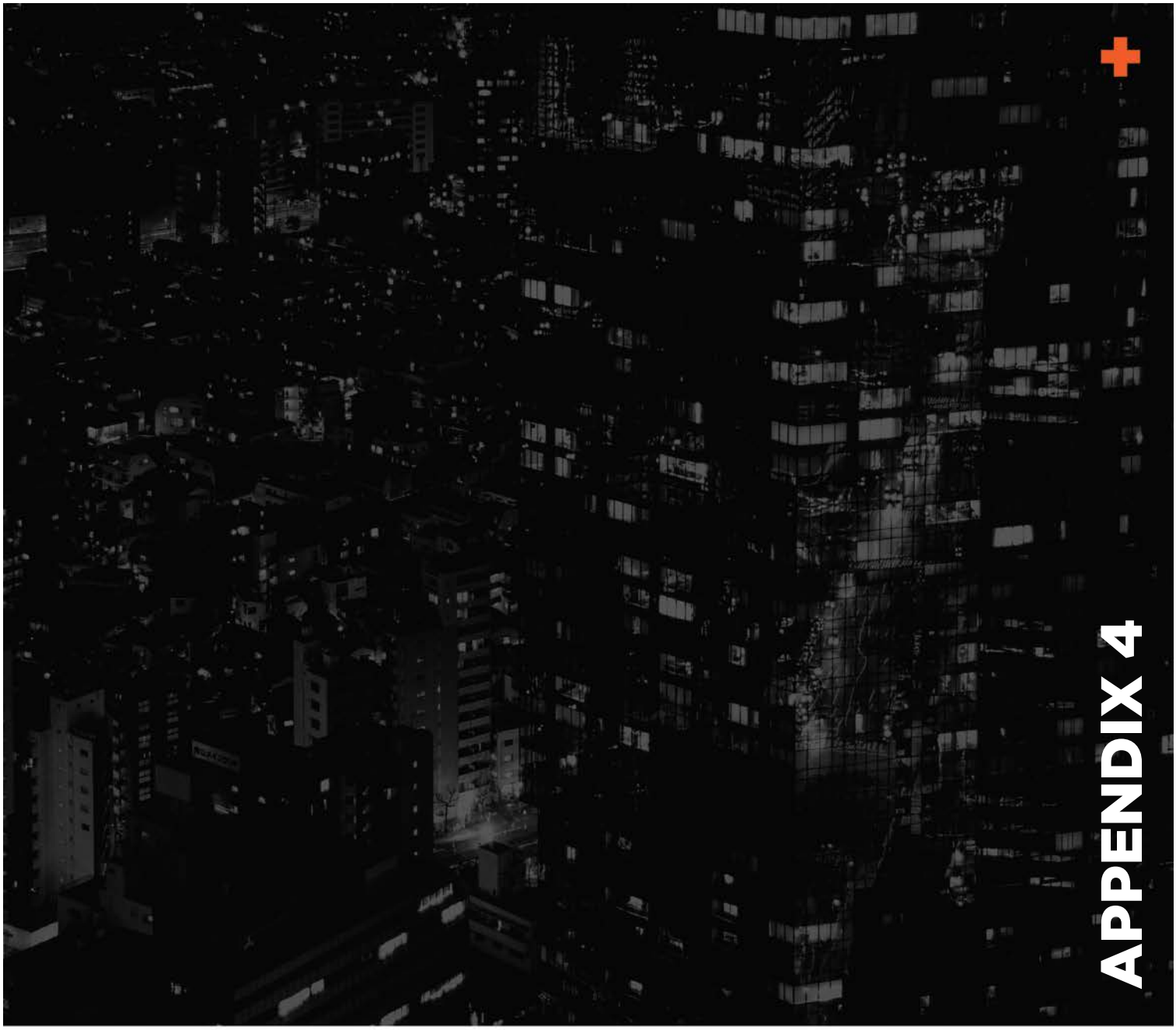

4. DISTRICT/LOCAL WATER MANAGEMENT STRATEGY

Prepared by: JDA

Reference: J6123k

Dated: 9 August 2018

The Glow Development (WA) Pty Ltd

Lot 19 Sixty Eight Road, Baldivis:

District/Local Water Management Strategy

August 2018

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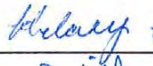
Author	Hilary Chin		9 August 2018
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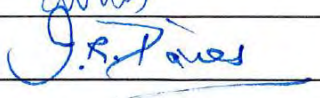
Approved by	Jim Davies		9 August 2018

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1. INTRODUCTION

1.1 Background

The Lot 19 Sixty Eight Rd, Baldivis District/Local Water Management Strategy (DWMS/LWMS) has been prepared by JDA Consultant Hydrologists on behalf of the Glow Development (WA) Pty Ltd (hereafter referred to as the Study Area). The Study Area is within the City of Rockingham, located approximately 13.5 km southeast of the Rockingham town site and approximately 50 km south of Perth (Figure 1).

1.1.1 Regional Planning

The Study Area is zoned 'Urban' under the Metropolitan Regional Scheme (Map Sheet 31).

1.1.2 District Planning

Consistent with the Better Urban Water Management (WAPC, 2008) and policy measures outlined in the State Planning Policy 2.9: Water Resources, the proposed scheme amendments to Urban shall be supported by a District Water Management Strategy (DWMS). The DWMS is to demonstrate that the subject area can support the proposed change in zoning with regard to water quality and quantity, to inform future structure plans.

Lot 19 is located in a very conducive environment. It has greater than 10 m separation to the groundwater and is located in the Spearwood Sands Formation on sand with high infiltration rate and high capacity to store nutrients, particularly phosphorus. As such, the proposed change in zoning is unlikely to give any adverse impact on water quality and quantity regime of the area.

As there is no District Water Management Strategy (DWMS), based on the lot size and a very conducive environment, this document fulfils the requirements for both the DWMS and LWMS.

1.1.3 Local Structure Plan

The DWMS/LWMS is presented in support of a request to lift the Urban Deferred zone under MRS (completed 27 October 2016; Appendix A) and a Local Structure Plan (LSP) as part of the Better Urban Water Management Framework (WAPC, 2008).

The DWMS/LWMS addresses the LSP and provides a refinement of the flood modelling, surface water management strategy and groundwater management strategy to a local scale. This DWMS/LWMS is consistent with water sensitive urban design practices as described in the Stormwater Management Manual of WA (DoW, 2007).

1.2 Key Design Principles and Objectives

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

- Stormwater Management Manual for Western Australia (DoW, 2007).
- Better Urban Water Management (WAPC, 2008).
- City of Rockingham Planning Procedure 1.8 – Water Sensitive Urban Design (City of Rockingham, 2015).
- Adoption Guidelines for Stormwater Biofiltration Systems (CRC, 2015).

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

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

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

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

DoW has recently completed a major review of the Manual in consultation with a working team comprising industry and government representatives. The revised manual was officially launched in August 2007.

DoW's current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: *Understanding the Context of the Stormwater Management Manual for Western Australia* (DoW, 2007), which details the management objectives, principles and a stormwater delivery approach for WA. Principle objectives for managing urban water in WA are stated as:

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

1.2.2 Better Urban Water Management (WAPC, 2008)

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

This LWMS complies with the BUWM process.

1.2.3 City of Rockingham Planning Procedure 1.8 – Water Sensitive Urban Design (City of Rockingham, 2015)

The City of Rockingham Planning Procedure 1.8 Water Sensitive Urban Design (WSUD) is a guideline used to assist the city in making decisions under the Planning and Development (Local Planning Schemes) Regulations 2015 (gazetted on 25 August 2015 and took effect on 19 October 2015) and the Town Planning Scheme no. 2 District Zoning Scheme (City of Rockingham, 2016). This planning procedure used alongside the Adoption Guidelines for Stormwater Biofiltration Systems (CRC, 2015) are the City's guidelines to provide the protection and conservation of all water resources within the City, along with the wetland and bushland areas, including the Peel Harvey Estuary.

The planning procedure provides environmental quality criteria including design objectives for water conservation, water quality protection, water quality management, stormwater modelling criteria and disease vector and nuisance insect management.

TABLE 1: SUMMARY OF DESIGN PRINCIPLES AND OBJECTIVES

Key Guiding Principles		
• Facilitate implementation of sustainable best practice urban water management. • Provide integration with planning processes and clarity for agencies involved with implementation. • To minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation. • Encourage environmentally responsible development. • Facilitate adaptive management responses to the monitored outcomes of development.		
Category	**DWMS Objectives**	**LWMS Criteria**
Surface Water Management	• Minimise changes in hydrology to prevent impacts on receiving environments. • Manage water flows from major events to protect infrastructure and assets. • Apply the principles of WSUD. • Adopt nutrient load reduction design objectives for stormwater runoff. • Floodplain management and urban drainage. • Adopt treatment train approach.	• Post-development critical 100yr ARI peak flow shall be retained on site • On site retention of 1 year 1 hour event runoff and use of planted roadside swales (where possible) to achieve water quality treatment objectives. • Manage surface water flows from major events to protect infrastructure and assets from flooding and inundation. • Retention of stormwater at source and infiltration basins located in Public Open Space (POS)
Groundwater Management	• Manage groundwater levels to protect infrastructure and assets. • Maintain groundwater regimes for the protection of groundwater-dependent ecosystems. • Protect the value of groundwater resources. • Adopt nutrient load reduction design objectives for discharges to groundwater.	• Managing and minimising changes in groundwater levels and groundwater quality following development.
Monitoring and Implementation	• Adopt an adaptive management approach. • Maintain drainage and treatment structures.	• Design based on methodology in the Stormwater Management Manual (DoW, 2007) of adopting structural and non-structural measures to reduce applied nutrient loads.
Water Conservation	• Adopt drinking water consumption target. • Ensure that non-potable water supply systems deliver a net benefit to the community. • Ensure that non-potable water supply systems are designed as part of an integrated water supply.	• Aim to achieve the State Water Plan target for water use of 100 kL/person/yr. • Consider alternative fit for purpose water sources where appropriate and cost-effective.

2. PROPOSED DEVELOPMENT

Lot 19 (herein referred to as the Study Area) is 9.12 ha and situated within the southern corridor of the Perth Metropolitan Region, approximately 50 km south of the Perth Central Business District (Figure 1).

The proposed land use is for residential development consistent with regional planning (Appendix A). The structure plan for the Study Area is shown on Figure 1.

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

- Use of structural and non-structural measures to reduce applied nutrient loads;
- Retention of stormwater at source and infiltration at Public Open Space (POS); and
- Local native plants make up a minimum 50% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements.

3. PRE-DEVELOPMENT ENVIRONMENT

3.1 Existing Land Use

The northern portion of the Study Area contains native vegetation whilst the southern portion has been cleared for previous market garden purposes.

3.2 Climate

The Baldivis area is characterised by a Mediterranean climate with warm dry summers and cool wet winters. Rainfall data is available from the nearby Bureau of Meteorology (BoM) Medina Research Station (Site No. 9194).

The long term average annual rainfall is 747 mm (1986 to 2015). This average has decreased between 2005 to present, to an average annual rainfall of 661 mm, reflecting a 12% reduction compared to the long term average, consistent with a general trend in the South West of WA.

The average (from 1983 to 2015) annual pan evaporation is 1725 mm, as estimated from data recorded at Medina Station, with monthly distribution shown in Figure 2.

3.3 Existing Vegetation

An Environmental Assessment was carried out by PGV Environmental (2015). A summary of the results of the Flora and Vegetation Survey are as follows:

- Native vegetation occurs on approximately 4ha of the site. Two woodland vegetation types were recorded with Tuart, Jarrah, Sheoak (Allocasuarina fraseriana) and Banksia attenuate the dominant species. Native understorey was low and sparse to absent.
- The condition of the vegetation was rated as good – Degraded in the northern portion and Completely Degraded (parkland cleared) in the southern portion.
- A total of 73 plant species were recorded on the site including 44 native and 29 introduced species. The low number of native species and high proportion of introduced species (40%) reflected the poor condition of the understorey vegetation;
- No Threatened (Declared Rare), Priority or other conservation significant species were recorded on the site;
- The vegetation is part of the Karrakatta – Central and South vegetation complex but is considered too degraded to be a good example of this vegetation complex;
- The vegetation is too degraded to be assigned to a Floristic Community Type;
- The trees provide some habitat value to avifauna (birds and bats) but the understorey is too open and degraded to have much value for ground-dwelling fauna; and
- The vegetation is not part of any local or regional linkage.

In summary the environmental assessment conducted across the Study Area (PGV, 2015) reported existing vegetation to be heavily disturbed and highly degraded. Concurrently vegetation retention was not a recommendation of the EAR.

The large majority of existing native vegetation resides within the northern portion of the development where it is necessary to remove fill, consequently it is unlikely existing native vegetation will remain in this area.

However as part of the subdivision works all mature and ecologically significant trees will be maintained where possible.

3.4 Topography

Topography of the site is undulating with a high of 34 mAHD at the northeast corner of the Study Area. The topography falls toward the southern end to a low point of approximately 14 mAHD approximately 90 m north of the Sixty Eight Road (Figure 3).

3.5 Geology and Soils

Surface geology mapping by Gozzard (1983) is shown on Figure 4. The area is underlain by sand derived from the weathering of Tamala Limestone.

The Study Area is situated in the Spearwood Sands Formation (S7), described as: *pale yellowish brown, medium to coarse-grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin* (Gozzard, 1983). Sands from Spearwood Formation have very little capacity to store water (Salama, et al., 2005). The yellow Spearwood sands are known to have a relatively high phosphorus holding capacity due to high phosphorus retention index (PRI) of up to 10 (DAFWA, 2013), which is good to reduce phosphorus export to the environment.

A geotechnical investigation was completed by Galt Geotechnics in October 2015 (Galt, 2015). The investigation included 10 bore holes (BH1 to BH10) between 3 and 5 m depth. Dynamic Cone Penetrometer testing was also conducted at the 10 test pit locations with a maximum depth of 1.95 m below existing ground surface. The geotechnical report with lithological logs of the test pits is included as Appendix B with bore holes locations shown on Figure 4.

3.6 Hydraulic Conductivity

Hydraulic conductivity testing was completed on site by JDA using a Borehole Permeameter on 15 February 2016. The locations of testing (TP1, TP2, TP3, and TP4) is shown in Figure 4, with efforts made to test locations in proposed infiltration basins.

Testing was conducted at depths of 0.5 m with three or four replicates at each testing location. The soils were saturated prior to the test so that results are representative of the saturated hydraulic conductivity (K_{sat}). Test results are provided in Appendix C, and summarised in Table 2.

TABLE 2: MEASURED HYDRAULIC CONDUCTIVITY

Test Site	Easting	Northing	K_{SAT} (m/day)
TP1	388859	6419253	88
TP2	388886	6419239	57
TP3	388867	6419224	113
TP4	388790	6418844	31

3.7 Site Contamination

There are no known sources of contamination with the Study Area (DEC, 2009a).

A preliminary site investigation by PGY Environmental (2015) determined the northern part of the site to have a very low potential to be contaminated. No further investigation was recommended for most of the northern area unless materials are unearthed during earthworks.

The shed in the northern part of the site and the southern part of the site, which was previously used for a market garden, will require further investigation. Sampling and testing is to be carried out when the local structure plan or subdivision has been finalised to pinpoint areas which will require investigation (PGV Environmental, 2015).

3.8 Acid Sulphate Soils

Based on the Acid Sulphate Soil Risk Mapping (DER, 2014) in Figure 4, the area does not have Acid Sulphate Soils (ASS) Risk within 3 m of natural soil surface.

3.9 Surface Water Hydrology

There is no existing surface drainage within the Study Site.

The site borders the Peel Main Drain Sub-Catchment to the east which forms part of the Peel-Harvey Drainage Catchment.

3.10 Wetlands

There are no existing wetlands or any water dependent ecosystems within or adjacent the study area (Figure 3).

3.11 Groundwater Hydrology

There are two aquifers of significance underlying the Study Area; each assigned the name of the major geological unit containing it. In descending order of depth from natural surface they are:

- Superficial Aquifer (unconfined, +3 to -15 mAHD)
- Leederville Aquifer (confined, -15 to –250 mAHD)

3.11.1 Superficial Aquifer

The Superficial Aquifer in Baldivis is part of the Stakehill Mound area with flow in a southeast direction towards Serpentine River. The saturated thickness of the aquifer is approximately 17m and consists of sand and limestone with an average transmissivity of 1000m^2/d. The salinity of the aquifer is generally 500-1000mg/L (Davidson & Yu, 1995).

There are no groundwater level monitoring bores installed in the Study Area. The closest DoW monitoring bores are AWRC Ref 61410063 (T340(O)) and 61410064 (T340(I)) to the north and 61410063 (T430(O)) and 61410064 (T430(I)) to the south, locations presented in Figure 5.

Groundwater Levels for May 2003 (DoW, 2004) are between 2 to 3 mAHD (Figure 5), more than 10 m below ground level.

The time-series plots of the four DoW monitoring bores provided in Figure 6 show the seasonal variation of the water table is about 1.0 m, with maximum in September-October and minimum in April-May. Maximum groundwater levels (MGL) are expected to be approximately 1.5 m above the contours shown in Figure 5.

Water quality of the Superficial Aquifer is described in Hydrochemical Assessment of the Superficial Aquifer (DoW, 2010). The average (2003-2007) measurement of pH and TDS of the Superficial Aquifer are approximately 6-6.5 and 800-1050 mg/L, respectively (Figure 7).

3.11.2 Leederville Aquifer

The Leederville Aquifer is of Cretaceous age and consists of interbedded sandstone, siltstone and shales made up by the Mariginiup, Wanneroo and Pinjar Members and the Henley Sandstone Formation. The Leederville Aquifer is a major regional aquifer, from which large yields of fresh groundwater can be obtained. The groundwater in the Leederville Formation is confined with the potentiometric surface in this area at approximately ground level (Davidson, 1995).

3.11.3 Groundwater Resources for Irrigation

The Superficial Aquifer is the most cost effective groundwater source for the development.

The Study Area is located within the Superficial Formation Stakehill Groundwater Area and the Outridge Groundwater Sub-area. Groundwater Well Licence (GWL) GWL183032(1) with an of allocation 24,875 kL/yr for irrigation and earthworks dust suppression was issued on 12 September 2016 and expires on 11 September 2026 (Appendix H).

4. LOCAL WATER MANAGEMENT STRATEGY

4.1 Water Balance

The water balance of the site will be influenced by the frequency and intensity of rainfall and evapotranspiration. The most reliable estimates of rainfall, evaporation, transpiration and recharge are at regional scales. Annual average values have been assumed and the site has been considered as a whole, without further detailed assessment of the various land uses.

Pre-development Water Balance

The pre-development water balance assumptions are as follows:

- Rainfall based on the long term annual average for Medina Research Station of 750 mm,
- Soil moisture is 2% for the site soil matrix of 8 m depth,
- Recharge is 9% of rainfall as estimated in Davidson and Yu (2008).

Post-development Water Balance

Assumptions for the post-development water balance are;

- Water supply for all Public Open Space (POS) irrigation will be met by local groundwater supplies. An irrigation rate of 6750 kL/ha/yr is assumed consistent with DoW allocation,
- 10% of landowners assumed to have a private bore for irrigation supply,
- Soil moisture 2% for the site soil matrix of 8 m depth.

Results of the site water balance are presented in Table 3, showing increase in recharge post-development.

TABLE 3: SITE WATER BALANCE

Pre Development		Use	Area (ha)	Quantity mm/yr		Total kL/yr	%
Inputs	**Rainfall**		9.12	750		68,400	100
					Input total	68,400	100
Outputs							
	Evapotranspiration	*Native Bush*	5.47	600		32,820	47
		Rural (Cleared)	3.65	400		14,600	21
	Soil Moisture Storage		9.12	160		14,592	21
	Superficial Aquifer Recharge		9.12	70		6,388	9
					Output Total	68,400	100
					Balance	0	
Post Development		**Use**	**Area (ha)**	**Quantity mm/yr**		**Total kL/yr**	**%**
Inputs	**Rainfall**		9.12	750		68,400	93.5
	Groundwater Abstraction	*Parks*	0.65			4,388	6.0
		Private gardens	0.05			338	0.5
					Input total	**73,125**	100
Outputs							
	Evapotranspiration	*Residential*	3.8	350		13,300	18
		Parks	0.65	1200		7,800	11
	Soil Moisture Storage		9.12	160		14,592	20
	Superficial Aquifer Recharge		9.12	410		37,433	51
					Output Total	**73,125**	100
					Balance	0	

4.2 Water Use & Sustainability Initiatives

4.2.1 Water Supply

Public Open Spaces

Considering the fit for purpose strategy, water supply for POS is proposed to be from local groundwater resources.

Residential Lots

Water supply to households will be via extension of the scheme water system. The project civil engineer will negotiate the extension of the system with Water Corporation.

4.2.2 Water Efficiency Measures

Public Open Spaces

The estimated irrigated POS area for the development is 0.65 ha which will require approximately 4,875 kL/yr, assuming 7,500 kL/ha/yr. This will be sourced from the superficial groundwater reserves consistent with a fit for purpose strategy. Landscaped POS areas are to be at least 50% native plants, with water wise irrigation system design. A preliminary breakdown of anticipated irrigation areas and associated irrigation requirement is provided below in Table 4.

TABLE 4: PRELIMINARY BREAKDOWN OF IRRIGATED AREAS

Location	Total Area (ha)	Garden Beds (ha)	Turfed Area (ha)
Catchment A - POS	0.53	0.23	0.31
Catchment B - POS	0.12	0.04	0.07
Total	**0.65**	**0.27**	**0.38**

At this stage the preferred method of watering street trees (establishment only) is expected to be by a connection to private lots.

Development Area

Water conservation measures will be encouraged to reduce scheme water consumption within the development and include:

- All houses built to current Building Commission Australia water efficiency standards including water efficient fixtures and fittings (taps, showerheads and toilets) and waterwise landscaping;
- Use of native plants in POS/Neighbourhood Park /street verges; and
- Use of fit for purpose groundwater resource for irrigation of POS and vegetated areas.

4.3 Stormwater Management

4.3.1 Local Stormwater Management

The stormwater drainage system will be designed using a major/minor approach. The major drainage system is defined as the arrangement of roads, drainage reserves, detention basins, potential underground storage units and Public Open Space (POS). The major drainage system is planned to provide safe passage of stormwater runoff from major events which exceed the capacity of the minor system, typically greater than 5yr ARI. The major drainage system is described below with the key elements of the drainage system shown in Figure 8.

The minor drainage system is defined as the series of roadside swales, pipes, kerbs, potential underground storage units and gutters, etc. designed to carry runoff generated by low frequency ARI storms, typically less than 5yr ARI. The minor drainage incorporates water quality structural controls such as vegetated storage systems on local soils with high phosphorus retention capability that is sufficient to provide water quality treatment for stormwater generated from the proposed development.

Major Drainage System

The major drainage system is designed to manage rainfall events greater than the 5yr ARI, up to the 100yr ARI.

The design strategy is consistent with the objectives provided in the Stormwater Management Manual (DoW, 2007). Key points of the major drainage system are as follows:

- All lot finished levels will have a minimum 0.3 m clearance above the estimated 100yr ARI flood level of the retention storages;
- Roads graded to direct flow to the lowest point in the catchment; and
- At the low point (where practical), verges graded to drain flows off the street into the retention storage (POS). The POS storage area above the 1yr 1hr ARI event will have 1 in 6 side slopes.

The drainage basin for Catchment A is intended to be consolidated with the drainage basin in the adjacent Lot 20 POS. Rainfall runoff from Catchment B is currently proposed to be stored in either an underground storage unit (see Figure 8), roadside swales or a combination of both. Both options will be further refined

at detailed design stage. Currently there is sufficient area within the southern POS to carry out either option and contain runoff up to the 100yr ARI; see Figure 8 for indicative location. Results presented in Table 6 are for the underground storage option.

Minor Drainage System

The minor drainage system is designed to manage rainfall events up to the 5yr ARI. The minor drainage system incorporates management of the 1 year 1 hour ARI storm event for water quality. Stormwater runoff from Catchment A (and potentially Catchment B) will be managed by road side bio-retention swales. In Catchment A, the swales will be positioned around the northern and southern boundary of the linear POS (shared with neighbouring Lot 20), with each swale sized to store and infiltrate a portion of the 1yr 1 hr storm event. The roadside swales will be positioned within the road reserve, see Figures 8 and 9 for indicative locations. The roadside swales will be 0.3 m deep and feature nutrient stripping vegetation planted in the existing natural sands which have an elevated Phosphorus Retention Index (PRI) of $\geq$10 (DAFWA, 2013) to improve stormwater quality as it infiltrates to the aquifer.

To meet the design criteria for the minor drainage system, the following strategies are proposed:

- Soakwells will be adopted for lot drainage provided to infiltrate the 1yr 1hr ARI rainfall event;
- The roadside pipe network will be sized to convey the 5yr ARI flow; and
- The use of open base manholes for infiltration of road drainage will be adopted (wherever practicable) consistent with DoW stormwater management principles.
- Roadside swales in the road reserve around the POS to infiltrate localised road runoff. Swales are typically 0.3 m deep with 1 in 6 side slopes and planted with vegetation to strip nutrients from the stormwater.
- Bio-retention basin within the POS to capture and treat stormwater runoff exceeding the roadside swales, up to the 1yr 1hr ARI event. The conceptual basin design is 0.3 m deep with vertical walls.

4.3.2 Surface Water Modelling

Due to high separation to the groundwater and high soil hydraulic conductivity, all stormwater runoff (up to 100 year ARI) will be retained within the Study Area and infiltrated within lots (up to 1 year ARI) and POS.

The Study Area is proposed to be divided into three stormwater catchments based on preliminary earthwork plans with the school retaining its own stormwater runoff. Catchment areas are presented in Table 5.

A runoff coefficient of 80% has been adopted for roads. After reviewing the lot sizes, JDA considers a 30% lot contribution appropriate when sizing basins due to the density of the housing to be provided in the Study Area. Lots were assumed to infiltrate the 1 yr ARI and do not contribute runoff in the 1 yr ARI.

To calculate the stormwater runoff generated, the runoff coefficients presented in Table 5 have been used.

TABLE 5: LAND USE RUNOFF PARAMETERS FOR INFIL MODEL

Land Use	Runoff Coefficient (%)	Catchment Areas (ha)		
		A	B	C
Lots	30	3.02	0.78	-
Road Reserve	80	1.60	1.09[1]	-
POS	10	0.52	0.12	-
School	50	-	-	2.65
Catchment Area	**-**	**5.14**	**1.99**	**2.65**
Total Area	**-**		**9.78**	

Note

1. Includes 0.60 ha external Sixty Eight Rd catchment

Calculation of Soil Infiltration Rate (K_{sat}) Utilised for INFIL

Based on the separation to groundwater, the infiltration model INFIL was selected to determine the 1yr1hr, 5yr, 10yr, and 100yr ARI storage requirements.

TP1 to TP3 (Section 3.5) were carried out in the location of Catchment A infiltration basin with an average hydraulic conductivity recorded of >50 m/day. Based on the results and JDA experience from other infiltration testing of similar soil types, a K_{sat} of 50 m/day is considered representative of the northern POS. A soil moderation factor of 0.5 is applied to field measurements consistent with guidance provided in Chapter 9, Section 3.1 of the Stormwater Management Manual (DoW, 2009) to derive a design K_{sat} value of 25 m/day. A clogging factor of 0.5 was further applied, and a K_{sat} of 12.5 m/day was used in the INFIL model.

TP4 was carried out in the location of Catchment B retention basin. The average hydraulic conductivity recorded was >30 m/day. Based on the results, a K_{sat} of 30 m/day is considered representative of the southern POS. With a soil moderation factor of 0.5 applied, a design K_{sat} value of 15 m/day is derived. A clogging factor of 0.5 was further applied, and a K_{sat} of 7.5 m/day was used in the INFIL model.

No infiltration testing was carried out within the school site. For concept design purposes, a conservative hydraulic conductivity of 5 m/day was used. Permeameter testing should be carried out at UWMP stage to determine site specific hydraulic conductivity.

Results from the INFIL modelling for major and minor storm events, including the retention areas required for each catchment are presented in Tables 6 and 7, respectively. The maps of proposed stormwater system and event plan are provided in Figures 8 and 9. Preliminary engineering drawings are provided in Appendix D and concept landscape plans are provided in Appendix E.

TABLE 6: MAJOR STORM EVENTS DRAINAGE MODELLING RESULTS

Post Development Catchments	A	B	C
Catchment Area (ha)	5.14	1.86	2.65
Storage Invert (mAHD)	21.0	18.0	20.5
Basin Base Area (m^2)	115	120	330
>1 yr ARI Tier Area (m^2)	540	-	-
>1 yr ARI Side Slopes	Walls	-	-
>5 yr ARI Side Slopes	1:10	-	-
Depth to Estimated MGL (m)	18	15	17.5
K_{sat} (m/day)	12.5	7.5	5
10 year ARI			
Impervious Catchment Area (ha)	2.28	1.12	1.33
Critical Storm Duration (hrs)	1	1	1
Storm Rainfall (mm)	29.0	29.0	29.0
Runoff Volume (m^3)	663	325	385
Water Level Rise (m)	0.8	0.50	0.55
Top Water Level TWL (mAHD)	21.80	18.50	21.05
Area at TWL (m^2)	610	450	480
Stored Volume (m^3)	295	165	200
Stored Volume/Runoff Volume (%)	44	51	52
100 year ARI			
Impervious Catchment Area (ha)	2.28	1.12	1.33
Critical Storm Duration (hrs)	1	1	1
Storm Rainfall (mm)	46.5	46.5	46.5
Runoff Volume (m^3)	1063	521	620
Water Level Rise (m)	1.15	1.1	0.75
Top Water Level TWL (mAHD)	22.15	19.1	21.55
Area at TWL (m^2)	1055	450	770
Stored Volume (m^3)	615	320	390
Stored Volume/Runoff Volume (%)	58	61	63

Note

1. Detailed drainage of these areas will be addressed in the UWMP.
2. Storage inverts and catchment areas are based on the Project Engineers (Pritchard Francis) Engineering Servicing Report (Appendix D). The actual catchment areas and storage inverts are subject to refinement at detailed design in the UWMP.

TABLE 7: MINOR STORM EVENTS DRAINAGE MODELLING RESULTS

Post Development Catchments	A	B	C
Catchment Area (ha)	5.14	1.32	2.65
Storage Invert (mAHD)	21.0	18.0	20.5
Basin Base Area (m^2)	115	120	330
1 yr ARI Side Slopes	Walls	-	-
>1 yr ARI Tier Area (m^2)	540	-	-
>1 yr ARI Side Slopes	Walls	-	-
Depth to Estimated MGL (m)	18	15	17.5
K_{sat} (m/day)	12.5	7.5	5
1 year ARI (BASIN)			
Impervious Catchment Area (ha)	1.32	0.87	1.33
Critical Storm Duration (hrs)	0.5	1	1
Storm Rainfall (mm)	12	16	16
Runoff Volume (m^3)	158	139	210
Water Level Rise (m)	0.3	0.15	0.25
Top Water Level TWL (mAHD)	21.30	18.15	20.75
Area at TWL (m^2)	115	450	330
Stored Volume (m^3)	35 (remainder 15 in swales)	35	70
Stored Volume/Runoff Volume (%)	22	33	33
Treatment Area/Impervious Area (%)	1.5	3.4	2.5
5 year ARI			
Impervious Catchment Area (ha)	2.28	1.12	1.33
Critical Storm Duration (hrs)	1	1	1
Storm Rainfall (mm)	25.6	25.6	25.6
Runoff Volume (m^3)	585	289	340
Water Level Rise (m)	0.70	0.40	0.50
Top Water Level TWL (mAHD)	24.70	18.40	21.00
Area at TWL (m^2)	540	450	440
Stored Volume (m^3)	240	135	160
Stored Volume/Runoff Volume (%)	41	47	47

Note

1. Detailed drainage of these areas will be addressed in the UWMP.
2. Storage inverts and catchment areas are based on the Project Engineers (Pritchard Francis) Engineering Servicing Report (Appendix D). The actual catchment areas and storage inverts are subject to refinement at detailed design in the UWMP.

4.4 Groundwater Management

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

The objectives are to:

- Manage groundwater levels to protect infrastructure and assets,
- Maintain groundwater regimes for the protection of groundwater dependent ecosystems,
- Protect the value of groundwater resources, and
- Adopt nutrient load reduction design objectives for discharges to groundwater.

Based on a desktop investigation outlined in Section 3, there is more than 10 m clearance to groundwater for the entire Study Area (Figure 6). The minimum of habitable floor level of 1.5 m above the Maximum

Groundwater Level (MGL) is therefore met. Changes to groundwater levels will not impact on the development.

Detailed cross sections including stormwater pits and pipes and detailed designed of drainage is to be undertaken at subdivision stage and included in the UWMP.

Finished lot levels are a detailed design issue to be addressed during preparation of the UWMP and submitted for council approval at that stage.

On behalf of the client, a 5C groundwater license for irrigation of POS areas and construction earthworks was submitted to the DoW on 22nd June 2016. The license application is for the extraction of approximately 49,875 kL/yr; following license approval further details will be included in the forthcoming UWMP.

4.5 Water Quality Management

4.5.1 Nutrient Source Controls

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

Non-structural source controls to reduce nutrient export from the site need to focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed;

- Local native plants make up a minimum 50% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements, and
- Street sweeping. The UWMP will outline the schedule and cleaning requirements for street sweeping which will be co-ordinated with the City of Rockingham.

Structural source controls are proposed to compliment the non-structural source controls and provide a complete treatment train for stormwater movement through the development. The following structural controls are considered appropriate for the development area;

- The use of bio-retention systems to treat road runoff. Treatment to be in the form of bio-retention storages and rain gardens. A minimum treatment capacity of approximately 2% of the connected impervious area will be provided;
- All inlets to any underground storage basins to have a gross pollutant control structure subject to the City's preference, location of inlet and gross pollutant control structure to be determined as part of detailed design; and
- The GPT will be sized to treat the 3 month ARI but with capacity to bypass the 5yr ARI.

The minimum specifications for all bio-retention systems (swales and storages) are presented in Table 8.

TABLE 8: MINIMUM SPECIFICATIONS FOR BIO-RETENTION SYSTEMS

Item	Specification
In Situ Soil	• Natural soil medium
Plant selection	• As per south-west vegetation guidelines (Monash University, 2014) • Tolerant of periodic inundation and extended dry periods. • Spreading root system. • Preferential selection of endemic and local native species. • Planting to provide 70-80% coverage at plant maturity.
Planting density and distribution	• As per south-west vegetation guidelines (Monash University, 2014) • Planting density appropriate for species selection. • Even spatial distribution of plant species.

Details of plant selection, maintenance and likely nutrient uptake in the Baldivis environment are not well known at this stage. The specifications provided in this document should be considered as the best available information at the time. Some flexibility in the specifications will be required as the knowledge base increases.

4.5.2 Land Use Change Nutrient Impacts

The UNDO (Urban Nutrient Decision Outcomes) decision support tool (DoW, 2016) has been used to help quantify the nutrient inputs for the post-development scenario. The UNDO tool analyses inputs for Total Phosphorus and Total Nitrogen only. The calculation is provided in Appendix F.

Results from UNDO Modelling show that 613.1 kg/yr of Nitrogen and 135.6 kg/yr of Phosphorus enter the treatment train within the Study Area. Following treatment by the natural soils (Spearwood Sand) 56.71 kg/yr (91%) of Nitrogen and 1.07 kg/yr (99%) of Phosphorus is removed within the soil profile. Considering the impact of the natural soils to effectively attenuate nutrients and the significant depth to groundwater the implementation of structural and non-structural controls to remove Nitrogen and Phosphorus was not deemed necessary in this instance.

5. IMPLEMENTATION

5.1 Urban Water Management Plan (Subdivision)

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

Further works that are identified for inclusion in the UWMP include:

- Groundwater monitoring snapshot prior to subdivision which will include collecting one sample from a groundwater supply bore.
- Design of treatment structures, vegetated swales and ephemeral storages as outlined in the Stormwater Management Manual (DoW, 2007).
- Amended soil media will be used in treatment structures and will include a filter, transitional and drainage layer as per DoW guidelines for bio-filters (DoW, 2011) and Monash University vegetation (Monash University, 2014). A suitable amended soil media will be agreed upon at detailed design stage.
- Testing of in-situ soil media should be completed to determine if the existing soil profile meets the minimum specifications for bio-retention systems, outlined in Table 8.
- Where appropriate stormwater treatment areas in excess of 2% of the connected impervious area will be reduced through detailed design, ensuring a minimum treatment area of 2% is achieved.
- Refine the final configuration (storage side slopes, etc.) and exact location of the retention storage areas dependent on final earthworks, drainage and road design levels for the development.
- Restricted and unrestricted areas of POS are to be consistent with the POS table contained in the approved Structure Plan, or the Structure Plan POS schedule will be amended.
- Outline POS water efficiency measures, including production bore locations and proposed water application methods.

5.2 Construction Management

5.2.1 Dewatering

Given the depth of groundwater, no dewatering is expected.

5.2.2 Acid Sulphate Soils

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

ASS will be investigated and managed in accordance with the applicable DEC Acid Sulphate Soil Guideline Series.

5.3 Stormwater System Operation and Maintenance

The operation and maintenance of the drainage system will initially be the responsibility of the developer, ultimately reverting to the local authority, City of Rockingham.

The surface drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be required periodically:

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

5.4 Monitoring Program

A monitoring program will be required to allow quantitative assessment of hydrological impacts of the proposed development.

The post development monitoring program requirements, including targets, and schedule will be addressed in the future preparation of the UWMP.

5.5 Role and Responsibilities

Table 9 details the roles and responsibilities to undertake the implementation plan.

TABLE 9: IMPLEMENTATION RESPONSIBILITIES

IMPLEMENTATION	RESPONSIBILITY	
Action	**The Developer**	**City of Rockingham**
Preparation of an Urban Water Management Plan for individual development stages	✓	
Construction of stormwater system and 12 months maintenance post construction (defects period)	✓	
Long-term stormwater system operation and maintenance		✓
Monitoring program – 2 years post development	✓	

6. REFERENCES

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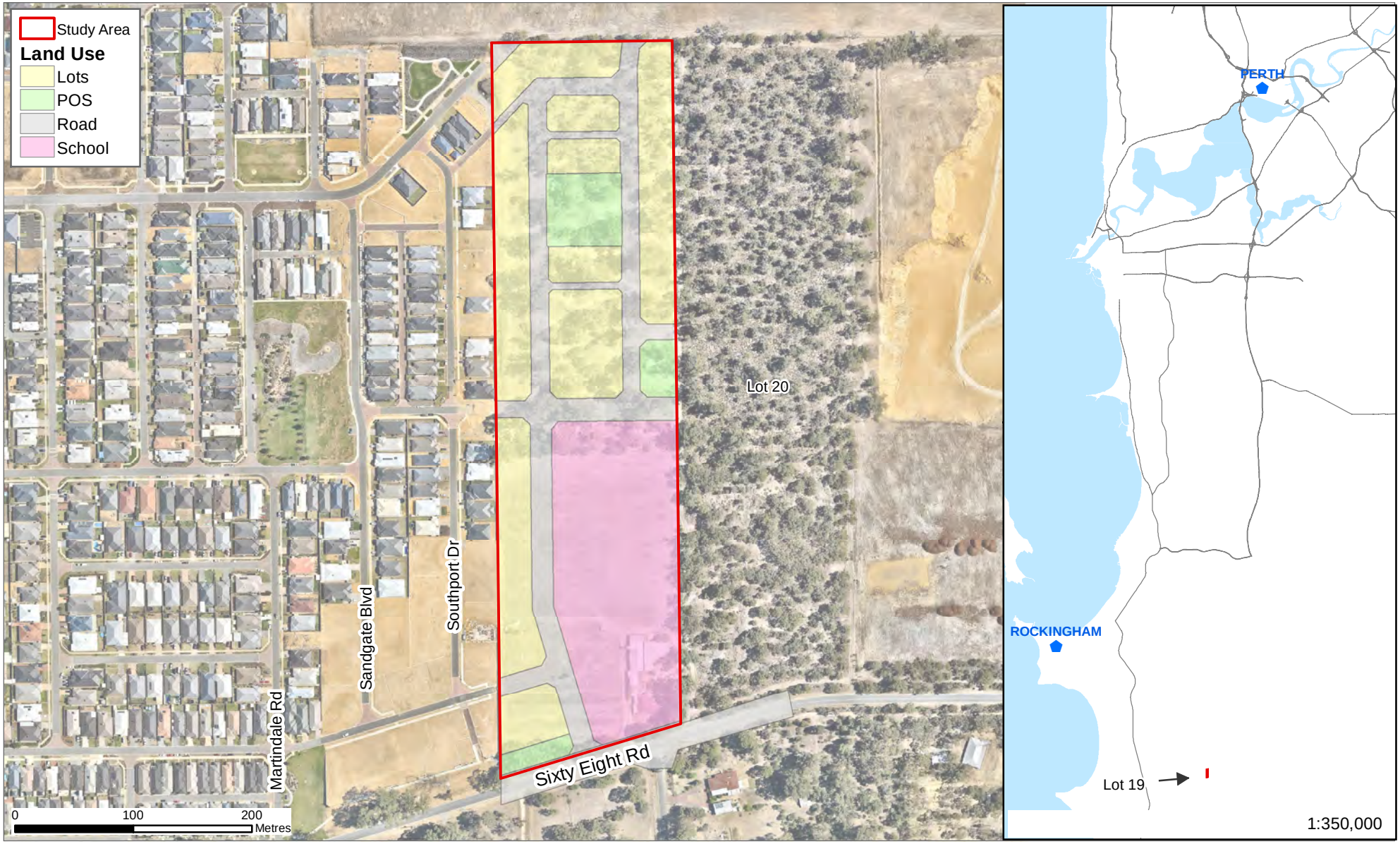
FIGURES



Data Source: Nearmap (aerial photo 10 Feb 2016), SITE Planning + Design (2017) Baldivis LSP_V1.0_20170623

Coordinate System: GDA 94, Zone 50

Job No. J6123

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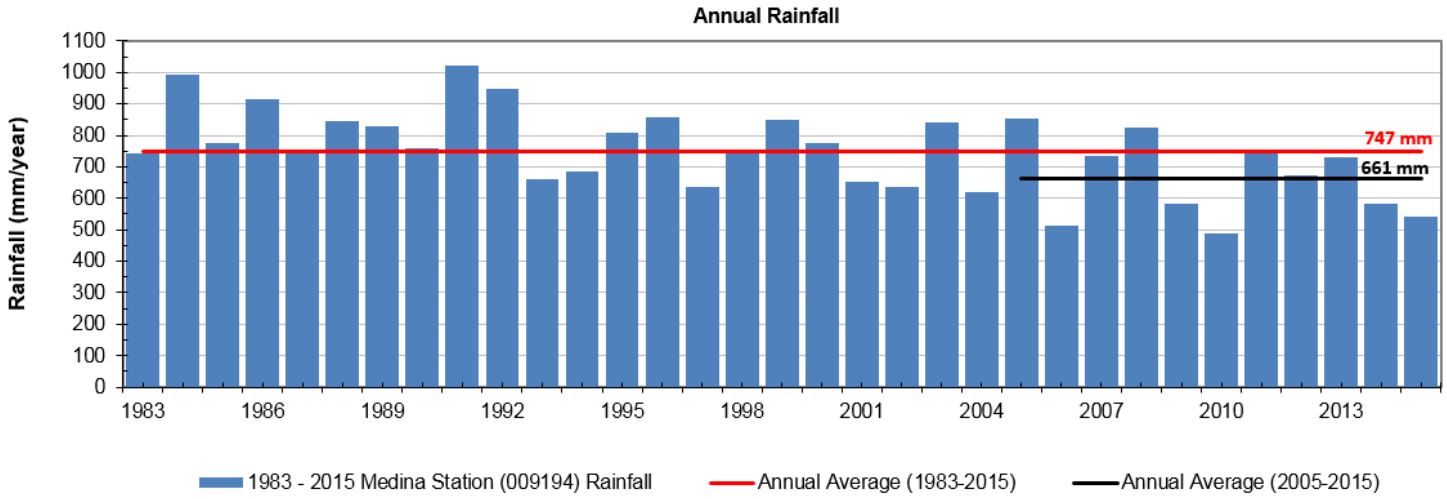
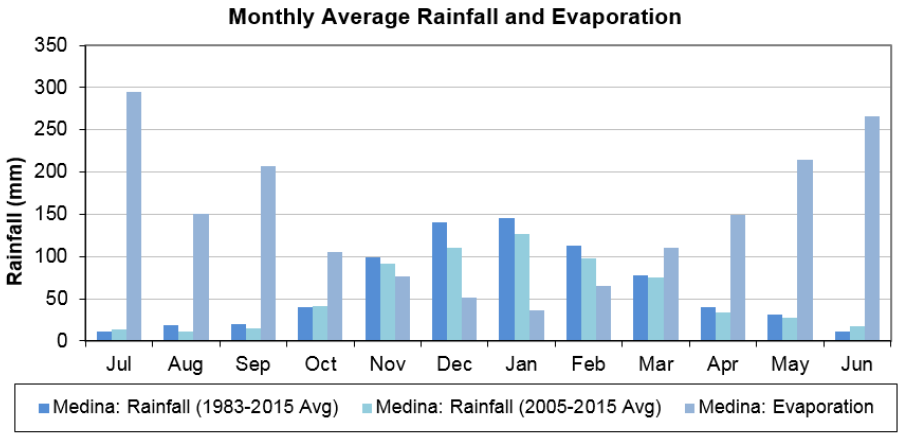
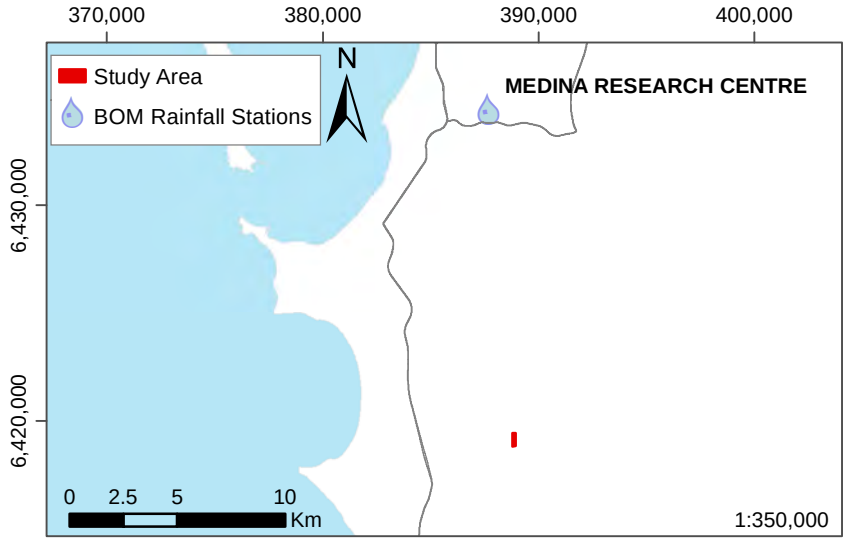
The Glow Development (WA) Pty Ltd

Lot 19 Sixty Eight Road, Baldivis: District/Local Water Managment Strategy

Figure 1: Location Plan







Data Source: BoM Data Online, accessed 01 Feb 2016

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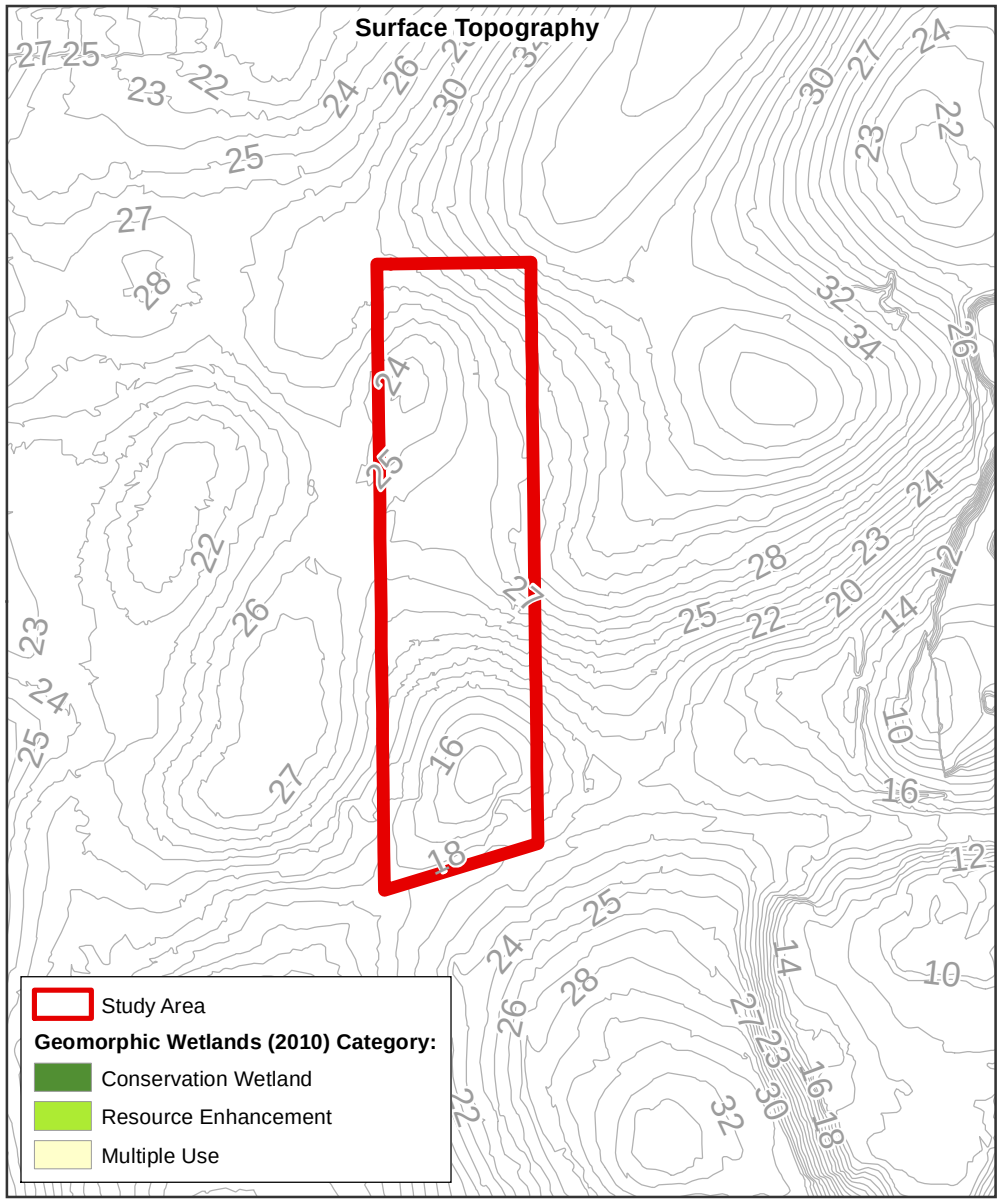
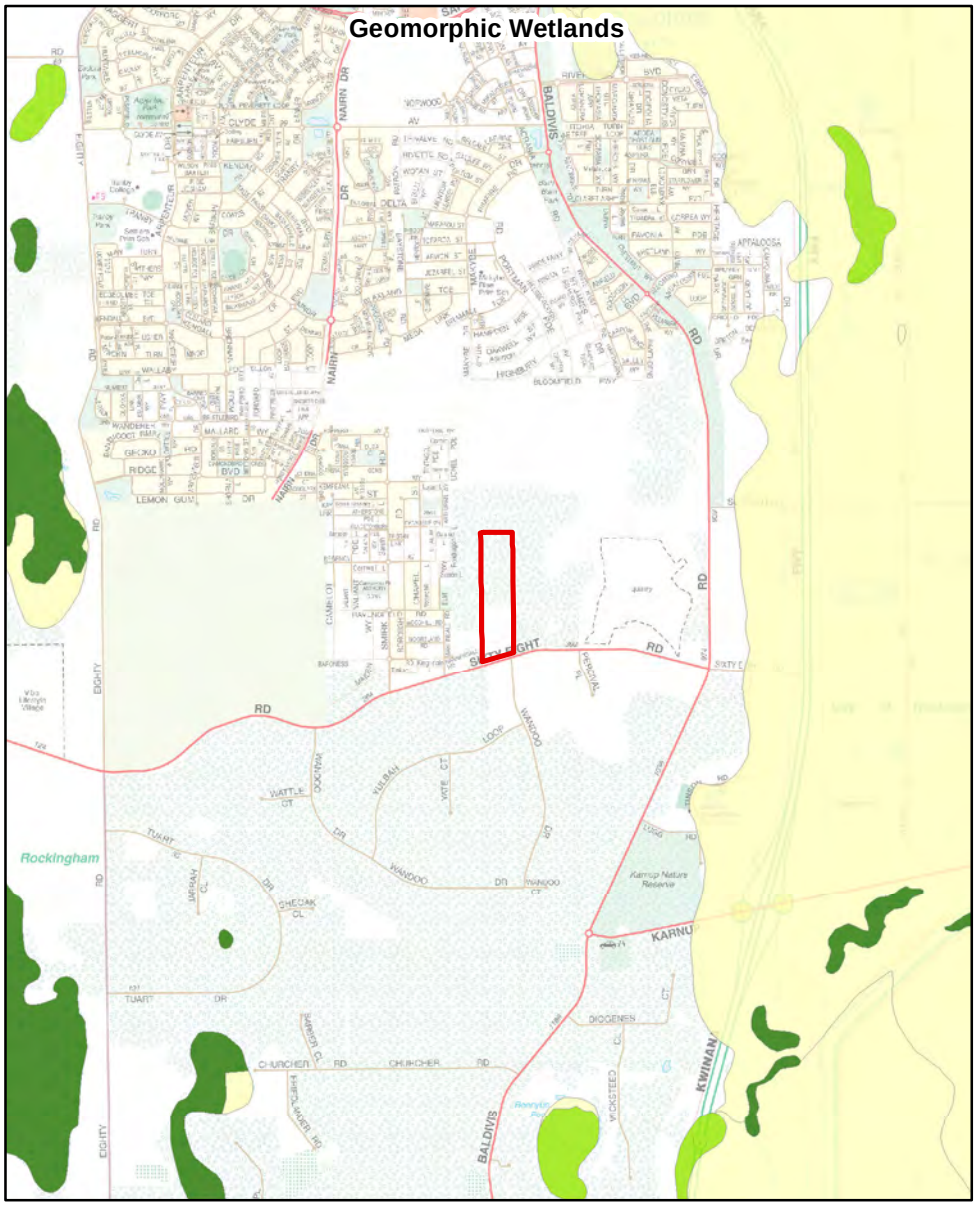
Job No. J6123

The Glow Development (WA) Pty Ltd

Lot 19 Sixty Eight Road, Baldivis: District/Local Water Management Strategy

Figure 2: Climate Data



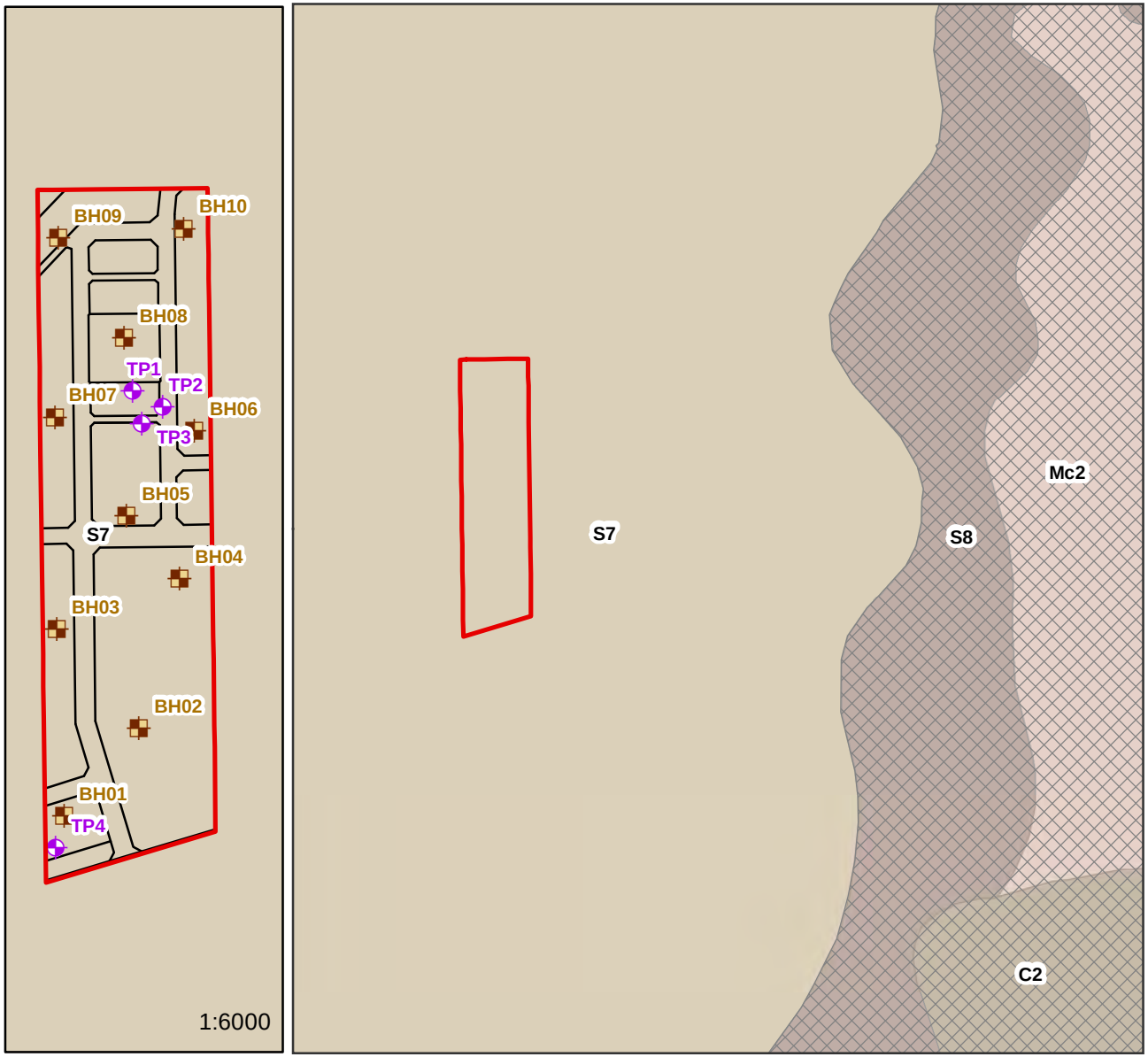


Data Source: LiDAR Topography Contours Swan Coast Plan (DoP, 2008), Geomorphic Wetlands (DEC, 2013), Floodplain Area Mapping (DoW, 2009)

Job No. J6123
Scale: 1:7,500

0 200 400 Metres

The Glow Development (WA) Pty Ltd
Lot 19 Sixty Eight Road, Baldivis: District/Local Water Management Strategy
Figure 3: Topography and Wetlands



Study Area
Bore Holes (Galt, 2015)
Permeameter Test Locations
Acid Sulphate Soil Risk
High to moderate risk
Moderate to low risk

Geology
C2
Mc2
S7
S8

Geology

S7 Spearwood Sands:
SAND - pale yellowish brown, medium to coarse-grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin

S8 Bassenden Sands:
SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin as relatively thin veneer over C2, M4 and Mc2

C2:
CLAY - strong brown and dark grey clay, plastic in places, soft when wet, variable silt content in matrix, of alluvial origin

Mc2:
CLAYEY SILT - dark greyish brown, mottled in part, soft when wet, plastic in part, blocky, variable clay content, of alluvial origin

Acid Sulphate Soils

High to moderate risk
High to moderate risk of ASS occurring within 3m of natural soil surface.

Moderate to low risk:
Moderate to low risk of ASS occurring within 3m of natural soil surface.

Data Source: Acid Sulphate Soil Risk Mapping (DER, 2014), Surface Geology (Gozzard, 1983). Galt Geotechnics (2015)

JDA

Job No. J6123
Scale: 1:15,000
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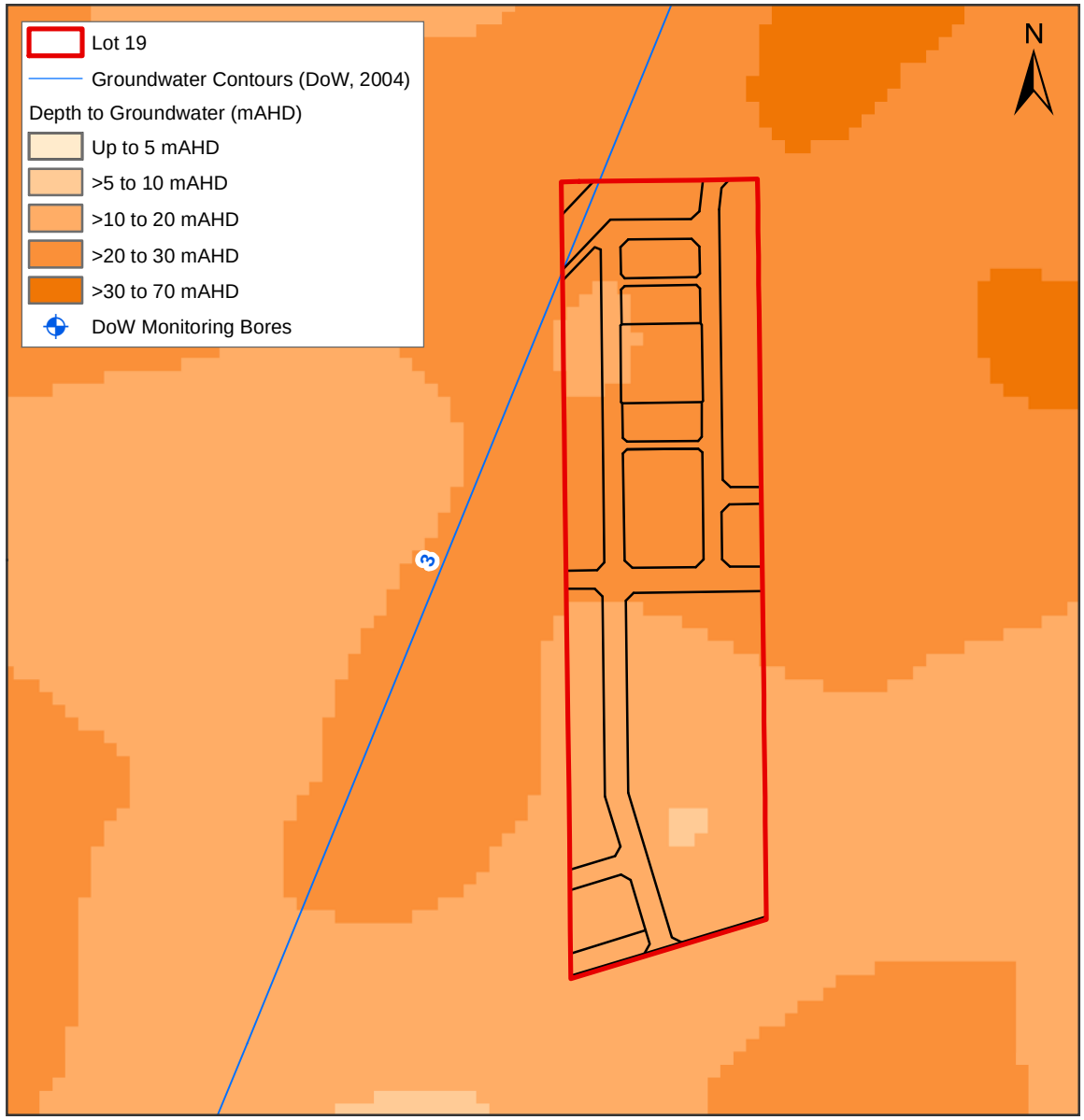
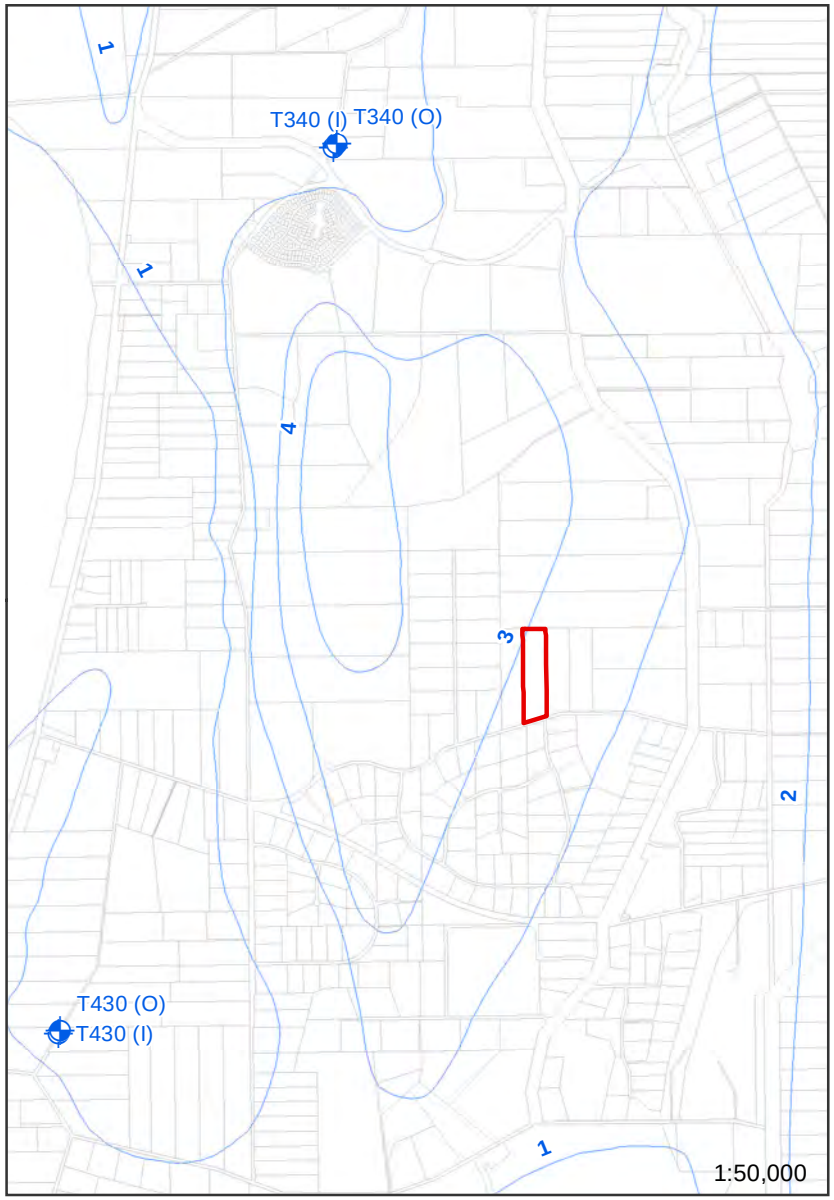
The Glow Development (WA) Pty Ltd
Lot 19 Sixty Eight Road, Baldivis: District/Local Water Management Strategy
Figure 4: Surface Geology and Soil



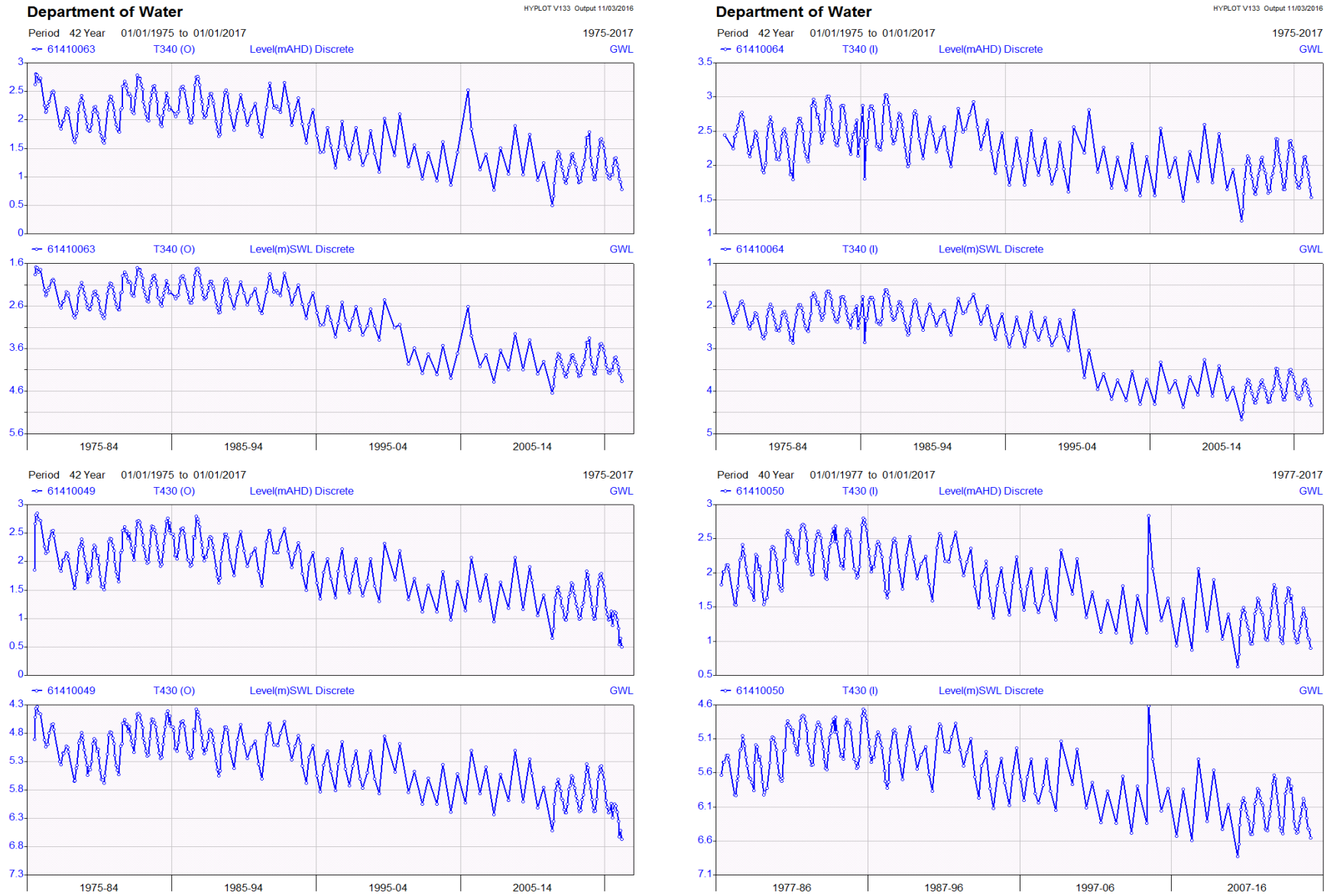


Data Source: LiDAR Contours Swan Coastal Plain (DoP, 2008), SCP Groundwater Levels (DoW, 2004).

Job No. J6123
Scale: 1:5,500

0 250 500 Metres

The Glow Development (WA) Pty Ltd.
Lot 19 Sixty Eight Road, Baldivis: District/Local Water Management Strategy
Figure 5: Groundwater Levels



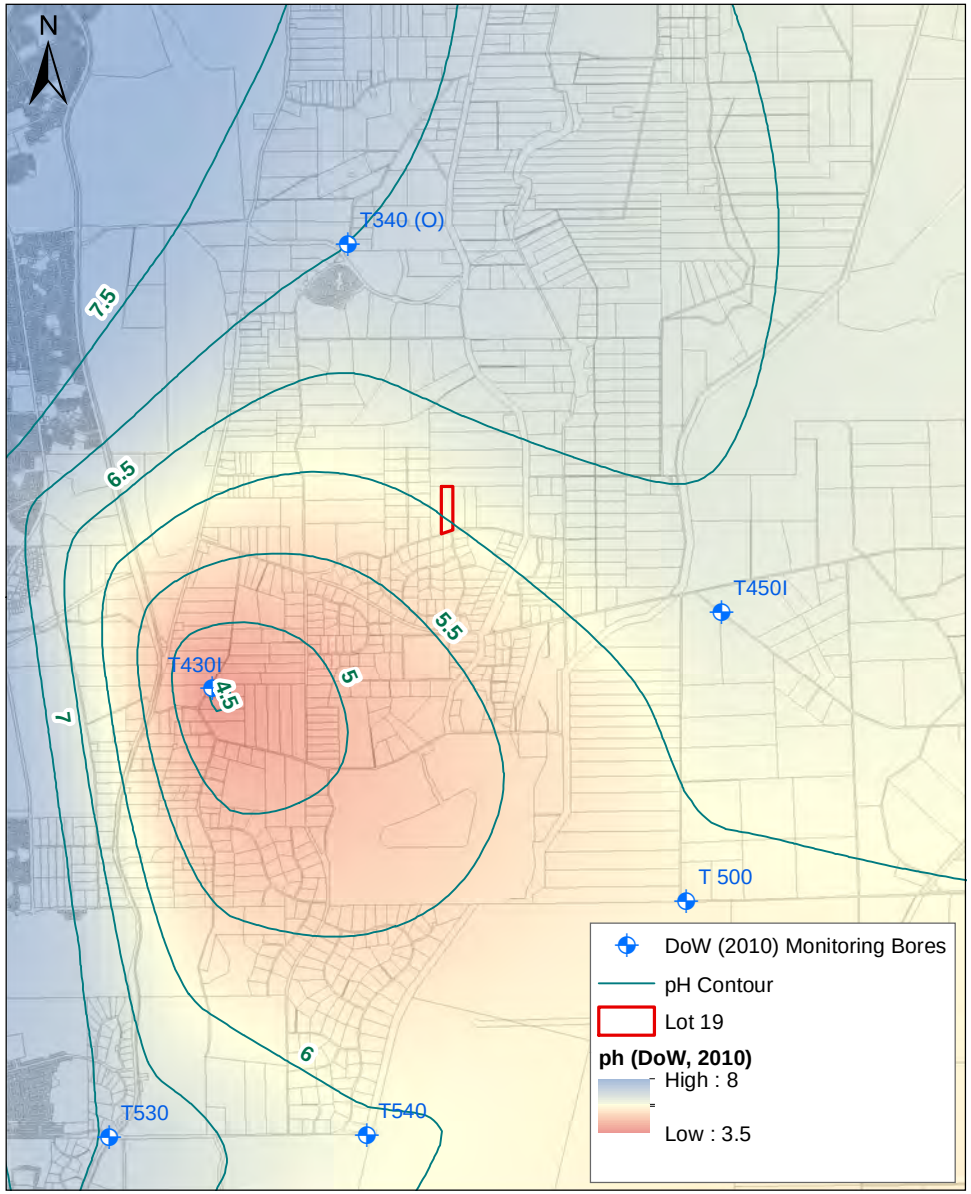
Data Source: Water Information (WIN) database - discrete sample data [16 Mar 2016]. Departement of Water, Water Information section, Perth Western Australia

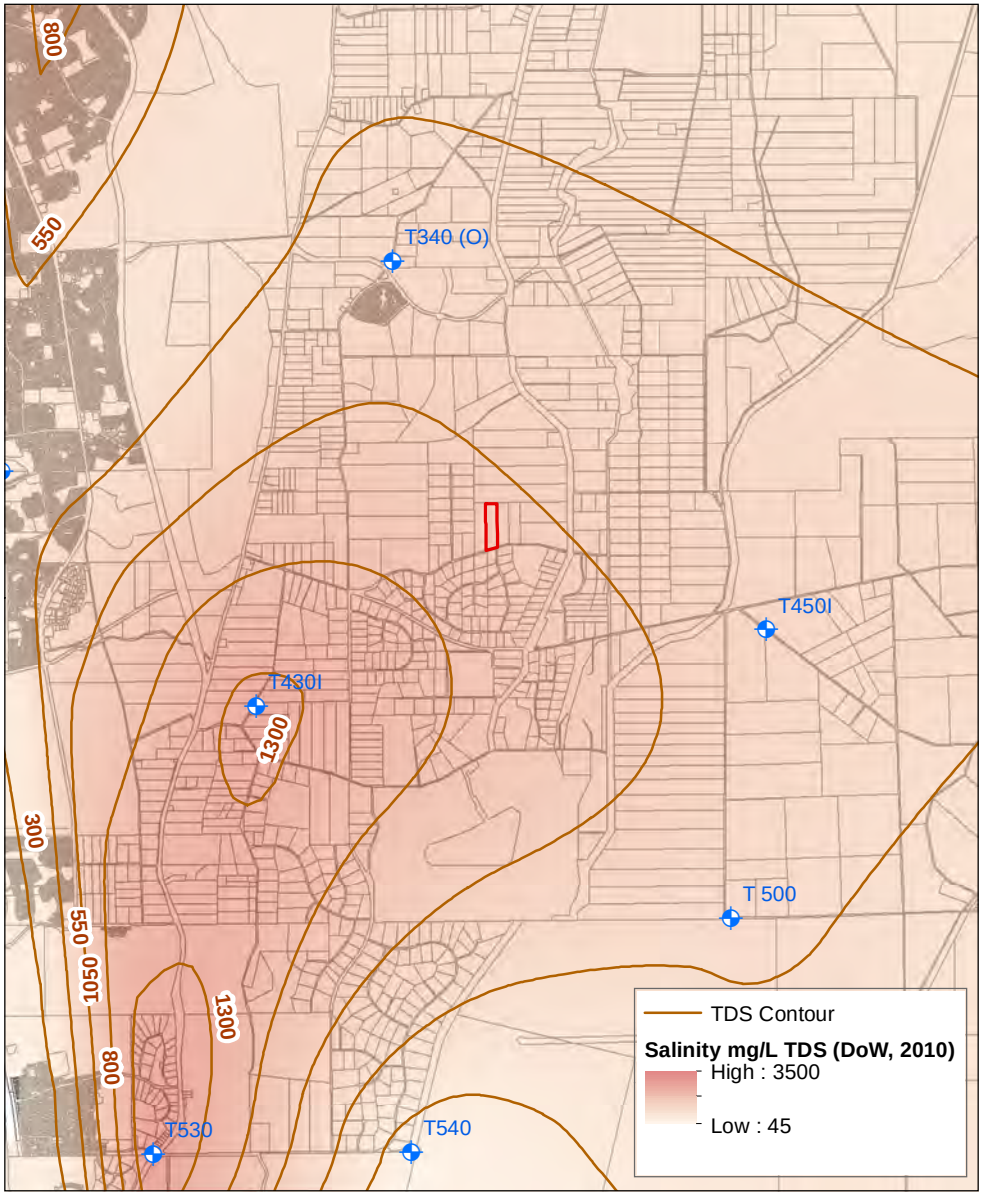
Job No. J6123

The Glow Development (WA) Pty Ltd

Lot 19 Sixty Eight Road, Baldivis: District/Local Water Management Strategy

Figure 6: Groundwater Level Measured at DoW Monitoring Bores





Data Source: DoW (2010)

Coordinate System: GDA 94, Zone 50

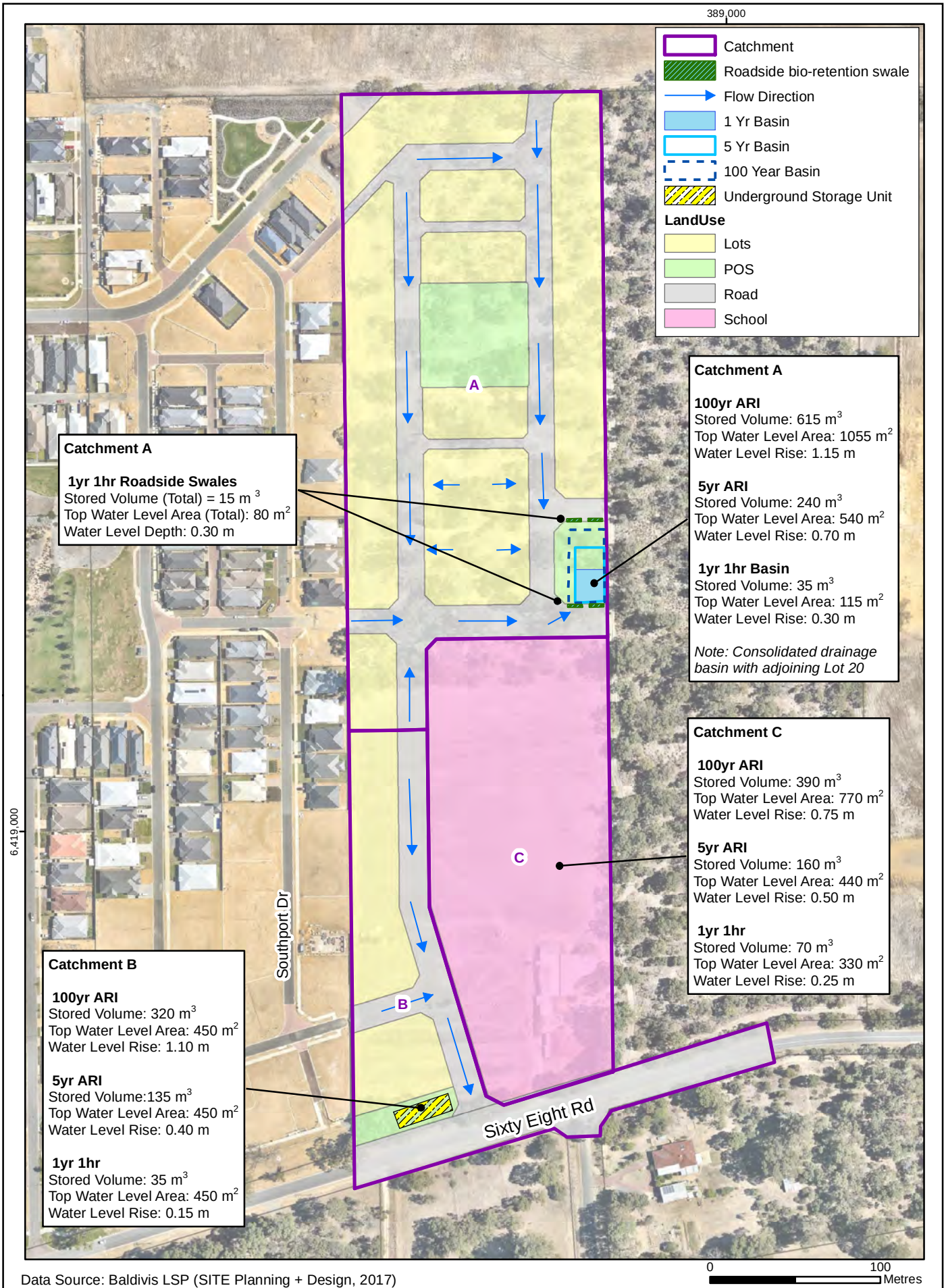
Job No. J6123

Scale: 1:100,000 @A4

The Glow Development (WA) Pty Ltd

Lot 19 Sixty Eight Road, Baldivis: District/Local Water Management Strategy

Figure 7: Groundwater pH and TDS (2003 to 2007) average (DoW, 2010)



Data Source: Baldivis LSP (SITE Planning + Design, 2017)

JDA

Job No. J6123
Scale 1:3,000 @A4
Coordinate System: GDA 94, Zone 50

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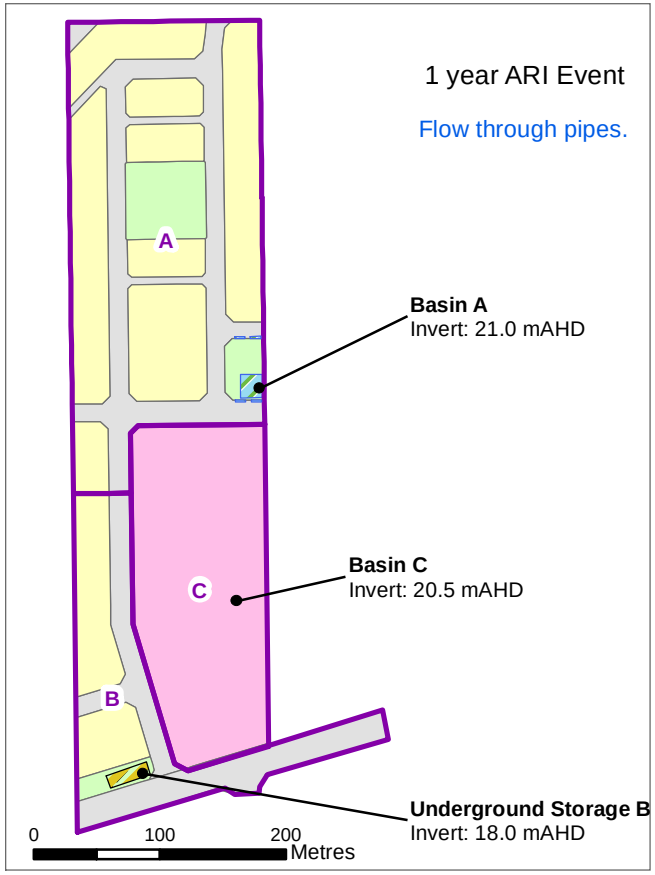
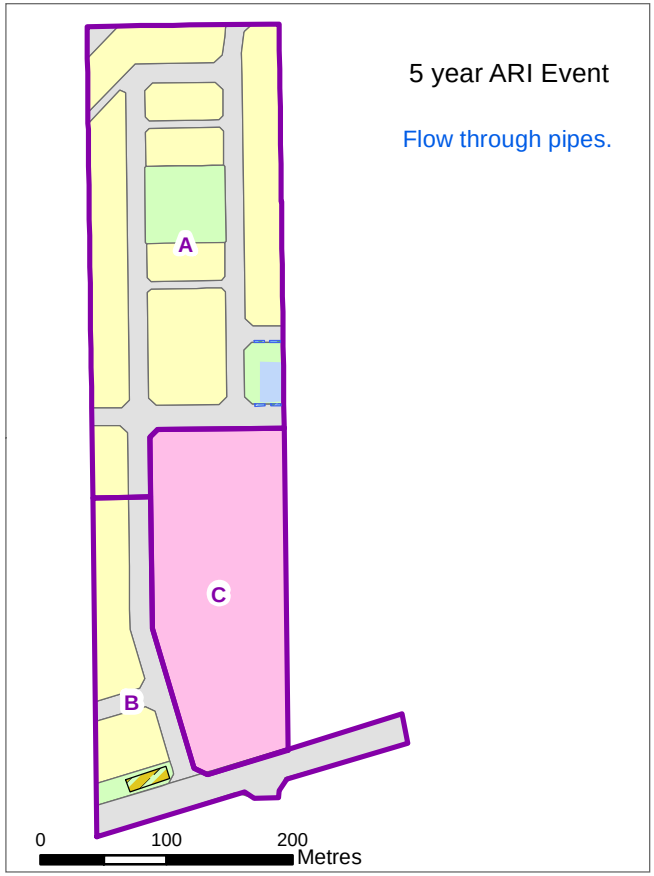
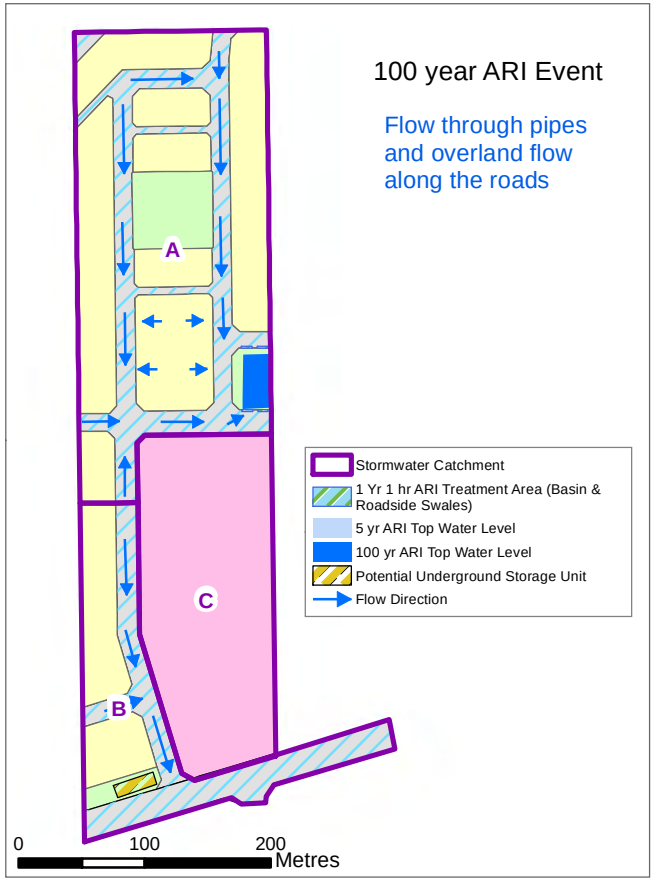
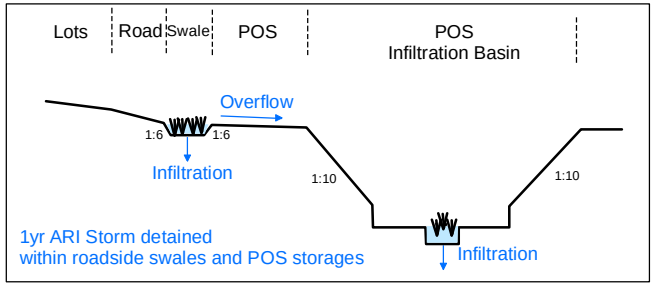
The Glow Development (WA) Pty Ltd
Lot 19 Sixty Eight Road, Baldivis: DWMS/LWMS

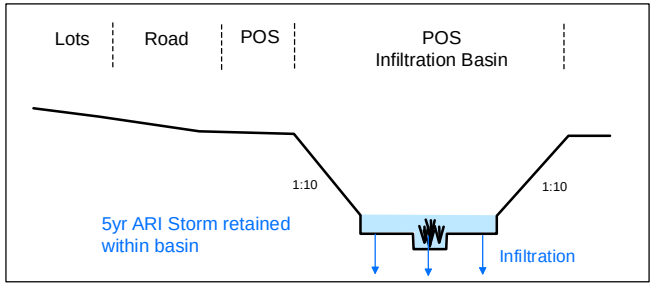
Figure 8: Proposed Development and Stormwater System

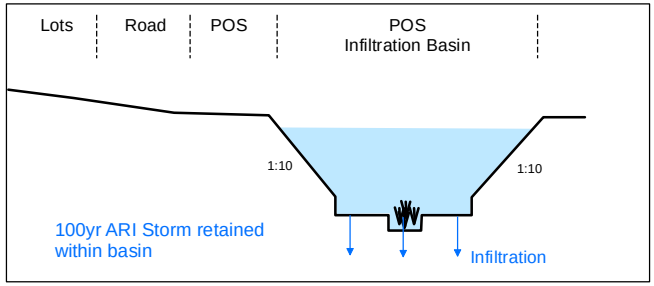












Note: Cross Sections are conceptual only, and are not drawn to scale

Coordinate System: GDA 94, Zone 50

Job No. J6123

N

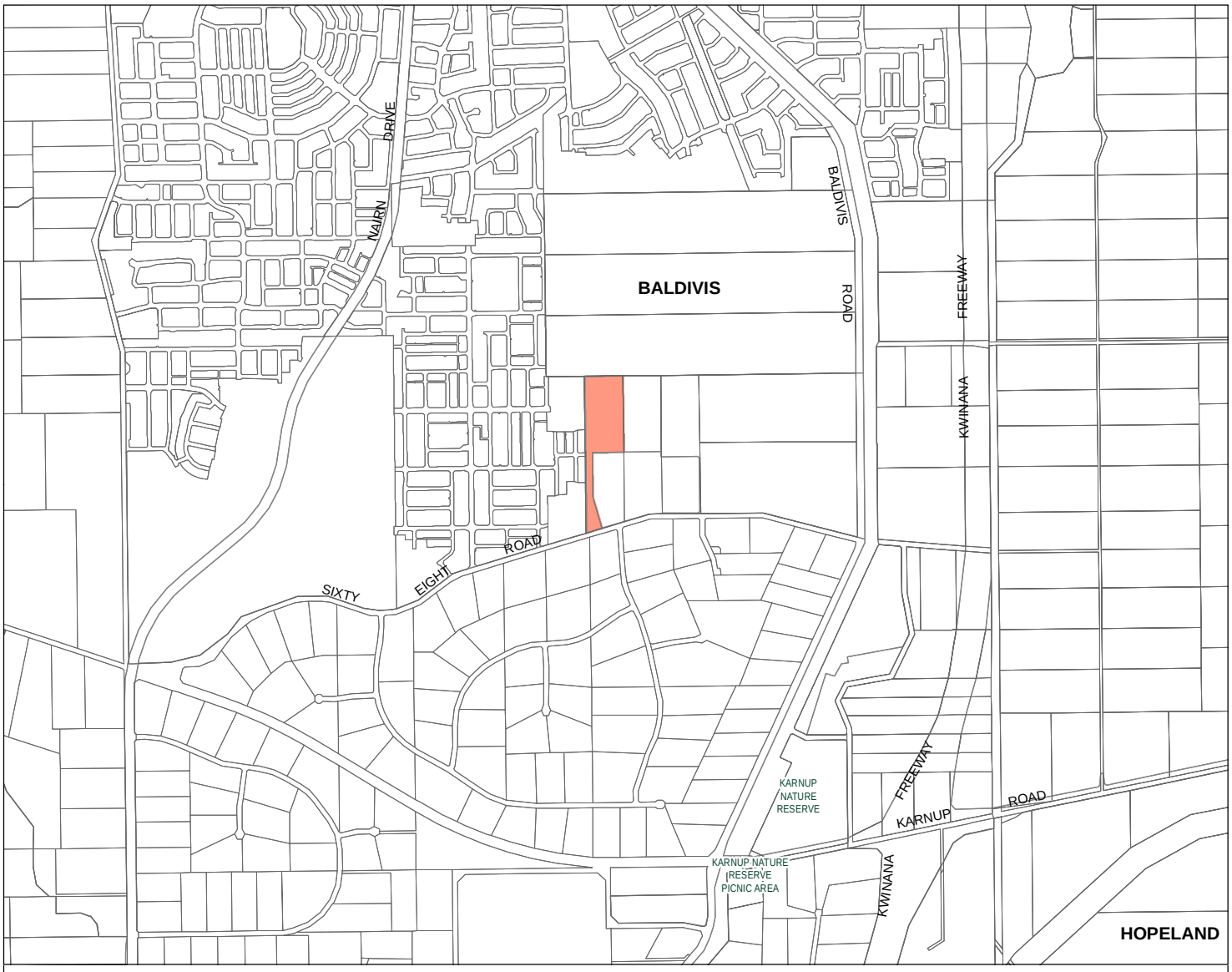
The Glow Development (WA) Pty Ltd

Lot 19 Sixty Eight Road, Baldivis: District/Local Water Management Strategy

Figure 9: 1yr, 5yr and 100yr ARI Event Plan

APPENDIX A

Metropolitan Region Scheme Amendment Plan (4.1606/1)



Signed for and on behalf of the
Western Australian Planning Commission

_____

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

_____
Witness

_____
Date

Metropolitan Region Scheme

Clause 27 - Transfer of land
from urban deferred zone to urban zone

Amendment No. 1319 /27

Legend

Excluded from urban deferred and included in urban zone

N

0 0.25 0.5 0.75 1
kilometres

Department of Planning

Western Australian Planning Commission

Program Manager: A. Muscara

Geospatial Officer: S. Jenkins

Examined: J. Ballarotta

Revised:

Version No. 2

Date: Item No. 249.11.2 25 Oct 2016

File number: 812/02/26/0011P V

Plan reference:
MRS 1:25000 sheet 31
detail plans: 1.6916,1.6922

Oracle reference no: 2788

Plan Number 4.1606/1

Created on date: Thursday, 27 October 2016
Document Name: _GeoRS Create Proposed Amendment_55348
Produced by GeoSpatial Research and Modelling, Department of Planning, Perth WA
Base information supplied by Western Australian Land Information Authority LI 782-2015-1

APPENDIX B

Geotechnical Study
Proposed Residential Subdivision
Lot 19 Sixty Eight Road, Baldivis
(Galt Geotechnics, 2015)

(provided on CD)

APPENDIX C

Borehole Permeameter Testing Results

Measuring Saturated K with the Borehole Permeameter

For saturated soils:

$$K_s = \frac{Cq}{2\pi H^2 + C\pi r^2}$$

where; Ks is saturated hydraulic conductivity (cm/s)
H is the height of the water in the hole (cm)
r is the radius of the hole (cm)
C is the well-shape factor, determined based on the h/r ratio
q is the steady state infiltration volume (cm3/s)

q is calculated by the cross sectional area of the tube.
q = 15.2 cm2/cm for a 4.4 cm diameter tube

C Calculator

The equation for calculating C is dependent on the soil type:
(Zhang et al. 1998)

1. Structured soils - medium to coarse sands

$$C_1 = \left(\frac{H/r}{2.074 + 0.093\,H/r}\right)^{0.754}$$

2. Unstructured fine textured soils (clay/silt) and fine sands

$$C_2 = \left(\frac{H/r}{1.992 + 0.091\,H/r}\right)^{0.683}$$

3. Compacted clays

$$C_3 = \left(\frac{H/r}{2.102 + 0.118\,H/r}\right)^{0.655}$$

Further Reading

Reynolds, W.D. & Elrick, D.E. (1983) 'A reexamination of the constant head well permeameter method for measuring saturated hydraulic conductivity above the water table', *Soil Science,* vol. 136, no. 4. **- JDA Library Ref IN75**

Smettem, K. (2004) *Measuring saturated hydraulic conductivity with the borehole permeameter.* Presentation to JDA. **- JDA Library Ref IN63**

Zhang, Z.F., Groenevelt, P.H. & Parkin, G.W. (1998) 'The well-shape factor for the measurement of soil hydraulic properties using the Guelph Permeameter'. *Soil & Tillage Research* vol. 49, pp. 219-221. **- JDA Library Ref IN77**

BOREHOLE PERMEAMETER TESTING RESULTS

J6123 - Soil Infiltration Testing

User to enter: ER

TP1

Location: 0388859 E 6419253 N
(GDA 1994 MGA Zone 50)
Depth: 0.5 m BNS
Date: 15/02/2016
Staff: RD and ER

r = radius of hole (cm)
H = height of water in hole (cm)
C = based on H/r ratio
q = steady state infiltration volume (cm^3/s)
*(q is based on the cross sectional area of tube **15.2** cm^2 for 4.4cm diamter tube)*
Ks = saturated Hydraulic Conductivity (m/d)

Soil Type: 1

Time Step (s): 5

Soil Types
1. Structured soils - medium to coarse sands
2. Unstructured fine textured soils (clay/silt) and fine sands
3. Compacted clays

Rep 1

r = 3.75
H = 1.5
H/r = 0.4
C= 0.2852713

Time (sec)	Level (cm)	Diff (cm)
0	21	0
5	23.5	2.5
10	26	2.5
15	28.5	2.5
20	31	2.5
25	34	3
30	37	3
35	39.5	2.5
40	42.5	3
45	45.5	3
50	48	2.5
55	51	3
60	54	3
65	57	3
Steady State Average		2.77

q = 8.42 cm^3/s
Ks = 0.0899 cm/s

Ks (m/day) **77.64**

Rep 2

r = 3.75
H = 1.5
H/r = 0.4
C= 0.2852713

Time (sec)	Level (cm)	Diff (cm)
0	52	0
5	56	4
10	60	4
15	63.5	3.5
20	66.5	3
25	70	3.5
30	73.5	3.5
35	76.5	3
40	79.5	3
45	83	3.5
50	87	4
55	90	3
60	93.5	3.5
Steady State Average		3.46

q = 10.51 cm^3/s
Ks = 0.1122 cm/s

Ks (m/day) **96.95**

Rep 3

r = 3.75
H = 0.5
H/r = 0.1333333
C= 0.1257124

Time (sec)	Level (cm)	Diff (cm)
0	26	0
5	28	2
10	29	1
15	30.5	1.5
20	32.5	2
25	34.5	2
30	36.5	2
35	38.5	2
40	40	1.5
45	42	2
50	44	2
55	46.5	2.5
60	48.5	2
65	50.5	2
70	52.5	2
75	54.5	2
Steady State Average		1.90

q = 5.78 cm^3/s
Ks = 0.1020 cm/s

Ks (m/day) **88.10**

Average Ks from 3 Repetitions = **87.56 (m/day)**

Notes: Yellow coarse sands below topsoil

BOREHOLE PERMEAMETER TESTING RESULTS

J6123 - Soil Infiltration Testing

User to enter: ER

TP2

Location: 388886 E 6419239 N
(GDA 1994 MGA Zone 50)
Depth: 0.5 m BNS
Date: 15/02/2016
Staff: RD and ER

r = radius of hole (cm)
H = height of water in hole (cm)
C = based on H/r ratio
q = steady state infiltration volume (cm^3/s)
*(q is based on the cross sectional area of tube **15.2** cm^2 for 4.4cm diamter tube)*
Ks = saturated Hydraulic Conductivity (m/d)

Soil Type: 1

Time Step (s): 5

Soil Types
1. Structured soils - medium to coarse sands
2. Unstructured fine textured soils (clay/silt) and fine sands
3. Compacted clays

Rep 1
r = 3.75
H = 0.5
H/r = 0.1333333
C= 0.1257124

Time (sec)	Level (cm)	Diff (cm)
0	38	0
5	41	3
10	43.5	2.5
15	46	2.5
20	48.5	2.5
25	50.5	2
30	52.5	2
35	54.5	2
40	56.5	2
45	58	1.5
50	59.5	1.5
55	61	1.5
60	62	1
65	63.5	1.5
70	64.5	1
75	65.5	1
80	66.5	1
Steady State Average		1.78

q = 5.42 cm^3/s
Ks = 0.0956 cm/s

Ks (m/day) **82.59**

Rep 2
r = 3.75
H = 0.5
H/r = 0.1333333
C= 0.1257124

Time (sec)	Level (cm)	Diff (cm)
0	43.5	0
5	44.5	1
10	45.5	1
15	46.5	1
20	47.5	1
25	48.5	1
30	49.5	1
35	50.5	1
Steady State Average		1.00

q = 3.04 cm^3/s
Ks = 0.0537 cm/s

Ks (m/day) **46.37**

Rep 3
r = 3.75
H = 0.5
H/r = 0.1333333
C= 0.1257124

Time (sec)	Level (cm)	Diff (cm)
0	17.5	0
5	18.5	1
10	19.5	1
15	20.5	1
20	21.5	1
25	23	1.5
30	24.5	1.5
35	26	1.5
40	27	1
45	28.5	1.5
50	30	1.5
55	31	1
60	32	1
65	33.5	1.5
70	35	1.5
Steady State Average		1.25

q = 3.80 cm^3/s
Ks = 0.0671 cm/s

Ks (m/day) **57.96**

Rep 4
r = 3.75
H = 1
H/r = 0.2666667
C= 0.211064

Time (sec)	Level (cm)	Diff (cm)
0	68.5	0
5	70.5	2
10	71.5	1
15	73	1.5
20	74	1
25	75	1
30	76.5	1.5
35	78	1.5
40	79	1
45	80	1
50	81.5	1.5
55	82.5	1
60	83.5	1
Steady State Average		1.15

q = 3.51 cm^3/s
Ks = 0.0475 cm/s

Ks (m/day) **41.00**

Average Ks from 4 Repetitions = **56.98 (m/day)**

Notes:
Dark brown coarse sands

BOREHOLE PERMEAMETER TESTING RESULTS

J6123 - Soil Infiltration Testing

User to enter: ER

TP3

Location: 388867 E 6419224 N
(GDA 1994 MGA Zone 50)
Depth: 0.5 m BNS
Date: 15/02/2016
Staff:

r = radius of hole (cm)
H = height of water in hole (cm)
C = based on H/r ratio
q = steady state infiltration volume (cm^3/s)
*(q is based on the cross sectional area of tube **15.2** cm^2 for 4.4cm diamter tube)*
Ks = saturated Hydraulic Conductivity (m/d)

Soil Type: 1

Time Step (s): 5

Soil Types
1. Structured soils - medium to coarse sands
2. Unstructured fine textured soils (clay/silt) and fine sands
3. Compacted clays

Rep 1

r = 3.75
H = 1.5
H/r = 0.4
C= 0.2852713

Time (sec)	Level (cm)	Diff (cm)
0	19	0
5	26	7
10	31	5
15	36	5
20	40	4
25	44	4
30	48	4
35	52.5	4.5
40	57	4.5
45	61	4
50	65	4
55	69	4
Steady State Average		4.55

q = 13.82 cm^3/s
Ks = 0.1475 cm/s

Ks (m/day) **127.43**

Rep 2

r = 3.75
H = 1.5
H/r = 0.4
C= 0.2852713

Time (sec)	Level (cm)	Diff (cm)
0	20	0
5	22.5	2.5
10	26	3.5
15	29	3
20	32.5	3.5
25	36	3.5
30	39	3
35	43	4
40	47	4
45	50	3
50	54	4
55	58	4
60	61.5	3.5
65	66	4.5
Steady State Average		3.54

q = 10.76 cm^3/s
Ks = 0.1148 cm/s

Ks (m/day) **99.20**

Rep 3

r = 3.75
H = 1.5
H/r = 0.4
C= 0.2852713

Time (sec)	Level (cm)	Diff (cm)
0	40	0
5	45	5
10	48	3
15	53	5
20	57	4
25	60	3
30	64	4
35	68	4
40	72	4
45	76	4
50	80	4
55	84	4
60	88	4
Steady State Average		4.00

q = 12.16 cm^3/s
Ks = 0.1298 cm/s

Ks (m/day) **112.14**

Average Ks from 3 Repetitions = **112.92 (m/day)**

Notes:
Yellow coarse sands below topsoil

BOREHOLE PERMEAMETER TESTING RESULTS

J6123 - Soil Infiltration Testing

User to enter: ER

TP4

Location: 388790 E 6418844 N
(GDA 1994 MGA Zone 50)
Depth: 0.5 m BNS
Date: 15/02/2016
Staff: RD and ER

r = radius of hole (cm)
H = height of water in hole (cm)
C = based on H/r ratio
q = steady state infiltration volume (cm^3/s)
(q is based on the cross sectional area of tube ***15.2*** cm^2
for 4.4cm diamter tube)
Ks = saturated Hydraulic Conductivity (m/d)

Soil Type: 1

Soil Types
1. Structured soils - medium to coarse sands
2. Unstructured fine textured soils (clay/silt) and fine sands
3. Compacted clays

Time Step (s): 5

Rep 1

r = 3.75
H = 0.5
H/r = 0.1333333
C= 0.1257124

Time (sec)	Level (cm)	Diff (cm)
0	40	0
5	41	1
10	42	1
15	43	1
20	43.5	0.5
25	44.5	1
30	45.5	1
35	46.5	1
40	47.5	1
45	48.5	1
Steady State Average		0.94

q = 2.87 cm^3/s
Ks = 0.0507 cm/s

Ks (m/day) **43.79**

Rep 2

r = 3.75
H = 0.5
H/r = 0.1333333
C= 0.1257124

Time (sec)	Level (cm)	Diff (cm)
0	83	0
5	84.5	1.5
10	85	0.5
15	85.5	0.5
20	86.5	1
25	87	0.5
30	87.5	0.5
35	88	0.5
40	88.5	0.5
Steady State Average		0.69

q = 2.09 cm^3/s
Ks = 0.0369 cm/s

Ks (m/day) **31.88**

Rep 3

r = 3.75
H = 0.5
H/r = 0.1333333
C= 0.1257124

Time (sec)	Level (cm)	Diff (cm)
0	33	0
5	33.5	0.5
10	34	0.5
15	34.5	0.5
20	35	0.5
25	35.5	0.5
30	36	0.5
35	36.5	0.5
40	36.5	0
45	37	0.5
50	37.5	0.5
55	38	0.5
60	38.5	0.5
Steady State Average		0.46

q = 1.39 cm^3/s
Ks = 0.0246 cm/s

Ks (m/day) **21.25**

Rep 4

r = 3.75
H = 0.5
H/r = 0.1333333
C= 0.1257124

Time (sec)	Level (cm)	Diff (cm)
0	69.5	0
5	71	1.5
10	71.5	0.5
15	72	0.5
20	72.5	0.5
25	73	0.5
30	73.5	0.5
35	74	0.5
40	75	1
45	75.5	0.5
50	76	0.5
55	76.5	0.5
60	77	0.5
65	77.5	0.5
Steady State Average		0.62

q = 1.87 cm^3/s
Ks = 0.0330 cm/s

Ks (m/day) **28.53**

Average Ks from 4 Repetitions = **31.36 (m/day)**

Notes:
Brown coarse sands

APPENDIX D

Engineering Servicing Report

pritchard francis

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15-322

Engineering Servicing Report

for

The Glow Development

on

Lot 19 Sixty Eight Road, Baldivis

Revision	Description	Date
0	Issued for Structure Plane Report	18-Nov-15
1	Electrical Reticulation Revised	24-Nov-15

Contents

1	Introduction	1
2	Site Description	1
3	Earthworks Strategy and Retaining Walls	2
4	Stormwater Drainage	3
5	Sewer Reticulation	3
6	Water Reticulation	4
7	ATCO Gas	4
8	Electrical Reticulation	4
9	Communications	4
10	Conclusion	4

Appendices

Appendix One	*Subdivision Concept Plan*
Appendix Two	*Conceptual Levels Plan*
Appendix Three	*Sewer Catchment Plan*
Appendix Four	*Wastewater Reticulation – Concept Plan*
Appendix Five	*Water Concept Plans*

1 Introduction

At the request of The Glow Development, this Engineering Servicing Report has been prepared in support of lifting the Urban Deferred zoning to Urban on Lot 19 Sixty Eight Road, Baldivis.

The servicing strategy outlined within this report is based on the subdivision concept plan provided by The Spatial Group. This plan can be found in Appendix One.

Pritchard Francis is currently involved with the detailed engineering design of the adjacent Lot 21 Sixty Eight Road as well as Lots 569 and 1263 Baldivis Road and the previously completed Lot 18 Sixty Eight Road. As such, Pritchard Francis is well versed in servicing requirements for the area, and has already been liaising with service authorities to ensure this land is appropriately serviced.

2 Site Description

2.1 Locality

The site is located in the suburb of Baldivis within the City of Rockingham, west of the Kwinana Freeway and South of Safety Bay Road. The 9.1Ha site is bound by the recently completed subdivision of Lot 18 Sixty Eight Road to the west, the undeveloped Lot 20 Sixty Eight Road to the east and the undeveloped Lot 740 Baldivis Road to the north. The location of the site can be seen in the aerial image below.

Photo 1: Location Plan

2.2 Topography

Currently the northern portion of the site contains native vegetation whilst the southern portion has been cleared for market garden purposes. There are existing homesteads in the south-east corner and sheds/greenhouses remaining from when the site was used for farming/market gardens. The soils should be investigated by an environmental consultant for any potential impacts from previous land use.

The levels are around 26m AHD at the north-west corner of the site and the high point is around 34m at the north-east corner. The level towards the eastern side is likely to have been lowered to around 28m AHD at the time of development due to the development of Lot 740 and Lot 20 which are likely to commence prior to Lot 19. This is under the assumption that the owner of Lot 19 would give permission for the required batter to extend into their land.

Levels fall toward the southern end of the site such that there is a low point at 14m AHD approximately 90m north of Sixty Eight Road and the levels at the tie-in point with Sixty Eight Road are around 20m AHD.

It is understood that Lot 19 will tie-in smoothly with the surrounding developments and minimal retaining walls will be required.

2.3 Soils and Groundwater

The majority of soils within the site are fine to coarse grained sand, with minor limestone formation at depth in some areas.

According to the Department of Environment and Conservation's Acid Sulfate Soil (ASS) risk mapping, the site contains soils that are identified as having low to nil risk of containing ASS.

Groundwater levels are well below the surface level across the entire lot. As a result we envisage that groundwater will not pose any constraints for the development.

3 Earthworks Strategy and Retaining Walls

To meet Water Corporation requirements for provision of potable water in the Tamworth Gravity Catchment the land must be lowered below RL28 to ensure adequate water pressure is delivered to the properties. The majority of the site is already below 28m AHD and only the northern most portion of the site will require lowering to satisfy this requirement. Cut from this area can be used to fill the lower areas to the south, for example, the low point at 14m AHD within the proposed high school site. Additionally an earthworks strategy for the site needs to tie into existing Lot levels to the west, existing road levels to the south, and proposed Lot levels to the north and east as part of the proposed developments. Pritchard Francis has liaised with surrounding landholders, City of Rockingham, Water Corporation and Department of Education (School Site) in this regard.

In order to accommodate these levels the site will be terraced with retaining on lots to suit.

The key items of the earthworks concept plan are:

- Provide for a cut to fill scenario to eliminate the need to import Structural fill. It is likely that the exportation of clean material will be undertaken on this project.
- Consider the existing levels found across the site and create level Lots within the LSP area using retained Lots that step down the site.
- Match into ground levels proposed for the adjoining landholdings situated immediately to the north and west.
- Create finished levels within the subdivision that accommodate gravity-reliant infrastructure to facilitate appropriate servicing (sewer and drainage).

Pritchard Francis has also developed a Conceptual Levels Plan to ensure that the proposed development reasonably ties into the surrounding developments, the proposed high school and Sixty Eight Road. This plan is attached in Appendix Two.

4 Stormwater Drainage

A Local Water Management Strategy (LWMS) and Urban Water Management Plan (UWMP) will be required for the proposed subdivision as part of the Local Structure Plan process. There are currently multiple LWMS prepared for the surrounding developments/proposed subdivisions, for example, Lots 18, 740 and 21.

Due to the fact that the geology and topology of these areas are all similar to that of Lot 19, it is reasonable to assume that LWMS for Lot 19 will be similar. The LWMS and UWMP will therefore be likely to contain the following requirements:

- A water quality system designed to manage a one year one hour event. All stormwater will need to be retained and infiltrated on site within bio-retention areas. These bio-retention areas are likely to be located within either of the two POS areas. The bio-retention areas will need to be located within a larger retention basin, allowing for overflow during a larger event.
- Gross Pollutant Traps located at entry to POS soakage areas to ensure all litter and sediment is contained for easy cleaning.
- Pit and pipe systems designed to contain and transport up to and including five year events to the bio-retention areas within the POS.
- Up to a one hundred year event should be contained within the site. This will involve the roads grading towards the POS areas in order to retain and infiltrate all water within the retention basins.

Also, it is worth noting that the High School will be self-contained and so no runoff will need to be allowed for from the High School.

5 Sewer Reticulation

Pritchard Francis were involved with the planning of the future wastewater pump station which will serve the catchment inclusive of Lot 19. The relevant sheet of the catchment plan which has been approved by the Water Corporation is attached in Appendix Three.

Ultimately, sewerage reticulation within the proposed Lot 19 subdivision will connect to a gravity main through Lot 20, north of the High School. This can be seen in the attached wastewater reticulation concept plan prepared by Pritchard Francis and approved by the Water Corporation which is attached in Appendix Four.

In order to achieve serviceability, the gravity main downstream of Lot 19, (through Lots 20 and 21 and through to the proposed pump station near Baldivis road) must be completed. This means that development of Lot 19 will be dependent on development of the lots to the east. Alternatively, development of Lot 19 could occur earlier given that coordination with the relevant land owners can occur and the downstream sewer infrastructure can be installed prior to the eastern development. This could potentially involve significant earthworks.

6 Water Reticulation

Pritchard Francis has liaised with Water Corporation concerning water servicing in the area. Attached in Appendix Five is a water concept plan prepared by Pritchard Francis and approved by Water Corporation, as well as a broader area plan prepared by Water Corporation. From these plans it can be seen that Lot 19 will achieve water servicing via connection to existing water mains within the Lot 18 subdivision to the west. The water mains will either need to be extended to connect into existing water mains to the east and north or extended to provide a future connection point if the Lot 20 and/or Lot 740 developments are not yet complete.

7 ATCO Gas

There is existing gas reticulation servicing the development immediately to the west of Lot 19 (subdivision of Lot 18). This reticulation is high pressure and is likely to have sufficient capacity to service the proposed subdivision of Lot 19. This will need to be confirmed with ATCO Gas however, gas servicing will not be a WAPC condition and thus cannot prevent development should it not be available.

8 Electrical Reticulation

Electrical services are likely to be provided to the area by connection with the existing underground power available within Bannerdale Road, Lamorak Way and Hayling Way which are all located to the west of Lot 19. It is anticipated that the overhead power lines which are located on the southern verge of Sixty Eight Road will not be required to service this development and thus any upgrade or relocation of the existing overheads is not anticipated to be a condition of this development. It is noted that the recently completed developments to the west of Lot 19 have not been required to upgrade or relocate the existing overheads.

According to the Western Power Network Capacity Mapping Tool there is a relatively small amount of capacity remaining within this area of the Western Power network (<5MVA). There may be enough capacity for the proposed subdivision however this will need to be confirmed with Western Power. If there is not enough capacity the network may require upgrading, however, this situation is likely to change given the ongoing development of Lots 740, 569 and 1263.

9 Communications

There is existing NBN Co. infrastructure servicing the Lot 18 subdivision to the west of Lot 19. As a result there should not be any significant constraints for connecting the proposed subdivision to the NBN Co network. This will involve a deployment charge of $600 per single-dwelling unit and $400 per multiple-dwelling unit (rates as of November 2015). It is unlikely that any co-contribution will be charged as it appears that NBN Co have sufficient infrastructure in the area to avoid considerable backhaul costs.

10 Conclusion

Pritchard Francis have been commissioned by The Glow Development to review engineering servicing requirements for Lot 19 Sixty Eight Road, Baldivis.

The subject site falls within current water and sewer Water Corporation service areas which will be extended to the boundary of the site through adjacent development. As such the infrastructure will support an urban zoning.

Based on preliminary investigations, we do not envisage any issues servicing the development with Western Power. This is subject to confirmation pending application and receipt of a Design Information Package from Western Power however power infrastructure is available to the site.

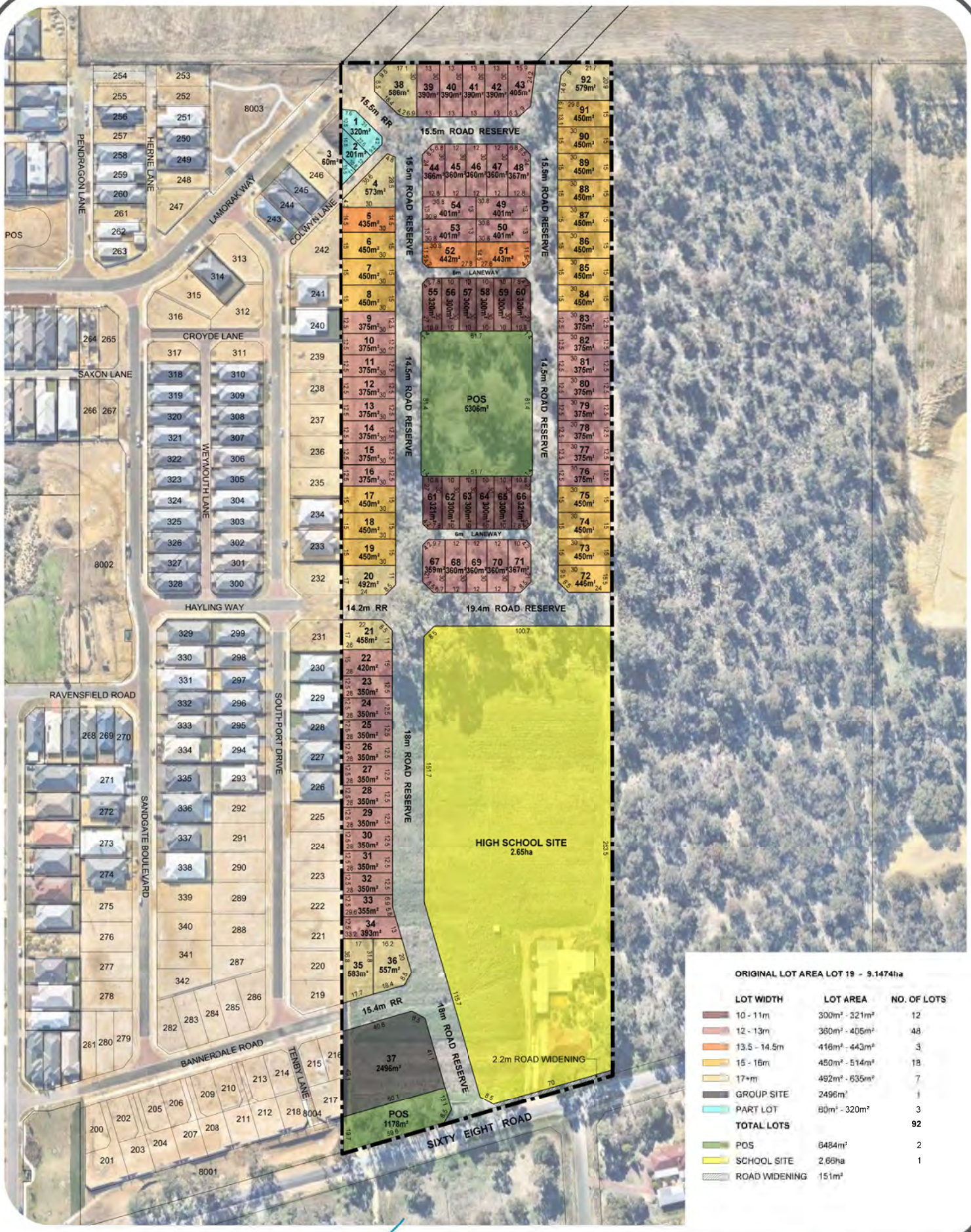
Stormwater infiltration within Public Open Space is proposed to treat all stormwater run-off from the road reserves.

Based on all items within the Engineering Services Report, Pritchard Francis Pty Ltd believes that the proposed development is capable of being serviced with all essential services and with careful consideration in design will result in a high quality urban development.

Appendices

Appendix One	*Subdivision Concept Plan*
Appendix Two	*Conceptual Levels Plan*
Appendix Three	*Sewer Catchment Plan*
Appendix Four	*Wastewater Reticulation – Concept Plan*
Appendix Five	*Water Concept Plans*

Appendix One *Subdivision Concept Plan*



ORIGINAL LOT AREA LOT 19 - 9.1474ha

LOT WIDTH	LOT AREA	NO. OF LOTS
10 - 11m	300m² - 321m²	12
12 - 13m	360m² - 405m²	48
13.5 - 14.5m	416m² - 443m²	3
15 - 16m	450m² - 514m²	18
17+m	492m² - 635m²	7
GROUP SITE	2496m²	1
PART LOT	80m² - 320m²	3
TOTAL LOTS		92
POS	6484m²	2
SCHOOL SITE	2.66ha	1
ROAD WIDENING	151m²	

{the spatial group}
planning + design

Lot 19 Sixty Eight Road, Baldivis | SUBDIVISION CONCEPT - OPTION 1

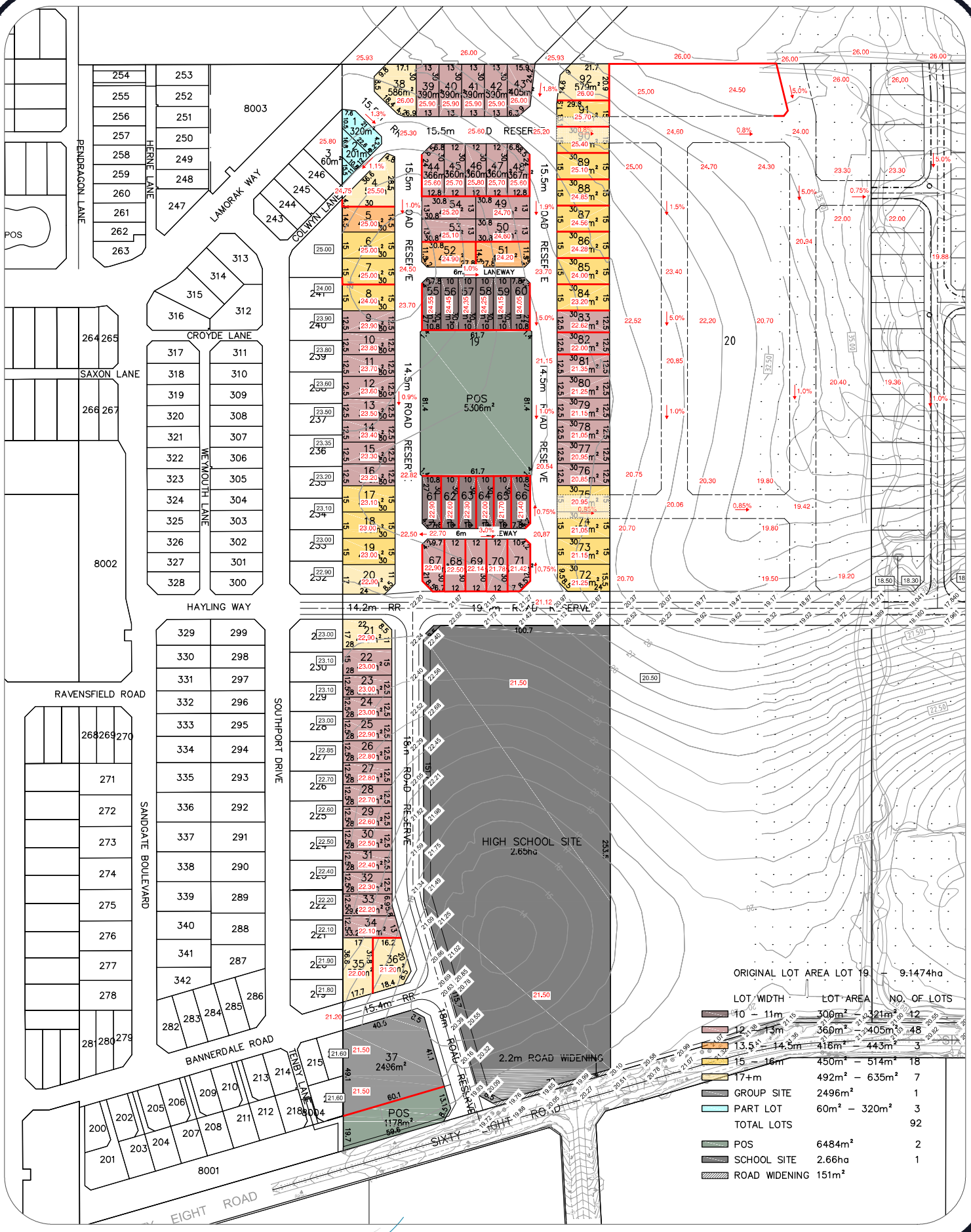
LEIGHTON land development DRAFTING & visuals
bleighton@westnet.com.au
0408 820 007

0 20 40 60 80
metres

Client	:	The Glow Development
Plan No.	:	19-subcon 3
Revision	:	A
Date	:	12 November 2015
Drawn	:	BDL
Scale	:	1:2,000

e: info@thespatialgroup.com.au w: www.thespatialgroup.com.au a: po box 1345 south perth wa 6951

Appendix Two Conceptual Levels Plan



ORIGINAL LOT AREA LOT 19 – 9.1474ha

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15 – 16m	450m² – 514m²	18
17+m	492m² – 635m²	7
GROUP SITE	2496m²	1
PART LOT	60m² – 320m²	3
TOTAL LOTS		92
POS	6484m²	2
SCHOOL SITE	2.66ha	1
ROAD WIDENING	151m²	

{the spatial group} Lot 19 Sixty Eight Road, Baldivis — SUBDIVISION CONCEPT – OPTION 1

planning + design

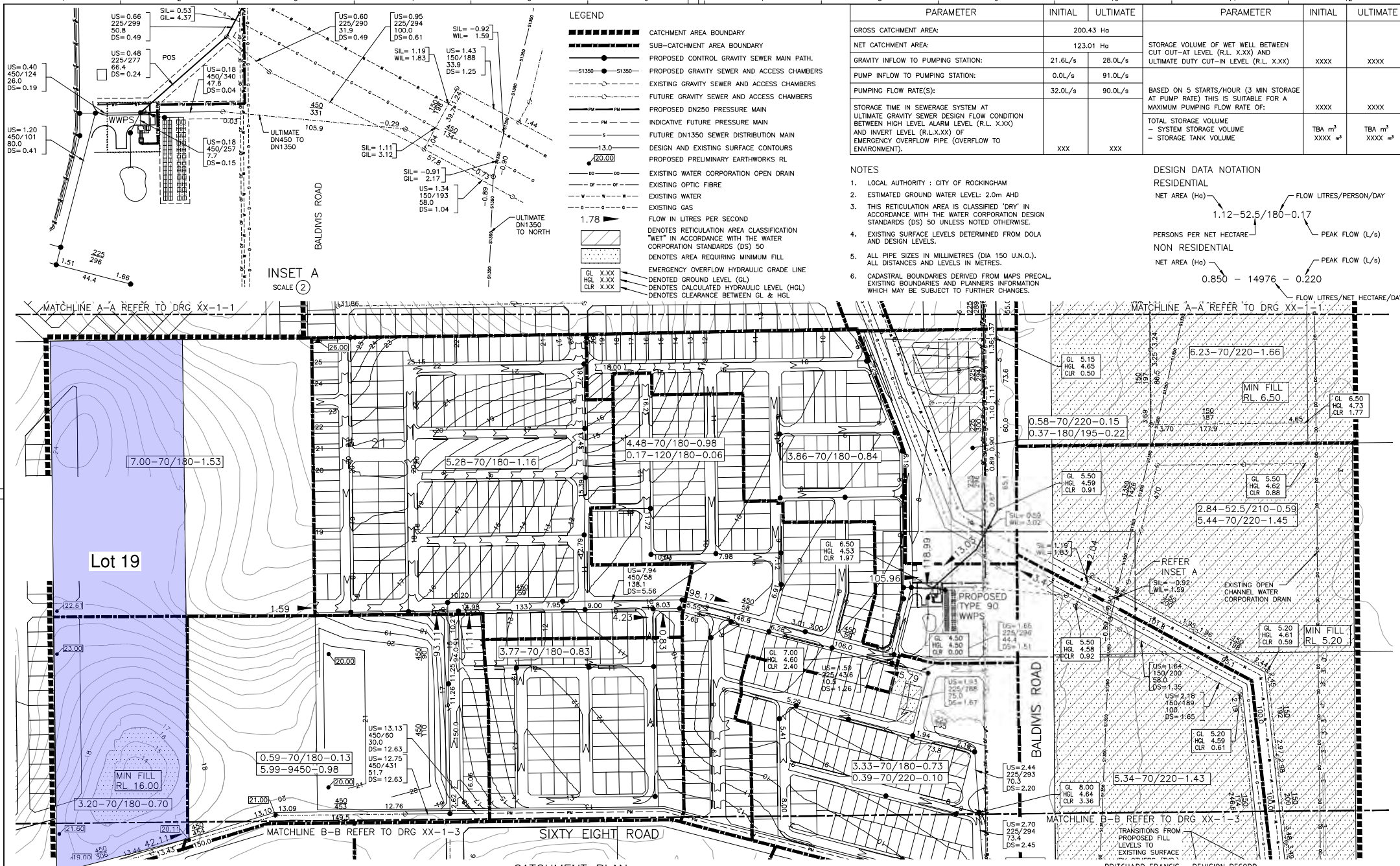
LEIGHTON land development DRAFTING visual — bleighton@westnet.com.au 0408 820 001

0 20 40 60 80 metres

Client	:	The Glow Development
Plan No.	:	19– subcon 3
Revision	:	A
Date	:	12 November 2015
Drawn	:	BDL
Scale	:	1:1000

e: info@thespatialgroup.com.au w: www.thespatialgroup.com.au m: po box 1345 south perth wa 6951

Appendix Three Sewer Catchment Plan



PARAMETER	INITIAL	ULTIMATE	PARAMETER	INITIAL	ULTIMATE
GROSS CATCHMENT AREA:	200.43 Ha				
NET CATCHMENT AREA:	123.01 Ha		STORAGE VOLUME OF WET WELL BETWEEN CUT OUT-AT LEVEL (R.L. X.XX) AND ULTIMATE DUTY CUT-IN LEVEL (R.L. X.XX)	XXXX	XXXX
GRAVITY INFLOW TO PUMPING STATION:	21.6L/s	28.0L/s			
PUMP INFLOW TO PUMPING STATION:	0.0L/s	91.0L/s			
PUMPING FLOW RATE(S):	32.0L/s	90.0L/s	BASED ON 5 STARTS/HOUR (3 MIN STORAGE AT PUMP RATE) THIS IS SUITABLE FOR A MAXIMUM PUMPING FLOW RATE OF:	XXXX	XXXX
STORAGE TIME IN SEWERAGE SYSTEM AT ULTIMATE GRAVITY SEWER DESIGN FLOW CONDITION BETWEEN HIGH LEVEL ALARM LEVEL (R.L. X.XX) AND INVERT LEVEL (R.L.X.XX) OF EMERGENCY OVERFLOW PIPE (OVERFLOW TO ENVIRONMENT).	XXX	XXX	TOTAL STORAGE VOLUME - SYSTEM STORAGE VOLUME - STORAGE TANK VOLUME	TBA m^3 XXXX m^3	TBA m^3 XXXX m^3

NOTES

1. LOCAL AUTHORITY : CITY OF ROCKINGHAM
2. ESTIMATED GROUND WATER LEVEL: 2.0m AHD
3. THIS RETICULATION AREA IS CLASSIFIED 'DRY' IN ACCORDANCE WITH THE WATER CORPORATION DESIGN STANDARDS (DS) 50 UNLESS NOTED OTHERWISE.
4. EXISTING SURFACE LEVELS DETERMINED FROM DOLA AND DESIGN LEVELS.
5. ALL PIPE SIZES IN MILLIMETRES (DIA 150 U.N.O.). ALL DISTANCES AND LEVELS IN METRES.
6. CADASTRAL BOUNDARIES DERIVED FROM MAPS PRECAL, EXISTING BOUNDARIES AND PLANNERS INFORMATION WHICH MAY BE SUBJECT TO FURTHER CHANGES.

DESIGN DATA NOTATION

RESIDENTIAL

NET AREA (Ha) — FLOW LITRES/PERSON/DAY — PERSONS PER NET HECTARE — PEAK FLOW (L/s)

1.12-52.5/180-0.17

NON RESIDENTIAL

NET AREA (Ha) — PEAK FLOW (L/s) — FLOW LITRES/NET HECTARE/DAY

0.850 - 14976 - 0.220

CATCHMENT PLAN

SCALE 1

1 2010 0 20 40 60 80 100 120 140 m (SCALE 1:2000 - A1 SHEET)

2 10 5 0 10 20 30 40 50 60 70 m (SCALE 1:1000 - A1 SHEET)

FOR INFORMATION ONLY

NOT TO BE USED FOR CONSTRUCTION PURPOSES

PRITCHARD FRANCIS - REVISION RECORD

A2	22/04/15	SK	PA	RB	MR	AMENDED AS PER WATER CORPORATION COMMENTS
A1	08/08/14	SAK	DH	DH	MR	ISSUED FOR APPROVAL
No	DATE	DRAFTING CHECK	DESIGN REVIEW	REV'D P.MGR	APP'D P.DIR	AMENDMENT

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY NONE | VERTICAL DATUM AHD | COORDINATE SYS MGA94-50 | ASCON SURVEY NONE | DES REF | DES CALC S.KENNEDY | DES CHD A.LIN | DRN C.BAILEY | Q.C. CHD R.REVY

NORTH POINT

pritchard francis civil and structural engineering consultants
Level 1, 430 Roberts Road
PO Box 2150
Subiaco WA 6904
Telephone: (08) 9382 5111
Facsimile: (08) 9382 5199
admin@pfeng.com.au
ACN. 008 801 094

RECOMMENDED
CONSULTANT PROJECT MANAGER
APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC XXXXXX
BALDIVIS SOUTH INTERIM WWPS NO. 902-XX-UNNAMED RD & PM
CATCHMENT PLAN
SHEET 2 OF 3

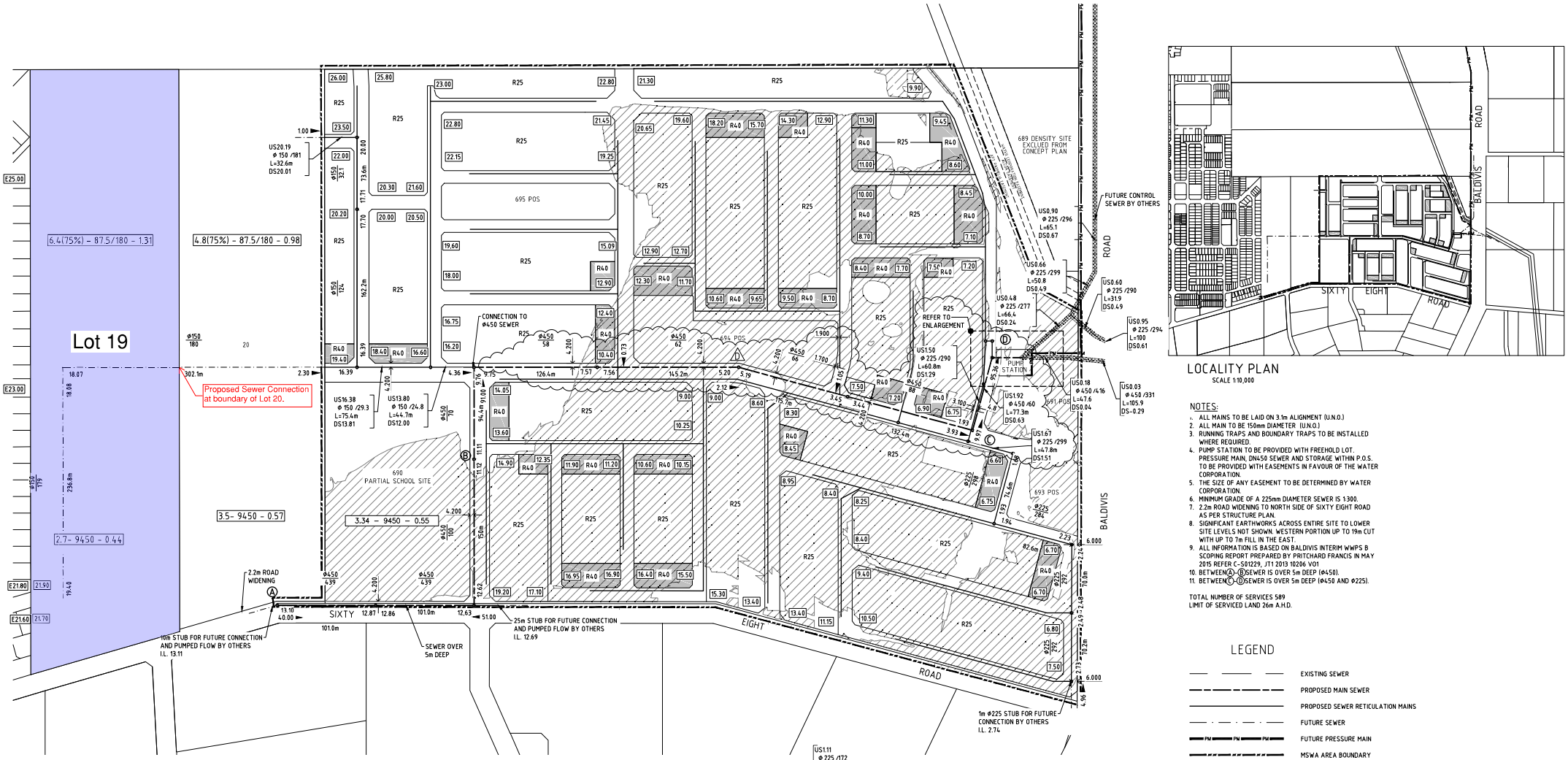
FILE JT1 2013 10206 | PLAN XX-1-2 | CAD | ISSUE A

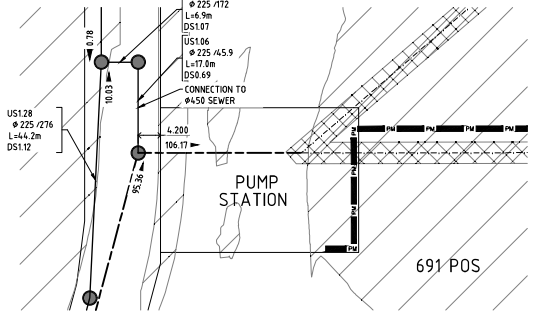
PROJECT C-S01229

ORIGINAL SHEET SIZE A1

566
810

Appendix Four Wastewater Reticulation – Concept Plan





ENLAREMENT
SCALE 1:500

LOCALITY PLAN
SCALE 1:10,000

NOTES:
1. ALL MAINS TO BE LAID ON 3.1m ALIGNMENT (U.N.O.)
2. ALL MAIN TO BE 150mm DIAMETER (U.N.O.)
3. RUNNING TRAPS AND BOUNDARY TRAPS TO BE INSTALLED WHERE REQUIRED.
4. PUMP STATION TO BE PROVIDED WITH FREEHOLD LOT. PRESSURE MAIN, DN450 SEWER AND STORAGE WITHIN P.O.S. TO BE PROVIDED WITH EASEMENTS IN FAVOUR OF THE WATER CORPORATION.
5. THE SIZE OF ANY EASEMENT TO BE DETERMINED BY WATER CORPORATION.
6. MINIMUM GRADE OF A 225mm DIAMETER SEWER IS 1:300.
7. 2.2m ROAD WIDENING TO NORTH SIDE OF SIXTY EIGHT ROAD AS PER STRUCTURE PLAN.
8. SIGNIFICANT EARTHWORKS ACROSS ENTIRE SITE TO LOWER SITE LEVELS NOT SHOWN. WESTERN PORTION UP TO 19m CUT WITH UP TO 7m FILL IN THE EAST.
9. ALL INFORMATION IS BASED ON BALDIVIS INTERIM WWPS B SCOPING REPORT PREPARED BY PRITCHARD FRANCIS IN MAY 2015 REFER C-S01229, JT1 2013 10206 V01
10. BETWEEN Ⓐ-Ⓑ SEWER IS OVER 5m DEEP (Φ450).
11. BETWEEN Ⓒ-Ⓓ SEWER IS OVER 5m DEEP (Φ450 AND Φ225).

TOTAL NUMBER OF SERVICES 589
LIMIT OF SERVICED LAND 26m A.H.D.

LEGEND

- EXISTING SEWER
- PROPOSED MAIN SEWER
- PROPOSED SEWER RETICULATION MAINS
- FUTURE SEWER
- FUTURE PRESSURE MAIN
- MSWA AREA BOUNDARY
- PUMP STATION CATCHMENT BOUNDARY
- EASEMENT
- 6.10 PAD LEVELS
- E6.10 EXISTING PAD LEVELS
- AREA TO BE FILLED
- CONTROL LINE
- 1.04 FLOW IN LITRES PER SECOND
- R40 R-CODE DENSITY

THIS PLAN IS ACCEPTED AS COMPLYING WITH OVERALL SCHEME PLANNING. COMPLIANCE WITH WATER CORPORATION DESIGN STANDARDS OR STATUTORY REQUIREMENTS HAS NOT BEEN CHECKED AND REMAINS THE RESPONSIBILITY OF THE CONSULTING ENGINEER.

FOR: MANAGER LAND SERVICING DATE

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
D	10/2015		RETICULATION CONNECTIONS TO Φ450 SEWER REMOVED	RT		RB
C	08/2015		WATER CORPORATION AMENDMENTS	RT		RB
B	08/2015		WATER CORPORATION AMENDMENTS	RT		RB
A	07/2015		ISSUED FOR APPROVAL	RT		RB

DESIGN SURVEY NONE
VERTICAL DATUM AHD
COORDINATE SYS PCG94
ASCON SURVEY NONE
DES REF
DES CALC
DES CHD
DRN RT
Q.C. CHD

NORTH POINT

pritchard francis
civil and structural engineering consultants
Level 1, 430 Roberts Road
PO Box 2150
Subiaco WA 6904
Telephone: (08) 9382 9111
Facsimile: (08) 9382 5199
admin@pfeng.com.au
ACN: 008 891 094

RECOMMENDED
CONSULTANT PROJECT MANAGER
APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN SUBDIVISON WAPC 151913 – MSWA
BRIGHTWOOD – BALDIVIS
WASTEWATER RETICULATION – CONCEPT PLAN

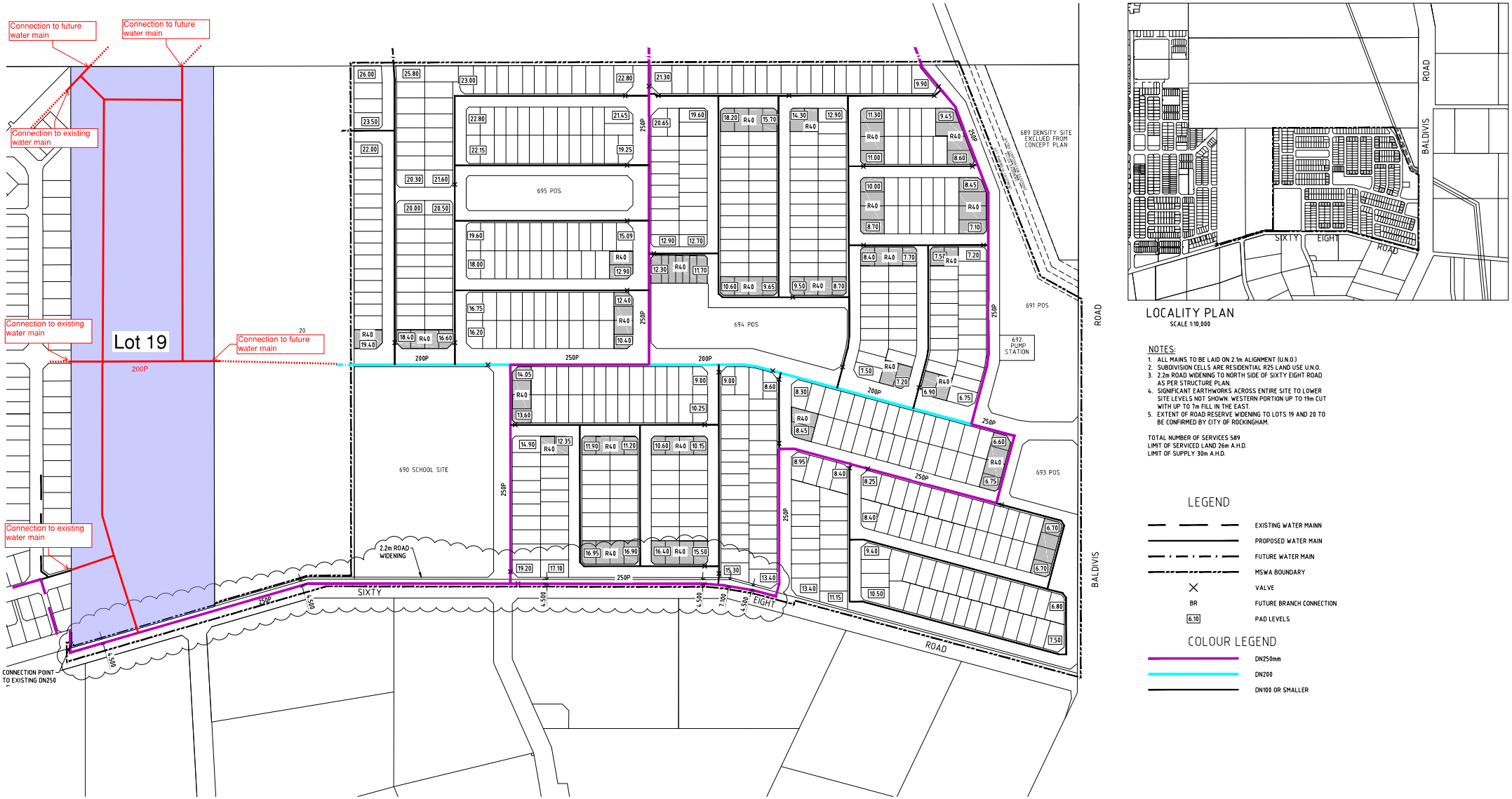
ORIGINAL SHEET SIZE A1

FILE JT1 2015 08045 V01
PROJECT
PLAN MA72-200-001-01A
CAD
ISSUE D
MF

566
810

WORKING\2013\13-114 ARN 68 ROAD\CIVIL\13-114 OVERALL\MA72-200-001-01B 24/08/2015

Appendix Five Water Concept Plans



SCALE 1:2000

LOCALITY PLAN
SCALE 1:10,000

NOTES:
1. ALL MAINS TO BE LAID ON 2.1m ALIGNMENT (U.N.O.)
2. SUBDIVISION CELLS ARE RESIDENTIAL R25 LAND USE U.N.O.
3. 2.2m ROAD WIDENING TO NORTH SIDE OF SIXTY EIGHT ROAD AS PER STRUCTURE PLAN.
4. SIGNIFICANT EARTHWORKS ACROSS ENTIRE SITE TO LOWER SITE LEVELS NOT SHOWN. WESTERN PORTION UP TO 19m CUT WITH UP TO 7m FILL IN THE EAST.
5. EXTENT OF ROAD RESERVE WIDENING TO LOTS 19 AND 20 TO BE CONFIRMED BY CITY OF ROCKINGHAM.

TOTAL NUMBER OF SERVICES 589
LIMIT OF SERVICED LAND 26m A.H.D.
LIMIT OF SUPPLY 30m A.H.D.

LEGEND

- EXISTING WATER MAINN
- PROPOSED WATER MAIN
- FUTURE WATER MAIN
- MSWA BOUNDARY
- VALVE
- BR — FUTURE BRANCH CONNECTION
- 6.10 — PAD LEVELS

COLOUR LEGEND

- DN250mm
- DN200
- DN100 OR SMALLER

THIS PLAN IS ACCEPTED AS COMPLYING WITH OVERALL SCHEME PLANNING. COMPLIANCE WITH WATER CORPORATION DESIGN STANDARDS OR STATUTORY REQUIREMENTS HAS NOT BEEN CHECKED AND REMAINS THE RESPONSIBILITY OF THE CONSULTING ENGINEER.

FOR: MANAGER LAND SERVICING DATE

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
D	09/2015		ALIGNMNET IN SIXTY EIGHT ROAD AMENDED	RT		RB
C	08/2015		WATER CORPORATION AMENDMENTS	RT		RB
B	08/2015		WATER CORPORATION AMENDMENTS	RT		RB
A	07/2015		ISSUED FOR APPROVAL	RT		RB

DESIGN SURVEY NONE | VERTICAL DATUM AHD | COORDINATE SYS PCG94 | ASCON SURVEY NONE | DES REF | DES CALC | DES CHD | DRN RT | Q.C. CHD

NORTH POINT

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Facsimile: (08) 9382 5199
admin@pfeng.com.au
ACN: 008 891 094

RECOMMENDED
CONSULTANT PROJECT MANAGER
APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN SUBDIVISON WAPC 151913 – MSWA
BRIGHTWOOD – BALDIVIS
WATER RETICULATION – CONCEPT PLAN

ORIGINAL SHEET SIZE A1

FILE JT1 2015 08045 V01 | PLAN MA72-100-001-01A | CAD | ISSUE D | MF
PROJECT

WORKING\2013\13-114 ARN 68 ROAD\CIVIL\13-114 OVFRALL\MA72-100-001-01A 17/09/2015

566
810

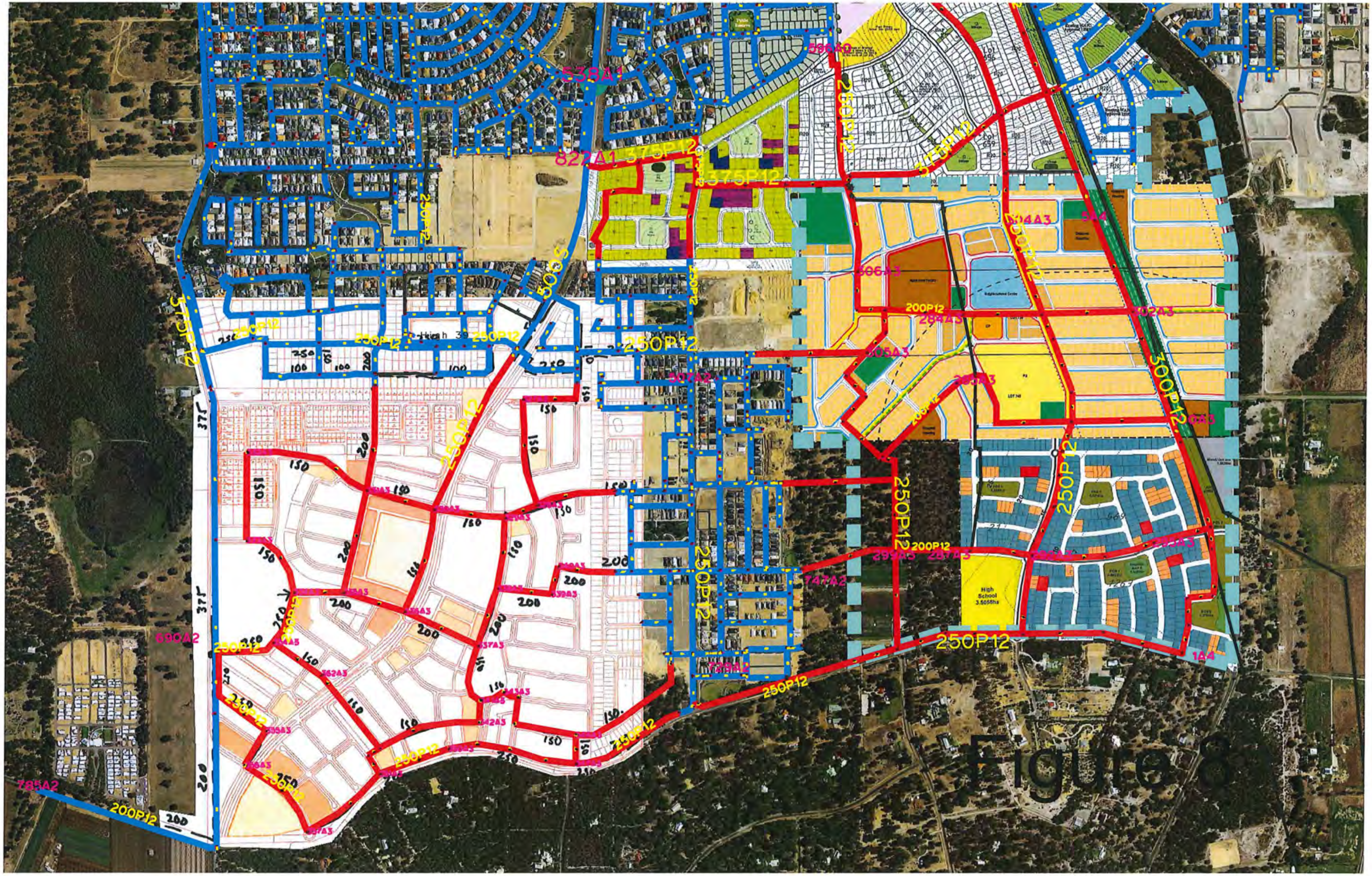

300P12
250P12
375P12
200P12
822A1
538A1
506A3
505A3
302A3
304A3
284A3
747A2
690A2
785A2
1A4
High School 3.5056ha

Figure 8

APPENDIX E

Concept Landscape Plan

LOT 19 SIXTY EIGHT ROAD BALDIVIS

LEGEND

1	POS to Sixty Eight Road
2	POS with feature node area
3	POS with drainage basin @115m² for 1:1yr events
4	Future High school site linking with Brightwood Estate
5	Verge/Streetscape trees and planting to Lots
6	Residential Lots
7	Adjoining Lot/s

0 25 50 75 100
metres

N

* Concept Plan subject to change in detailed design

LD TOTAL
LEADERS IN LANDSCAPING

APPENDIX F

UNDO Modelling Results

Government of Western Australia
Department of Water

Project: 25 Date: 13/06/2016

Proponent: Anonymous User Version: Trial 1.0.0.3

Subregion name: **Residential**

Landuse	Percent	Area	Input N-Load	Input P-Load
	%	ha	(kg)	(kg)
Residential	100	3.83	285.90	72.71
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public Open Space	0	0.00	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total Area (ha) :	**3.83**
Total percent (%) :	**42**
NUTRIENT INPUT	
Nitrogen (kg/yr) :	**285.90**
Phosphorus (kg/yr) :	**72.71**
NUTRIENT EXPORT	
Nitrogen (kg/yr) :	**26.36**
Phosphorus (kg/yr) :	**0.49**

Residential

Size	Percent	Area	Input Load Nitrogen	Input Load Phosphorus
(m²)	(%)	(ha)	(kg)	(kg)
<400	25	0.96	22.50	6.59
401-600	70	2.68	244.14	61.04
601-730	5	0.19	19.27	5.08
>730	0	0.00	0.00	0.00

Total Area (ha) :	**3.8304**
Total percent (%) :	**100**
Nitrogen input (kg) :	**285.90**
Phosphorus input (kg) :	**72.71**

Soil and Drainage Information

Type of drainage	Infiltration	Does it contain imported fill?	No
Soil type	Spearwood Dune	Does subregion contain onsite sewage diposal system?	No
Depth to groundwater (m)	15		
Groundwater slope (%)	0.1		
Soil PRI	11.025		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: School

			Input	
Landuse	Percent	Area	N-Load	P-Load
	%	ha	(kg)	(kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	100	2.64	267.12	53.16
Rural living	0	0.00	0.00	0.00
Public Open Space	0	0.00	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total Area (ha) :	2.64
Total percent (%) :	29
NUTRIENT INPUT	
Nitrogen (kg/yr) :	267.12
Phosphorus (kg/yr) :	53.16
NUTRIENT EXPORT	
Nitrogen (kg/yr) :	25.16
Phosphorus (kg/yr) :	0.36

Commercial, Industry and Schools

Landuse	Percent	Area
	(%)	(ha)
Light industrial	0	0.00
Heavy industrial	0	0.00
Commercial / Offices	0	0.00
Schools	100	2.64
Public buildings	0	0.00

Total Area (ha) :	2.64
Total percent (%) :	100
Nitrogen input (kg) :	267.12
Phosphorus input (kg) :	53.16

Soil and Drainage Information

Type of drainage	Infiltration	Does it contain imported fill?	No
Soil type	Spearwood Dune	Does subregion contain onsite sewage diposal system?	No
Depth to groundwater (m)	15		
Groundwater slope (%)	0.1		
Soil PRI	11.025		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: Road

			Input	
Landuse	Percent	Area	N-Load	P-Load
	%	ha	(kg)	(kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public Open Space	0	0.00	0.00	0.00
Road reserve	100	2.01	21.77	4.00

Total Area (ha) :	2.01
Total percent (%) :	22
NUTRIENT INPUT	
Nitrogen (kg/yr) :	21.77
Phosphorus (kg/yr) :	4.00
NUTRIENT EXPORT	
Nitrogen (kg/yr) :	1.39
Phosphorus (kg/yr) :	0.19

Road reserve

Landuse	Percent	Area
	(%)	(ha)
Roads	80	1.61
Road reserve - Impervious	5	0.10
Road reserve - Native garden	5	0.10
Road reserve - Non-native garden	5	0.10
Road reserve - Turf	5	0.10
Road reserve - Not maintained	0	0.00

Total Area (ha) :	2.0064
Total percent (%) :	100
Nitrogen input (kg) :	21.77
Phosphorus input (kg) :	21.77

Soil and Drainage Information

Type of drainage	Piped drainage	Does it contain imported fill?	No
Soil type	Spearwood Dune	Does subregion contain onsite sewage diposal system?	No
Depth to groundwater (m)	15		
Groundwater slope (%)	0.1		
Soil PRI	11.025		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: POS

			Input	
Landuse	Percent	Area	N-Load	P-Load
	%	ha	(kg)	(kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public Open Space	100	0.64	38.30	5.70
Road reserve	0	0.00	0.00	0.00

Total Area (ha) :	0.64
Total percent (%) :	7
NUTRIENT INPUT	
Nitrogen (kg/yr) :	38.30
Phosphorus (kg/yr) :	5.70
NUTRIENT EXPORT	
Nitrogen (kg/yr) :	3.81
Phosphorus (kg/yr) :	0.04

Public Open Space (POS)

Landuse	Percent	Area
	(%)	(ha)
Native gardens	25	0.16
Non-native gardens	25	0.16
Not maintained	0	0.00
Remnant bush	0	0.00
Active turf	45	0.29
Passive turf	0	0.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	5	0.03
Water body	0	0.00

Total Area (ha) :	0.64
Total percent (%) :	100
Nitrogen input (kg) :	38.30
Phosphorus input (kg) :	5.70

Soil and Drainage Information

Type of drainage	Infiltration	Does it contain imported fill?	No
Soil type	Spearwood Dune	Does subregion contain onsite sewage diposal system?	No
Depth to groundwater (m)	15		
Groundwater slope (%)	0.1		
Soil PRI	11.025		

Note: Please attach the results of soil tests to this report when submitting.

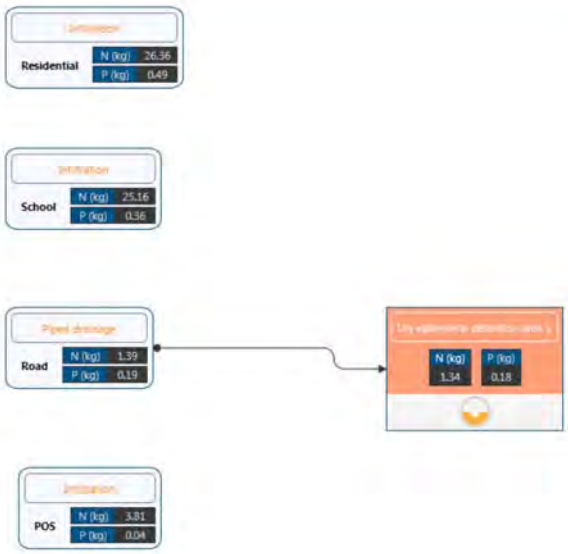
Summary: Nutrient stripping devices

Treatment	Name	Size (m²)	Treated area (ha)	Treating	N Removed (kg/yr)	P Removed (kg/yr)
Dry ephemeral detention area	Dry ephemeral detention area 1	500.00	2.01	Sandy soils – Runoff only	0.04	0.00
Load removed					0.04	0.00
Net export					56.67	1.06

Summary: Nutrient load exports

Region	Area (ha)	P Export (kg/yr)	N Export (kg/yr)
Residential	3.83	0.49	26.36
School	2.64	0.36	25.16
Road	2.01	0.19	1.39
POS	0.64	0.04	3.81
Pre-treatment load		1.07	56.71
Load removed by structures		0.00	0.04
Net load export		1.06	56.67

Treatment diagram



APPENDIX G

INFIL MODELLING RESULTS

CATCHMENT A - INFIL RESULTS

1 Year 1 hour ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now: F9
Help On: Ctrl+h
Help Off: Ctrl+j

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 1yr ARI storm event. Catchment A

Input Parameters

Catchment

Catchment area	1.32	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	12.5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.063	[ha]

Initial Conditions

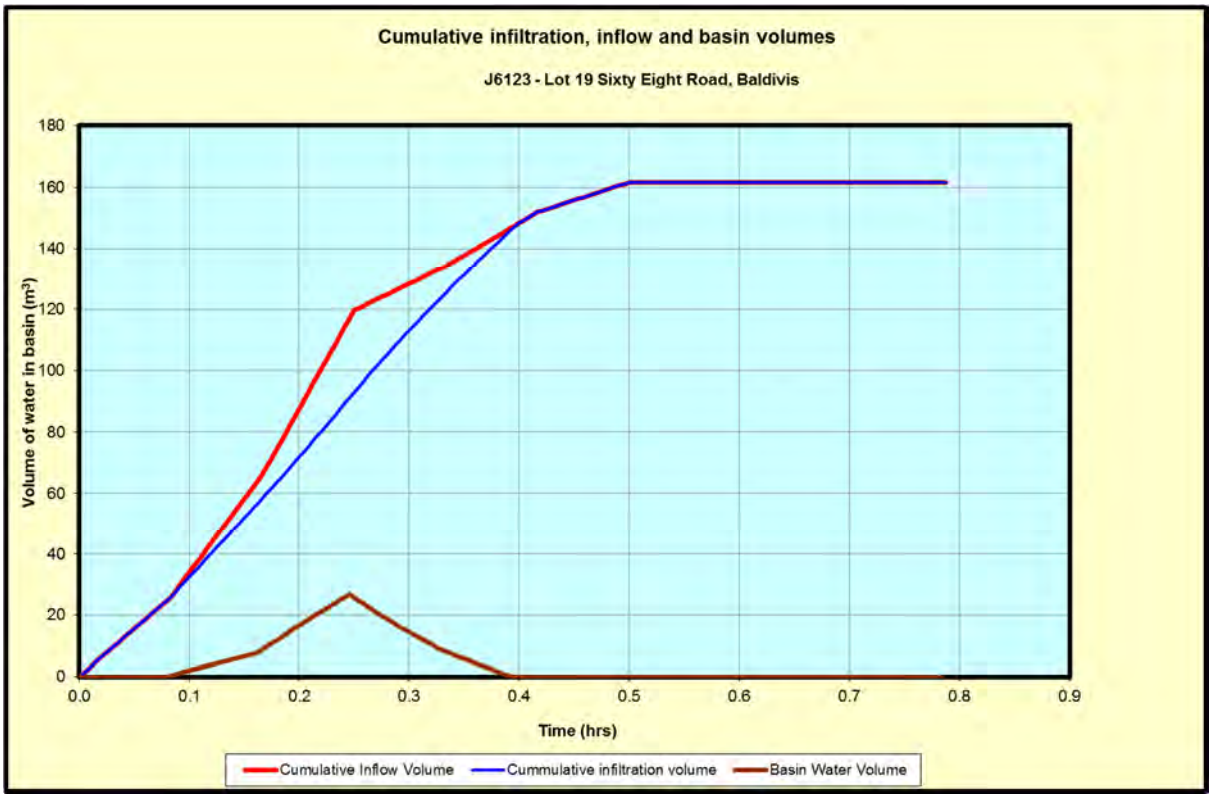
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms — **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m^3]	Area [m^2]	Wetting Front [m]
	1	0.5	24.50	1	0.23	27	115	1.6
	2	1	16.00	1	0.16	18	115	2.1
	3	3	7.90	1	0.03	3	115	3.1
	4	6	5.04	1	0.00	0	0	4.0
	5	12	3.24	1	0.00	0	0	5.1
	6	24	2.10	1	0.00	0	0	6.6
	7	48	1.33	1	0.00	0	0	8.4
	8	72	0.99	1	0.00	0	0	9.3
Critical	**1**	**0.5**	**24.5**	**1**	**0.23**	**27**	**115**	
Plot	1	0.5	24.5	1	0.23	27	115	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	115
0.00	0	115
0.10	12	115
0.20	23	115
0.30	35	115
0.31	40	540
0.40	89	540
0.50	143	540
0.60	197	540
0.70	251	540
0.80	309	637
0.90	378	742
1.00	458	856
1.10	550	977
1.20	654	1106
1.30	771	1243
1.30	771	1243
1.30	771	1243



5 Year ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now : F9
Help On: Ctrl+h
Help Off: Ctrl+j

Input Parameters

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 5yr ARI storm event. Catchment A

Catchment

Catchment area	2.28	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	12.5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.06	[ha]

Initial Conditions

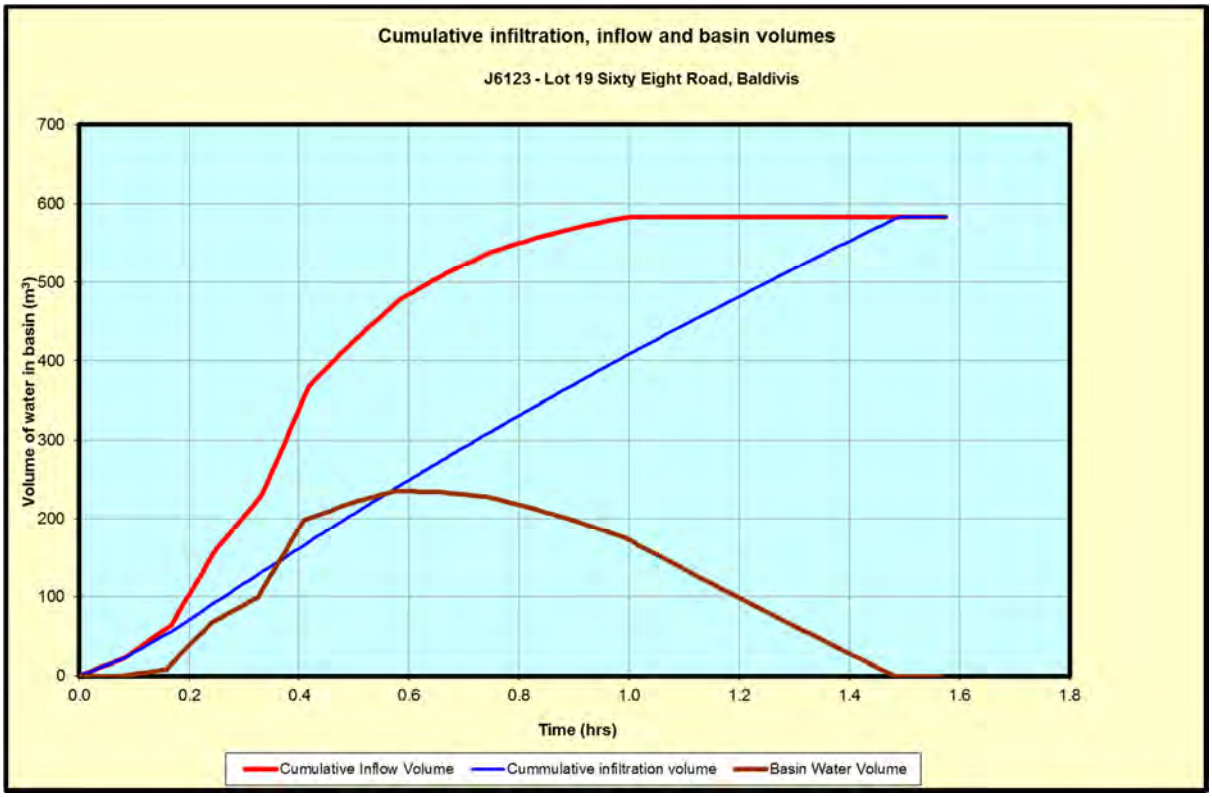
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms — **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m³]	Area [m²]	Wetting Front [m]
	1	0.5	40.00	5	0.65	221	540	2.4
	2	1	25.60	5	0.67	236	540	4.1
	3	3	12.40	5	0.62	208	540	8.4
	4	6	7.84	5	0.51	150	540	10.7
	5	12	5.01	5	0.59	192	540	13.6
	6	24	3.24	5	0.45	117	540	17.6
	7	48	2.07	5	0.00	0	0	22.5
	8	72	1.55	5	0.00	0	0	25.3
Critical	**2**	**1**	**25.6**	**5**	**0.67**	**236**	**540**	
Plot	2	1	25.6	5	0.67	236	540	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	115
0.00	0	115
0.10	12	115
0.20	23	115
0.30	35	115
0.31	40	540
0.40	89	540
0.50	143	540
0.60	197	540
0.70	251	540
0.80	309	637
0.90	378	742
1.00	458	856
1.10	550	977
1.20	654	1106
1.30	771	1243
1.30	771	1243
1.30	771	1243



10 Year ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now: F9
Help On: Ctrl+h
Help Off: Ctrl+j

Input Parameters

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 10yr ARI storm event.
Catchment A

Catchment

Catchment area	2.28	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	12.5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.06	[ha]

Initial Conditions

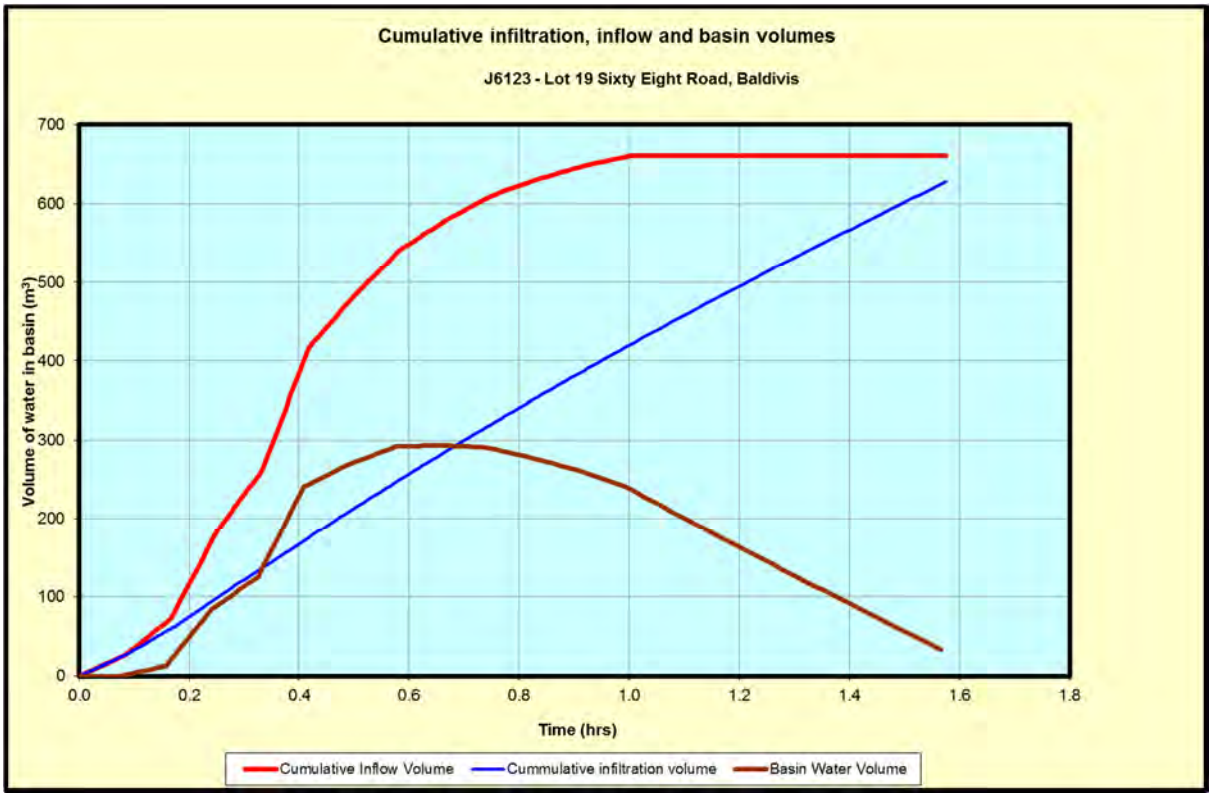
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms — **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m^3]	Area [m^2]	Wetting Front [m]
	1	0.5	45.70	10	0.74	276	581	2.5
	2	1	29.00	10	0.77	294	611	4.2
	3	3	13.90	10	0.72	261	557	9.4
	4	6	8.76	10	0.59	189	540	11.9
	5	12	5.60	10	0.69	246	540	15.2
	6	24	3.62	10	0.55	170	540	19.7
	7	48	2.32	10	0.32	46	540	25.2
	8	72	1.73	10	0.00	0	0	28.2
Critical	**2**	**1**	**29**	**10**	**0.77**	**294**	**611**	
Plot	2	1	29	10	0.77	294	611	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	115
0.00	0	115
0.10	12	115
0.20	23	115
0.30	35	115
0.31	40	540
0.40	89	540
0.50	143	540
0.60	197	540
0.70	251	540
0.80	309	637
0.90	378	742
1.00	458	856
1.10	550	977
1.20	654	1106
1.30	771	1243
1.30	771	1243
1.30	771	1243



100 Year ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now : F9
Help On: Ctrl+h
Help Off: Ctrl+j

Input Parameters

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 100yr ARI storm event. Catchment A

Catchment

Catchment area	2.28	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	12.5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.06	[ha]

Initial Conditions

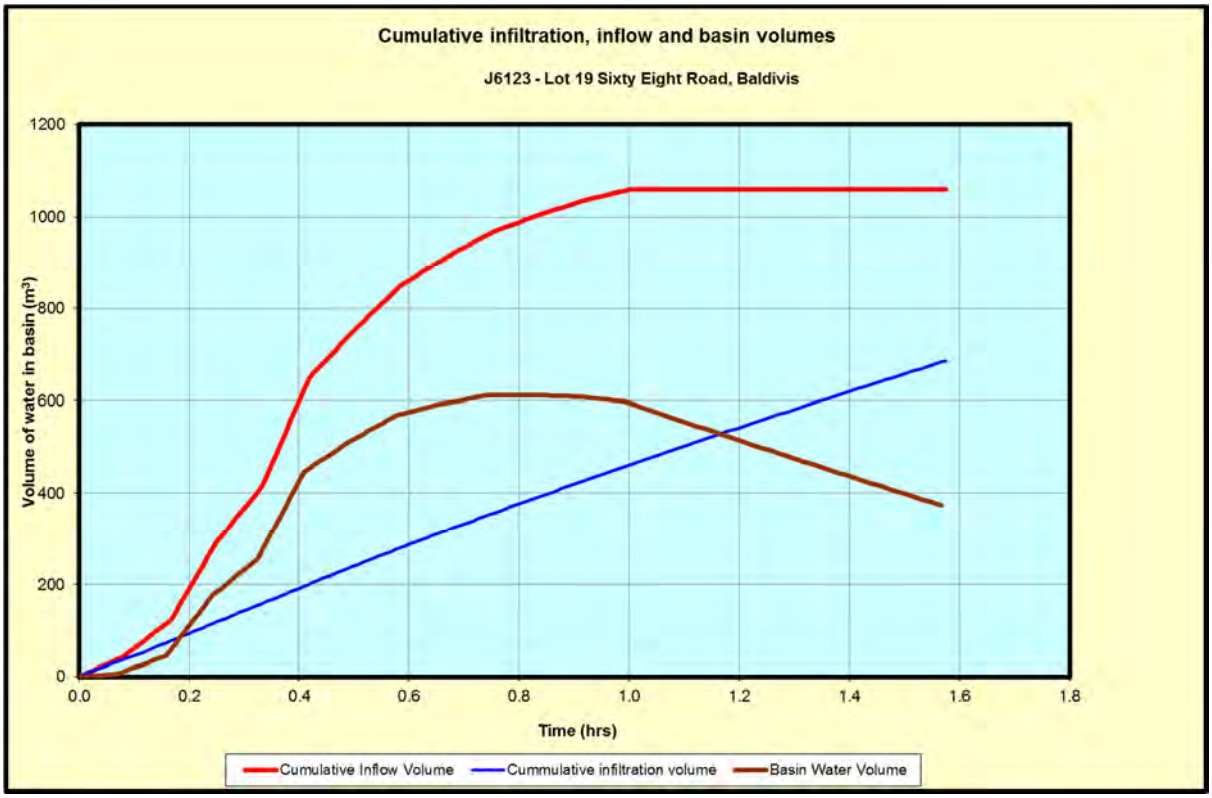
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms — **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m³]	Area [m²]	Wetting Front [m]
	1	0.5	75.10	100	1.13	580	1015	2.7
	2	1	46.50	100	1.16	613	1055	4.6
	3	3	21.70	100	1.03	487	895	11.8
	4	6	13.60	100	0.88	368	726	18.5
	5	12	8.67	100	0.90	379	744	23.6
	6	24	5.61	100	0.79	305	630	30.5
	7	48	3.61	100	0.63	215	540	39.3
	8	72	2.71	100	0.00	0	0	44.2
Critical	**2**	**1**	**46.5**	**100**	**1.16**	**613**	**1055**	
Plot	2	1	46.5	100	1.16	613	1055	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	115
0.00	0	115
0.10	12	115
0.20	23	115
0.30	35	115
0.31	40	540
0.40	89	540
0.50	143	540
0.60	197	540
0.70	251	540
0.80	309	637
0.90	378	742
1.00	458	856
1.10	550	977
1.20	654	1106
1.30	771	1243
1.30	771	1243
1.30	771	1243



CATCHMENT B – INFIL RESULTS

1 Year:1 hour ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now: F9
Help On: Ctrl+h
Help Off: Ctrl+j

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 1yr ARI storm event. Catchment B

Input Parameters

Catchment

Catchment area	0.87	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	7.5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.045	[ha]

Initial Conditions

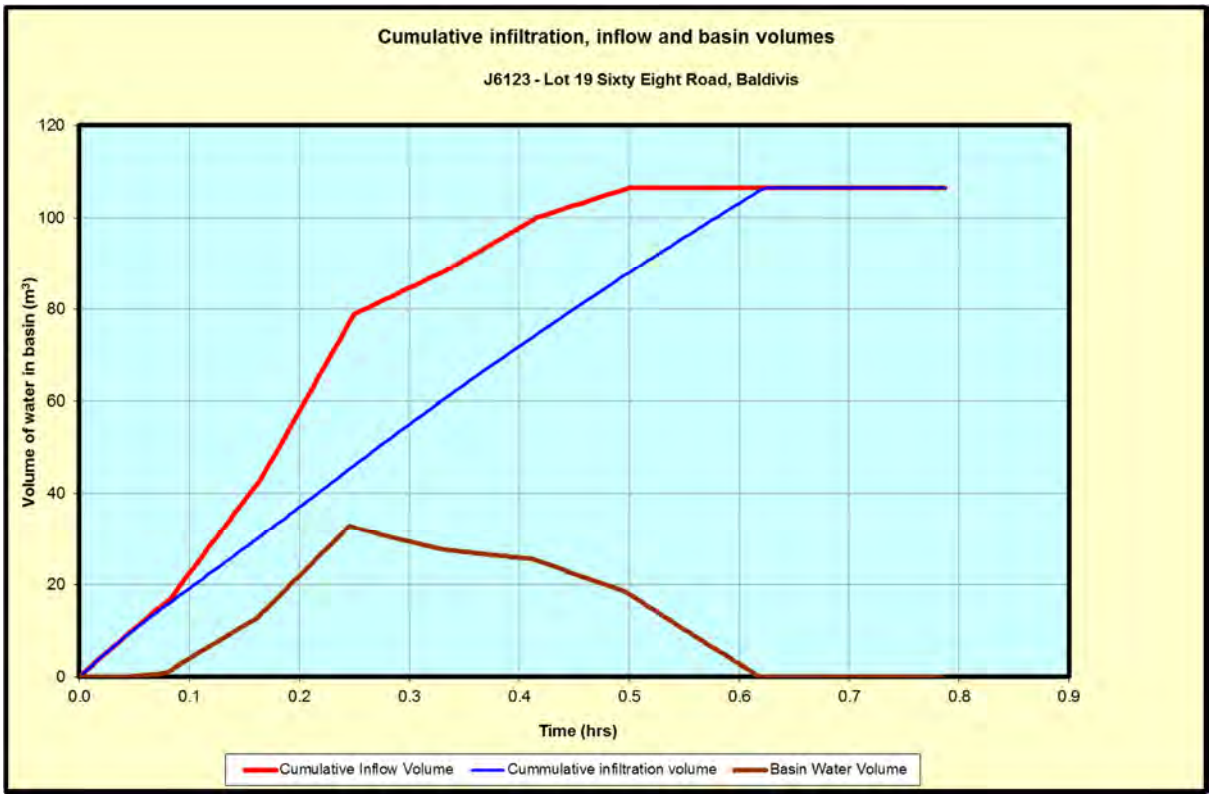
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms / **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m^3]	Area [m^2]	Wetting Front [m]
	1	0.5	24.50	1	0.14	33	450	1.2
	2	1	16.00	1	0.13	30	450	1.9
	3	3	7.90	1	0.10	20	450	2.9
	4	6	5.04	1	0.04	7	450	3.7
	5	12	3.24	1	0.08	16	450	4.7
	6	24	2.10	1	0.00	0	0	6.1
	7	48	1.33	1	0.00	0	0	7.7
	8	72	0.99	1	0.00	0	0	8.6
Critical	**1**	**0.5**	**24.5**	**1**	**0.14**	**33**	**450**	
Plot	1	0.5	24.5	1	0.14	33	450	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	450
0.10	19	450
0.20	50	450
0.30	92	450
0.40	131	450
0.53	179	450
0.61	206	450
0.71	240	450
0.81	269	450
0.91	291	450
1.00	311	450
1.10	320	450
1.20	320	450
1.30	320	450
1.40	320	450
1.50	320	450
1.60	320	450
1.60	320	450



5 Year ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now : F9
Help On: Ctrl+h
Help Off: Ctrl+j

Input Parameters

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 1yr ARI storm event. Catchment B

Catchment

Catchment area	1.125	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	7.5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.05	[ha]

Initial Conditions

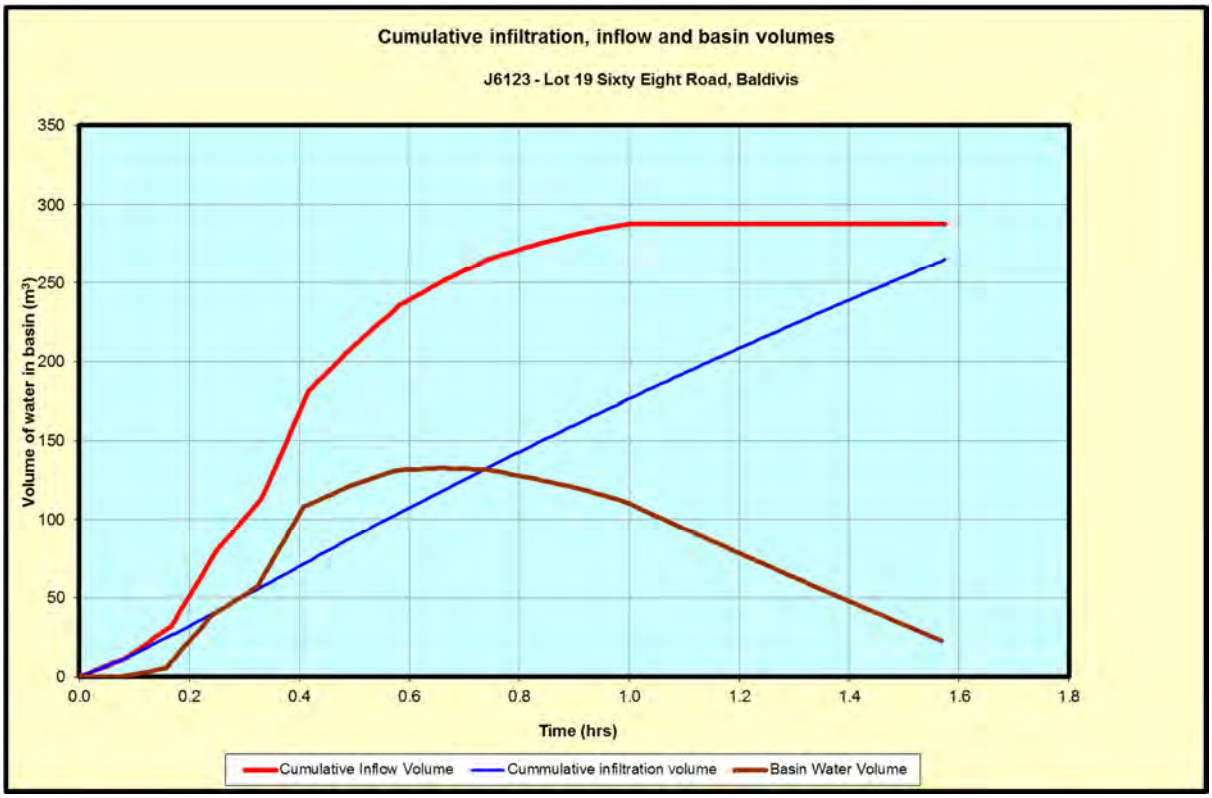
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms — **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m^3]	Area [m^2]	Wetting Front [m]
	1	0.5	40.00	5	0.38	123	450	1.4
	2	1	25.60	5	0.40	133	450	2.5
	3	3	12.40	5	0.37	121	450	5.8
	4	6	7.84	5	0.29	87	450	7.4
	5	12	5.01	5	0.36	114	450	9.4
	6	24	3.24	5	0.27	81	450	12.2
	7	48	2.07	5	0.13	29	450	15.5
	8	72	1.55	5	0.00	0	0	17.4
Critical	**2**	**1**	**25.6**	**5**	**0.40**	**133**	**450**	
Plot	2	1	25.6	5	0.40	133	450	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	450
0.10	19	450
0.20	50	450
0.30	92	450
0.40	131	450
0.53	179	450
0.61	206	450
0.71	240	450
0.81	269	450
0.91	291	450
1.00	311	450
1.10	320	450
1.20	320	450
1.30	320	450
1.40	320	450
1.50	320	450
1.60	320	450
1.60	320	450



10 Year ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys

Auto Calc On:	Ctrl+o
Auto Calc Off:	Ctrl+f
Calc Now :	F9
Help On:	Ctrl+h
Help Off:	Ctrl+j

Input Parameters

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 10yr ARI storm event. Catchment B

Catchment

Catchment area	1.125	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	7.5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.05	[ha]

Initial Conditions

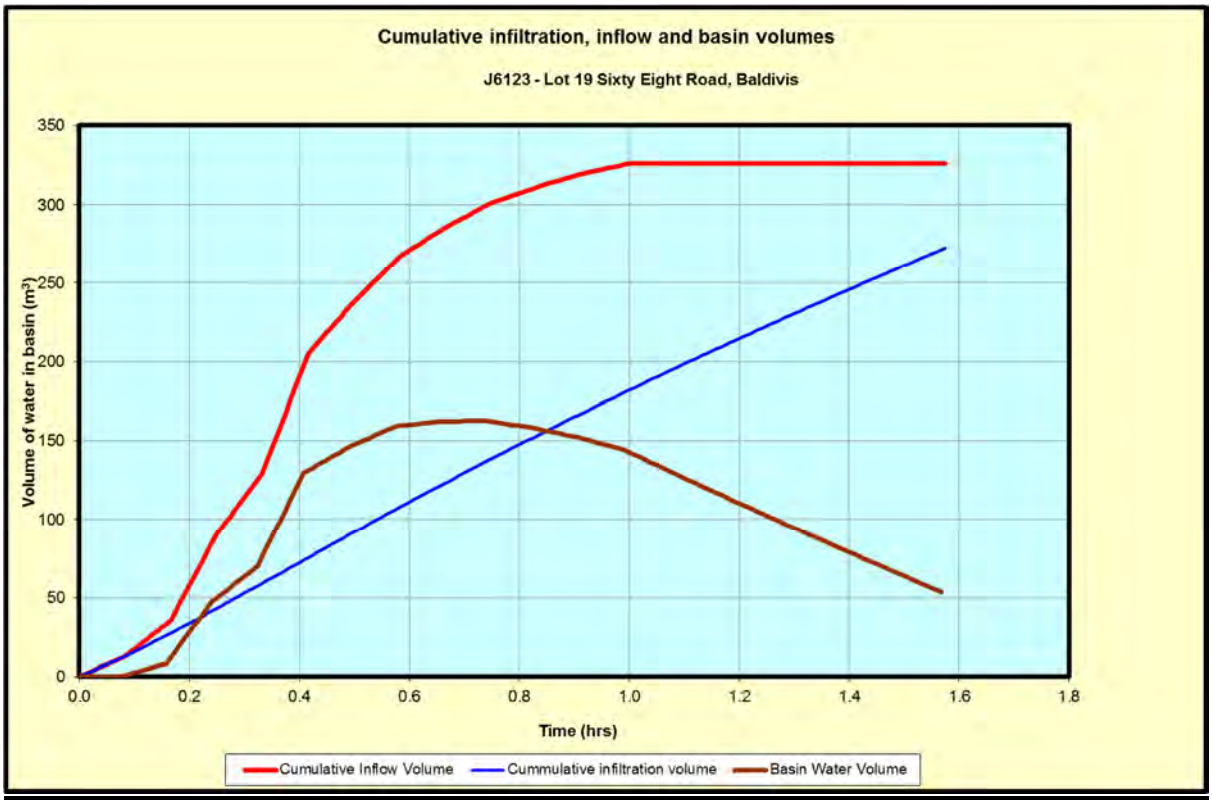
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms / **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m^3]	Area [m^2]	Wetting Front [m]
	1	0.5	45.70	10	0.45	150	450	1.5
	2	1	29.00	10	0.49	163	450	2.5
	3	3	13.90	10	0.44	148	450	6.5
	4	6	8.76	10	0.33	106	450	8.2
	5	12	5.60	10	0.43	142	450	10.5
	6	24	3.62	10	0.34	108	450	13.6
	7	48	2.32	10	0.24	65	450	17.4
	8	72	1.73	10	0.00	0	0	19.5
Critical	**2**	**1**	**29**	**10**	**0.49**	**163**	**450**	
Plot	2	1	29	10	0.49	163	450	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	450
0.10	19	450
0.20	50	450
0.30	92	450
0.40	131	450
0.53	179	450
0.61	206	450
0.71	240	450
0.81	269	450
0.91	291	450
1.00	311	450
1.10	320	450
1.20	320	450
1.30	320	450
1.40	320	450
1.50	320	450
1.60	320	450
1.60	320	450



100 Year ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now: F9
Help On: Ctrl+h
Help Off: Ctrl+j

Input Parameters

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 100yr ARI storm event. Catchment B

Catchment

Catchment area	1.125	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	7.5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.05	[ha]

Initial Conditions

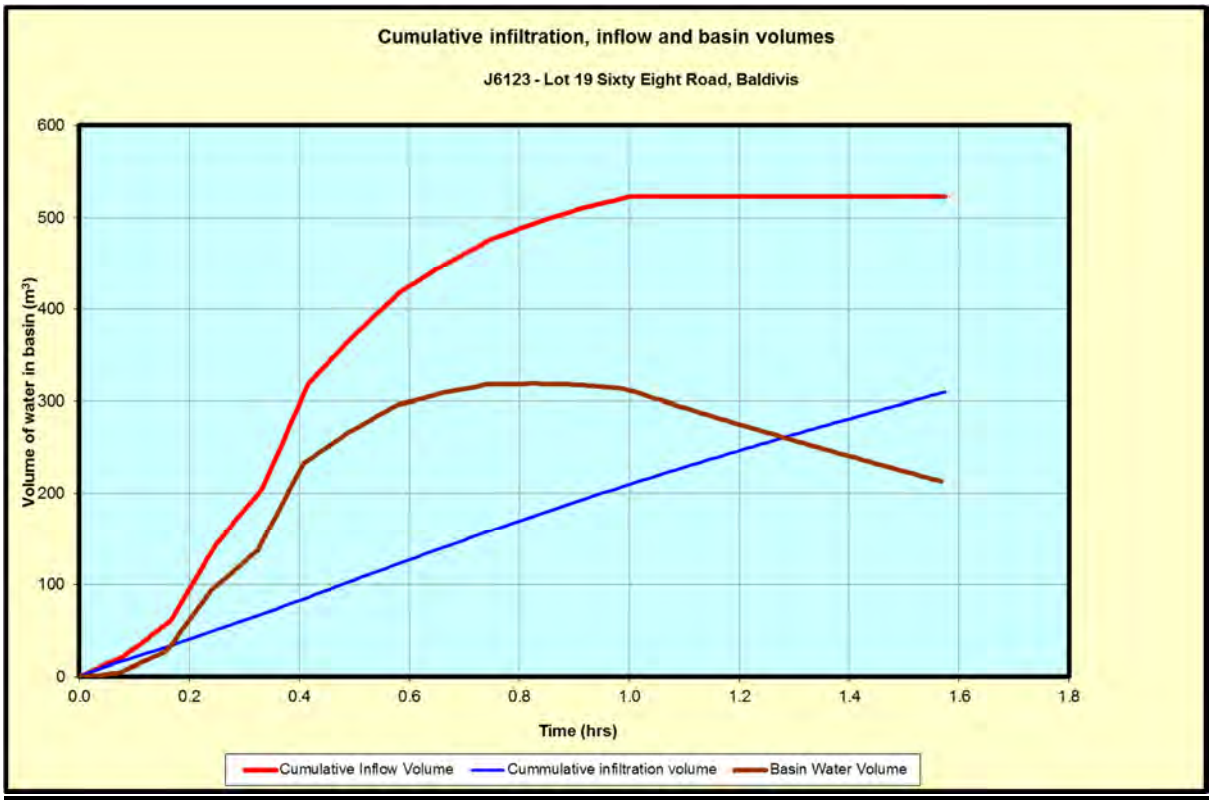
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms — Maximum Levels

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m³]	Area [m²]	Wetting Front [m]
	1	0.5	75.10	100	0.95	300	450	1.7
	2	1	46.50	100	1.08	319	450	2.9
	3	3	21.70	100	0.86	280	450	7.3
	4	6	13.60	100	0.68	231	450	12.7
	5	12	8.67	100	0.63	212	450	16.3
	6	24	5.61	100	0.55	187	450	21.0
	7	48	3.61	100	0.45	150	450	27.1
	8	72	2.71	100	0.11	22	450	30.5
Critical	**2**	**1**	**46.5**	**100**	**1.08**	**319**	**450**	
Plot	2	1	46.5	100	1.08	319	450	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	450
0.10	19	450
0.20	50	450
0.30	92	450
0.40	131	450
0.53	179	450
0.61	206	450
0.71	240	450
0.81	269	450
0.91	291	450
1.00	311	450
1.10	320	450
1.20	320	450
1.30	320	450
1.40	320	450
1.50	320	450
1.60	320	450
1.60	320	450



CATCHMENT C – INFIL RESULTS

1 Year:1 hour ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now: F9
Help On: Ctrl+h
Help Off: Ctrl+j

Input Parameters

Project Description
Infiltration of stormwater for 1yr ARI storm event. School Site

Catchment

Catchment area	1.325	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.067	[ha]

Initial Conditions

Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

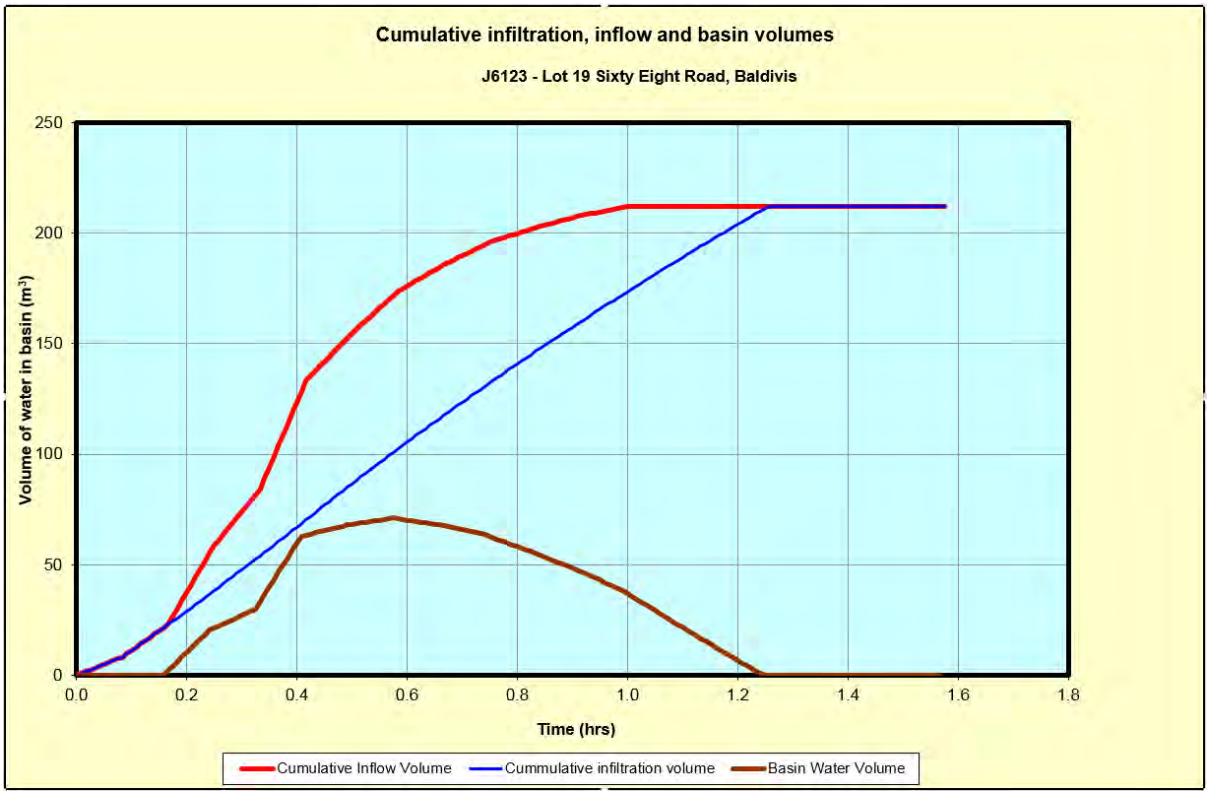
Design Storms / **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m^3]	Area [m^2]	Wetting Front [m]
	1	0.5	24.50	1	0.24	65	320	1.0
	2	1	16.00	1	0.26	71	328	1.6
	3	3	7.90	1	0.23	62	315	2.9
	4	6	5.04	1	0.18	46	294	3.7
	5	12	3.24	1	0.22	59	312	4.8
	6	24	2.10	1	0.11	27	267	6.2
	7	48	1.33	1	0.00	0	0	7.8
	8	72	0.99	1	0.00	0	0	8.8
Critical	**2**	**1**	**16**	**1**	**0.26**	**71**	**328**	
Plot	2	1	16	1	0.26	71	328	

p

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0.00	225
0.10	24.35	262
0.20	52.58	303
0.30	85.00	346
0.40	121.87	392
0.50	163.50	441
0.60	210.17	493
0.70	262.16	548
0.80	319.78	605
0.90	383.29	666
1.00	453.00	729
1.10	529.19	795
1.20	612.14	864
1.30	702.16	936
1.40	799.51	1011
1.50	904.50	1089
1.60	1017.41	1170
1.70	1138.52	1253



5 Year ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now : F9
Help On: Ctrl+h
Help Off: Ctrl+j

Input Parameters

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 5yr ARI storm event. School Site

Catchment

Catchment area	1.325	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.07	[ha]

Initial Conditions

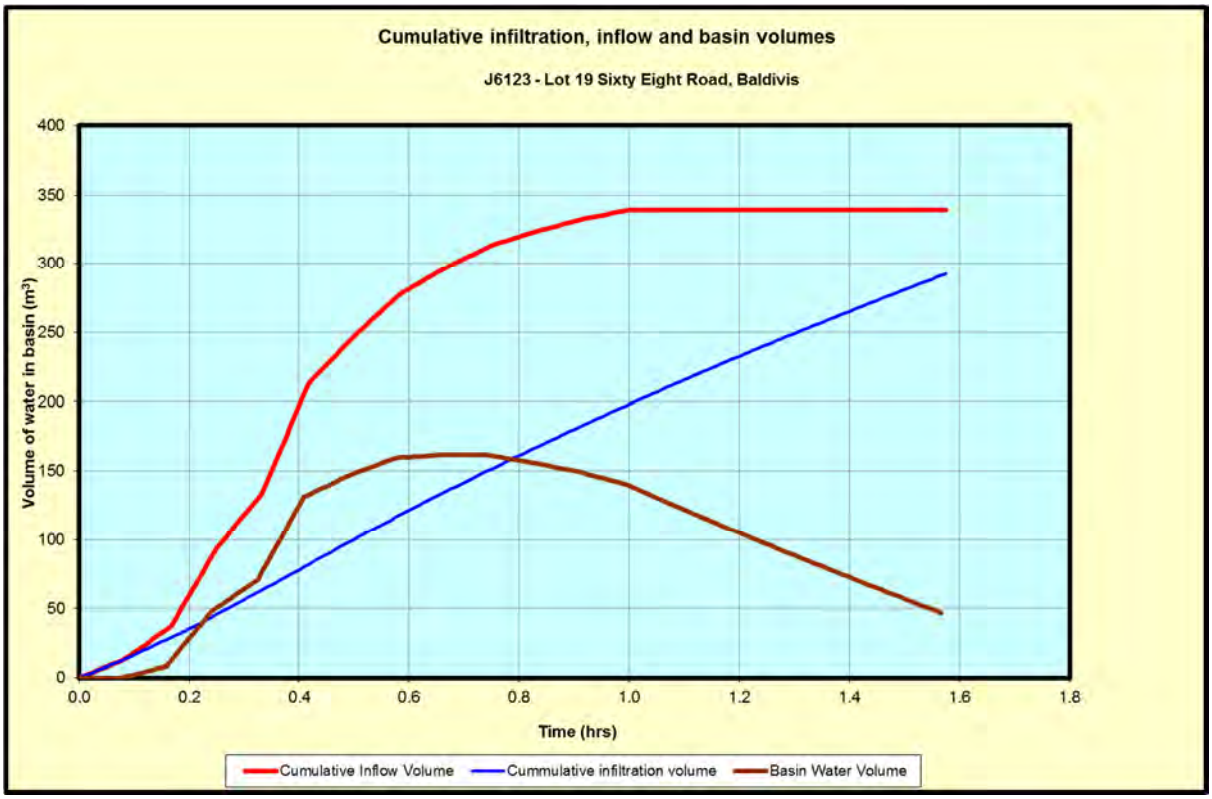
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms — **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m³]	Area [m²]	Wetting Front [m]
	1	0.5	40.00	5	0.46	147	422	1.1
	2	1	25.60	5	0.50	162	439	1.8
	3	3	12.40	5	0.47	151	426	4.6
	4	6	7.84	5	0.38	113	381	5.8
	5	12	5.01	5	0.47	150	425	7.4
	6	24	3.24	5	0.39	117	386	9.6
	7	48	2.07	5	0.28	78	337	12.2
	8	72	1.55	5	0.00	0	0	13.7
Critical	**2**	**1**	**25.6**	**5**	**0.50**	**162**	**439**	
Plot	1	0.5	40	5	0.46	147	422	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	225
0.10	24	262
0.20	53	303
0.30	85	346
0.40	122	392
0.50	164	441
0.60	210	493
0.70	262	548
0.80	320	605
0.90	383	666
1.00	453	729
1.10	529	795
1.20	612	864
1.30	702	936
1.40	800	1011
1.50	905	1089
1.60	1017	1170
1.70	1139	1253



10 Year ARI

JDA **INFIL** v3.1 - INF 2.02
March 2007

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 10yr ARI storm event. School Site

Function Keys

Auto Calc On:	Ctrl+o
Auto Calc Off:	Ctrl+f
Calc Now :	F9
Help On:	Ctrl+h
Help Off:	Ctrl+j

Input Parameters

Catchment

Catchment area	1.325	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.07	[ha]

Initial Conditions

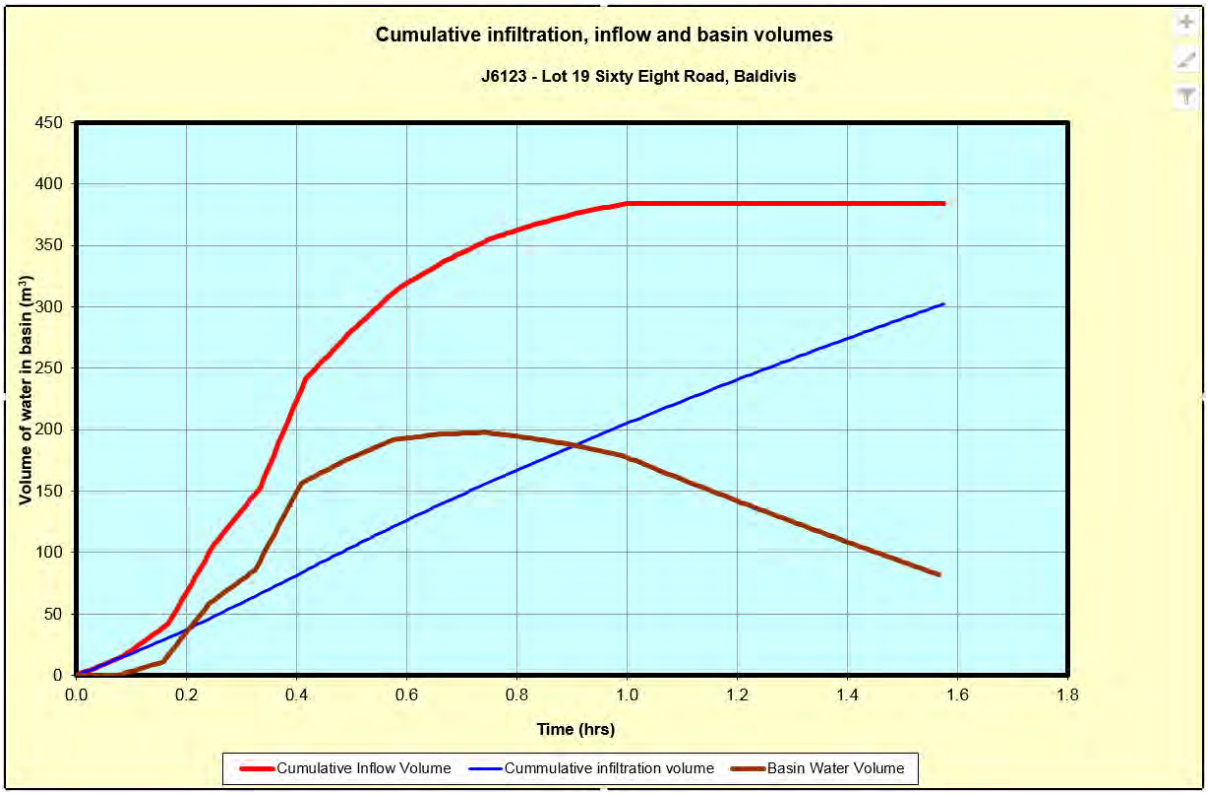
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms / **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m^3]	Area [m^2]	Wetting Front [m]
	1	0.5	45.70	10	0.53	179	458	1.1
	2	1	29.00	10	0.57	198	479	1.9
	3	3	13.90	10	0.54	182	462	4.8
	4	6	8.76	10	0.45	144	418	6.5
	5	12	5.60	10	0.54	183	463	8.3
	6	24	3.62	10	0.48	153	429	10.7
	7	48	2.32	10	0.40	120	390	13.7
	8	72	1.73	10	0.00	0	0	15.3
Critical	**2**	**1**	**29**	**10**	**0.57**	**198**	**479**	
Plot	2	1	29	10	0.57	198	479	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	225
0.10	24	262
0.20	53	303
0.30	85	346
0.40	122	392
0.50	164	441
0.60	210	493
0.70	262	548
0.80	320	605
0.90	383	666
1.00	453	729
1.10	529	795
1.20	612	864
1.30	702	936
1.40	800	1011
1.50	905	1089
1.60	1017	1170
1.70	1139	1253



100 Year ARI

INFIL v3.1 - INF 2.02
JDA March 2007

Function Keys
Auto Calc On: Ctrl+o
Auto Calc Off: Ctrl+f
Calc Now : F9
Help On: Ctrl+h
Help Off: Ctrl+j

Input Parameters

Project Name
J6123 - Lot 19 Sixty Eight Road, Baldivis

Project Description
Infiltration of stormwater for 100yr ARI storm event. Catchment A

Catchment

Catchment area	1.325	[ha]
Runoff coefficient	1	

Soil

Hydraulic conductivity	5	[m/d]
Soil suction	-5	[cm]
Effective porosity	0.2	

Basin

Base length	See Basin Data entry on the right	
Base width		
Average side slope		
Total depth		
Infiltration area	0.07	[ha]

Initial Conditions

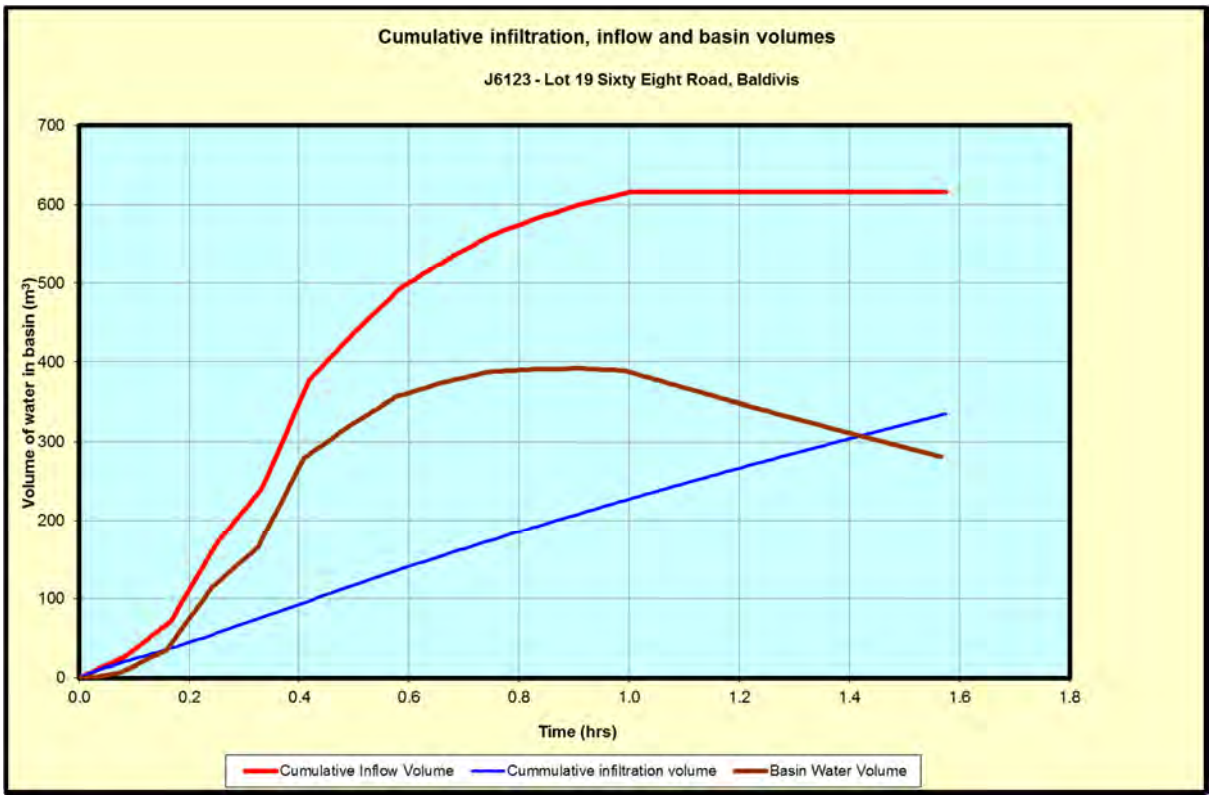
Water depth in basin	0	[m]
Wetting front depth	0	[m]
Soil saturation	0.2	

Design Storms — **Maximum Levels**

	Storm	Duration [hrs]	Intensity [mm/hr]	ARI [yrs]	Level [m]	Volume [m³]	Area [m²]	Wetting Front [m]
	1	0.5	75.10	100	0.70	361	744	1.2
	2	1	46.50	100	0.74	392	770	2.0
	3	3	21.70	100	0.69	356	739	5.1
	4	6	13.60	100	0.62	308	696	8.8
	5	12	8.67	100	0.57	271	661	12.3
	6	24	5.61	100	0.53	249	641	15.9
	7	48	3.61	100	0.48	213	606	20.5
	8	72	2.71	100	0.21	79	380	23.1
Critical	**2**	**1**	**46.5**	**100**	**0.74**	**392**	**770**	
Plot	2	1	46.5	100	0.74	392	770	

Basin Stage Volume Area Data

Depth [m]	Volume [m^3]	Area [m^2]
0.00	0	380
0.10	38	380
0.20	76	380
0.30	114	380
0.30	114	506
0.40	167	561
0.50	226	620
0.60	291	681
0.70	363	745
0.80	441	812
0.90	525	882
1.00	617	955
1.10	716	1030
1.20	823	1109
1.30	938	1190
1.40	1061	1274
1.50	1193	1361
1.60	1334	1451



APPENDI□ □

Department of □ ater □□ L18□0□2□1□

WRD 353944

Government of **Western Australia**
Department of **Water**

looking after all our water needs

Your ref: CAW183032 & CAW183031
Our ref: RF14487
Enquiries: Alana Patterson
Tel: 95504236

The Glow Development (WA) Pty Ltd
6 Arrowgrass Rd
CANNINGVALE WA 6155

Attn: Mr Samuel Ling

Dear Mr Ling

Re: Issue of a licence under the *Rights in Water and Irrigation Act 1914*
Property: Lot 19 Sixty eight Rd Baldivis

Please find enclosed the following:

- Your licence to take water *(GWL183032)*
- Brochure *Your licence to take water*
- Brochure *Metering your water use*
- Meter Water Use Card & example card can be downloaded from the department's website: http://www.water.wa.gov.au/licensing/water-licensing/metering or refer to Water Online information below
- Your licence to construct or alter a well *(CAW183031)*
- Form 2 "Information to be provided on completion of a non-artesian well"
- Brochure *Your licence to construct a well*

Please take time to read these documents as they contain important information about your rights and responsibilities.

You may apply to the State Administrative Tribunal (SAT) for a review of our decision. You will need to contact the SAT office directly, within 28 days.

In person State Administrative Tribunal
Level 6, 565 Hay Street PERTH WA 6000

In writing: State Administrative Tribunal
GPO Box U1991
PERTH WA 6845

By telephone: Metro: (08) 9219 3111
Regional: 1300 306 017 (for the cost of a local call)

Kwinana Peel Region
107 Breakwater Parade Mandurah Ocean Marina Mandurah Western Australia 6210
PO Box 332 Mandurah Western Australia 6210
Telephone (08) 9550 4222 Facsimile (08) 9581 4560
www.water.wa.gov.au

By fax: (08) 9325 5099

For more information about the SAT please visit their website www.sat.justice.wa.gov.au.

You can now use online services to manage all of your licensing and metering needs. Water Online provides the easiest, fastest and most efficient way to:

- Apply for a new licence or permit
- Apply to amend, renew or transfer an existing licence
- Submit meter readings in accordance with a licence; and
- Manage your account details.

Register for Water Online at www.water.wa.gov.au by clicking on the Water Online Login icon.

The instructions for registering, checking your details and updating them where required can be found by selecting the Quick Reference Guides link on the water online home page.

Please check your details to ensure that they are correct. If they are not correct please contact the department's online business support unit on 1800 508 885 (select option 2).

If you have any queries about this or any other water licensing matter please contact Alana Patterson on telephone 95504236.

Yours sincerely

A Patterson

Alana Patterson
Natural Resource Management Officer
Peel Region

12 September 2016

LICENCE TO TAKE WATER

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

Licensee(s)	The Glow Development (WA) Pty Ltd		
Description of Water Resource	Stakehill Perth - Superficial Swan	**Annual Water Entitlement**	24875 kL
Location of Water Source	Lot 19 On Plan 8420 - Volume/Folio 613/69a - Lot 19 Sixty Eight Rd Baldivis		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dust suppression for earthworks and construction purposes Irrigation of up to 0.65 ha of public open space	Lot 19 On Plan 8420 - Volume/Folio 613/69a - Lot 19 Sixty Eight Rd Baldivis
Duration of Licence	From 12 September 2016 to 11 September 2026	

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

1 The licensee shall not use water for public open space between 9 am and 6 pm except for the establishment of newly planted areas. For newly planted areas water may be used within these hours for a period of up to 28 consecutive days, commencing from the date of planting.

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

3 The licensee must install an approved meter to each water draw-point through which water is taken under this licence.

4 The annual water year for water taken under this licence is defined as 1July to 30 June.

5 The licensee must not, in any water year, take more water than the annual water entitlement specified in this licence.

6 The licensee must take and record the reading from each meter required under this licence at the beginning and another at the end of the water year defined on this licence.

7 The licensee must take and record the reading from each meter required under this licence, at the end of each month.

8 Unless otherwise approved, all meter readings must be recorded on the 'Meter Water Use Card' available from the Department of Water.

9 The completed Meter Water Use Card must be submitted to the Department of Water every 12 month(s) commencing 14/07/2017.

10 The licensee must ensure the installed meter(s) accuracy is maintained to within plus or minus 5% of the volume metered, in field conditions.

11 The licensee must notify the Department of Water in writing of any water meter malfunction within seven days of the malfunction being noticed.

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000

LICENCE TO TAKE WATER

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

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

12 The licensee must obtain authorisation from the Department of Water before removing, replacing or interfering with any meter required under this licence.

End of terms, conditions and restrictions

File No: RF14487

Government of Western Australia
Department of Water

Instrument No. CAW183031(1)

LICENCE TO CONSTRUCT OR ALTER WELL

Granted by the Minister under section 26D of the Rights in Water and Irrigation Act 1914

Licensee(s)	The Glow Development (WA) Pty Ltd	
Description of Water Resource	Stakehill Perth - Superficial Swan	
Location of Well(s)	Lot 19 On Plan 8420 - Volume/Folio 613/69a - Lot 19 Sixty Eight Rd Baldivis	
Authorised Activities	**Activity**	**Location of Activity**
	Construct 1 non-artesian well(s).	Lot 19 On Plan 8420 - Volume/Folio 613/69a - Lot 19 Sixty Eight Rd Baldivis
Duration of Licence	From 12 September 2016 to 11 September 2017	

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

1 The well must be constructed by a driller having a current class 1 water well drillers certificate issued by the Western Australian branch of the Australian Drilling Industry Association or equivalent certification recognised nationally by the Australian Drilling Industry Association.

2 The licensee must install an approved meter to each well, and provide evidence of the installation to the Department of Water within 30 days of completion of the well.

3 The licensee shall provide to the Department of Water within 30 days of drilling, the results of down-hole lithological logging of the bore hole drill cuttings. The results must contain a strata description and their corresponding depth intervals.

4 The depth of the well(s) shall be limited to the superficial aquifer.

End of terms, limitations and conditions

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Fax: +61 8 9381 9279

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