



Lot 20

Sixty Eight Rd, Baldivis

District & Local Water Management Strategy

Prepared for:

Alcock Brown Neaves Group

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● people ● planet ● professional

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Executive Summary

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management)			
Integration of water and land use planning, Integrate Stormwater Treatment into the landscape Ensure stormwater management is part of total water cycle management and stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse		Define stormwater quality management objectives in relation to the sustainability of the receiving environment Recognise the need for Site specific solutions and implement appropriate non-structural and structural solutions add value while minimising development costs	
Category	Objectives	Site Considerations	Key Management Features
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	Promote efficient use of potable water and alternative water sources. Apply for a groundwater licence for irrigation of POS. Use local, native waterwise plants in POS and streetscape landscaping. Remove wastewater from the site via mains sewerage system.	The Site currently has no groundwater extraction licences. The superficial aquifer (Perth-Superficial Swan) has sufficient allocation available. ABN owns two existing 5C Licence's to at the property to the east to support development.	ABN's existing groundwater allocation to the East may be utilised. Households will adhere to WC waterwise home guidelines. Local, native waterwise plants used in landscaping.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Retain natural drainage lines and minimise use of piped drainage systems. Frequent events (≤ 1yr ARI) retained and infiltrated within property boundaries, using soakwells where possible. Large events (> 1yr ARI) contained in landscape retention/detention areas, road reserves, POS and linear multiple use corridors. Attenuate runoff (≤ 100yr ARI) to pre-development peak flows.	There are no surface water features (wetlands, waterways or drains) within the Site The Site is suitable for disposal of stormwater through infiltration according to the conservative average saturated hydraulic conductivity of 10m/day	Existing flow paths and catchment will be maintained. Frequent events (≤ 1yr ARI) will be infiltrated within larger lots (R25) through the use of soakwells. Runoff from roads and smaller lots (R40) will drain to bio-retention area and infiltrate in pits. Major events (up to 100yr ARI) will be conveyed to the POS via road network.
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	Maintain appropriate recharge characteristics and groundwater levels, and minimise impervious areas. Ensure 1.2m of separation from maximum groundwater levels, including the use of subsoil drainage and importation of fill, where required. Maximise infiltration close to source or high in the catchment. Convey excess groundwater to the nearest watercourse.	The depth to AAMGL is estimated to be > 15m from natural surface for the entire Site based on the groundwater monitoring. The contour from May 2003 shows groundwater level of between 2mAHD and 3mAHD for the Site Pre-development groundwater monitoring by JDA indicated the general westward direction of groundwater with the estimated AAMGL of around 2.75mAHD east of the Site	No direct measures, subsoil drainage or lowering of groundwater are proposed for managing groundwater across the Site. The use of subsoils is not anticipated. Imported granular fill must comply with the material requirements as stated in AS3798. Final lot levels and clearance to groundwater will be provided in the UWMP following refinement of any earthwork design.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Install bio-retention areas, sized at ≥ 2% of constructed impervious areas for treatment of frequent (≤ 1yr ARI) events. Apply a treatment-train approach to flows prior to discharge. Implement non-structural controls, such as education programs.	Groundwater samples were collected as part of the monitoring program by JDA for the adjacent eastern lots. Average Total Nitrogen and Phosphorus exceed ANZECC guideline values. No previous land use on the Site would have contributed to excessive nutrients within the groundwater.	A treatment train approach to water quality improvement is adopted. Frequent events will be infiltrated close to source by soakwells, pits and bio-retention area. Further measures will be outlined in the UWMP.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	Maintain pre-development hydrological and water quality conditions. Retain seasonal wetlands and vegetation and apply appropriate buffers. No direct drainage to conservation category wetlands.	The Site is not within any ESAs, Conservation Category Wetlands or Bush Forever areas. The closest downstream ESA is a CCW located 3km west of the Site.	The treatment train approach (above) will provide water quality improvement measures and protection to receiving environments.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	Prevent flooding (0.5m clearance from 100yr ARI water levels to lots), water logging and erosion of waterways/slopes/banks. Immobile stormwater infiltrated within 96hrs to prevent mosquitos. Manage acid sulphate soils and contamination risks.	No water logging was identified during geotechnical investigations across the site and adjacent lots. ASS investigations indicate that the risk for the Site is unknown. No contaminated sites exist on or within proximity of the Site.	The habitable floor level will be > 0.5m above the 100yr ARI flood level to prevent flooding. Stormwater will be infiltrated within 96hrs to prevent standing water and mosquito breeding.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	Integrate stormwater structures into the landscape and POS. Retain remnant vegetation (where possible). Minimise the use of artificial/piped drainage systems. Conserve Aboriginal Heritage and environmentally sensitive areas,	The remnant vegetation may offer social aesthetic and cultural value, as should be conserved where possible. There are no areas of Aboriginal Heritage on this Site.	Stormwater structures will be integrated into the POS Design. Remnant vegetation will be retained (where possible).
Further Planning To ensure delivery of best practice stormwater management through planning.	Integrate water management with urban planning and ensure all BUWM (WAPC, 2008) requirements are fulfilled. Apply WSUD approach to road, lot and POS layouts.	Water management on the Site has been prepared consistent with the D/LWMS for the adjacent ABN property.	The UWMP will document the final stormwater management strategy incorporating any additional engineering, planning and landscaping requirements.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Prevent impacts on the hydrological regime during construction. Apply sediment control measures during construction to prevent excessive waterways/slopes/banks erosion. Utilised a non-potable water source for dust-suppression. Monitor water quality, flows, and levels near sensitive environments.	The UWMP will need to incorporate further information that becomes available (from the project team) and adjust strategies/plans accordingly. There is sufficient clearance to groundwater to prevent the need for dewatering.	Direct impacts from construction activities, such as dust, erosion and waste disposal will be managed through appropriate site practices. Where possible, the timing of construction works be undertaken to minimise impacts on the water cycle.
Post-Development To implement stormwater systems that are economically viable in the long term.	Consider the maintenance requirements of proposed stormwater systems. Following completion of construction, monitor groundwater and surface water near sensitive environments.	Post-Development groundwater targets are based on Groundwater Monitoring Data collected from the adjacent sites (JDA, 2014) (Galt, 2015).	No post-development groundwater water quantity or quality monitoring program is considered across the Site.

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1 Introduction

360 Environmental Pty Ltd (360 Environmental) were commissioned by Alcock-Brown Neaves (ABN) Group (the Client) to prepare this District & Local Water Management Strategy (D&LWMS) in support of the Local Structure Plan (LSP) for Lot 20 Sixty Eight Rd, Baldivis (the Site). A combined D&LWMS, which includes the level of details in line with both DWMS and LWMS (based on the Better Urban Water Management Guidelines), has been prepared consistent with the approach for the adjacent ABN site. This approach was recommended by Department of Water (DoW) and City of Rockingham (CoR).

The Site is approximately 8.33 hectares (ha) in size and is located in the City of Rockingham. It is approximately 50km south of the Perth CBD (Figure 1).

The proposed development will influence the total water cycle as a result of an increase in impervious areas, the clearing of native vegetation, cut and fill. The D&LWMS has been prepared to provide strategies and plans for total water cycle management across the Site in accordance with the principles of Water Sensitive Urban Design (WSUD) and the guiding documents in Section 1.2. It provides a summary of local and regional environmental data that informs management strategies for stormwater, groundwater, protection of receiving environments and water conservation. A strategy for implementing the total water cycle management during construction and post-development is also provided.

A checklist for the LWMS requirements is included in Appendix A and outlines the compliance of this document with the Better Urban Water Management (BUWM) (WAPC, 2008) framework.

1.1 Planning Background

The BUWM framework (WAPC, 2008) integrates water management into the land use planning process to ensure planning strategies include total water cycle management and WSUD.

The Site is located within the City of Rockingham's local government area and is currently zoned as 'Residential' under the Councils most recent Town Planning Scheme (TPS No. 2) (DoP, 2015). The Site is listed as 'Urban deferred' under the Western Australian Planning Commission (WAPC, 2015) Metropolitan Region Scheme (MRS). The LSP has been developed to coordinate the provision and planning for land use development at the Site (Appendix B). The D&LWMS is prepared in support of the LSP.

1.2 Guiding Documents

Development and associated water management strategies for the Site have been prepared with consideration for the following guidelines and policy documents:

- Planning Procedure 1.8 Water Sensitive Urban Design (CoR, 2010)
- State Planning Policy 2.9 Water Resources (WAPC, 2006)
- Stormwater Management Manual for Western Australia (DoW, 2004-07)
- Better Urban Water Management (WAPC, 2008)
- Decision Process for Stormwater Management in Western Australia (DoW, 2009)

A summary of the key principles and objectives for the Site, based on the guiding documents, is provided in Table 1.

Table 1: D&LWMS Key Principles and Objectives.

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management).	
Integration of water and land use planning, Integrate Stormwater Treatment into the landscape Ensure stormwater management is part of total water cycle management and stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse Define stormwater quality management objectives in relation to the sustainability of the receiving environment Recognise the need for Site specific solutions and implement appropriate non-structural and structural solutions add value while minimising development costs	
Category	Objectives
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	Promote efficient use of potable water and alternative water sources. Apply for a groundwater licence for irrigation of POS. Use local, native waterwise plants in POS and streetscape landscaping. Remove wastewater from the site via mains sewerage system.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Retain natural drainage lines and minimise use of piped drainage systems. Frequent events (≤ 1 yr ARI) retained and infiltrated within property boundaries, using soakwells where possible. Large events (> 1 yr ARI) contained in landscape retention/detention areas, road reserves, POS and linear multiple use corridors. Attenuate runoff (≤ 100 yr ARI) to pre-development peak flows.
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	Maintain appropriate recharge characteristics and groundwater levels, and minimise impervious areas. Ensure 1.2m of separation from maximum groundwater levels, including the use of subsoil drainage and importation of fill, where required. Maximise infiltration close to source or high in the catchment. Convey excess groundwater to the nearest watercourse.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Install bio-retention areas, sized at $\geq 2\%$ of constructed impervious areas for treatment of frequent (≤ 1 yr ARI) events. Apply a treatment-train approach to flows prior to discharge. Implement non-structural controls, such as education programs.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	Maintain pre-development hydrological and water quality conditions. Retain seasonal wetlands and vegetation and apply appropriate buffers. No direct drainage to conservation category wetlands.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	Prevent flooding (0.5m clearance from 100yr ARI water levels to lots), water logging and erosion of waterways/slopes/banks. Immobile stormwater infiltrated within 96hrs to prevent mosquitos. Manage acid sulphate soils and contamination risks.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	Integrate stormwater structures into the landscape and POS. Retain remnant vegetation (where possible). Minimise the use of artificial/piped drainage systems. Conserve Aboriginal Heritage and environmentally sensitive areas,
Further Planning To ensure delivery of best practice stormwater management through planning.	Integrate water management with urban planning and ensure all BUWM (WAPC, 2008) requirements are fulfilled. Apply WSUD approach to road, lot and POS layouts.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Prevent impacts on the hydrological regime during construction. Apply sediment control measures during construction to prevent excessive waterways/slopes/banks erosion. Utilised a non-potable water source for dust-suppression. Monitor water quality, flows, and levels near sensitive environments.
Post-Development To implement stormwater systems that are economically viable in the long term.	Consider the maintenance requirements of proposed stormwater systems. Following completion of construction, monitor groundwater and surface water near sensitive environments.

2 Proposed Development

A brief summary of the pre-development land use and proposed development are provided in this section.

2.1 Land Use

The Site is located in the suburb of Baldivis, within the City of Rockingham (Figure 1). Baldivis is dissected to the east by the Wilkinson Road and Serpentine River and to the west by Mandurah Road, with neighbouring suburb Wellard in north.

At present, the Site consists largely of bush with large mature trees and has no current land uses (Figure 2). The adjacent lot to the east is currently being developed for residential purposes and the Site to the north and east exhibit an undeveloped rural land use. Sixty eight Road is in the southern boundary of the Site.

2.2 Development Features

The proposed development for the Site is shown in Figure 3. The layout of this development has considered the existing environmental and drainage conditions, as well as surrounding land use and planning constraints.

The preliminary proposed land use is a mixture of residential R25 (90%) and R40 (10%). Specific lot layout will be determined at subdivision stage and for the UWMP. Public Open Space (POS) is proposed in the centre and a high school will be in the southern section of the Site (Appendix B). The current stormwater management doesn't include the high school catchment area as stormwater will be managed internally.

The key element of the development plan is the POS area integrated with stormwater retention and treatment areas and road alignments that convey major events.

3 Site Characteristics

The pre-development environmental conditions provide opportunities and constraints for water management on the Site. A summary of the environmental characteristics are provided in this Section.

3.1 Previous Studies

The environmental characterisation is based on a desktop assessment of the Site and review of the following documents for the Site and adjacent properties:

- Report on geotechnical study proposed residential development Lots 20, 21, 569 & 1263 Sixty Eight Rd Baldivis, WA (Galt, 2014)
- Lot 20 Sixty Eight Road, Baldivis Environmental Assessment (Bayley Environmental Services, 2015)
- Supplementary Geotechnical and Environmental Study Proposed Sewer Alignment Lot 1263 Sixty Eight Road Baldivis (Galt, 2015)
- Golder Associates Report on Geotechnical Investigation Lot 21, Sixty-Eight Road Baldivis, WA 2007
- Lot 569 & 1263 Baldivis Road & Lot 21 Sixty Eight Road, Baldivis, District and Local Water Management Strategy (JDA, 2014)

3.2 Topography

Topography at the Site is from 18 meters Above Height Datum (mAHD) in the south west corner to 37mAHD in the north east corner (Figure 2). The Site generally slopes to the west in the northern portion of the Site and to the south in the southern portion of the Site.

3.3 Climate

The climate of the south western region of Western Australia is characterised by the Koppen Climate Classification as Dry Subtropical featuring mild winters with low humidity and hot to very hot summers with moderate humidity. The dominant rainfall mechanisms are frontal systems caused by cold fronts associated with low pressure systems that extend across southern Australian between May and October. During the summer months, thunderstorms and ex-tropical cyclones can bring intense rainfall.

Kwinana BP Refinery BoM weather station (009064), approximately 15km north west of the Site, provides a climate dataset with a range of approximately 57 years (BoM, 2015a). As demonstrated in Figure 4, there is a variation in the annual totals ranging between 417mm (2010) and 1,005mm (1963). The data indicates a decreasing trend in annual and winter rainfall totals, particularly since 2000 where the annual average rainfall

has decreased from 745mm to 615mm (approximately a 17% decrease). Winter rainfall (May-August) has decreased by 19% during the same period.

Evaporation, as shown in Figure 4, is highest between November and March. A comparison of the mean monthly rainfall and evaporation totals demonstrates that the region is water limited between September and April. Between May and August rainfall exceeds evaporation.

The key rainfall characteristic for hydrological analysis is the Intensity-Frequency-Duration (IFD), a statistic derived from frequency analysis to provide estimates of rainfall intensity for a given durations and return periods. Analysis of rainfall and hydrology in the D&LWMS is based on IFDs published in Australian Rainfall and Runoff (AR&R1987) (Engineers Australia, 1987) and are summarised in Table 2. In recent years, IFDs have been revised utilising more extensive datasets (BoM, 2015b), but corresponding methods and data for hydrological estimation are yet to be published.

Table 2: Rainfall IFDs for Baldvis (EA, 1987)

Duration	IFD Rainfall Intensity (mm/hr)				
	1 Year	2 Year	5 Year	10 Year	100 Year
1hr	16	20.7	25.6	29	46.5
3hr	7.9	10.1	12.4	13.9	21.7
6hr	5.04	6.45	7.84	8.76	13.6
12hr	3.24	4.14	5.01	5.6	8.67
24hr	2.1	2.67	3.24	3.62	5.61
72hr	0.99	1.27	1.55	1.73	2.71

3.4 Geotechnical

Regional soil classification (DAFWA, 2013) indicates the Site is covered in yellow deep sands (Figure 5).

3.4.1 Soils

A geotechnical investigation of the Site was conducted by Galt Geotechnics in August 2014 to support the residential development of the Site. The investigation assessed the subsurface soil and groundwater conditions for the Site with particular emphasis on the depth to limestone (or cemented soils). The investigation was undertaken in areas of cut to a depth of 6.2m to 22.2m. Fieldwork included Lot 20 with cone penetration testing at 14 locations (CTP1-CTP14) across the Site (Figure 5).

Based on the material encountered in the CPT probes, the general subsurface conditions encountered for the cut area are below:

- Sand (SP): typically medium dense to very dense, however locally very loose to loose directly above limestone layer, very weakly cemented in localised areas at depth, present from the existing surface to depths of between 8 m and the maximum depth of testing (22.2 m); overlying

- Limestone, variably cemented (inferred)

Groundwater was not encountered during the Geotechnical investigation, despite depths of excavation extending to a maximum depth of 22.2m.

3.4.2 Permeability

Permeability testing was completed on the eastern adjacent lot by JDA in March 2010 at two locations (Figure 5). The average saturated hydraulic conductivity rate of 16m/day was considered representative of the sandy soils. A conservative average saturated hydraulic conductivity of 10m/day has been adopted owing to the similar conditions to with the property to the east (JDA, 2014).

3.5 Groundwater

The underlying aquifers pre-development groundwater quality and depth to groundwater below the natural surface requires consideration for total water cycle management. These items are discussed in detail in the following sections.

3.5.1 Aquifers

The Site is situated in the Stakehill groundwater area and the Outridge groundwater sub-area (DoW 2008). Groundwater resources below this region feature three separate aquifer systems; Perth-Superficial Swan aquifer, the Leederville aquifer and the Yarragadee aquifer (DoW, 2015b). The shallowest aquifer, Perth-Superficial Swan, consists of calcareous aeolianite (Tamala Limestone) with a maximum known thickness of up to 110m (DoW, 2010). Recharge to the superficial aquifer occurs through direct rainfall infiltrating to the water table. Alternatively, groundwater reaches impermeable layers, at which point groundwater flows laterally to the underlying aquifer. Water is lost from the aquifer through evapotranspiration from wetlands and shallow groundwater areas, groundwater reaching the ocean and downward leakage to the Leederville Aquifer.

The Leederville Aquifer is a major confined aquifer that consists of sandstones, siltstones and shales with a thickness up to 250m. It is a major groundwater source for the Perth region. The deeper Yarragadee aquifer is confined and occurs at depths of 450m below ground surface. As with the Leederville, the Yarragadee is a major groundwater source for the Perth region.

3.5.2 Groundwater Levels

The Perth Groundwater Atlas (DoW, 2012) provides the maximum groundwater level covering mostly Perth metropolitan area. The contour from May 2003 shows groundwater level of between 2mAHD and 3mAHD for the Site (Figure 6).

Pre-development groundwater monitoring program was conducted by JDA from April 2010 to October 2011 for the adjacent lot to the east (JDA, 2014). This ground water level monitoring indicated that the general direction of groundwater flow was west

toward Serpentine River. The estimated AAMGL was ranging from 4mAHD in the northeast corner to around 2.75mAHD in the west (east of the Site).

The depth to AAMGL is estimated to be greater than 15m from natural surface for the entire Site owing to the existing topography (Section 3.2).

3.5.3 Groundwater Quality

Owing to the existing depth to groundwater, an ongoing monitoring program (two winters) is not required for the Site. However a groundwater quality sampling snapshot will be performed to confirm that groundwater is suitable as a non-potable water source for irrigation of POS. This will be discussed further in Section 4.1. The results of the snapshot would then be compared with the monitoring program performed on the adjacent property with results presented in the future UWMP.

Groundwater samples were collected as part of the monitoring program by JDA for the adjacent eastern lots. Quarterly groundwater quality monitoring was conducted over 18 months from April 2010 to October 2011. Eight bores were analysed for physical parameters (pH, EC) and nutrients (Nitrogen & Phosphorous), consistent with the DoW water monitoring guidelines (DoW 2012). A summary of the monitoring results is displayed in Table 3 below.

Table 3: Groundwater Quality Results.

Physiochemical Parameter	Monitoring Range	Monitoring Average	ANZECC Guideline Values*
EC (mS/cm)	0.11 – 0.69	0.32	0.12 – 0.30
pH	5.09 – 7.89	6.72	6.5 – 8.0
Total N (mg/L)	0.27 – 23	3.66	1.2
TKN (mg/L)	0.005 – 5.8	0.98	-
NO _x -N (mg/L)	0.005 – 18	2.68	-
Total P (mg/L)	0.01 – 1.3	0.075	0.065
FRP (mg/L)	0.005 – 0.08	0.013	0.04

*South-West Australia.

Average Total Nitrogen exceeds ANZECC guideline value of 1.2 mg/L. The average Total Phosphorus was slightly above ANZECC guidelines of 0.065mg/L.

3.6 Surface Water

No surface water features or drainage lines that exist within the boundaries of the Site. The nearest surface drainage is an artificial drain serving the Kwinana Freeway, approximately 1,200m to the east. This drain joins the Serpentine River about 2.2km south-east of the subject land before ultimately discharging into the Peel Inlet.

3.7 Water Resources

The Site is located within the Outridge Groundwater Sub Area of the Stakehill Groundwater Area. An Aquifer Allocation Report requested in November 2015 shows that there is approximately 195,474kL available in the superficial aquifer, with 91% of the total allocation for the Outridge groundwater subarea already allocated. ABN has an existing allocation for the adjacent property for 96,250kL to support the various developments.

The Site is not located within any public drinking water source protection areas (DoW, 2015b).

3.8 Environmental

Several environmental features influence and/or are dependent on the total water cycle for this Site. A brief summary of these is provided below.

3.8.1 Land Use Change

Review of historical aerial photographs from Landgate's Shared Land Information Platform (SLIP) mapping found imagery from 1965 to 2014 (Figure 7). It shows that Lot 20 has always been vegetated without any significant changes in the land use type. During 1965 and 1985, the areas west of the Site were cleared to make for farm lands. Land to the east is currently being developed as part of ABN's Brightwood project. Lot 20 is surrounded by undeveloped sites to the north, residential development to the west and Sixty Eight Road to the south.

3.8.2 Aboriginal Heritage

The Government of Western Australia's State Heritage Office has not identified any areas of Aboriginal or European heritage within the site. A search of the Department of Aboriginal Affairs (DAA 2015), Aboriginal Heritage Inquiry System (AHIS) identified that no Aboriginal heritage sites are on Lot 20. The nearest site is an "other heritage place" (non-registered), Site 4347: Artefact Scatter, located on Percival Place with its boundary about 50m southeast of Lot 20. A larger, registered site, 3582: Serpentine River, is located from about 350m south of Lot 20. Neither of these Aboriginal sites will affect or be affected by development on Site.

3.8.3 Flora and Fauna

Bayley Environmental Services undertook an Environmental Assessment for the Site which included assessing the flora and fauna. The Site was surveyed in June 2015 and three vegetation units below were described:

- Tuart Woodland (T)
- Jarrah-Sheoak-Banksia Woodland over Mesomelaena stygia Sedgeland (M1)
- Jarrah-Banksia-Sheoak Woodland over Mixed Grasslands (M2).

80 species were found in the Site, comprising 61 natives and 19 introduced species with no Declared Rare Flora, Priority Flora or Threatened Flora was found.

The Bush Forever Site 376 (Karnup Reserve) is the closest to the Site located 0.8 km from the southern boundary of the Site (DER, 2015a) (Figure 8).

The desktop study identified 172 vertebrate fauna species as potentially occurring in the Site, including nine frogs, 36 reptiles, 105 birds, 15 native and seven introduced mammals. Only one conservation-significant invertebrate species was known to occur within 10km of the Site: the Graceful Sunmoth (*Synemon gratiosa*) (DPaW Priority 4).

3.8.4 Wetlands

The Site is not located within or adjacent to any geomorphic, Conservation Category or Resource Enhancement wetlands (DPAW 2014) (Figure 8). The nearest Conservation category wetland is approximately 2km west of the site.

3.8.5 Acid Sulfate Soils

Regional Acid Sulphate Soil (ASS) mapping indicates that the Site does not fall within a class 1 (low to moderate) or class 2 (moderate to high) ASS risk area. This mapping applies to depths of 3m below the natural surface (DEC, 2010) (Figure 9).

3.8.6 Contaminated Sites

A search of the DER Contaminated Sites Database identified no record of the site having a contaminated site classification (DER, 2014). The nearest registered contaminated site, registered as "Contaminated - Remediated for restricted use" is located 5km north of the site.

3.9 Summary

Based on the geotechnical, hydrological and environmental information, the Site can be considered as posing a low level of risk, based on the DoW's Guidance Note 3 (DoW, 2013). The Site conditions fulfil the criteria of >5m depth to groundwater and infiltration on site (10m/day). It does not contain any natural waterways or environmentally sensitive area, and there is adequate groundwater allocation available which supports a low level of risk. The developments will be proposed in a way to retain the flows within the Site boundaries. The strategies for urban water management and implementation have been prepared in consideration to account for the Low level of risk. A summary of gaps in the data and considerations for water management are provided below.

3.9.1 Gap Analysis

Numerous studies have been undertaken for the Site and adjacent lots including geotechnical investigations, environmental assessment and water quality and level monitoring. Based on the completion of these studies to date, there are not considered to be any significant data gaps that would further enhance water management concepts and design for the proposed development.

3.9.2 Site Considerations

The desktop assessment and previous investigations have identified a number of constraints and opportunities that require consideration in management of the total water cycle. These are summarised in Table 4.

Table 4: Key Site Considerations

Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management).

Integration of water and land use planning, Integrate Stormwater Treatment into the landscape
 Ensure stormwater management is part of total water cycle management and stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity
 Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse
 Define stormwater quality management objectives in relation to the sustainability of the receiving environment
 Recognise the need for Site specific solutions and implement appropriate non-structural and structural solutions
 add value while minimising development costs

Category	Site Considerations
Water Sustainability To maximise the reuse or stormwater and minimise use of potable water particularly for non-drinking water purposes.	The Site currently has no groundwater extraction licences. The superficial aquifer (Perth-Superficial Swan) has sufficient allocation available. ABN owns two existing 5C Licence's to at the property to the east to support development.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	There are no surface water features (wetlands, waterways or drains) within the Site The Site is suitable for disposal of stormwater through infiltration according to the conservative average saturated hydraulic conductivity of 10m/day
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	The depth to AAMGL is estimated to be > 15m from natural surface for the entire Site based on the groundwater monitoring. The contour from May 2003 shows groundwater level of between 2mAHD and 3mAHD for the Site Pre-development groundwater monitoring by JDA indicated the general westward direction of groundwater with the estimated AAMGL of around 2.75mAHD east of the Site
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	Groundwater samples were collected as part of the monitoring program by JDA for the adjacent eastern lots. Average Total Nitrogen and Phosphorus exceed ANZECC guideline values. No previous land use on the Site would have contributed to excessive nutrients within the groundwater.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	The Site is not within any ESAs, Conservation Category Wetlands or Bush Forever areas. The closest downstream ESA is a CCW located 3km west of the Site.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	No water logging was identified during geotechnical investigations across the site and adjacent lots. ASS investigations indicate that the risk for the Site is unknown. No contaminated sites exist on or within proximity of the Site.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	The remnant vegetation may offer social aesthetic and cultural value, as should be conserved where possible. There are no areas of Aboriginal Heritage on this Site.
Further Planning To ensure delivery of best practice stormwater management through planning.	Water management on the Site has been prepared consistent with the D/LWMS for the adjacent ABN property.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	The UWMP will need to incorporate further information that becomes available (from the project team) and adjust strategies/plans accordingly. There is sufficient clearance to groundwater to prevent the need for dewatering.
Post-Development To implement stormwater systems that is economically viable in the long term.	The depth to groundwater indicates that post development monitoring is not required.

4 Water Sustainability Initiatives

The supply of water and sustainable use within the proposed development are key components of the D&LWMS.

4.1 Water Supply

Potable water for households within the development will be supplied from scheme water. The Water Corporation's (WC) Integrated Water Supply Scheme (IWSS) supplies scheme water from groundwater, desalinated seawater and surface water (dams) (WC, 2015a). For the Site, both at the lot scale and development scale, measures to limit the supply of potable water will be implemented.

At the development scale, irrigation water of Public Open Space (POS) and streetscape areas will be sourced from untreated non-potable groundwater supply. The Aquifer Allocation Report shows that there is approximately 195,474kL available in the superficial aquifer (Section 3.7). As discussed in Section 3.7, there are 2 existing 5C Licence's taking 96,250kL at ABN's Brightwood development that is available for irrigation of POS in this Site. Table 5 below provides a breakdown of irrigation requirements for the adjacent ABN Sites. Additional allocation will be utilised for irrigation at ABN's Brightwood East development.

Table 5: Groundwater Irrigation Requirements.

Site	POS Area	Irrigation Rate	Irrigation Total
Lot 20 Sixty Eight Road	0.43ha	7,500kL/ha/yr	3,225kL/yr
Brightwood	3.79ha	7,500kL/ha/yr	28,425kL/yr
Total			31,650kL/yr

Appendix E provides a copy of the groundwater license for this development which notes the allocation of water to irrigate 3.5 Ha of ovals and playing fields, which will be transferred to the Department of Education (DoE) when the school is constructed. It is also understood that a separate allocation allowance of 24,000 KI of groundwater has been tagged in DoW's database for Lot 19 (not owned by our client) for the DoE to access.

Development scale water reuse schemes are not proposed for the development.

4.2 Water Conservation

Significant savings in scheme water are possible through conservations measures provided by Water Corporation (WC, 2015b) and through the Building Codes of Australia. Within houses, water efficient showerheads, taps and toilets will be installed consistent with Water Efficient Labelling and Standards (WELS) scheme standards.

The Development will aim for water consumption targets based on the State Water Plan (DoPC, 2007) targets for household use in Perth. These targets are less than 100kL/person/yr, including no more than 40-60kL/person/yr from potable water supply schemes.

Outside of the home, where approximately 40% of household water is used, the following conservation measures will be applied;

- Garden designs will incorporate waterwise or endemic plant species;
- Garden will be mulched and use dripper/ subsurface irrigation systems; and,
- Minimal use of lawn areas.

The type of vegetation throughout the development, both within the gardens and POS, significantly influences the water use throughout the development. For the street scape and POS, local, native vegetation will be planted to reduce water demand. Further details on the waterwise vegetation species will be provided in the UWMP.

To promote water efficiency amongst residents, waterwise recommendations will be provided to home owner through marketing brochures and building displays.

4.3 Wastewater Management

Wastewater from the development will be managed through connection to the mains sewerage system.

5 Stormwater Management Strategy

The stormwater management strategy has been prepared in accordance with the guiding principles (Section 1.2) and site considerations (Section 3). The strategies preserve and enhance the ecological and social aspects of the Site and provide measures to mitigate the risk of flooding and waterlogging on the development.

5.1 Stormwater Management Concepts

The stormwater management system concepts for development of the Site have been prepared to meet the objectives and principles of urban water management outlined in Table 1 (Section 1.2). Specifically the system will manage catchment runoff to near pre-development peak flow rates.

Key elements of the stormwater management conceptual design are:

- Maintain the existing catchment and flow paths to the south and centre of the Site through earthworks and alignment of road networks. POS area in the centre will feature drainage infrastructure;
- Adopt a treatment train approach to water quality management and protection of receiving environments, including infiltration of frequent events close to source and bio-retention area to strip nutrients;
- The high school area south of the Site has not been included in the stormwater management as they will manage stormwater at the lot scale;
- Frequent events (≤ 1 yr ARI Event) infiltrated within the majority of lots through the use of soakwells, with runoff from roads infiltrated via soakage pits in the road reserve and bio-retention system within the POS;
- Major events (≤ 100 yr ARI Event) will be retained and infiltrated onsite within the POS;
- The basin within the POS will provide aesthetic values for the community and alleviate the need for fenced drainage sumps; and,
- No direct groundwater management measures (permanent dewatering or control of groundwater levels) are to be implemented owing to the existing clearance to groundwater.

5.2 Stormwater Management System

A major and minor approach to the design of stormwater management systems has been adopted for the Site. The minor system consists of underground pipes, kerbs and gutters designed to convey runoff up to the 5yr ARI event and ensure serviceability of the road network. The major system consists of roads and the POS and provides protection of the

community from extreme flooding events (up to the 100yr ARI event) that exceed the capacity of the minor system. Details of these systems are described below.

5.2.1 Minor System (Frequent Events)

Management of the frequent event (1yr 1hr) event is largely related to the protection of receiving environments. Runoff from this event is the most likely to mobilise pollutants within the catchments and therefore measures are required to retain and treat this storm event on site.

At the lot scale, the 1yr 1hr event (approximately 16mm) will be retained within the lot boundary and infiltrated using soakwells. Impervious areas, such as driveways, paving and roof will be connected directly to the soakwells. Infiltration is supported by the clearance to groundwater at the proposed lots locations (generally >15m), favourable infiltration rate of 10m/day and subsurface conditions (Section 3.4).

Installation of soakwells is difficult on smaller lots owing to the building footprint and clearances required. Therefore lot connections may be provided for lots <300m².

Bio-retention system within the POS will be installed for runoff from the 1yr 1hr ARI event from road reserve and smaller lots (where soakwells cannot be utilised). This system will be located at the outlets of the road drainage network. Details on the bio-retention system specification are provided in Section 5.4.

Details of road drainage network, including pipe sizes, will be determined through engineering design and will be provided in the UWMP in the form of engineering drawings. This infrastructure will be sized to ensure serviceability of the road network during the 5yr ARI event. Gross Pollutant Traps (GPT) will be installed upstream of each piped outlet into the basin and POS. To allow for local road runoff to enter the POS, flush kerbing and breaks in the kerbing will be considered in detailed design.

Runoff from events up to the 5yr ARI event will be conveyed via the road drainage system to the POS in the centre. The Site condition allows for infiltration through the network open pits. Details of the respective flow rates and drainage infrastructure are provided in Section 5.2.2.

5.2.2 Major System (Extreme Events)

The major drainage system will consist of roads and the drainage basin within the POS. Events larger than the 5yr ARI event will be conveyed via overland flow along the road network to the POS (Figure 10). In order to determine the requirements for the drainage basin, hydrologic modelling of the site was undertaken with the model XP-Storm.

The following parameters have been used to determine pre-development runoff using the XP-Storm model:

- The catchment (total area of 4.77ha) for the Site has been defined. This area excludes the high school as stormwater will be managed locally;
- Lots are combination of R25 (90%) and R40 (10%) densities; and

- Rainfall for the Site is based on 1987 IFD Data (Section 3.3).

The post-development scenario for the Site was modelled to determine the basin configuration. The catchment breakdown is provided in Table 6 and Appendix C, and Table 7 outlines the runoff coefficients used in the post-development model. It should be noted that these values are conservative estimates and that the breakdown of lot densities are estimates only and will be confirmed in the UWMP.

Table 6: Catchment Area Breakdowns

Land Use	Areas (ha)
Lots (R25)	2.68ha
Lots (R40)	0.30ha
Road Reserve	1.28ha
Public Open Space	0.51ha
Total Area	4.77ha
Equivalent Imp. Area ^	1.14ha
2% of Equivalent Imp. Area	230m ²

^ Equivalent Impervious Area is area based on Runoff Rates (Table 6). These areas do not include contribution from Lots(R25), as runoff from frequent events (1yr ARI) is contained within these lots (soakwells).

Table 7: Post-Development Runoff Coefficients

Land Use	Initial Loss (mm)	Runoff Coefficient (≤5yr ARI)	Runoff Coefficient (>5yr to 100yr ARI)
Lots (R25)	16	20%	30%
Lots (R40)	0	40%	50%
Road Reserve	0	80%	80%
POS	0	10%	10%

Hydrographs generated in XP-Storm were imported in the PONDS model to determine the infiltration and storage volumes. The PONDS software calculates infiltration areas and volumes, based on the finite-difference groundwater model MODFLOW, developed by the US Geological Survey.

The PONDS mode was configured with the following parameters:

- Water table elevation of 3mAHD (Section 3.5.2);
- Basin Invert of 17.5mAHD;
- Infiltration rate of 10m/day (Section 3.4);
- Porosity of 30%;
- Horizontal Hydraulic Conductivity (K_{hor}) of 15m/day (DoW, 2010);
- Base of Superficial Aquifer of -13mAHD (DoW, 2004); and
- Hydrographs generated from XP-Storm.

The stormwater was designed to contain the 5yr and 100yr ARI events within the basin and POS area. The proposed stormwater management system is presented in Table 8 and Figure 10.

Table 8: Stormwater Management System

Post-Development Catchment		Catchment	
Catchment Area		4.77ha	
Storage Data			
Type		Retention (Infiltration) Basin	
Side Slopes		1:6 (v:h)	
Base Invert		17.5mAHD	
Depth to Groundwater		14.5m	
Base Area		170m ²	
1yr ARI Event			
Bio-Retention Area		170m ² (within the basin); 60m ² (outside the basin)	
	5yr ARI Event	10yr ARI Event	100yr ARI Event
Top Water Level Area	430m ²	540m ²	1,540m ²
Flood Storage	185m ³	291m ³	643m ³
Flood Rise	0.64m	0.86m	1.12m
Top Water Level	18.14mAHD	18.36mAHD	18.62mAHD
Critical Duration	1hr	1hr	2hr
Inflow Peak	0.243m ³ /s	0.403m ³ /s	0.325m ³ /s

Flow paths for the 1yr, 5yr and 100yr ARI events are shown in Figure 11 and demonstrate areas that are inundated during each event. Similarly, a cross section of the stormwater system is shown with the maximum water levels (also in Appendix D). The system allows for minimum habitable floor levels to be at least 0.5m above the proposed top water level in the basin.

The proposed basin design is conceptual only. The UWMP will provide the final configuration that may be modified following a review of additional earthwork and road design levels. Associated landscaping and engineering drawings will also be included in the UWMP.

5.3 Groundwater Management

Based on the groundwater contours and analysis (Section 3.5.2) there is sufficient clearance between the groundwater and the natural surface across the Site where lots are proposed (Figure 6). No direct measures, including subsoil drainage or lowering of

groundwater are proposed for managing groundwater. Final lot levels and clearance to groundwater will be provided in the UWMP following refinement of the earthwork design.

Where fill is imported, imported granular fill will comply with the material requirements as stated in AS3798-2007: Guidelines on Earthworks for Commercial and Residential Developments (Australian Standard, 2007).

5.4 Protection of Receiving Environments

There are no existing wetlands or waterways within the Site that require ongoing management and the stormwater systems are designed to ensure minimal retention times by allowing the water to drain freely through the Site's sandy soils. The downstream receiving environment is the superficial aquifer. Protection of these environments involves managing the post-development use of nutrients and the export of pollutants off site. A treatment train approach, including the use of structural and non-structural controls, will be implemented to achieve this protection.

Non-structural controls are an essential part of the treatment train process as they contribute to the reduction stormwater volumes and pollutants. They differ from structural controls as they are not fixed, permanent infrastructure and can offer relatively inexpensive and flexible approaches (DoW, 2004-2007).

For this Site, the following non-structural controls will be implemented:

- Planning: residential lot density;
- Construction: erosion and dust control;
- Maintenance: street sweeping, stormwater infrastructure maintenance; and,
- Education: WSUD community education through waterwise landscaping;

Implementation of these non-structural controls occurs during various stages of development. Key aspects of these measures that will contribute significantly to the reduction of post-development nutrient application are the higher lot densities (R40) that will reduce areas available for domestic gardens. Construction management practices are discussed further in Section 6.2.

Structural controls for the Site will be implemented to retain and infiltrate the frequent (up to 1yr 1hr) events close to source throughout the catchment. On the larger lots (R25), soakwells will be installed to retain runoff from impervious areas, such as driveways, paving and the roof. Throughout the pipe drainage system for the road network, soakage pits will be installed to promote infiltration. GPTs will also be installed at the outlets of the road drainage network.

Runoff from frequent events from the smaller lots (R40) and road reserves will be directed towards a bio-retention area located within the POS. The bio-retention will feature filter media designed to remove nutrients and suspended soils. The amended soil within the filter will include different types of soil such as stone mulch and filter layers.

The total depth will be between approximately 400mm and 650mm. The construction of the bio-retention will be in accordance with the *Bio-filters Guideline* (DoW, 2011). Appropriate plant species will be selected from the *Vegetation Guidelines for Stormwater Bio-filters in South-west of Western Australia* (Monash, 2014).

Final design including landscaping plans will be provided in the UWMP. The current area (230m²) is indicative only, and will be dependent on the final lot density and configuration.

These methods are based on the Stormwater Management Manual of Western Australia (DoW, 2004-2007). Specific targets for improvement in water quality will be detailed in the UWMP.

6 Implementation Strategy

The success of the water management strategies relies heavily on their implementation throughout all stages of development including further planning, construction and post-development.

6.1 Subdivision Phase

Following approval of the LSP, a Subdivision Application will be submitted. In support of this application, an Urban Water Management Plan will be prepared.

The UWMP will document the final water management plans for this Site. It will include a summary of the Site conditions in a number of plans; environmental, geotechnical, surface water, groundwater and Site condition plans.

A key focus of the UWMP will be to provide detail of the final stormwater system design, including engineering drawings of infrastructure, details of control point inverts, any lot connections, and bio-retention areas. Further information that is obtained from any additional geotechnical investigations and details on the final lot density will allow for an analysis of the conceptual designs provided in the D&LWMS.

The following information will also be provided in the UWMP:

- Details on the piped road drainage network and roads finished levels and grades, provided in engineering drawings.
- Further detail of the landscaping design, including POS area and water requirements, and water use sustainability initiatives.
- Design of the bio-retention system and non-structural controls.
- Confirmation of final development earthwork levels and the any remnant vegetation that can be retained.
- Measures to mitigate mosquito populations.

6.2 Construction Phase

Water management during the construction phase of the protection requires consideration of direct impacts from construction activities and maintaining pre-development hydrological performance prior to completion of the post-development stormwater system.

6.2.1 Abstraction Licensing

Water will be required for construction activities such as dust suppression. A temporary water licence may be applied for the Site to cover construction activities and establishment of vegetation. Abstractions will be carried out in accordance to conditions of this licence.

Dewatering is not considered likely given the separation to groundwater across the Site. However, any dewatering undertaken will occur in a manner consistent with a dewatering licence.

6.2.2 Management of Subdivisional Works

Potential impacts from construction activities related to the water cycle include:

- Nuisance dust generation during bulk earthworks
- Erosion of exposed surfaces
- Inappropriate disposal of waste building material

All of these potential impacts are manageable through appropriate engineering design and appropriate site management practices. Contractors and staff will be notified of the requirement to implement management practices to limit any potential impacts resulting from construction activities.

Timing of the construction activities will be dependent on a number of factors not related to water management. Where possible, the construction schedule should allow for work to be undertaken when impacts on the water cycle will be minimised.

6.3 Post Development

Following the completion of construction activities, maintenance of the stormwater system and assessment of the system performance will be required to determine whether additional water management measures are required.

6.3.1 Maintenance

Operation and maintenance of the stormwater management system will initially be the responsibility of the developer, until handover of the development to the City of Rockingham. The following measures will be undertaken to ensure the system functions correctly:

- Removal of debris to prevent blockages
- Street sweeping to reduce particulate build up on road surfaces
- Cleaning of sediment build up and litter layer from the bio-retention systems
- Assessment of the health of vegetation in bio-retention and modified areas and removal and replacement of dead plants where necessary.

6.3.2 Monitoring Program

Water quality objectives are to be managed as per Water Sensitive Urban Design (WSUD) principles and Best Management Practices (BMPs) using bio-retention system in POS area. This is industry standard and as such water quality treatment cannot practicably be expected to be improved upon beyond these design controls.

As stated in Section 3.9, the Site is also considered to be low risk from a surface water, groundwater and environmental management perspective. Therefore any post-development groundwater water quality monitoring program to assess the performance of the stormwater management system is not considered necessary for this Site.

6.4 Roles and Responsibilities

Table 9 details the roles and responsibilities for water management during the subdivision and construction phase of the development and post-development.

Table 9: Roles and Responsibilities

Action	Developer	City of Rockingham / DoW
Preparation of UWMP	✓	
Assessment / Approval of the UWMP		✓
Design of Stormwater System	✓	
Construction of Stormwater System	✓	
Construction Phase Monitoring	✓	
Maintenance Prior to Handover	✓	
Maintenance Following Handover		✓

7 Conclusion

The key management strategies from the D&LWMS, discussed in detail in Sections 4 to 6 are summarised in Table 10.

Table 10: Key Management Features**Key Water Management Principles (Adapted from State Planning Policy 2.9, Stormwater Management Manual for WA & Better Urban Water Management)**

Integration of water and land use planning

Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity

Ensure stormwater management is part of total water cycle management

Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse

Define stormwater quality management objectives in relation to the sustainability of the receiving environment

Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions

Integrate Stormwater Treatment into the landscape

Add value while minimising development costs

Category	Key Management Features
Water Sustainability To maximise the reuse of stormwater and minimise use of potable water particularly for non-drinking water purposes.	ABN's existing groundwater allocation to the East may be utilised. Households will adhere to WC waterwise home guidelines. Local, native waterwise plants used in landscaping.
Stormwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from flooding.	Existing flow paths and catchment will be maintained. Frequent events (≤ 1 yr ARI) will be infiltrated within larger lots (R25) through the use of soakwells. Runoff from roads and smaller lots (R40) will drain to bio-retention area and infiltrate in pits. Major events (up to 100yr ARI) will be conveyed to the POS via road network.
Groundwater To maintain the total water cycle balance within development areas relative to the pre-development conditions. To protect the built environment from water-logging.	No direct measures, subsoil drainage or lowering of groundwater are proposed for managing groundwater across the Site. The use of subsoils is not anticipated. Imported granular fill must comply with the material requirements as stated in AS3798. Final lot levels and clearance to groundwater will be provided in the UWMP following refinement of any earthwork design.
Water Quality To maintain or improve the surface water and groundwater quality within development areas relative to pre-development conditions.	A treatment train approach to water quality improvement is adopted. Frequent events will be infiltrated close to source by soakwells, pits and bio-retention area. Further measures will be outlined in the UWMP.
Protection of Receiving Environments To retain natural drainage systems and protect ecosystem health.	The treatment train approach (above) will provide water quality improvement measures and protection to receiving environments.
Public Health and Risk To minimise the public risk, including risk of injury or loss of life to the community.	The habitable floor level will be >0.5 m above the 100yr ARI flood level to prevent flooding. Stormwater will be infiltrated within 96hrs to prevent standing water and mosquito breeding.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.	Stormwater structures will be integrated into the POS Design. Remnant vegetation will be retained (where possible).
Further Planning To ensure delivery of best practice stormwater management through planning.	The UWMP will document the final stormwater management strategy incorporating any additional engineering, planning and landscaping requirements.
Implementation/ Construction To ensure delivery of best practice stormwater management through high quality developed areas in accordance with sustainability and precautionary principles.	Direct impacts from construction activities, such as dust, erosion and waste disposal will be managed through appropriate site practices. Where possible, the timing of construction works be undertaken to minimise impacts on the water cycle.
Post-Development To implement stormwater systems that are economically viable in the long term.	No post-development groundwater water quantity or quality monitoring program is considered across the Site.

8 Limitations

This report is produced strictly in accordance with the scope of services set out in the contract or otherwise agreed in accordance with the contract. 360 Environmental makes no representations or warranties in relation to the nature and quality of soil and water other than the visual observation and analytical data in this report.

In the preparation of this report, 360 Environmental has relied upon documents, information, data and analyses ("client's information") provided by the client and other individuals and entities. In most cases where client's information has been relied upon, such reliance has been indicated in this report. Unless expressly set out in this report, 360 Environmental has not verified that the client's information is accurate, exhaustive or current and the validity and accuracy of any aspect of the report including, or based upon, any part of the client's information is contingent upon the accuracy, exhaustiveness and currency of the client's information. 360 Environmental shall not be liable to the client or any other person in connection with any invalid or inaccurate aspect of this report where that invalidity or inaccuracy arose because the client's information was not accurate, exhaustive and current or arose because of any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to 360 Environmental.

Aspects of this report, including the opinions, conclusions and recommendations it contains, are based on the results of the investigation, sampling and testing set out in the contract and otherwise in accordance with normal practices and standards. The investigation, sampling and testing are designed to produce results that represent a reasonable interpretation of the general conditions of the Site that is the subject of this report. However, due to the characteristics of the Site, including natural variations in site conditions, the results of the investigation, sampling and testing may not accurately represent the actual state of the whole Site at all points.

It is important to recognise that site conditions, including the extent and concentration of contaminants, can change with time. This is particularly relevant if this report, including the data, opinions, conclusions and recommendations it contains, are to be used a considerable time after it was prepared. In these circumstances, further investigation of the site may be necessary.

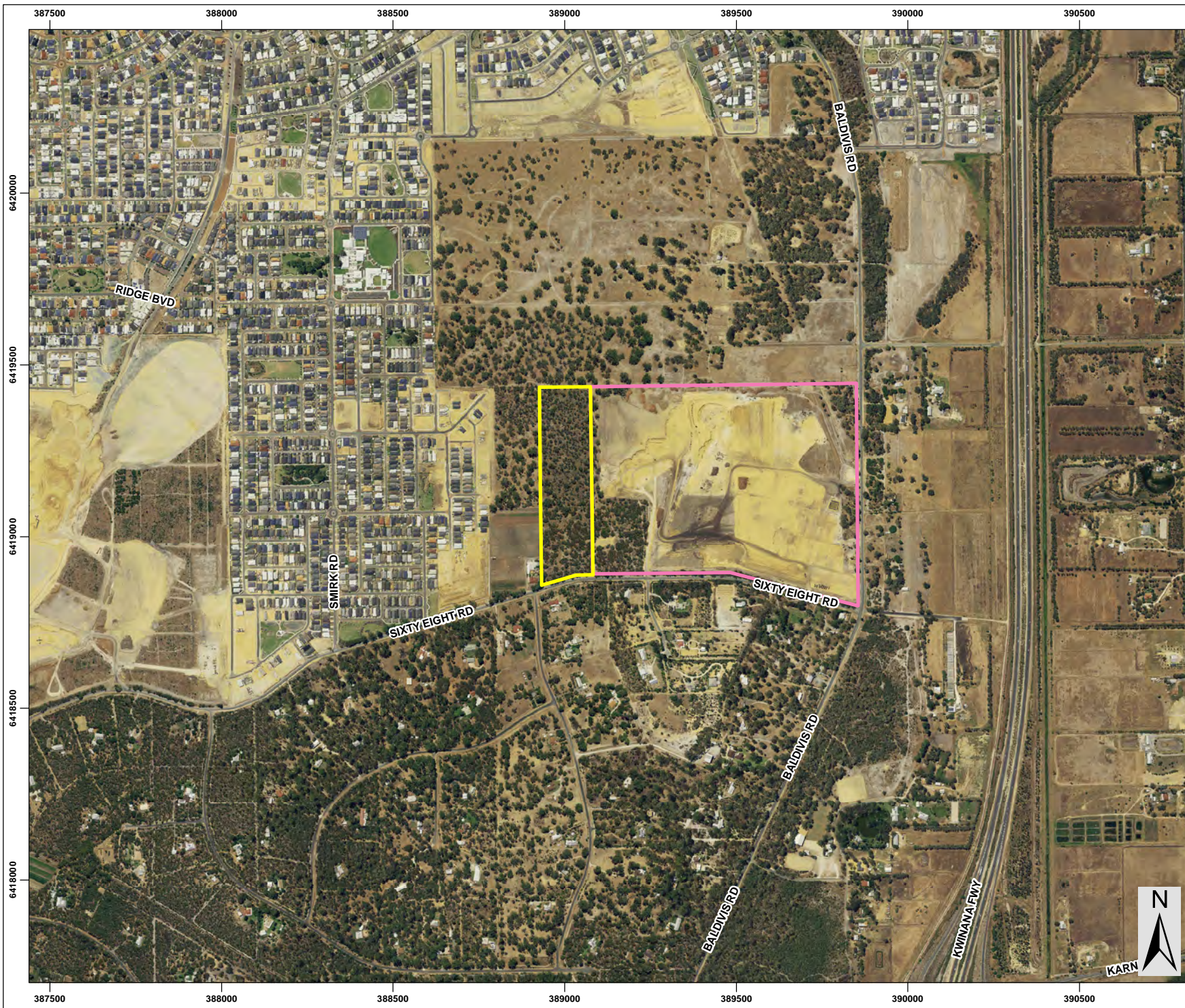
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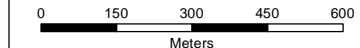
FIGURES



- ### Legend
- Site Location
 - ABN Brightwood Development
 - Roads

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
 - AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2015
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LOCALITY MAP

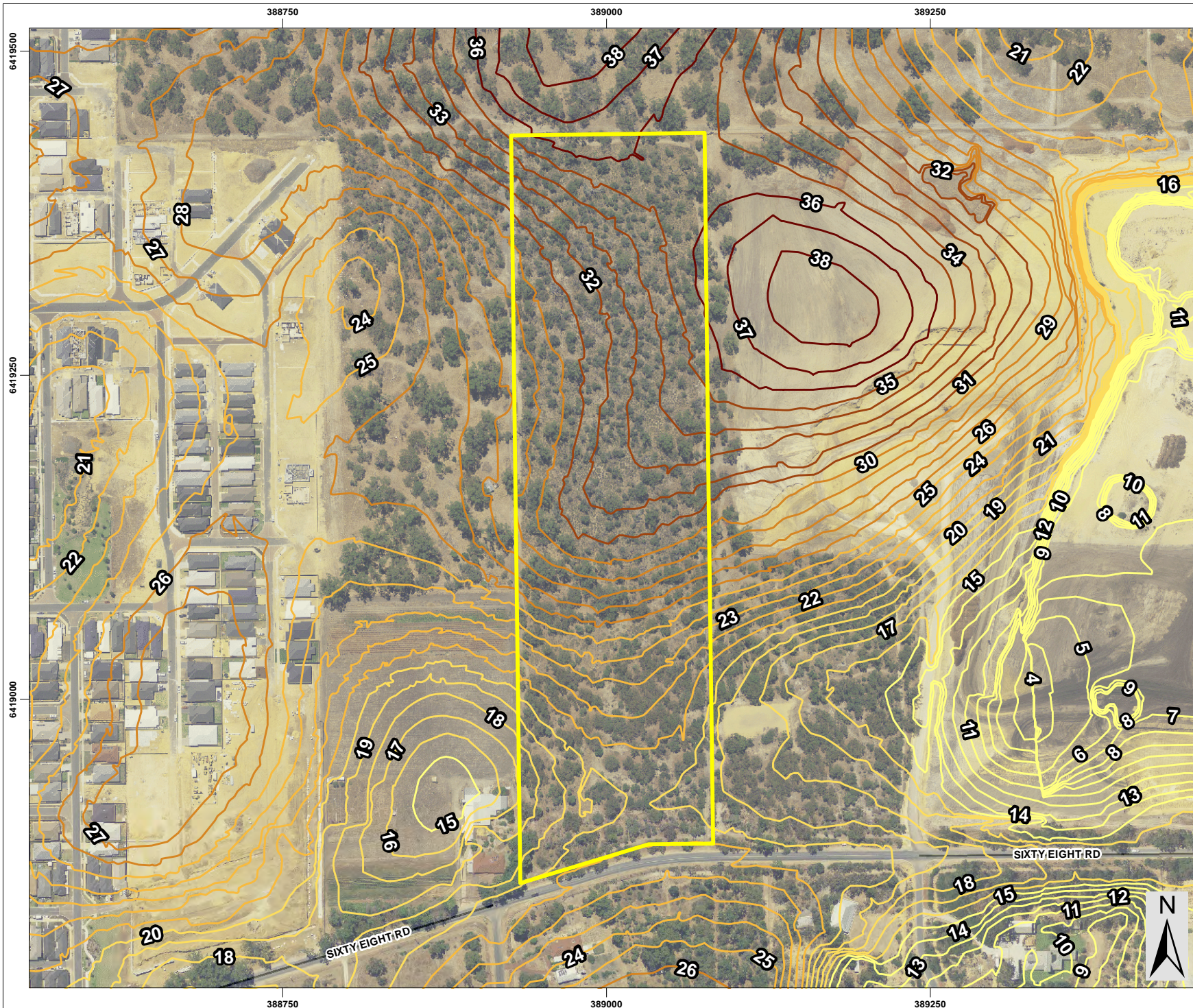


PROJECT ID 1351		DATE 26/11/2015	
HORIZONTAL DATUM AND PROJECTION GDA 1994 MGA Zone 50			
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Alcock Brown Neaves Group
Lot 20 Sixty Eight Rd, Baldvis

District & Local Water Management Strategy




Figure 1 - Location Plan



Legend

 Site Location

ELEVATION

-  < 15mAH
-  15mAH - 20mAH
-  20mAH - 25mAH
-  25mAH - 30mAH
-  30mAH - 35mAH
-  35mAH - 40mAH

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
- ELEVATION SOURCED DOW LIDAR 2015
- AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2015
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LOCALITY MAP

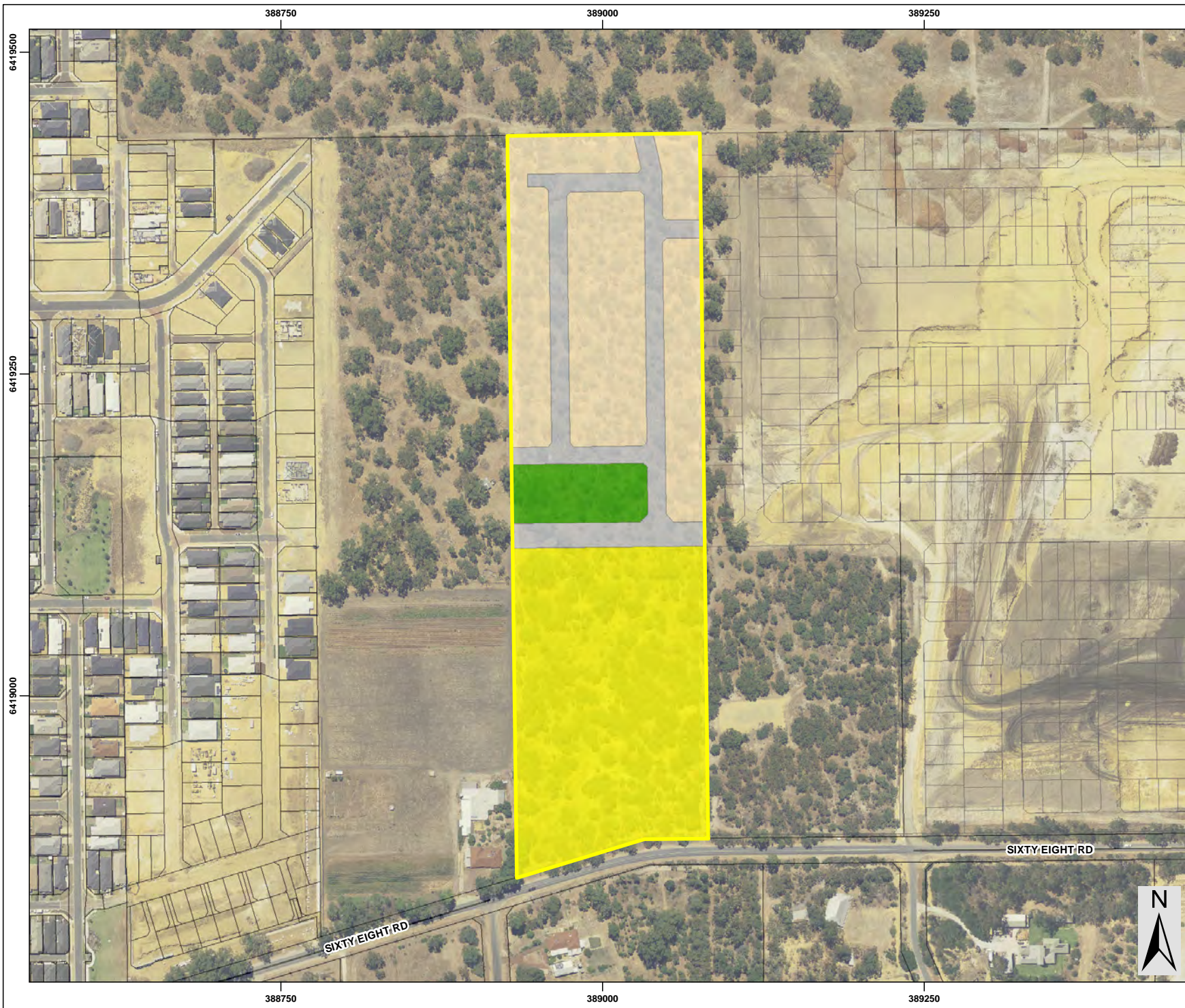


GOLDEN BAY SINGLETON			
PROJECT ID 1351		DATE 12/11/2015	
HORIZONTAL DATUM AND PROJECTION GDA 1994 MGA Zone 50			
CREATED CS	CHECKED AF	APPROVED TSm	REVISION 0

Alcock Brown Neaves Group
Lot 20 Sixty Eight Rd, Baldvis

District & Local Water Management
Strategy

**Figure 2 -
Topography and Aerial Imagery**

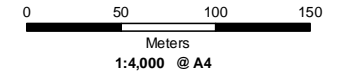


Legend

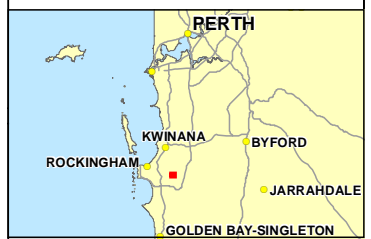
- Site Location
- High School
- Lots
- Public Open Space
- Road Reserve

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
 - DESIGN LAYOUT PROVIDED CLIENT CURRENT AT 12/11/2015
 - AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2015
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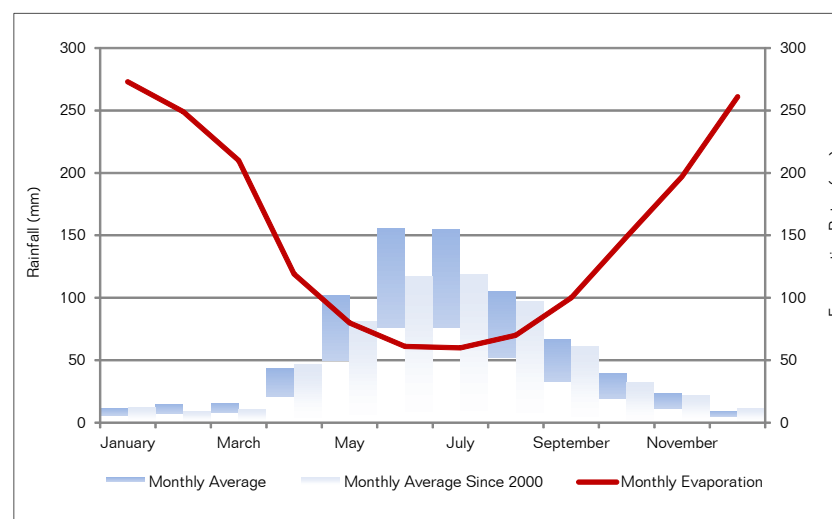
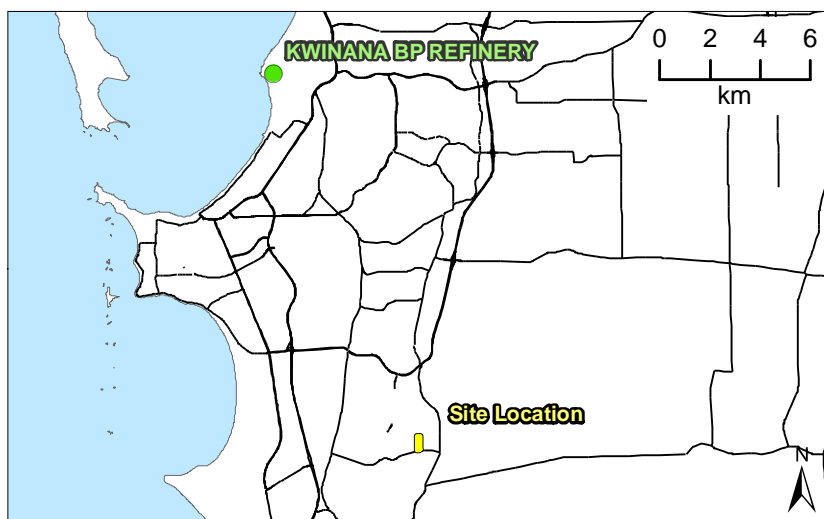
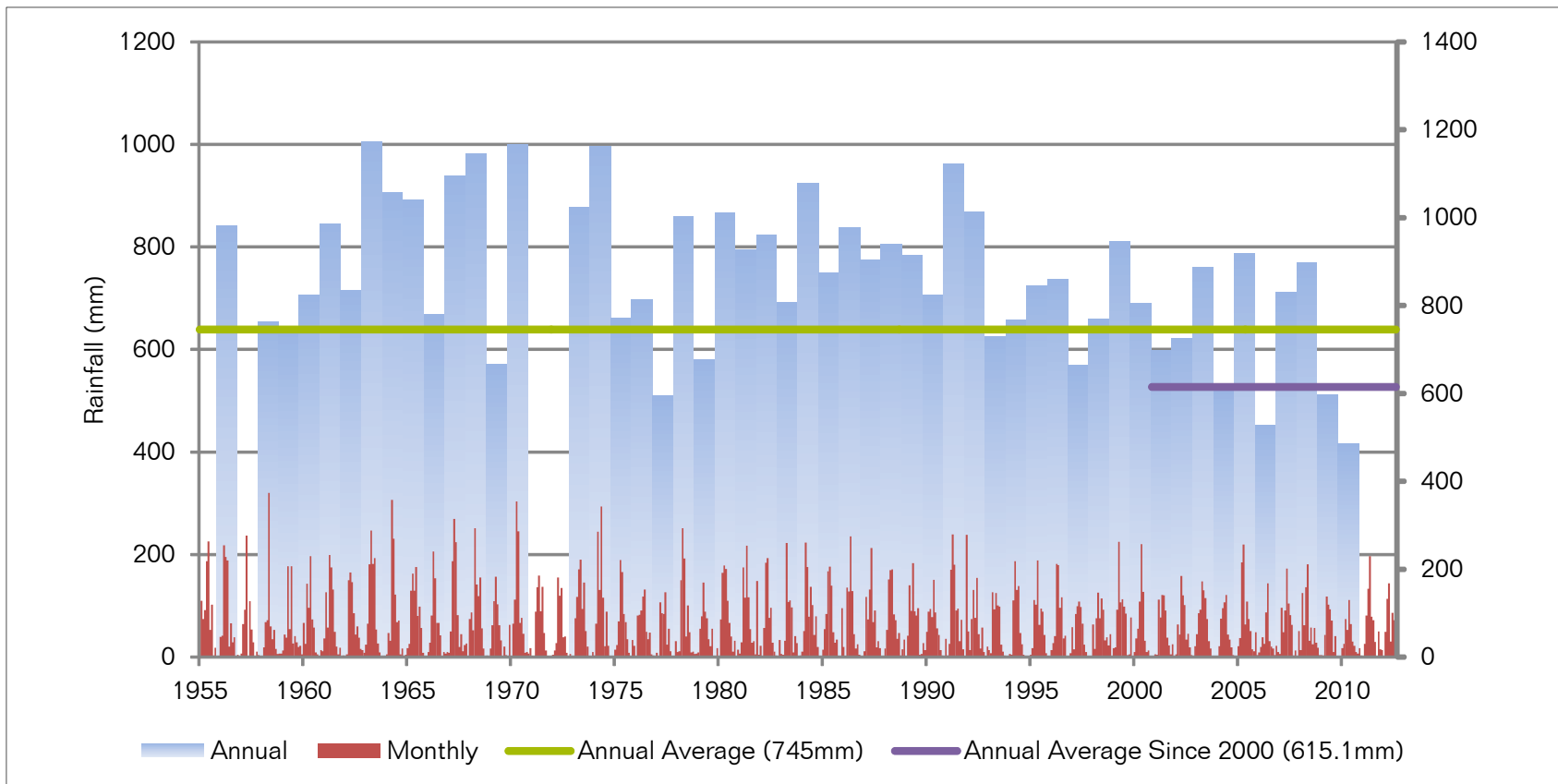
LOCALITY MAP



PROJECT ID 1351		DATE 30/05/2016	
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CREATED CS	CHECKED AN	APPROVED RHo	REVISION 0

Alcock Brown Neaves Group
Lot 20 Sixty Eight Rd, Baldvis

District & Local Water Management Strategy
Figure 3 -
Proposed Structure Plan



Legend

- Site Location
- Weather Stations

NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
 LOCALITY MAP SOURCED FROM LANDGATE 2006
 STREET DIRECTORY MAP SOURCED FROM STREETSMART 2008
 AERIAL PHOTOGRAPHY SOURCED FROM LANDGATE 2012
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LOCALITY MAP



PROJECT ID
1275

DATE
12/11/2015

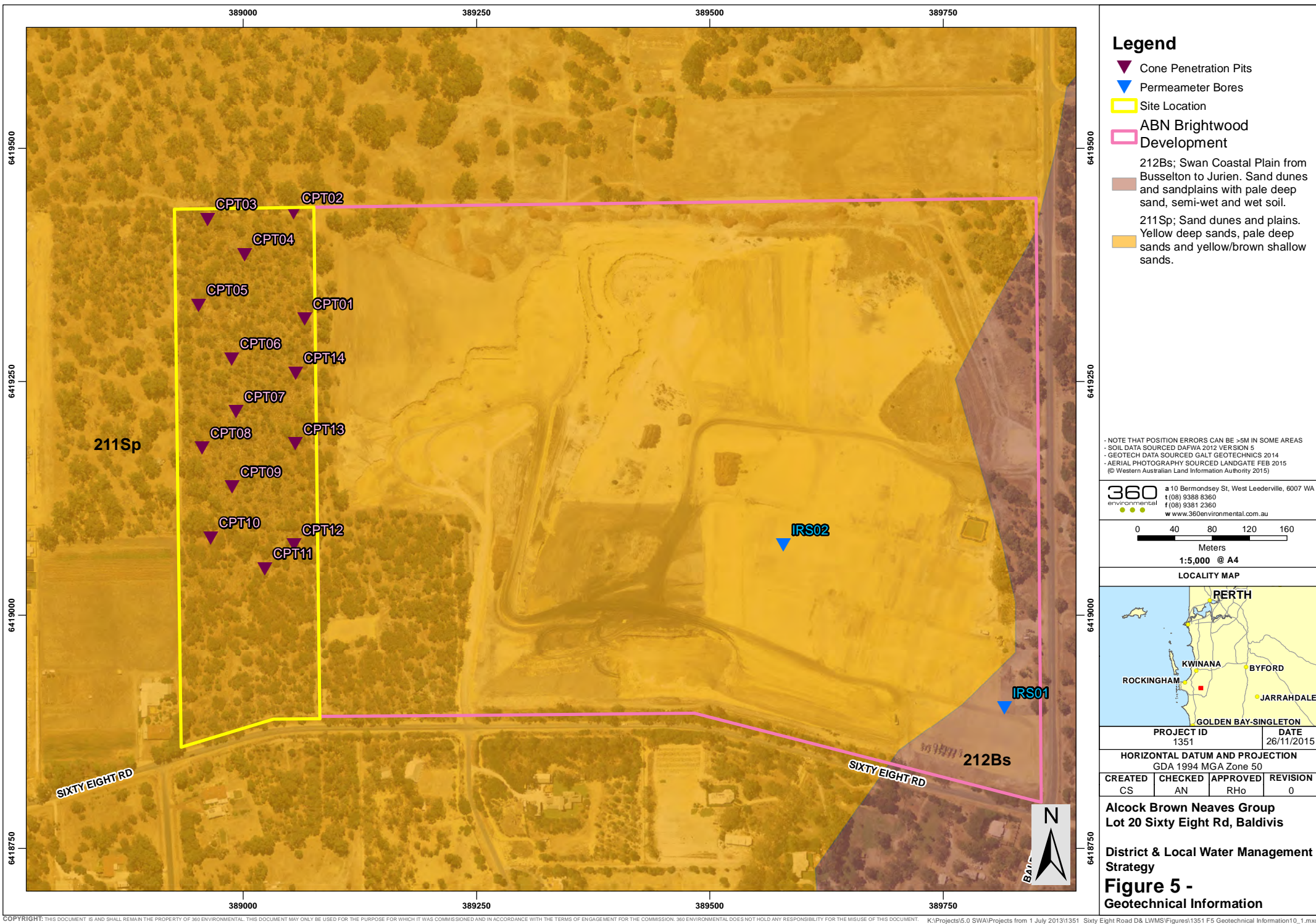
HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

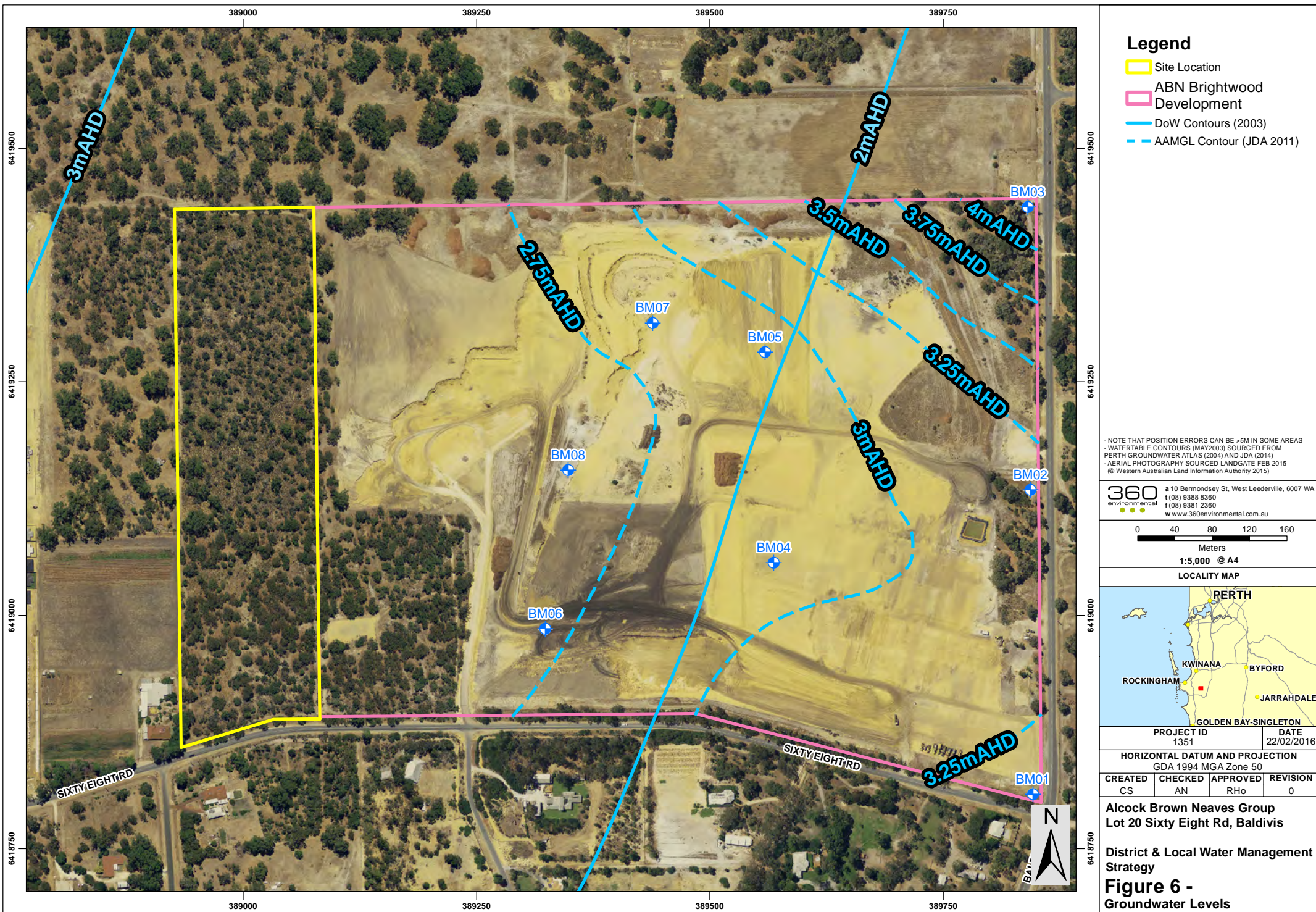
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 Baldvis Rd, Baldvis

District & Local Water Management Strategy

**Figure 4 -
 Rainfall and Evaporation Data**

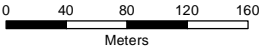




- Legend**
- Site Location
 - ABN Brightwood Development
 - DoW Contours (2003)
 - AAMGL Contour (JDA 2011)

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS
 - WATERTABLE CONTOURS (MAY2003) SOURCED FROM PERTH GROUNDWATER ATLAS (2004) AND JDA (2014)
 - AERIAL PHOTOGRAPHY SOURCED LANDGATE FEB 2015
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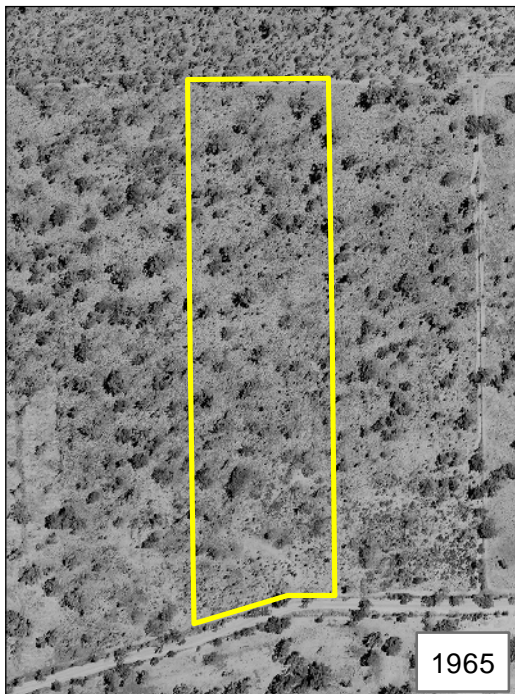
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LOCALITY MAP

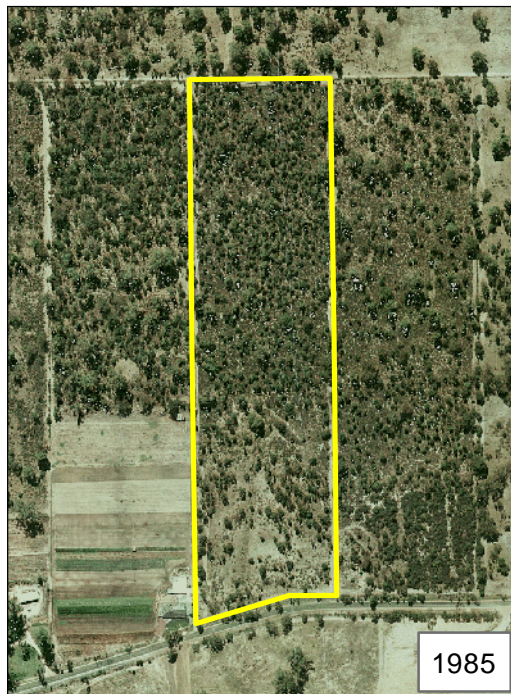


PROJECT ID 1351			DATE 22/02/2016
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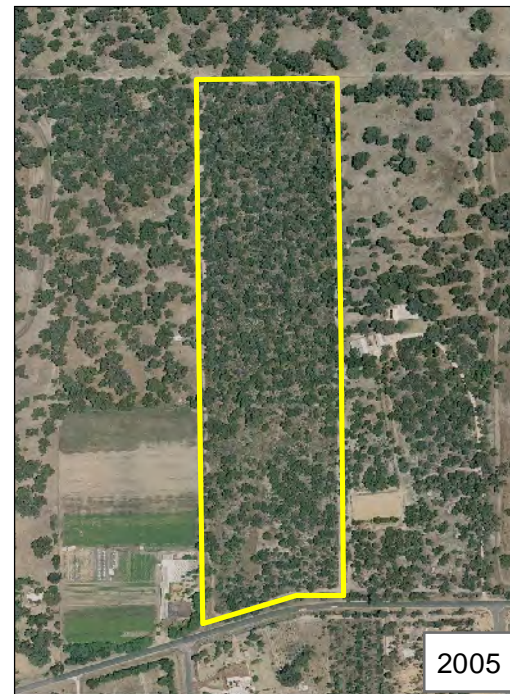
Alcock Brown Neaves Group
Lot 20 Sixty Eight Rd, Baldvis
District & Local Water Management Strategy
Figure 6 - Groundwater Levels



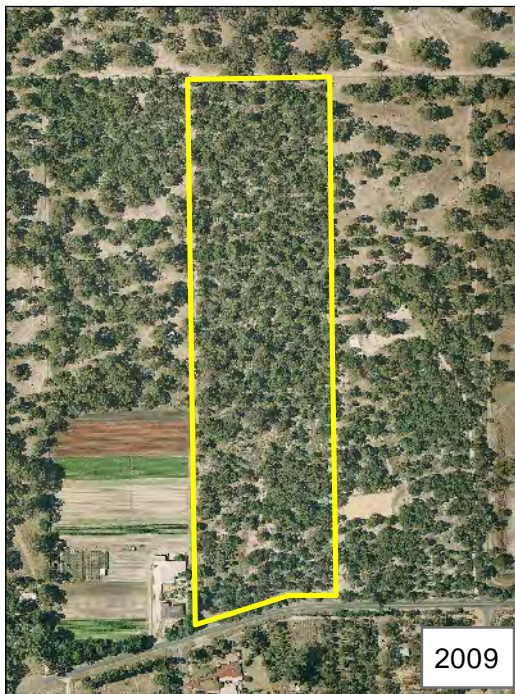
1965



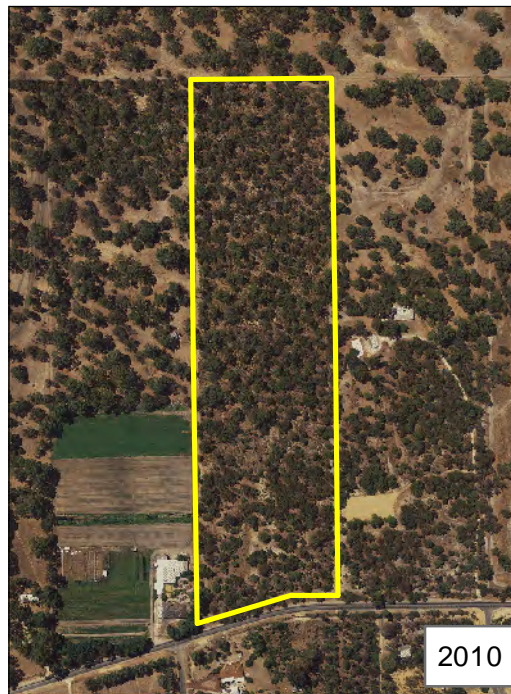
1985



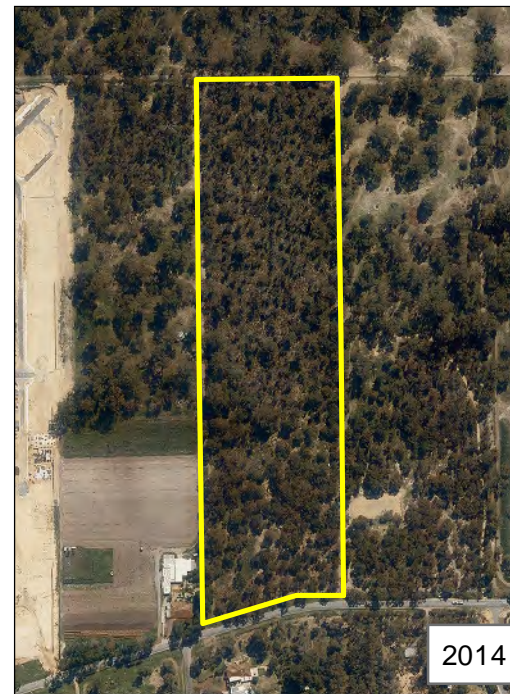
2005



2009



2010



2014

Legend

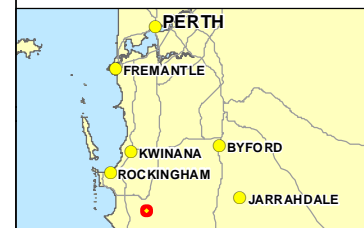
 Site Location

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LOCALITY MAP

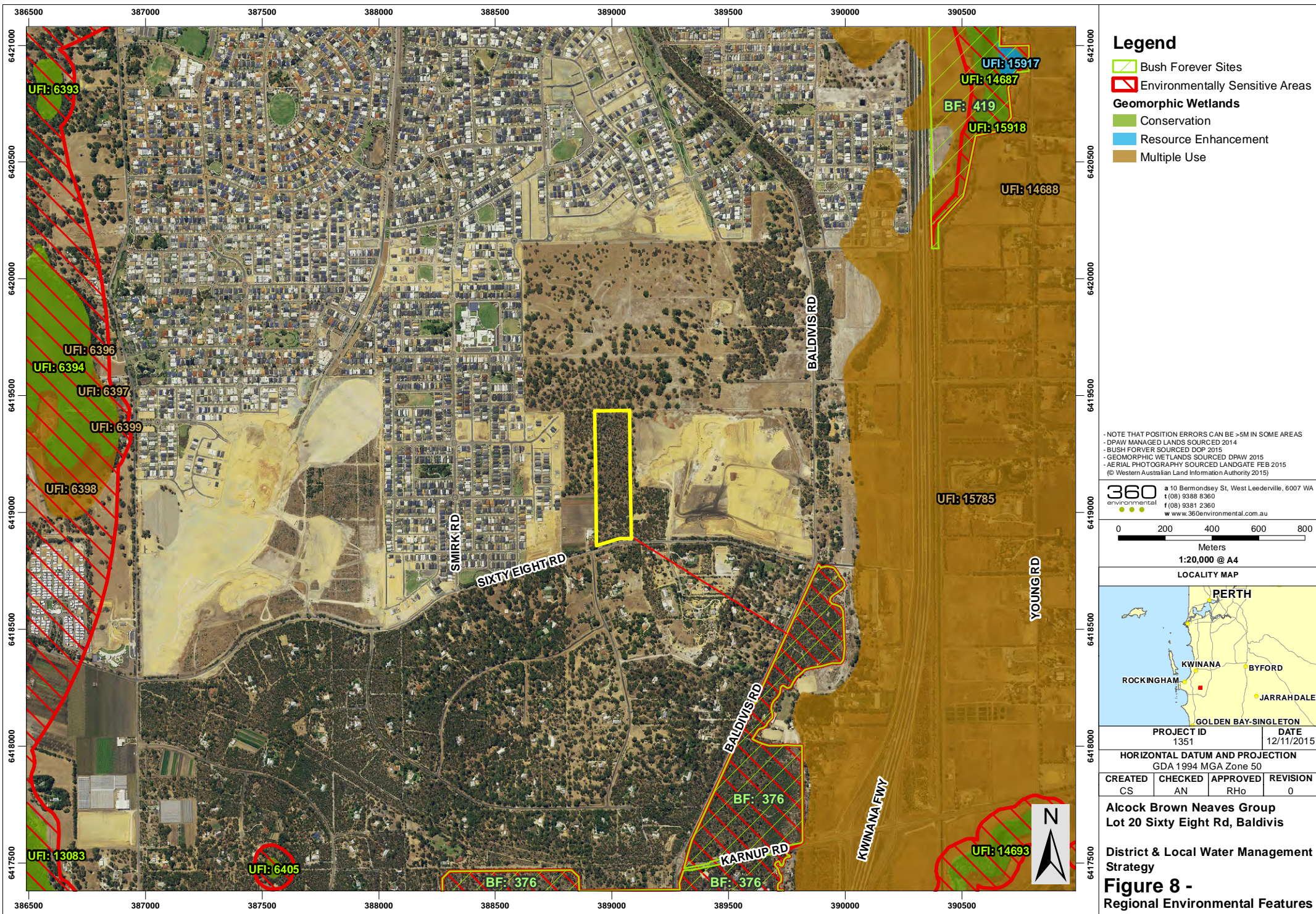


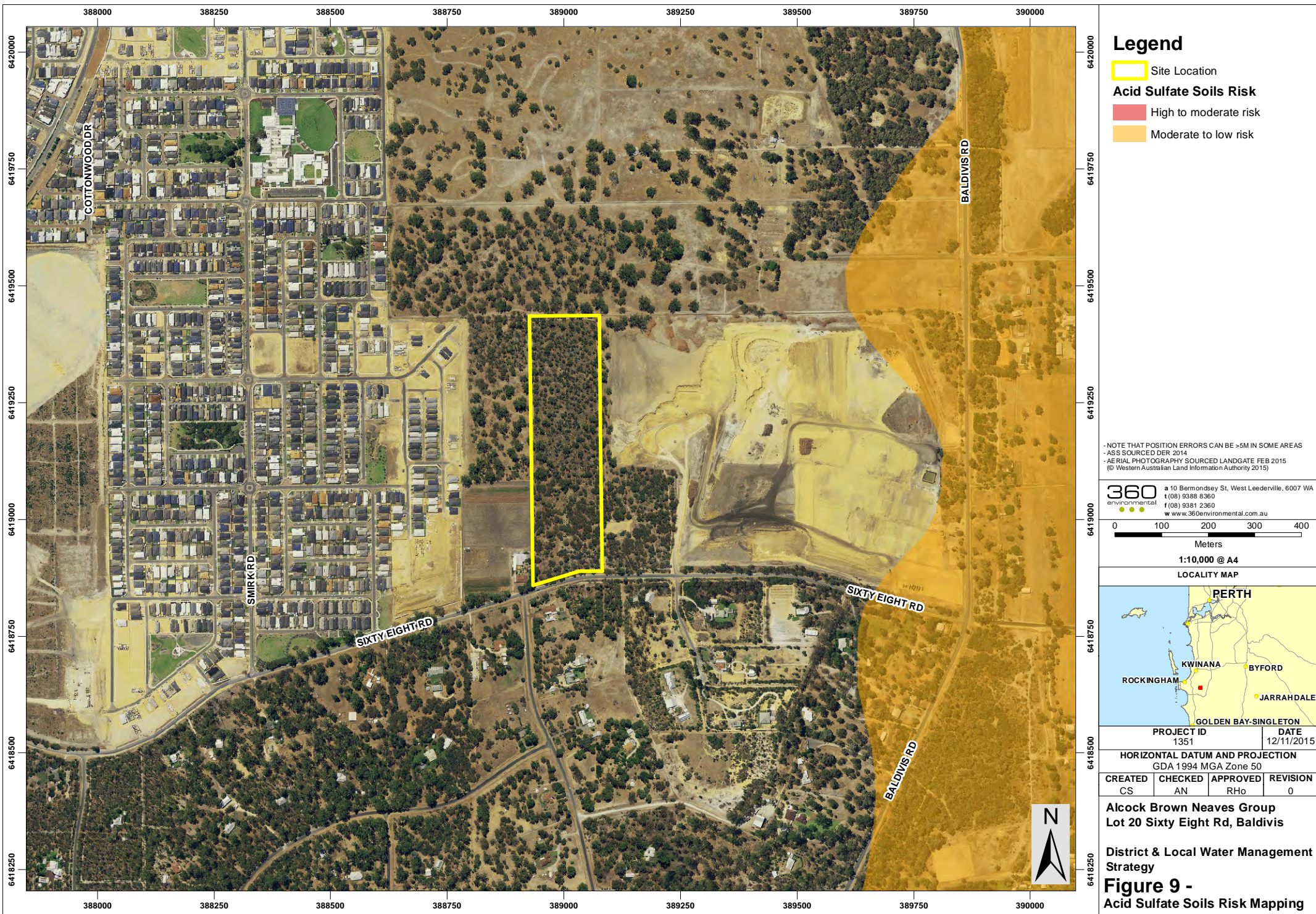
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1351 F7 Historical Imagery		10/27/11/2015	
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GDA 1994 MGA Zone 50			
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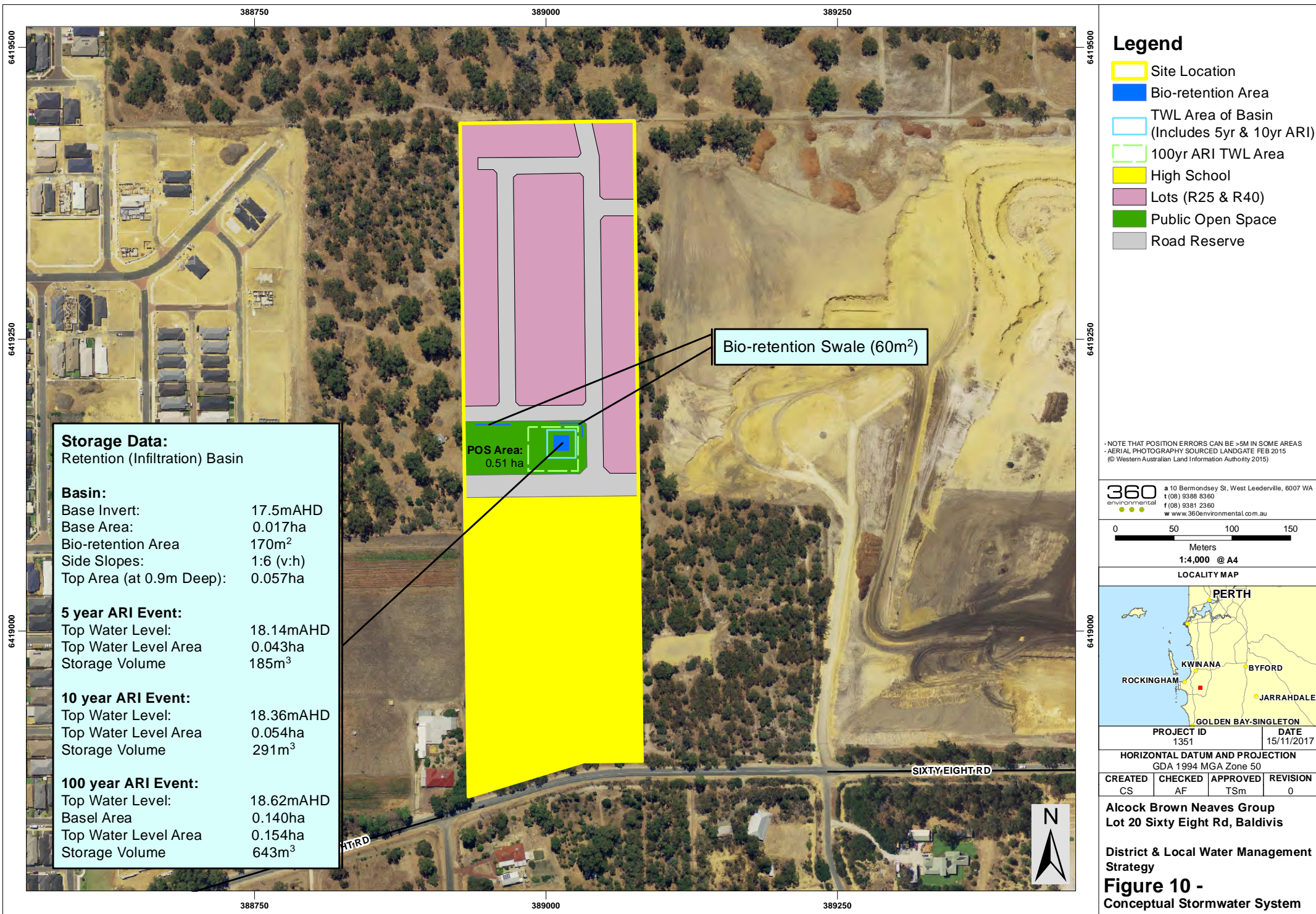
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Baldivis Rd, Baldivis

District & Local Water Management
Strategy

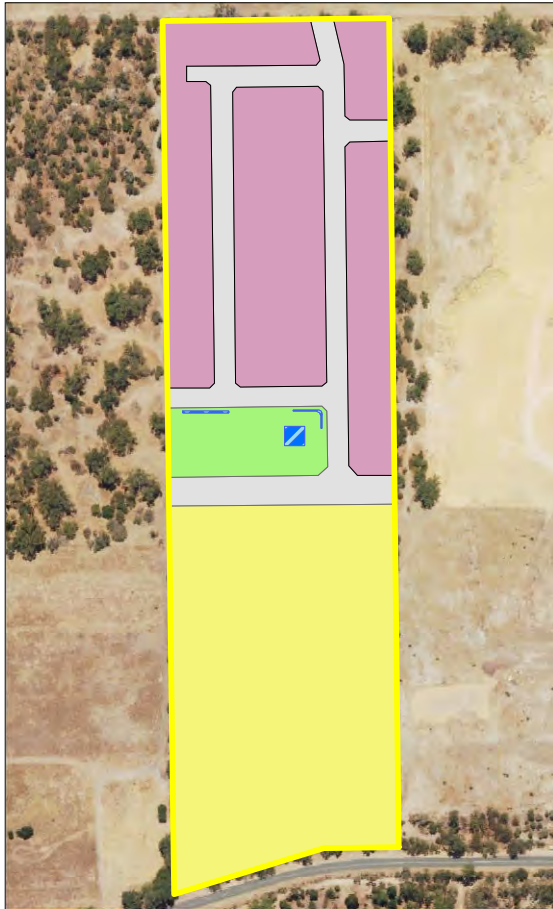
Figure 7 - Historical Imagery



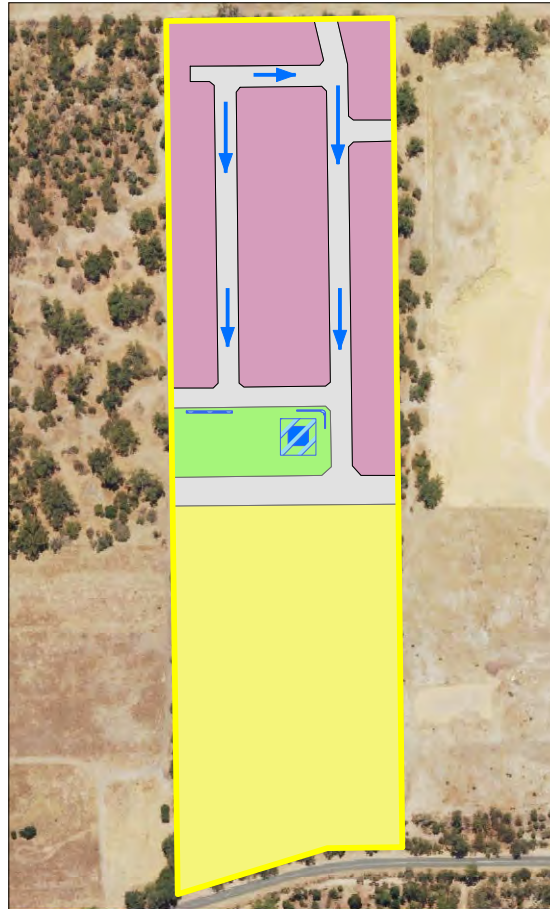




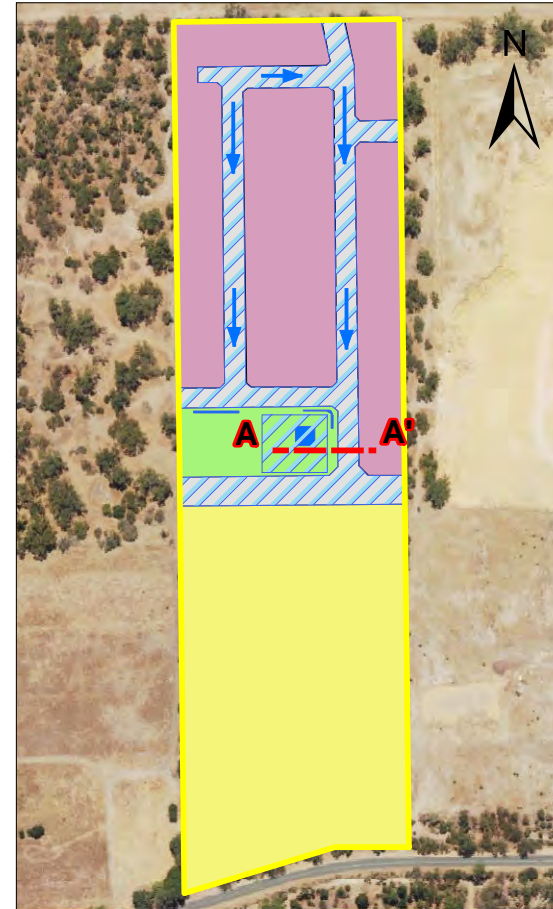
1 Year ARI Event Plan



5 Year ARI Event Plan



100 Year ARI Event Plan



Legend

- Site Location
- Flow Direction
- Cross Section
- Inundation
- Bio-retention Area
- High School
- Lots
- Public Open Space
- Road Reserve

Note: Opportunities for co-locating drainage within the POS may be considered subject to future approvals and agreement between all parties.

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LOCALITY MAP



PROJECT ID 1351 DATE 14/11/2017

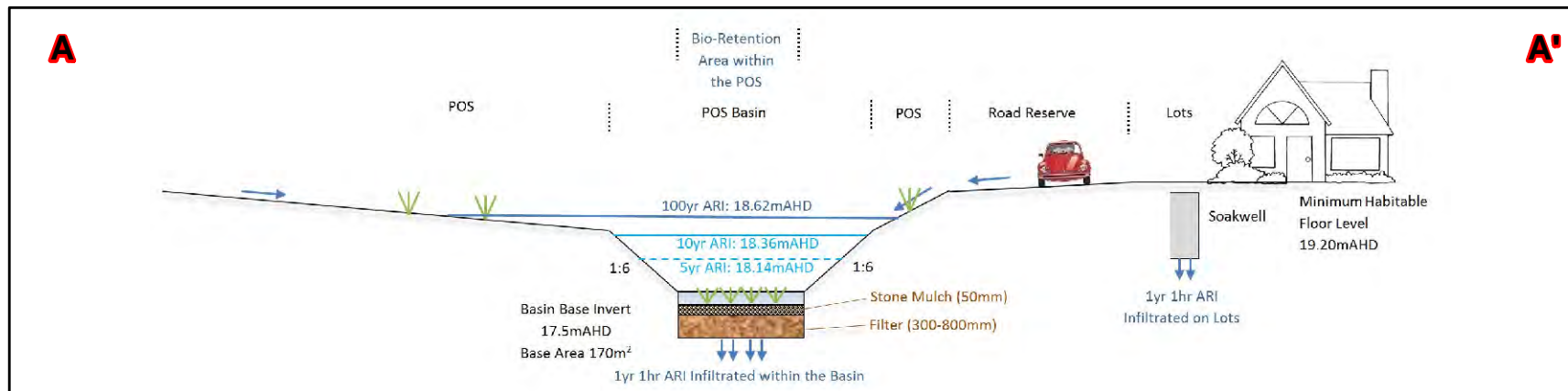
HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

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Alcock Brown Neaves Group
Lot 20 Sixty Eight Rd, Baldviss

District & Local Water Management Strategy

Figure 11 - Stormwater Event Plans



APPENDIX A: URBAN WATER MANAGEMENT PLAN CHECKLIST

Better Urban Water Management (WAPC, 2008)

Local Water Management Strategy Item	Required Deliverable	Deliverable		<input type="checkbox"/>	Comment
		D&LWMS Reference	Comment		
Executive Summary					
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMP's and critical control points	Executive Summary	The executive summary is a table of the key points of the proposed Local Water Management Strategy	<input checked="" type="checkbox"/>	
Introduction					
Total water cycle management – principles & objectives Planning background Previous Studies		Section 1.1, 1.2 and Table 1	A summary of the guiding documents and design principles are outlined. Specific objectives for the site are summarised in Table 1.	<input checked="" type="checkbox"/>	
Proposed Development					
Structure plan, zoning and land use. Key landscape features Previous land Use	Site context plan Structure Plan	Section 2, App B, App C, Figure 3, Figure 7	The proposed LSP is provided in Appendix B with lot, road and POS layouts shown in Figure 3. Historical aerial photos are presented in Figure 7.	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	

Landscape- proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas.	Development Plan	Appendix B Figures 3 & 11	POS area and basin schematic cross section is presented in Figure 11..	<input checked="" type="checkbox"/>	
Design Criteria					
Agreed design objectives and source of objective		Section 1, Table 1	Site specific design objectives and criteria are summarised in Table 1.	<input checked="" type="checkbox"/>	
Pre-development environment					
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		Section 3, Table 4	This is presented in Section 3, and key site considerations are summarised in Table 4	<input checked="" type="checkbox"/>	
Site conditions – existing topography. Contours, aerial photo underlay, major physical features	Site condition plan	Section 3.2, Section 3.8.1, Figure 1, Figure 2	Location plan and pre-development aerial photo is shown in Figure 1&2. Existing land use is discussed in Section 3.8.1.	<input checked="" type="checkbox"/>	
Geotechnical – topography, soils including acid sulphate soils and infiltration capacity, test pit locations	Geotechnical Plan	Section 3.4, Section 3.8.5, Figure 5, Figure 9	The geotechnical investigation is summarised in Section 3.4. ASS is discussed in Section 3.8.5.	<input checked="" type="checkbox"/>	
Environmental – areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	Section 3.8, Figure 8	Figure 8 demonstrates the wetland locations. Other environmental factors are discussed in Section 3.8	<input checked="" type="checkbox"/>	
Surface Water – topography, 100 year floodways and flood fringe	Surface Water Plan	Section 3.6,	Section 3.6 indicates that no surface water features or	<input checked="" type="checkbox"/>	

areas, water quality of flows entering and leaving (if applicable)			drainage lines that exist within the boundaries of the Site.		
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	Section 3.5, Figure 6	Groundwater monitoring results are discussed in Section 3.5. Water levels are presented in Figure 6.	☑	
Water use sustainability initiatives					
Water efficiency measures – private and public open spaces including method of enforcement		Section 4.2	Section 4.2 outlines water conservation measures.	☑	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		Section 4.1	Water supply options are discussed in Section 4.1.	☑	
Wastewater management		Section 4.3	Section 4.3 provides the wastewater management strategy.	☑	
Stormwater management strategy					
Flood protection – peak flow rates, volumes and top water levels at control points, 100 year flow paths and 100 year detentions storage areas	100 year event Plan Long section of critical points	Section 5.1, Section 5.2.2, Figure 10, Figure 11, Table 8	The management strategies for the 100yr ARI event are discussed in Section 5.2.2. Table 7, Figures 10 and Figures 11 provide the control points and levels.	☑	
Manage serviceability – storage and retention for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	10yr event Plan	Section 5.1, Section 5.2.2, Figure 10, Figure 11, Table 8	The 5yr event plan is provided in Figure 11. Table 7 outlines volumes and levels. Section 5.2.2 discusses serviceability.	☑	

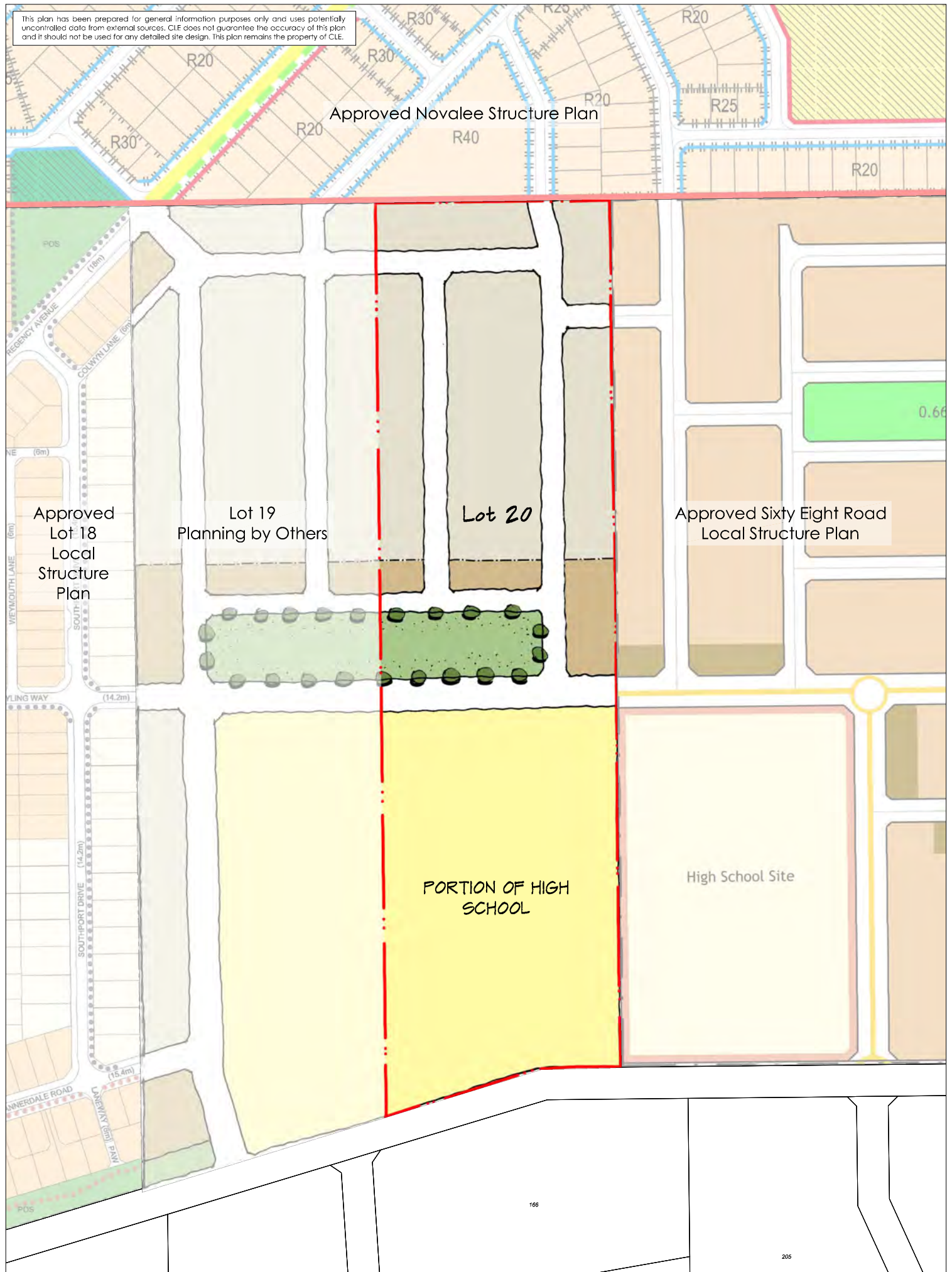
Protect ecology – detention areas for the 1 yr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event Plan Typical cross sections	Section 5.1, Section 5.2.1, Section 5.4, Figure 10, Figure 11	Section 5.1 and 5.2.1 outline the stormwater management strategy for the 1yr ARI event. Measures to protect receiving environments are discussed in Section 5.4.	<input checked="" type="checkbox"/>	
Groundwater management strategy					
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	Section 5.3	Section 5.3 provides the management plans for groundwater.	<input checked="" type="checkbox"/>	
Actions to address acid sulphate soils or contamination		Section 5.3, Section 6.2.1	The measures to mitigate ASS risk are provided in Section 5.3 and Section 6.2.1.	<input checked="" type="checkbox"/>	
The next stage – subdivision and urban water management plans					
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design		Section 6.1	The requirements for the UWMP are outlined in Section 6.1.	<input checked="" type="checkbox"/>	
Monitoring					
Recommended future monitoring plan including timing, frequency, locations and parameters, together with		Section 6	Pre-development, construction and post-development	<input checked="" type="checkbox"/>	

arrangements for ongoing actions			monitoring is discussed.		
Implementation					
Developer Commitments		Section 6	The developers commitments through subsequent phases of development are discussed in Section 6.	<input checked="" type="checkbox"/>	
Roles, responsibilities, funding for implementation		Section 6.4, Table 8	Table 8 outlines the roles and responsibilities beyond the D&LWMS.	<input checked="" type="checkbox"/>	
Review		Section 7	Opportunities for review are discussed in Section 7.	<input checked="" type="checkbox"/>	

APPENDIX B: DEVELOPMENT PLAN

(CLE, 2016)

This plan has been prepared for general information purposes only and uses potentially uncontrolled data from external sources. CLE does not guarantee the accuracy of this plan and it should not be used for any detailed site design. This plan remains the property of CLE.



DEVELOPMENT CONCEPT

Lot 20, Sixty Eight Road, Baldvis
City of Rockingham

plan no: 2342-67A-01

scale: 1:3000 @ A4

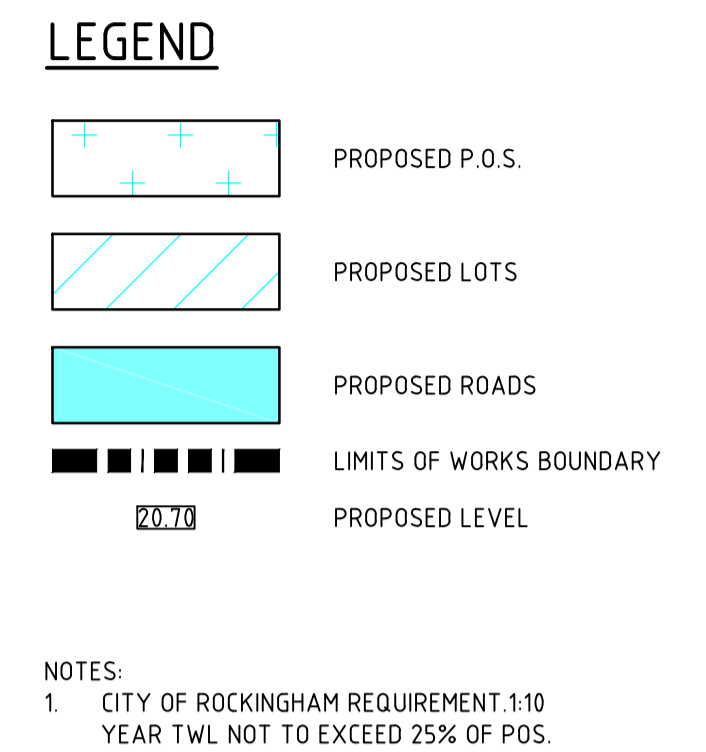
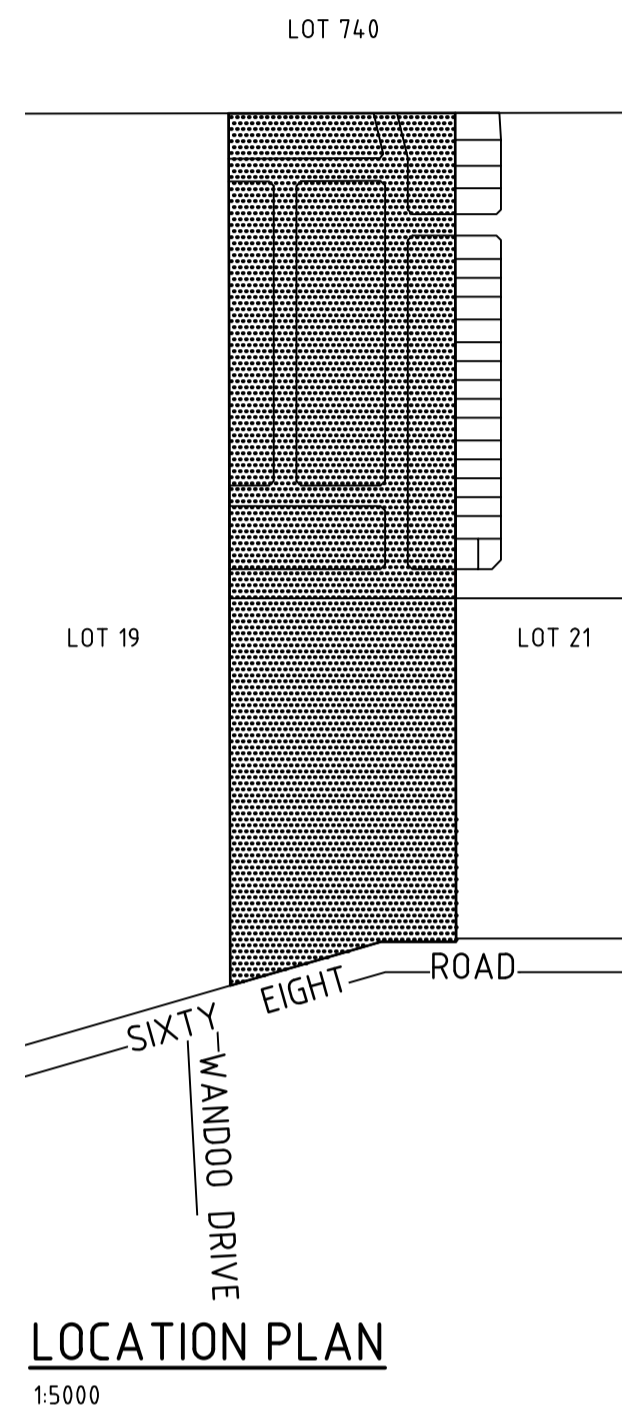
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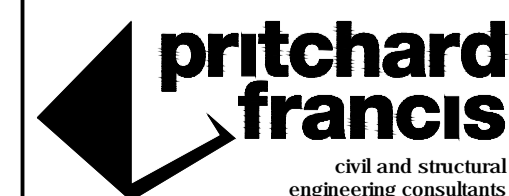
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APPENDIX C: DRAINAGE AND LEVELS CONCEPT PLAN

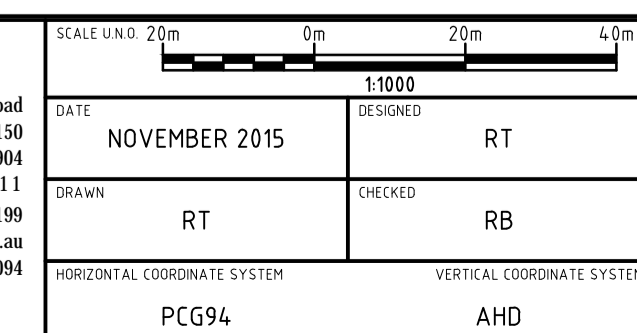
(Pritchard Francis, 2016)



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Subiaco WA 6904
Telephone: (08) 9382 5111
Facsimile: (08) 9382 5199
admin@pfeng.com.au
ACN: 008 891 094



CLIENT & JOB	ABN BALDIVIS JOINT VENTURE LOT 20 SIXTY EIGHT ROAD, BALDIVIS
TITLE	DRAINAGE AND LEVELS CONCEPT PLAN

EM	SHEET SIZE A1	DRG No. 13114-C9-SK-16	REVISION A
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APPENDIX D: LANDSCAPE CONCEPT PLAN

(LD Total, 2016)



INTERNAL ROAD

SECTION

ACTIVE PLAY AREA
TURF

BASIN

BIO-RETENTION
2 SWALE(S) 30 x1 x0.3m
depth

MELALEUCAS

BIO RETENTION
PLANTING
+ GRAVEL MULCH

EUCALYPTUS TBC

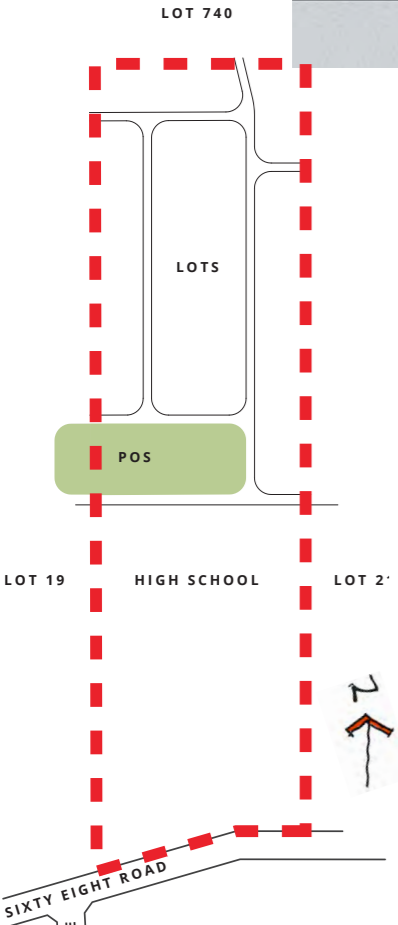
STREET TREE TBC
PYRUS 'BRADFORD'

POSSIBLE SMALL PLAY
AREA - MIXED AGES
WHERE POSSIBLE

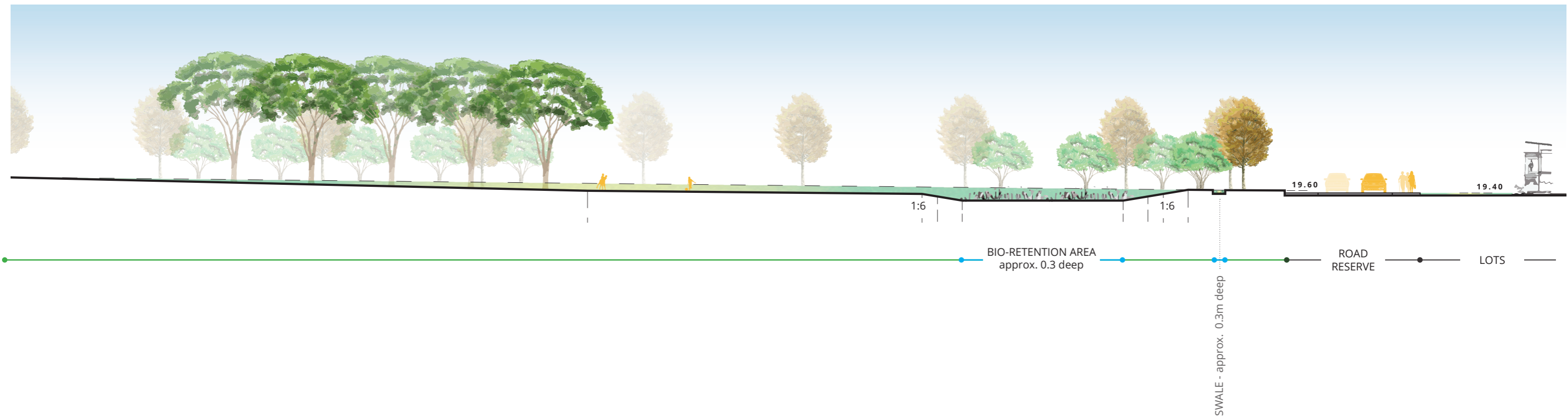
- Q1 - 170m²
- Q5 - 430m²
- Q10 - 540m²
- Q100 - 1,540m²

NOTE: THERE IS REDUCE ASSETS
PROPOSED IN THE LOT 20 POS,
AS A RESULT OF THE INCREASED
ASSETS THAT ARE INCLUDED IN
THE CENTRAL POS.

LANDSCAPE DESIGN TO BE
FINALISED DURING DETAILED
DESIGN AND APPROVED BY CITY
OF ROCKINGHAM.



CONCEPT SECTION: POS + BASIN



CONCEPT BIO RETENTION PLANTING



ISO NOD Isolepis nodosa



JUN PAL Juncus pallidus



LEP EFF Lepidosperma effusum



BAU RUB Baumea rubiginosa

CONCEPT PROPOSED TREE SPECIES



PYB Pyrus calleryana 'Bradford'



MRA Melaleuca raphiophylla



EUC SNQ Eucalyptus 'Snow Queen'

APPENDIX E: GROUNDWATER LICENSE



LICENCE TO TAKE WATER

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

Licensee(s)	Caversham Land Co Pty Ltd		
Description of Water Resource	Stakehill Perth - Superficial Swan	Annual Water Entitlement	66250 kL
Location of Water Source	Lot 1263 On Plan 152941 - Volume/Folio 1394/7 - Lot 1263 Baldivis Rd Baldivis		
Authorised Activities	Taking of water for	Location of Activity	
	Irrigation of up to 3.5ha ovals and playing fields	Lot 21 On Plan 8420 - Volume/Folio 1720/135 - Lot 21 Sixty Eight Rd Baldivis	
	Irrigation of up to 4 ha of public open space	Lot 1263 On Plan 152941 - Volume/Folio 1394/7 - Lot 1263 Baldivis Rd Baldivis Lot 21 On Plan 8420 - Volume/Folio 1720/135 - Lot 21 Sixty Eight Rd Baldivis Lot 569 On Plan 152941 - Volume/Folio 2212/746 - Lot 569 Baldivis Rd Baldivis	
	Irrigation of up to 2 ha of road verge	Lot 1263 On Plan 152941 - Volume/Folio 1394/7 - Lot 1263 Baldivis Rd Baldivis Lot 21 On Plan 8420 - Volume/Folio 1720/135 - Lot 21 Sixty Eight Rd Baldivis Lot 569 On Plan 152941 - Volume/Folio 2212/746 - Lot 569 Baldivis Rd Baldivis	
Duration of Licence	From 3 January 2014 to 2 January 2024		

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

- 1 The licensee shall not use water for irrigation purposes 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 meter(s) must be installed in accordance with the provisions of the document entitled "Guidelines for Water Meter Installation 2009" before any water is taken under this licence.
- 4 The annual water year for water taken under this licence is defined as 1 July to 30 June.
- 5 The licensee must not, in any water year, take more water than the annual water entitlement specified in this licence.

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:

- 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 All meter readings must be recorded on the "Meter Water Use Card" available from the Department of Water.
- 9 The completed Water Use Card must be returned to the Department of Water every 12 month(s) commencing 14/07/2014.
- 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.
- 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
