Local Water Management Strategy

YORK LWMS

Prepared for York Farm Holdings (WA) Pty ltd

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Cardno

Shaping the Future

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Executive Summary

The York Farm Holdings (WA) Pty. Ltd. has undertaken an Outline Development Plan (ODP) of the Morris Edward Drive and Trews Road Residential/Commercial development, known as the Daliak subdivision and referred to as the site henceforth. The site is situated on the south west boundary of the York townsite within the municipality of the Shire of York (Shire). The development of a Local Water Management Strategy (LWMS) is the appropriate mechanism to establish broad level designs and management measures for flood mitigation and effective stormwater management at the structure planning stage.

The LWMS is a key supportive document for the ODP. The development of the LWMS is intended to provide overall guidance to the general stormwater management principles for the area and to guide future Urban Water Management Plans (UWMP) that will support subdivision approval.

This LWMS has been developed to:

> Provide a broad level stormwater management framework to support future urban development.
> Incorporate appropriate Best Management Practices (BMP) into the drainage systems that address the environmental and stormwater management issues identified.
> Minimise development construction costs and ongoing operation and maintenance costs for the land owners and Shire.
> Gain support from the Department of Water (DoW) and Shire for the proposed method to manage stormwater within the Daliak area and potential impacts on downstream areas.

A number of broad level studies that include the site provide a regional environmental context for the LWMS. These have been reviewed in order to provide suitable background information and provide an indication of the issues requiring further investigation. In addition, a number of site specific investigations have been conducted as a part of the ODP preparation process. In summary, the investigations conducted to date indicate that:

> predominately agricultural in nature;
> gently sloping eastwardly from 240mAHD in to 185mAHD along the eastern site boundary;
> soils are considered to be sandy in nature with good infiltration capabilities;
> groundwater is expected to be greater than 3m below the surface with low salinity;
> an ephemeral streamline runs through the centre of the main site;
> extensive clearing of native vegetation for agricultural purposes;
> no identified contaminated sites are recorded on the DEC's Contaminated Sites database;
> there are no recorded Indigenous Heritage sites within the site boundaries; and
> no recorded wetlands or Bush Forever sites are noted within the site.

The LWMS has determined appropriate water conservation, stormwater management and groundwater management design criteria based on overarching documents, the requirements of the Shire, DoW and from similar developments.

The overall aim of total water cycle management includes the sustainable consumption of potable water and consideration of all water sources. Therefore the use of water within the development will be minimised wherever possible. This will be achieved through considered landscaping of the Public Open Space (POS) to minimise areas requiring irrigation. In addition, POS areas will be irrigated with fit-for-purpose groundwater. Water efficient appliances and water efficient gardens will be promoted at the lot scale. This will encourage the development to meet the net use of water within household's target of 100m3/person/year (Government of Western Australia 2007).

The stormwater management objectives for the site are to mitigate post development peak discharge rates to pre-developments rates and to retain (and treat) the 1 year 1 hour ARI rainfall event as close to source as possible. The 5 year ARI rainfall event will be conveyed within the piped road network and 100 year ARI storm event will be carried to drainage basins in the POS areas via the road reserves. The LWMS document provides the location and size of all retention and detention storage areas.

The POS area will contain four vegetated basins connected by swales in order to detain high flow events, reduce peak flows and provide mitigation of sediment transportation. Other strategies to minimise erosion

and mitigate sediment transport have also been identified within the LWMS, such as the installation of sediment control devices during construction and the need for an Erosion and Sediment Control Program to be referred to within future UWMP.

The site discharges runoff into the drainage basins at multiple locations to spread the impact of the development on the drain. Modelling of the site, detailed within Section 6 and Appendix A**,** shows culverts peak flow.

The overall objectives for groundwater management are to minimise any changes to the underlying groundwater level and quality as a result of development. It is recommended that prior to commencement of the next stage of the planning process groundwater monitoring is undertaken to characterise annual groundwater fluctuations.

It is proposed that the overall condition of POS areas be monitored on a bi-annual basis following completion of the civil and landscaping works. It is also proposed that five groundwater boreholes be installed and monitored for salinity. POS and groundwater salinity monitoring will ensure that the high amenity value of the development is maintained prior to handover of the POS areas to the Shire.

This LWMS provides a framework that the proponent can utilise to assist in implementing stormwater management methods that:

- have been based on site-specific investigations;
- are consistent with relevant State policies; and
- have been endorsed by the Shire;

The responsibility for working within the framework established within the LWMS rests with the proponent and their contractors, although it is anticipated the future management actions beyond the proposed management timeframes will be the responsibility of the Shire.

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1 Introduction

York Farm Holdings (WA) Pty. Ltd (York Farm Holdings) has commenced outline development planning of the Morris Edward Drive and Trews Road residential/commercial development, known as the Daliak subdivision (and henceforth known as the site). The site is situated on the south west boundary of the townsite of York within the municipality of the Shire of York (Shire). The locality of the site is shown in Figure 1.

It is important that the manner in which stormwater runoff from urban areas will be managed is clearly documented early in the planning process. This provides a framework for actions and measures to achieve the desired outcomes at the subdivision stage. The development of a Local Water Management Strategy (LWMS) is considered to be the appropriate mechanism to establish the concept designs and management measures for flood mitigation and effective stormwater management.

Historical land use within the site has been predominantly agriculture. Changing land use from agriculture to urban can have implications for quality and quantity of stormwater generated can affect the local and downstream environments. In addition, the development of the site will require the sustainable use of water resources. The overall aim of the LWMS is to ensure that any potential impacts on the local and downstream environments from land use change, and subsequent development, are minimised.

1.1 Town Planning Context

The site is currently zoned "Development" and Lots 1,2,52 and 102 as “Public Purpose” under the Town Planning Scheme (TPS) No. 2 (Shire of York, 2010).

In order to rezone, develop and subdivide this land, an Outline Development Plan (ODP) was prepared and endorsed by the Shire. The Western Australian Planning Commission (WAPC), however, rejected the ODP until a LWMS was undertaken. This LWMS is intended to support the amended ODP subdivision application as required by the WAPC (Reference No; 853/4/34/2pt29).

1.2 Policy Framework

There are a number of State Government documents that relate to the site. These documents include:

> *State Water Plan* (Government of WA 2007).
> *Guidance Statement 33: Environmental Guidance for Planning and Development* (EPA 20086).
> *State Planning Policy No 3: Urban Growth and Settlement* (WAPC 2006).
> *Liveable Neighbourhoods* (WAPC 2007).

In addition to the above documents, there are a number of published guidelines and standards available that provide guidance regarding the objectives stormwater management should aim to achieve. These are key inputs and include:

> *Decision Process for Stormwater Management in Western Australia* (DoW 2009).
> *National Water Quality Management Strategy* (ANZECC 2000).
> *Stormwater Management Manual of Western Australia* (DoW 2007).
> *Better Urban Water Management* (WAPC 2008).

These guidance documents, together with information from the Shire and Department of Water (DoW), were reviewed to determine the likely requirements for the site which is proposed for future urban development.

1.3 Objectives

The LWMS for the site has been developed to meet the following major objectives:

> Develop a stormwater management strategy for the site and downstream environments.
> Incorporate appropriate Best Management Practices (BMP) into the drainage system that addresses erosion and sediment transport within the site.
> Develop a site water conservation strategy.

> Gain support from the DoW and Shire for the proposed method to manage stormwater across the site and potential impacts on the site and downstream environments.

2 Pre-development Environment

The site is noted to be split into two sections; a small circa. 8ha development area located to the south east of the main site (TAFE site) and the larger circa. 111ha development area (main site). The main site is bounded by Morris Edwards Drive to the north, Great Southern Highway to the south and Ulster Road to the east. Principally agricultural land a small number of properties are noted along the southern boundary and in the centre of the northern boundary. Bed and breakfast accommodation is located in the north east corner. This property will remain after the redevelopment.

The TAFE site is bound by agricultural land to the north, Forrest Street to the east and Great Southern Highway to the south and west. This land is entirely agricultural land with no development.

The townsite irrigation reservoir is located immediately to the east of the main site with an unnamed streamline also flowing eastwards through the centre of the main site. This streamline drains the surrounding agricultural land directing water, via the reservoir, to the River Avon circa. 1km east of the site.

2.1 Geotechnical Conditions

2.1.1 Topography

Topographic contours indicate that the surrounding area gently undulates, with the site sitting at the base of low hills to the north, west and south Figure 2. Both the main site and the TAFE site gently slope eastwards with the main site falling from 245m Australian Height Datum (mAHD) to circa. 185mAHD and the TAFE site falling from 200mAHD to circa. 185mAHD.

2.1.2 Geology, Soils and Contamination

The townsite of York exists within the highly weathered Yilgarn Craton. Bedrock geology is considered to be granulite and migmatite from a high grade metamorphic rock. The site contains exposed Saprolite and Saprock (WA Atlas, accessed 2012).

Soils are considered to be poor in structure, with very thin poorly developed topsoil. Soil is often sandy in nature, with low levels of Nitrogen and Phosphorous and poor nutrient retention (WA Atlas, accessed 2012).

No identified contaminated sites are recorded on the Department of Environment and Conservation (DEC) Contaminated Sites database either within or directly adjacent to the site. Acid Sulfate Soil (ASS) mapping has not been undertaken in this area.

2.2 Hydrology

The York region is part of the Swan Avon catchment. The site is contained within an 880ha agricultural catchment and receives inflow from the surrounding catchment from seven separate points on its boundary (Wheatbelt NRM, 2011). The existing drainage network within the main site is limited to a streamline which flows eastwards through the centre of the site. This streamline is a tributary of the River Avon which flows northwards through York, circa. 1km east of the site boundary. Stormwater which does not infiltrate to ground will flow overland into this streamline. Flow from this streamline is directed into an engineered reservoir, located immediately east of the site boundary, for collection for irrigation use within the townsite preferentially before flowing towards the River Avon.

The capacity of the irrigation reservoir, constructed by the Shire is unknown. In addition three small farm dams have been constructed to attenuate surface water for irrigation use across the agricultural land.

2.2.1 Groundwater

The Department of Agriculture undertook a groundwater study of the York townsite in May 2002. Groundwater levels away from the Avon River are typically more than 3m below the surface with a relatively low salinity risk (Wheatbelt NRM, 2009).

2.2.2 Surface Water

Surface runoff is estimated using available data on topography, infiltration rates, vegetation and existing surface channels using a hydraulic model to calculate likely discharges, volume of runoff and flow paths. The

Shire undertook broad scale regional modelling of the townsite to determine peak flow rates using MUSIC software. A site specific surface water model was developed by Cardno using the XPSWMM modelling package to determine discharge flows for the site. Table 1 provides a comparison of flows from the XPSWMM and Shire studies.

Table 1 Comparison of Pre-development Flow Rates

Model Node (see Figure A2 in Appendix A)	Shire 10yr ARI (m^3/s)	Cardno 10yr (m^3/s)	Cardno Peak duration (hr)
C7	3.6	3.93	6
Nxs19	4.2	5.54	6
C9	1.0	0.77	6
C10	0.7	1.03	6
C11	0.7	1.14	6
C12	2.4	2.37	6
C13	0.3	0.65	6
C14	0.5	0.45	6
Flow at Ulster Road	3.0	4.80	6

2.2.2.1 Regional Surface Water Modelling – HECRAS

Hydraulic simulation was undertaken by Wheatbelt NRM (using HEC-RAS-USGS 2010) to determine the capacity of the main flow path through the York commercial precinct. Peak flow modelling undertaken at the site indicate that the 10yr Average Recurrence Interval (ARI) stormwater discharge from the site (assuming no discharge from the surrounding agricultural catchment) would be approximately 6.0m^3/s for the 1 hour storm event. If modelling includes discharge of the surrounding agricultural catchments, then peak flow discharge for a 10yr ARI event is estimated to exceed 8.0m^3/s.

2.2.2.2 Site Surface Water Modelling

The site was divided into a total of eight catchments. An additional 10 external catchments were also included in the modelling to ensure the model accurately represented the runoff directed towards the site. The pre-development catchments are shown in Figure 3.

An 'initial loss - continuing loss' infiltration model was adopted to generate stormwater runoff hydrographs in the XPSWMM model. The loss values were selected based on the soil types and catchments identified in the site (see Section 2.1). The infiltration rates for the different soil and land types are presented in Table A2 of Appendix A.

The XPSWMM model was run for the 5 year and 100 year ARI event. A multi-storm analysis was conducted to determine the critical duration event that produces the largest peak discharge from the existing site. The analysis concluded that the critical storm duration for the 5 and 100 year ARI events was 6 hours. The pre-development peak flows and volumes discharging from the site are shown in Table 2.

Table 2 Pre-development ARI Flows

Catchment	Corresponding Area (ha)	Critical duration 100yr flow (m^3/s)	Critical duration 5yr flow (m^3/s)	1hr 1yr flow (m^3/s)
SA1	28.93	1.54	0.45	0.00
SA2	32.2	1.18	0.29	0.01
SA3	11.95	0.56	0.15	0.01
SA4	32.46	1.68	0.48	0.01
SA5	14.23	0.81	0.25	0.04
SA6	16.96	0.97	0.30	0.08
SA7	12.51	0.62	0.17	0.00

2.3 Environmental Assets

Extensive clearing has resulted in the area becoming highly degraded.

There are no recorded wetlands or Bush Forever sites within or immediately adjacent to the site boundaries.

2.4 Ethnographic Assets

A search of the Department of Indigenous Affairs database (DIA 2010) indicates there are no recorded Indigenous Heritage sites within, or immediately surrounding, the site.

2.5 Summary of Existing Environment

The pre-development environment is:

> predominately agricultural in nature;
> gently sloping eastwardly from 240mAHD in to 185mAHD along the eastern site boundary;
> soils are considered to be sandy in nature with good infiltration capabilities;
> groundwater is expected to be greater than 3m below the surface with low salinity;
> an ephemeral streamline runs through the centre of the main site;
> extensive clearing of native vegetation for agricultural purposes;
> no identified contaminated sites are recorded on the DEC's Contaminated Sites database;
> there are no recorded Indigenous Heritage sites within the site boundaries; and
> no recorded wetlands or Bush Forever sites are noted within the site.

3 Proposed Development

The site is approximately 119ha in size, located to the south west of the townsite of York. The ODP shows the site is proposed to be developed for mixed use; principally residential, a retirement village and education facility.

The majority of the main site is proposed to be residential; zoned for R12.5, R15, R20, R25 and R30 with some homestead lots in addition. This will be spread across the site with the retirement village situated in the centre to the north of the streamline. POS is proposed along the length of the streamline. A small section of commercial and residential mixed use is also proposed in the centre of the main site to the south of the streamline.

The TAFE site is proposed to be used for educational purposes.

The endorsed ODP is included in Appendix B.

4 Design Criteria and Objectives

4.1 Total Water Cycle Management

Total water cycle management recognises the finite limit to a region's water resources, and the inter-relationships between the uses of water and its role in the natural environment. The *State Water Plan* (Government of Western Australia 2007) endorses the promotion of total water cycle management and application of Water Sensitive Urban Design (WSUD) principles to provide improvement in the management of stormwater, and to increase the efficient use of existing water supplies. Total water cycle management addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Stormwater management design objectives should therefore seek to deliver better outcomes in terms of:

> Non-potable and potable water consumption.
> Stormwater quality management.
> Flood mitigation.

The overall objective for preparing a total water cycle management plan is to mitigate flooding, minimise sediment transport and maintain an appropriate water balance.

4.2 Water Conservation

The overall aim of total water cycle management includes the sustainable consumption of potable water and consideration of all water sources. Therefore the use of water within the development will be minimised wherever possible. The design criteria for water conservation are detailed below:

> Minimise the net use of water within households to meet the target of 100m^3/person/yr (Government of Western Australia 2007).
> Minimise the use of potable (scheme) water within households to meet the aspirational target of 40-60m^3/person/yr (Government of Western Australia 2007).
> Minimise water requirements for the establishment of POS areas.
> Achieve a target of 7,500m^3/ha/yr of water for irrigation of POS areas, as recommended by the DoW.

4.3 Stormwater Management

The overall guiding document for the development of stormwater management strategies is the *Stormwater Management Manual of Western Australia* (DoW 2007). The *Decision Process for Stormwater Management in Western Australia* (DoW 2009) provides guidance on how urban development can achieve compliance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual of Western Australia*.

4.3.1 Stormwater Quality

Water treatment systems and WSUD structures must be designed in accordance with the *Stormwater Management Manual of Western Australia* (DoW 2007) and *Australian Runoff Quality* (Engineers Australia 2006). *Better Urban Water Management* (WAPC 2008) advocates a water quality management principle where existing surface water and groundwater quality is maintained as a minimum, and preferably improved prior to discharge offsite. Through consideration of these guidelines, the primary objective for this LWMS is to avoid further deterioration of water quality within the receiving streamline.

The key design criteria that will be adopted to maintain stormwater quality include:

> Treat runoff prior to discharge by detaining low flow events on site as close to source as possible.
> Apply appropriate structural and non-structural measures to minimise the transportation of sediments offsite and reduce applied nutrient loads.
> Bio-retention systems are to be sized at 2% of the connected impervious area.

4.3.2 Stormwater Quantity

Stormwater retention and detention structures must be designed in accordance with the *Stormwater Management Manual of Western Australia* (DoW 2007) and *Australian Rainfall and Runoff* (AR&R) (Engineers Australia 1997). *Better Urban Water Management* (WAPC 2008) advocates a water quantity management principle where pre-development peak flows are maintained in the post-development environment.

Key design criteria that will be adopted to manage stormwater quantity are detailed below:

> Retaining the 1 year 1 hour ARI storm event onsite as close to source as practicably possible.
> Convey the 5 year ARI rainfall event within the piped road network.
> Ensuring the 100 year ARI event can be contained within the road reserve with a minimum 300mm freeboard to adjacent properties finished floor level.
> Ensuring properties have a finished floor level of 500mm above the 100 year flood level within the adjacent basins.
> Detention of the 5 year ARI through to the 100 year ARI rainfall events so that the post development peak discharge is comparable to the pre-development peak discharge.

4.4 Groundwater Management

The overall objectives for groundwater management are to minimise changes to the underlying groundwater level and quality as a result of development. The design criteria for groundwater management that will be adopted for this LWMS are as follows:

> Minimise changes to underlying groundwater levels as a result of development
> Provide separation distance of at least 1.2m to Maximum Groundwater Level (MGL).
> Minimise risk of nutrient enrichment of downstream receiving surface water bodies from groundwater sources.
> Ensure that groundwater quality leaving the site is at least the same, or better, than the water entering the site.

5 Water Conservation Strategy

A residential development will use water within lots (for external and internal uses) and landscaped areas. The total water consumption can be reduced through the incorporation of water conservation measures discussed in the following sections. The conservation strategy has been designed to meet the objectives and criteria stated in Section 4.2.

5.1 Development Scale Water Conservation Measures

5.1.1 Landscaping

There is a number of landscaping design and POS management measures that will be implemented to achieve the design criteria stated in Section 4.2:

> Retention of native trees within POS areas (where possible) to reduce demand for water during establishment of the POS area.
> A minimal proportion of the POS will be turfed to reduce the annual irrigation demand. The selected turf species will require minimal water and fertiliser.
> POS will be largely vegetated with local native species to enhance the environmental values of the POS area.

5.1.2 Irrigation

There are a number of irrigation management measures that can be implemented to achieve the design criteria stated in Section 4.2:

> Irrigation systems will be designed and installed according to best water efficient practices.
> Irrigation of revegetated swales and bush areas within the POS can be established on a two year sacrificial irrigation drip system, which can be decommissioned following plant establishment.
> Only feature garden beds or lawn areas are to be serviced with an ongoing irrigation system.
> Management of irrigation practices to minimise losses to evaporation (e.g. volume applied is not excessive, timed irrigation to avoid wastage, metered system to monitor for leaks, emitters disperse coarse droplets or are subterranean).

Conservation of potable water through fit-for-purpose use is encouraged so that water is not wasted. The term fit-for-purpose describes the use of water that is of a quality suitable for the required use of the water. It is noted the groundwater has been described as having low salinity. As such further testing will be required to confirm the suitability of this supply for irrigation purposes prior to use.

At present landscape design of the POS areas has not been undertaken. It is proposed that the UWMP for the site provides full landscape plans which meet the DoW recommended target of 7,500m^3/ha/annum of water for irrigation. It is likely that significant amounts of the land set aside for POS will remain native vegetation which will not require irrigation.

5.1.3 Community Awareness and Education

Landowners shall be provided with reputable reference material from sources such as the Water Corporation's *Waterwise Program* (2011), King's Park Master Gardeners (Government of Western Australia 2011) and the *Your Home* initiative (Commonwealth of Australia 2011). This information will cover a number of topics including:

> Grey water recycling.
> Water conservation in the home.
> Sustainable landscaping and water efficient gardening.
> Sediment control and erosion mitigation on Lots.

5.2 Lot Scale Water Conservation Measures

5.2.1 Potable Water Supply

Scheme water within the town of York comes from Mundaring Weir catchment area. The Water Corporation (WC) manage both distribution and reticulation pipe network infrastructure within the Shire of York.

5.2.2 Alternative Water Supply

The conservation of the potable scheme water supplied by WC can also be achieved by using low quality water, such as grey water, for uses that do not require high quality water e.g. subsoil irrigation or toilet flushing. Grey water can be described as all the wastewater used in the home with the exception of water from toilets (and potentially water from washing machines and sinks). The adoption of grey water recycling systems shall not be mandated within this LWMS, but landowners will be made aware of the benefits of these systems at the point of sale.

5.2.3 Water Efficient Appliances

Significant reductions in in-house water uses can be achieved with the use of water efficient appliances. Table 3 gives an example of the water uses of typical appliances versus water efficient appliances (ACT Government 2007). The water efficient use rates have been used in the water balance investigation.

Table 3 Water Efficient Appliances

Appliance	Water Consumption	
	Standard Device	Water Efficient Device
Toilet	12 L/flush	4 L/flush
Washing Machine	130 L/wash	40 L/wash
Shower Head	15 - 25L/minute	6 - 7L/minute
Taps	15 - 18L/minute	5 - 6L/minute

The water conservation strategy proposes all dwellings use water efficient appliances. Water efficient shower heads and tap fittings are already mandated as part of the *Building Code of Australia* (ABCB 2011), however, although not mandated the uptake of other devices will be encouraged through education from the developers at the point of sale.

5.2.4 Water Efficient Gardens

Studies by WC (Water Corporation 2003) has found that for a typical dwelling, 56% of water consumed by the lot is used on gardens. Therefore, reductions in water irrigation by employing water efficient garden measures can significantly reduce the total water usage of the lot. The following water efficiency measures can be used on lot gardens:

> Installing an irrigation system that was designed and installed according to best water efficient practices. The controller must be able to irrigate different zones with different irrigation rates. Emitters must disperse coarse drops or be subterranean.
> Gardens should include large permeable areas such as gravel, dry creek bed features or swales limiting the amount of turfed area within the design and consider the use of mulch or gravel as alternatives.
> Garden beds to be mulched to 75mm with a product certified to Australian Standard AS4454.
> It is strongly encouraged that gardens be planted with local plant species.

5.2.5 Water Balance

A potable water balance base on general assumptions was conducted to determine the effectiveness of the water conservation strategy presented in the WC Spreadsheet *AltWaterSupply_Water_Use_Model.xls*.

At this stage of the planning process no detailed design of the proposed development has been undertaken. As such the water balance has been calculated using assumptions and calculation methodology as present in Appendix C.

The resulting water consumption for the development has been calculated as 112m^3/person/yr. This value is above the 100m^3/person/yr target however, when detailed design of the masterplan has been finalised it is likely that the development water consumption will reduce. The encouragement of water efficient practices within the development and the requirement of UWMP for subsequent stages of development to meet water targets will ensure water consumption is limited to at least 100m^3/person/yr.

6 Stormwater Management Strategy

6.1 Proposed Stormwater Management Strategy

Surface water runoff will be managed both on a development scale and a lot scale. The principle behind the stormwater management strategy is to mitigate flooding and minimise sediment transport by discharging large flows offsite and detaining low flows on site. Other strategies to minimise sediment transport while also discussed in the following sections. The drainage system has been designed to achieve the objectives and criteria stated in Section 4.3**.**

The proposed stormwater management strategy is to retain the 1yr 1hr ARI storm events on lots. The 5 and 100yr ARI event runoff will be directed to the basins via the pipe drainage network and overland flow within the road reserves, respectively. Overflow from the basins discharge to the streamline to mimic the existing site drainage.

6.2 Post Development Surface Water Modelling

In order to demonstrate the performance of the proposed drainage strategy modelling of the post development environment has been undertaken using XPSWMM. This model was built to characterise the hydrological behaviour of the post development environment, incorporating eight catchments as shown in Figure 4. Modelling parameters and assumptions are provided in Appendix A.

The basin storage was calculated using 12D software from the survey contours received as the Shire did not have engineering details of the constructed reservoir.

At this stage of the masterplanning development post development ground levels have not been completed. Ground levels across the site are noted to be relatively flat and as such it has been assumed post development ground levels will mimic existing ground levels for the purposes of the modelling. To ensure the redevelopment does not disrupt the existing York townsite stormwater harvesting system, the reservoir located immediately east of the main site boundary has been utilised within this management strategy.

6.2.1 1yr 1hr ARI Storm Event

Runoff generated in a 1yr 1hr ARI rainfall event in lots will be retained on site in rainwater tanks or soakwells. No site specific permeability testing has been undertaken at the site, however, anecdotal evidence and summary geology information suggests a sandy substrate which would be acceptable for infiltration. In addition, groundwater is likely to be at least 3m below ground level, therefore allowing soakwells with a depth of 1.2m to be installed and still allow at least 1.2m from groundwater to allow sufficient space for infiltration.

The total amount of storage required to retain the 1yr 1hr ARI events on lots is approximately 7106m^3 or an average of 9.4m^3/1000m^2 across the site. Table 4 details the required storage per catchment as shown in Figure 4.

Table 4 Soakwell Volumes

Catchment	Total Lot Area (m^2)	Total Storage Required (m^3)	Infiltration Rate (mm/hr)	Required Storage per 1000m^2 of lot (m^3)
SA1	125,390	1371.62	180	10.9
SA2	171,160	1581.50	180	9.2
SA3	59,750	560.07	180	9.4
SA4	159,331.6	1712.05	180	10.7
SA5	80,020	491.50	180	6.1
SA6	99,269	681.37	180	6.9
SA7	57,770	707.85	180	12.3

Drainage from all roads during the 1yr 1hr ARI event will be directed to bioretention areas within the detention basins in the POS for treatment and infiltration to ground. Table 5 details the proposed basin dimensions and water depths for the 1yr 1hr ARI storm event. The location of the proposed detention basins are provided in Figure 4. At present no detailed design has been undertaken for the detention basins, however, guidance from the *Stormwater Management Manual of Western Australia* (DoW 2007) have been used when modelling these features.

Table 5 1yr 1hr ARI Basin Characteristics

Basin	Side Slope	Base Area (m^2)	Surface Area (m^2)	Infiltration Rate (m/s)	Volume (m^3)	Maximum Water Depth (m)
SA1	1:6	1250	2064	$5x10^{-5}$	1371.62	0.84
SA2	1:6	1450	2331	$5x10^{-5}$	1581.50	0.85
SA3	1:6	410	934	$5x10^{-5}$	560.07	0.86
SA4	1:6	1500	2429	$5x10^{-5}$	1712.05	0.88
SA5	1:6	350	843	$5x10^{-5}$	491.50	0.85
SA6	1:6	550	1124	$5x10^{-5}$	681.37	0.83
SA7	1:6	550	1141	$5x10^{-5}$	707.85	0.86

6.2.2 5yr ARI Storm Event

The strategy for stormwater management for events greater than the 1yr 1hr ARI event is to ensure post development flow rates within the study area remain equal or less than pre-development flow rates.

Stormwater runoff generated by up to the critical duration (30 minute storm) 5 year ARI event will be collected via road side entry pits and carried within piped road network to detention basins located within POS areas. Water is discharged via weir structures from the basins into the streamline. Table 6 details the proposed basin dimensions and water depths for the 5yr ARI storm event. The location of the proposed detention basins are provided in Figure 4. At present no detailed design has been undertaken for the detention basins, however, guidance from the *Stormwater Management Manual of Western Australia* (DoW 2007) have been used when modelling these features.

Table 6 Critical Duration 5yr ARI Basin Characteristics

Basin	Side Slope	Base Area (m^2)	Surface Area (m^2)	Infiltration Rate (m/s)	Weir Depth (m)	Weir Width (m)	Volume (m^3)	Maximum Water Depth (m)	Peak Outflow (m^3/s)
SA1	1:6	2064	3600	$5x10^{-5}$	0.25	5.0	737.08	0.33	0.00
SA2	1:6	2331	4045	$5x10^{-5}$	0.25	4.0	836.03	0.33	0.00
SA3	1:6	934	1866	$5x10^{-5}$	0.25	2.5	299.89	0.29	0.00
SA4	1:6	2429	4134	$5x10^{-5}$	0.25	5.0	914.68	0.35	0.00
SA5	1:6	843	1764	$5x10^{-5}$	0.25	4.0	262.93	0.28	0.00
SA6	1:6	1124	2190	$5x10^{-5}$	0.25	5.0	365.48	0.29	0.00
SA7	1:6	1141	2134	$5x10^{-5}$	0.25	2.0	377.64	0.30	0.00

6.2.3 100yr ARI Storm Event

Stormwater runoff generated between the 5yr and the critical duration (30 minute storm) 100 year ARI event will be directed towards the detention basins located within POS areas via overland flow. This flow will be designed to be contained within the road reserves. Water is discharged via weir structures from the basins into the streamline. Table 7 details the proposed basin dimensions and water depths for the 100yr ARI storm event. The location of the proposed detention basins are provided in Figure 4. At present no detailed design has been undertaken for the detention basins, however, guidance from the *Stormwater Management Manual of Western Australia* (DoW 2007) have been used when modelling these features.

Table 7 Critical Duration 100yr ARI Basin Characteristics

Basin ID	Side Slope	Base Area (m^2)	Surface Area (m^2)	Infiltration Rate (m/s)	Weir Depth (m)	Weir Width (m)	Volume (m^3)	Maximum Water Depth (m)	Peak Outflow (m^3/s)
SA1	1:6	2064	3600	$5x10^{-5}$	0.25	5.0	3309.69	1.19	0.94
SA2	1:6	2331	4045	$5x10^{-5}$	0.25	4.0	3817.10	1.23	0.60
SA3	1:6	934	1866	$5x10^{-5}$	0.25	2.5	1321.82	0.98	0.34
SA4	1:6	2429	4134	$5x10^{-5}$	0.25	5.0	4034.97	1.25	1.03
SA5	1:6	843	1764	$5x10^{-5}$	0.25	4.0	1247.41	1.01	0.50
SA6	1:6	1124	2190	$5x10^{-5}$	0.25	5.0	1659.81	1.04	0.65
SA7	1:6	1141	2134	$5x10^{-5}$	0.25	2.0	1635.61	1.02	0.37

6.2.4 Basin Drain Times

To ensure sufficient capacity within designed basins should rainfall events of magnitude occur back to back the Urban Water Resources Centre (2008) has produced a series of recommended emptying times criteria. These are:

> 0.5 days (12hrs) for a 1 year ARI event;
> 1.5 days (36hrs) for a 5 year ARI event; and
> 3.5 days (84hrs) for a 100 year ARI event.

Table 8 details the drain times for the basins for the 1yr, 5yr and 100yr critical duration ARI events. This table confirms the designed system complies with the recommended emptying times.

Table 8 Basin Drain Times

Basin	1yr 1hr ARI Basin Drain Time (hrs)	5yr 30min ARI Basin Drain Time (hrs)	100yr 30min ARI Basin Drain Time (hrs)
SA1	7.75	9.25	14
SA2	8	9.25	15
SA3	8	9	13
SA4	8.25	9.5	14.5
SA5	7.75	9	13.25
SA6	7.75	9	13.25
SA7	8	9.25	13

6.2.5 Culverts

There are five culverts within the site. The pre and post developed peak discharges at these culverts are summarised in Table 9. The dimensions of these culverts were provided from measurements undertaken on site. A plan showing the culvert locations is presented as Figure A3 in Appendix A.

Table 9 Culverts Peak Discharges

Culvert: Model Node	Size	Peak Discharge (m^3/s)				Downstream Maximum Depth (m)			
		Pre-development		Post Development		Pre-development		Post Development	
		5 year ARI	100 year ARI	5 year ARI	100 year ARI	5 year ARI	100 year ARI	5 year ARI	100 year ARI
1: NXS19	2 x 900mm	3.48	5.90 (ORF[1]-7.07)	3.48	5.90 (ORF-7.07)	0.38	0.75	0.38	0.75
2: C7	3 x 525mm	1.769 (ORF-0.34)	2.487 (ORF-0.94)	1.769 (ORF-0.34)	2.487 (ORF-0.94)	0.21	0.35	0.21	0.35
3: C9	400mm	0.142 (ORF-0.39)	0.221 (ORF-1.52)	0.142 (ORF-0.39)	0.221 (ORF-1.52)	0.03	0.06	0.03	0.06
4: C10	2 x 250mm	0.116 (ORF-0.59)	0.172 (ORF-2.09)	0.116 (ORF-0.59)	0.172 (ORF-2.09)	0.04	0.05	0.04	0.05
5: C12	3 x 750mm	1.43	3.693 (ORF-1.17)	1.43	3.693 (ORF-1.17)	1.05	1.10	1.05	1.10
	2 x 300mm	0.22	0.40	0.22	0.40				
6: Ulster Street[2]	2 x 700mm	0.97	2.949 (ORF-26.45)	0.3	2.94 (ORF-25.47)	0.22	0.40	0.12	0.40

Table 9 confirms that the peak flows recorded at Ulster Road, the downstream site boundary of the streamline, in the post development, are equal to or less than the pre-development flows. As such the mitigation measures detailed above are considered sufficient to manage stormwater runoff generated across the site.

6.2.6 Streamline Modelling Results

Table 10 details the water levels within the modelled streamline pre and post development. This table shows that maximum water levels have been maintained or lowered by the proposed stormwater management system proposed across the site.

[1] ORF = over road flow
[2] Site discharge point

Table 10 Streamline Water Levels

Model Node	Left bank	Right Bank	Invert Elevation (m)	Pre-development Maximum WL			Post Development Maximum WL		
				1yrARI 12hr	5yrARI 6hr	100yrARI 6hr	1yrARI 12hr	5yrARI 6hr	100yrARI 6hr
Out1	181.12	181.12	179.82	179.86	180.03	180.23	179.87	179.94	180.23
DummySA6	182	181.9	181.00	181.05	181.30	182.49	181.06	181.15	182.48
Nxs1	182.01	181.9	181.11	-	-	182.52	-	-	182.51
ChBlock[3]	183.69	183.71	182.27	-	-	182.78	-	-	182.77
Nxs2	183.69	183.71	182.20	182.24	182.52	183.12	182.26	182.52	183.11
Nxs3	182.84	184.28	182.81	182.88	183.30	183.78	182.91	183.31	183.77
Nxs4	184.55	184.27	183.72	183.89	184.56	184.76	184.00	184.56	184.75
Nxs5	184.75	184.57	184.06	184.14	184.97	185.56	184.21	184.97	185.55
Nxs6	185.4	185.34	184.88	185.06	185.63	186.02	185.15	185.63	186.01
Nxs7	187.52	187.99	187.23	187.36	187.76	188.26	187.43	187.76	188.26
Nxs8	188.57	188.89	188.02	188.22	189.13	189.71	188.22	189.16	189.70
Nxs9	190.41	190.37	189.73	189.83	190.44	190.64	189.84	190.44	190.64
Nxs10	192.49	192.43	191.74	191.95	192.61	192.74	191.97	192.61	192.74
Nxs11	192.99	192.69	192.19	192.31	192.86	193.15	192.34	192.86	193.15
Nxs12	193.13	193.06	192.54	192.68	193.11	193.33	192.71	193.10	193.32
Nxs13	195.17	195.13	194.30	194.45	195.27	195.67	194.48	195.26	195.67
Nxs15	198.46	199.4	199.49	199.61	200.35	200.56	199.63	200.33	200.56
Nxs14	200.43	201.13	198.09	198.24	198.85	199.08	198.27	198.84	199.08
Nxs16	202.41	202.96	201.95	202.08	202.37	202.42	202.08	202.37	202.42
Nxs17	204.77	205.03	204.61	204.72	205.08	205.37	204.72	205.08	205.37
Nxs18	207.03	207.75	206.47	206.61	207.31	207.80	206.61	207.31	207.80
Nxs19	207.16	207.94	207.11	207.23	207.90	208.27	207.23	207.90	208.27
Nxs20	208.17	208.13	207.97	207.98	209.30	210.40	207.98	209.30	210.40
Nxs21	211.77	212.1	211.40	211.53	212.04	212.24	211.53	212.04	212.24
ArbtNxs0	204.22	204.21	204.00	204.03	204.19	204.24	204.03	204.19	204.24
DumC1	205.25	205.25	204.25	204.30	204.46	204.61	204.30	204.46	204.61
BSA2	182.2	182.2	178.95	178.97	182.24	182.59	179.00	182.06	182.58

6.3 Criteria for UWMP

In addition to the design criteria detailed in Section 4.3 the following additional design criteria for stormwater quality management that will require to be met at the UWMP stage are:

> Retain the 1 year 1 hour ARI storm event onsite as close to source as practicably possible.
> Bio-retention systems are to be sized at 2% of the connected impervious area.
> There must be a minimum depth of 0.3m of high infiltration sand under the infiltration areas.
> Apply appropriate structural and non-structural measures to reduce applied nutrient loads.

[3] This node directs water into reservoir

6.4 Stormwater Quality Management

Management of erosion and sediment transport within the study area must occur at all levels of planning from pre-construction until handover of the POS areas to the Shire. Strategies that will be adopted to minimise erosion and control sediment transport prior to and during construction include:

> Vegetation will be retained on site for as long as possible.
> The development will be cleared in stages to minimise erosion opportunities.
> Ground disturbance activities will be avoided during intense rainfall events.
> Straw bale barriers may be installed if necessary prior to construction to control sediment transport
> Temporary offline sedimentation basins would be utilised to collect fine sediments in the event that drainage from the stage being developed cannot follow the drainage strategy described above.
> Revegetation will occur as soon as possible.
> An Erosion and Sediment Control Program will be documented for the development.

Long-term stormwater quality management within the site will occur within the POS areas and specifically, within basins. The basins will be designed to maximise the removal of suspended solids by lengthening the storage time to minimise the transport of sediments. This will be achieved by sizing the outflow appropriately and maximising the flow path length between the entry and exit points.

> Basins are to be vegetated with local plant species and minimal lawn to assist with nutrient stripping and sediment control.
> Should swales be used to discharge water to the streamline from basins erosion and sediment control features such as vegetation and rock armour should be included in the design where appropriate.

7 Management and Maintenance

Design of the basins and any associated swales will be undertaken in a manner that facilitates effective management of the POS areas. These areas often require active ongoing management, particularly in the first years after construction to ensure that the features continue to provide the designed functions while also maintaining high standards of amenity. A Management and Maintenance Plan (MMP) will incorporate an effective monitoring regime to provide guidance to the required level of intensity of management actions and provide guidance of the actions required to ensure that the overall objective (below) is met:

› *Maintain amenity and stormwater functions of the vegetated basins and swales whilst minimising potential environmental impacts and disturbance to surrounding residents in the long term and to ensure that the system is in an appropriate and sustainable condition at the point of management handover.*

The overall objective will be achieved through the implementation of a number of management actions that will be carried out at regular intervals for a period of five years from practical completion. The key areas that will be addressed through the implementation of this management plan include:

> Nutrients and water quality.
> Gross pollutants and sediments.
> Vegetation.

7.1 Nutrients and Water Quality

7.1.1 Structural Measures

Structural measures proposed within this LWMS maximise the removal of nutrients from stormwater flows as detailed in **Section 6.2.1**. The designed stormwater system provides detention and treatment of the first 15mm of rainfall through the use of soakwells and basins. The combination of these components provides primary and secondary treatment to the stormwater discharging from the site.

7.1.2 Non-Structural Measures

Nutrient inputs are managed to ensure that the water quality of downstream environments (i.e. Avon River) does not decline. Ongoing management and maintenance measures that will be utilised to control nutrient inputs and therefore downstream water quality include:

> Apply slow release fertiliser at the base of planted species that require fertiliser.
> Conduct leaf and tissue analysis to determine the requirement for any ongoing fertilisation, which is applied as required.
> Harvesting of vegetation (thinning) to remove bound nutrients as required (the removal of sediments is discussed in **Section 7.2**)
> Provide information to residents concerning fertiliser application at point of sale.

These actions and the manner in which they should be implemented are detailed in Table 11.

7.2 Gross Pollutants and Sediments

7.2.1 Structural Measures

Gross Pollutants (GP) can potentially introduce health risks and reduce the overall visual amenity of an area. Sediments can carry nutrients to downstream water bodies and clog up the stormwater structural measures, in particular during the construction stage, preventing the system from working efficiently. Straw bale barriers are proposed to be used on the downslope side of lots and road reserves to prevent sediments being transported onto the road reserves and flushed towards the stormwater drainage system during the construction period. Vegetation planted can be used to trap GPs and sediment which can be removed manually as part of the management plan.

7.2.2 Non-Structural Measures

While the swales and basins will trap the collected GPs, ongoing management and maintenance of GPs will include:

> Periodic visual inspection of the entire POS area.
> Removal of GPs to an offsite disposal facility in response to observations.
> Provide street sweeping to remove sediment-bound nutrients prior to runoff into vegetated basins and swales.

These actions and the manner in which they should be implemented are detailed in Table 11.

7.3 Vegetation

7.3.1 Installation of Specialised Vegetation

The basins and swales, if required, will utilise specialised vegetation to remove nutrients from the surface runoff. Management of the vegetation is outlined in Table 11.

7.3.2 Weeds

Heavy growth of aquatic and terrestrial weeds can impair the aesthetic value and hydrological functioning of the basins. The primary means of monitoring and detecting weed growth will be regular visual inspections by maintenance contractors. Management of weeds will therefore include:

> Visual monitoring of drainage features for presence of weeds. The information gained will then be used to direct the need for any remedial actions.
> Manual removal of weeds as deemed necessary.
> Application of approved herbicides (Round-up, Fusilade or similar) to terrestrial weeds.
> Provide information to residents concerning preferred lot scale landscaping and weeds.

These actions and the manner in which they should be implemented are detailed in Table 11.

7.3.3 Infill Planting

Experience with managing other developments has shown that some plants are subject to theft and vandalism. Additionally, there is the potential for some plants to perish prior to establishing deeper root systems. To manage this potential issue, infill planting will be conducted to maintain the required plant densities as per the future landscape plan. Management of infill planting will include:

> Visual inspections of the POS and drainage features for infill planting requirements. The information gained during inspections will be used to guide the need for infill planting.
> Conduct infill planting.

These actions and the manner in which they should be implemented are detailed in Table 11.

Table 11 Maintenance Schedule and Responsibility for Management Actions

Action	Timing	Location	Responsibility
Fertilise requiring species with Eight to Nine Month Slow Release Fertiliser	When planted	POS	Landscape Contractor
Conduct leaf and tissue analysis to determine nutrient requirements	Annually, beginning one year after planting		
Apply fertiliser at rates indicated by leaf and tissue analysis	In response to leaf and tissue analysis	POS	Maintenance Contractor
Harvest of nutrient removing vegetation	As required	Drainage features	Maintenance Contractor
Provide information to residents	At point of sale	Entire site	Proponent
Install straw bale barriers	During construction of the stormwater drainage network	Downward slope of all lots and road reserves	Civil contractor
Construct swales with gabion walls, rock armour and low flow outlets		Swales	
Vegetate swales / basins		POS, drainage features	Landscape contractor
Inspect for GPs and sediments	Minimum three-monthly	POS, drainage features	Maintenance contractor
Remove GPs and sediments	In response to observations		
Dispose of waste to an approved facility	Following removal of GPs	Offsite disposal facility	
Provide street sweeping	Monthly – Especially during the building phase	Entire site to prevent/reduce amount of sediment entering drainage system	
Visually monitor for terrestrial weeds	Three-monthly basis	POS, drainage features	Maintenance Contractor
Manually remove weeds	In response to visual inspections		
Apply herbicide to weeds at manufacturer's recommended rates			
Visually monitor for infill planting requirements	Three-monthly basis		
Conduct infill planting	In response to visual inspections		
Provide information to residents	At point of sale	Entire site	Proponent

8 Monitoring

It is proposed that the overall condition of POS areas and groundwater salinity monitoring be undertaken for five years, from completion of the civil and landscaping works. Reporting to the Shire will occur annually, detailing the monitoring performed to date. At the end of the five year monitoring and reporting period, the condition of the POS areas and groundwater salinity will be assessed and reported to the Shire.

A visual assessment will be undertaken on a bi-annual basis to monitor POS condition to ascertain that the maintenance activities specified within Section 7 achieve the objectives of the MMP. The rapid visual assessment sheet is given in Appendix C**.** If the results from the annual monitoring report indicate that action is required to address an issue, a number of contingency measures can be employed (see Table 12).

Table 12 Visual Assessment and Contingency Actions Plan

Aspect to Monitor	Trigger for Action	Contingency Action
Debris in drainage system	Visual assessment finds the condition of an aspect poor as compared to the initial visual assessment undertaken at completion of construction.	Remove debris
GP litter		Remove litter
Storm damage		Repair drainage system to original condition
Silt		Remove silt build up and restore to original condition
Weed infestation		Removal of weeds
Condition of garden beds and park trees		Restore to original condition through actions such as re-planting, pruning or application of fertiliser.
Turf condition		Restore to original condition through actions such as re-planting or application of fertiliser.
Damage to irrigation system		Repair irrigation system to original condition.
Condition of paving		Restore paving to original condition.
Condition of furniture/structures/fences		Repair and/or replace to original condition.
Indicators of theft/vandalism		Restore to original condition by taking appropriate action on a case-by-case basis.
Litter		Remove litter.

The post development groundwater level and quality monitoring program is proposed to include five boreholes for monitoring groundwater levels and quality, including salinity. Four boreholes will be spread across the main site, located within POS areas where appropriate, the remaining borehole will be located in the TAFE site. These boreholes will be monitored to ensure that the saline water is not utilised for irrigation of POS. If the results from the annual monitoring report indicate that action is required to address an issue, a number of contingency measures can be employed. A detailed monitoring program will be detailed within future UWMP.

9 Requirement for an Urban Water Management Plan

The requirement to undertake preparation of more detailed water management plans is generally imposed as a condition of subdivision. The development of the UWMP should follow the guidance provided in the *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW 2008).

While strategies have been provided within this LWMS that address planning for water management across the site, it is a logical progression that future subdivision designs and the supportive UWMP will clarify details not provided within the LWMS. The main areas that will require further clarification within future UWMP are detailed in the following sections and include:

- Modelling of the local drainage network.
- Configuration of treatment and retention areas and associated outlet structures.
- Implementation of water conservations strategies.
- Groundwater use and licensing requirements.
- Non-structural water quality improvement measures.
- Management and maintenance requirements.
- Construction period management strategies.
- Monitoring and evaluation program.

9.1 Modelling of Stormwater Management Strategy

It is acknowledged that the drainage strategies documented in this LWMS are based on broad assumptions and data. These assumptions are considered adequate for development of the proposed basin sizes and of an appropriate level of detail. Verification of proposed subdivision drainage designs should be undertaken by modelling the detailed drainage design. These detailed drainage designs should include road designs that show longitudinal grades and outlet controls into the streamline, if required. Modelling should confirm that runoff from the 5 and 100 year ARI event can be conveyed within the piped road network and road reserve, respectively. Such modelling will allow verification that development undertaken is consistent with the design criteria given in Section 4.

9.2 Configuration of Treatment and Retention Areas

While the drainage catchments have been defined based on the current plans and available information, it is possible that these could undergo some change to accommodate stakeholder feedback prior to final subdivision design.

The exact location and shape of the drainage features will be specified and presented within the future UWMP. In order to review the final configurations, the hydrological model that has been developed to support the LWMS may need to be refined. It is expected that the drainage features will be designed to a level that provides detailed cross-sections, sizes of retention and storage areas, detained volumes, culvert sizes, longitudinal grade, inverts etc. The ultimate aim of revising the hydrological model will be to confirm that the final detailed drainage design meets the design criteria and drainage strategy presented in this LWMS.

9.3 Water Conservation Strategies

A number of potential measures to conserve water have been presented. Landscape design measures that will be incorporated into the water conservation strategy should be detailed within future UWMP. The manner in which the developer intends to promote water conservation measures to future lot owners should also be discussed within future UWMP.

9.4 Groundwater Use and Licensing Requirements

The LWMS has provided the volumes required for irrigation of POS areas according to the Draft ODP (Appendix C). The UWMP may be required to update these volume estimates following the finalised landscape design, which must also be provided within the UWMP.

9.5 Non-structural Measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007). Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of subdivisions and the POS areas. These measures are expected to be detailed within future UWMP.

9.6 Management and Maintenance

The management measures to be implemented address surface water quality, such as the use of vegetation in drainage features, will require ongoing maintenance. It is therefore expected that the future UWMP will provide detailed MMP that will set out maintenance actions (e.g. weeding), timing, locations and responsibilities. Given that approval from the Shire and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

9.7 Construction Period Management Strategy

It is anticipated that the construction stage will require some management of various aspects (e.g. sediment, dust, surface runoff, noise, traffic etc). In particular, sediment transport and dust generation must be minimised during construction works.

Measures to control dust generation during construction may include:

> Not undertaking earthworks during dry, windy conditions.

> Water down cleared areas will occur as necessary during dry dusty periods.

> Covering materials during construction to reduce dust emissions.

Measures to prevent erosion and minimise sediment transport during construction must be documented within an Erosion and Sediment Control Program.

9.8 Monitoring

It will be necessary to confirm that the management measures that are implemented are able to fulfil the intended management purpose, and are in a satisfactory condition at handover to the Shire. A monitoring program should be developed to provide details of the program objectives, relevant issues and information, proposed methodology, monitoring frequency and reporting obligations. The monitoring identified in Section 8 will be further detailed at the UWMP stage.

10 Implementation

10.1 Roles and Responsibility

This LWMS provides a framework that the proponent can utilise to assist in implementing stormwater management methods that have been based on site specific investigations, are consistent with relevant State policies and have been endorsed by the Shire. The responsibility for working within the framework established within the LWMS rests with the proponent and contractors, although it is anticipated the future management actions beyond the proposed management timeframes will be the responsibility of the Shire.

10.2 Assessment and Review

Reporting to the Shire will occur annually, detailing the monitoring performed to date. This encompasses the visual/qualitative assessment of the overall condition of the development. At the end of the five year monitoring and reporting period, the overall condition of the drainage features will be assessed and the condition reported to the Shire within the final monitoring report.

The overall criteria for successful completion and establishment of the area will be to fulfil the intended purpose of providing a stormwater attenuation function and increasing the overall visual amenity of the site in general. If the drainage features fulfil the stated objectives, the site will be considered to be complete and in a suitable condition for management handover to the Shire.

If, at the end of the five year monitoring and reporting period, the drainage features are not considered to fulfil the management objectives, the proponent will work with the Shire to select appropriate contingency actions that will aim to achieve a mutually satisfactory outcome.

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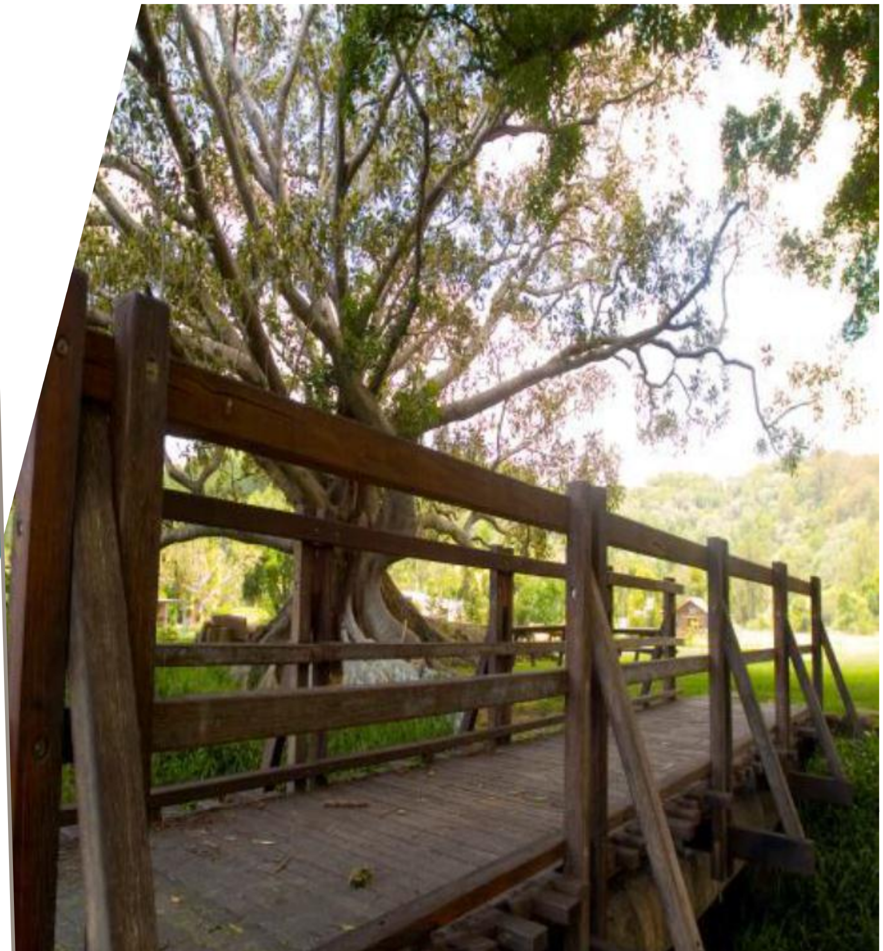
12 Abbreviations

A	
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
ASS	Acid Sulfate Soil
B	
BMP	Best Management Practices
D	
DEC	Department of Environment and Conservation
DoW	Department of Water
G	
GP	Gross Pollutants
L	
LWMS	Local Water Management Strategy
O	
ODP	Outline Development Plan
ORF	Over Road Flow
M	
mAHD	metre Australian Height Datum
MGL	Maximum Groundwater Level
MMP	Management and Maintenance Plan
N	
NRM	Natural Resource Management
S	
Shire	Shire of York
T	
TAFE	Technical and Further Education
TPS	Town Planning Scheme
U	
UWMP	Urban Water Management Plan
W	
WAPC	Western Australia Planning Commission
WC	Water Corporation
WSUD	Water Sensitive Urban Design

YORK LWMS



FIGURES

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

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Scale: 1:15,000 0 250 500 1,000 1,500 Metres

PROJECT	York LWMS	Project Number V12005	Original A4
DRAWING TITLE	FIGURE 1 : Site Locality Plan	Drawing Number SK01	Revision 00
PRINCIPAL	York Farm Holdings	Designed NK	Checked
		Drawn MGW	Approved
		Local Authority Shire of York	
		Sheet 1 of 1	Date: 24/10/2012

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

PROJECT **York LWMS**

DRAWING TITLE **FIGURE 2 : Topography**

PRINCIPAL **York Farm Holdings**

Scale: **1:7,000**

0 50 100 200 300 400 500 600 700 800 900 1,000 Metres

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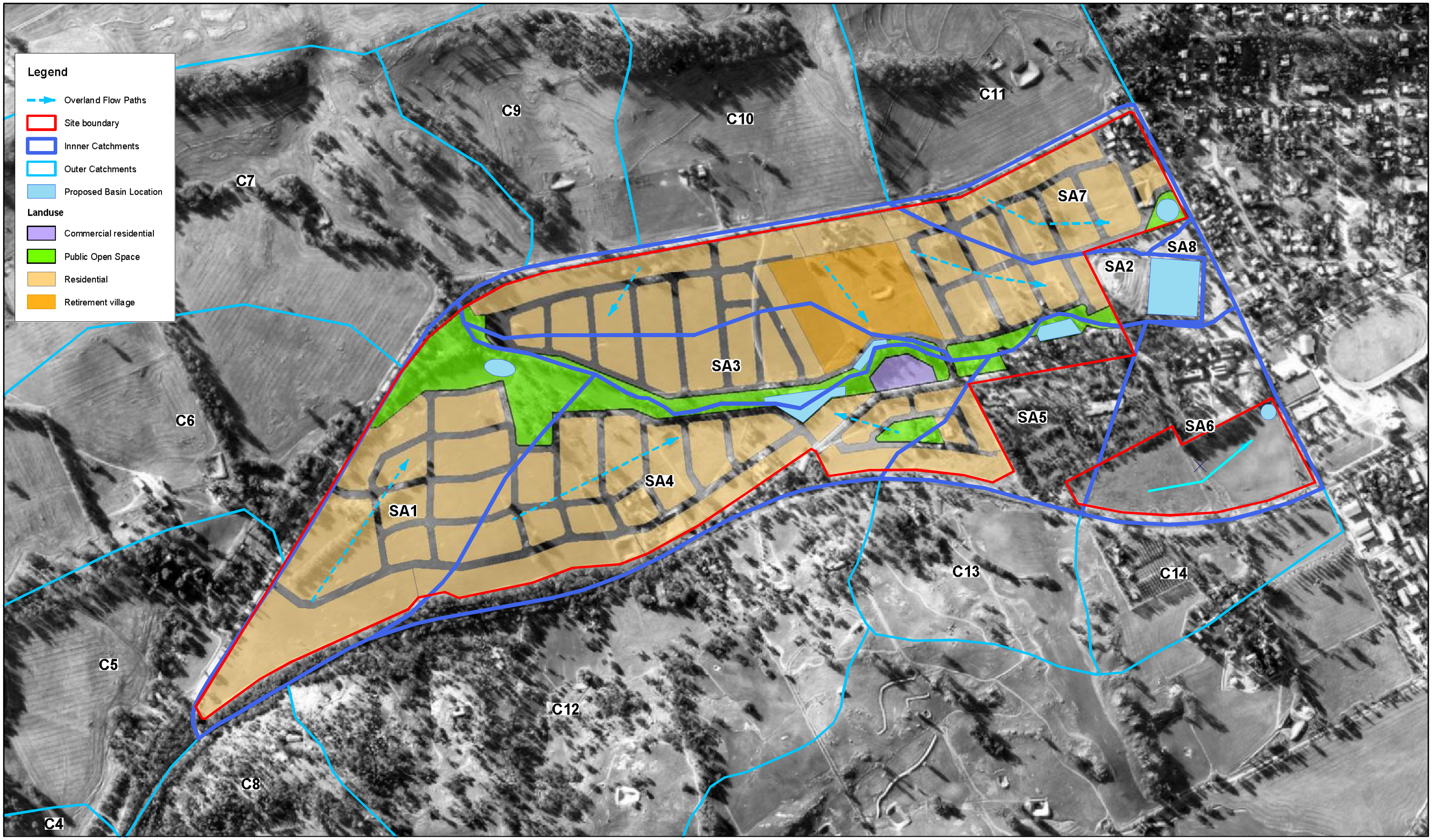
Project Number **V12005** | Drawing Number **SK02** | Revision **00** | Original **A3**

Designed AK | Checked | Date: 24/10/2012

Drawn MGW | Approved | Sheet 1 ` 1

Local Authority City of Swan



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

PROJECT York LWMS

DRAWING TITLE **FIGURE 4: Post-development Catchments**

PRINCIPAL York Farm Holdings

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0 250 500 1,000 Metres

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Project Number	Drawing Number	Revision	Original
V12005	SK03	00	A3

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Date: 1/11/2012

Sheet 1 ` 1

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

PROJECT York LWMS

DRAWING TITLE FIGURE 3: Pre-development Catchments

PRINCIPAL York Farm Holdings

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0 250 500 1,000 1,500 2,000 Metres

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Project Number	Drawing Number	Revision	Original
V12005	SK04	00	A3

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Drawn MGW Approved
Local Authority City of Swan

Date: 24/10/2012
Sheet 1 ˜ 1

YORK LWMS

APPENDIX A
XPSWMM
MODELLING

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Modelling Methodology

Modelling was done using XPSWMM, an industry standard hydrologic and hydraulic modelling software system. It routes flow from hydrological sub-catchments through 1D connections, allowing an analysis of the hydraulics of the site drainage. All hydrological sub-catchments modelled use the Laurenson Routing Method, with a B value calculated by the XPSWMM software.

Rainfall Parameters

Design rainfall events for York (i.e. temporal rainfall pattern Zone 8) were determined following the procedure detailed in *Australian Rainfall and Runoff* (Engineers Australia 1997). Catchment areas and slopes are determined from analysis of topographical data. The catchment roughness and percentage imperviousness are conservative and were determined from a combination of field experiments, review of AR&R and other technical documents (e.g. *Stream Channel Analysis* (Water and Rivers Commission 2001)).

Pre-development Modelling

The pre-development area was modelled as eight sub-catchments (see Figure 3) with an additional 13 external sub-catchments to model the runoff generated in surrounding land. Areas, slopes and runoff assumptions are provided in Tables A1 and A2.

Table A 1 Pre-development Catchment Areas and Slopes

Sub - Catchment	Total Area (ha)	Impervious Area (ha)	Pervious Area (ha)	Slope	Slope (%)	Land type
C1	69.33	0.69	68.64	0.044	4.4	Sand-Dense Veg
C2	81.52	0.41	81.11	0.047	4.7	Sand-Medium Veg
C3	66.24	0.00	66.24	0.046	4.6	Sand -Spare Veg
C4	66.00	0.00	66.00	0.063	6.3	Sand -Spare Veg
C5	47.43	0.00	47.43	0.05	5	Sand -Spare Veg
C6	47.56	0.00	47.56	0.05	5	Sand -Spare Veg
C7	87.29	0.00	87.29	0.033	3.3	Sand -Spare Veg
C8	54.29	0.00	54.29	0.04	4	Sand -Spare Veg
C9	23.44	0.00	23.44	0.05	5	Sand -Spare Veg
C10	36.35	0.00	36.35	0.038	3.8	Sand -Spare Veg
C11	40.50	0.00	40.50	0.0385	3.85	Sand -Spare Veg
C12	79.67	0.40	79.27	0.0645	6.45	Sand -Spare Veg
C13	17.21	0.00	17.21	0.0625	6.25	Sand -Spare Veg
C14	13.05	0.65	12.40	0.044	4.4	Sand -Spare Veg
SA1	28.93	0.00	28.93	0.022	2.2	Sand -Spare Veg
SA2	32.20	0.16	32.04	0.0095	0.95	Sand -Spare Veg
SA3	11.95	0.06	11.89	0.0095	0.95	Sand -Spare Veg
SA4	32.46	0.16	32.30	0.021	2.1	Sand -Spare Veg
SA5	14.23	0.43	13.80	0.019	1.9	Sand -Spare Veg
SA6	16.96	0.85	16.11	0.021	2.1	Sand -Spare Veg
SA7	12.51	0.00	12.51	0.0115	1.15	Sand -Spare Veg
SA8	1.38	0.00	1.38	0.0065	0.65	Sand -Spare Veg

Table A 2 Pre-development Infiltration Rates

Infiltration Land Type	Initial Loss (mm)	Continuing Loss (mm/hr)	Manning's n
Sand-Sparse Veg	17.5	2.5	0.03
Sand-Medium Veg	21.5	2.5	0.04
Sand-Dense Veg	25	2.5	0.07
Impervious	1	0	0.013

The aim of the pre-development modelling was to determine the peak runoff rates for the development area and water levels at specific locations along the streamline. This information provides a reference for post development conditions and sets stormwater management criteria. Table A3 summarises the pre-development flows from each sub-catchment and the flows within the streamline at a number of locations along the modelled reach.

Table A 3 Pre-development Catchment and Streamline Modelled Flows

Model Node[4]	Critical Duration[5] 1yr (m^3/s)	Critical Duration[6] 5yr (m^3/s)	Critical Duration[6] 100yr (m^3/s)
SA1	0.000	0.000	0.95
SA2	0.014	0.025	0.58
SA3	0.005	0.009	0.30
SA4	0.014	0.025	1.00
SA5	0.038	0.067	0.55
SA6	0.076	0.132	0.68
SA7	0.000	0.000	0.35
Nxs20	0.04	3.00	10.23
Culv6-Us	0.05	3.50	12.98
Culv6-Ds	0.05	3.48	12.97
Nxs19	0.05	3.49	12.98
Nxs18	0.05	3.48	12.97
Nxs17	0.05	3.47	12.95
Nxs16	0.05	3.46	12.84
Nxs16	0.03	2.16	11.50
Nxs15	0.07	5.47	23.42
Nxs14	0.07	5.73	24.79
Nxs13	0.07	5.69	24.68
Nxs12	0.07	5.65	24.51
Nxs11	0.07	5.65	24.51
Nxs10	0.07	5.65	24.51
Nxs9	0.07	5.63	28.08
Nxs8	0.07	5.63	28.02
Nxs7	0.07	5.54	27.83
Nxs6	0.08	5.89	29.57
Nxs5	0.08	5.86	29.05
Nxs4	0.08	5.81	28.59
Nxs3	0.08	5.81	28.67
Nxs2	0.08	5.81	28.61
BSA2	0.08	6.00	22.47
Outflow from BSA2	-	-	21.72
ChBlock	-	-	7.0571
Nxs1	-	-	6.98
DummySA6	-	-0.03[7]	6.66
Out1 (Ulster Street Culvert)	0.04	0.86	2.95

[4] Catchment nodes are denoted by the prefix SA. All other nodes represent the downstream streamline node.
[5] Sub-catchment critical duration = 1hr, streamline critical duration = 12hrs
[6] Sub-catchment critical duration = 30mins, streamline critical duration = 6hrs
[7] This negative flow has been generated by backing up from downstream restrictions.

Model Node[4]	Critical Duration[5] 1yr (m^3/s)	Critical Duration[6] 5yr (m^3/s)	Critical Duration[6] 100yr (m^3/s)
Out1 (Ulster Street ORF)	-	-	26.45

The model nodes and links for the pre-development model are shown in Figure A2.

Post Development Modelling

The post development was modelled as eight sub-catchments (see Figure 4) with an additional 13 external sub-catchments to model the runoff generated in surrounding land. Areas, slopes and runoff assumptions are provided in Tables A4 and A5.

Table A 4 Post Development Catchment Areas and Slopes

Sub - Catchment	Total Area (ha)	Impervious Area (ha)	Pervious Area (ha)	Slope	Slope (%)	Land type
C1	69.33	0.69	68.64	0.044	4.4	Sand-Dense Veg
C2	81.52	0.41	81.11	0.047	4.7	Sand-Medium Veg
C3	66.24	0.00	66.24	0.046	4.6	Sand -Spare Veg
C4	66	0.00	66.00	0.063	6.3	Sand -Spare Veg
C5	47.43	0.00	47.43	0.05	5	Sand -Spare Veg
C6	47.56	0.00	47.56	0.05	5	Sand -Spare Veg
C7	87.29	0.00	87.29	0.033	3.3	Sand -Spare Veg
C8	54.29	0.00	54.29	0.04	4	Sand -Spare Veg
C9	23.44	0.00	23.44	0.05	5	Sand -Spare Veg
C10	36.35	0.00	36.35	0.038	3.8	Sand -Spare Veg
C11	40.5	0.00	40.50	0.0385	3.85	Sand -Spare Veg
C12	79.67	0.40	79.27	0.0645	6.45	Sand -Spare Veg
C13	17.21	0.00	17.21	0.0625	6.25	Sand -Spare Veg
C14	13.05	0.65	12.40	0.044	4.4	Sand -Spare Veg
SA1	28.93	16.13	12.80	0.022	2.2	Sand -Spare Veg
SA2	32.2	18.77	13.43	0.0095	0.95	Sand -Spare Veg
SA3	11.95	6.68	5.27	0.0095	0.95	Sand -Spare Veg
SA4	32.46	19.99	12.47	0.021	2.1	Sand -Spare Veg
SA5	14.23	5.84	8.39	0.019	1.9	Sand -Spare Veg
SA6	16.96	8.07	8.89	0.021	2.1	Sand -Spare Veg
SA7	12.51	8.40	4.11	0.0115	1.15	Sand -Spare Veg
SA8	1.38	0.00	1.38	0.0065	0.65	Sand -Spare Veg

Table A 5 Post Development Infiltration Rates

Infiltration Land Type	Initial Loss (mm)	Continuing Loss (mm/hr)	Manning's n
Sand-Sparse Veg	17.5	2.5	0.03
Impervious	1	0	0.013

In addition to the assumptions detailed in Tables A4 and A5 the following assumptions were made in the development of the model:

> Basins were assumed to provide localised infiltration with an outflow structure for larger events.

> A saturated hydraulic conductivity of $5x10^{-5}$m/s has been adopted to calculate the basin infiltration loss rating curve (DoW 2007).

> All flows associated with the 1yr 1hr ARI event are discharged to ground via infiltration only.

> Flows detained within the 100yr ARI basins are expected to discharge downstream via the weir.

> Figure A1 details schematically the proposed drainage network.

> For residential lots an average impervious area of 50% was used.

> For the Mixed Use, TAFE, Retirement Village and Proposed Aged Care average impervious area of 80% was used.

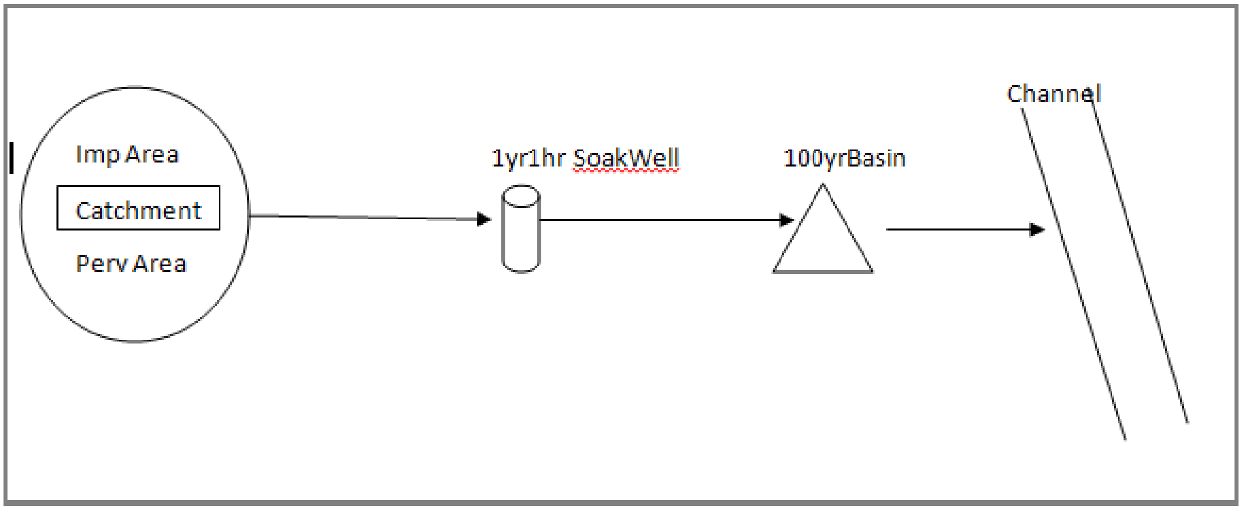

Figure A 1 Pre-development Model

The aim of the post development modelling is to demonstrate the proposed drainage design is capable of mitigating peak flow rates to those of pre-development and to show that the development is able to safely convey the critical storm events through the site. Table A6 summarises the post development flows from each sub-catchment and the flows within the streamline at a number of locations along the modelled reach.

Table A 6 Post Development Catchment and Streamline Modelled Flows

Model Node[8]	Critical Duration[9] 1yr (m^3/s)	Critical Duration[10] 5yr (m^3/s)	Critical Duration[10] 100yr (m^3/s)
SA1	-	-	0.94
SA2	-	-	0.60
SA3	-	-	0.34
SA4	-	-	1.03
SA5	-	-	0.50
SA6	-	-	0.65
SA7	-	-	0.37
Nxs20	0.04	3.00	10.23
Culv6-Us	0.05	3.49	12.98
Culv6-Ds	0.05	3.48	12.97
Nxs19	0.05	3.48	12.98
Nxs18	0.05	3.48	12.97
Nxs17	0.05	3.47	12.95
Nxs16	0.05	3.45	12.85
Nxs16	0.03	2.15	11.50
Nxs15	0.07	5.45	23.41
Nxs14	0.12	5.50	24.58
Nxs13	0.12	5.45	24.46
Nxs12	0.12	5.42	24.28
Nxs11	0.12	5.42	24.28
Nxs10	0.12	5.42	24.28
Nxs9	0.09	6.08	27.85
Nxs8	0.08	6.08	27.78
Nxs7	0.08	5.98	27.60
Nxs6	0.22	6.08	28.92
Nxs5	0.21	6.04	28.46
Nxs4	0.21	5.98	28.02
Nxs3	0.21	5.98	28.09
Nxs2	0.21	5.98	27.97
BSA2	0.23	6.12	22.14
Outflow from BSA2	-	-	21.72
ChBlock	-	-	6.77
Nxs1	-	-	6.68
DummySA6	-	-	6.38
Out1 (Ulster Street Culvert)	0.06	0.30	2.94

[8] Catchment nodes are denoted by the prefix SA. All other nodes represent the downstream streamline node.
[9] Sub-catchment critical duration = 1hr, streamline critical duration = 12hrs
[10] Sub-catchment critical duration = 30mins, streamline critical duration = 6hrs

Model Node[8]	Critical Duration[9] 1yr (m^3/s)	Critical Duration[10] 5yr (m^3/s)	Critical Duration[10] 100yr (m^3/s)
Out1 (Ulster Street ORF)	-	-	25.48

The model nodes and links for the post development are shown in Figure A3. Hydrographs showing the discharge from all sub-catchment basins and through the downstream culvert at Ulster Street have been provided in Figures A4 to A13. These figures show a comparison between pre-development and post development conditions for the critical duration storm events.

Pre-development

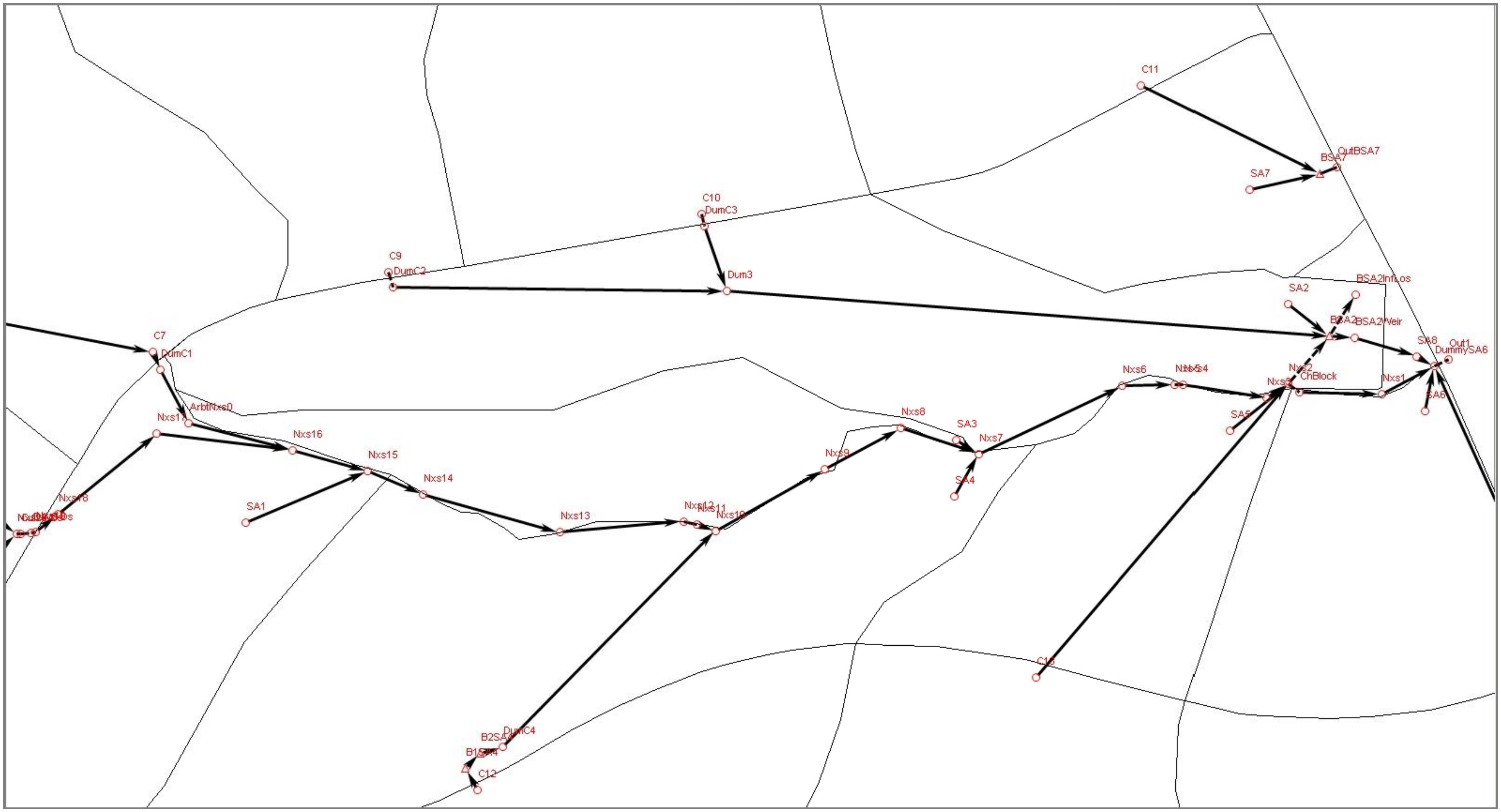

Figure A 2 Pre-development Model

Post Development

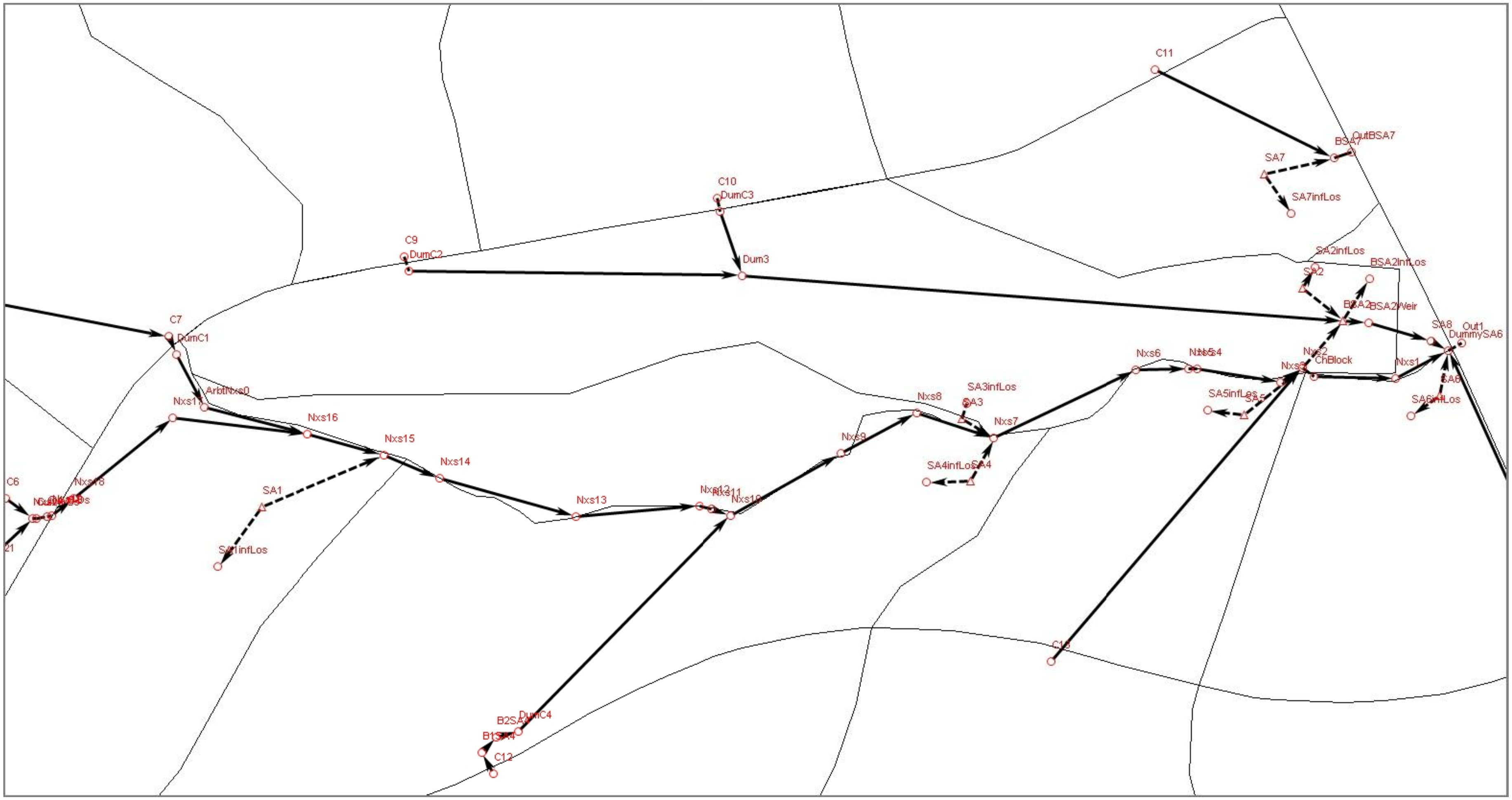

Figure A 3 Post Development Model

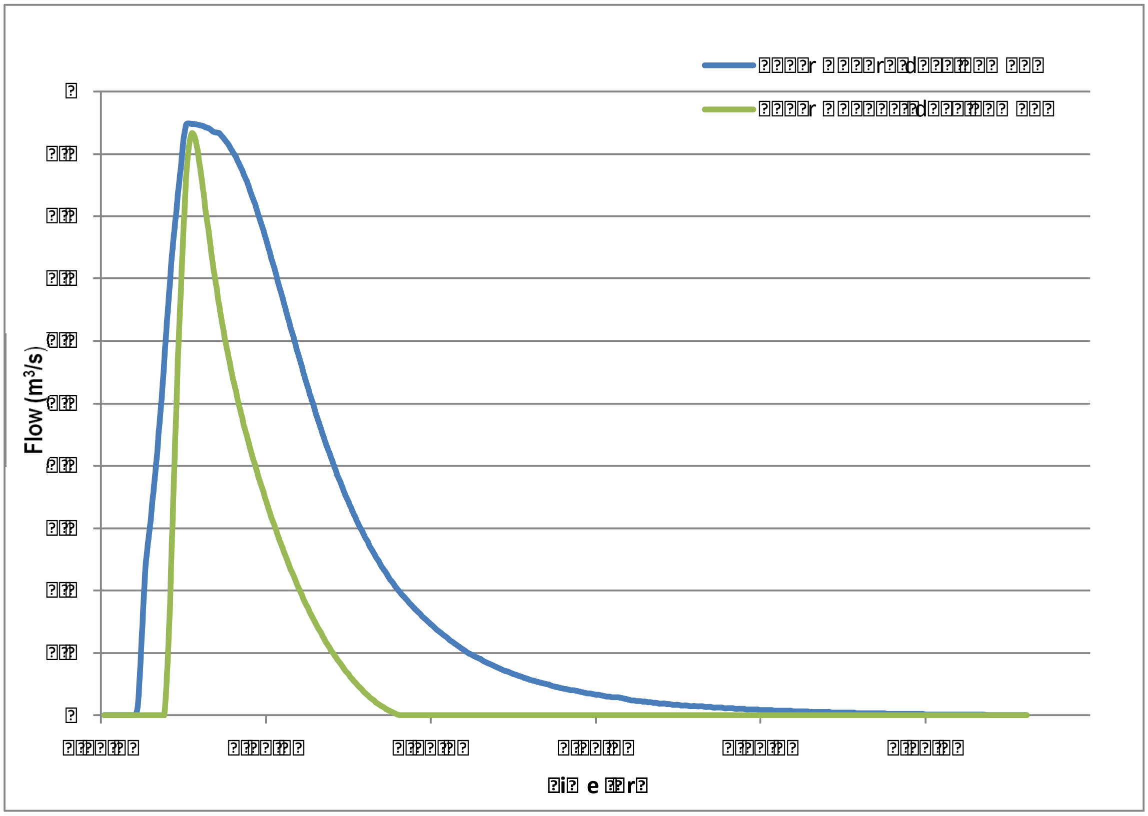

Figure A 4 Discharge from SA1

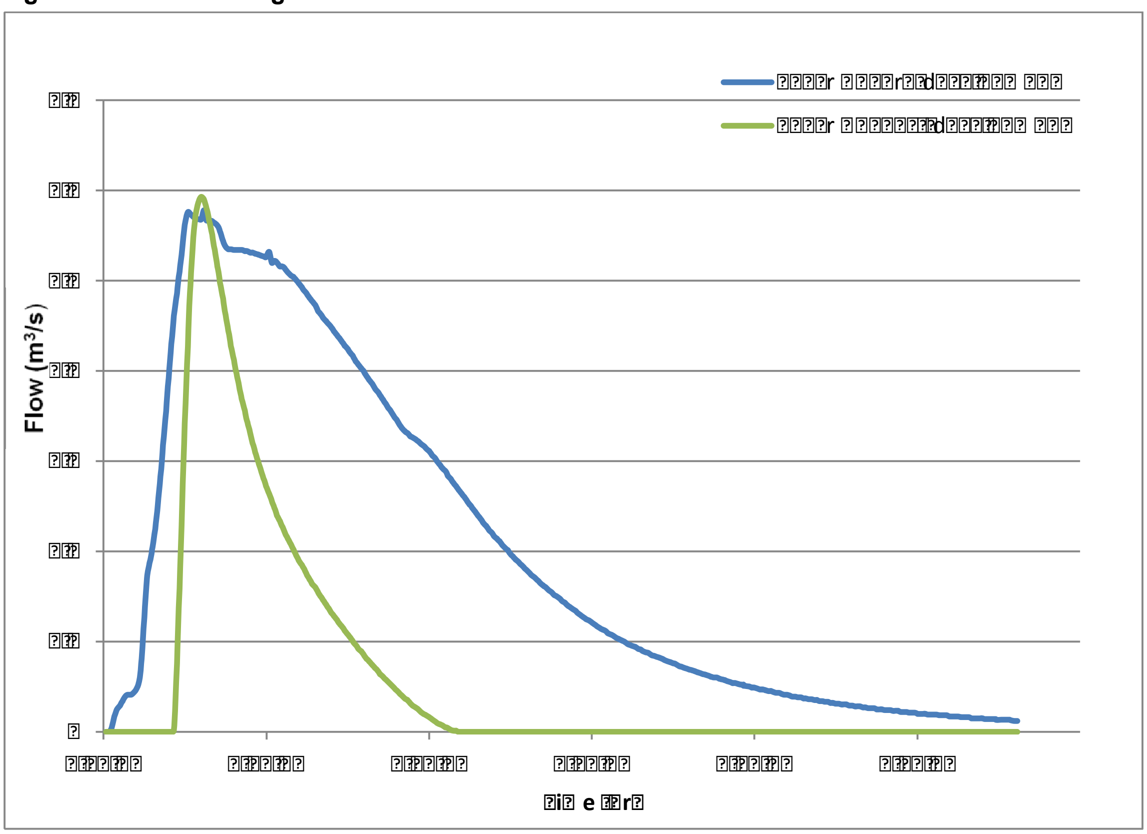

Figure A 5 Discharge from SA2

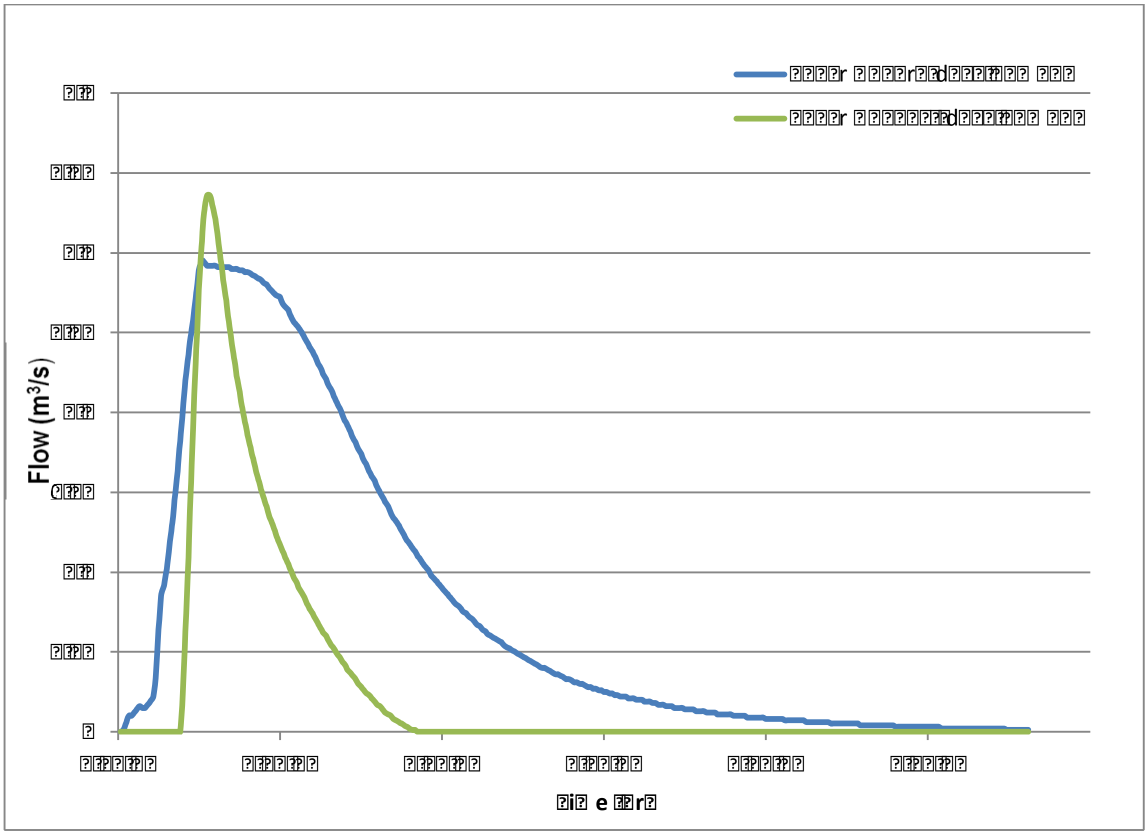

Figure A 6 Discharge from SA3

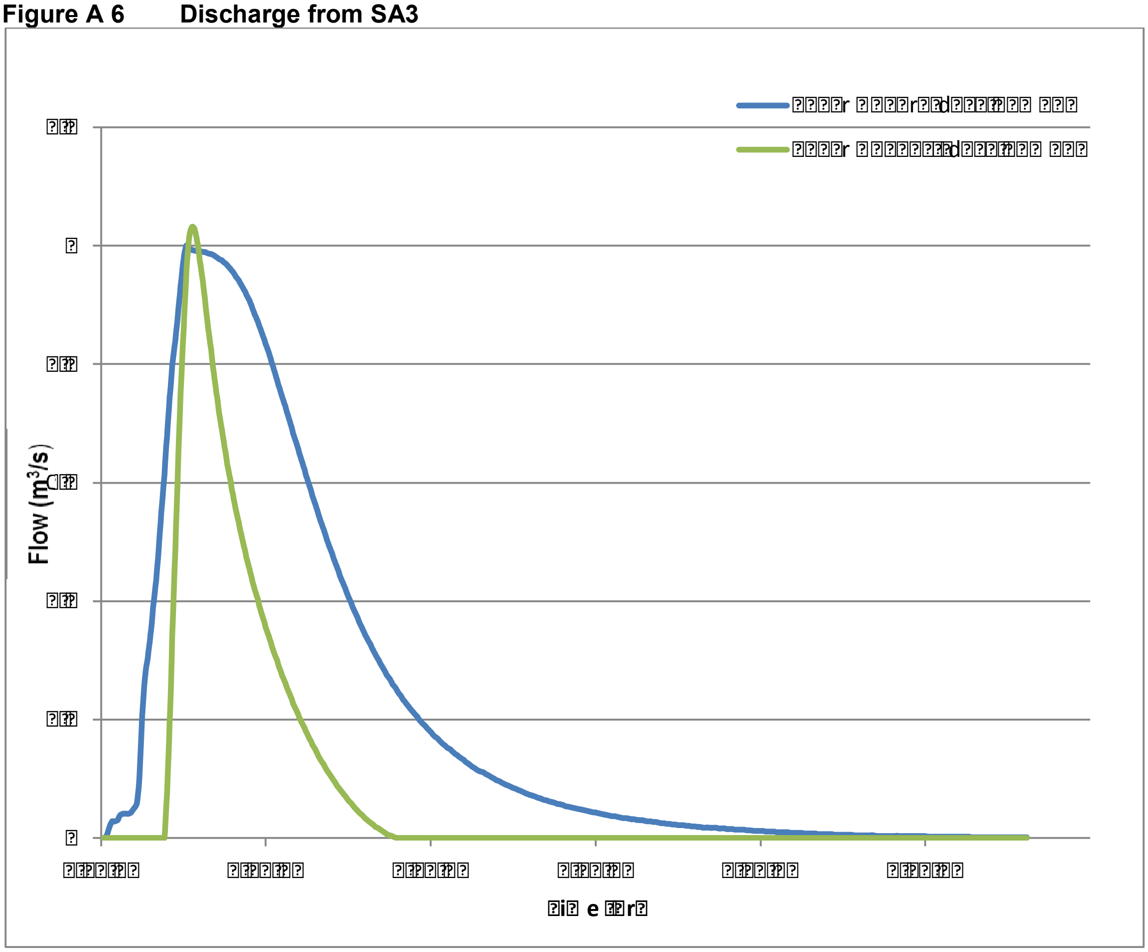

Figure A 7 Discharge from SA4

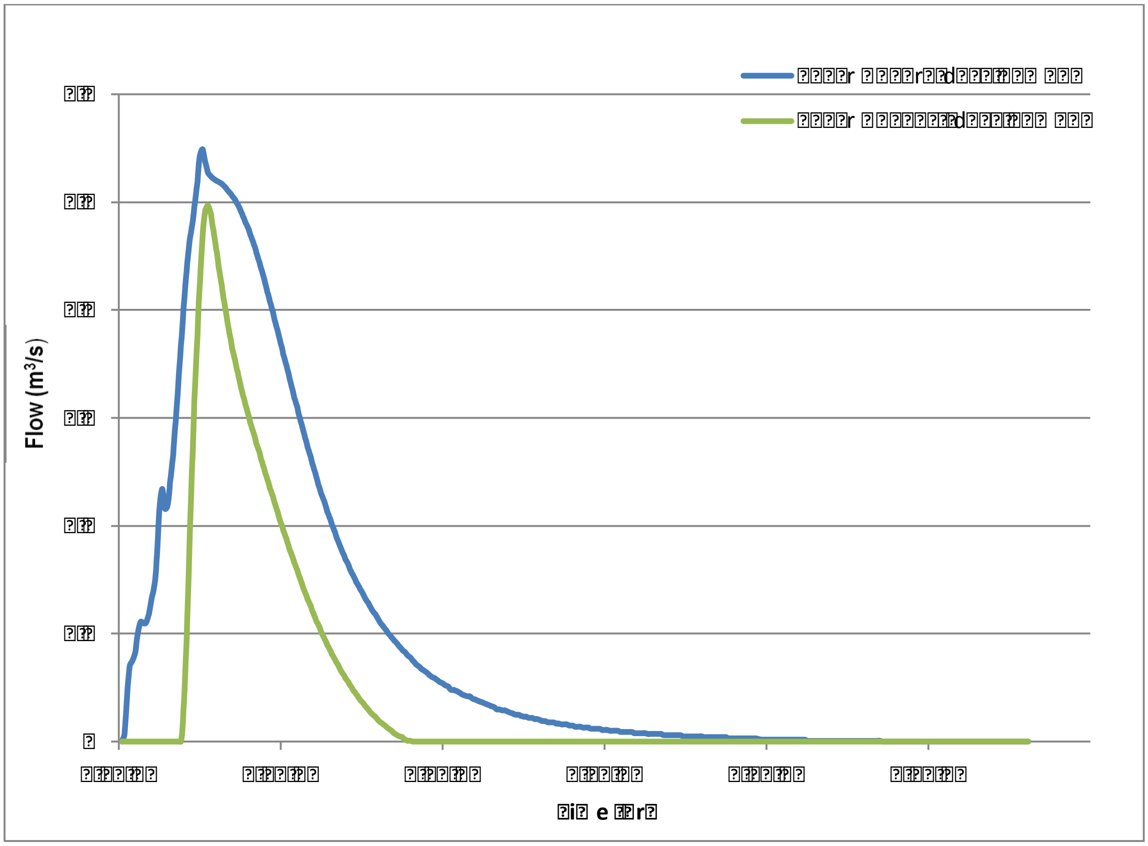

Figure A 8 **Discharge from SA5**

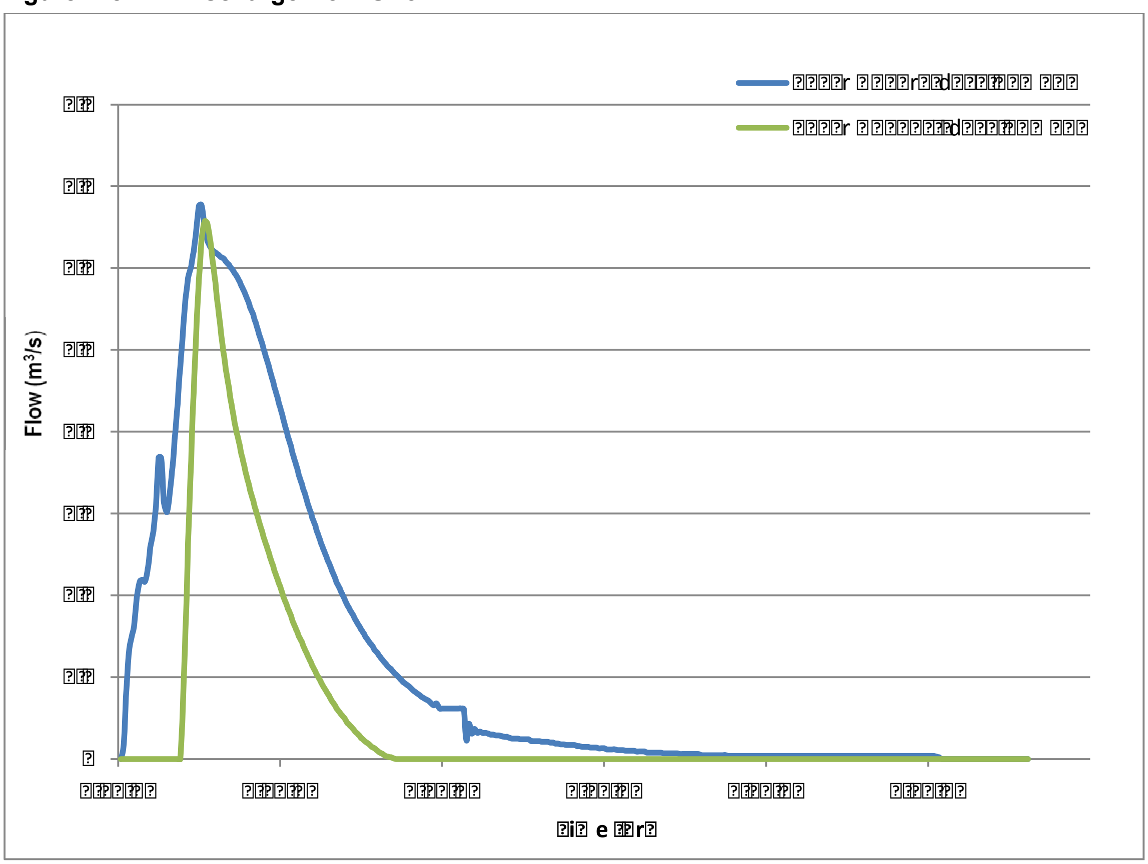

Figure A 9 **Discharge from SA6**

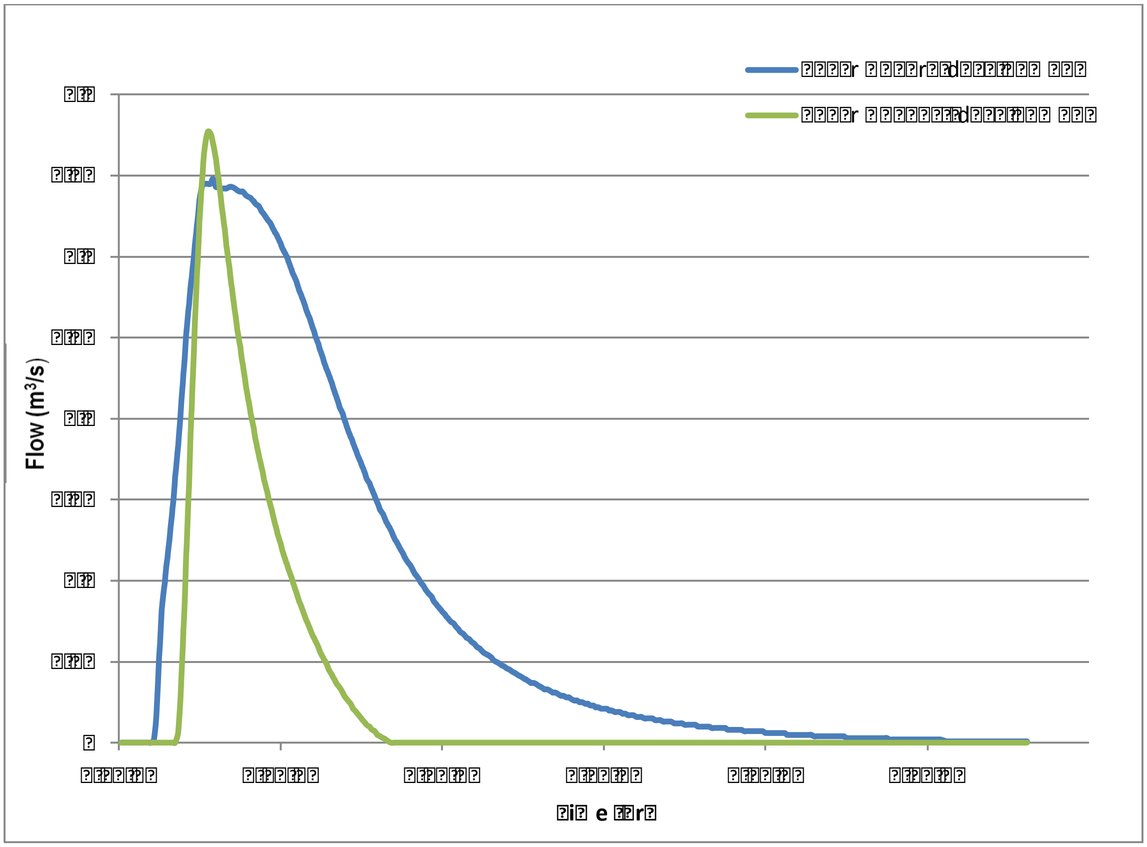

Figure A 10 Discharge from SA7

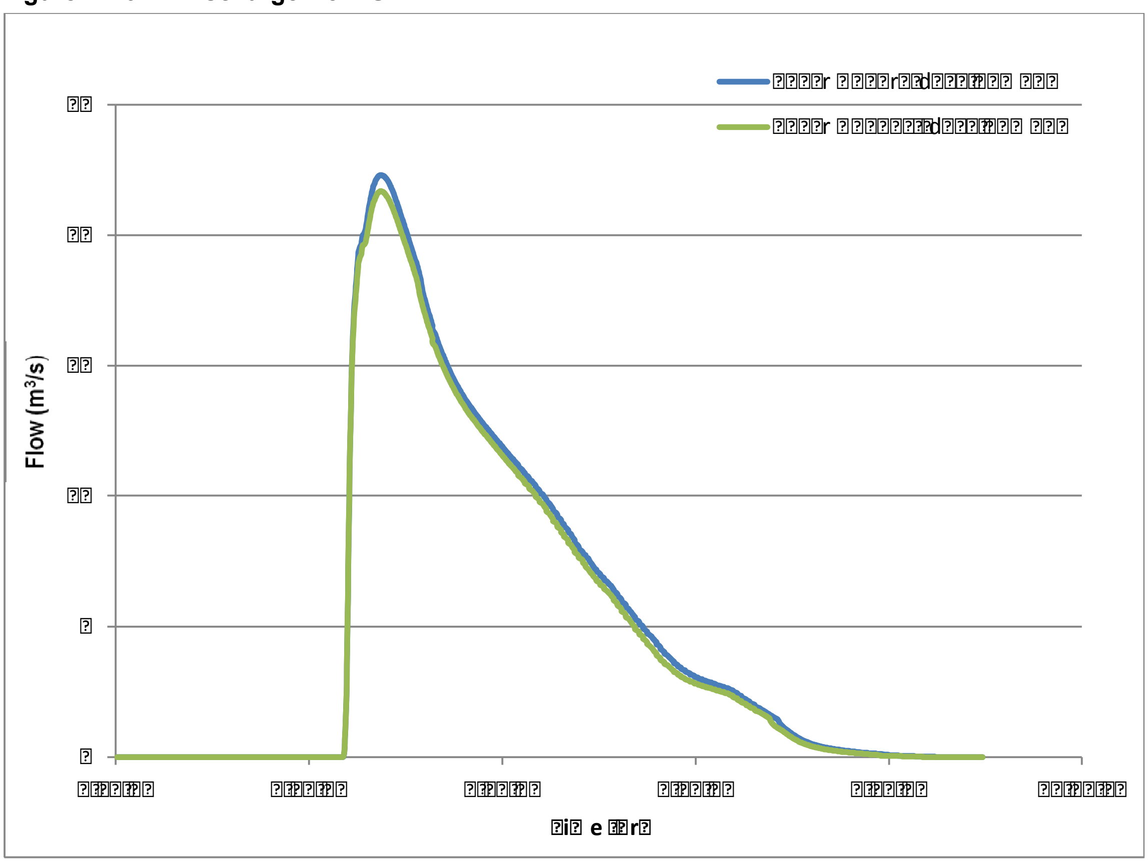

Figure A 11 Discharge from BSA2 Upstream of Ulster Street

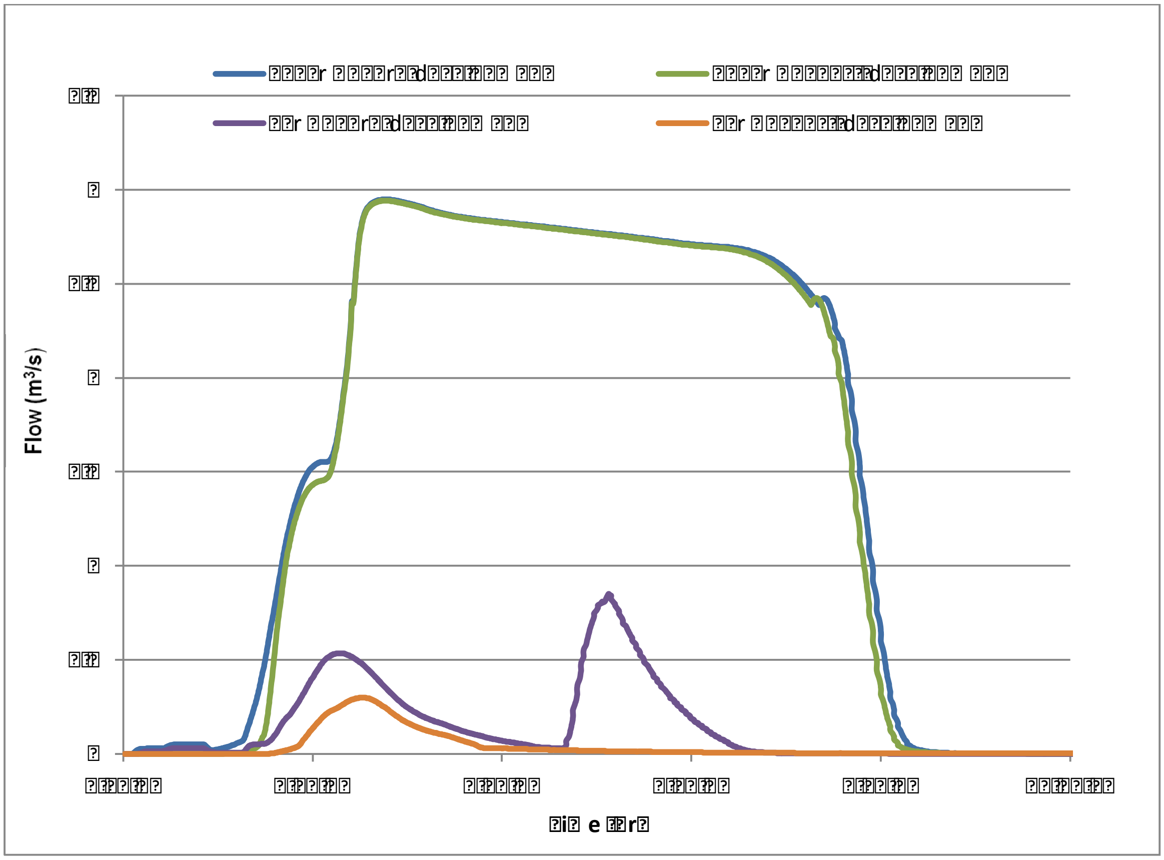

Figure A 12 Discharge through Ulster Street Culvert

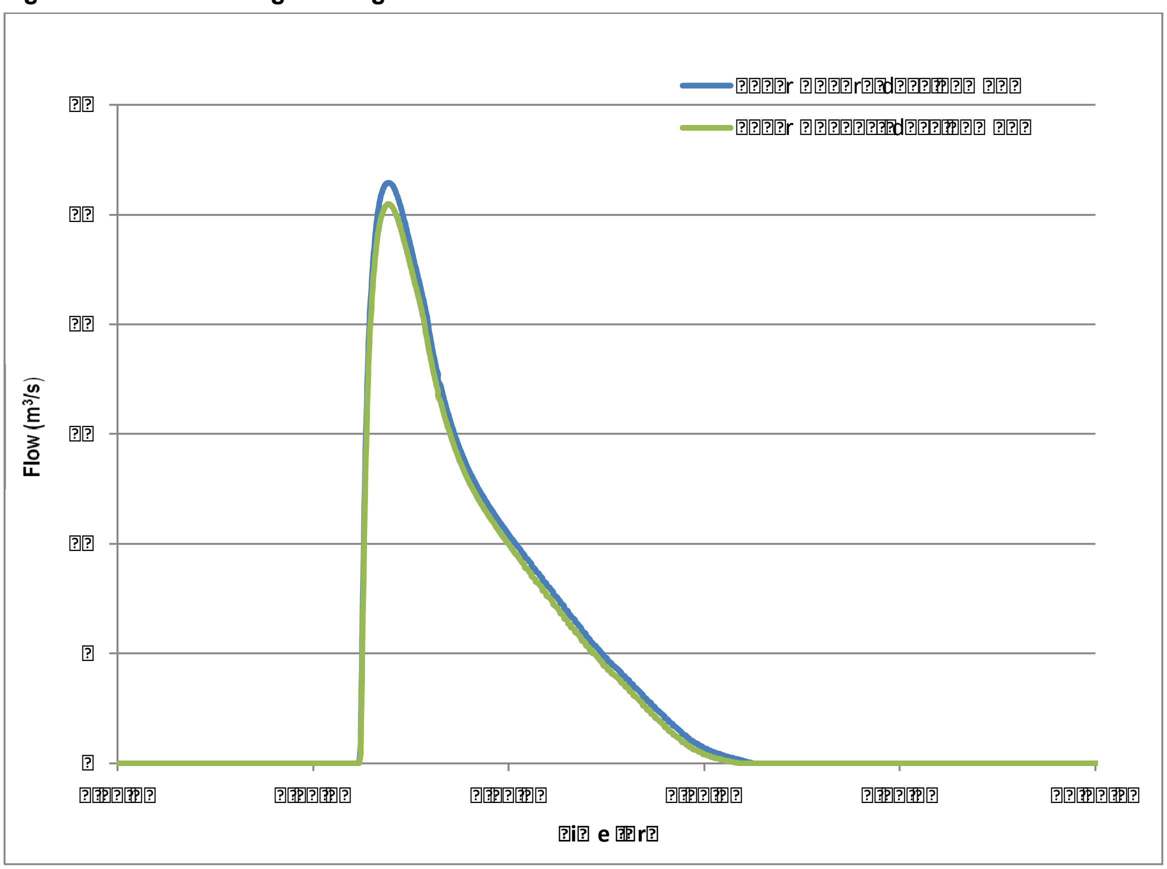

Figure A 13 Discharge over Ulster Street

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APPENDIX B

OUTLINE DEVELOPMENT PLAN

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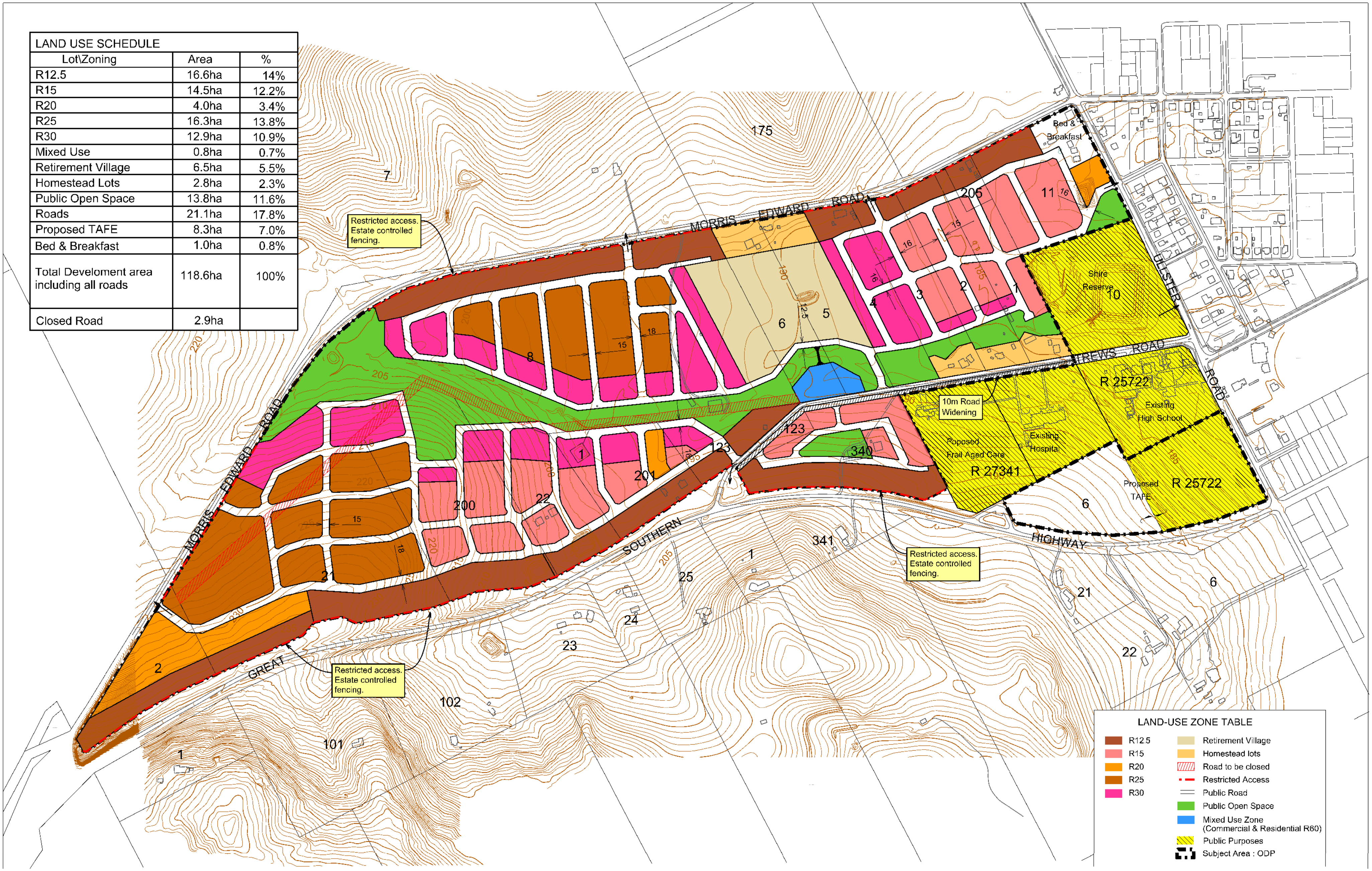

LAND USE SCHEDULE

Lot\Zoning	Area	%
R12.5	16.6ha	14%
R15	14.5ha	12.2%
R20	4.0ha	3.4%
R25	16.3ha	13.8%
R30	12.9ha	10.9%
Mixed Use	0.8ha	0.7%
Retirement Village	6.5ha	5.5%
Homestead Lots	2.8ha	2.3%
Public Open Space	13.8ha	11.6%
Roads	21.1ha	17.8%
Proposed TAFE	8.3ha	7.0%
Bed & Breakfast	1.0ha	0.8%
Total Develoment area including all roads	118.6ha	100%
Closed Road	2.9ha	

Plan No. : 11749-5
Revision : REV.B
Scale : 1:5000@A2

SHIRE OF YORK

All dimensions and areas are subject to survey

Draft

DALIAK - OUTLINE DEVELOPMENT PLAN
MORRIS EDWARD DRIVE AND
GREAT SOUTHERN HIGHWAY
YORK

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TOWN PLANNING

133 Scarborough Beach Road Mount Hawthorn WA 6016 www.whelans.com.au

YORK LWMS

APPENDIX C
WATER BALANCE CALCULATION

Water Balance

The site water balance given in Section 5.2.5 was calculated with the assumptions detailed below.

> Residential housing densities as detailed in Table C1 extracted from State Planning Policy 3.1 (WAPC 2010) and H20ptions (WC 2012).

> Mixed use development area was assumed to be light industrial with 95% of the site considered lettable area. There will be no irrigation requirement.

> The retirement village will have 100 beds and 20% of the site will require irrigation.

> The TAFE site will be solely used for educational purposes, with 200 students and 1200 staff.

> 25% of the total road area will be verge.

> 25% of the POS area will be active and require irrigation. The remainder will be bushland and therefore not require irrigation.

Table C 1 Pre-development Catchment Areas and Slopes

Residential Code	Average lot size (m^2)	Minimum open space (% of lot area)	People/dwelling
Homestead	800	55	2.7
R12.5	800	55	2.7
R15	66	50	2.7
R20	500	50	1.5
R25	350	50	1.5
R30	300	45	1.5

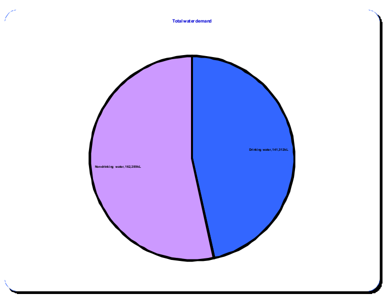
Water Balance Results

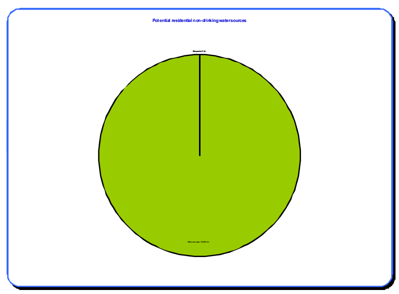
Name of developer	York Farm Holdings
Name of development	York LWMS
Date of entry	22 October 2012
Location of development	Shire of York
Total development area (m²)	1,176,688

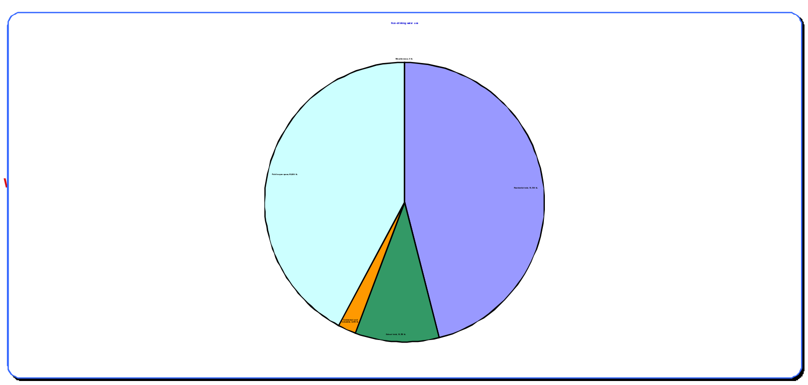
	DEMAND (kL/year)	REQUIRED SUPPLY (kL/year)	
		Drinking water	Non-drinking water
Residential indoor	151,687	124,384	27,304
Residential outdoor	53,283	5,861	47,422
Residential total	204,971	130,245	74,726
School irrigation	15,272	0	15,272
School non-irrigation	1,500	1,050	450
School total	16,772	1,050	15,722
Commercial and industrial	12,744	9,326	3,418
Public open space	69,115	691	68,424
Miscellaneous	0	0	0
Development total	303,602 kL	141,312 kL	162,289 kL
kL / person / year	112.08		

Potential residential non-drinking water sources (kL/year)

Rainwater	Greywater	Other sources
0	0	74,726







YORK LWMS

APPENDIX D
VISUAL ASSESSMENT SHEET

POS Condition Monitoring Field Assessment Sheet

Project Information

Project: **Date:**

Project Number: **Assessor:**

Assessment

Is this the initial POS condition assessment? Y / N

Location	Aspect	Good	Poor	Comment/Description
Drainage System	Debris			
	Gross Pollutant Litter			
	Storm Damage			
	Silt			
POS Area	Weed Infestation			
	Condition of Garden Beds and Park Trees			
	Turf Condition			
	Visible Damage to Irrigation System			
	Condition of Paving			
	Condition of Furniture/Structures/Fences			
	Indications of Theft/Vandalism			
	Litter			

About Cardno

Cardno is an ASX200 professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company, listed on the Australian Securities Exchange [ASX: CDD].

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