the Byford Town Centre along Orton Road, Byford (Figure 10: Location Plan).

The LSP area is generally bound by:

- Orton Road to the south;
- Brickwood Reserve (Bush Forever Site No. 351) and Soldiers Road to the east; and
- 'The Glades' residential estate to the north, south and west.

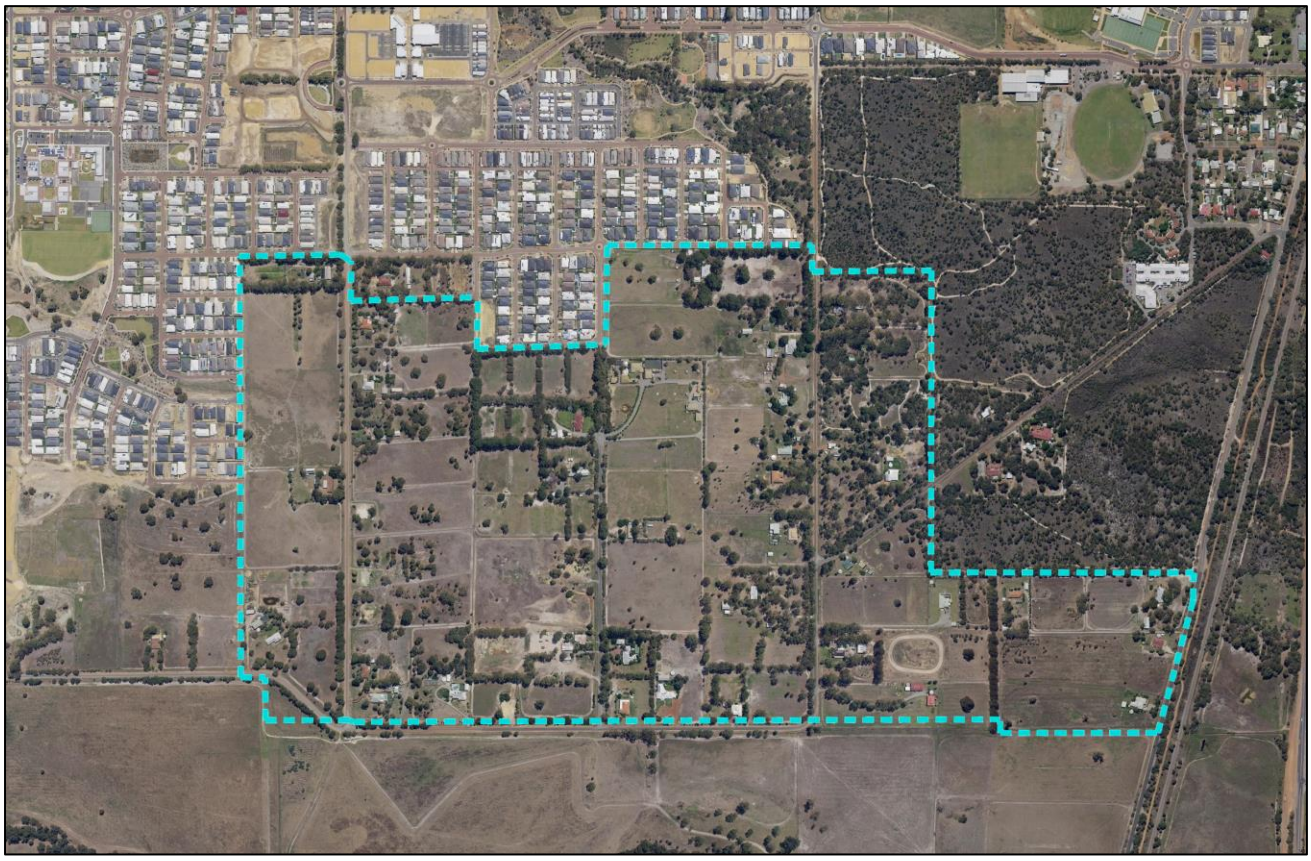


Figure 1 March 2017 aerial of the Doley Road Precinct LSP area.

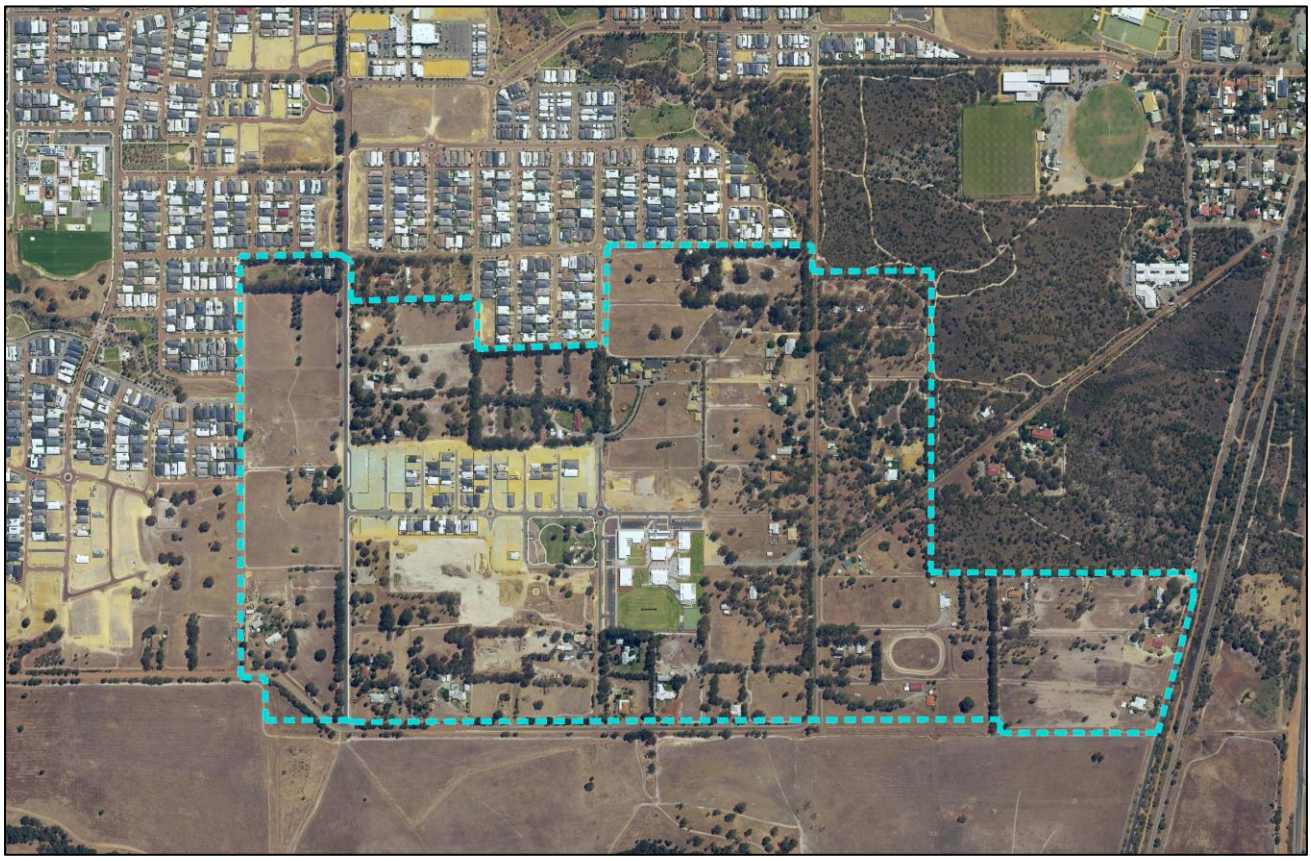


Figure 2 March 2020 Comparison aerial of the Doley Road Precinct LSP area.

1.2.2 Area and Land Use

The LSP comprises a total land area of 120.5ha. The lots have generally been cleared over the years for agricultural use with only small pockets of vegetation remaining.

In recent years many of the original holdings have been subdivided into single, albeit large rural-lifestyle lots with a number of dwellings constructed on these lots during the 1970's. These lots are still used for peri-agricultural activities.

Figure 1 and 2 on the previous page demonstrate the increased development of the LSP area since 2017 when it was first approved. This new development includes Beenyup Primary School and a large number of houses.

1.2.3 Ownership and Title Details

The LSP area is comprised of 47 freehold lots.

The LSP has been prepared over all of the aforementioned properties at the request of the Shire of Serpentine-Jarrahdale, to ensure integrated planning over the entire site.

1.2.4 Surrounding Land Use and Context

The LSP is located within the Byford Urban Growth Cell which is rapidly developing residential front that surrounds the Byford town centre. The LSP will bring this significant growth cell to a logical conclusion.

The following is a summary of the local context:

- Brickwood Reserve abuts the site to the east;
- 'The Glades' residential estate adjoins the LSP area along the northern and western boundaries.
- Land on the southern side of Orton Road consists of cleared rural land. This land is approved for residential development as part of 'The Glades' estate.
- The Byford town centre is located 2km north-east of the LSP, on the South Western Highway.
- The Metropolitan Redevelopment Authority's Forrestdale West Business Park Estate is located 10km to the north. It is a significant 190ha business and service commercial estate, which will support future population growth in the corridor.

1.3 PLANNING FRAMEWORK

1.3.1 Metropolitan Region Scheme

The Metropolitan Region Scheme is a broad regional planning document which sets out the zoning and use of land in the Perth metropolitan area.

The SP area is zoned 'Urban' under the Metropolitan Region Scheme and the Blackwood Reserve abutting the SP area is reserved for 'Parks and Recreation.

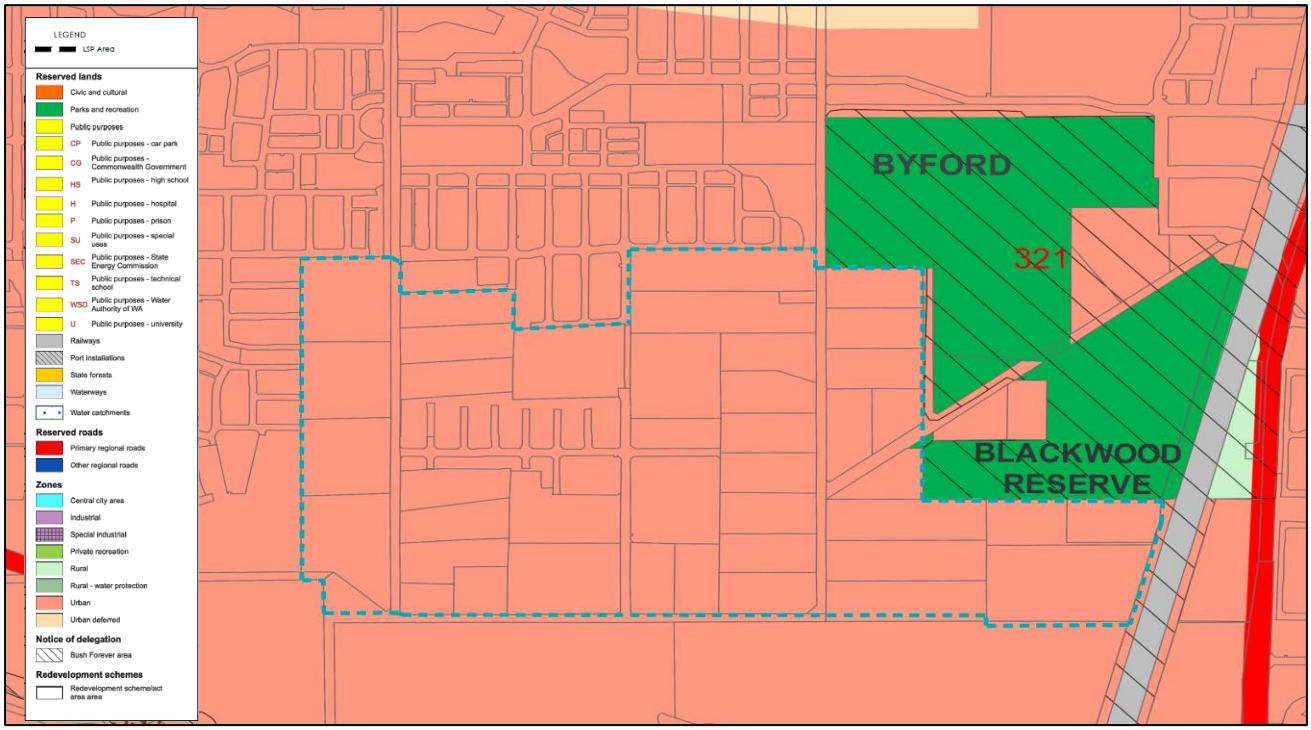


Figure 3: Metropolitan Region Scheme Map Sheet 28. Source: WAPC 2020.

1.3.2 Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2

The structure plan area is zoned "Urban Development" under the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2.

The objectives and purpose of the Urban Development zoned land are as follows:

The purpose of the Urban Development zone is to provide for the orderly planning of large areas of land in a locally integrated manner and within a regional context, whilst retaining flexibility to review planning with changing circumstances. The zone will allow for the following:

a) development of functional communities consistent with orderly and proper planning and the establishment and maintenance of an appropriate level of amenity;

b) variety in the range of lot sizes and dwelling types within communities, consistent with a cohesive and attractively built environment;

c) provision of retail, commercial, industrial and mixed use facilities to service the needs of residents within the communities, and integration of these facilities with social and recreational services, so as to maximise convenience;

d) provision of retail, commercial, business park and industrial facilities to provide local employment opportunities;

e) provision of open space and recreation networks, appropriate community services, school sites and other recreational facilities;

f) establishment of multiple use corridors for drainage, nutrient control and recreational purposes, in association with the development of communities based on the principles of water sensitive urban design;

g) optimisation of convenience in respect of rail, road, cycleway and other transportation means, to and within the communities;

The above components will be facilitated by means of:

a) establishment of Structure Plans to ensure that development takes place in conformity with those Plans;

b) establishment of a mechanism to coordinate the provision of infrastructure for subdivision and development to and within the communities;

c) establishment of an equitable method for the distribution, between owners within area, of the costs of nominated infrastructure components required for subdivision and development of the areas into communities; and

d) provision of administrative procedures to ensure the expedient and successful execution of the above matters.

It is considered that the proposed local structure plan amendment, and potential development as a result, is wholly consistent with the objectives of "Urban Development" zoned land, as elaborated on and detailed in the Planning Assessment and Justification section of this report. The proposed local structure plan is consistent with the existing approved structure plan insofar as its achievement and satisfaction of its objectives and site context.

The structure plan area is also located within Development Area 3, which is known as the Byford Development Area. The Byford Development Area covers an area of approximately 1370ha and is separated into 15 precincts as per Plan 9A of TPS2.

In addition, the structure plan area is also located within Development Contribution Area 1, which is known as the Byford Traditional Infrastructure Development Contribution Plan. This plan broadly requires a monetary contribution from landowners for:

- The upgrades and construction of existing and new roads.
- Improvements to the existing sporting facilities and playing fields within Byford as well as the provision for and development of new facilities.
- The development of land for local and neighbourhood parks, multiple-use corridors for recreation and drainage areas and land for purely for drainage.
- The compensation costs to acquire land for roads, public open space and drainage.

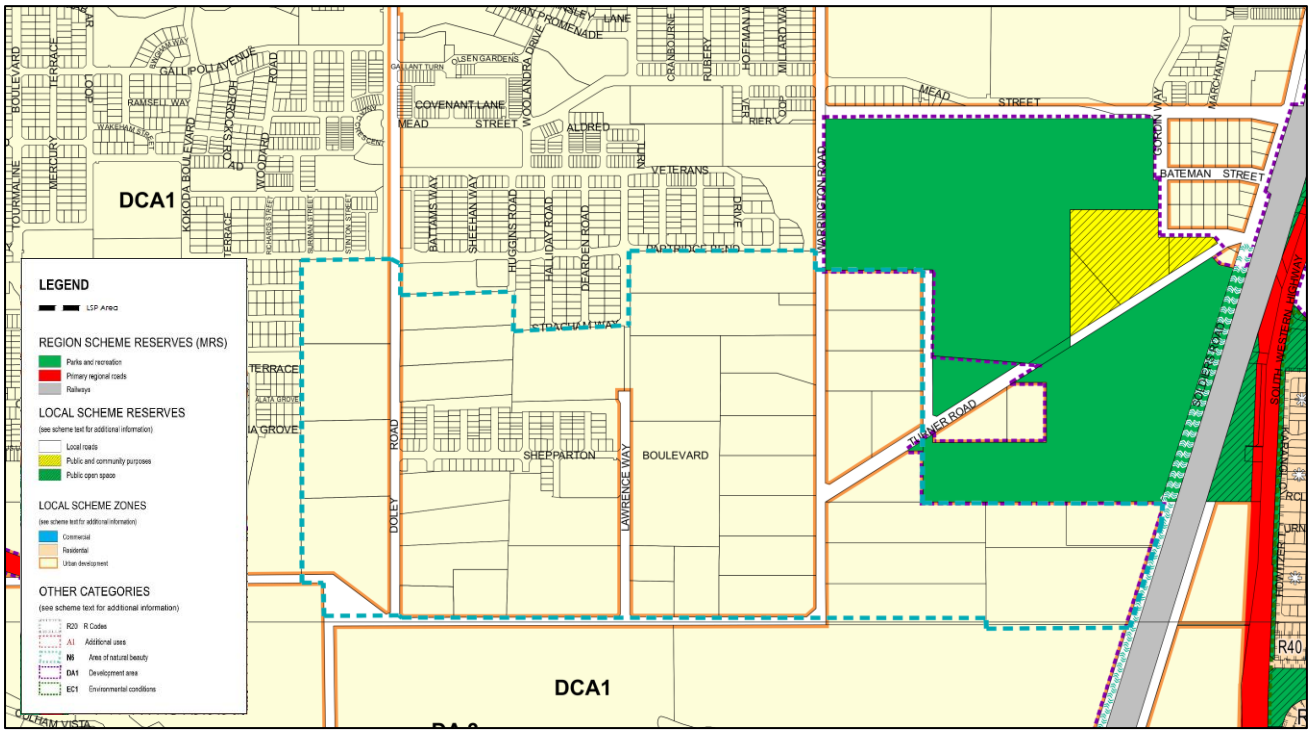


Figure 4: Shire of Serpentine-Jarrahdale TPS No. 2 Map 1 of 7. Source: WAPC 2020.

1.3.3 Byford District Structure Plan (2005)

The LSP is within the Byford Structure Plan. This is the district level structure plan for the area generally bound by Thomas Road to the north, Hopkinson Road and the future Tonkin Highway extension to the west, Cardup Siding Road to the south and the Byford town centre and the Darling Range foothills to the east.

The Byford Structure Plan establishes 12 precincts, and allows for the preparation of individual local structure plans over any one of these precincts, in lieu of one large local structure plan covering the entire Byford Structure Plan area. The LSP corresponds with Precinct 7 of the Byford Structure Plan (Figure 5: Byford Structure Plan).

The LSP is consistent with Byford Structure Plan in that it:

- Proposes predominately residential development;
- Creates a primary school site in the general location identified by the Byford Structure Plan;
- Locates a neighbourhood centre at the corner of Orton and Doley Roads;
- Provides road interface between Brickwood Reserve and residential development;
- Creates a multiple use corridor through the site from the Brickwood Reserve, to accommodate an existing waterway; and
- Provides for the widening of Orton Road to accommodate stormwater drainage.

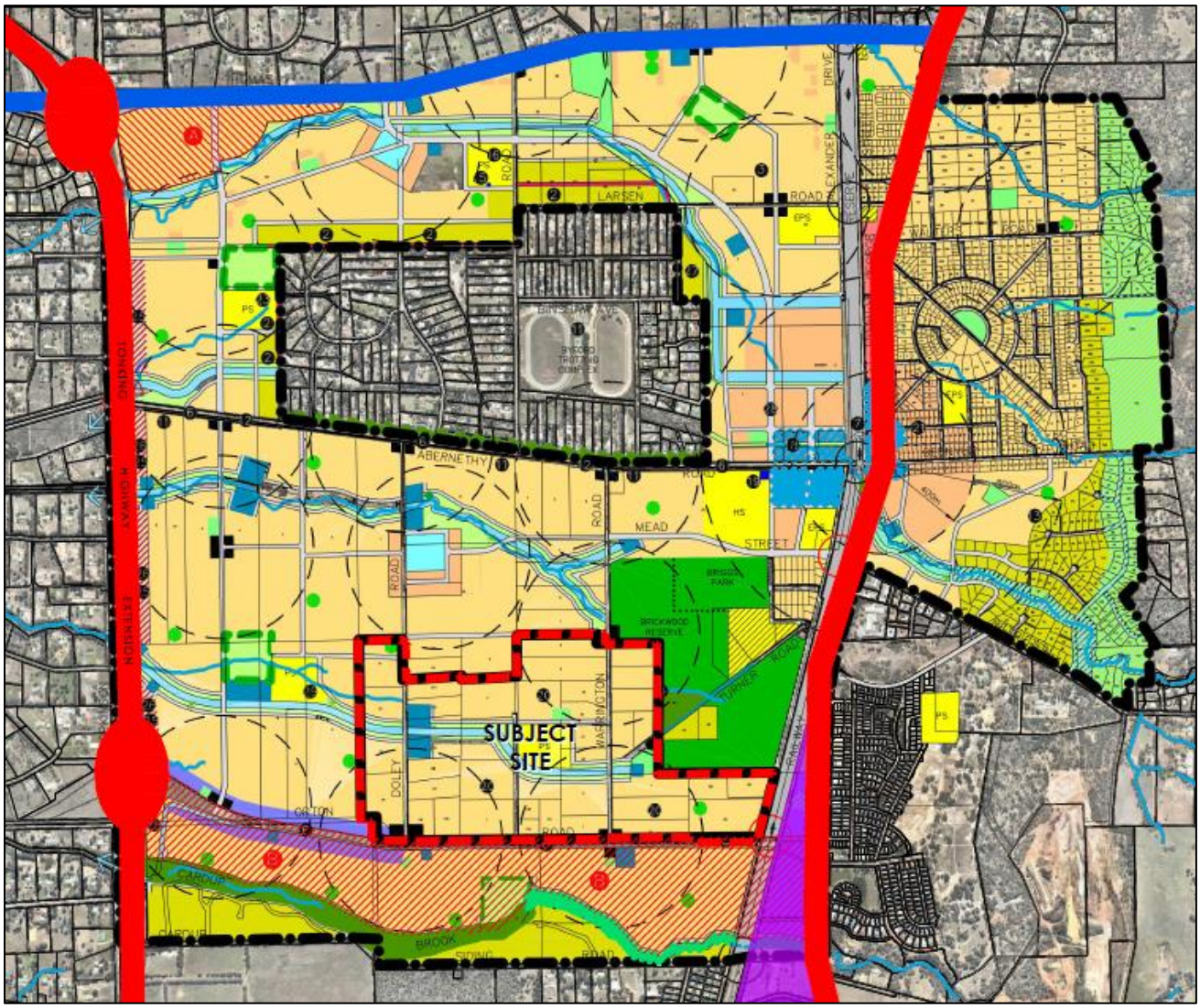


Figure 5: Byford District Structure Plan

1.3.4 Strategic Planning Framework

Perth and Peel@3.5million

Perth and Peel@3.5million is the overarching strategic planning framework for the Perth and Peel metropolitan regions. Perth and Peel@3.5million proposes five strategic themes for a liveable, prosperous, connected, sustainable and collaborative Shire. The framework aspires to a Shire that provides '…a network of connected activity centres which deliver employment, entertainment and high-density lifestyle choices'. The site is located within the South Metropolitan Peel Sub-Region. The framework further identifies that additional an additional 14,680 dwellings will be required to be accommodated in the Shire of Serpentine-Jarrahdale (urban infill) over the 35 years to 2050.

The structure plan responds to the objectives and intent of Perth and Peel@3.5million by achieving the following:

1. The site recognises the priority of public transport over the use of private vehicles, and will take advantage of future public transport options, as urban densification occurs;
2. The site provides for appropriate and responsive urban consolidation;

3. The site provides for higher-density residential development;
4. The site provides a minimal impact of the existing fabric of the surrounding local area; and
5. The site contributes to an increase in density and diversity of beneficial land-uses by allowing for a variety of complementary uses in the Local Centre zone.

Based on this information, and given the above, the structure plan is considered to achieve the intent and objectives of Perth and Peel@3.5million.

1.3.5 Other Planning Considerations

Liveable Neighbourhoods

Liveable Neighbourhoods is an operational policy, adopted by the WAPC, for the design and assessment of new structure plans and subdivisions. The elements of Liveable Neighbourhoods primarily relate to larger-scale structure plans and subdivisions and accordingly a detailed assessment of this structure plan against these elements is not considered necessary in this instance due to its small scale and simple nature. There are two versions of Liveable Neighbourhoods—the 2009 approved version and 2015 draft version.

Nethertheless, it is acknowledged that the general intent and objectives of Liveable Neighbourhoods are relevant in terms of addressing such elements as connectivity and walkability, provision of public parkland, urban water management and utilities. A detailed description of the design rationale for the LSP has accordingly been provided in Section 3 of this LSP report as a result.

State Planning Policy 3.7 (SPP3.7) – Planning in Bush Fire Prone Areas

SPP 3.7 – Planning in Bushfire Prone Areas was gazetted in December 2015 and sets out a range of matters that need to be addressed through the planning process to provide an appropriate level of protection of life and property from bushfires. The LSP is accompanied by a Bushfire Management Plan which includes a Bushfire Hazard Assessment as per the Guidelines. The manner in which the LSP responds to bushfire risk is discussed in further detail in Section 3.4.

Shire of Serpentine-Jarrahdale Local Planning Policies

The following Shire of Serpentine-Jarrahdale Local Planning Policies (LPP) are applicable to the Doley Road Precinct Local Structure Plan area. Their relevance will depend on the proposed use/development of land within the Structure Plan Area and therefore should be considered in any future development or subdivision of the subject site:

- LPP 2.4 – Water Sensitive Urban Design Guidelines
- LPP 2.7 – Bio-Diversity Planning Policy
- LPP 2.8 – Public Open Space Policy
- LPP 4.7 – Placement of Fill in Non-Urban Areas
- LPP 4.13 – Revegetation Policy
- LPP 4.16 – Landscape and Vegetation Policy
- LPP 4.18 – Street Trees Policy

2. SITE CONDITIONS & CONSTRAINTS

2.1 TOPOGRAPHY & GEOLOGY

The topography and soils within the LSP area are suitable for urban development. The LSP area is relatively flat, grading from 43m Australian Height Datum (AHD) in the east to 37.5m AHD in the west. Regional geology mapping broadly describes the LSP area as "Guildford Formation". This is further classified as Sandy Clay, comprising white grey to brown, fine to coarse grained sand and clay of moderate plasticity gravel and silt layers. A preliminary earthworks strategy responding to the geology of the LSP area is discussed further in Section 3.9.

2.1.1 Acid Sulphate Soils

The Department of Environment and Regulation (DER) Acid Sulphate Soil (ASS) Risk Map shows the majority of the site as "low to moderate risk of ASS occurring within 3m of the natural soils surface". The LSP area is therefore suitable for urban development with an ASS investigation (if necessary) and management plans to be prepared in the usual manner, prior to any excavation as part of the subdivision, as set out in the WAPC's Planning Bulletin 64/2009—Acid Sulphate Soils.

2.1.2 Contamination

The LSP area is not located within any DER listed contaminated sites, with the past and present use of the site not generating a high risk of contamination.

2.2 BIODIVERSITY & NATURAL ASSETS

The subject site is primarily vacant with only open grassland and shrubbery existing on the site.

2.2.1 Flora and Vegetation

The land has been subject to long periods of clearing and agricultural activity and has little remaining ecological value. In accordance with the EPA (2003) "Guidance Statement No. 51 – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment", a Level 1 (desktop) Flora and Vegetation Survey was undertaken to identify flora species of conservation significance.

The survey found:

- Past clearing of the LSP area for agriculture has adversely affected the biodiversity rating and ecological value, making the site suitable for development.
- Vegetation onsite is degraded and does not contain any areas with an intact understorey.
- There are no declared rare flora or priority species found within the LSP area.

2.2.2 Fauna

A Level 1 Fauna Impact Assessment and Black Cockatoo site assessment was undertaken by 360 Environmental, identifying fauna values of the site. The Fauna Impact Assessment is included as part of the Environmental Report.

The Assessment found:

- No recorded species of conservation significance in the LSP area.

- No quality Black Cockatoo foraging habitat, with no evidence of roosting.
- Extensive clearing and the significant degradation of remnant vegetation has resulted in any potential habitat being of low value to native fauna.

The Fauna Impact Assessment concludes that development of the LSP area has the potential to increase the ecological value of the site through the provision and treatment of the multiple use corridor and public open space.

2.3 HYDROLOGY

The management of ground and surface water is comprehensively addressed in the Local Water Management Strategy (LWMS) prepared by Urbaqua that clearly demonstrate hydrology is not a constraint to development.

The LWMS was prepared in accordance with the "Byford Townsite Drainage and Water Management Plan" (GHD and Department of Water, 2008) which is the district water management strategy for the locality.

The existing hydrological conditions of the LSP are summarised below, while the key principles of the LWMS are discussed further in Section 3.6 of this report.

The structure plan amendment is supported by an addendum (2021) to the LWMS (2016) to demonstrate the suitability of the realigned multiple use corridor.

2.3.1 Surface Water

The Department of Parks and Wildlife Swan Coastal Plain geomorphic wetlands database classifies the LSP area as Multiple Use Wetland (Armadale Palusplain: seasonally waterlogged flat land), a low management category that has little ecological value, making it suitable for development.

Surface water from northern portion of the LSP area is conveyed to a minor watercourse that flows through the site in a westerly direction. The LSP has this watercourse being modified into a "living stream" embedded in a multiple use corridor, consistent with the "Byford Townsite Drainage and Water Management Plan".

Surface water from the southern portion of the LSP area flows to a drain located in the Orton Road reserve. The LSP provides a 5m road widening of Orton Road, allowing for Shire of Serpentine-Jarrahdale planned upgrades to this drain, accommodating surface water requirements.

There are no mapped Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 wetlands located within or in proximity to the LSP area.

2.3.2 Ground Water

Water modelling carried out by the Department of Water as part of the Lower Serpentine hydrological studies in 2010 found that groundwater levels are close to the natural surface throughout the LSP area. Groundwater monitoring carried out as part of the adjacent "The Glade" Structure Plan confirmed the findings of the Department of Water hydrological studies. Ground water levels can be managed through importing clean fill and the use of subsoil drainage.

2.4 BUSHFIRE MANAGEMENT

Linfire has prepared a Bushfire Management Plan (FMP) in accordance with WAPC's "Planning in Bushfire Prone Areas". The BMP includes a Bushfire Hazard Assessment that identifies bushfire hazards (post development) (Figures 8) in the amendment area. Figure 14 provides a complete BMP for the overall LSP area. A complete copy of the BMP is included in Appendices 3 and 6.2.

The BMP concludes that bushfire risk is not an impediment to development, subject to the implementation of building protection zones and the construction of dwellings within 100m of bushfire prone vegetation in accordance with AS3959 "Construction of buildings in bushfire prone areas".

The manner in which the LSP responds to bushfire hazards is discussed in further detail within Section 3.4 of this report.

2.5 HERITAGE

A desktop search of the Department of Aboriginal Affairs' Aboriginal Heritage Inquiry System has indicated that the subject site has no known European heritage or Indigenous Australian heritage significance.

3. LAND USE & SUBDIVISION REQUIREMENTS

3.1 PROPOSED LSP AMENDMENT

Local Structure Plan Amendment Proposal and Justification.

No change in density is proposed and the land which is zoned for residential purposes (subject to this amendment) will remain with a split density of R25 / 40.

The purpose of the proposed LSP amendment is to amend the configuration and location of the POS and the road layouts within No. 55 (Lot 61) Lawrence Way, Byford. The proposed amendment does not alter the POS locations or road network layout that adjoins Lot 61.

The original endorsed LSP illustrated the POS being located in the south-western corner of Lot 61, directly abutting Lawrence Way. Lawrence Way currently exists as a cul-de-sac road, which terminates alongside Lot 61. The endorsed LSP illustrated the POS extending beyond the cul-de-sac, effectively resulting in Lot 61 being landlocked, until such time adjoining lots developed.

The amendment proposes to include a residential area to the south and north of Lot 61 with the POS being situated through the centre of the site. This allows the Multiple Use Corridor (MUC) to connect to Lot 4 to the west and Lot 51/Lot 52 to the east, whilst providing a sizeable active open space area for the community.

3.2 LAND USE

A Development Concept Plan has been prepared for the site to demonstrate how development could occur based on the principles and requirements of the LSP (Figure 15: Development Concept Plan). It is important to note that this Development Concept Plan represents only one-way development could occur and that it will be refined at the time of subdivision.

The key principles of the Development Concept Plan are as follows:

- Enable the creation of a diverse range of high-quality housing choices that appeal to a wide market segment.
- Provide an urban form that responds to the local context.
- Recognise the natural amenity and value of the area through interfacing with the adjacent Brickwood Reserve.
- Provide for the existing watercourse that flows through the site, originating from Brickwood Reserve.
- Create accessible and integrated multi-functional public open spaces that offer a range of active and passive recreational opportunities.
- Extend all necessary services and infrastructure in a timely and efficient manner.
- Establish a legible and permeable road network.
- Provide the primary school site planned for in the Byford Structure Plan.

Building on these broader key principles, the LSP provides for the following:

- Approximately 1,850–1,950 lots across the LSP area, with residential densities of R25, R40 and R60. The R40 and R60 densities are focused around key access roads, primary school, neighbourhood centre and areas of high local amenity. R60 will also be allocated to grouped or multiple dwelling development sites.
- Approximately 11.2ha of open space distributed throughout the LSP area, meeting active and passive recreational needs.
- Rehabilitation of the existing waterway that originates from the Brickwood Reserve, to accommodate local and district storm water drainage.
- Construction of a permeable movement network that connects into existing regional and local road networks and provides for pedestrian and cycling infrastructure, and future public transport services.
- Appropriate separation between Brickwood Reserve and all future dwellings to minimise potential risk from bushfire.
- Creation of 4ha primary school site collocated with an area of active open space.
- Provision a Neighbourhood Centre at the intersection of Orton and Doley Roads, providing residents with convenient access to retail.

A Land Use Schedule has been included as Table 2, and should be read in conjunction with the Landscape Masterplan for the amendment area (Figure 5) and the overall LSP area (Figure 16). This is accompanied by the Public Open Space Schedule (Table 2).

3.3 RESIDENTIAL

The LSP provides for the delivery of a range of lot types, housing products and lifestyle options in a manner that satisfies state density targets. The delivery of quality housing and streetscapes is one of the primary objectives of the LSP.

3.3.1 Dwellings Yields and Density Targets

The LSP has the potential to create approximately 1,850–1,950 residential lots, with a density range of R25 to R60. This is based around the following principles:

- A base density code of R25 applies.
- Medium density R40 areas are typically located adjacent areas of public open space (where a higher level of amenity exists), in proximity to the school and neighbourhood centre, or at the end of street blocks. This coding provides the opportunity to deliver "cottage" style housing (single or double storey, front of rear loaded) or for contemporary "compact" lots that typically bookend street blocks. Single lots sizes will generally range from 180m2 to 300m2.
- The R60 code will be applied adjacent areas of public open space and in proximity to the school or neighbourhood centre, similar to the aforementioned R40 criteria. This coding provides opportunities for smaller cottage lots that can accommodate contemporary two storey residential development. This coding will also be allocated to grouped or multiple dwelling sites, providing for an efficient built form response on these sites.

The LSP has the potential to achieve 16.4 dwellings per gross urban zoned hectare, meeting the 15 dwellings per gross urban zoned hectare density target set out in Perth & Peel@3.5million. Similarly, the LSP achieves a target of approximately 28.2 dwellings per site hectare (being the pure residential area, excluding open space, roads and other non-residential uses), exceeding the density requirement of 22 dwellings per site hectare required by Liveable Neighbourhoods.

3.3.2 R-Code Variations

Local Development Plans (LDPs, formerly known as Detailed Area Plans) will be required for a select number of circumstances where specific development requirements are needed to deliver a suitable built form response. These LDPs will be imposed as a condition of subdivision and will be determined by the Shire of Serpentine-Jarrahdale in accordance with section 5.18.5 of TPS NO. 2.

The following outlines the key provisions that will be addressed in these LDPs, with a brief explanation of their application.

Lots abutting areas of Public Open Space Liveable Neighbourhoods supports residential lots directly abutting open space under particular circumstances and where the functionality of the POS is not compromised, and where the dwelling addresses the open space providing adequate visual surveillance.

Typically the interface to public open space at the time of subdivision will be via roads, however, in some instances direct lot frontage is an appropriate design response to provide greater product diversity, address amenity and increase surveillance of the public spaces.

To ensure these public open spaces are not compromised by such a design initiative subsequent subdivision design and engineering detail will ensure that visitor parking is provided along adjacent streets, and the adjacent residential lots are elevated a minimum of 500mm above the POS ground level to create a visible separation between the private and public realm.

Where lots interface with open space, LDPs will need to be prepared to control built form. These LSPs will address:

- minimum setbacks to the public open space.
- major openings (other than bedrooms) to address the space.
- permeable fencing to ensure constant surveillance.

3.3.3 Lots within a designated Bushfire Prone Area

LDPs will be prepared for lots identified as located within a designated bushfire prone area, discussed further in Section 3.4.

These LDPs will ensure that landowners will be notified of bushfire risk, and that dwellings must be constructed to an appropriate Building Attack Level (BAL) standard. Mandatory boundary setbacks can also form part of any required building protection zone (if applicable).

3.4 PUBLIC OPEN SPACE

The Landscape Masterplan prepared by LD Total Landscaping describes the intended function and design principles of each open space area, shown in the Landscape Master Plan in Figure 5 below. The overall Landscape Master Plan for the LSP area has been provided in Figures 6 and 16.

The LSP ensures that public open space can serve a variety of functions throughout the LSP area, balancing active and passive recreational pursuits, whilst allowing for the rehabilitation of the “living stream” that conveys surface water through the site from Brickwood Reserve.

Structure Plan Amendment 1 slightly reduces the POS component on Lot 61 Lawrence Way. The reconfiguration of POS5 has resulted in a relocation of a residential area to the south of POS5 that is able to connect to the public road network. This also allows development to commence prior to the construction of the section of Lawrence Way abutting Lot 61 that has not yet been ceded as road reserve by the respective landowner.

A cash-in-lieu component will be required upon subdivision of Lot 61, in respect of the POS shortfall of 700sqm, compared to the 2017 SP.

As illustrated and described below the POS design will include the following key elements:

- A living stream with natural vegetation within the MUC.
- An open, levelled lawn area to be used as an active POS area in the north-eastern portion of the POS. It is envisaged this space will act as a ‘kick-a-bout’ space that may include sporting goals/posts and/or a half basketball court or the like. The sporting equipment provided should target the age group of approximately

8+ years and should be contained to the western side of the active POS area as residential lots will abut in the eastern side in the future.

- 'Turf pockets' are also proposed to the north of residential block 4, which is abutting the proposed lots and to the south of the residential block 1. These spaces will include footpath connections to Lawrence Way as well as heavier landscaping directly abutting the lots for privacy.

- A smaller active space is also provided to the east of residential block 4 on the opposite side of the MUC to the larger active space. It is envisaged that this space would contain exercise equipment and a seating/rest node as well as a bridge connection over the living stream to connect the two active POS spaces.

The landscaping of the amendment area will include an attractive pedestrian friendly path network flowing alongside the living stream, interspersed with seating, grassed areas, and native and WaterWise plantings.

The Landscape Masterplan is included in Appendices 5 and 6.



Figure 5: Landscape Master Plan. Source: LD TOTAL 2021.



Figure 6: Landscape Master Plan. Source: LD TOTAL 2017.

3.4.1 Multiple Use Corridor (Living Stream)

The LSP provides for a 16m wide multiple use corridor that passes through the LSP area, incorporating an existing waterway originating from Brickwood Reserve.

In accordance with the "Byford Townsite Drainage and Water Management Plan", this is to be landscaped as a "living stream" and can potentially provide the following:

- Native and WaterWise groundcover, plants, and trees for easy and low cost maintenance.
- Pedestrian pathways and seating, including a respite area for passive recreation outside areas affected by frequent storm events.
- Viewing nodes for viewing opportunities over the "living stream", including through visually permeable fencing.
- A design which achieves the principles and objectives of Water Sensitive Urban Design.

This multiple use corridor is critical in that it conveys local and district drainage for all rainfall events as well as providing a high-quality landscaped space for passive recreation and local amenity. The multiple use measures approximately 30m in width. There are opportunities to further the amenity of this space through the inclusion of pedestrian pathways, along with seating and shaded areas, as per the detailed section Landscape Plans of Appendices 5 and 6.3.

3.4.2 Local Parks

Local parks of between 3000m² and 8000m² are provided to ensure all dwellings are within a 400m walk, in accordance with Liveable Neighbourhoods. The design of local parks is based on the following principles:

- Retention of remnant trees wherever appropriate.
- Comprising native or low water use shrubs and grasses, for easy and low cost maintenance.
- Open turfed areas will provide an informal play and a kick-about spaces within selected local parks.
- Opportunities to provision shelter and picnic facilities.
- Potential for fitness nodes and play equipment.

3.4 BUSHFIRE MANAGEMENT

A review of the Department of Fire and Emergency Services (DFES) dataset revealed that the subject site is designated as a Bushfire Prone Area.

A Bushfire Management Plan (BMP) has been prepared for Lot 61 (No. 55) Lawrence Way by Linfire for the Local Structure Plan Amendment No. 1 area, and accompanies the BMP which was previously prepared by Essential Environment which covered the whole Structure Plan area (refer to Appendices 3 and 6.2). These BMP have been prepared as a strategic document to guide the delivery of compliant development at future planning stages in accordance with the Guidelines.

In accordance with the WAPC's "Planning in Bushfire Prone Areas", the Bushfire Management Plan (BMP) includes a Bushfire Hazard Assessment identifying bushfire prone areas (a bushfire prone area is defined as any land that may experience a bushfire that has the potential to impact development). The images effectively show that the post-development bushfire hazard level is low, and ultimately there are no risks or concerns which have been identified which would otherwise limit or restrict residential development. The images shown below illustrate that Amendment No. 1 area will result in a "low" bushfire hazard level.

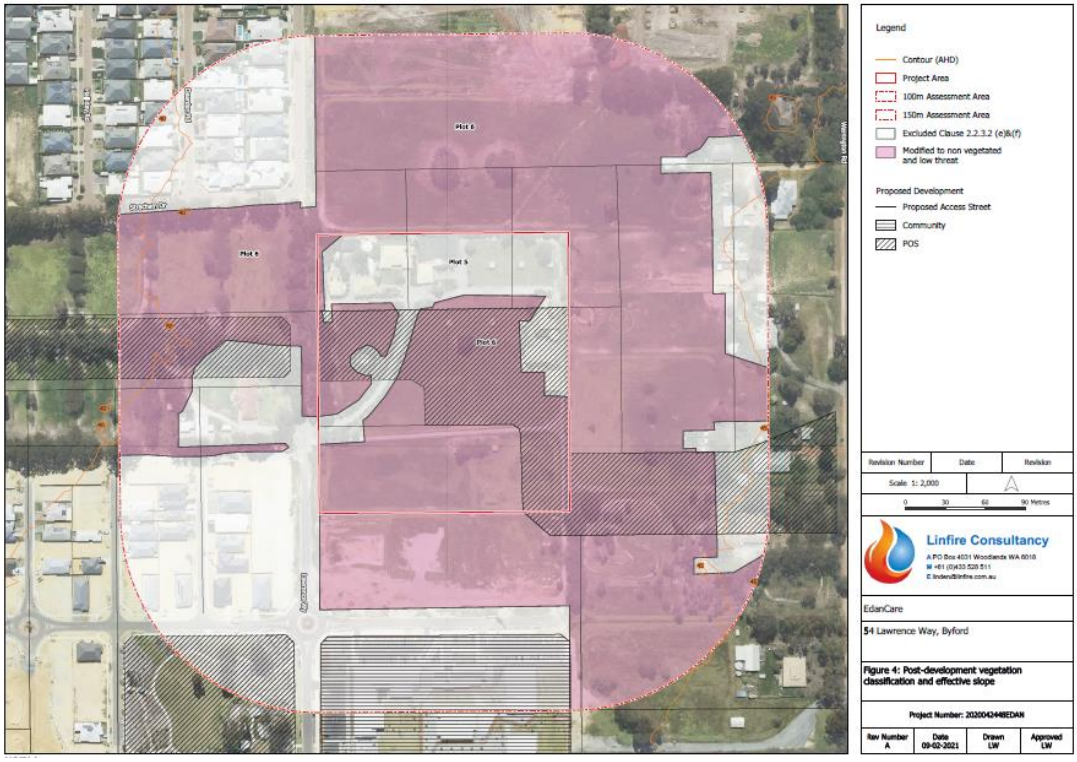


Figure 7: Post-development vegetation classification and effective slope. Source: Linfire Consultancy 2021.

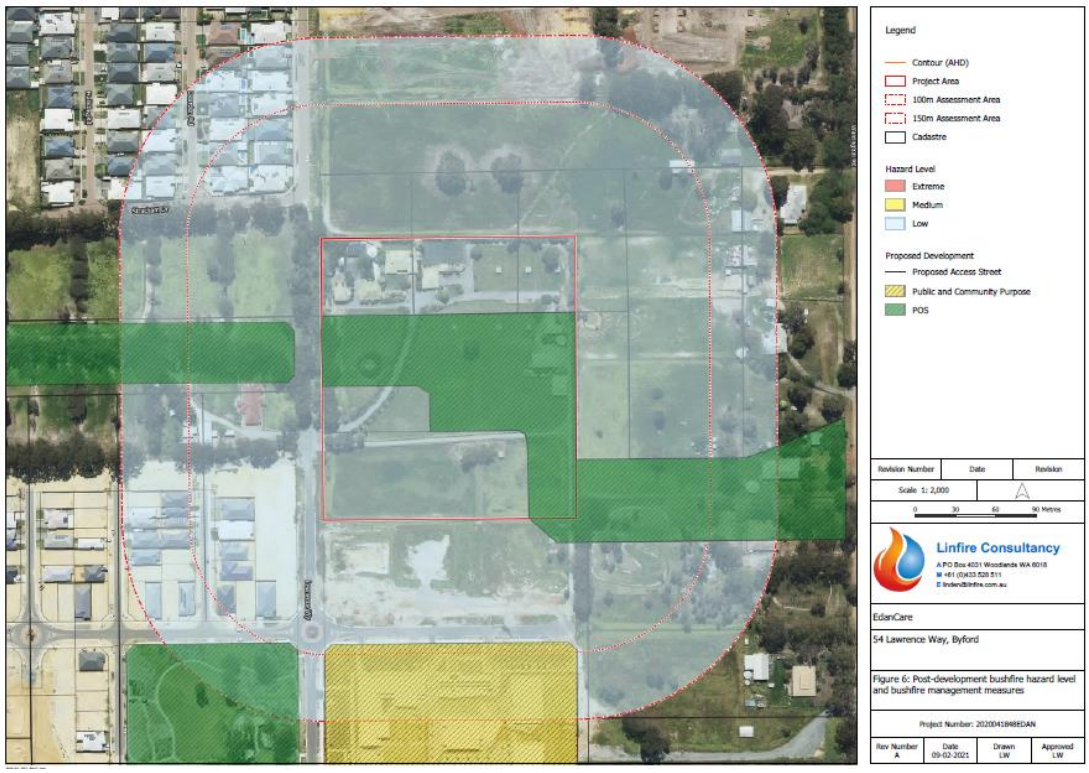


Figure 8: Post-development bushfire hazard level and bushfire management measure. Source: Linfire Consultancy 2021.

The low-risk nature of the post-development condition has been assigned to the Amendment No. 1 area by Linfire Consultancy as follows:

> *The bushfire hazard levels have been assigned on the basis of the vegetation discussed in Section 3.1.4 and the future expected vegetation extent within and surrounding the project area.*

The LSP provides a design response and the planning framework to address potential bushfire risk. It demonstrates that bushfire risk is not an impendent to development as this can be managed through a combination of Asset Protection Zones (APZ) and appropriate construction standards.

The FMP requires the APZ to be sufficient to achieve a Bushfire Attack Level (BAL) of 29 or less in accordance with AS 3959 "Construction of buildings within bushfire prone areas". Fences constructed from non-combustible materials away from the vulnerable parts of the building such as windows and doors.

The LSP responds by creating an APZ to provide sufficient separation from surrounding classified vegetation and ensuring all landscaping within the project complies with the APZ standards. Proposed residential dwellings will also be constructed to the specifications of AS 3959 for the assessed BAL rating. All areas of POS will be landscaped and maintained to a "low hazard" standard within the LSP area.

Vehicle access to the proposed development will be configured to comply with the Guidelines and include any temporary access arrangements to ensure compliance during staged development. The northern and southern portions of Lawrence way will be linked, removing the cul-de-sac.

The existing town main and street hydrant connections will be extended to the project area in accordance with the requirements for reticulated water supplies of the Guidelines.

In light of the above, Linfire considers the associated bushfire risks to be manageable through standards bushfire management responses in compliance with the Guidelines and AS 3959 to combat any potential bushfire hazards within and adjacent to the project area.

Any future lots constructed to a BAL12.5 standard or greater needs to provide appropriate notifications on titles to inform landowners of the need to construct dwellings to higher (BAL) construction standard as a condition of subdivision. Any mandatory constructions standards will be implemented via Local Development Plans at the time of subdivision approval, as discussed in Section 3.2.2. In addition, the retention of vegetation within the Lawrence Way road reserve will occur where possible.

3.5 MOVEMENT NETWORK

A comprehensive Transport Impact Assessment has been prepared by KCTT traffic engineers, included as Appendix 6.4.

The following section discusses the key elements of the Assessment, including existing and planned movement network, road hierarchy classification and an overview of the cyclist and pedestrian network.

3.5.1 Existing Movement Network

The LSP is supported by a road network that allows for excellent connections to local, district and regional destinations. Key aspects of this existing road network are:

- Hopkinson Road runs in a north-south direction, approximately 1.3km west of the LSP area.
- Orton Road abuts the southern edge of the LSP area, intersecting with Hopkinson Road to the west and Soldiers Road to the east.
- Doley Road passes through the LSP area, connecting The Glades development to the north with Orton Road to the south.
- Warrington Road provides local access to the area, connecting to Orton Road. Soldiers Road abuts the eastern most edge of the LSP.
- Perrone Avenue, Allanson Drive, Patridge Bend, Haliday Road and Lawrence Way provide local traffic connections to adjacent development.
- Recorded weekday traffic flows (MRWA) are as follows:
    - Hopkinson Road (south of Abernathy Road): 3,097 vpd
    - Doley Road (south of Abernathy Road): 2,743 vpd.
    - Orton Road: 449 vpd
    - Soldiers Road (south of Abernathy Road): 2,158 vpd.
- Public bus service 254 connects to Armadale Train Station and runs along Doley Road, approximately 400m north of the LSP area, providing an quarter hour service Monday to Friday, with an hourly service on Saturdays.
- Abernethy Road located approximately 2.3km north of the LSP area, is considered a good riding environment in accordance with the Department of Transport's Perth Bike Map series.
- Main Roads Western Australia planning shows the future Tonkin Highway extension replacing Hopkinson Road with a full interchange at Orton Road. No timeframe has been established for this infrastructure works. Once complete this will dramatically improve regional access for the LSP area.

3.5.2 Proposed Movement Network

Road Network

The road network reflects the principles and standards of Liveable Neighbourhoods and has been designed to provide a permeable and legible movement structure. Road alignments also reflect the constraints imposed by surrounding land uses and existing road connections.

The KCTT Road Hierarchy Plan shows the hierarchy of the movement network planned for the area and the external connections to the existing network (Figure 19: Road Hierarchy Plan). The road network has been planned and modelled on known and forecast traffic volumes and will be refined further at the time of subdivision to relevant Shire of Serpentine Jarrahdale standards.

The key aspects of the planned road network are as follows:

- **Orton Road**—to be classified as an Other Regional Road, is to be widened from 20 metres to 32 metres (6 metres to be ceded by landholdings north and south of the road).

- **Soldiers Road**—to be classified as an Other Regional Road, is to be widened to 30 metres with 10 metres to be ceded by landholdings abutting Soldiers Road.
- **Turner Road**—is to be extended westwards to connect to Doley Road and classified as a neighbourhood Connector B, with a reservation width of 19.4m.
- **Doley and Warrington Roads**—to be classified as Neighbourhood Connector A roads, with a reservation width of 24.4m.
- **Lawrence Way**—to be classified as Neighbourhood Connector B roads, with a reservation width of 19.4m.
- **Access Streets**—these will range in width from 14.2 to 17.9m road reserves with the majority to be constructed as 15.4m road reserves with a 6.0m–7.2m carriageway. These road reserve widths will be reduced by 1m when the access street is adjacent to public open space as set out in Liveable Neighbourhoods.
- **Laneways**—to be a minimum width of 6m to accommodate two-way movements and rubbish collection.

This proposed local road network will be refined further at the time of subdivision.

Pedestrian and Cyclist Facilities

The LSP provides an excellent level of accessibility and permeability for pedestrians and cyclists, both within the site and via connections to surrounding areas (Figure 20: Pedestrian and Cyclist Facilities).

The pedestrian and cyclist facility network will be provided in accordance with the following key principles:

- Footpaths on at least one side of all access roads, constructed to a minimum width of 1.8m.
- Neighbourhood Connector (A and B) roads will be provided with a 2.3m wide footpath to one side, in addition to a 1.8m footpath on the opposite side.
- Orton Road will be provided with a 2.3m wide footpath to the northern side.
- Roads adjacent to the primary school site will be provided with a dual use path.
- Dual use pathways will be provided, connecting to the existing “Trails Network” located within Brickwood Reserve.

The precise location and alignment of footpaths and shared paths will be determined in consultation with the Shire of Serpentine- Jarrahdale as part of the detailed engineering stage following subdivision approval.

Public Transport

It is common for development to precede public transport services as these are not provided until there is a critical population mass to demand and warrant such services. Presently bus route 254 connects to Armadale Train Station and runs along Doley Road, approximately 400m north of the LSP area.

It is anticipated that existing bus routes will be extended to service the LSP area once local population mass warrants these services. Doley Road, Lawrence Way and Warrington Road are planned as Neighbourhood Connectors and will be capable of accommodating a public bus route.

3.5.3 Transport Network Analysis

KCTT have undertaken comprehensive traffic modelling for the movement network proposed by the LSP. It demonstrates that the proposed network and associated reserve widths have the capacity to accommodate expected traffic volumes in the year 2036. This is consistent with the long-term planning horizon in Perth and Peel@3.5million and Main Roads regional modelling.

All vehicle movements fall within the acceptable limits outlined by Liveable Neighbourhoods for the respective road categories proposed by the LSP.

It is important to note that the traffic modelling undertaken incorporates all land anticipated for future urban development, as identified by the Byford Structure Plan and Perth and Peel@3.5million. This has ensured a transparent and robust model.

Internal Intersections

The precise nature and function of all internal intersections will be determined once the location and alignment of access streets have been finalised as part of the subdivision approval. All intersection spacing and treatments will be designed to Liveable Neighbourhoods standards.

The Paramics Model and SIDRA capability analysis carried out for the site confirms that uninterrupted traffic flows can be expected at all internal intersections during typical operating conditions.

3.6 WATER MANAGEMENT

In accordance with the WAPC's Better Urban Water Management Guidelines, Urbaqua has prepared a Local Water Management Strategy (LWMS) that establishes key principles for the management of stormwater runoff and groundwater quality for the subject site. The amended structure plan involves the realignment of the POS layout and area within Lot 55 and the increase of residential area. Therefore, this LWMS outlines the strategies which will be implemented to manage stormwater within the Multiple Use Corridor.

Pursuant to Schedule 15 (DCA1) of TPS NO. 2, the LWMS is consistent with the "Byford Townsite Drainage and Water Management Plan" and has been prepared in consultation with the Shire of Serpentine-Jarrahdale and the Department of Water.

This LWMS is supportable for approval of the structure plan by the City as the proposed stormwater and groundwater strategies are appropriate for the management of the project area. Any increase in surface runoff to the POS caused by the expansion of residential development will be limited through the extension of subsoil and stormwater drainage along Lawrence Road.

In addition, due to the increase in length of the main channel by 50m (approximately), the reconfigured layout of POS can provide an increased flood storage capacity, as well as within the MUC. Furthermore, as shown in the concept below, there is an adequate amount of POS available to accommodate the recommended meander length design and therefore avoid sharp bends in the live stream.

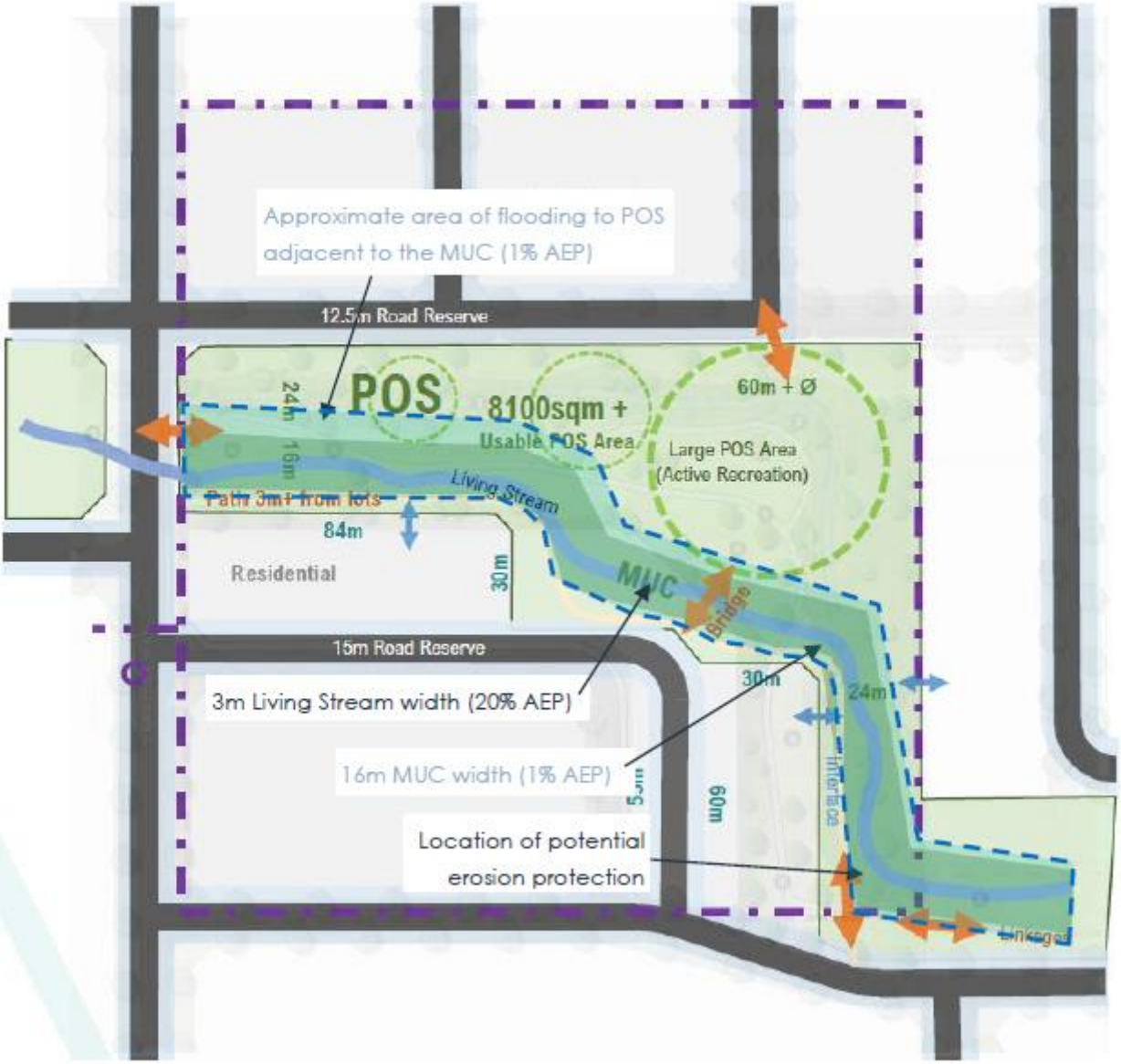


Figure 9: Living Stream and MUC Concept. Source: Urbaqua 2020.

The management principles set out in the LWMS will be refined and implemented as part of subsequent Urban Water Management Plans (UWMP) which will be prepared at the time of subdivision.

A copy of the LWMS is provided in Appendices 4 and 6.5.

3.6.1 Stormwater Management

The LWMS proposes stormwater management and groundwater recharge in a manner that is consistent with "Byford Townsite Drainage and Water Management Plan" and water sensitive design practices:

Soak wells on individual lots will allow onsite infiltration for the small stormwater event (first 15mm of rainfall). Rainwater from street pavements and commercial sites for the small stormwater event will be infiltrated as close to source as practicable, via bio-retention structures and tree pits located in the road reserves.

Rainwater exceeding the small stormwater event (5 year ARI) will be conveyed through a series of pipes and overland drains to either the multiple use corridor that passes through the LSP area, or the drain located in the Orton Road reserve.

Rainwater from major flood events (100 year ARI) will be conveyed via drains and road reserves to join flow paths leading to the multiple use corridor or the Orton Road reserve drain.

Interim Stormwater Solution

Land under the ownership of Delfina Properties Pty Ltd is proposed to be developed in advance of the remainder of the LSP area. The multiple use corridor where the majority of stormwater flows are to be discharged, falls outside this initial area of development.

An interim stormwater solution is proposed to allow this initial stage of development to proceed.

This involves the northern boundary of the Delfina Properties land being retained in the ownership of Delfina Properties, with a cut-off drain conveying stormwater towards Doley Road being placed in this land. An open drain within the Doley Road reserve will then convey flows northwards, into the multiple use corridor located in the adjacent "The Glades" (Figure 21: Interim Drainage Solution).

Once development to the north of the Delfina Properties land proceeds, stormwater flows will be redirected to the multiple use corridor as set out in the "Byford Townsite Drainage and Water Management Plan".

3.6.2 Groundwater Management

A preliminary earthworks strategy has been prepared over the LSP area in order to achieve adequate separation to groundwater. Minimum separation between finished lot levels and groundwater will be achieved by a combination of clean fill and subsoil drainage to protect against any post-development groundwater rise.

Finished lot levels and fill requirements will be confirmed and reported during the Urban Water Management Plan stage, given the level of detailed engineering design involved.

3.6.3 Implementation and Delivery

The LWMS establishes the strategy in which development within the LSP can occur in a water sensitive manner. It will be the responsibility of the developer to construct and maintain the stormwater drainage system at subdivision stage.

A post-development monitoring programme will be designed in cooperation with the Shire of Serpentine-Jarrahdale and the Department of Water. This will involve monitoring surface water during August to October to capture peak winter flows, and in March to capture the first baseline flows. Groundwater levels and quality will be carried out on a quarterly basis with samples being analysed at a NATA accredited laboratory.

3.7 ACTIVITY CENTRES

The LSP is located in close proximity to a number of existing and planned activity centres, ensuring excellent access to retail and employment opportunities:

- The Byford Town Centre is located 2km north-east of the LSP area, identified as a district centre in "State Planning Policy 4.2 – Activity Centres for Perth and Peel".
- The "Byford Village Centre" is a large neighbourhood centre located only 500m north of the LSP area. Construction of the "Byford Village Centre" is expected to commence in 2016.
- A neighbourhood centre and mixed-use strip is situated immediately west of the LSP area on Orton Road.

The Byford Structure Plan provides for a further neighbourhood centre at the intersection of Orton and Doley Roads, "bookending" the mixed use strip on Orton Road. This Centre is included within the LSP.

A Retail Needs Assessment was undertaken by RPS to confirm that the location and size of this neighbourhood centre was appropriate in its context. The Assessment concluded that the location of the neighbourhood centre allowed for excellent customer exposure via its dual frontage to Orton and Doley Roads. The Assessment forecast at ultimate development, the neighbourhood centre can support 1,500m² of retail floor space. A copy of the Retail Needs Assessment is provided as Appendix 6.6.

3.8 EDUCATION

The LSP is well serviced by existing and planned education facilities as established by the Byford Structure Plan.

Three primary schools currently serve the Byford Structure Plan area, with an additional four primary schools and one high school planned for the Structure Plan area. The Byford Structure Plan has located each school so as to be centrally located within its surrounding catchment.

The LSP delivers one of the planned primary school sites, at the location shown in the Byford Structure Plan.

The school is provided with excellent access and circulation consistent with the principles of Liveable Neighbourhoods, surrounded by Lawrence Road to the west, Turner Road to the north and two local access roads to the south and east.

The Department of Education supports the size and location of the primary school site.

3.9 INFRASTRUCTURE COORDINATION, SERVICING, & STAGING

The following section summarises the engineering considerations in the Engineering Servicing Report prepared by Pritchard Francis Engineers.

A copy of the Engineering Services Report is provided as Appendix 6.7.

3.9.1 Earthworks Strategy

A preliminary earthwork strategy has been prepared for the LSP.

Key aspects of the Strategy are:

- Provide at least 1.2 m of clean permeable sand in order to provide adequate clearance for onsite drainage (i.e. soakwells).
- Provide minimal retaining due to minimal fall across the LSP area.
- Match into the ground levels found on adjoining landholdings, including Brickwood Reserve abutting the eastern boundary of the LSP.
- Earthwork the multiple use corridor to allow for free water flows across the site, originating from Brickwood Reserve.
- Create finished levels that accommodate gravity-reliant infrastructure that facilitates sewer and drainage services.

3.9.2 Waste Water

The Water Corporation planning shows waste water from LSP being gravity fed southwards to a proposed main along Orton Road. This line feeds to the Byford pump station located adjacent to Hopkinson Road within "The Glades". A small northern portion of the LSP will feed into existing catchments to the north through connections to existing reticulated sewer systems within "The Glades".

3.9.3 Water Supply

The Water Corporation has confirmed reticulated water will be provided via a 250P main within the Orton Road reserve, turning north into Doley Road and ultimately connecting into the existing mains along Soldiers Road.

3.9.4 Power Supply

Existing overhead High Voltage power lines within the LSP area have capacity to service future development. These power lines will be placed underground as part of Western Power development requirements. Any incremental demand increases will be considered by Western Power as normal network growth which may require additional High Voltage feeder cables being extended into the area.

3.9.5 Gas Supply

The LSP will be serviced via medium pressure 100PVC gas mains which exists within the Doley, Lawrence, Orton and Turner Road reserves. These mains have the capacity to service future development.

3.9.6 Telecommunications

The size and expected yield of the LSP means that the National Broadband Network (NBN Co.) will be the telecommunications provider, with NBN connected developments already existing to the north-west of the LSP area and within the nearby Byford town centre. The design and installation of a "pit and pipe" network will be undertaken as development of the site progresses, with optic fibre to be provided by the NBN Co.

3.9.7 Staging and Timing

The LSP will be staged to ensure the efficient supply of infrastructure and to meet market demand. The first stage of development is planned to be centrally located within the land controlled by the Delfina Properties Pty Ltd, with the subsequent stage moving southward towards Orton Road (Figure 22: Indicative Staging Plan).

Initial lot release is expected in early 2017, subject to subdivision design and approvals being in place.

The remainder of the LSP area will be staged as demand grows, planned around the logical and efficient connection to services. This planned staging should be taken as indicative only is subject to change depending on market demand, landowner timeframes and other variables.

3.9.8 Development Contributions

The LSP area is located within Development Contribution Area 1 (DCA1) under appendix 16A (for Byford Development Contribution Area) within TPS No. 2 and is subject to the "Byford Townsite Development Contribution Plan".

4. CONTEXT PLANS & FIGURES

4.1 CONTEXT PLANS

Context plans have been prepared for the LSP which provide a comprehensive overview of the site conditions and context. These context plans are accompanied and supported by the consultant's reports and technical appendices. The provided context plans which are provided on the following pages include the following:

Context Plan 1: Topography and Cadastre
Context Plan 2: Public Transport
Context Plan 3: Roads
Context Plan 4: Cycling Network
Context Plan 5: Heritage
Context Plan 6: Bush Fire & Soils
Context Plan 7: Flooding & Wetlands

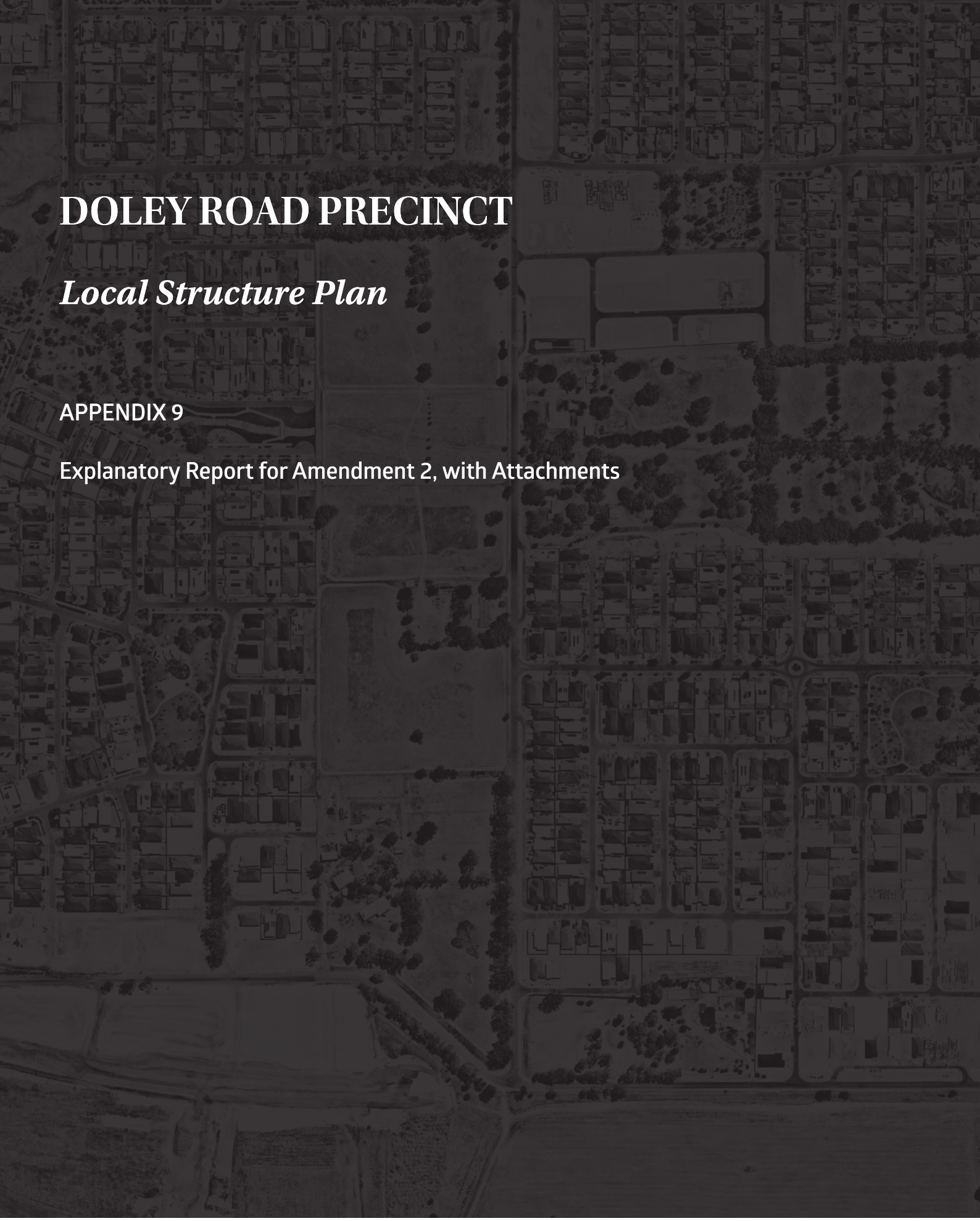
4.2 2017 DOLEY ROAD PRECINCT LSP FIGURES

In support of the Doley Road Precinct LSP Amendment No. 1, the figures of the 2017 LSP have been retained and are provided on the following pages for reference. Given the small area which has been affected by Amendment No. 1 these figures (like the associated technical appendices in Appendix 6) remain relevant, however their interpretation should be treated with a common-sense approach, with regard to the changes in the Amendment No. 1 area. These figures include:

Figure 10: Location Plan
Figure 11: Byford Structure Plan
Figure 12: The Glades Local Structure Plan
Figure 13: South Metropolitan Peel Sub-Regional Planning Framework
Figure 14: Bushfire Hazard Assessment Plan
Figure 15: Development Concept Plan
Figure 16: Landscape Masterplan
Figure 17: Multiple Use Corridor Cross Section
Figure 18: Indicative BAL Ratings
Figure 19: Road Hierarchy Plan
Figure 20: Pedestrian and Cyclist Facilities
Figure 21: Interim Drainage Solution
Figure 22: Indicative Staging Plan

APPENDIX 9

Amendment 2 documentation



DOLEY ROAD PRECINCT

Local Structure Plan

APPENDIX 9

Explanatory Report for Amendment 2, with Attachments

CLE Town Planning + Design

CLE Town Planning + Design

Title:	Doley Road Precinct - Local Structure Plan Appendix 9 - Explanatory Report for Amendment 2, with Attachments
Prepared for:	Parcel Property
CLE Reference:	3410Rep135B
Date:	11 February 2025
Status:	Final
Prepared by:	CLE Town Planning + Design

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APPENDICES

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Appendix 2 Walkable Catchment for the Lot 32 POS (CLE Ref. 3410-137-01)

Appendix 3 Reference Plan for the POS Schedule (CLE Ref. 3410-138-01)

Appendix 4 POS Schedule (CLE Ref. 3410POS139)

Appendix 5 BAL Contour Plan (EcoLogical, March 2023)







Above: Doley Road Precinct (Source: Parcel Property)

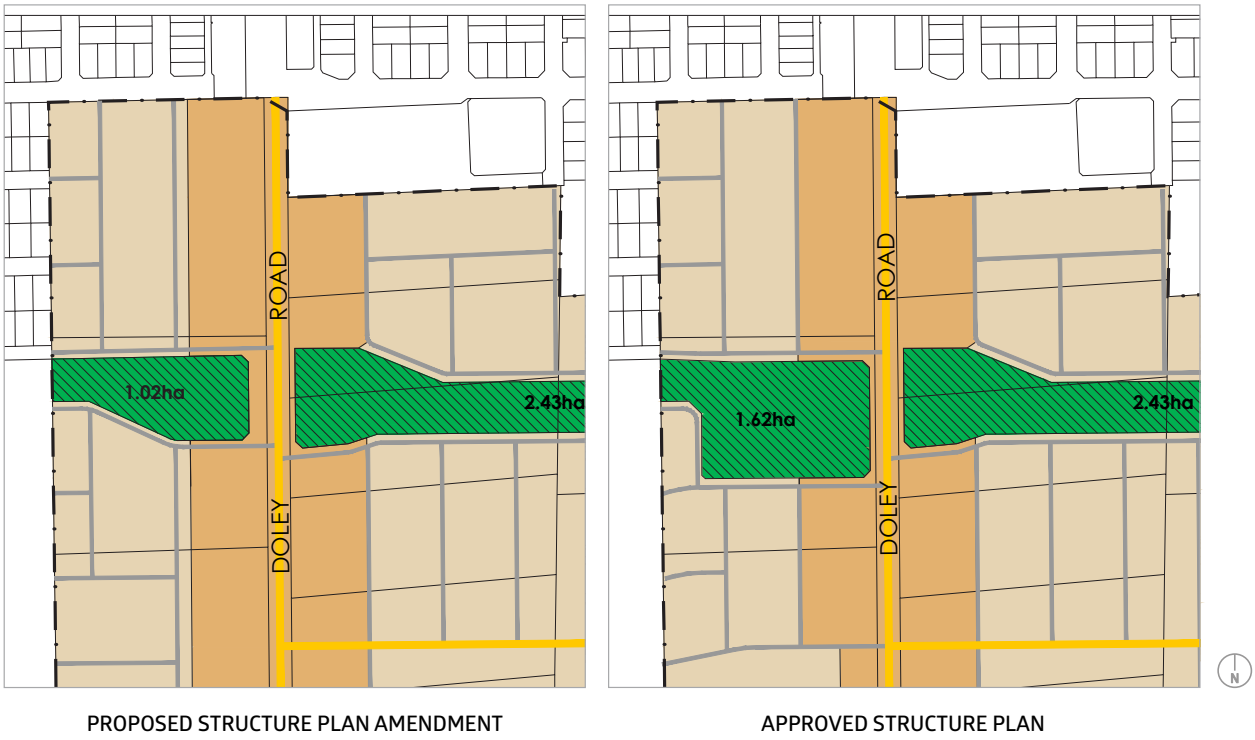
1.0 Purpose of the Amendment

The purpose of this amendment is to modify the shape and size of the Public Open Space ('POS') parcel planned for Lot 32 Doley Road, Byford, upgrading the current passive design to a more active design. The new layout will make more efficient use of urban-zoned land and enable a higher level of activation. The proposal is shown in the Structure Plan Map within Part 1 of the LSP (as amended; plan CLE Ref. 3410-22C-01) and the Landscape Concept Plan appended to this report.

The structure plan identifies approximately 1.92ha of Lot 32 for urban purposes (future residential land and local roads) and 1.62ha for public open space ('POS'). This amendment proposes to reduce the POS to 1.02ha to reflect a new, more efficient design for the drainage infrastructure and maintain east-west connectivity.

Detailed design work undertaken recently for the developer, Parcel Property, has identified a narrower profile for the Multiple Use Corridor ('MUC') that passes through Lot 32. This reduces the extent of land occupied by the MUC and accordingly, there is an opportunity to reduce the overall size of the POS. In parallel, Parcel has been investigating ways to improve the useability of the POS in its new layout by incorporating hardscape features (a more active template) as a point of difference to lawns and gardens, which are more passive. This is shown at **Attachment 1**.

Figure 1 below shows the existing and proposed layout for the Lot 32 POS.



PROPOSED STRUCTURE PLAN AMENDMENT

APPROVED STRUCTURE PLAN

Figure 1: Existing and proposed layout for the Lot 32 POS

Source: Urbanista

2.0 Background

The structure plan was originally approved by the WAPC in March 2017 and it was amended in March 2022. It covers land zoned 'Urban' under the Metropolitan Region Scheme and 'Urban Development' under Shire of Serpentine-Jarrahdale Local Planning Scheme No. 3.

The structure plan area is part of an urban precinct west of Byford and south of Abernethy Road that began development in the late 2000s. The Doley Road Precinct Local Structure Plan is one of two major structure plans covering this area, the other being 'The Glades, Byford' Local Structure Plan. A significant proportion of 'The Glades Byford' Local Structure Plan has been developed and normalised.

The extent of the two above-mentioned structure plans is primarily defined by original land ownership rather than any significant physical features, and when complete, the new urban area will function as one integrated precinct with neighbourhoods loosely delineated by mid-tier roads such as Doley Road, Lawrence Way and Warrington Road.

The two structure plans propose an east-west MUC containing a minor drainage line running through the urban precinct. The local area was farmland before it was urbanised, so there are isolated trees but no significant remnant vegetation, particularly understorey. The drainage line is proposed to be landscaped as a swale and there are places, such as at Lot 32, where the MUC widens out and accommodates informal recreation, augmenting other POS areas nearby.

Lots 32 and 33 were the subject of a subdivision approval issued in 2023. This enables residential lot creation over Lot 33. An Urban Water Management Plan to support this, required by a condition of approval, will be lodged in late April or early May of 2024. The narrower MUC has been incorporated into UWMP, as it is relevant to the drainage of the approved lots, and it performs as required.



Above: Doley Road Precinct (Source: Parcel Property)

3.0 Proposal

As shown in **Figure 1** above, the MUC within Lot 32 is proposed to cover 1.62ha and is rectangular in shape. As shown in the approved Landscape Plan (**Appendix 3**), the 'waterway' component of the MUC (a swale) through Lot 32 is approximately 45m wide and there is a space for informal, passive recreation to the south of the swale.

Parcel Property has identified an opportunity to make more efficient use of urban land by reducing the width of the swale within Lot 32, enabling the overall MUC to also be reduced in area. A Landscape Concept Plan has been prepared by LD Total, informed by our project hydrologist Urbaqua, showing a narrower swale and a smaller overall MUC. This appears at **Attachment 1** to this appendix.

The effect of the proposed change is detailed in Table 1 below. In summary, although the reduction in planned POS is 6,000sqm, the loss of useable POS is only 3,500sqm, which is insignificant in the context of the location.

	Existing (ha)	Proposed (ha)
Swale area	0.85	0.6
Recreational area	0.77	0.42
Total MUC within Lot 32	1.62	1.02

Table 1: Comparison Table for MUC within Lot 32

The reduction in the width and consequent extent of the MUC is a positive outcome. It performs the same hydrological function as the existing MUC but reduces the future maintenance burden on the Shire. The new landscaping concept for the POS also facilitates greater useability by reducing the extent of land devoted to passive activities and providing more for informal active pursuits.

The reduction of 3,500sqm in the recreational component of the MUC POS will not be to the detriment of the community for the reason that the local area is over-provided with POS, as detailed in the following section.

4.0 POS in Context

As discussed above, the recreational, amenity and hydrological function of the POS within Lot 32 will be little changed from the approved structure plan in a practical sense. The new landscaping concept for the POS also facilitates greater useability by reducing the extent of land devoted to passive activities and providing more for informal active pursuits.

As mentioned above, hydrological performance is being demonstrated through the UWMP for an adjacent stage of subdivision, and there will be a recreational benefit because Parcel intends to facilitate more active uses (for example, play equipment, exercise equipment and/or parkour infrastructure) than are contemplated in the design approved in the current structure plan.

There will also be little change in terms of the *Liveable Neighbourhoods* POS calculation, as the local area is over-provided with POS even with the planned reduction incorporated into the calculation. Using the definitions in **Liveable Neighbourhoods**, the Lot 32 POS is a 'Local Park' and therefore serves a walkable catchment of up to 300m (Element 4, R14). The extent of this is shown on **Figure 2** below, and in full in **Attachment 2**. The catchment includes the following other parks:

- Icaria Park (covering 1.06ha and constructed but not yet reserved);
- Lot 8031 Allanson Drive (covering 0.45ha and reserved under LPS 3); and
- Other portions of the MUC.

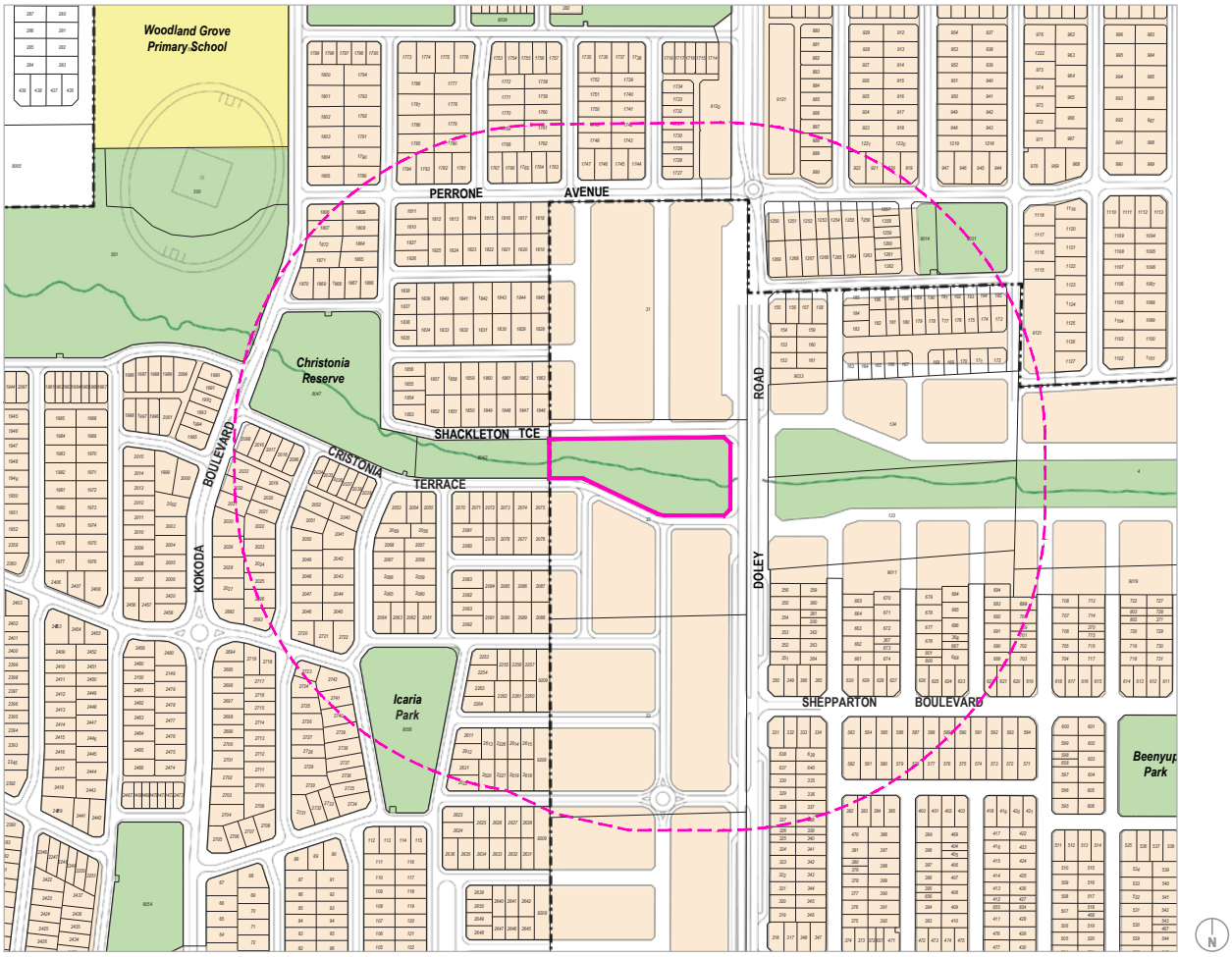


Figure 2: Walkable Catchment for Lot 32 POS

The 300m walkable catchment for the Lot 32 POS straddles the Doley Road and The Glades structure plans. Lot 32 is at the western end of the Doley Road structure plan. As such, POS needs to be considered in its broader locational context. As discussed above, the urban precinct will, on completion, function as one neighbourhood irrespective of the structure plan.

POS provision within the two structure plans is as follows:

- Doley Road LSP: 9.81%.
- The Glades LSP: 17.4%.

The Doley Road LSP was originally approved with a POS figure of 10.0%. The reduction to 9.81% was accepted by the Shire and the WAPC through **Amendment 1**, which was progressed by Urbanista for another landowner. The reduction related to a portion of the MUC located further east, approximately 500 metres away on Lot 61 Lawrence Way. In that instance, a similar proposal to reduce the width and extent of the swale was supported.

The over-provision of POS in The Glades structure plan suggests that in a cross-boundary catchment area such as this, there may be adequate POS even with a reduced MUC. To investigate this, the above-mentioned 300m walkable catchment has been overlaid on an amalgam of the two relevant structure plans and a POS Schedule produced – refer to **Attachments 3 and 4**. The POS Schedule confirms that the 300m walkable catchment of the Lot 32 POS has a provision rate of 14.0%, and an unrestricted provision rate of 13.8%. These outcomes exceed the requirements of *Liveable Neighbourhoods*, which are for a 10% rate of provision, 80% of which must be unrestricted.

Amending the Lot 32 POS would ensure that the maintenance and irrigation implications that an over-provision of POS generates are not imposed in this area. It would also have no practical effect on the availability of useable POS. As mentioned, Icaria Park and Lot 8031 are within a short walk (<300m) and there is useable space on both sides of the swale. This contrasts with the existing design for the Lot 32 POS, which only contemplates useable space to the south, not the north.

For the reasons given above, we contend that the smaller Lot 32 POS is compliant with the relevant requirements of *Liveable Neighbourhoods* in its own right and in context, and will deliver ample amenity to local residents. The local area is well-served with POS.

5.0 Stormwater Management

The structure plan includes an approved Local Water Management Strategy prepared by hydrologists Essential Environmental. In accordance with *Stormwater Management Manual for Western Australia*, Urban Water Management Plans are being prepared on a stage-by-stage basis in the context of the LWMS.

In December 2023, Parcel Property received a subdivision approval from the WAPC relating to Lot 33 Doley Road (WAPC Ref. 163451). An Urban Water Management Plan pursuant to the relevant condition on that approval is in preparation by Urbaqua and will be submitted to the Shire in April or May of 2024. This covers both Lots 32 and 33.

The UWMP addresses Lot 32 by adopting the existing MUC POS boundary (the squarer shape) and a related subdivision layout and road network. This is consistent with the existing structure plan and necessary in order to enable Lot 33 to progress. However, the UWMP adopts the new MUC cross-section shown in this LSP amendment request (refer to **Attachment 1**) and is therefore sufficient to justify the new cross-section in terms of its hydrological performance.

We note that Amendment 1 to the structure plan, which made a similar proposal for a reduction in the extent of the MUC, was accompanied by an LWMS Addendum justifying the change. In this case, we respectfully request that this not be required, as the MUC change is minor and is addressed comprehensively via the UWMP.

6.0 Bushfire Risk Management

Lot 32 is identified as being bushfire-prone in the map database administered by the Department of Fire and Emergency Services. In accordance with the requirements of State Planning Policy 3.7: Planning in Bushfire-Prone Areas, a Bushfire Management Plan (Essential Environmental, June 2016; 'the BMP') was approved with the structure plan. This confirms that all bushfire hazards affecting the amendment area can be managed through subdivision design and built form controls, and is therefore not a constraint to subdivision and development.

Subdivision applications within the structure plan area are being accompanied by BAL Contour Plans prepared on a stage-by-stage basis in the context of the BMP. The above-mentioned application for Lot 33, WAPC Ref. 163451, was accompanied by the BAL Contour Plan appended to this report at Attachment 5 (EcoLogical, March 2023) and this incorporates both the POS layout proposed in this amendment request and a related lot layout and road network. It confirms that the proposed POS does not generate a bushfire hazard, which is consistent with the outcomes of the BMP approved with the structure plan.

7.0 Conclusion

The purpose of this amendment is to modify the shape and size of the POS parcel planned for Lot 32 Doley Road, Byford, upgrading the current passive design to a more active design. The new layout will make more efficient use of urban-zoned land by addressing the over-supply of POS that is in place and planned for the local area via the Glades LSP and the Doley Road Precinct LSP. It will also facilitate better activation of the POS, with Parcel investigating ways to improve useability by incorporating hardscape features as a point of difference to lawns and gardens.

The new landscape design for the POS that is the subject of this amendment request introduces additional hardscaped activity spaces and reduces the proportion of the POS that is occupied by drainage infrastructure. This means that the reduction in useable POS will be less than the reduction in POS in gross terms, and the outcome is a more efficient design that leaves the local area still over-supplied with POS. Consistent with recent discussions with the Shire, the new landscape concept prioritises informal active pursuits over passive recreation.

Overall, the proposed amendment makes a positive contribution to the extent of urban-zoned land in a rapidly-growing part of the metropolitan region, whilst maintaining POS amenity for future residents.

APPENDICES

Appendix 1 Landscape Concept Plan by LD Total

Appendix 2 Walkable Catchment for the Lot 32 POS (CLE Ref. 3410-137-01)

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Appendix 5 BAL Contour Plan (EcoLogical, March 2023)

APPENDIX 1

Landscape Concept Plan by LD Total

POS 1 Landscape Concept Plan

Beenyup Grove
Lots 32 & 33 Doley Road



Location Key Plan NTS



north

POS1
NOT TO SCALE

Legend

1. Footpath network for pedestrian circulation
2. Parkour and exercise/obstacle course area. Divided into three distinct areas, providing age-appropriate spaces, allow each group to enjoy tailored experiences - 500 m^2
3. Open turf kickabout space
4. Living stream with shrub or reed plantings on the side slopes
5. Planted basins

LD TOTAL

PARCEL PROPERTY	10.7188	B	06.02.2025	1 OF 1
CLIENT	PROJECT NO	REVISION	DATE	PAGE

APPENDIX 2

Walkable Catchment for the Lot 32 POS (CLE Ref. 3410-137-01)

This plan has been prepared for general information purposes only and uses potentially uncontrolled data from external sources. CLE does not guarantee the accuracy of this plan and it should not be used for any detailed site design. This plan remains the property of CLE.

Woodland Grove Primary School

Christonia Reserve

Icaria Park

Beenyup Park

PERRONE AVENUE

SHACKLETON TCE

CRISTONIA TERRACE

BOULEVARD

KOKODA

ROAD

DOLEY

SHEPPARTON BOULEVARD

ORTON ROAD

LEGEND

- Lot 32 MUC POS
- POS Catchment Area (300m)
- Structure Plan Boundary

0 50 100 150 200 250 300m

CLE Town Planning + Design

POS CATCHMENT PLAN

Lot 32 Doley Road, Byford

plan no: **3410-130**
date: 17 July 2023
scale: 1:4,000 @A3, 1:2,000 @A1

N

APPENDIX 3

Reference Plan for the POS Schedule (CLE Ref. 3410-138-01)

This plan has been prepared for general information purposes only and uses potentially uncontrolled data from external sources. CLE does not guarantee the accuracy of this plan and it should not be used for any detailed site design. This plan remains the property of CLE.

PRIMARY SCHOOL 3.5ha

Glades POS 14
Total Area = 0.6ha

Glades POS 15
Total Area = 1.95ha

Beenyup POS 1
Total Area = 1.02ha

Beenyup POS 2 (Portion)
Total Area = 1.38ha

Icaria Park
Total Area = 1.06ha

2.4ha

5 min WALK

THE GLADES LOCAL STRUCTURE PLAN

DOLEY ROAD PRECINCT LOCAL STRUCTURE PLAN

CRISTONIA TERRACE

ALATA GROVE

ALBIZIA GROVE

LUZULA GROVE

PEPPER GROVE

LINUM WAY

ORTON ROAD

DOLEY ROAD

SHEPPARTON BOULEVARD

YANDRA STREET

LISMORE STREET

GOODENIA WAY

VISTA

PIRIE ROAD

12m Reserve

15m Reserve

Public Park Space

LEGEND

GLADES STRUCTURE PLAN AREA

RESIDENTIAL

RESIDENTIAL R10

RESIDENTIAL R12.5

RESIDENTIAL R15

RESIDENTIAL R20

RESIDENTIAL R25

RESIDENTIAL R30

RESIDENTIAL R40

RESIDENTIAL R50

RESIDENTIAL R60

CENTRES

VILLAGE CENTRE (RESIDENTIAL R80)

NEIGHBOURHOOD NODE (RESIDENTIAL R80)

MIXED-USE (RESIDENTIAL R80)

OPEN SPACE

PUBLIC OPEN SPACE AND DRAINAGE

FORESHORE RESERVE

DRAINAGE CHANNELS SUBJECT TO DETAILED DESIGN

30m FORESHORE BUFFER

OTHER

COMMUNITY

SCHOOLS

400m (5 MINUTE WALK) AND 800m (10 MINUTE WALK) WALKABLE CATCHMENTS

AREA SUBJECT TO VILLAGE CENTRE LOCAL PLANNING POLICY

LEGEND

Lot 32 MUC POS

POS Catchment Area (300m)

Neighbourhood Area

ZONES

Residential R25-R40

Residential R40-R60

Residential R60

Mixed Use R80

LOCAL RESERVES

Public Open Space

Public and Community Purposes

OTHER

Structure Plan Boundary

Neighbourhood Connector

Access Street

Source: The Glades, Byford_Revised Local Structure Plan (Taylor Burrell Barnett_January 2019) & Doley Road Precinct Local Structure Plan_Amendment No.1 (Urbanista Town Planning_March 2022)

0 50 100 150 200 250 300m

CLE Town Planning + Design

NEIGHBOURHOOD CONTEXT PLAN

Lot 32 Doley Road, Byford

plan no: **3410-138-02**
date: 5 April 2024
scale: 1:4,000 @A3, 1:2,000 @A1

N

APPENDIX 4

POS Schedule (CLE Ref. 3410POS139)

Public Open Space (POS) Schedule

Glades / Beenyup Grove interface area

CLE Town Planning + Design

Public Open Space Schedule (all areas are in hectares)		
Site Area		**40.40**
Existing Deductions		
n/a	0.00	
Total existing deductions	0.00	
Net Site Area		40.40
Structure Plan and Subdivision Deductions		
1:1 Drainage within POS	0.38	
Restricted Open Space Surplus	0.00	
Total Structure Plan Deductions	0.38	
Gross Subdivisible Area		**40.02**
POS @ 10%		4.00
Public Open Space Requirement		
May Comprise:		
Min 8% unrestricted POS	3.20	
Max 2% restricted POS	0.80	
TOTAL POS REQUIRED		**4.00**
Public Open Space Provided	Unrestricted POS Area	Restricted POS Area
Lot 8031 (Glades POS 14)	0.45	0.00
Glades POS 15 (MUC)	1.85	0.00
Icaria Park	1.06	0.00
Beenyup POS 1 (MUC)	0.93	0.03
Beenyup POS 2, pt (MUC)	1.25	0.04
TOTAL (ha)	**5.54**	**0.08**
Additional Deductions		
Restricted Open Space Surplus		0.00
Revised Public Open Space Contribution		
Min 8% unrestricted POS provided	5.54	13.8%
Max 2% restricted POS provided	0.08	0.2%
Total Creditable POS Provided	**5.61**	**14.0%**

Notes

1. In accordance with Liveable Neighbourhoods: the area subject to inundation more frequently than a one year average recurrance interval rainfall event is not included as restricted or unrestricted open space and is a deduction from the net site area (LN R33); areas for the detention of stormwater for a greater than one year average recurrance interval up to the five year recurrance interval is restricted open space up to 20%, the area greater than 20% is a deduction (not applicable in this case) (LN R26 & Table 11); areas for the detention of stormwater for a greater than five year average recurrance interval is within unrestricted open space (LN R25).
2. This Schedule is for plan CLE Ref. 3410-138-01. It is informed by The Glades LSP and the Doley Rd (Beenyup Grove) LSP.
3. The Glades drainage figures are taken from Figure 14 in The Glades LSP.
4. The Beenyup Grove drainage figures are taken from Table 3 in the Doley Road LSP.
5. The Icaria Park figure reflects its actual size and Table 7 in The Glades LSP, which indicates it does not perform a drainage function.

APPENDIX 5

BAL Contour Plan (EcoLogical, March 2023)

Level 1, Bishop's See 235 St Georges Terrace Perth WA 6000
t: (08) 6218 2200

Bushfire Attack Level (BAL) Assessment Report for Lot 32-33 Doley Road, Byford

Site Details			
Address: Lot 32 & 33 Doley Road, Byford			
Suburb:	Byford, 6122	**State**	Western Australia
Local Government Area:	Shire of Serpentine Jarrahdale		
Description of building works:	Residential development		

Report details			
Report/Job number:	22PER2700 Variation 4	**Report version:**	v1
Assessment date:	8/03/2023	**Report date:**	23/03/2023
Author:	Maitland Ely	**Review:**	Daniel Panickar (BPAD Level 3-37802)

SITE ASSESSMENT AND SITE PLAN

The assessment of the 97 proposed residential lots and one Public Open Spaces (POS) area was undertaken on 8 March 2023 for the purpose of determining the Bushfire Attack Level (BAL) in accordance with *Australian Standard AS 3959: 2018 Construction of Buildings in Bushfire Prone Areas* (SA 2018) Simplified Procedure (Method 1). An overview of the site is presented in Figure 1.

VEGETATION CLASSIFICATION

All vegetation within 150 m of the 97 residential lots and POS area was classified in accordance with Clause 2.2.3 of AS 3959: 2018. Each distinguishable vegetation class with the potential to determine the BAL is identified below and presented in Table 1 and Figure 1.

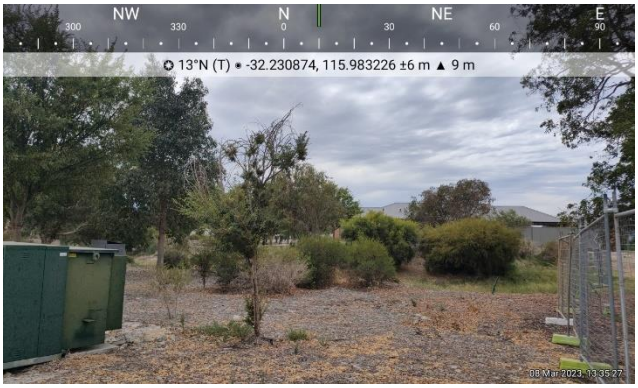
Plot 1	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (a)

Photo Point 1

Classified vegetation within this plot is comprised of shrubs >2 m high with >30% foliage cover. Isolated trees are present within this plot.

Slope under this plot was assessed as upslope/flat land.

Vegetation has been excluded as it is located greater than 100 m from the subject site.



Plot 2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (e) & (f)

Photo Point 2

Non-vegetated area that is permanently cleared of vegetation (i.e. driveways and residential development).

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass (managed yard).

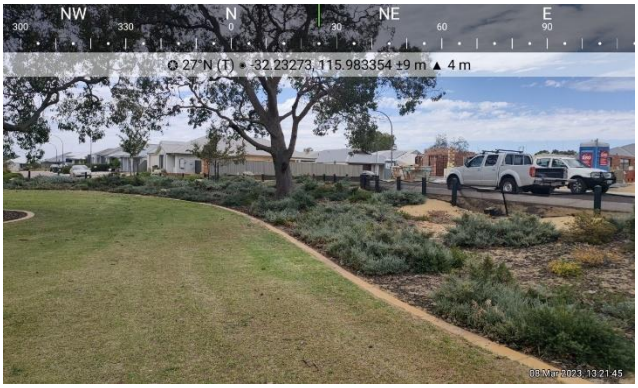
Grass within this property is currently <50 mm in height and is required to be maintained as such in accordance with the Shire of Serpentine Jarrahdale Firebreak Notice.



Plot 2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (f)

Photo Point 3

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass and landscaping.



Plot 2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (e) & (f)

Photo Point 4

Non-vegetated area that is permanently cleared of vegetation (i.e. sheds and residential development).

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass.



Plot 2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (e) & (f)

Photo Point 5

Non-vegetated area that is permanently cleared of vegetation (i.e. sheds and residential development).

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass.

Grass within this property is currently <50 mm in height and is required to be maintained as such in accordance with the Shire of Serpentine Jarrahdale Firebreak Notice.



Plot 2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (f)

Photo Point 6

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass.

Grass within this property is currently <50 mm in height and is required to be maintained as such in accordance with the Shire of Serpentine Jarrahdale Firebreak Notice.



Plot 2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (e) & (f)

Photo Point 7

Non-vegetated area that is permanently cleared of vegetation (i.e. roads and residential development).

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass (managed yards and landscaping).



Plot 2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (f)

Photo Point 8

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass.

Grass within this property is currently <50 mm in height and is required to be maintained as such in accordance with the Shire of Serpentine Jarrahdale Firebreak Notice.



Plot 2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (f)

Photo Point 9

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass.

Grass within this property is currently <50 mm in height and is required to be maintained as such in accordance with the Shire of Serpentine Jarrahdale Firebreak Notice.



Plot	2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (f)

Photo Point 10

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass.

Grass within this property is currently <50 mm in height and is required to be maintained as such in accordance with the Shire of Serpentine Jarrahdale Firebreak Notice.



Plot	2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (f)

Photo Point 11

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass (managed vegetation).



Plot	2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (f)

Photo Point 12

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass (managed yard). Trees are present, however these are sparsely distributed and ground fuel is very well managed.

Grass within this property is currently <50 mm in height and is required to be maintained as such in accordance with the Shire of Serpentine Jarrahdale Firebreak Notice.



Plot	2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (e) & (f)

Photo Point 13

Non-vegetated area that is permanently cleared of vegetation (i.e., roads and residential development).

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass (managed yards and landscaping).



Plot	2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (f)

Photo Point 14

Vegetation within this plot is regarded as low threat due to factors such as flammability, moisture content and fuel load as it is managed grass.

Grass within this property is currently <50 mm in height and is required to be maintained as such in accordance with the Shire of Serpentine Jarrahdale Firebreak Notice.



Plot	2	Classification or Exclusion Clause	Excluded AS 3959: 2018 2.2.3.2 (e)

Photo Point 15

Non-vegetated area that is permanently cleared of vegetation (i.e., roads and residential development).



RELEVANT FIRE DANGER INDEX

The fire danger index for this site has been determined in accordance with Table 2.1 of AS 3959: 2018.

Relevant Fire Danger Index			
FDI 40 ☐	FDI 50 ☐	FDI 80 ☑	FDI 100 ☐
Table 2.4.5	*Table 2.4.4*	*Table 2.4.3*	*Table 2.4.2*

POTENTIAL BUSHFIRE IMPACTS

The potential bushfire impact to the site / proposed development from each of the identified vegetation plots are identified below, Table 1 and Figure 1.

Table 1: BAL Analysis AS 3959: 2018

Plot	Vegetation Classification	Effective Slope	Separation distances required				
			BAL-FZ	BAL-40	BAL-29	BAL-19	BAL-12.5
1	Excluded AS 3959: 2018 2.2.3.2 (a)	-	No separation distances required – BAL-LOW				
2	Excluded AS 3959: 2018 2.2.3.2 (e) & (f)	-	No separation distances required – BAL-LOW				

DETERMINED BUSHFIRE ATTACK LEVEL (BAL)

The determined Bushfire Attack Level (highest BAL) for the proposed works has been determined in accordance with Clause 2.2.6 of AS 3959: 2018 relevant data from the site assessment shown in Figure 2 and Table 2.

Table 2: BAL Assessment summary

BAL	Affected lots	Construction sections to be consulted in AS 3959-2018
BAL-LOW	All proposed lots	3 and 5

Note: This BAL rating is based on the information current at the date of this document and is valid for 12 months.

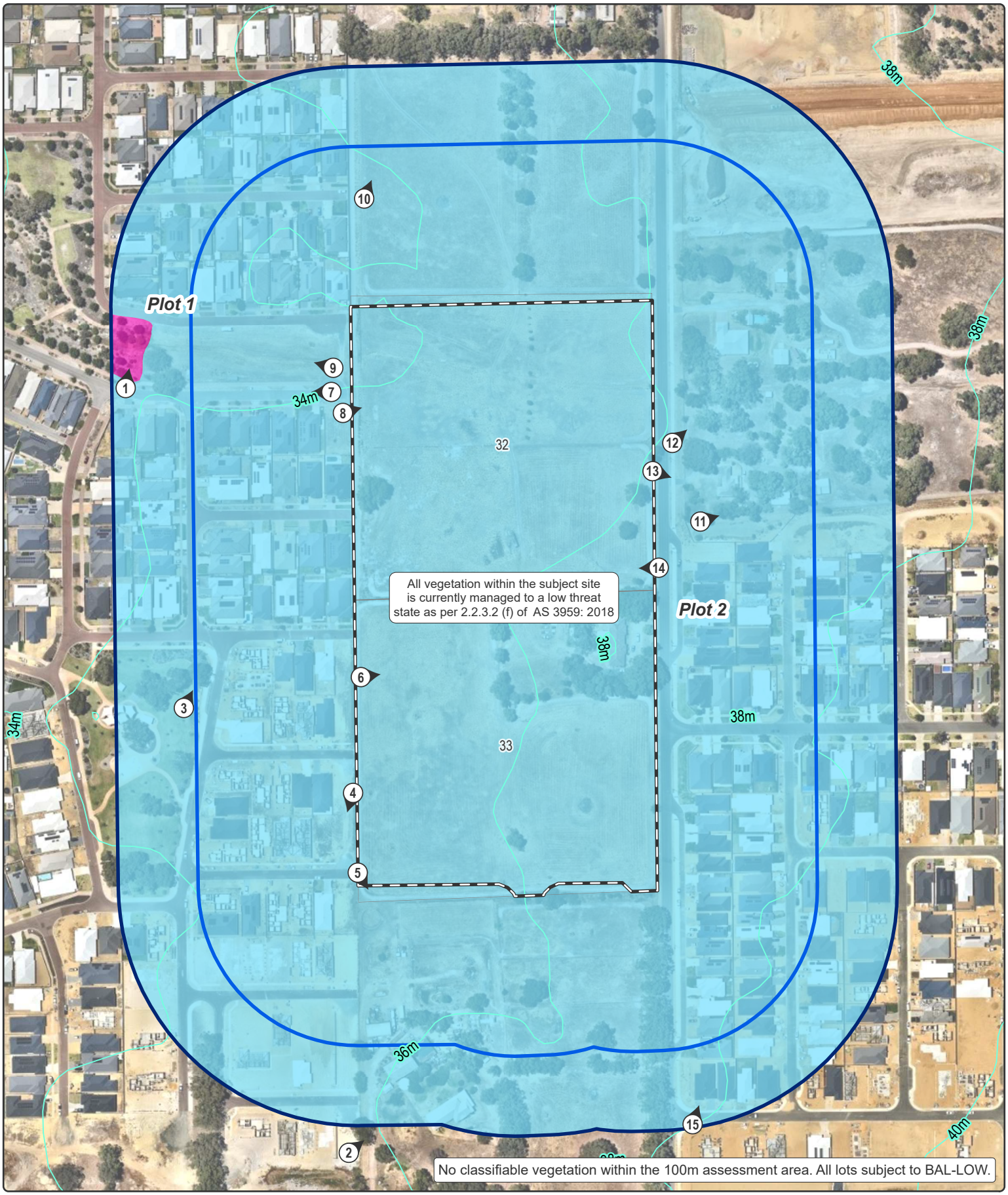


Figure 1: Vegetation Classification

Subject site
100m site assessment
150m site assessment
Photo location
Contour (2m)

Vegetation classification

Excluded as per clause 2.2.3.2 (a)
Excluded as per clause 2.2.3.2 (e) and (f)

0 25 50 100
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2700-SM Date: 21/03/2023

N

eco logical AUSTRALIA
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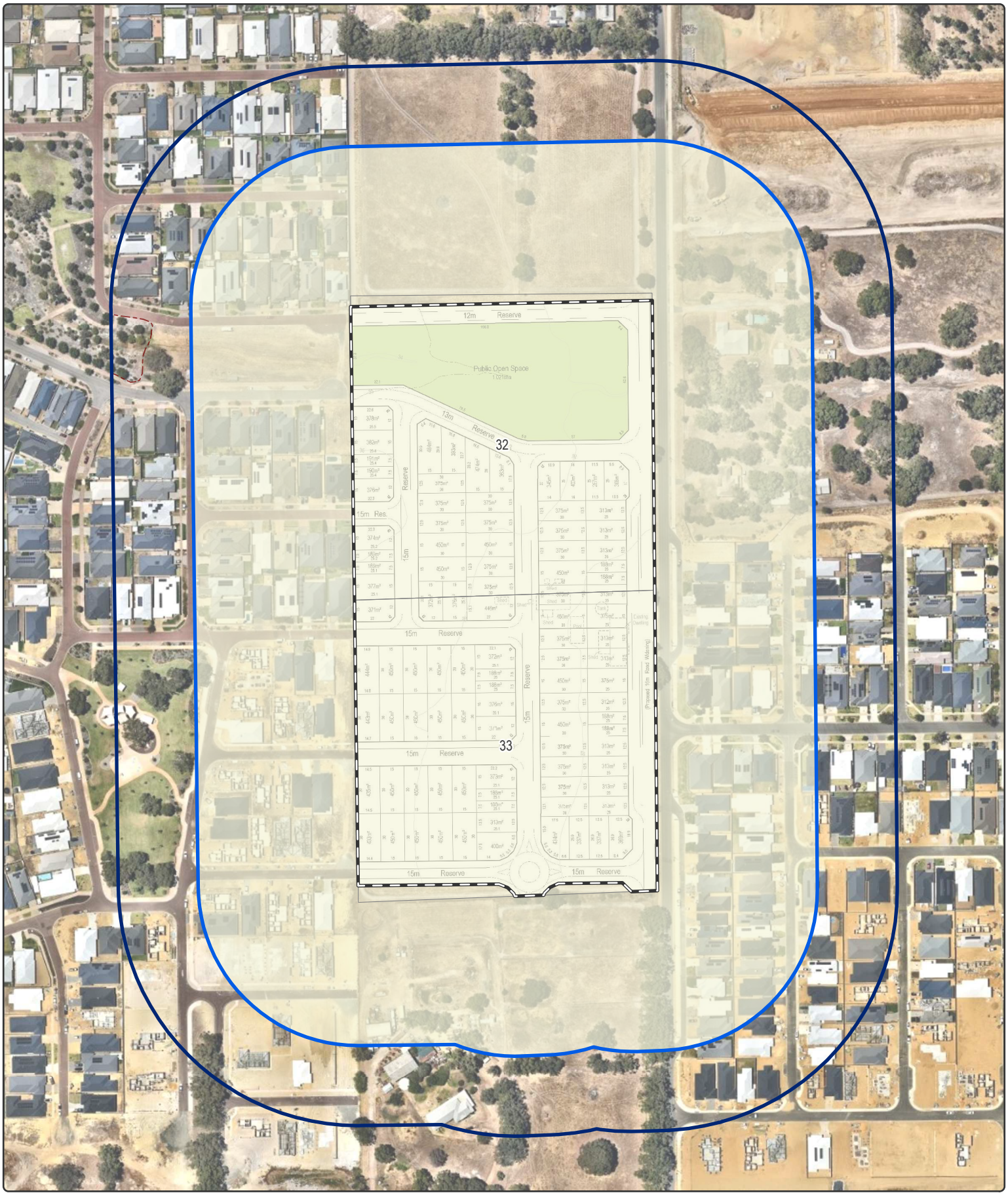


Figure 2: Bushfire Attack Level (BAL) Contours

- Subject site
- 100m site assessment
- 150m site assessment
- Bushfire hazard interface

Bushfire Attack Level (BAL)

- BAL - FZ
- BAL - 40
- BAL - 29
- BAL - 19
- BAL - 12.5
- BAL - LOW

0 25 50 100
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2700-SM Date: 21/03/2023

N

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Appendix A – Additional Information / Advisory Notes

This assessment was undertaken as per AS 3959: 2018. It is important that the current version of AS 3959, is consulted for construction purposes.

This BAL rating is based on the information current at the date of this letter and is valid for 12 months from the date of this letter.

Bushfire Attack Level (BAL) as set out in the *Australian Standard 3959 Construction of Buildings in Bushfire-Prone Areas* (AS 3959), as referenced in the *Building Code of Australia*.

Bushfire Attack Level (BAL)	Classified vegetation within 100 m of the site and radiant heat flux exposure thresholds	Description of predicted bush fire attack and levels of exposure	Construction Section as per AS 3959
BAL-LOW		There is insufficient risk to warrant specific construction requirements.	4
BAL-12.5	≤12.5 kW/m^2	Ember attack	3 and 5
BAL-19	>12.5 kW/m2 ≤19 kW/m^2	Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing radiant heat flux.	3 and 6
BAL-29	>19 kW/m2≤29 kW/m^2	Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing radiant heat flux	3 and 7
BAL-40	>29 kW/m2≤40 kW/m^2	Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing radiant heat flux with the increased likelihood of exposure to flames.	3 and 8
BAL-FZ	>40 kW/m^2	Direct exposure to flames from fire front in addition to radiant heat flux and ember attack	3 and 9

Source: "*AS 3959: 2018 Construction of buildings in bushfire-prone areas*" published by Standards Australia, Sydney

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