Cardno BSD

Shaping the Future

CITY OF COCKBURN
DEVELOPMENT AREA 19
DISTRICT WATER MANAGEMENT STRATEGY

January 2008
Job No. E07007

City of Cockburn

Cardno BSD Pty Ltd
ABN 77 009 119 000
Cardno BSD Centre
2 Bagot Road
Subiaco WA 6008
PO Box 155, Subiaco
Western Australia 6904 Australia
Telephone: 08 9273 3888
Facsimile: 08 9388 3831
International: +61 8 9273 3888
reception@cardno.com.au
www.cardno.com.au

Document Control

Version	Date	Author		Reviewer	
		Name	Initials	Name	Initials
1	January 2008	Aaron Jobbins		Wayne Burns	

DEVELOPMENT AREA 19 LOCAL WATER MANAGEMENT STRATEGY

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This District Water Management Strategy (DWMS) has been prepared by Cardno BSD for Koltasz Smith, Town Planning Consultants to further the development of the Area 19 District Structure Plan, to be submitted to and approved by the City of Cockburn and Western Australian Planning Commission.

An Arterial Drainage Scheme Review (ADSR) report was prepared by David Wills and Associates for City of Cockburn. This report provided parameters, recommendations and minimum requirements for the stormwater drainage network of the entire region which includes Development Area 19. This DWMS provides an interpretation of the ADSR report for aspects relevant to Development Area 19.

The regional stormwater design philosophies of the ADSR report include minimum separation to the groundwater, promoting on-site stormwater disposal and the use of drainage features to limit rises of the groundwater are to be adopted for the stormwater design.

The ADSR report provided Design Regional Control Groundwater Level (DRCGL) contours based upon existing hydrologic and hydraulic data. Minimum separation distances between lot levels road centreline levels and the DRCGL contours have been provided. Filling will be required in some areas in order to achieve minimum separation distances. Additional earthworks are also likely to be required in order to achieve minimum grades for the stormwater network for Development Area 19.

Sub-catchment areas provided in the ADSR report have been altered to suit the proposed District Structure Plan for Development Area 19. Based upon the altered catchment areas, volumes of runoff for the relevant ARI rainfall events have been calculated. However, volumes are to be used as a guide and are likely to change following design of the stormwater network.

Alternatives for stormwater disposal into the regional network in accordance with Water Sensitive Urban Design (WSUD) principals and the regional design philosophies of the ADSR report exist within each catchment area. Final disposal methods for each catchment will need to be determined at the design stage.

1. INTRODUCTION

Koltasz Smith and Associates are currently preparing a District Structure Plan (DSP) for the area depicted as Development Area No.19 (‘*Area 19’*) under the City of Cockburn’s Town Planning Scheme No.3. The DSP is to be submitted to the City of Cockburn for community consultation and approval and subsequently the Western Australian Planning Commission for final approval. Once approved, the DSP is to provide a strategic planning guide to the future subdivision and development of the site.

Cardno BSD have been commissioned by Koltasz Smith Town Planning Consultants on behalf of associated landowners to prepare a District Water Management Strategy (DWMS), to support the DSP.

The objective of this DWMS is to detail the recommended strategy and the requirements for managing stormwater drainage within and surrounding Development Area 19. In doing so the DWMS will facilitate for a coordinated approach in the treatment of stormwater drainage within this area. It is the intention of this report to keep within the general design philosophies and requirements of the David Wills and Associates Arterial Drainage Scheme Review (ADSR) revision D, November 2005 and this DWMS should be read in conjunction with the ADSR report.

This DWMS focuses on the management of stormwater for the proposed DSP at the completion of development. Although the possible need for intermediate and temporary measures for stormwater management are recognised being most likely required, as Development Area 19 undergoes staged development, these measures are considered outside the scope of this report.

2. PROPOSED SITE DEVELOPMENT

2.1 Site Background

Area 19 is located within the City of Cockburn, approximately 16km south of the Perth Central Business District and 10km south east of Fremantle. The site is bound by Kwinana Freeway, Kentucky Court, North Lake Road, Semple Court and Verna Court, as shown in **Figure 1**, and covers an area of approximately 78ha.

The site is comprised of 86 semi-rural/residential lots generally ranging in size of 5,000m2 to 2 ha and commercial lots. Immediately west of the site, is the established residential suburb of South Lake, which continues around to the north of the site, north of Berrigan Drive.

The current land use is described as semi-rural/residential, with dwellings surrounded by cleared paddocks with pockets of existing vegetation and dampland areas scattered throughout. The site generally has a very gentle grade down towards the west with some slightly higher and lower lying areas. The total catchment currently discharges stormwater informally into Yangebup Lake located to the west of the site.

2.2 Proposed Land Use

A DSP has been developed by Koltasz Smith which seeks to develop Development Area 19 with a combination of high, medium and low density residential uses, in response to the sites proximity to the imminently operational Thompson Park Light Rail Station. In this regard, the plan proposes a maximum residential density of R160 within approximately 400m of the Thompsons Park Light Rail Station site, R40 at approximately 400m to 800m from the station site and R20 for the remainder of the site with some exceptions including R40 zoning adjacent POS and major distributor roads.

The plan also entails a strip of mixed use lots fronting North Lake Drive, which forms the site's southern boundary. Three Public Open Space (POS) areas have been incorporated into the DSP and the existing Church and Child Care Centre are to remain, as shown.

Please refer to **Figure 2** for the DSP, which shows proposed zoning and POS locations.

2.3 Proposed Regional Drainage

Development Area 19 and the surrounding locality has been earmarked for future development by the City of Cockburn.

In order to resolve technical drainage and groundwater issues associated with the provision of an integrated stormwater drainage system for the future development of this region, David Wills and Associates Consulting Engineers were commissioned by the City of Cockburn to undertake an Arterial Drainage Scheme Review (ADSR) report which was completed in November 2005.

The ADSR report identified existing drainage infrastructure and groundwater levels and outlined the general design philosophies, objectives and requirements for stormwater treatment and disposal for the region. This report is summarised in **section 3**.

3. ARTERIAL DRAINAGE SCHEME REVIEW (ADSR) SUMMARY

Our interpretation of the Arterial Drainage Scheme Review (ADSR), with a specific emphasis on facets relevant to Development Area 19, has been summarised below.

3.1 Existing Drainage Features

The ADSR report identified existing drainage systems and relevant drainage features of the region. Existing drainage systems considered to be significant to the Area 19 site include;

- Yangebup Lake;
- Open drain along North Lake Road which discharges into Yangebup Lake;
- Open drain along southern end of Semple Court feeding the North Lake Road drain;
- '*Lakelands*' compensating basin serving the South Lake residential development;
- 450mm dia pipeline on Berrigan Drive feeding into '*Lakelands*'; and
- Wetlands to the south of North Lake Road (Sub-catchment Area 3).

The above drainage features were identified in the ADSR report for (possible) integration into the future development and have been highlighted in Figure 1.

3.2 Regional Groundwater Table

The ADSR Report identified maximum seasonal groundwater levels for the region via a series of Water & Rivers Commission and Water Corporation monitoring bores located throughout the region.

From the available monitoring bore data, and taking into consideration various other climactic, hydrologic and hydraulic data, '*Design Regional Control Groundwater Levels*' (DRCGL) have been established. Contours showing the DRCGL's are shown on **Figure 3 and 4**. Various groundwater control measures are to be incorporated throughout Development Area 19 to assist with the setting of the DRCGL.

3.3 Regional Design Philosophies

The key design philosophies in the development of the ADSR report can be summarised as;

- Filling of the site to provide separation from groundwater and promote infiltration of stormwater;
- Maximising on-site stormwater disposal and minimising direct connection to the existing drainage system with this system to also promote recharge into the groundwater; and
- Use of subsoil drainage to control rises in the groundwater levels.

The ADSR report separated the study region into 2 specific areas, those being the '*Solomon Road Development Area'* and the '*Cockburn Central Development Area*'.

Area 19 falls within the '*Cockburn Central Development Area'*, which forms part of the Water Corporation Yangebup Main Drainage Catchment. The main design philosophy in this area is to continue discharging into Yangebup Lake but only after stormwater management practices, which have adopted the above design philosophies, have been applied.

These design philosophies are further detailed in the ADSR report with parameters relevant to Area 19, discussed below.

3.4 Site Specific Design Parameters

The '*Cockburn Central Development Area*' has been divided into a number of sub-catchment areas. For locations of these sub-catchments please refer to the ADSR report. Area 19 encompasses all of Sub-catchment Area 5 and the majority of sub-catchment Areas 4 and 6. The sub-catchments' locations and boundaries are understood to have been selected based upon their proximity to possible drainage outlets, likely zoning for development and general separation depth to the Design Regional Groundwater Level (DRCGL) below existing ground levels. These sub-catchment areas were intended to be indicative only.

For each sub-catchment, the ADSR report provided possible alternatives for the disposal of stormwater into the regional network, parameters for which to base minimum depths/levels of lot fill and road levels etc in relation to the DRCGL, as well as requirements for stormwater and groundwater transport, detention and infiltration (treatment).

The options for stormwater disposal into the regional network by the relevant sub-catchments may be summarised as follows;

Sub-catchment Area 4

- Outfall at the western end of Area 4 into the open drain along North Lake Road.
- Transport to the wetland area to the south of North Lake Road (Sub-catchment Area 3).

Sub-catchment Area 5

- In part an open drain on southern end of Semple Court (to be upgraded).
- Remaining stormwater to open drain along North Lake Road.

Sub-catchment Area 6

- Transport north to Berrigan Drive and into the existing 450mm pipe then to '*Lakelands*'.
- Transport south through Area 5 and into open drain along North Lake Road (to be upgraded).

Design parameters used to set minimum separation depths between final levels and the DRCGL for the different zoning types, based upon the ADSR report, are summarised in **Table 1** below.

Table 1 - Final Level Design Parameters vs Zoning Type		
	MIXED BUSINESS	**URBAN**
Minimum Lot Level	1.2m above DRCGL, but minimum 1.5m preferred	1.5m above DRCGL
Minimum Stormwater Disposal Within Lot	Min 15mm of stormwater over total lot area disposed on site	All to be disposed on site via soak wells
Lot Subsoil Drainage Required When…	Lot level less than 1.5m above DRCGL	Lot level less than 1.5m above DRCGL
Maximum Stormwater Discharge Offsite	Max 50L/s/gross ha discharged to street drainage system	N/A – All disposed on site
Minimum Road Centreline Level	1.2m above DRCGL	1.2m above DRCGL
Road Subsoil Drainage Required When…	Road Centreline less than 1.5m above DRCGL	Road Centreline less than 1.7m above DRCGL
Soakwells Within Road Reserve May Be Considered When…	Road Centreline at least 1.7m above DRCGL	Road Centreline at least 1.7m above DRCGL

General requirements for stormwater transport, detention and treatment and groundwater recharge for each sub-catchment were provided in the ADSR report, our interpretation of which for this DWMS is summarised below.

- The 1 in 1 year ARI event shall be contained in a formalised area(s) or swale(s) and should be designed to infiltrate into the groundwater.
- Storm events above the 1 in 1 year may need to be detained in a formalised area(s), which could include a Compensating (Detention) Basin in order to meet maximum outflow criteria.
- A Groundwater Collection Basin(s), with the invert set a minimum 0.5m below the DRCGL, may be adopted in POS to assist in setting the DRCGL. Where Groundwater Collection Basins are not adopted in POS, subsoil drainage or the use of the piped stormwater drainage network set at the DRCGL should be considered to assist in setting the DRCGL.
- Consideration should be given to lowering the base of Groundwater Collection Basin level in order to create a permanent water body and avoid the base becoming swampy in summer. It is understood that the use of a lined lake to create a permanent water body would not be supported.
- The Groundwater Collection Basin(s) may also be used as a Compensating (Detention) Basin for large storm events, i.e. have a dual use.
- Maximum outflow for the Groundwater Collection Basin(s) should be set at 8 litres/second/impervious hectare of catchment area for the peak of the 5 year ARI event and 9.6 litres/second/impervious hectare of catchment area for the peak of the 100 year ARI event (to be checked at detailed design stage).
- The 100 year ARI Top Water Level shall be a minimum 0.3m below the lowest lot level, unless otherwise set by Local Authority.
- The road network may be used as an overland overflow path.

- Subsoil drains, where required, shall be set to the DRCGL and transport groundwater to the next down gradient Groundwater Collection Basin or the regional drainage network.
- Stormwater pipes should generally not be laid below DRCGL. If below DRCGL, the pipe network should be fully sealed.
- All manholes and gullies within the drainage system shall comply with City of Cockburn drainage details, with base extended a minimum 0.6m (where not below DRCGL). Bases to have a suitable filter material below manhole to act as a groundwater recharge point and groundwater collection point, particularly where set at the DRCGL.
- Where grade permits, the piped stormwater drainage network may be set to DRCGL with intake and outtake allowed at bases of manholes, possibly in conjunction with a small strip of subsoil drainage, grading down to the manhole. This would negate the requirement for subsoil drainage along road alignments.

Specific Sub-catchment Area requirements were also provided in the ADSR report and these are discussed in **section 4**.

4. DISTRICT WATER MANAGEMENT STRATEGY SPECIFICATIONS

Specifics of the District Water Management Strategy (DWMS) for future developments within Development Area 19, based upon the ADSR report summarised above, are set out in this section.

4.1 Interpretation of ADSR for the DWMS

Various sub-catchments were set out in the ADSR based upon locations of drainage outlets, likely future zoning for development and the general separation depth of the Design Regional Control Groundwater Level (DRCGL) below existing ground levels. Now that a District Structure Plan (DSP) has been proposed, detailing zoning and POS areas, the sub-catchment boundaries can be modified to suit the proposed DSP and DWMS.

Considering the locations of proposed POS, existing surface levels, DRCGL contours, proposed road alignments and minimum grades required to achieve drainage, the boundaries of sub-catchments set out in the ADSR have been altered slightly in order to more accurately approximate likely flow paths for piped and overland stormwater flow. These adjusted sub-catchments, re-labelled Northern Catchment, Western Catchment and South-Eastern Catchment to save confusion with the ADSR sub-catchments, are shown in **Figure 3**. The proposed mixed business zoning along North Lake Road has been excluded from these catchment areas as it has been assumed that this area will abide by the minimum on-site storage requirements (15mm of gross lot area) and maximum discharge rates (50L/sgross ha) with runoff discharged directly to the North Lake Road open drain, or alternatively, to Sub-catchment Area 3 basin (wetlands).

Please note that the catchments have been adopted for the purpose of this DWMS to allow for the approximation of stormwater volumes for the various rainfall events. If, once more detailed design has been carried out, the piped and/or overland flow paths and therefore catchment areas are changed from those shown in **Figure 3**, the volume of runoff for each catchment could simply be adjusted accordingly.

The ADSR set out minimum requirements for Lots zoned as '*mixed business*' and those zoned '*urban*'. The proposed DSP has mixed business zones, as well as R20, R40 and R160 residential zoning. Due to the density of R40 and R160 zoning, these residential zones are generally assumed to adopt the minimum requirements of '*mixed business*'. That is, these lots will need to meet the required minimum separation distances for '*mixed business*' set out in **Table 1** and will be allowed to discharge a maximum of 50L/s/gross ha to the street drainage system. The invert level of the connection point shall be no greater than 0.8m below the adjacent gutter level to maximise onsite storage.

4.2 Earthworks

In order to achieve the required minimum separation to the DRCGL, bulk earthworks involving filling would be required in some areas. Filling would be required to achieve the required minimum separation between lot and/or road centrelines and the DRCGL. Cutting or filling is also likely to be required in order to allow for minimum grades for the piped and overland flow drainage networks, which are to be directed towards POS or the regional drainage network.

Existing surface level contours were provided by the Water Corporation. These contours, along with the DRCGL contours provided in the ADSR report, have been incorporated into **Figure 4.** These levels have been used to determine areas requiring filling in order to achieve necessary separation requirements. Fill areas are based on achieving a minimum separation of 1.5m, even in areas of mixed business, R160 and R40 zoning to ensure roads and POS are depressed below lots levels and to assist with on-site storage (soakwells). A minimum separation of between 1.2m and 1.5m for Lot levels within mixed business, R40 and R160 zoning may be adopted if following more detailed design. Fill depths generally range between 0.5m and 0.8m. These areas have been highlighted in **Figure 4.**

Please note that the abovementioned depths and highlighted areas have not taken into consideration the need to remove and replace topsoil, unsuitable existing fill or natural strata, final grading of roads in order to suit drainage flow paths or the need for lots to be raised or lowered to suit final road levels and 100 year ARI event top water levels. The final detailed design of the stormwater drainage system and road network will effect final earthworks requirements, and it is likely the extent of filling required to service the site will increase accordingly.

Please note that the requirement for subsoil drainage would also be dependent on final design levels for lots and road centrelines. In locations where final levels are designed to be below the minimum required clearances from the DRCGL, as detailed in **Table 1**, then subsoil drains would be required for those locations.

4.3 Design Assumptions

Various design assumptions have been made to allow for the development of this DWMS. The primary purpose of the design assumptions was to allow for the calculation of approximate stormwater runoff volumes for the various ARI events for each catchment. These volumes may be used as a guide for determining the most suitable method(s) of disposal into the regional network, sizing of basins/storage, practicality/benefits of using soakwells within road reserves etc. Design assumptions have attempted to be realistic whilst slightly conservative and made with an emphasis on the likely cost and practicality of future works whilst also considering the possible need for flexibility within the proposed DSP.

A summary of our design assumptions is listed below:

- Coefficient of Runoff of R40 Lots = 70% of gross lot area.
- Coefficient of Runoff of R160 Lots = 90% of gross lot area.
- For South-eastern Catchment, a Coefficient of Runoff of Lots of 80% has been used due to both R40 and R160 zoning being proposed within this catchment.
- Coefficient of Runoff of road reserve = 70% total road reserve area (100% for lanes).
- Distributor Roads with median strip have road reserve width of 20m.
- Distributor Roads without median strip have road reserve width of 18m.
- Local streets have road reserve width of 15m.
- Lanes have width of 6m.
- Ksat = 0.0001m/s for infiltration (soakwells, basins etc) (as per Brown Geotechnical & Environmental Geotechnical Investigation Report, Ref 06036.01, May 2007).

- Infiltration rate for infiltration areas/basins assumed to be 2/3 Ksat value, however this would be highly dependable on the separation to the DRCGL and therefore should be revised during detailed design. Infiltration through the bases of manholes has been conservatively assumed to be zero.
- Area of base(s) for 1 year ARI event storage has been assumed based on average depth of approximately 0.33m (this has a significant impact on infiltration rates).
- Area of base(s) for 10 year ARI event has been assumed based on average depth of approximately 1m (this has a significant impact on infiltration rates).
- 100 year ARI event assumed to have an outflow equivalent to the maximum allowed discharge of the catchment area (i.e. zero infiltration).
- Soakwells within road reserves have not been allowed for however may be used as a means of reducing required storage capacity and the size of the piped stormwater network where road centreline is greater than 1.8m above DRCGL.
- Mixed business zone to discharge excess runoff directly into Open Drain on North Lake Road, or alternatively into Sub-catchment Area 3 basin (wetlands).

4.4 Drainage Requirements

Based upon the designated catchment areas shown in **Figure 3** and the above design assumptions, approximate volumes of runoff for the relevant ARI storm events have been determined and are provided in **Table 2** below. These volumes represent the volume of storage capacity that would be required in any compensating basin(s), swales or similar for each individual catchment assuming that runoff from the entire catchment (excluding the mixed business zoning) is contained within the site, which may not necessarily be the case (refer **section 4.5**).

Volumes shown in **Table 2** have accounted for infiltration losses via the base of compensating basins, however have not considered the storage capacity or infiltration capacity of the piped stormwater network. Therefore, the volumes shown in **Table 2** represent maximum storage volumes required and should be used as a guide only. Final total volumes would be dependent upon the adopted method(s) of disposal into the regional network, final catchment boundaries, final total impervious areas, volume of storage within soakwells (high density lots), the use of soakwell storage within road reserves, base area of detention/infiltration storage areas, final design Ksat values of sub-surface strata for soakwells and/or detention/infiltration storage areas, and consideration of infiltration losses and storage capacity of the piped drainage network.

Calculations used to determine the volumes provided in **Table 2** are provided in the **Appendix**. The rainfall intensities used to determine these volumes have been calculated using the Australian Rainfall and Runoff Guide to Flood Estimation, Volume 2 (1987) and are provided in **Table 3** below.

Table 2 - Runoff Volumes for ARI Events (m^3)

ARI Event	Northern Area	Western Area	South Eastern Area
1 Year	675	340	230
5 Year	1800	940	1080
10 Year	2300	1650	1350
100 Year	5030	3450	3750

Table 3 - Average Recurrence Interval (ARI) Rainfall Events for Cockburn										
mm/h	minutes					hours				
Recurrence (yrs)	5	6	*10*	*20*	30	*1*	*2*	*3*	*6*	*12*
1	58.6	54.5	43.5	30.5	24.2	15.7	10.2	7.9	5.1	3.3
2	77.5	72	57.3	39.8	31.4	20.3	13.1	10.1	6.5	4.2
5	102.4	94.9	74.6	51.1	39.8	25.2	16.1	12.4	7.8	5
10	120.4	111.2	86.9	58.9	45.7	28.5	18.2	13.9	8.7	5.5
20	145.2	133.9	104.1	69.9	53.9	33.3	21.1	16	10	6.3
50	182.1	167.6	129.4	86	65.8	40.1	25.2	19.1	11.8	7.3
100	214	196.6	151	99.6	75.8	45.8	28.6	21.6	13.3	8.2

4.5 Stormwater Disposal and Treatment Options and Recommendations

Various disposal and treatment options were provided for each sub-catchment area specified in the ADSR report, as briefly mentioned in **section 3.4**. The interpretation of these disposal and treatment options, relative to the Northern, Western and South-Eastern catchments, as well as the Semple Court and North Lake Road open drains, are discussed below.

Northern Catchment

Stormwater disposal options from this catchment included either transportation north to the existing 450mm diameter pipe on Berrigan Drive and into '*Lakelands*', or through the western catchment and towards the open drain on North Lake Road.

The existing 450mm dia pipeline on Berrigan Drive feeding into '*Lakelands*', may be of adequate depth and capacity to serve the future drainage network of the catchment area. However this would depend upon final finished lot levels and subsequent minimum pipe levels and grades and the possible limitations of the capacity and level of the existing 450mm diameter stormwater pipe. The feasibility of disposal and treatment of stormwater into '*Lakelands*' for the Northern Catchment, either in part or full, should be determined at the detailed design stage once finished levels are determined. No specific discharge limit would need to be put on outlet flows and so this discharge rate would only be limited by the capacity of the drainage system.

Transportation north to Berrigan Drive is considered the most practical option and therefore we recommend that this be undertaken. '*Lakelands*' is understood to be suitable for both storage and treatment of stormwater runoff and this option also takes advantage of the existing 450mm diameter pipeline beneath Berrigan Drive which terminates just west of Dorrigo Way.

For this option, the treatment of the runoff within the road reserves for the 1 year ARI event via roadside or centre median swales, soakwells within road reserves etc, could be considered in order to keep inline with the regional design principles and WSUD principles.

Runoff not transported to '*Lakelands*' would need to be directed towards, the North Lake Road open drain. If this option is adopted/required, temporary storage may be required, possibly within POS, due to the limited maximum discharge rates (see **section 3.4**). Sizing of storage within POS would take into consideration infiltration into the groundwater. For this option, the 1 year ARI event would need to be allowed to infiltrate (be treated) in a formalised area(s). The treatment of the 1 year ARI event could be carried out within POS, roadside or centre median swales, or via soakwells within road reserves. Although soakwells within road reserves were not allowed for in calculating the volumes of runoff shown in **Table 1**, this may be a practical method of disposal considering the separation to the DRCGL. Soakwells within road reserves would also reduce the total volume of runoff of the 5, 10 and 100 year ARI events.

A Groundwater Collection basin is not considered to be required for the POS area in this catchment due to the significant separation distance between the existing ground levels and the DRCGL.

Western Catchment

Stormwater runoff from this catchment was to be in part discharged into the open drain on Semple Court, with the remaining runoff to be discharged into the open drain along North Lake Road.

This catchment does not necessarily require any rainfall event to be detained within the POS, however the 1 in 1 year ARI event would still need to be allowed to infiltrate (be treated) in a formalised area(s) and runoff in excess of the 1 year ARI event would be subject to the maximum discharge rates discussed below and therefore some sort of storage/detention is likely to be required.

Stormwater treatment and storage could be incorporated into the catchment's POS or within either of the open drain on Semple Court and North Lake Road, both of which are to be upgraded to incorporate landscaping features which could include areas for treatment and even storage (although storage may be limited). Any combination of the POS, Semple Court open drain and North Lake Road open drain may be used to treat and detain the relevant stormwater events.

The peak discharge into the Semple Court open drain should be limited to approximately 8L/s/impervious ha, but can be increased to ensure the pipeline connection to the main open drain does not become blocked easily. The remaining runoff, discharging either directly or indirectly (via POS) to the open drain on North Lake Road, would be set at a maximum 8L/s/impervious ha for the peak of the 5 year ARI event, and 9.6L/s/impervious ha for the peak of the 100 year ARI event, as detailed in **section 3.4**. For this catchment, this would relate to approximately 76L/s for the 5 year ARI event. Excess runoff could be detained within either POS or in bunded areas incorporated into the open drains, where space permits. It should be noted that additional flows than those given above may be directed into the Semple Court or North Lake Road open drain, provided that the additional flow is compensated within the open drain via storage areas incorporated into the proposed drain upgrade. This would reduce any required volume of storage within the Western Catchment.

Either a Groundwater Collection Basin or subsoil drainage should be incorporated within POS for this catchment. Should Groundwater Collection Basins not be preferred, a network of subsoil drainage set to the DRCGL within POS would need to be adopted.

Please note that any existing pipeline infrastructure beneath North Lake Road could be considered to reduce construction costs.

Soakwells within road reserves have not been allowed for when calculating runoff volumes, however could be incorporated where the minimum required separation to the DRCGL can be achieved. Road reserve soakwells could be used to assist in the treatment of the 1 year ARI event runoff as well as reduce the overall volume of larger stormwater events.

South-Eastern Catchment

Excess stormwater runoff from this catchment is to be either discharged into the open drain on North Lake Road or transported to the wetland area to the south of North Lake Road (Sub-catchment Area 3).

Part or all of the runoff could be directed towards the Sub-catchment Area 3 basin (wetlands). The use of this area would be dependent on available grade between proposed finished levels of the South-eastern catchment and Sub-catchment Area 3, the development fronts of these catchment areas and the ability of the wetland area to contain the additional volume of water whilst controlling peak discharge. Runoff transported to the wetlands would not require any pre-treatment. However, treatment of runoff from within the road reserves for the 1 year ARI event via roadside or centre median swales, soakwells within road reserves etc, should be considered inline with the regional design philosophies and WSUD principles.

Any runoff not transported to the wetlands area would need to be directed towards POS within the South-Eastern Catchment or possibly partially into a swale adjacent the Kwinana Freeway.

The 1 year ARI event would need to be detained and allowed to infiltrate (be treated) into the groundwater. Excess runoff over the 1 year ARI event, taking into consideration the above maximum discharge rates, would need to be detained within POS either within a separate formalised area [basin(s) or swale(s)] or within the Groundwater Collection Basin. The runoff for the 10 year ARI event would need to be stored in a formalised basin(s) with a minimum 300mm freeboard. A flood route for events in excess of the 100 year ARI event should be allowed to flood onto the regional open space or be directed to the North Lake Road open drain. The Top of Water Level for the 100 year ARI event should be a minimum 300mm below the lowest Lot level.

A Groundwater Collection Basin is required within this catchment. This could be incorporated into POS or a large depression swale adjacent the Kwinana Freeway. The peak discharge into the North Lake Road open drain from the Groundwater Collection Basin (or swale) would be set at a maximum 8L/s/impervious ha for the peak of the 5 year ARI event and 9.6L/s/impervious ha for the peak of the 100 year ARI event, as provided in **section 3.4**. For this catchment, this would relate to approximately 84L/s for the 5 year ARI event. Please note that additional flows over and above those given may be directed into the North Lake Road open drain, provided that the additional flow is compensated within the open drain via storage areas incorporated into the proposed drain upgrade. This would reduce the required volume of storage within the South-eastern Catchment.

Any storage component such as a Detention Basin may be incorporated into the Groundwater Collection Basin. The outlet pipe within the Groundwater Collection Basin, with invert set to DRCGL, shall discharge into the open drain on North Lake Road.

Please note that it is proposed to allow for some discharge from Sub-catchment Area 2 to be incorporated into the drainage system for Sub-catchment Area 4 (South-Eastern Catchment). More specifically, an allowance of an additional 30L/s of pipe capacity should be included for the section of pipework downstream of the Sub-catchment Area 2 connection point to South-Eastern Catchment.

Soakwells within road reserves have not been allowed for when calculating runoff volumes, however could be incorporated where the minimum required separation to the DRCGL can be achieved. For this catchment, these areas may be limited depending on final levels. Road reserve soakwells could be used to assist in the treatment of the 1 year ARI event runoff as well as reduce the overall volume of runoff of larger stormwater events.

Semple Court and North Lake Road Open Drains

It was recommended in the ADSR report that the existing open drains along North Lake Road and Semple Court, within the Anning Park Reserve, be upgraded to landscaped open channels as part the development of the region. This upgrade is to be undertaken to allow for possible storage (detention) and treatment of runoff during rainfall events, assist in setting the DRCGL and to improve the aesthetics and community use of the area.

The Semple Court landscaped channel (previously referred to as open drain) invert level should be set to the DRCGL, with sections excavated below this level to create small open bodies of water to assist with year round vegetation growth aiding nutrient removal (treatment). This drain may also be designed to be used for treatment (1 year ARI event) and detention (major events) of discharge from the Western Catchment, however due to the size of this channel, treatment and detention volumes may be minimal.

The North Lake Road landscaped channel (previously referred to as open drain) invert level should be generally set to the DRGL. This landscaped channel could be used as treatment and storage of runoff from the Western Catchment and South-eastern Catchment. The total volume able to be treated / detained would be dependent upon the final design of the landscaped channel. Please refer to the ADSR report for further details, design constraints and considerations of the North Lake Road landscaped channel.

4.6 Additional Considerations

The use of vegetation within areas designated for storage/infiltration of the 1 year ARI event, within POS, Groundwater Collection Basins and the proposed landscaped channels on North Lake Road and Semple Court should be carefully considered. Vegetation species should be selected taking into consideration their ability to take up relevant nutrients/pollutants, their suitability with regard to the predicted water level above and below surface level and their ability to improve the aesthetics of the area.

Community education, with regard to the ecologically sensitive nature of the regional drainage network, should be promoted. Community understanding of the importance of the environment and the possible negative impacts of pollutants such as fertilizers and oils, etc, should be an objective of the future developer and City of Cockburn.

5. CONCLUSIONS

The regional stormwater design philosophies of separation above DRCGL, promoting on-site stormwater disposal and treatment and the use of drainage features to limit rises of the groundwater are to be adopted for the stormwater design.

Catchment boundaries have been provided based upon estimated future design drainage paths. These catchment boundaries should be taken as indicative and may be altered during the design stage.

Different regional stormwater disposal options have been identified for each catchment area with the most practical method of disposal to be determined during the design stage. Design of regional disposal for Development Area 19 should be undertaken in conjunction with the regional stormwater network design to allow for the design of neighbouring landscaped channels and wetlands etc.

The 1 year ARI event should be '*treated*' either by bio-retention basin/swale type structures (infiltration) or wetlands (nutrient uptake) or a combination of the two. The existing regional drainage features of '*Lakelands*' and the wetland within Sub-catchment Area 3 are considered suitable for stormwater treatment of the 1 year ARI event. Major storm events above the 1 year ARI event may need to be detained to minimise peak flows approximately to pre-development levels and to maximise localised recharge to the groundwater.

Volumes of runoff for the relevant ARI rainfall events have been calculated based upon the indicative catchment areas and a series of design assumptions and therefore should be used as a guide only. Final volumes will need to be determined during the design stage.

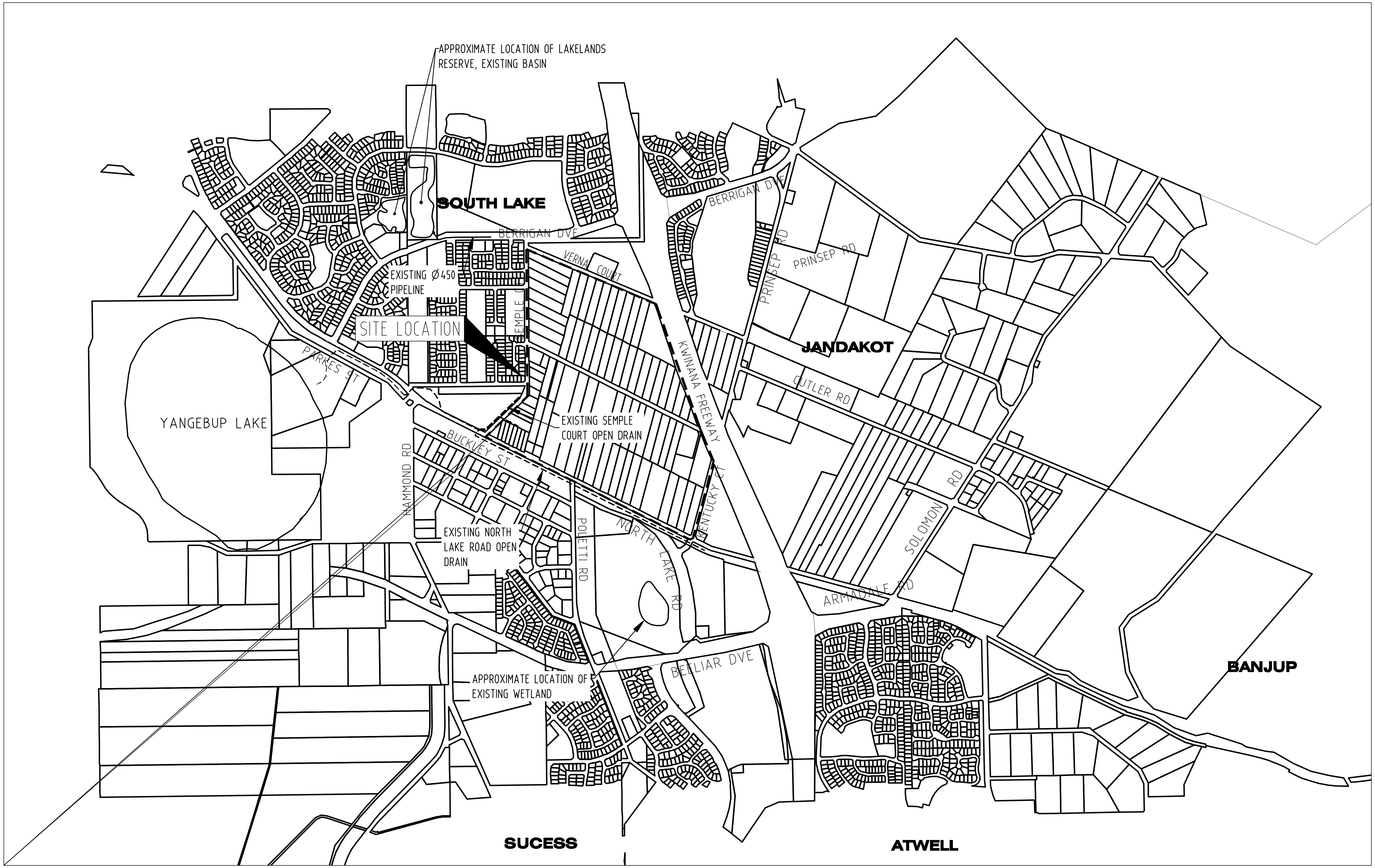
Appropriate infrastructure would need to be integrated throughout the development area in order to assist in setting the DRCGL. This may be undertaken by either Groundwater Collection Basins, subsoil drainage or the piped drainage network.

Minimum separation distances between the finished lot and road levels and the DRCGL have been specified. Where existing surface levels do not achieve the minimum separation, filling will be required, as shown in **Figure 4**. The final design of the road network and drainage network within Development Area 19 will result in the need for additional earthworks to those shown in **Figure 4.**

The need for community education regarding the ecological importance of the drainage network and negative impacts of common household pollutants should be promoted.

FIGURE 1

SITE LOCALITY PLAN



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D
21-01-08	A	INITIAL ISSUE		TAM		

PROJECT
DEVELOPMENT AREA 19

DRAWING TITLE
SITE LOCALITY PLAN

PRINCIPAL
CITY OF COCKBURN

N W E S

Cardno BSD

Cardno BSD Centre
2 Bagot Road
P.O. Box 155 Subiaco
Western Australia 6904
Telephone (08) 9273 3888
Facsimile (08) 9388 3831

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS
BUILDING DESIGN

7 Harris Road
P.O. Box 713 Busselton
Western Australia 6280
Telephone (08) 9754 2397
Facsimile (08) 9752 2471

Date 22-01-08 Scale N.T.S
Designed Checked
Drawn TAM Approved
Local Authority CITY OF COCKBURN Sheet Of
Project Number E07007 Drawing Number FIG. 1 Revision A
ORIGINAL A3

FIGURE 2

PROPOSED DISTRICT STRUCTURE PLAN

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD
						8														

PROJECT **DEVELOPMENT AREA 19**

DRAWING TITLE **PROPOSED STRUCTURE PLAN**

PRINCIPAL **CITY OF COCKBURN**

This drawing has been prepared in accordance with the Cardno BSD Quality Management System. It remains the property of Cardno BSD Pty. Ltd. and shall not be used without permission. This drawing shall be preliminary only and/or not for construction until signed approved.

N W E S

SCALE: 1:5000

Cardno BSD

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS

Cardno BSD Centre 2 Bagot Road
P.O. Box 155 Subiaco
Western Australia 6904
Telephone (08) 9273 3888
Facsimile (08) 9388 3831

Project Number	Drawing Number	Revision	Original
E07007	FIG 2		A3
Designed	Checked	Date	22-01-08
Drawn TAM	Approved	Sheet	Of
Local Authority	CITY OF COCKBURN		

FIGURE 3

CATCHMENT BOUNDARIES

LEGEND

CATCHMENT BOUNDARYS

DRCGL CONTOURS

1:5000 0 50m 100 150 200 250 300 350 400 450 500

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APP'D

PROJECT **DEVELOPMENT AREA 19**

DRAWING TITLE **CATCHMENT BOUNDARIES**

PRINCIPAL **CITY OF COCKBURN**

N W E S

SCALE: 1:5000

Cardno BSD

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS

Cardno BSD Centre 2 Bagot Road
P.O. Box 155 Subiaco
Western Australia 6904
Telephone (08) 9273 3888
Facsimile (08) 9388 3831

Project Number: E07007
Drawing Number: FIG 3
Revision:
Original: A3
Designed:
Checked:
Date: 22-01-08
Drawn: TAM
Approved:
Sheet Of
Local Authority: CITY OF COCKBURN

FIGURE 4

EXISTING GROUND LEVEL CONTOURS, DRCGL CONTOURS AND FILL AREAS

NOTE: FILL AREAS SHOWN ARE ACHIEVING MINIMUM SEPERATION BETWEEN FINISHED LEVELS AND DRCGL CONTOURS AND DOES NOT TAKE INTO CONSIDERATION POSSIBLE REQUIREMENT TO REPLACE UNSUITABLE STRATA OR FINAL DESIGN ROAD AND LOT LEVELS TO SUIT DRAINAGE ETC.

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD

PROJECT **DEVELOPMENT AREA 19**

DRAWING TITLE **EXISTING GROUND LEVEL CONTOURS, DRCGL CONTOURS AND FILL AREAS**

PRINCIPAL **CITY OF COCKBURN**

This drawing has been prepared in accordance with the Cardno BSD Quality Management System. It remains the property of Cardno BSD Pty. Ltd. and shall not be used without permission. This drawing shall be preliminary only and/or not for construction until signed approved.

N W E S

SCALE: 1:5000

Cardno BSD
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS

Cardno BSD Centre 2 Bagot Road
P.O. Box 155 Subiaco
Western Australia 6904
Telephone (08) 9273 3888
Facsimile (08) 9388 3831

Project Number	Drawing Number	Revision	Original
E07007	FIG 4		A3

Designed | Checked | Date 22-01-08
Drawn TAM | Approved | Sheet Of
Local Authority CITY OF COCKBURN

APPENDIX

DEVELOPMENT AREA 19 - CALCULATIONS

APPENDIX- Development Area 19 - Calculations

Areas

Northern Catchment

% Coefficient of Runoff of road re 70

Area of Roads (m^2)

15m wide road reserves	2131	x 15m =	**31965**
6m wide lanes	1490	x 6m =	**8940**
18m wide reserves	1260	x 18m =	**22680**
20m wide reserves	1060	x 20m =	**21200**

Impervious Road Area = **62031.5**
(equivalent area impervious)

Area of R40 (m^2) **87806** m^2

Area of R160 (m^2) **0** m^2

Total Area of R40 and R160 = **87806** m^2 = 8.7806 ha
Only R40 so impervious area of lots = 70% = 0.7
Max outflow = 50litres/second/gross hectare = 1580.508 m^3/hr

Therefore total outflow from R40 and R160 = 439.03 L/s

Western Catchment

% Impervious of road reserve = 70

Area of Roads (m^2)

15m wide road reserves	1886	x 15m =	**28290**
6m wide lanes	869	x 6m =	**5214**
18m wide reserves	595	x 18m =	**10710**
20m wide reserves	200	x 20m =	**4000**

Impervious Road Area = **35314**
(equivalent area impervious)

Area of R40 (m^2)
85273

Area of R160 (m^2)
0

Total Area of R40 and R160 = **85273** = 8.5273 ha
Only R40 so impervious area of lots = 70% = 0.7
Max outflow = 50litres/second/gross hectare = 1534.914 m^3/hr

Therefore total outflow from R40 and R160 = 426.365 L/s

South-Eastern Catchment

% Impervious of road reserve = 70

Area of Roads (m^2)

15m wide road reserves	1335	x 15m =	**20025**
6m wide lanes	255	x 6m =	**1530**

18m wide reserves 820 x 18m = **14760**
20m wide reserves 96 x 20m = **1920**

Impervious Road Area = **27223.5** m^2
(equivalent area impervious)

Area of R40 (m^2)
50949

Area of R160 (m^2)
46468.33

Total Area of R40 and R160 = **97417.33333** = 9.741733333 ha
Combined R40 and R160, impervious area = 80% 0.8
Max outflow = 50litres/second/gross hectare = 1753.512 m^3/hr

Therefore total outflow from R40 and R160 = 487.087 L/s

Mixed Use Area

Area of Mixed Use (m^2)
96820 = 9.682 ha

Max outflow = 50litres/second/gross hectare

Therefore total outflow from Mixed Use = 484.1 L/s

Volumes and Flows of Runoff

1 YEAR ARI EVENT

Northern Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 440m
S = 0.005
t = 92.3/I^0.4
n = 0.012
I = Intensity (mm/hr)

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha = 158.0508 m^3/hr
Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s = 0.0001 m/s
Area of Base (A) for 1yr event infiltration = 1250 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration = 0.125 m^3/s = 450 m^3/hr
Assume infiltration only 300 m^3/hr to allow for some clogging

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)	Infiltration (base)	Total Vol
0.5	24.2	0.43	750.58115	0	150	600.581
1	15.7	0.51	973.89455	0	300	673.895
2	10.2	0.61	1265.4426	0	600	665.443
3	7.9	0.67	1470.14655	0	900	570.147
6	5.1	0.8	1898.1639	0	1800	0
12	3.3	0.95	2456.4474	-779.72	3600	0

So approx total Volume Req'd = **675m^3** for the above assumptions

Western Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 280m
S = 0.005
t = 70.4/I^0.4
n = 0.012
I = Intensity (mm/hr)

70.4

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha = 153.4914 m^3/hr
Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s = 0.0001 m/s
Area of Base (A) for 1yr event infiltration = 900 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration = 0.09 m^3/s = 324 m^3/hr
Assume infiltration only 216 m^3/hr to allow for some clogging

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)	Infiltration (base)	Total Vol
0.33333	30.5	0.29902	359.0220764	0	71.99928	287.023
0.5	24.2	0.32802	427.2994	0	108	319.299
1	15.7	0.39	554.4298	0	216	338.43
2	10.2	0.46343	720.4056	0	432	288.406
3	7.9	0.5133	836.9418	0	648	188.942
6	5.1	0.6115	1080.6084	0	1296	0
12	3.3	0.72781	1398.4344	-757.22	2592	0

So approx total Volume Req'd = **340m^3** for the above assumptions

South-Eastern Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 330m
S = 0.005
t = 77.7/I^0.4
n = 0.012
I = Intensity (mm/hr)

77.7

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha = 175.3512 m^3/hr
Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s = 0.0001 m/s
Area of Base (A) for 1yr event infiltration = 900 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration = 0.09 m^3/s = 324 m^3/hr
Assume infiltration only 216 m^3/hr to allow for some clogging

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)	Infiltration (base)	Total Vol
0.16666	43.5	0.28633	197.3624802	0	35.99856	161.364
0.3333	30.5	0.33003	276.7445728	0	71.9928	204.752
0.5	24.2	0.36203	329.40435	0	108	221.404
1	15.7	0.43044	427.40895	0	216	211.409
2	10.2	0.51148	555.3594	0	432	123.359
3	7.9	0.56652	645.19695	0	648	0
6	5.1	0.6749	833.0391	0	1296	0
12	3.3	0.80327	1078.0506	-479.29	2592	0

So approx total Volume Req'd = **230m^3** for the above assumptions

5 YEAR ARI EVENT

Northern Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3)   where   L = 440m
S = 0.005
t = 92.3/I^0.4   n = 0.012
92.3   I = Intensity (mm/hr)

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha =   158.0508 m^3/hr
Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s =   0.0001 m/s
Area of Base (A) for 1yr event infiltration =   1400 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration =   0.14 m^3/s =   504 m^3/hr
Assume infiltration only   336 m^3/hr to allow for some clogging

Note: For 5 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)	Outflow (pipe/base)	Total Vol
0.5	39.8	0.35245	1234.42685	0	168	1066.43
1	25.2	0.42315	1563.1938	73.757	336	1300.95
2	16.1	0.5062	1997.4143	345.956	672	1671.37
3	12.4	0.56193	2307.5718	495.226	1008	1794.8
6	7.8	0.67641	2903.0742	611.13	2016	1498.2
12	5	0.8081	3721.89	474.152	4032	164.042

So approx total Volume Req'd = **1800m^3** for the above assumptions

Western Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3)   where   L = 280m
S = 0.005
t = 70.4/I^0.4   n = 0.012
I = Intensity (mm/hr)

70.4

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha =   153.4914 m^3/hr
Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s =   0.0001 m/s
Area of Base (A) for 1yr event infiltration =   1200 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration =   0.12 m^3/s =   432 m^3/hr
Assume infiltration only   288 m^3/hr to allow for some clogging

Note: For 5 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)	Outflow (pipe/base)	Total Vol
0.33333	51.1	0.24325	601.5091182	0	95.99904	505.51
0.5	39.8	0.26882	702.7486	0	144	558.749
1	25.2	0.32275	889.9128	71.6293	288	673.542
2	16.1	0.38609	1137.1108	335.976	576	897.086
3	12.4	0.4286	1313.6808	480.94	864	930.621
6	7.8	0.51592	1652.6952	593.5	1728	518.195
12	5	0.61636	2118.84	460.474	3456	0

So approx total Volume Req'd = **940m^3** for the above assumptions

South-Eastern Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3)   where   L = 330m
S = 0.005
t = 77.7/I^0.4   n = 0.012
I = Intensity (mm/hr)

77.7

Assumptions:

Soakwells Infiltration = 18m^3/hr/ha = 175.3512 m^3/hr

Infiltration of Base = K.A.(dh/dl)

Assume K = 1x10^-4m/s = 0.0001 m/s

Area of Base (A) for 1yr event infiltration = 1200 m^2

Hydraulic Gradient (dh/dl) = 1

Infiltration = 0.12 m^3/s = 432 m^3/hr

Assume infiltration only 288 m^3/hr to allow for some clogging

Note: For 5 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)	Outflow (pipe/base)	Total Vol
0.16666	74.6	0.23077	338.4653108	0	47.99808	290.467
0.3333	51.1	0.26847	463.6605793	0	95.9904	367.67
0.5	39.8	0.2967	541.74765	1.94835	144	399.696
1	25.2	0.35621	686.0322	327.322	288	725.354
2	16.1	0.42613	876.5967	697.508	576	998.105
3	12.4	0.47304	1012.7142	911.826	864	1060.54
6	7.8	0.56942	1274.0598	1133.94	1728	679.998
12	5	0.68027	1633.41	1110.56	3456	0

So approx total Volume Req'd = **1080m^3** for the above assumptions

10 YEAR ARI EVENT

Northern Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 440m

S = 0.005

t = 92.3/I^0.4

n = 0.012

92.3

I = Intensity (mm/hr)

Assumptions:

Soakwells Infiltration = 18m^3/hr/ha = 158.0508 m^3/hr

Infiltration of Base = K.A.(dh/dl)

Assume K = 1x10^-4m/s = 0.0001 m/s

Area of Base (A) for 1yr event infiltration = 1500 m^2

Hydraulic Gradient (dh/dl) = 1

Infiltration = 0.15 m^3/s = 540 m^3/hr

Assume infiltration only 360 m^3/hr to allow for some clogging

Note: For 10 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)*	Outflow (pipe/base)	Total Vol
0.5	45.7	0.33349	1417.419775	8.34157	180	1245.76
1	28.5	0.40282	1767.89775	276.589	360	1684.49
2	18.2	0.48197	2257.9466	604.105	720	2142.05
3	13.9	0.53684	2586.71355	771.815	1080	2278.53
6	8.7	0.6475	3238.0443	943.036	2160	2021.08
12	5.5	0.77787	4094.079	842.938	4320	0

*Requirement for additional soakwell capacity to be determined during detailed design stage

So approx total Volume Req'd = **2300m^3** for the above assumptions

Western Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 280m

S = 0.005

t = 70.4/I^0.4

n = 0.012

I = Intensity (mm/hr)

70.4

Assumptions:

Soakwells Infiltration = 18m^3/hr/ha = 0 m^3/hr

Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s = 0.0001 m/s
Area of Base (A) for 1yr event infiltration = 1450 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration = 0.145 m^3/s = 522 m^3/hr
Assume infiltration only 350 m^3/hr to allow for some clogging

Note: For 10 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)*	Outflow (pipe/base)	Total Vol
0.33333	58.9	0.22981	693.3246	0	116.6655	576.659
0.5	45.7	0.25436	806.9249	84.8466	175	716.772
1	28.5	0.30724	1006.449	422.101	350	1078.55
2	18.2	0.36761	1285.4296	893.661	700	1479.09
3	13.9	0.40946	1472.5938	1210.02	1050	1632.62
6	8.7	0.49387	1843.3908	1836.78	2100	1580.17
12	5.5	0.5933	2330.724	2660.52	4200	791.242

*Requirement for additional soakwell capacity to be determined during detailed design stage

So approx total Volume Req'd = **1650m^3** for the above assumptions

South-Eastern Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 330m
S = 0.005
t = 77.7/I^0.4
n = 0.012
I = Intensity (mm/hr)

77.7

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha = 175.3512 m^3/hr
Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s = 0.0001 m/s
Area of Base (A) for 1yr event infiltration = 1450 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration = 0.145 m^3/s = 522 m^3/hr
Assume infiltration only 350 m^3/hr to allow for some clogging

Note: For 10 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)*	Outflow (pipe/base)	Total Vol
0.16666	86.9	0.2171	394.2712535	0	58.331	335.94
0.3333	58.9	0.25364	534.4346012	10.244	116.655	428.024
0.5	45.7	0.28074	622.056975	231.853	175	678.91
1	28.5	0.3391	775.86975	584.504	350	1010.37
2	18.2	0.40573	990.9354	1024.83	700	1315.77
3	13.9	0.45192	1135.21995	1262.53	1050	1347.75
6	8.7	0.54508	1421.0667	1554.78	2100	875.847
12	5.5	0.65482	1796.751	1578.16	4200	0

*Requirement for additional soakwell capacity to be determined during detailed design stage

So approx total Volume Req'd = **1350m^3** for the above assumptions

100 YEAR ARI EVENT

Northern Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 440m
S = 0.005
t = 92.3/I^0.4
n = 0.012
92.3
I = Intensity (mm/hr)

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha = 158.0508 m^3/hr

Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s = 0.0001 m/s
Area of Base (A) for 1yr event infiltration = 1750 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration = 0.175 m^3/s = 630 m^3/hr
Assume infiltration only 420 m^3/hr (not used for 100yr)

Note: For 100 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)*	Outflow (pipe/base)	Total Vol
0.5	75.8	0.27238	2350.99385	427.5	213.4005696	2565.09
1	45.8	0.3332	2841.0427	1339.92	426.8011392	3754.16
2	28.6	0.40226	3548.2018	1882.56	853.6022784	4577.16
3	21.6	0.45006	4019.6412	2191.64	1280.403418	4930.88
6	13.3	0.5464	4950.1137	2639.45	2560.806835	5028.76
12	8.2	0.66302	6103.8996	2834.38	5121.61367	3816.66

*Requirement for additional soakwell capacity to be determined during detailed design stage
So approx total Volume Req'd = **5030m^3** for the above assumptions

Western Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 280m
S = 0.005
t = 70.4/I^0.4
n = 0.012
I = Intensity (mm/hr)

70.4

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha = 153.4914 m^3/hr
Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s = 0.0001 m/s
Area of Base (A) for 1yr event infiltration = 1600 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration = 0.16 m^3/s = 576 m^3/hr
Assume infiltration only 384 m^3/hr (not used for 100yr)

Note: For 100 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)*	Outflow (pipe/base)	Total Vol
0.33333	99.6	0.18626	1172.413076	414.996	109.4447807	1477.96
0.5	75.8	0.20776	1338.4006	622.5	164.1688128	1796.73
1	45.8	0.25414	1617.3812	1301.27	328.3376256	2590.31
2	28.6	0.30681	2019.9608	1828.25	656.6752512	3191.54
3	21.6	0.34327	2288.3472	2128.41	985.0128768	3431.75
6	13.3	0.41675	2818.0572	2563.31	1970.025754	3411.34
12	8.2	0.5057	3474.8976	2752.61	3940.051507	2287.46

*Requirement for additional soakwell capacity to be determined during detailed design stage
So approx total Volume Req'd = **3450m^3** for the above assumptions

South-Eastern Catchment

t = (6.94x(L x n)^0.6)/(I^0.4 x S^0.3) where L = 330m
S = 0.005
t = 77.7/I^0.4
n = 0.012
I = Intensity (mm/hr)

77.7

Assumptions:
Soakwells Infiltration = 18m^3/hr/ha = 175.3512 m^3/hr
Infiltration of Base = K.A.(dh/dl)
Assume K = 1x10^-4m/s = 0.0001 m/s

Area of Base (A) for 1yr event infiltration = 1600 m^2
Hydraulic Gradient (dh/dl) = 1
Infiltration = 0.16 m^3/s = 576 m^3/hr
Assume infiltration only 384 m^3/hr (not used for 100yr)

Note: For 100 year ARI infiltration plus outlet pipe will reduce total volume required

Duration (hr)	I (mm/hr)	t (hrs)	Vol (roads)	Vol (Lots)*	Outflow (pipe/base)	Total Vol
0.16666	151	0.17405	685.097345	266.656	60.56822037	891.185
0.3333	99.6	0.20557	903.729818	533.28	121.1291723	1315.88
0.5	75.8	0.2293	1031.77065	800	181.7119296	1650.06
1	45.8	0.28049	1246.8363	1600	363.4238592	2483.41
2	28.6	0.33863	1557.1842	2645.85	726.8477184	3476.19
3	21.6	0.37887	1764.0828	3062.8	1090.271578	3736.61
6	13.3	0.45997	2172.4353	3705.76	2180.543155	3697.65
12	8.2	0.55814	2678.7924	4103.22	4361.08631	2420.92

*Requirement for additional soakwell capacity to be determined during detailed design stage
So approx total Volume Req'd = **3750m^3** for the above assumptions

Outlet Flows

Northern Catchment

Max outflow = 50litres/second/gross hectare = 855 m^3/hr

5 yr ARI Discharge from Southeastern POS = 8L/s/impervious ha
Impervious ha = 12.34957 ha
Max peak discharge during 5 year ARI event = 98.79656 L/s
355.667616 m^3/hr

100 Year ARI Discharge from Southeastern POS = 8L/s/impervious ha
Impervious ha = 12.34957 ha
Max peak discharge during 100 year ARI event = 118.555872 L/s
426.8011392 m^3/hr

Western Catchment

Max outflow = 50litres/second/gross hectare 1245 m^3/hr

5 yr ARI Discharge from Southeastern POS = 8L/s/impervious ha
Impervious ha = 9.50051 ha
Max peak discharge during 5 year ARI event = 76.00408 L/s
273.614688 m^3/hr

100 Year ARI Discharge from Southeastern POS = 8L/s/impervious ha
Impervious ha = 9.50051 ha
Max peak discharge during 100 year ARI event = 91.204896 L/s
328.3376256 m^3/hr

South-Eastern Catchment

Max outflow = 50litres/second/gross hectare = 1600 m^3/hr

5 yr ARI Discharge from Southeastern POS = 8L/s/impervious ha
Impervious ha = 10.51574 ha
Max peak discharge during 5 year ARI event = 84.12589333 L/s

302.853216 m^3/hr

100 Year ARI Discharge from Southeastern POS = 8L/s/impervious ha
Impervious ha = 10.51574 ha
Max peak discharge during 100 year ARI event = 100.951072 L/s
363.4238592 m^3/hr