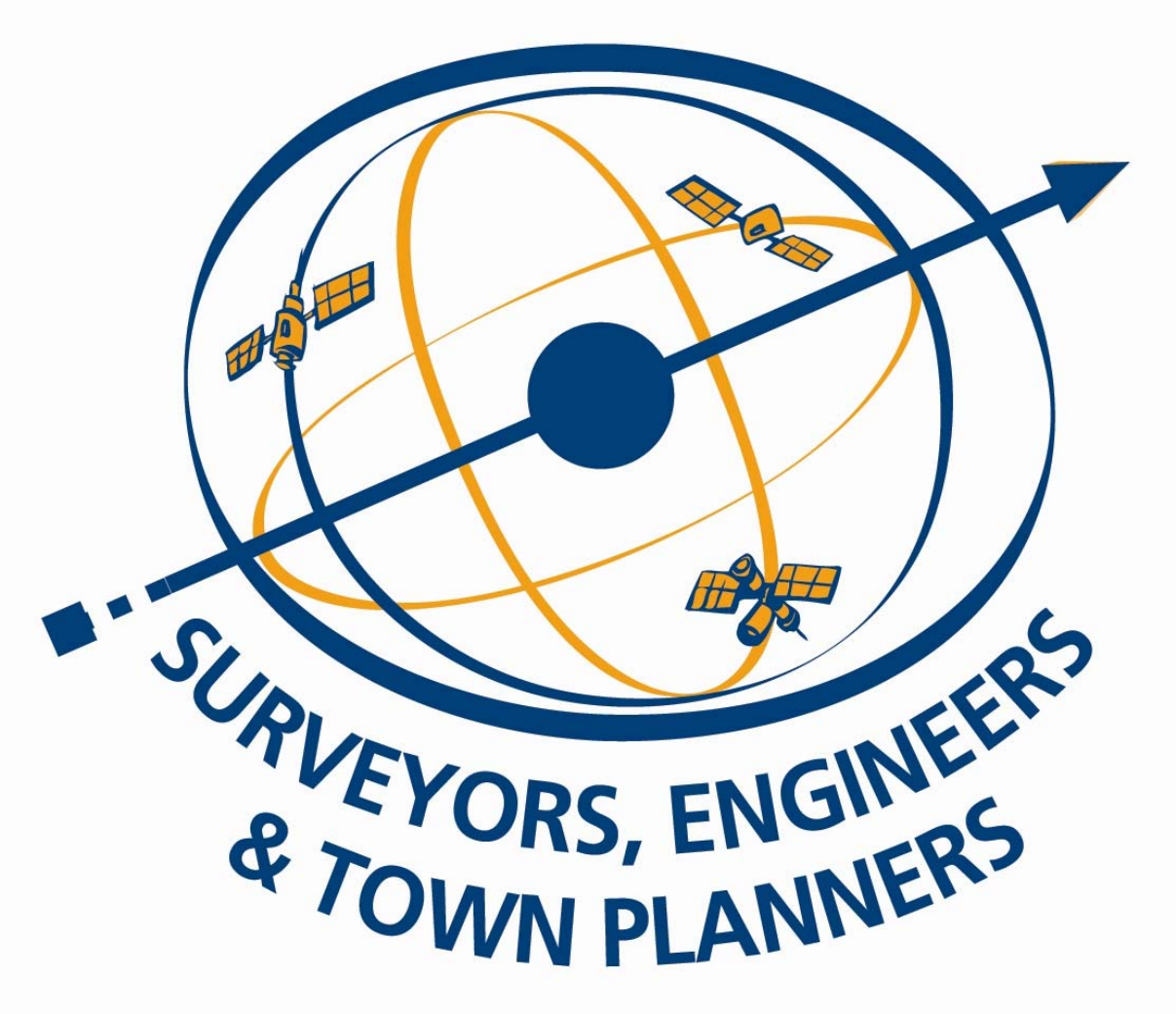
STORMWATER MANAGEMENT PLAN AND FLOOD STUDY



58 LOT RESIDENTIAL SUBDIVISION OF
LOT 682 DP 568678, Lot 705 DP 613881 and Lot 810 DP 247285,
Manyana Drive
MANYANA

Prepared by:
Watkinson Apperley Pty Limited

July 2009
Revision A

EXECUTIVE SUMMARY

This flood study and stormwater master plan has been prepared by Watkinson Apperley Pty Ltd on behalf of the property owner, Vacenta Pty Ltd in a joint venture with JWA Enterprises Pty Ltd for the Development Application of a proposed 58 Lot subdivision at Manyana. The subject site is Lot 682 DP 568678, Lot 705 DP 613881 and Lot 810 DP 247285, Manyana Drive, Manyana (Figure 1.1). The proposed subdivision layout is described in Figure 1.2.

This report has been prepared as a supplementary report to the Stormwater Master Plan prepared by Storm Consulting dated November 2005. This report supersedes the November 2005 report as a result of a reduction in the number of proposed new Lots resulting from subsequent environmental assessment and consequent constraints on development. Additionally, rainwater tanks have been removed from the stormwater concept due to Shoalhaven City Council's proposed dual water main reticulation scheme. The stormwater quality model provided in this report is based on the November 2005 model refined to match the revised lot layout and developed catchment characteristics.

The outcomes of this report are presented to address the necessary changes to the water quality model described in the Storm Consulting report and the stormwater issues raised by Shoalhaven City Council and the NSW Department of Planning in their initial assessment of the Proposal (Refer Section 1.4).

The site is located along the eastern edge of the existing developed residential area of Manyana and is located at the downstream end of a stormwater catchment approximately 70ha in size. The catchment draining through the site includes a large portion of the existing development within the Manyana township. A remnant watercourse traverses the lower portion of the site, carrying stormwater flows from the catchment through to Manyana Beach.

The subject lots to be developed are residue lots from previous subdivisions of the area that have been progressively developed in stages over a period of 45 years. This proposal forms infill development of the residue lots to complete development in this area and as a result will involve some integration of new drainage into existing infrastructure. The stormwater concept plan is provided in Figure 1.3 and incorporates water sensitive urban design Best Management Practices where possible in infill development.

Water quality modelling of the catchment for the proposed development and water quality treatment devices predicted a net reduction in pollutant load for gross pollutants, suspended solids, and total phosphorous, with a less than 2% increase in total nitrogen. (Refer Section 5.4). It was noted that as the catchment currently has no specific water quality management and that the measures will provide treatment for the whole catchment, the proposal will provide a net benefit to water quality for the catchment.

Hydrologic and hydraulic modelling was performed and detailed in this report to estimate the impact on peak flows in the catchment from the proposed development. It was determined that there would be no increase in the total peak flow from the development within the limits of accuracy of the hydraulic modelling (Refer Section 4.1).

The hydraulic modelling performed for this report also estimated the peak water levels over the remnant creek and proposed lots at the lower end of the catchment for estimation of flooding impact in major storms (Refer Section 4.2). Ground survey was performed to accurately represent selected cross sections for analysis within the model. The limit of inundation at each cross-section was estimated for the 100 year ARI event and for the 100 year ARI event incorporating climate change and plotted as described in Figure 4.2: 100 Year ARI Inundation Limits and Figure 4.3: 100 Year ARI Inundation Limits Incorporating Climate Change respectively. Flood levels between sections were interpolated. Figure 4.2 shows that proposed Lots 115, 116 and 119 are the only lots impacted by flood flows from the 100 year flood event (and therefore all events of lesser magnitude). However, lots 103, 115, 116, 117, 118 and 119 were affected when taking into consideration the affects of future climate change.

As a consequence of the predicted flood extents a minimum finished floor height of 500mm above the predicted 100 year ARI incorporating climate change flood level is proposed. The minimum habitable finished floor levels of the affected lots are provided in Table 6.3.

On the basis of a minimum habitable floor level of 500mm above the 100 year peak water level incorporating climate change it is considered that an acceptable level of flood protection is provided to residents in the long term.

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1 INTRODUCTION

1.1 Location

The subject site is Lot 682 DP 568678, Lot 705 DP 613881 and Lot 810 DP 247285, Manyana Drive, Manyana (Figure 1.1).

The site is located along the eastern edge of the existing developed residential area of Manyana in the area bounded by Manyana Drive, Sunset Strip, The Palisade, The Barbette, The Bounty and the fore dunes of Manyana Beach.

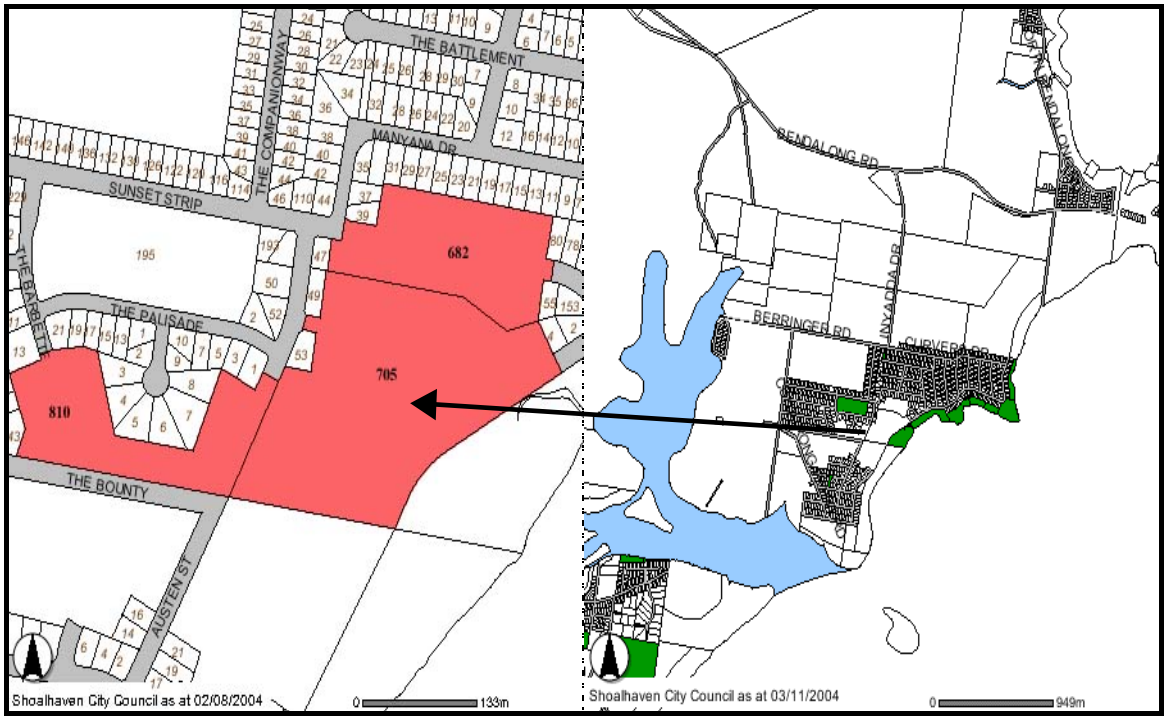


Figure 1.1: Site Location

1.2 Existing Environment

The site is partly cleared and partly covered by the natural coastal vegetation. It is located at the downstream end of a 70ha catchment, which takes in a large portion of the developed portion of Manyana. A remnant watercourse traverses the site, in a west to east direction generally behind the location of proposed lots 115, & lots 103 to 101, through to Manyana Beach. There is also a smaller drainage path running from a piped drainage outlet at the rear of Lot 630 DP247282 (No. 25) Manyana Drive to the remnant watercourse. (Refer Figure 1.2: Proposed Subdivision Layout)

The subject site slopes generally and gradually towards the watercourse and the ocean at grades of between 1% and 5%.

FIGURE 2.1

N

W E

S

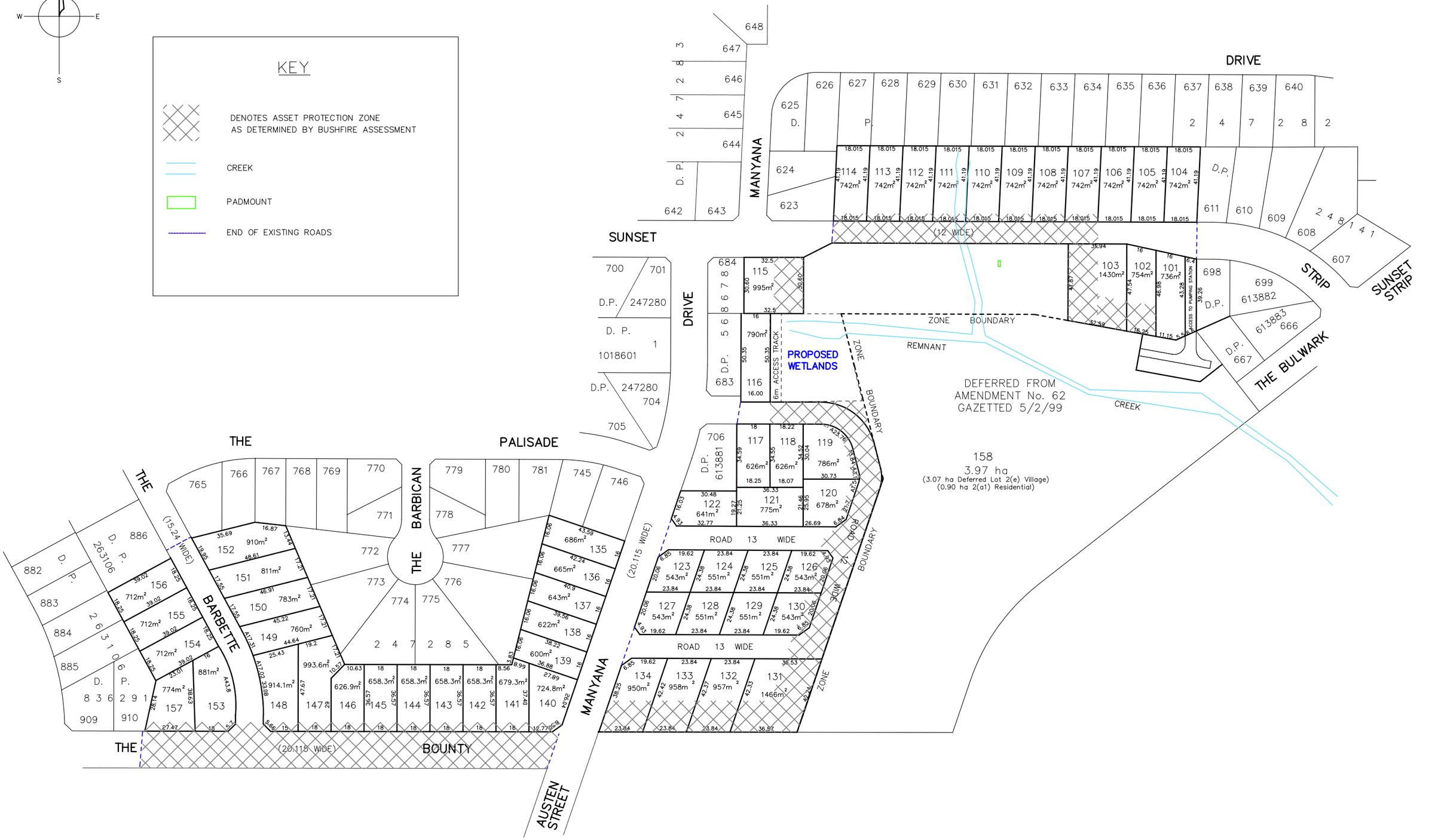
KEY

DENOTES ASSET PROTECTION ZONE
AS DETERMINED BY BUSHFIRE ASSESSMENT

CREEK

PADMOUNT

END OF EXISTING ROADS



REDUCTION RATIO	DATUM			AMENDMENTS	BY	DATE
1:1000 A1 1:2000 A3	AHD	SURVEY	0	0. ORIGINAL PLAN	BP	22/8/03
		DESIGN	TW	1. AMEND LOT BOUNDARIES & ADD SCC SEWER PUMPING STATION	TW/VI	16/12/03
		DRAWN	BP	2. AMEND LOT BOUNDARIES 725–730, PATHWAY & SCC SEWER PUMPING STATION	TW/VI	18/2/04
		CHECKED	TW	3. AMEND LOT BOUNDARIES, ADD SEWER PUMPING STATION & PERIMETER FIRE TRAIL	TW/VI	31/3/05
		APPROVD		4. REMOVE 14 LOTS, AMEND LOT BOUNDARIES, REDUCE ROAD WIDTH & CHANGING APZs	DCA	20/12/07
				5. AMEND LOT BOUNDARIES	DMC	24/04/08

NOTE: DIMENSIONS AND AREAS ARE SUBJECT TO FINAL SURVEY

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SURVEYORS & ENGINEERS
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DATE: 26 MARCH 2008

PROPOSED SUBDIVISION LAYOUT
LOT 682 DP 568678, LOT 705 DP 613881 AND LOT 810 DP 247285
MANYANA DRIVE, MANYANA
FOR JWA ENTERPRISES PTY LIMITED

SHEET 1 OF 1 SHEETS

REF. No. 101662

PLAN No. 03/141

101662 PROP SUBD.DWG

1.3 Proposed Development

JWA Enterprises Pty Ltd proposes to create a fifty eight lot residential subdivision over the subject site.

It is noted that the proposed development Layout (Figure 1.2) has been amended from versions dated prior to this report and that adopted in Storm Consulting's Stormwater Master Plan (November 2005) as a result of other site constraints.

1.4 Background and Aims

This report has been prepared as a supplement to the Stormwater Master Plan (Appendix A) dated November 2005 and prepared by Storm Consulting Pty Ltd for the subject development. The original Stormwater Master Plan provided a stormwater management philosophy for the site and an analysis of the stormwater runoff quality pre and post development.

As a result of necessary changes to the subdivision layout, the water quality model has been revised within this report based upon the original model to account for necessary changes in design.

The NSW Department of Planning and Shoalhaven City Council have reviewed the Stormwater Master Plan. The following matters relating to stormwater were identified as requiring further assessment.

NSW Department of Planning Issues

- Flood impact assessment to be prepared identifying flood mitigation strategies and any flood prone land on the site.
- Stormwater plan to be prepared for the subdivision based on best practice Water Sensitive Urban Design (WSUD) principles.

Shoalhaven City Council Issues

- Drainage easements and overflow paths through proposed Lots 108/109 (now Lot 111) and 7 (now deleted), and through 12/13 (now deleted) need to be identified and addressed.
- Provide some assessment (preliminary only) of the existing drainage system to cater for flows from new development off The Barbette.
- Interallotment Drainage to be provided for Lots 141 –146 and connected through an existing property to The Palisade.
- Assessment to be provided of development impact on peak flow quantities for stormwater, noting that the provision of detention basins will have limited if any benefit due to the development being at the downstream end of the catchment.

This report therefore has been prepared to address the comments from Shoalhaven City Council and the NSW Department of Planning.

1.5 Methods of Analysis

The 1:25000 topographical map, reference Cunjurong Point 9027-3-N, provided by *Centre Mapping Authority*, was used to provide general indications of creek locations, catchment sizes and slope grades. The contours of these maps, which were provided at 10 metre contour intervals, are shown in Figure 1.3. All levels are approximate Australian Height Datum (AHD).

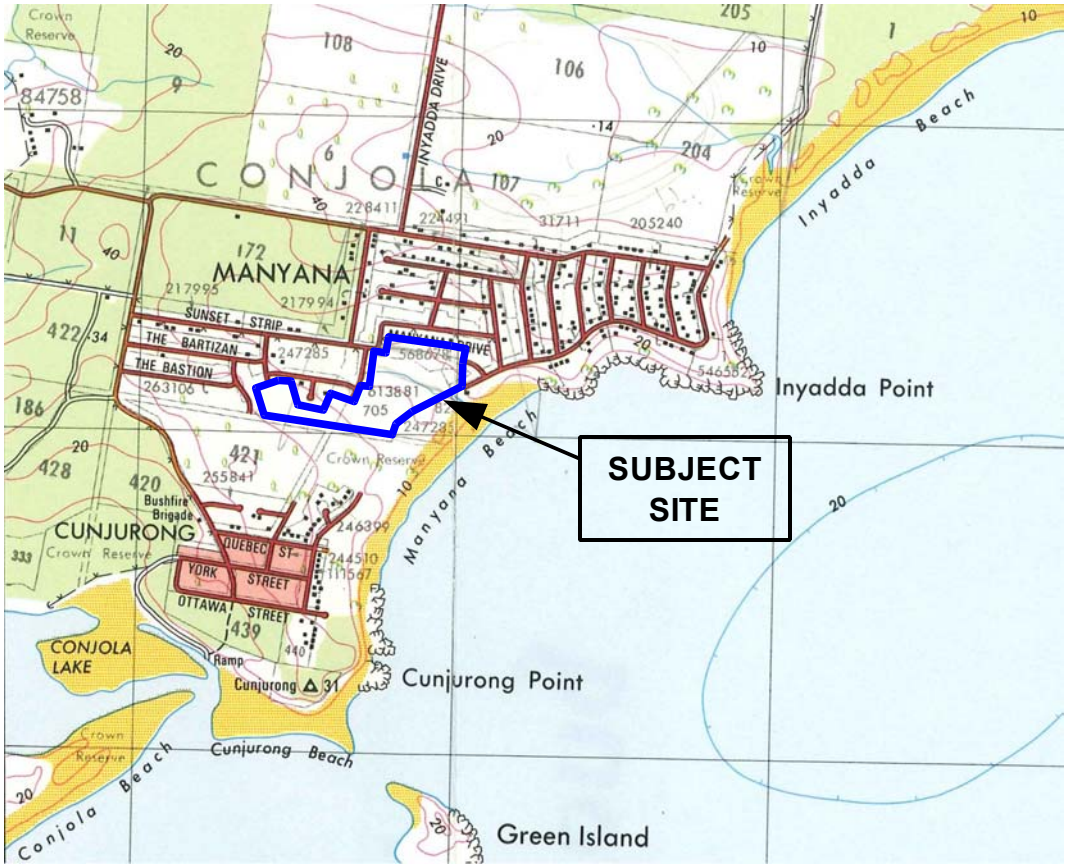

Figure 1.3: Topographical Map

Approximate pit locations and pipe sizes for the existing drainage network were estimated from Shoalhaven City Council survey records with ground truthing at connection and outlet points to the proposed subdivision (Appendix B). This data has been adopted for the preliminary consideration of connections of new drainage systems to the existing network only and does not necessarily represent the exact or full extent of the drainage network. As the existing drainage network currently drains a large extent of the Manyana urban catchment, any detailed assessment of the existing network should be performed by Shoalhaven City Council and does not form part of this report.

The catchment and rainfall data were determined using the methods described in *Australian Rainfall and Runoff, Vol. 1 (1987)* using the Statistical Rational method analysis.

The stormwater runoff and water levels for the various cross sections within the remnant creek were determined by modelling them in the urban drainage design and analysis modelling software “DRAINS”. “DRAINS” calculates catchment response by unit hydrograph and kinematic wave analysis. Flow depths for overland flow upstream of the creek were determined using open channel flow analysis with the peak overflows determined from the DRAINS model.

To determine peak water levels for assessment of flood conditions, cross-sections were taken at six locations along the water course. Additionally, two cross sections were taken upstream of the outlet headwall, one through Manyana Drive and one through proposed lots 115 and 116. These cross-section profiles were obtained from ground survey and were chosen to represent typical cross sections along the water course and overflow drainage path.

A revised water quality analysis was performed using the water quality modelling software “MUSIC”. The model parameters and the analysis methods in the original model were used as a base and updated for the revised lot layout to estimate the impact of the proposed development on water quality.

2 STORMWATER MANAGEMENT PHILOSOPHY

Figure 2.1: Stormwater Concept Plan shows the conceptual layout for the stormwater management system which is based on the following philosophies;

- The general drainage philosophy for the site will be to provide piped drainage for the 1 in 5 year Average Recurrence Interval (ARI) storm event within areas draining to existing drainage infrastructure and to provide an overland flow path for the 1 in 100 year ARI storm event. Detailed survey and calculations of the existing piped drainage within The Barbette, The Palisade, and Manyana Drive will form part of the detailed design for the development to confirm the existing pipe system capacity. Where the system capacity is determined to be marginal On Site Detention may be specified for the proposed lots draining to those areas.
- Low flows within the new section of Sunset Strip will be directed to bioretention filters within the road reserve and outflows from the existing piped drainage off Manyana Drive will pass through a proposed constructed wetland such as that identified in Storm Consulting's Stormwater Management Plan (Appendix A). Where possible, treatment of flows for water quality will follow a treatment train approach providing primary, secondary, and tertiary treatment for water quality, via gross pollutant trap, bioretention, and wetland water quality measures.
- The original Stormwater Master plan made allowance for water tanks and reuse of roof water which has benefits in both water quantity and water quality, however It is proposed by Shoalhaven City Council to provide a dual water reticulation scheme to this development. Dual reticulation of water supply will provide treated effluent for use in toilets and external garden use separate to the potable water supply. As these are the same uses that would be applicable for rainwater tanks, the proposed dual reticulation scheme would render rainwater tanks on the proposed lots ineffective. Therefore rainwater tanks no longer form part of the proposed stormwater management philosophy.
- Easements for drainage are to be created over proposed Lots 116 and 111 to cater for the existing drainage lines through those lots with the existing pipe terminating in Lot 111 to be extended through to drain on the downstream side of Sunset Strip.
- Where lots do not drain directly to the street interallotment drainage and easements shall be provided along the rear boundaries to connect to the street drainage system as shown in the Stormwater Concept Plan. An easement will be negotiated with the owners of either Lot 765, 766, or 767 DP 247285, The Palisade for connection of the proposed interallotment drainage with the existing system in The Palisade.

FIGURE 2.1

KEY

EXISTING STORMWATER PIPES (ESTIMATED LOCATION ONLY)

PROPOSED STORMWATER PIPES

PROPOSED INTERALLOTMENT PIPES

VEGETATED BUFFER ZONE

N

W E

S

DRIVE

MANYANA

SUNSET

(ACTUAL LOCATION UNKNOWN)

PROPOSED DRAINAGE EASEMENT 3.0m WIDE

PROPOSED DRAINAGE EASEMENT 1.0m WIDE

EXTEND EXISTING PIPE TO WETLAND

BIORETENTION FILTER

VEGETATED SWALE

6m ACCESS TRACK

ACCESS for PUMPING STATION

PROPOSED WETLANDS SEE DIAGRAM

REMANANT CREEK

SUNSET STRIP

THE BULWARK

THE PALISADE

THE BARBICAN

THE BARBETTE

THE BOUNTY

AUSTEN STREET

ROAD 13 WIDE

ROAD 12 WIDE

ROAD

625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640

624 623

114 113 112 111 110 109 108 107 106 105 104

611 610 609 608 607

115 116 117 118 119 120 121 122

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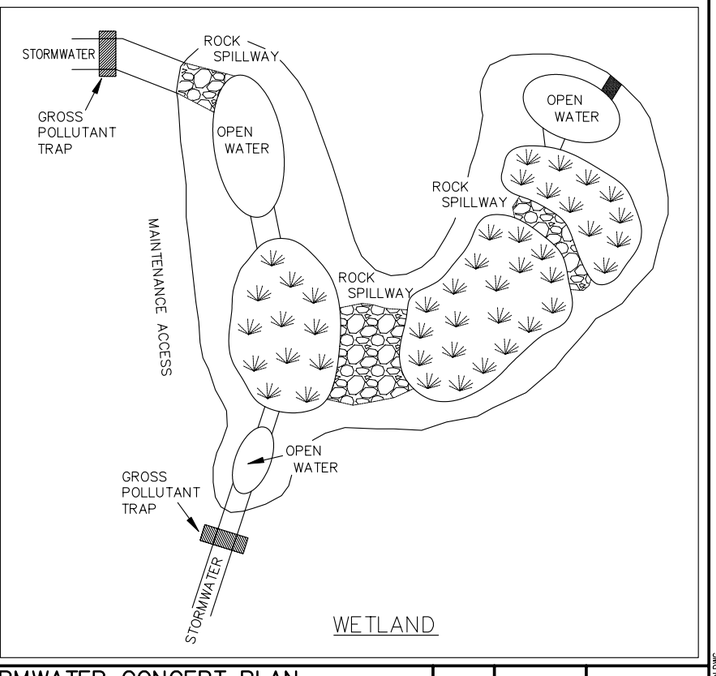

WETLAND

REDUCTION RATIO 1:2000 AT A3 SIZE	DATUM	SURVEY	WA	AMENDMENTS	BY	DATE	
		DESIGN	AR				
		DRAWN	GM				
		CHECK'D	AR				
		APPROV'D					

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DATE: 5 May 2008

STORMWATER CONCEPT PLAN
LOT 682 DP 568678, LOT 705 DP 613881 AND LOT 810 DP 247285
MANYANA DRIVE, MANYANA
FOR JWA ENTERPRISES PTY LIMITED

A3 SHEET 1 OF 1 SHEETS

REF. No. 101662

PLAN No. 08/39

STORMWATER CONCEPT PLAN.DWG

- Stormwater detention is not required for the proposed development as a result of its being predominantly at the downstream end of the catchment. It is generally accepted (and borne out by stormwater flow modelling) that detention facilities installed at the downstream or outlet end of a catchment provide either no reduction, or in some cases an increase in peak flows at the catchment outlet due to the lag time for the bulk of flows over the remainder of the catchment. The proposed wetland therefore is to be designed without specific attention to stormwater detention for peak flow reduction.

3 HYDROLOGY

3.1 Catchment Analysis

The Catchment was divided into 5 sub catchments for flow analysis, Catchments 1a, 1b, 1c, 2 and 3, these catchments are shown in Figure 3.1.

Figure 3.1: Sub Catchments

Catchments 1a, b, and c drain through the existing street pipe drainage network and via overland flows to the soccer field and subsequently to the head of the creek at the downstream end of the proposed development.

Catchment 2 is collected by the existing street drainage which discharges into an open drain through proposed Lot 111 to the water course at the downstream end of the proposed development.

Catchment 3 currently drains as overland flow directly to the creek.

It is noted that the subcatchment delineation adopted in Figure 3.1 is different to that adopted for the water quality model in Section 5 due to the differences between the function of the hydraulic and the water quality models.

3.2 Catchment Modelling and Calibration

The time of concentration and peak flow for each catchment in a totally predeveloped condition was estimated (Appendix C) using the Statistical Rational method for rural catchments less than 250km^2 in eastern NSW (Australian Rainfall and Runoff (ARR), Volume 1 1999).

Estimated peak flows from the statistical rational analysis for the 5 year and 100 year ARI events were used to calibrate the hydrologic model set up in the catchment and drainage modelling program "DRAINS". The DRAINS calibration model was based on a predeveloped condition assuming 0% impervious area over each subcatchment using kinematic wave analysis to model rainfall runoff hydrographs. Storm intensity values are determined in DRAINS based on Intensity Frequency Duration data from ARR 1987, Volume 2.

The DRAINS subcatchments were then adjusted to account for the existing impervious area to model the flows from the existing system. The DRAINS schematic models are provided with resultant flows in Appendix D for both the predeveloped condition and the existing condition. A summary of estimated rational method and DRAINS peak flows is provided in Table 3.1 for the predeveloped and existing conditions.

		Rational Method		DRAINS Predeveloped		DRAINS Existing	
Sub-Catchment	**Area (ha)**	**ARI5 Q_5**	**ARI100 Q_{100}**	**Q_5**	**Q_{100}**	**Q_5**	**Q_{100}**
1a	34.4	5.7	12.8	4.6	11.5	4.6	11.5
1b	7.5	1.6	3.5	1.8	3.7	2.4	4.7
1c	9	1.9	4.1	1.5	3.8	1.5	3.7
2	15.5	3.0	6.6	2.8	6.7	3.4	7.2
3	3.4	0.8	1.8	0.5	1.3	0.5	1.3
Total	69.8	10.0	22.8	11	25.6	11.9	26.3

Table 3.1: Predeveloped and Existing Peak Flows (m^3/s)

4 HYDRAULIC ANALYSIS

4.1 Post Development Site Discharge

The impervious areas for subcatchments 1c, 2, and 3 were adjusted in the DRAINS model to account for the estimated impervious area of the subject development assuming an increase to 40% impervious over the affected areas.

Peak flows for the catchment in a post developed condition were modelled for the 5 and 100 year ARI storm events. Table 4.1 summarises the peak flows for those events from the DRAINS schematics and results and data files are provided in Appendix D.

	DRAINS Post Development	
Sub-Catchment	Q_5	Q_{100}
1a	4.6	11.5
1b	2.4	4.7
1c	2.2	4.6
2	3.4	7.2
3	0.8	1.6
Total	12.1	26

Table 4.1: DRAINS Post Development Flows (m^3/s)

It is noted from comparison of the post development peak flow for the total catchment in Table 4.1 and Table 3.1 that there is no increase in total peak flows as a result of the proposed development for the 100 year ARI storm. Additionally,differences between the existing and post development peaks for the 1 year and 5 year storms (Appendix D) were only 15% and 1.7% respectively which could be considered within the limits of accuracy of the modelling.

4.2 Flood Extents

The extent of inundation over land adjoining the remnant creek was estimated within DRAINS using stream cross sections obtained by ground survey. Levels of inundation were also estimated for two cross sections just upstream of the head of the creek, through proposed lots 115 and 116, and at the Manyana Drive frontage of existing lots 683 and 684 in DP 568678. Figure 4.1 shows the location of those cross sections.

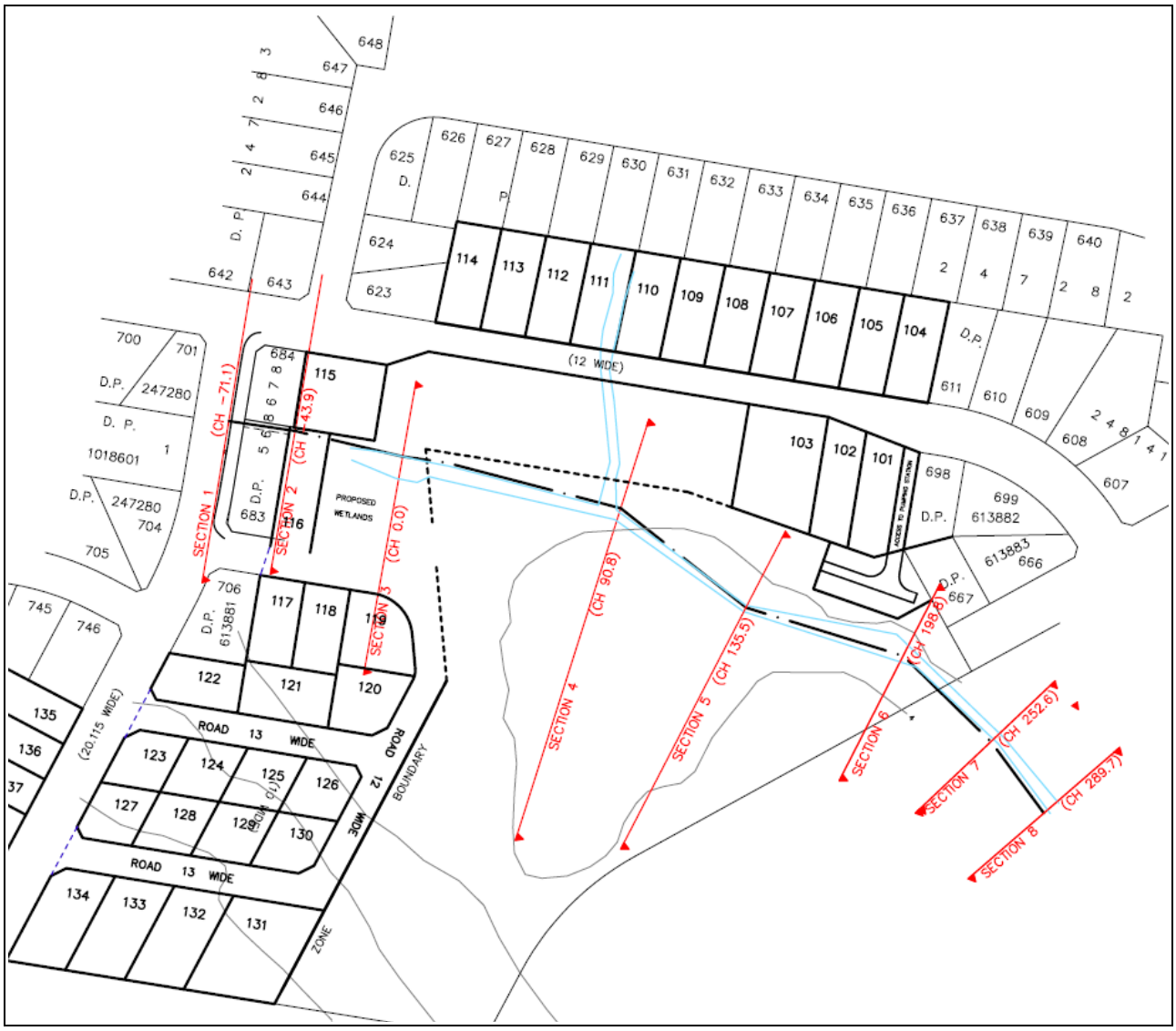

Figure 4.1: Creek Cross Section Locations

The waterway cross section profiles were entered into the "DRAINS" model along with Manning's roughness values for main channel and overbank flow. The Manning's roughness coefficients were estimated from the stream profiles and vegetation observed from the aerial photograph of the study area (Figure 3.1: Sub Catchments) and field investigation.

The Manning's Roughness coefficients adopted allowed for variation of main channel roughness from essentially unrestricted flow with some light weeds and no vegetation on the banks (n=0.025) to heavy weeds with vegetation on the banks and meandering sections (n=0.1). Overbank roughness coefficients were estimated to be generally in the order of 0.05 to 1, allowing for flood plain from light brush to heavy stands of timber.

The two cross sections upstream of the creek head were modelled using the system overflows determined within DRAINS in a simple Manning equation analysis of the overflow path from Manyana Drive to the head of the creek (Appendix E).

The input data and simulation output summaries from DRAINS are provided in Appendix D and the estimated peak water levels for each waterway cross section are tabulated in Table 4.2.

Cross Section No.	Creek Chainage	100 Year ARI Peak Water Level (m AHD)
1	-71.1	5.69
2	-43.9	5.37
3	0	4.68
4	90.8	4.19
5	135.5	4.11
6	198.8	3.72
7	252.6	3.44
8	289.7	2.86

Table 4.2: 100 Year Peak Flood Levels

The above water levels were plotted on the respective cross sections (Appendix F) to determine the extent of flows on each section and these extents were then transferred to catchment plan to produce a plan of the approximate limits of inundation (Figure 4.2) for the 100 year ARI flood event.

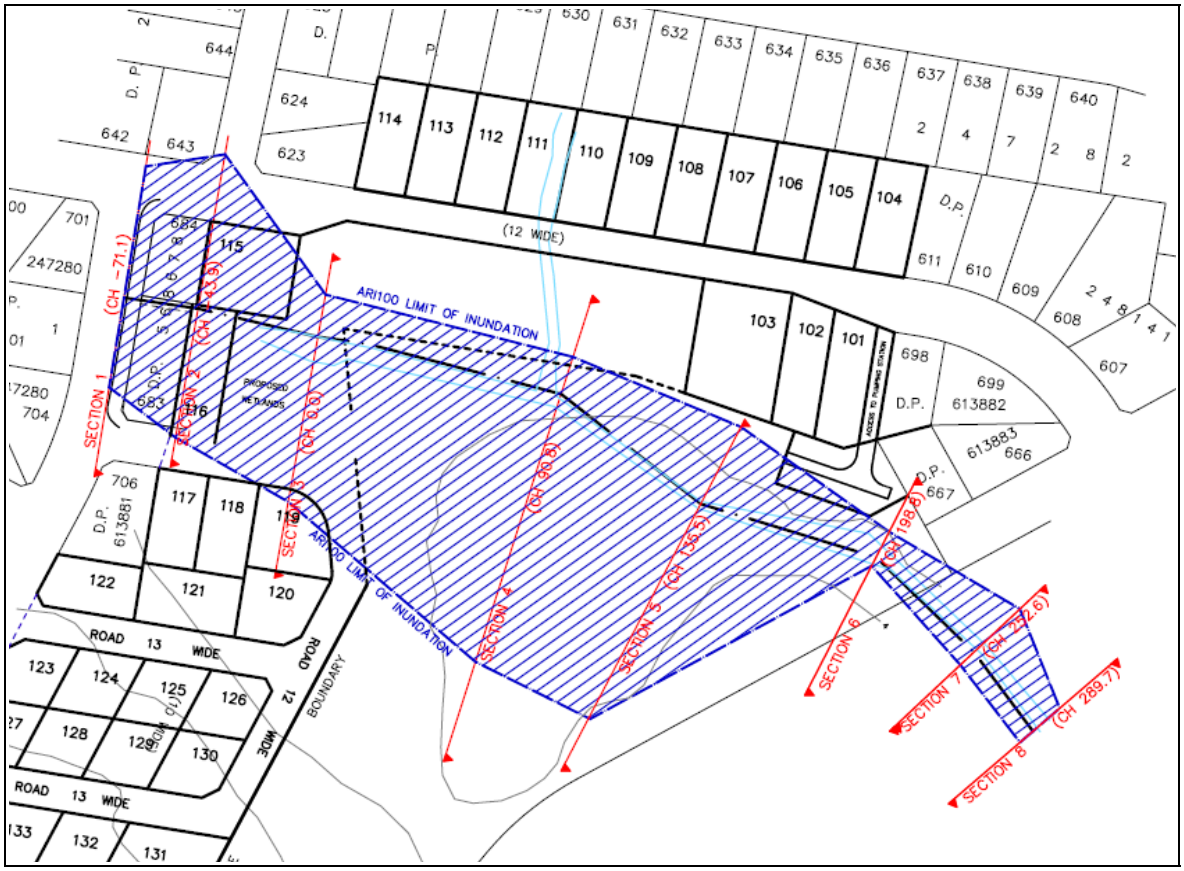

Figure 4.2: 100 Year ARI Inundation Limits

This report also assessed the extent of inundation over land adjoining the remnant creek for the existing 1% AEP event incorporating the increased rainfall intensities and sea level rise associated with future climate change, based on the current NSW Department of Environment and Climate Change (DECC) guidelines for assessing the effects of climate change on flooding and the draft Sea Level Rise Policy Statement respectively.

The waterway cross section profiles discussed above were modeled in “DRAINS” for the worst case scenario using a rainfall intensity increase of 30% above the existing 1% AEP event and a sea level rise of 90cm (sea level of RL 3.7 mAHD at the creek outlet).

The input data and simulation output summaries from DRAINS are provided in Appendix D and the estimated peak water levels for each waterway cross section are tabulated in Table 4.3.

Cross Section No.	Creek Chainage	100 Year ARI Peak Water Level incorporating future climate change (m AHD)
1	-71.1	5.72
2	-43.9	5.43
3	0	4.95
4	90.8	4.46
5	135.5	4.42
6	198.8	4
7	252.6	3.84
8	289.7	3.7

Table 4.3: 100 Year Peak Flood Levels incorporating Future Climate Change

The above water levels were plotted on the respective cross sections (Appendix F) to determine the extent of flows on each section and these extents were then transferred to catchment plan to produce a plan of the approximate limits of inundation (Figure 4.3) for the 100 year ARI flood event.

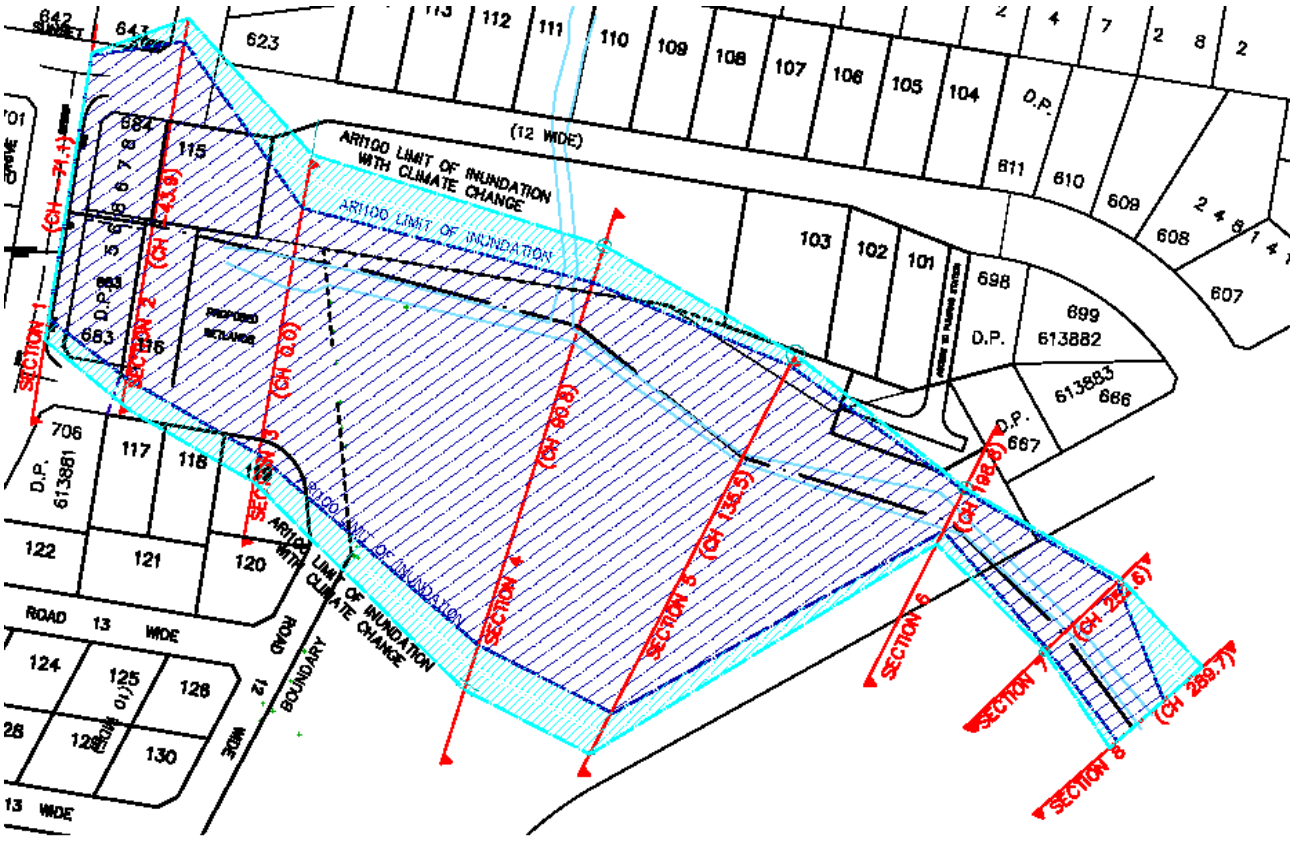

Figure 4.3: 100 Year ARI Inundation Limits Incorporating Climate Change

The detail survey performed over Manyana Drive at Section 1 (Appendix G) shows that the minimum level of the verge (RL5.75m) is above the peak water level for the 100year ARI storm and the 100year ARI storm incorporating future climate change at Section 1 (Table 4.1 - RL5.69m and Table 4.3 - RL5.72m). This would indicate that ponding of water occurs at the low point in Manyana Drive before reaching the level of the intersecting road pavement of Sunset Strip and overflowing down that road.

It could be anticipated that in minor overflows such as for the 1 year and 5 year ARI events this would be the general course of overflow water which would then travel east along Sunset Strip to its low point before joining with the remnant creek.

While direction of overflows along Sunset Strip may occur to some degree in larger events (such as the 100 year ARI and the 100year ARI storm incorporating future climate change), it has been considered that the volume of overland flow would at its peak breach the verge level of 5.75m AHD. This would cause the flow path to follow the natural drainage line through the rear of the existing Lots 683 and 684 in DP 568678, and proposed Lots 115 and 116, resulting in the flood levels extents predicted by the modelling and shown in Figure 4.2 and 4.3.

5 WATER QUALITY

5.1 Background

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is a water quality model. The model utilises a continuous simulation approach to model water quality and is suitable for simulating catchment areas of up to 100 km^2. However, it needs to be acknowledged that the model is only a representation of what is actually happening on the ground and is therefore only as accurate as the information and assumptions incorporated into the model.

The model present in this report was undertaken on MUSIC model Version 3.01 and is based on the stormwater report prepared by Storm Consulting Pty Ltd in November 2005 (Appendix A) as part of a preliminary environmental assessment application for the subject site. However, from the time when the stormwater report was prepared in 2005 there has been additional environmental assessment undertaken and further discussion held with Shoalhaven City Council, which has resulted in two main changes to the proposed subdivision:

- As part of the Environmental Assessment an endangered ecological community (‘*Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions’*) was identified on the subject land resulting in the proposed subdivision being reduced from 71 lots to 58 lots.
- Shoalhaven City Council (Shoalhaven Water) have advised that they intend to provide a dual pipe recycled water system to all the new large scale subdivisions within Manyana. The recycled water will initially be used for toilet flushing, gardening and other outdoor purposes. In the future the recycled water may also be used for the laundry facilities, once further research has been undertaken. As a result of the use of recycled water from the wastewater treatment facility we have removed the rainwater tanks from the individual lots.

The MUSIC model discussed below has been modified to take into consideration the reduction in the number of proposed lots and the removal of the rainwater tanks from the treatment system. The model also adopts the catchment boundaries set out in the Storm Consulting report for consistency with that report on water quality results.

The watercourse that runs through the subject site currently receives untreated runoff from the existing developed and undeveloped areas in the 70ha catchment. The stormwater treatment systems proposed as part of this development, will be required to treat runoff from the proposed development as well as the existing developed catchment. The proposed treatment system has been designed to retain and filter stormwater to remove pollutants such as litter, sediment and nutrients to protect the existing watercourse. The proposed treatment system for this proposal consists of the following:

- A gross pollutant trap to treat the stormwater from sub-catchments 1 and 2.
- A constructed wetland to provide a secondary level of treatment for the outflow from the gross pollutant trap.

- Kerbside bioretention areas will be constructed within the proposed extension to Sunset Strip to treat runoff from the new road and proposed lots within sub-catchments 3 and 4.
- A vegetated swale (comprising a rock armoured outlet treatment) will be constructed to convey the stormwater from the existing development within catchment 3 and 4 to the existing Creek. To ensure uniform flow distribution, maximum contact with vegetation and to minimise the risk of scour, the swales will be designed with a flat based or dished cross-section, a longitudinal slope ranging between 1% and 4% and a swale dimension or swale-to-catchment ratio which will ensure one-year ARI peak velocities do not exceed 0.5 m/s (preferably 0.25 m/s), and 100-year ARI peak velocities do not exceed 1 m/s ("*Australain Runoff Quality*" *(ARQ)*, Engineers Australia 2006). The swale will be vegetated with a range of native grasses, shrubs and sedge species, depending on hydraulic requirements.
- A 30 to 50m existing vegetated buffer (riparian zone) has been provided between sub-catchment 3 and 4 and the watercourse.

5.2 Meteorological Data

Continuous rainfall data at 6m intervals was obtained from the Bureau of Meteorology (BOM) for Point Perpendicular, the closest pluviograph station to the site (station number 68151). Five years of data (2001 to 2006) was used in the model.

5.3 Model Configuration

In order to assess the benefits of the treatment system, the model is configured to provide the following output:

- Pollutant loads from the existing development in the catchment;
- Pollutant loads from the existing development in the catchment and the proposed development; and
- Pollutant load reduction achieved by the proposed treatment measures.

The catchment is split into four main sub-catchments for the MUSIC model which are split into further sub-catchments to represent the land use type such as road or roof and represent either existing or proposed development. The Storm Consulting Report (Appendix A) contains the MUSIC catchment diagram as adopted and Figure 5.1 shows the model configuration.

To allow for the changes to the proposed subdivision (refer to Section 5.1) the following modifications have been made to the model used in Storm Consultants report:

- The catchment size of *old urban sub-catchment 2* was increased by 13ha. During the flood study this catchment was found to be larger than first modelled.
- The catchment size of *old urban sub-catchment 3* was increased by 1ha. During the flood study this catchment was found to be larger than first modelled.
- The catchment size of *sub-catchment 2 roof* was reduced by ½ to 0.025ha due to the reduction in lot numbers in that catchment. The area of the roof (0.025ha) was added to the catchment area of the *new urban sub-catchment 2*.

- The catchment size of *sub-catchment 1 roof* was reduced by 0.1ha due to the reduction in lot numbers in that catchment. The area of the roof (0.1ha) was added to the catchment area of the *new urban sub-catchment 1*.
- *Sub-catchment 3f roof* was removed due to the reduction in lot numbers in that catchment. The area of the roof (0.113ha) was added to the catchment area of the *new urban sub-catchment 3f*.
- *Sub-catchment new urban 4h2 and 4h2 roof* have been removed as the lots within those sub-catchments lots have been removed from the residential component of the subdivision and will comprise part of Lot 158 being dedicated to Shoalhaven City Council as public reserve.
- The parameters for the gross pollutant trap (GPT) were originally modelled on a generic GPT. The updated model has modelled the GPT on the parameters for the Ecosol RSF 4000 Gross Pollutant Trap.
- The runoff from the existing development in sub-catchment 3 and 4 will be piped into proposed Lot 158 where it will be discharge into a vegetated swale to be conveyed to the creek.

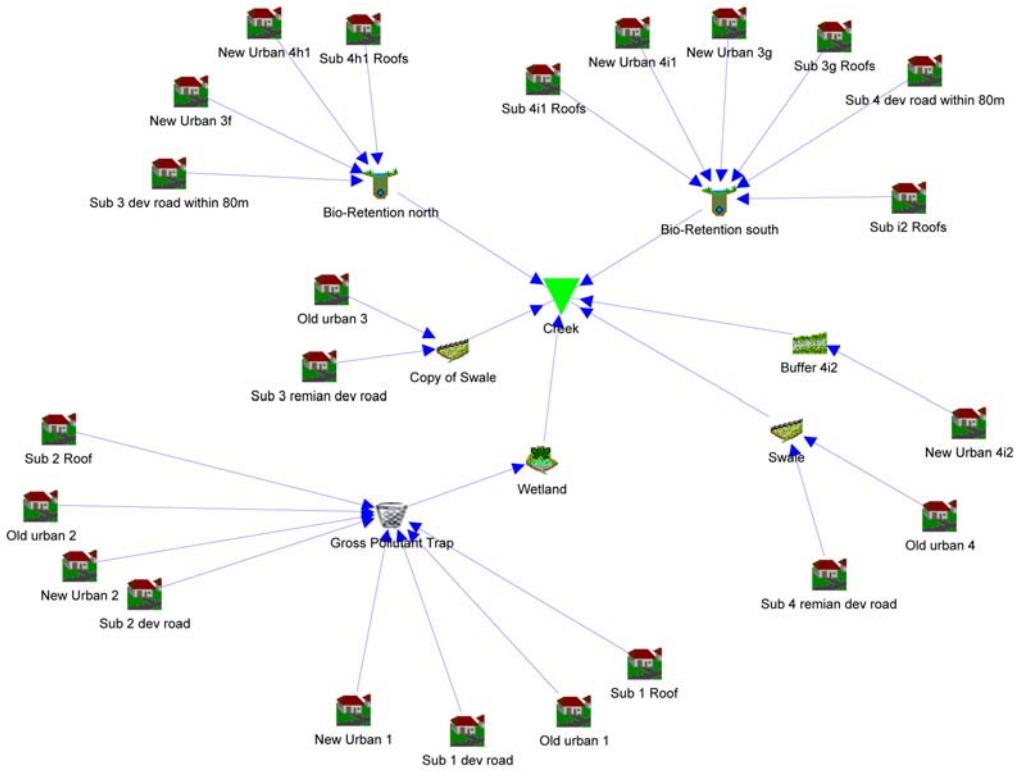

Figure 5.1: Conceptual MUSIC model layout of Stormwater

5.4 Results

Table 5.1 summarises the MUSIC results for the pollutant load currently produced by the catchment, the additional pollutant load produced and the pollutant load removed by the proposed stormwater treatment measures. The results show that pollutant loads will be reduced to below existing levels for suspended solids and phosphorus while nitrogen loads are predicted to increase by 1.8%. However it should be acknowledged that phosphorus is the limiting growth factor for most freshwater environments (ARQ, 2006) and therefore the impact of a 1.8% increase in nitrogen with the reduction of all other loads could be considered as minimal.

	Suspended Solids (kg/yr)	**Total Phosphorus (kg/yr)**	**Total Nitrogen (kg/yr)**	**Gross Pollutions (kg/yr)**
Existing Development in catchment	40190	76.23	586	6050
Proposed Development in catchment	8010	8.17	94	993
Total	**48200**	**84.4**	**680**	**7070**
Percentage reduction as a result of the *proposed stormwater treatment*	80%	35.6%	13.6%	98.8%
Overall reduction from proposed stormwater treatment	38560	30	92	7055

Table 5.1: Predicted annual pollutant loads

Table 5.2 show the predicted pollutant load as the result of the proposed development and the pollutant load removed by the proposed stormwater treatment measures. The MUSIC modelling shows that the proposed stormwater treatment system will remove a large amount of pollutants contained in the runoff from the proposed development with suspended solids and phosphorus being removed at rates in line with Best Management Practices.

	Suspended Solids (kg/yr)	**Total Phosphorus (kg/yr)**	**Total Nitrogen (kg/yr)**	**Gross Pollutions (kg/yr)**
Proposed Development in catchment	8010	8.17	94	993
Percentage reduction as a result of the *proposed stormwater treatment*	86.3%	45.6%	27%	98.8%
Overall reduction from proposed stormwater treatment	6912	3.72	26	981

Table 5.2: Predicted annual pollutant loads as the result of the proposed development

6 DISCUSSION

6.1 100 Year ARI Flood Levels

The estimated flood extents plotted in Figure 4.2 show that all proposed lots within the subdivision are outside the extent of the 1 in 100 year ARI flood with the exception of Lots 115, 116 and 119.

As the extend of flooding is otherwise fairly constrained, and emergency egress from proposed Lots 115, 116 and 119 is readily and safely available via the adjoining streets, construction of dwellings on these lots will be acceptable subject to the minimum habitable floor level being set at 500mm above the 100 year peak water level.

The boundaries of Lots 101,102, 103 and 118 were found to be close to the predicted flood levels and were checked for possible impact on building floor levels. It was found that the buildable envelope within these lots was at least 500mm above the 100 year ARI flood level and therefore no minimum floor level was required.

The proposed minimum floor levels for the 100 ARI event are shown in Table 6.1 for affected lots in the subdivision.

Lot	ARI 100 Peak Water Level (m AHD)	Minimum Habitable Floor Level (m AHD)
115	5.37	5.87
116	5.37	5.87
119	4.68	5.18

Table 6.1: Proposed Minimum Habitable Floor Levels for the 100 ARI event

6.2 100 Year ARI Flood Levels Incorporating Future Climate Change

Table 6.2 provides a comparison of the peak water levels associated with the ARI 100 year flood and the ARI 100 year flood incorporating future climate change. The comparison shows that the peak water level is anticipated to rise between 30mm and 840mm. Waterway cross sections 1 to 6 which incorporates the existing and proposed development are anticipated to experienced peak water level rises between 30mm and 280mm which is below the minimum habitable floor level of 500mm above the 100 year peak water level. Water cross section 8 was the only cross section to show a peak water level rise above 500mm, this cross section is located at the discharge point of the creek on Manyana Beach. The majority of the increase in peak water level at this section is due to the rise in sea level. There is no development located directly adjacent to this cross section and development in the vicinity of this cross-section is located behind the dune system at a higher elevation.

Cross Section No. Name	Creek Chainage	100 year ARI plus Climate Change Peak Water Level (m AHD)	100 year ARI Peak Water Level (m AHD)	Increase in Peak Water Level (m)	Increase in Peak Water Level (mm)
1	-71.10	5.71	5.69	0.03	27.00
2	-43.90	5.43	5.37	0.06	60.00
3	0.00	4.95	4.68	0.27	269.00
4	90.80	4.46	4.19	0.27	268.00
5	135.80	4.42	4.11	0.31	311.00
6	198.80	4.00	3.72	0.28	280.00
7	252.60	3.84	3.44	0.40	404.00
8	289.70	3.70	2.86	0.84	840.00

Table 6.2: A Comparison of Peak Water Levels

The estimated flood extents plotted in Figure 4.3 show that all proposed lots within the subdivision are outside the extent of the 1 in 100 year ARI flood

A comparison (Table 6.3) of the peak water levels associated with the ARI 100 year flood incorporating future climate change and the proposed minimum floor levels shown in Table 6.1 for the affected lots shows that all the affected lots will be below the minimum habitable floor level of 500mm above the 100 year peak water level. Therefore it is recommended that the minimum habitable floor level be set at 500mm above the 100 year peak water level incorporating climate change.

Lot	ARI 100 Peak Water Level incorporating Climate Change (m AHD)	Minimum Habitable Floor Level Based on Current ARI 100 Flood Levels (m AHD)	Adjusted Minimum Habitable Floor Level (m)
103	4.43	4.62	4.93
115	5.43	5.87	5.93
116	5.43	5.87	5.93
117	5.43	5.87	5.93
118	5.19	5.53	5.69
119	4.96	5.18	5.46

Table 6.3: Compassion of the peak water levels associated with the ARI 100 year flood incorporating future climate change and the proposed minimum floor levels

As the extend of flooding is otherwise fairly constrained, and emergency egress from proposed Lots 103, 115, 116, 117, 118 and 119 is readily and safely available via the adjoining streets, construction of dwellings on these lots will be acceptable subject to the minimum habitable floor level being set at 500mm above the 100 year peak water level incorporating climate change.

The boundaries of Lots 101,102, and 120 were found to be close to the predicted flood levels and were checked for possible impact on building floor levels. It was found that the buildable envelope within these lots was at least 500mm above the 100 year peak water level incorporating climate change and therefore no minimum floor level was required.

6.3 Existing System Capacity

The full extent of the existing drainage cannot be determined from surface investigation and is considered unnecessary for the purpose of conceptual modelling. Consequently a complete analysis of the existing piped drainage system downstream of the subject proposed subdivision has not been performed as part of this report.

Simplified modelling of the some of the trunk elements of the existing system was included in the DRAINS model based on some information obtained from Shoalhaven City Council data and site investigation. This provided a general indication of the existing system performance and provided some basis for the runoff routing through the urbanised subcatchments.

Adopting the observed pipe sizes for the simplified model, it is noted that the existing system likely does not comply with current standards for stormwater drainage capacity which require pipes to carry a minor system flow from the 5 year ARI event. The modelling performed identified system overflows in as little as the 1 year ARI event and therefore the system may at best only carry flows in the order of the 1 year ARI event (Refer DRAINS results Appendix D).

In the absence of detailed modelling of the existing drainage system and noting it's likely shortfall with respect to current drainage standards, a philosophy of nil increase in peak flows may need to be adopted for those sections of the proposed subdivision upstream of existing piped drainage. This would include all lots fronting The Barbette, The Bounty, and Manyana Drive where stormwater flows are connected to the existing system in the detailed stormwater design.

A nil increase in peak flows for the affected lots would be managed by the use of On Site Detention (OSD) to each of those lots to ensure flows from the developed lot did not exceed predeveloped conditions. This is best implemented at lot level by creation of a restriction over each affected lot requiring installation of an appropriate OSD system by each owner sized to their specific dwelling at time of construction.

It should be noted that the soccer field in located between Sunset Strip and The Palisade may provided some detention of flows upstream of that point. Site investigation indicated that there may be available a limited depth of ponding for detention (300mm to 500mm) with a small resultant ponding area. The size of the upstream catchment is such that a small detention volume has negligible affect of flows in the magnitude of the 1, 5, and 100 year ARI. Therefore no detention for the soccer field was allowed for in the model .

6.4 Rainwater Tank Usage

Rainwater tanks were included as part of Storm Consulting's original stormwater management plan providing benefits for both household water usage and downstream water quality.

Shoalhaven City Council has since commenced works on a dual water reticulation scheme to service three new developments in Manyana with the subject subdivision being one of those developments.

The dual reticulation scheme provide two separately piped water supplies, being potable water and recycled water. It is understood that it will be a condition of development that each new dwelling within the subject subdivision is connected to both water supplies, with the recycled water to be used for outdoor uses (gardens, washing cars, enc) and toilets. These uses are the same as would have been applied for the rainwater tanks, making the use of rainwater tanks obsolete.

Consequently rainwater tanks will not be installed on any of the proposed lots and their water conservation requirements under BASIX will otherwise be met by the the recycled system connections.

6.5 Drainage Easements

Due to the development being at the downstream end of a large catchment, drainage easements will be required over piped flows transport from roadways within the development to the watercourses below the development. Such easements are shown on the Stormwater Concept Plan (Figure 2.1) over proposed lots 115 and 111 and shall be a minimum 3 meters wide benefiting Shoalhaven City Council.

Interallotment drainage easements, 1.0m wide will also be required over all interallotment drainage lines as indicated in the Stormwater Concept Plan.

7 CONCLUSION

The following key conclusions were determined in this report with respect to water quality and storm water quantity management:

- The drainage philosophy for the site will be to provide piped drainage for the 1 in 5 year ARI storm event and to provide overland flow paths for the 1 in 100 year ARI storm event, with stormwater quality management devices to meet Best Management Practices. The existing piped drainage lines within proposed Lots 115 and 111 will be extended to the edge of the proposed Lot boundaries with drainage easements created over.
- The limits of inundation on the subject property from the 100 year ARI event and 100 year ARI event incorporating the effects of future climate change were determined at the nominated cross section and plotted on Figure 4.2 and 4.3 from those cross sections. Proposed lots 115, 116 and 119 are the only proposed lots affected by flood waters from the ARI 100 storm event. However, lots 103, 115, 116, 117, 118 and 119 were affected when taking into consideration the affects of future climate change. Minimum habitable floor levels should be adopted in accordance with Table 6.3. On the basis of a minimum habitable floor level of 500mm above the 100 year peak incorporating future climate change water level it is considered that an acceptable level of flood protection is provided to residents in the long term.
- If the stormwater management for the proposed subdivision is designed and installed in accordance the recommendations in this and Storm Consulting Report (2005), the stormwater runoff will be collected and treated prior to discharge from the site. Water quality modelling suggests that the installation of the recommended treatment systems will remove sediment and phosphorus loads greater than that added to the site by the proposed development. However there will be an additional 1.62kg/yr of nitrogen added to the watercourse.
- The existing development in the catchment has no stormwater management controls and the recommended treatment systems will also provide treatment to existing development. Therefore installation of the stormwater management measures outlined in this report is likely to reduce the pollutant loads reaching the watercourse and sensitive ecosystem at the base of the site.

APPENDIX A

Storm Consulting P/L
Stormwater Master Plan
November 2005

STORM_CONSULTING

Stormwater Master Plan
Lot 810 DP 247285, Lot 705 DP 613881 and Lot 682 DP 568678 Manyana

Report Prepared for:
Watkinson Apperley

Nov 2005
Project No. L492

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Document Verification

Project title	Manyana SMP	ACN 080 852 231 ABN 73 080 852 231
Document title	Stormwater Master Plan Manyana	Project number L492
Description	Draft	
Client Contact	Bronwyn Seiden	Client Ref

	Name	Signature	Revision	Date
Prepared by	Lachlan Bain		1	18/1/06
Checked by	Mal Brown			
Issued by	Mal Brown			
Filename	Masterplan report.doc			

	Revision Number					
Distribution Destination	1	2	3	4	5	6
Bronwyn Seiden	PDF					

Commercial in Confidence

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ACKNOWLEDGMENTS

STORM CONSULTING acknowledges the following who contributed to the production of this report:

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1. INTRODUCTION

1.1. Background

STORM_CONSULTING have been engaged to undertake the preparation of a Stormwater Master Plan for a proposed residential subdivision of Lot 810 DP 247285, Lot 705 DP 613881 and Lot 682 DP 568678 located in the south eastern corner of Manyana. The Stormwater Master Plan is a component of the information required for a development master plan as required by the State Environmental Planning Policy 71 (SEPP 71). SEPP 71 requires that untreated stormwater not be discharged to a coastal lake and that stormwater management is consistent with the requirements of the relevant Council *Stormwater Management Plan*.

This report and associated Stormwater Master Plan drawing will demonstrate how stormwater runoff from the site is treated in accordance with current best management practices.

1.2. Planning Context and Objectives

The principle objective of SEPP 71 is to protect the social, environmental and economic values of the NSW Coastline. Developments of a certain size and proximity to the coastline require a Master Plan of the proposed development be prepared to assist the Department of Planning in assessing the impacts of the development.

More specifically, SEPP 71 has the following clause relating the management of stormwater

> *"The consent authority must not grant consent to a development application to carry out development on land to which this Policy applies if the consent authority is of the opinion that the development will, or is likely to, discharge untreated stormwater into the sea, a beach, or an estuary, a coastal lake, a coastal creek or other similar body of water, or onto a rock platform."*

Council's LEP and Subdivision DCP require the control and treatment of stormwater to protect receiving environments. Key objectives relating to stormwater management from the LEP include:

- ...protect water quality
- ...protect aquatic habitats and riparian communities
- ...protect the scenic and recreational values of perennial water courses...

And from the Subdivision DCP, objectives include:

- ...ensure that existing downstream systems are not adversely affected and ensure no net increase in pollution levels discharging from the development.
- ...interception and treatment of pollutants through the use of appropriate water quality control measures prior to discharge to receiving waters, including wetlands, lakes and ponds.

1.3. Scope

The purpose of this report is to assess stormwater quality issues at the site and recommend management and treatment measures.

The scope of the report includes:

- Assessment of site constraints and opportunities
- Assessment of the proposed development layout
- Summary of water quality modelling of the proposed stormwater management measures
- Recommendations and conclusions.

2. SITE & DEVELOPMENT DESCRIPTION

2.1. Site locality

The proposed development is located in the southern extent of residential Manyana. The southern boundary borders Cunjurong Point, the eastern boundary is approximately 300 m west of Manyana Beach. The combination of the three lots is outlined in Figure 2.2.

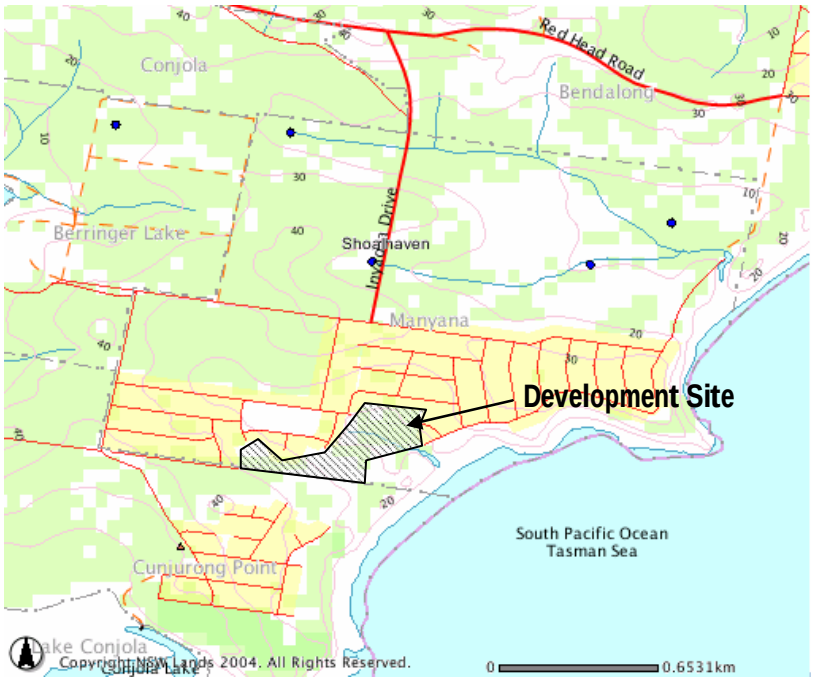

Figure 2.1: Site Locality

2.2. Proposed development

The developer proposes to subdivide Lot 810 DP 247285 into 24 residential blocks, Lot 705 DP 613881 into 39 residential blocks and Lot 682 DP 568678 into 11 residential blocks. New roads to service each new lot include:

- An extension of The Barbette and The Bounty to Lot 810.
- An extension of Manyana Drive and the addition of a loop road to the western side of Lot 705
- And the extension of Sunset Strip to the northern boundary of to access development of 705 and Lot 682.

Figure 2.2 shows the current lot layout and Figure 2.3 illustrates the proposed development lot layout.

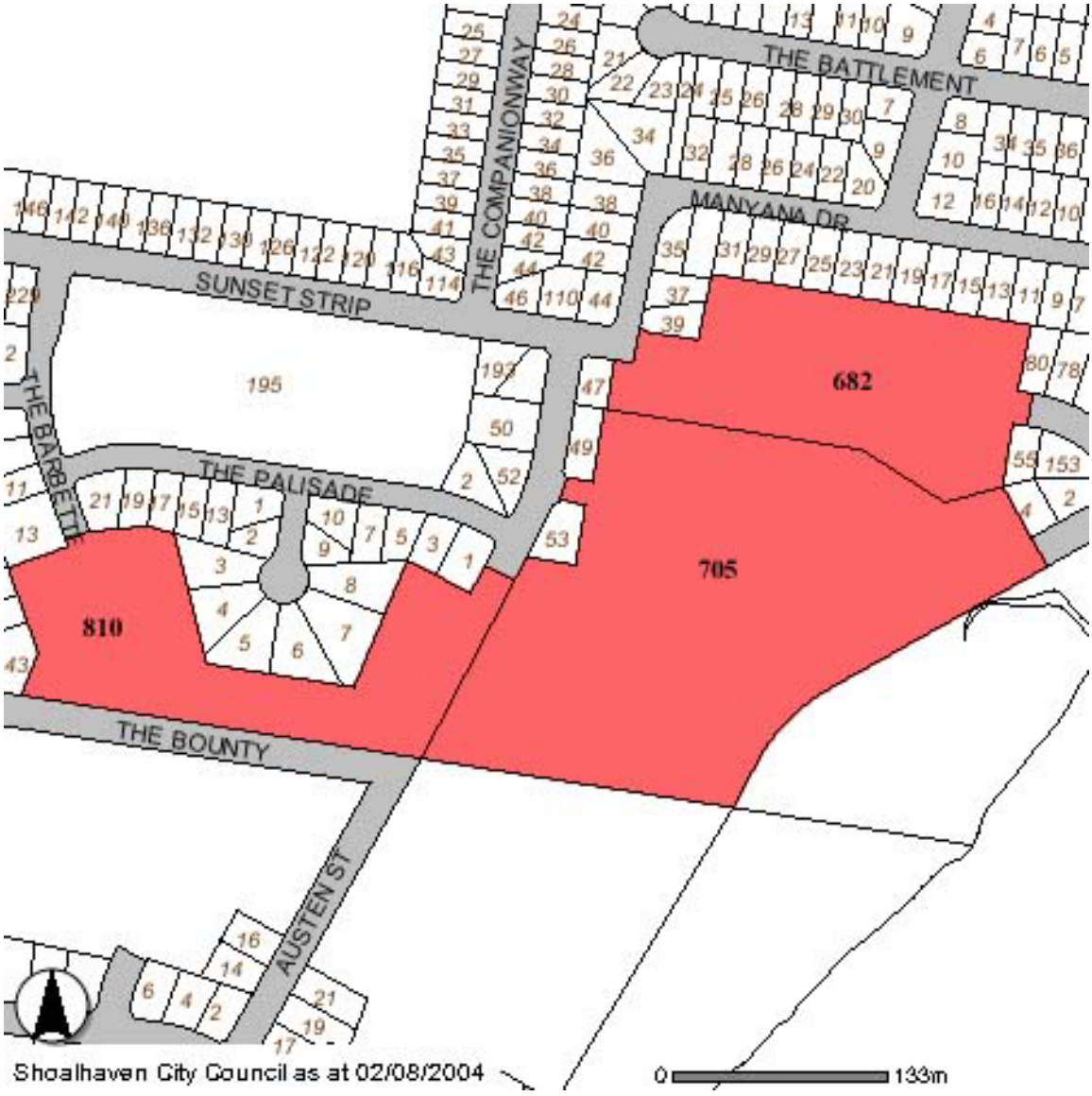

Figure 2.2 Current lot layout

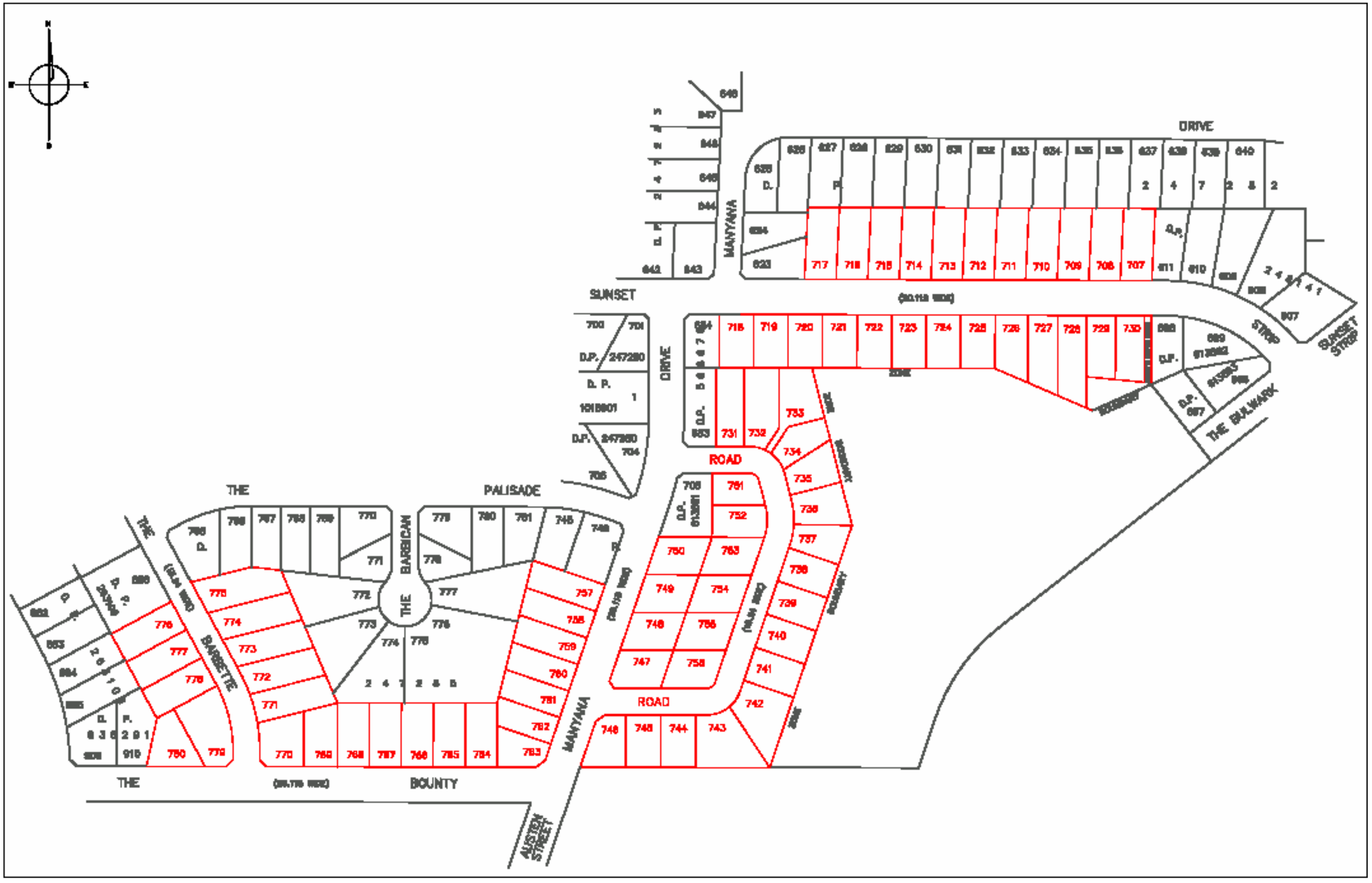

Figure 2.3 **Proposed development layout**

2.3. Site Conditions

Topography

The proposed development is located on the lower slopes of a 57 Ha catchment, straddling a small watercourse. Some of the development is located on the northern side of the watercourse providing a southerly aspect. The remainder of the development is located on the valley floor and southern slopes providing predominantly northern and easterly aspects.

Soils and Geology

The upper slopes on the northern and southern side of the site are characterised by clayey soils. Sections of these northern slopes at the eastern end of the site are showing signs of erosion, predominantly due to the removal of vegetation (Figure 2.4 and Figure 2.5)

Figure 2.4 Bicycle and dirt bike track

Figure 2.5 Cleared land

The lower slopes are characterised by alluvial material associated with the watercourse in the centre of the site along with sands associated with the dunes to the east. (Figure 2.7)

Figure 2.6 Walking track and creek crossing

The area around the watercourse at the lower end of the site is classified as an area of low risk (< 1m from surface) for Acid Sulphate Soils.

Drainage

The proposed development is located at the base of a 57 Ha catchment with approximately 50% of the catchment currently developed consisting of a school and residential areas. The catchment is piped through the current developed area upstream of Manyana Drive. Downstream of Manyana Drive the catchment drains to an existing watercourse which runs along the boundary of Lot 682 and Lot 705 with both lots sloping towards it. Lot 810 also grades towards this creek, however, water running off site is directed to a low point located between Lot 683 and Lot 684 DP 568678 *via* road. This low point is essentially the head of the creek. This creek extends to Manyana beach and opens to the sea after considerable periods of high rainfall (Figure 2.7).

Figure 2.7 Receiving waters (creek and Manyana Beach).

Vegetation

Lot 705 DP 613881 contains a community that "is floristically similar to the endangered ecological community swamp sclerophyll on coastal flood plains of the NSW North Coast, Sydney Basin and South East Corner Bioregions" (PMA Consulting, 2005).

3. PROPOSED STORMWATER MASTER PLAN

To comply with local and state guidelines for stormwater management a number of treatment systems are proposed to retain and filter stormwater to remove pollutants such as litter, sediment and nutrients to protect the existing watercourse at the lower end of the catchment. The watercourse receives untreated runoff from existing developed areas in the catchment. End-of-line treatment systems proposed as part of this development will treat runoff from the proposed development as well as the existing developed catchment.

The proposed treatment system (Figure 3.1) consists of the following:

- Minimum 10kL rainwater tanks for all new dwellings to retain stormwater runoff
- A gross pollutant trap to treat most of the proposed development site and the bulk of the existing development
- A water quality basin as a polishing mechanism for outflow from the gross pollutant trap which receives runoff from most of the proposed development site and the bulk of the existing development
- Kerbside bioretention areas along the proposed sunset strip to treat runoff from the new road and proposed lots
- Infiltration areas for properties draining directly to the watercourse

It is proposed that the biofiltration system be incorporated into traffic management measures to be placed along Sunset Strip.

Drainage control and revegetation should be undertaken on the upper slopes on the northern side of the development (Figure 2.5) to prevent further erosion.

Appendix A contains a Stormwater Master Plan outlining the location and layout of proposed stormwater management measures for the site.

MUSIC modelling (discussed in Section 4) has been undertaken to demonstrate how the stormwater management systems proposed for the site meet Shoalhaven Council's stormwater quality objectives.

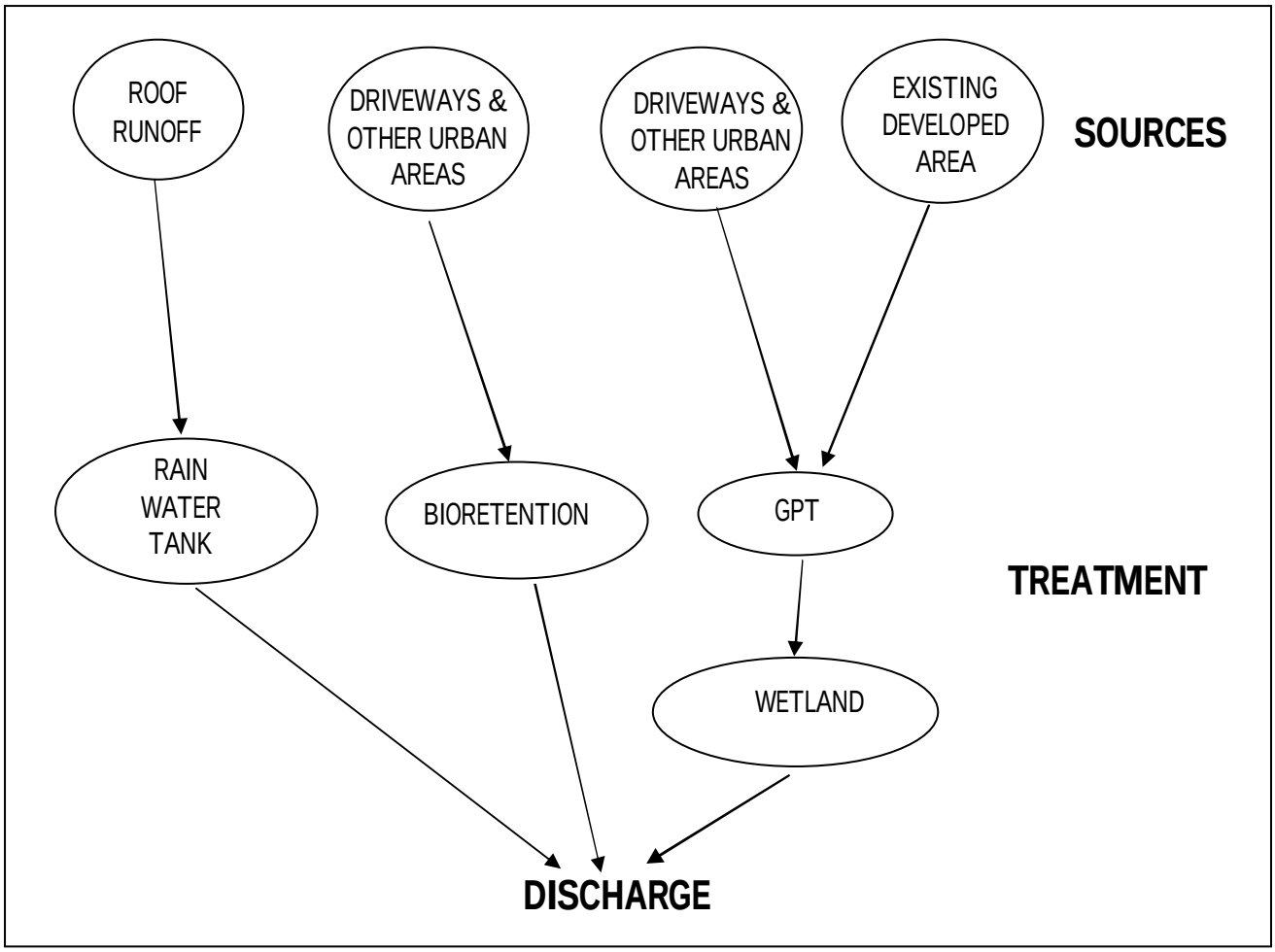

Figure 3.1 Stormwater Master Plan flow diagram

4. MUSIC MODELLING

4.1. Background

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) is a water quality model. The model utilises a continuous simulation approach to model water quality and is suitable for simulating catchment areas of up to 100 km^2. It is important to note that the model is only a representation of what is actually happening on the ground and is therefore only as accurate as the information and assumptions incorporated into the model.

4.2. Meteorological Data

Continuous rainfall data was obtained from the Bureau of Meteorology (BOM) for Point Perpendicular, the closest pluviograph station to the site (station number 68151). Three years of data (2002 to 2004) was used in the model. A full record of MUSIC input parameters is located in Appendix B.

4.3. Model Configuration

In order to assess the benefits of the treatment system, the model is configured to provide the following output:

- Pollutant loads from the existing development in the catchment
- Pollutant loads from the existing development in the catchment and the proposed development
- Pollutant load reduction achieved by the proposed treatment measures

The catchment is split into three main sub-catchments to represent the main drainage lines on the site, these sub-catchment are split into further sub-catchments to represent the land use type, for example road or house roof, and represent either existing or proposed development. Appendix A contains a catchment diagram and Figure 4.1 shows the model configuration.

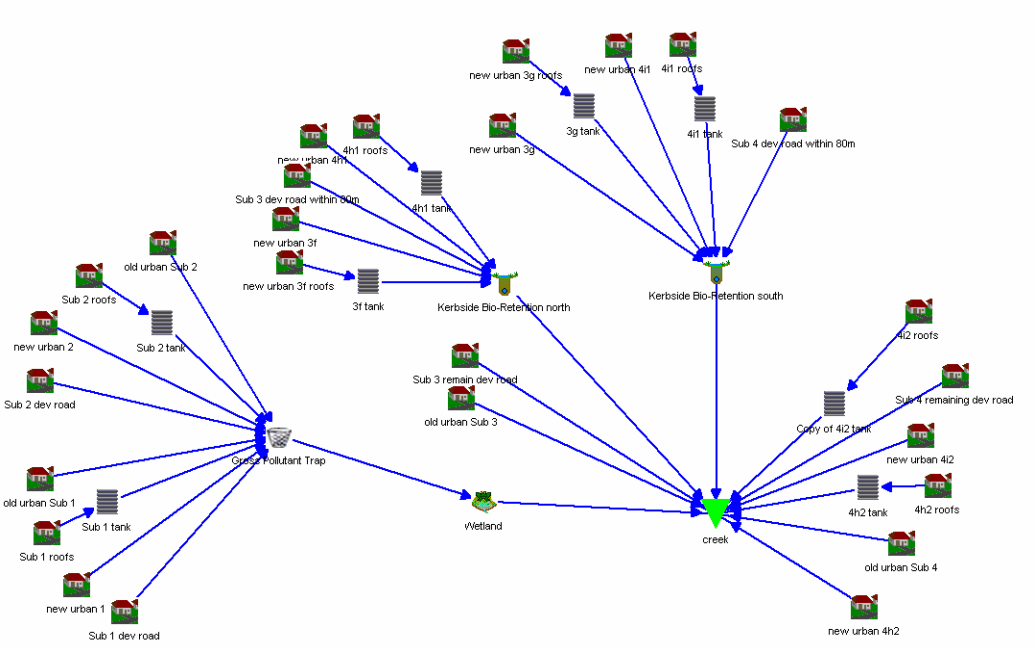

Figure 4.1 Conceptual MUSIC model layout of Stormwater Masterplan

4.4. Results

Results (Table 4.1) show the pollutant load currently produced by the catchment, the additional pollutant load produced and the pollutant load collected by the proposed stormwater treatment measures.

The proposed treatment measures retain in excess of the load created by the proposed development, particularly with respect to suspended solids.

Table 4.1 Predicted annual pollutant loads

	Suspended Solids(kg/yr)	Total Phosphorous (kg/yr)	Total Nitrogen (kg/yr)
Existing Development in catchment	35010	65.5	509.7
Proposed Development in catchment	8990	9.23	108.3
Total	**44000**	**74.7**	**618**
Overall reduction from proposed stormwater treatment	*22000*	*10.6*	*125*

5. RECOMMENDATIONS

5.1. Rainwater Tanks

Rainwater tanks are likely to be required for each household as part of the BASIX assessment for individual lot development. It is recommended that a minimum 10kL rainwater tank be installed on each house with a minimum of 80% of the roof area draining to it. Rainwater tanks should be plumbed to supply toilet flushing, laundry and outdoor water supply to maintain storage in the tank to retain runoff from the site.

5.2. Gross Pollutant Trap

A GPT that can achieve high levels of gross pollutant and coarse sediment removal is recommended. Removal rates shall not be below 90% for > 2mm size particles.

5.3. Wetland

The wetland area, or water quality pond will provide a secondary level of treatment to runoff passing trough the GPT. The wetland should contain the following key features:

- Open water inlet area to collect sediment
- Maintenance access to allow for collection of accumulated sediment
- Shallow water, reed bed area to proved surface area for pollutant filtration
- Water level control at the outlet.

A conceptual wetland configuration is shown on the Stormwater Master Plan drawing.

5.4. Kerbside Biofiltration

As discussed previously it is recommended to install biofilters within some traffic management measures along Sunset Strip. These should be configured to be at the low point of the road to collect as much road and lot runoff as possible. A conceptual configuration for these systems is contained in Appendix A.

5.5. Infiltration areas

Infiltration areas are recommended for lots that grade to the open space at the rear of properties. Rainwater tank overflow and runoff from lot impervious surfaces should be collected in an appropriately sized gravel trench on the property to infiltrate frequent runoff (3mth ARI) events.

5.6. Rehabilitation and vegetation management

The upper slopes on the northern side of the site are eroding as a result of clearing associated with access tracks and bikes making use of the area. Informal footpaths and bike use areas to be retained should be clearly identified to allow drainage through the area to be formalised and areas not to be developed to be revegetated as part of any vegetation management plan.

6. CONCLUSION

If designed and installed as proposed in the Stormwater Master Plan, stormwater runoff will be collected and treated prior to discharge from the site. Stormwater from the proposed development and the existing catchment will pass through the proposed gross pollutant trap and wetland. Water quality modelling suggests that the installation of these treatment systems will remove a sediment and nutrient load greater than that added to the site with the proposed development. Additionally, existing developments in the catchment which have no/little stormwater controls will also be afforded treatment.

Installation of the stormwater management measures outlined in Appendix A and the rehabilitation of the eroded areas on the northern side of the site are likely to reduce the pollutant loads reaching the watercourse and sensitive ecosystem at the base of the site.

REFERENCES

BCC (2003) ***Guidelines for Pollutant Export Modelling in Brisbane Version 7 – Draft,*** Brisbane City Council

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IEA (2004). ***Australian Runoff Quality.*** Institution of Engineers, Australia.

PMA Consulting (2005) ***DRAFT Flora and Fauna Assessmen Lot 682 DP 568678, Lot 705 DP 61385, and Lot 810 DP 247285 Manyana.***

APPENDIX A
Stormwater Master Plan

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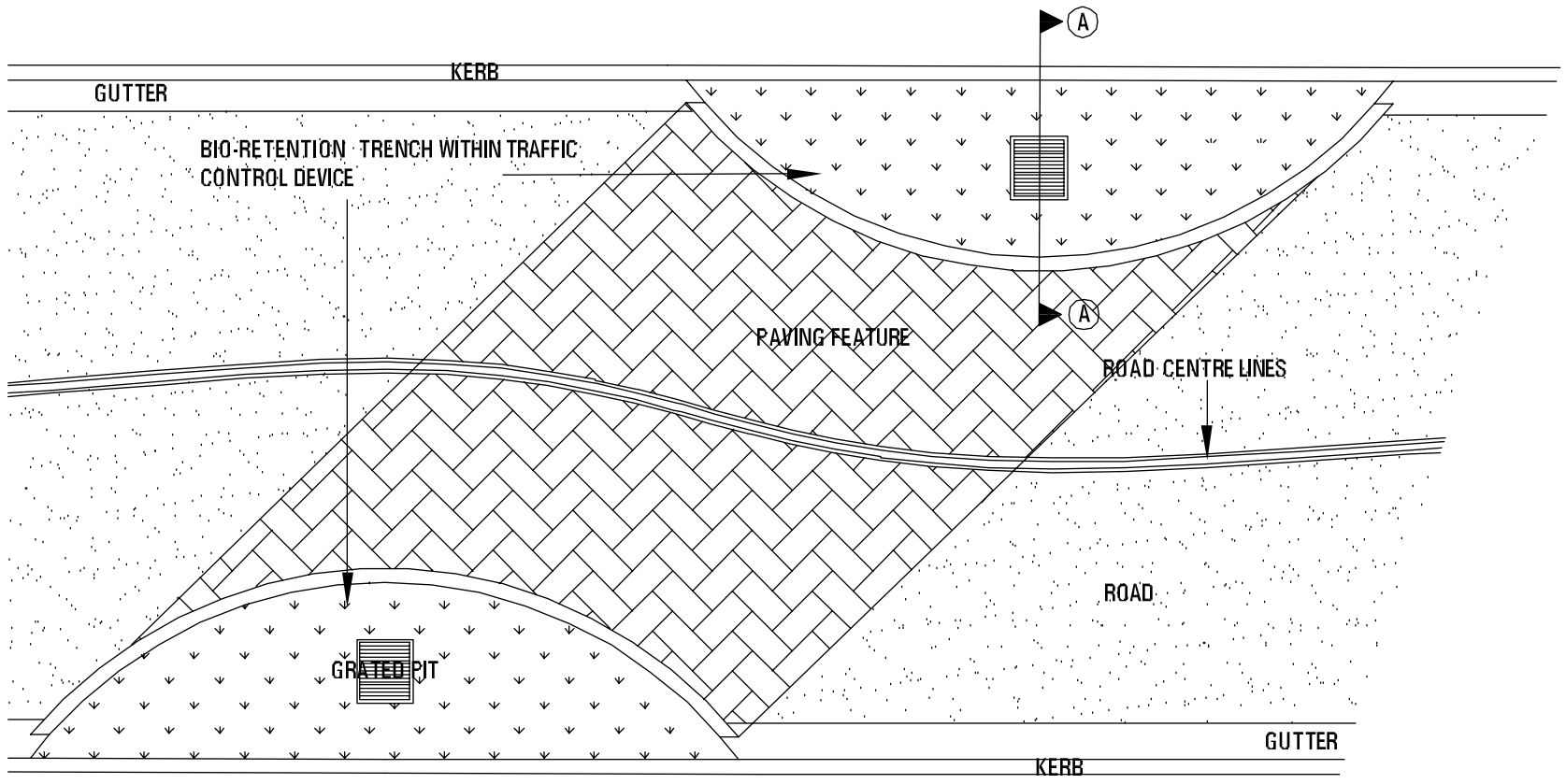
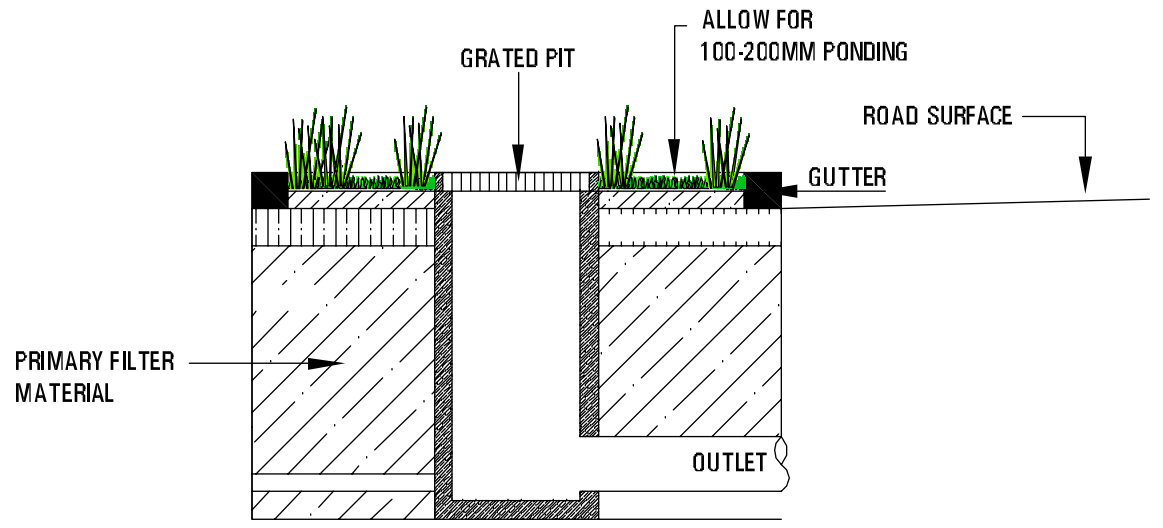
DEVELOPMENT LAYOUT
FLOW PATHS AND TREATMENT LOCATIONS
MANYANA STORMWATER TREATMENT PLAN

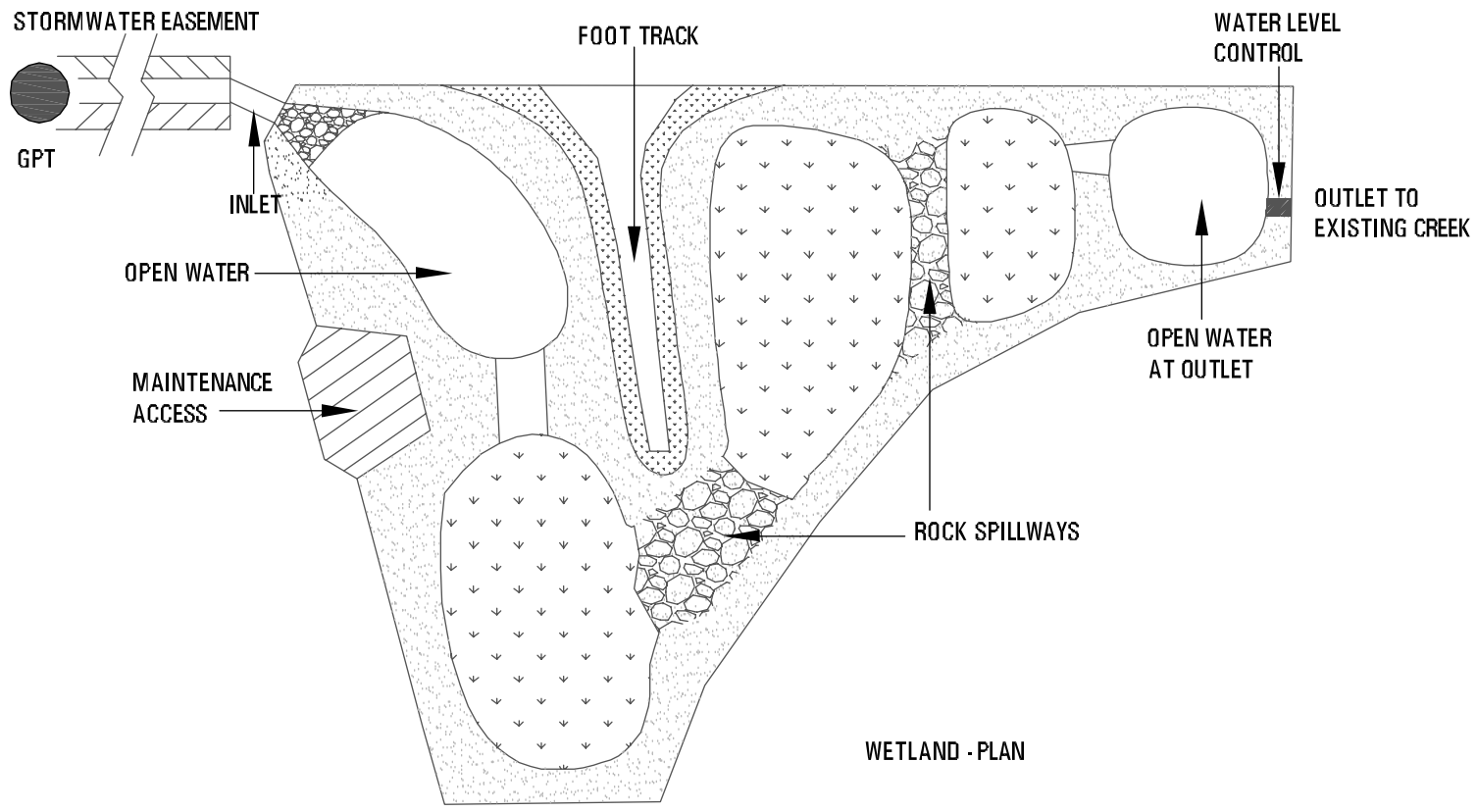
DRAWING: L492/PO1
SHEET: 1 OF 1
A3



BIO-RETENTION FILTER WITHIN TRAFFIC CONTROL DEVICE - PLAN



SECTION A
TYPICAL BIO-RETENTION TRENCH CROSS SECTION



WETLAND - PLAN

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STORMWATER TREATMENT DETAILS
BIO-RETENTION TRENCH & WETLAND
MANYANA STORMWATER TREATMENT PLAN

DRAWING: L492/P02
SHEET: 1 OF 1
A3

APPENDIX B

MUSIC modelling input and output

Source nodes

Location	new urban 1	new urban 2	new urban 3f	new urban 4h1	Sub 1 roofs	Sub 2 roofs	new urban 3f roofs	Sub 2 dev road	Sub 1 dev road	Sub 3 dev road within 80	Sub 4 dev road within 80	old urban Sub 1	old urban Sub 4
ID	1	2	3	4	5	6	7	14	15	16	17	18	19
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	1.765	0.103	0.223	0.194	1.15	0.05	0.113	0.033	1.554	0.16	0.161	26.512	6.207
Area Impervious (ha)	0.35	0.02	0.04	0.04	1.15	0.05	0.11	0.03	1.55	0.16	0.16	5.27	1.23
Area Pervious (ha)	1.41	0.08	0.18	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.24	4.97
Field Capacity (mm)	80	80	80	80	80	80	80	80	80	80	80	80	80
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	120	120	120	120	120	120	120	120	120	120	120	120	120
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30	30	30	30	30	30
Groundwater Initial Depth	10	10	10	10	10	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.146	2.146	2.146	2.146	1.3	1.3	1.3	2.43	2.43	2.43	2.43	2.146	2.146
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.602	-0.602	-0.602	-0.602	-0.886	-0.886	-0.886	-0.824	-0.824	-0.824	-0.824	-0.602	-0.602
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.342	0.342	0.342	0.342	0.301	0.301
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.204	1.204	1.204	1.204	-2	-2	-2	-2	-2	-2	-2	1.204	1.204
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.854	-0.854	-0.854	-0.854	-2	-2	-2	-2	-2	-2	-2	-0.854	-0.854
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	0.113	0.113	0.113	0.113	-2	-2	-2	-2	-2	-2	-2	0.113	0.113
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	6.61	0.386	0.835	0.727	10.4	0.451	1.02	0.298	14	1.44	1.45	99.3	23.2
OUT - TSS Mean Annual Load (kg/yr)	943	55.4	121	110	273	11.9	27.7	103	4.91E+03	512	510	1.38E+04	3.36E+03
OUT - TP Mean Annual Load (kg/yr)	1.74	9.96E-02	0.219	0.194	1.61	6.98E-02	0.161	5.20E-02	2.47	0.252	0.255	26.1	6.1
OUT - TN Mean Annual Load (kg/yr)	13.4	0.771	1.64	1.46	23.3	0.989	2.25	0.711	34.2	3.53	3.48	200	47.8
OUT - Gross Pollutant Mean Annual Load (kg/yr)	155	9.05	19.6	17	250	10.9	24.6	7.17	338	34.8	35	2.33E+03	545

Location	old urban Sub 2	old urban Sub 3	Sub 3 remain dev roa	Sub 4 remaining dev road	new urban 3g	new urban 4h2	new urban 4i2	new urban 4i1	new urban 3g roof	4h1 roofs	4h2 roofs	4i1 roofs	4i2 roofs
ID	20	21	23	25	26	27	28	29	30	33	34	36	38
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	19.463	5.033	0.036	0.104	0.144	0.125	0.135	0.127	0.113	0.1	0.063	0.1	0.063
Area Impervious (ha)	3.87	1.00	0.04	0.10	0.03	0.02	0.03	0.03	0.11	0.10	0.06	0.10	0.06
Area Pervious (ha)	15.59	4.03	0.00	0.00	0.12	0.10	0.11	0.10	0.00	0.00	0.00	0.00	0.00
Field Capacity (mm)	80	80	80	80	80	80	80	80	80	80	80	80	80
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	120	120	120	120	120	120	120	120	120	120	120	120	120
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30	30	30	30	30	30
Groundwater Initial Depth	10	10	10	10	10	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.146	2.146	2.43	2.43	2.146	2.146	2.146	2.146	1.3	1.3	1.3	1.3	1.3
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.602	-0.602	-0.824	-0.824	-0.602	-0.602	-0.602	-0.602	-0.886	-0.886	-0.886	-0.886	-0.886
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.301	0.301	0.342	0.342	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.204	1.204	-2	-2	1.204	1.204	1.204	1.204	-2	-2	-2	-2	-2
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.854	-0.854	-2	-2	-0.854	-0.854	-0.854	-0.854	-2	-2	-2	-2	-2
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	0.113	0.113	-2	-2	0.113	0.113	0.113	0.113	-2	-2	-2	-2	-2
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	72.9	18.8	0.325	0.938	0.539	0.468	0.506	0.476	1.02	0.902	0.568	0.902	0.568
OUT - TSS Mean Annual Load (kg/yr)	1.07E+04	2.72E+03	115	334	79	71.7	72.3	69.2	26.4	24.1	14.3	23.7	14.8
OUT - TP Mean Annual Load (kg/yr)	18.9	4.92	5.80E-02	0.165	0.144	0.128	0.131	0.127	0.155	0.141	8.50E-02	0.14	8.62E-02
OUT - TN Mean Annual Load (kg/yr)	148	37.6	0.779	2.34	1.09	0.935	1.02	0.952	2.28	1.98	1.23	1.99	1.23
OUT - Gross Pollutant Mean Annual Load (kg/yr)	1.71E+03	442	7.83	22.6	12.6	11	11.9	11.2	24.6	21.7	13.7	21.7	13.7

No Imported Data Source nodes

USTM treatment nodes

Location	Sub 1 tank	Sub 2 tank	3f tank	Wetland	Kerbside Bio-Retention nort	Kerbside Bio-Retention sout	3g tank	4h1 tank	4h2 tank	4i1 tank	Copy of 4i2 tank
ID	8	9	10	13	22	24	31	32	35	37	39
Node Type	RainWaterTankNode	RainWaterTankNode	RainWaterTankNode	WetlandNode	BioRetentionNode	BioRetentionNode	RainWaterTankNode	RainWaterTankNode	RainWaterTankNode	RainWaterTankNode	RainWaterTankNode
Lo-flow bypass rate (cum/sec)	0	0	0	0	0	0	0	0	0	0	0
Hi-flow bypass rate (cum/sec)	100	100	100	100	2	2	100	100	100	100	100
Inlet pond volume	0	0	0	200			0	0	0	0	0
Area (sqm)	230	10	22.5	300	19	19	22.5	20	12.5	20	12.5
Extended detention depth (m)	0.1	0.1	0.1	0.5	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Permanent pool volume (cum)	230	10	22.5	200			22.5	20	12.5	20	12.5
Proportion vegetated	0	0	0	0.5			0	0	0	0	0
Equivalent pipe diameter (mm)	50	50	50	100			50	50	50	50	50
Overflow weir width (m)	10	10	10	5	4	4	10	10	10	10	10
Notional Detention Time (hrs)	3.47	0.151	0.339	2.53			0.339	0.302	0.189	0.302	0.189
Orifice discharge coefficient	0.6	0.6	0.6	0.6			0.6	0.6	0.6	0.6	0.6
Weir coefficient	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Number of CSTR cells	2	2	2	5	3	3	2	2	2	2	2
Total Suspended Solids k (m/yr)	400	400	400	1500	8000	8000	400	400	400	400	400
Total Suspended Solids C* (mg/L)	12	12	12	6	20	20	12	12	12	12	12
Total Suspended Solids C** (mg/L)	12	12	12	6			12	12	12	12	12
Total Phosphorus k (m/yr)	300	300	300	1000	6000	6000	300	300	300	300	300
Total Phosphorus C* (mg/L)	0.13	0.13	0.13	0.06	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total Phosphorus C** (mg/L)	0.13	0.13	0.13	0.06			0.13	0.13	0.13	0.13	0.13
Total Nitrogen k (m/yr)	40	40	40	150	500	500	40	40	40	40	40
Total Nitrogen C* (mg/L)	1.4	1.4	1.4	1	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Total Nitrogen C** (mg/L)	1.4	1.4	1.4	1			1.4	1.4	1.4	1.4	1.4
Threshold hydraulic loading for C** (m/yr)	3500	3500	3500	3500			3500	3500	3500	3500	3500
Extraction for Re-use	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Filter area (sqm)					18	18					
Filter depth (m)					1	1					
Filter median particle diameter (mm)					5	5					
Saturated hydraulic conductivity (mm/hr)					100	100					
Voids ratio					0.3	0.3					
Length (m)											
Bed slope											
Base Width (m)											
Top width (m)											
Vegetation height (m)											
Proportion of upstream impervious area treated											
Seepage Rate (mm/hr)	0	0	0	3.6	3.6	3.6	0	0	0	0	0
Evap Loss as proportion of	0	0	0	1.25			0	0	0	0	0
Depth in metres below the drain pipe					0.1	0.1					
IN - Mean Annual Flow (ML/yr)	10.4	0.451	1.02	204	4.93	4.39	1.02	0.902	0.568	0.902	0.568

IN - TSS Mean Annual Load (kg/yr)	273	11.9	27.7	3.07E+04	776	691	26.4	24.1	14.3	23.7	14.8
IN - TP Mean Annual Load (kg/yr)	1.61	6.98E-02	0.161	50.9	0.935	0.794	0.155	0.141	8.50E-02	0.14	8.62E-02
IN - TN Mean Annual Load (kg/yr)	23.3	0.989	2.25	419	9.96	8.85	2.28	1.98	1.23	1.99	1.23
IN - Gross Pollutant Mean Annual Load (kg/yr)	250	10.9	24.6	4.55E+03	71.4	58.8	24.6	21.7	13.7	21.7	13.7
OUT - Mean Annual Flow (ML/yr)	10.4	0.451	1.02	197	4.7	4.18	1.02	0.902	0.568	0.902	0.568
OUT - TSS Mean Annual Load (kg/yr)	187	7.57	18	2.30E+04	355	297	17.4	15.5	9.48	15.5	9.55
OUT - TP Mean Annual Load (kg/yr)	1.46	6.24E-02	0.144	41.2	0.647	0.547	0.141	0.126	7.78E-02	0.127	7.79E-02
OUT - TN Mean Annual Load (kg/yr)	20.6	0.761	1.77	392	8.24	7.24	1.78	1.55	0.969	1.56	0.968
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	0	0	0	0	0	0	0	0

IN - Mean Annual Flow (ML/yr)	204
IN - TSS Mean Annual Load (kg/yr)	3.07E+04
IN - TP Mean Annual Load (kg/yr)	50.9
IN - TN Mean Annual Load (kg/yr)	419
IN - Gross Pollutant Mean Annual Load (kg/yr)	4.55E+03
OUT - Mean Annual Flow (ML/yr)	204
OUT - TSS Mean Annual Load (kg/yr)	3.07E+04
OUT - TP Mean Annual Load (kg/yr)	50.9
OUT - TN Mean Annual Load (kg/yr)	419
OUT - Gross Pollutant Mean Annual Load (kg/yr)	4.55E+03
Other nodes	
Location	creek
ID	12
Node Type	ReceivingNode
IN - Mean Annual Flow (ML/yr)	251
IN - TSS Mean Annual Load (kg/yr)	3.04E+04
IN - TP Mean Annual Load (kg/yr)	54.1
IN - TN Mean Annual Load (kg/yr)	500
IN - Gross Pollutant Mean Annual Load (kg/yr)	1.04E+03
OUT - Mean Annual Flow (ML/yr)	0
OUT - TSS Mean Annual Load (kg/yr)	0
OUT - TP Mean Annual Load (kg/yr)	0
OUT - TN Mean Annual Load (kg/yr)	0
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0

Links

Location	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link
Source node ID	6	7	5	2	1	9	8	11	13	14	15	18	20	21	19	10	3	16	23
Target node ID	9	10	8	11	11	11	11	13	12	11	11	11	11	12	12	22	22	22	12
Muskingum-Cunge Routing	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed
Muskingum K																			
Muskingum theta																			
IN - Mean Annual Flow (ML/yr)	0.451	1.02	10.4	0.386	6.61	0.451	10.4	204	197	0.298	14	99.3	72.9	18.8	23.2	1.02	0.835	1.44	0.325
IN - TSS Mean Annual Load (kg/yr)	11.9	27.7	273	55.4	943	7.57	187	3.07E+04	2.30E+04	103	4.91E+03	1.38E+04	1.07E+04	2.72E+03	3.36E+03	18	121	512	115
IN - TP Mean Annual Load (kg/yr)	6.98E-02	0.161	1.61	9.96E-02	1.74	6.24E-02	1.46	50.9	41.2	5.20E-02	2.47	26.1	18.9	4.92	6.1	0.144	0.219	0.252	5.80E-02
IN - TN Mean Annual Load (kg/yr)	0.989	2.25	23.3	0.771	13.4	0.761	20.6	419	392	0.711	34.2	200	148	37.6	47.8	1.77	1.64	3.53	0.779
IN - Gross Pollutant Mean Annual Load (kg/yr)	10.9	24.6	250	9.05	155	0	0	4.55E+03	0	7.17	338	2.33E+03	1.71E+03	442	545	0	19.6	34.8	7.83
OUT - Mean Annual Flow (ML/yr)	0.451	1.02	10.4	0.386	6.61	0.451	10.4	204	197	0.298	14	99.3	72.9	18.8	23.2	1.02	0.835	1.44	0.325
OUT - TSS Mean Annual Load (kg/yr)	11.9	27.7	273	55.4	943	7.57	187	3.07E+04	2.30E+04	103	4.91E+03	1.38E+04	1.07E+04	2.72E+03	3.36E+03	18	121	512	115
OUT - TP Mean Annual Load (kg/yr)	6.98E-02	0.161	1.61	9.96E-02	1.74	6.24E-02	1.46	50.9	41.2	5.20E-02	2.47	26.1	18.9	4.92	6.1	0.144	0.219	0.252	5.80E-02
OUT - TN Mean Annual Load (kg/yr)	0.989	2.25	23.3	0.771	13.4	0.761	20.6	419	392	0.711	34.2	200	148	37.6	47.8	1.77	1.64	3.53	0.779
OUT - Gross Pollutant Mean Annual Load (kg/yr)	10.9	24.6	250	9.05	155	0	0	4.55E+03	0	7.17	338	2.33E+03	1.71E+03	442	545	0	19.6	34.8	7.83

Location	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage	Drainage	Drainage	Drainage	Drainage	Drainage	Drainage	Drainage	Drainage	Drainage	Drainage	Drainage Link
Source node ID	22	25	29	26	4	17	27	28	30	31	33	32	34	35	36	37	38	39	24
Target node ID	12	12	24	24	22	24	12	12	31	24	32	22	35	12	37	24	39	12	12
Muskingum-Cunge Routing	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Route	Not Route	Not Route	Not Route	Not Route	Not Route	Not Route	Not Route	Not Route	Not Route	Not Route	Not Routed
Muskingum K																			
Muskingum theta																			
IN - Mean Annual Flow (ML/yr)	4.7	0.938	0.476	0.539	0.727	1.45	0.468	0.506	1.02	1.02	0.902	0.902	0.568	0.568	0.902	0.902	0.568	0.568	4.18
IN - TSS Mean Annual Load (kg/yr)	355	334	69.2	79	110	510	71.7	72.3	26.4	17.4	24.1	15.5	14.3	9.48	23.7	15.5	14.8	9.55	297
IN - TP Mean Annual Load (kg/yr)	0.647	0.165	0.127	0.144	0.194	0.255	0.128	0.131	0.155	0.141	0.141	0.126	8.50E-02	7.78E-02	0.14	0.127	8.62E-02	7.79E-02	0.547
IN - TN Mean Annual Load (kg/yr)	8.24	2.34	0.952	1.09	1.46	3.48	0.935	1.02	2.28	1.78	1.98	1.55	1.23	0.969	1.99	1.56	1.23	0.968	7.24
IN - Gross Pollutant Mean Annual Load (kg/yr)	0	22.6	11.2	12.6	17	35	11	11.9	24.6	0	21.7	0	13.7	0	21.7	0	13.7	0	0
OUT - Mean Annual Flow (ML/yr)	4.7	0.938	0.476	0.539	0.727	1.45	0.468	0.506	1.02	1.02	0.902	0.902	0.568	0.568	0.902	0.902	0.568	0.568	4.18
OUT - TSS Mean Annual Load (kg/yr)	355	334	69.2	79	110	510	71.7	72.3	26.4	17.4	24.1	15.5	14.3	9.48	23.7	15.5	14.8	9.55	297
OUT - TP Mean Annual Load (kg/yr)	0.647	0.165	0.127	0.144	0.194	0.255	0.128	0.131	0.155	0.141	0.141	0.126	8.50E-02	7.78E-02	0.14	0.127	8.62E-02	7.79E-02	0.547
OUT - TN Mean Annual Load (kg/yr)	8.24	2.34	0.952	1.09	1.46	3.48	0.935	1.02	2.28	1.78	1.98	1.55	1.23	0.969	1.99	1.56	1.23	0.968	7.24
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	22.6	11.2	12.6	17	35	11	11.9	24.6	0	21.7	0	13.7	0	21.7	0	13.7	0	0

APPENDIX B

Existing Drainage Network

SKETCH PLAN
SHOWING APPROXIMATE LOCATIONS OF EXISTING STORMWATER DRAINAGE PITS AT MANYANA FOR JWA ENTERPRISES P/L

NOT TO SCALE

N
W E
S

WARNING NOTE:

THE STORMWATER DRAINAGE INFORMATION SHOWN ON THIS PLAN IS APPROXIMATE ONLY AND HAS NOT BEEN CONFIRMED BY SURVEY. THE POSTIONS AND SIZES OF STORMWATER DRAINAGE SHOWN MAY NOT NECESSARILY REPRESENT THE EXACT OR FULL EXTENT OF THE EXISTING STORMWATER DRAINAGE.

WATKINSON APPERLEY PTY LTD ACCEPTS NO RESPONSIBILITY FOR THE RELIANCE OF ANY USER OF THIS PLAN FOR INFORMATION PROVIDED HEREIN AS IT IS A DRAFT PLAN FOR PRELIMINARY INFORMATION ONLY.

THE BATTLEMENT
THE BATTLEMENT
NEPTUNE STREET
MANYANA DRIVE
MANYANA DRIVE
SUNSET STRIP
SUNSET STRIP
THE BULWARK
THE BARTIZAN
THE BARBICAN
BARBETTE
PALISADE
PANNICLE
THE BOUNTY
MANYANA DRIVE
GRAVEL DRIVE
BITUMEN
KERB
SWPIT
GULLY PIT
SWPIT (BURIED)
0.375<
0.45<
0.675<
0.9<
1.0<
1.4<
0.2<
inv 3.73
OL DRAIN

WATKINSON APPERLEY PTY LIMITED
SURVEYORS, ENGINEERS & TOWN PLANNERS
51 GRAHAM STREET NOWRA 2541
Phone : (02)4421 4500 Fax : (02)4423 1496
Email: mail@watapp.com.au

Date – APRIL 2008

APPENIX C

Rational Method Calibration of DRAINS Hydrologic Model

Rational Method Flow Check

Sub-Catchment	Area (ha)	t_c (min)	Rational Method ARI5 I_5 (mm/hr)	ARI5 Q_5	ARI100 I_{100} (mm/hr)	ARI100 Q_{100}
1a	34.4	30	88	5.7	151	12.8
1b	7.5	17	115	1.6	191	3.5
1c	9	18	112	1.9	187	4.1
2	15.5	22	102	3.0	173	6.6
3	3.4	13	128	0.8	211	1.8
Total	69.8	40	76	10.0	133	22.8

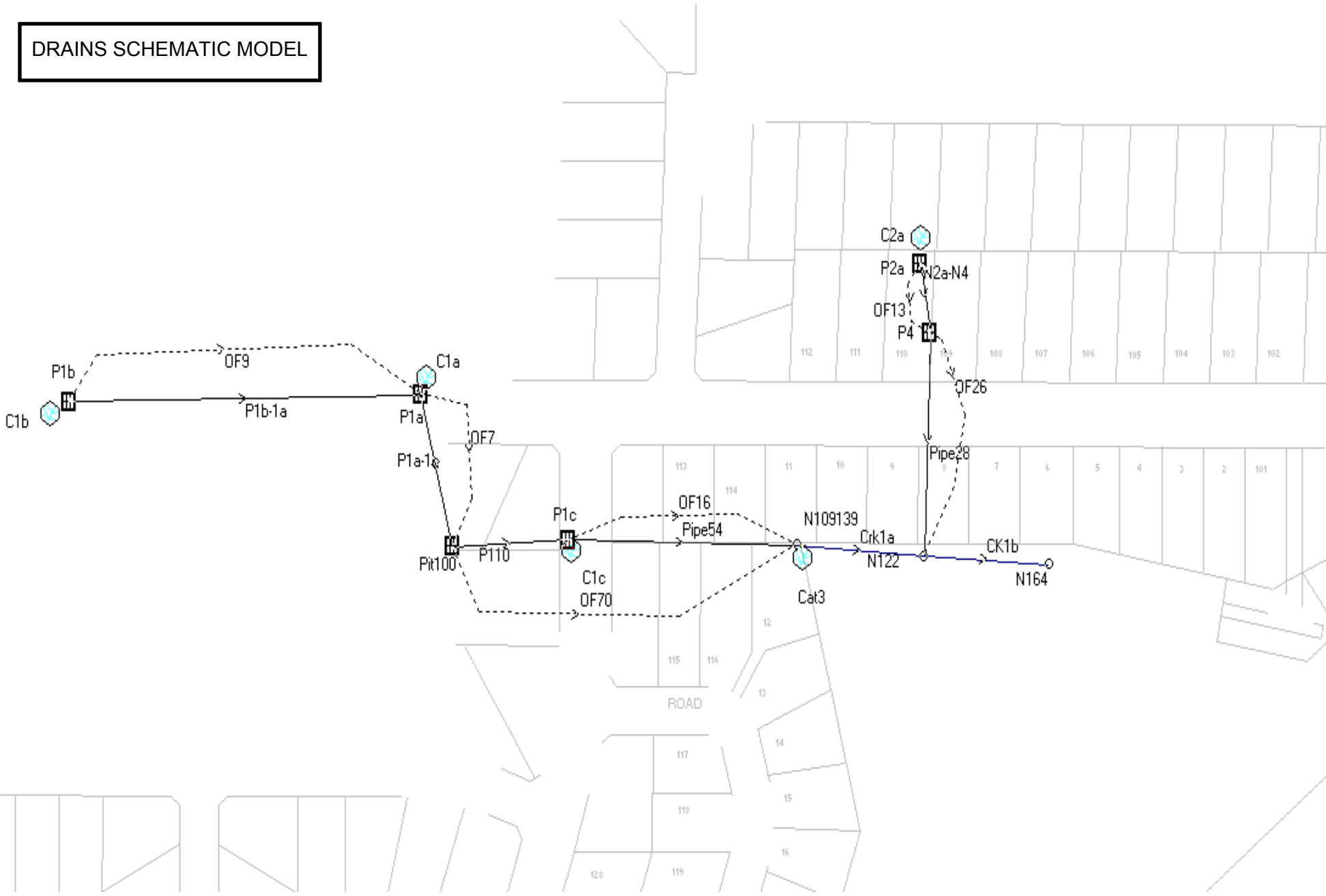
Runoff Coefficient

C5	0.68	=C10xFF5
C100	0.89	=C10xFF100
C10=	0.75	
FF5=	0.9	
FF100=	1.18	

APPENDIX D

DRAINS
Schematics
Input and Output Data

DRAINS SCHEMATIC MODEL



PRE-DEVELOPED DATA

PIT / NODE DETAILS Version 9

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor	x	y	Bolt-down lid	id	Part Full Shock Loss
P1b	OnGrade	Dummy	DUMMY FULL CAPTURE		4	9.7		0	0	-257.94	21.16	No	1438	1 x Ku
P1a	OnGrade	Dummy	DUMMY FULL CAPTURE		4.4	8		0	0	-122.26	23.13	No	1450	0.5 x Ku
Pit100	Sag	Dummy	DUMMY FULL CAPTURE	500	4.4	5.7	0.3	0	0	-110.24	-24.16	No	3247366	0.5 x Ku
P1c	OnGrade	Dummy	DUMMY FULL CAPTURE		2.6	5.5		0	0	-65.58	-22.13	No	1464	0.3 x Ku
N109139	Node					5.1		0		22.95	-23.83		8124709	
N122	Node					5.5		0		72.05	-27.29		1475	
N164	Node							0		120.39	-29.81		2339934	
P2a	OnGrade	Dummy	DUMMY FULL CAPTURE		4	6.73		0	0	70.72	64.4	No	270089	1 x Ku
P4	OnGrade	Dummy	DUMMY FULL CAPTURE		3.3	6		0	0	74.34	42.68	No	270109	1 x Ku

DETENTION BASIN DETAILS

Name	Elev	Volume	Init Vol. (cu.m)	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type	x	y	HED	Crest RL	Crest Length(m)	id

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)	Grass Length (m)	Supp Length (m)	Paved Slope(%) %	Grass Slope %	Supp Slope %	Paved Rough	Grass Rough	Supp Rough	Lag Time or Factor
C1b	P1b	7.46	0	100	0	5	2	0	5	70	0	3	7	0	0.08	0.4	0	0
C1a	P1a	34.35	9	91	0	5	15	0	3	120	0	3	4	0	0.08	0.3	0	0
C1c	P1c	9.02	0	100	0	8	2	0	3	170	0	3	6	0	0.08	0.3	0	0
Cat3	N109139	3.44	0	100	0	5	1	0	3	160	0	3	2.5	0	0.08	0.3	0	0
C2a	P2a	15.48	0	100	0	15	10	0	3	100	0	3	9	0	0.08	0.3	0	0

PIPE DETAILS

Name	From	To	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)	Rough	Pipe Is	No. Pipes	Chg From	At Chg	Chg (m)	Rl (m)	Chg (m)	RL (m)
P1b-1a	P1b	P1a	250	8.57	6.12	0.98	Concrete, under roads	1050	1070	0.3	New	1	P1b	0				
P1a-1c	P1a	Pit100	37.5	6.12	4.28	4.91	Concrete, not under roads	1050	1070	0.3	New	1	P1a	0				
P110	Pit100	P1c	56.6	4.28	3.6	1.2	Concrete, not under roads	1050	1070	0.3	New	1	Pit100	0				
Pipe54	P1c	N109139	38.72	3.6	3.49	0.28	Concrete, not under roads	1350	1370	0.3	New	1	P1c	0				
N2a-N4	P2a	P4	46.85	4.8	3.75	2.24	Concrete, under roads	900	900	0.3	New	1	P2a	0				
Pipe28	P4	N122	1	3.75	3.7	5	Concrete, under roads	1200	1200	0.3	New	1	P4	0				

DETAILS of SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of Service (m)	Chg (m)	Bottom Elev (m)	Height of Service (m)	Chg (m)	Bottom Elev (m)	Height of Service (m)	etc	etc

CHANNEL DETAILS

Name	From	To	Type	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Base Width (m)	L.B. Slope (1:?)	R.B. Slope (1:?)	Manning n	Depth (m)	Roofed
Crk1a	N109139	N122	Irregular	71.67									
CK1b	N122	N164	Irregular	195.97									

OVERFLOW ROUTE DETAILS

Name	From	To	Travel Time (min)	Spill Level (m)	Crest Length (m)	Weir Coeff. C	Cross Section	Safe Depth Major Storms (m)	SafeDepth Minor Storms (m)	Safe DxV (sq.m/sec)	Bed Slope (%)	D/S Area Contributing %	id
OF9	P1b	P1a	5				Full width 6m Road, Layback Kerb, 2m footpath @4%	0.15	0.09	0.6	3	0	232717
OF7	P1a	Pit100	4				6m road, roll kerb, 2m ftpth @6.0%, FULL WIDTH	0.16	0.11	0.6	3	0	1473
OF70	Pit100	N109139	4				6m road, roll kerb, 2m ftpth @6.0%, FULL WIDTH	0.16	0.11	0.6	3	0	3409687
OF16	P1c	N109139	3				8m wide road	0.14	0.14	0.6	1	0	1296351
OF13	P2a	P4	6				Grassed Swale 1m base 1:3 sides	0.4	0.4	0.6	2.5	0	270116
OF26	P4	N122	4				Pathway 4m wide	0.3	0.3	0.6	3	0	2444813

PRE-DEVELOPED 5 YEAR PEAK STORM RESULTS

DRAINS results prepared 25 March, 2008 from Version 2006.23

PIT / NODE DETAILS

Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		1.76		0	1.28	Outlet System
P1a	8		5.44		0	3.52	Outlet System
Pit100	6	6	3.52	500	-0.3	4.23	Outlet System
P1c	5.5		1.52		0	0.67	Outlet System
N109139	4.58		5.24				
N122	3.71		0				
N164	2.47		0				
P2a	6.73		2.83		0	1.59	Outlet System
P4	5.94		1.59		0.06	0	None

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	1.76	0	1.76	7.23	20.62	0	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
C1a	4.55	1.32	4.29	6.81	48.55	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
C1c	1.52	0	1.52	9.64	35.2	0	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
Cat3	0.49	0	0.49	6.64	42.64	0	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
C2a	2.83	0	2.83	16.64	31.38	0	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P1b-1a	0.49	0.9	9.19	8	AR&R 5 year, 5 minutes storm, average 174 mm/h, Zone 1
P1a-1c	2.42	7.4	6.54	6	AR&R 5 year, 5 minutes storm, average 174 mm/h, Zone 1
P110	2.16	2.4	5.74	5.5	AR&R 5 year, 20 minutes storm, average 102 mm/h, Zone 1
Pipe54	3.21	2.6	4.95	4.58	AR&R 5 year, 30 minutes storm, average 85 mm/h, Zone 1
N2a-N4	1.43	2.2	6.07	5.94	AR&R 5 year, 15 minutes storm, average 116 mm/h, Zone 1
Pipe28	2.74	7.6	4.18	4.13	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	8.26	2	0	4.58	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
		2.2	17.57	4.21	
		1	73.2	3.8	
CK1b	10.74	0.6	0	3.71	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
		1.3	62.3	3.56	
		1.1	125.6	3.25	
		0.9	179.4	2.99	
		2.2	216.5	2.47	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	1.28	1.28	0.46	0.13	0.28	9.1	2.15	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
OF7	3.52	3.52	0.77	0.17	0.62	10.48	3.63	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
OF70	4.23	4.23	0.77	0.17	0.74	10.48	4.37	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
OF16	0.67	0.67	0.25	0.19	0.3	4	1.59	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
OF13	1.59	1.59	1.25	0.4	0.72	3.41	1.79	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
OF26	0	0	1.81	0	0	0	0	

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

CONTINUITY CHECK for AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	2724.39	2724.39	0	0
P1a	15643.1	15643.12	0	0
Pit100	15643.06	15581.38	0	0.4
P1c	10641.85	10729.62	0	-0.8
N109139	20137.28	20137.29	0	0
N122	25726.53	25726.53	0	0
N164	25726.53	25726.53	0	0
P2a	5588.66	5588.66	0	0
P4	5588.66	5589.25	0	0

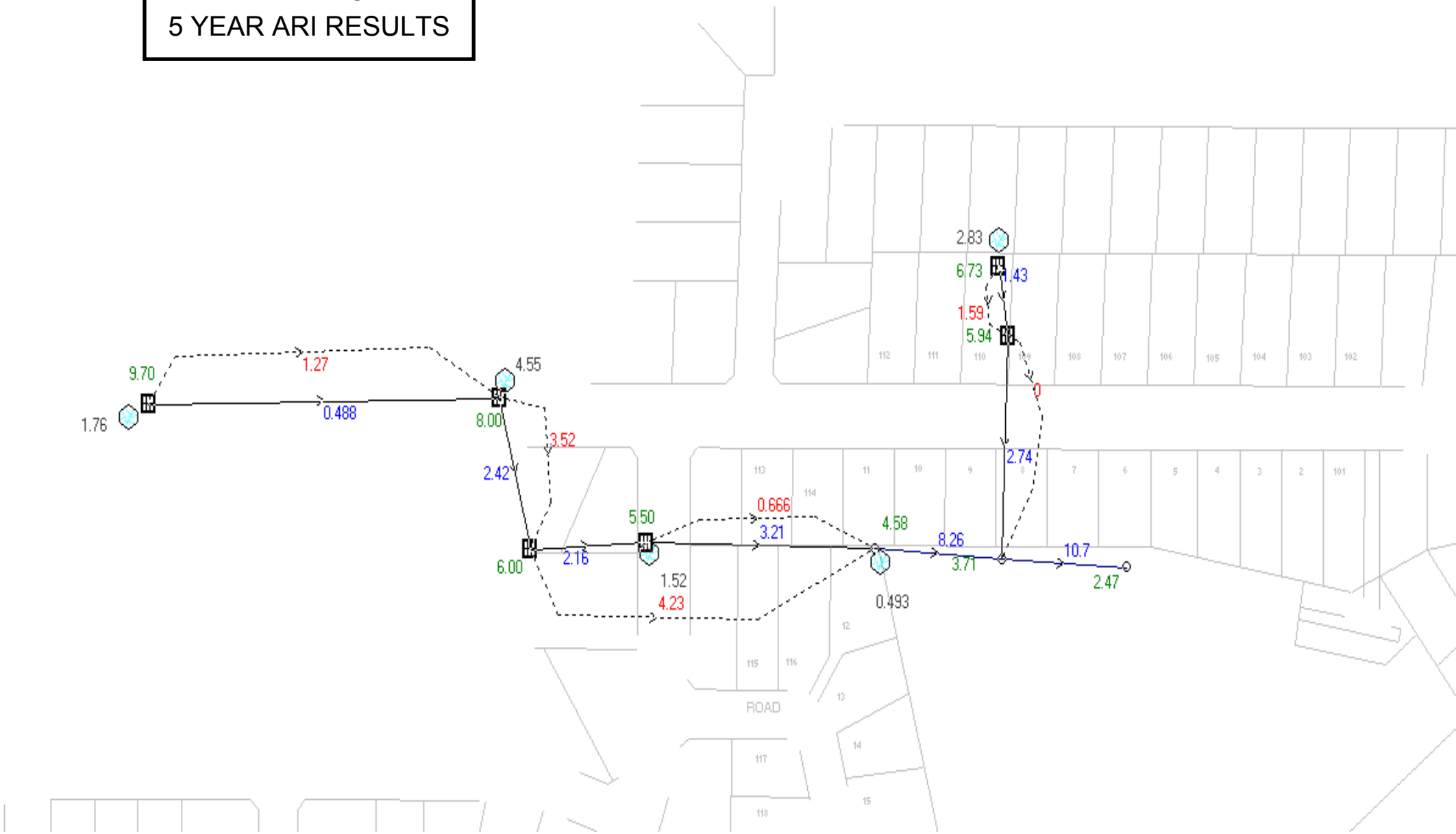
Run Log for Whole catchment PRE2.drn run at 10:33:59 on 25/3/2008

Water spilled (upwelling) from Pit100

Freeboard was less than 0.15m at P4, P2a, P1c, P1a, P1b

The maximum flow exceeded the safe value in the following overflow routes: OF70, OF16, OF13, OF9, OF7

PRE DEVELOPED
5 YEAR ARI RESULTS



PRE-DEVELOPED 100 YEAR PEAK STORM RESULTS

DRAINS results prepared 25 March, 2008 from Version 2006.23

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		3.93		0	3.44	Outlet System
P1a	8		13.78		0	11.85	Outlet System
Pit100	6	6	11.85	500	-0.3	12.11	Outlet System
P1c	5.5		3.83		0	2.97	Outlet System
N109139	4.68		16.01				
N122	4.16		3.87				
N164	2.85		0				
P2a	6.73		6.7		0	5.55	Outlet System
P4	6		5.55		0	3.87	Outlet System

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	3.93	0	3.93	6.74	16.56	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
C1a	11.47	2.25	10.92	6.28	38.79	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
C1c	3.83	0	3.83	9.28	27.96	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
Cat3	1.32	0	1.32	6.28	33.55	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
C2a	6.7	0	6.7	16.28	26.72	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P1b-1a	0.49	0.9	9.19	8	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
P1a-1c	2.42	7.4	6.54	6	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
P110	2.16	2.4	5.74	5.5	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
Pipe54	3.2	2.4	4.95	4.68	AR&R 100 year, 2 hours storm, average 74 mm/h, Zone 1
N2a-N4	1.43	2.2	6.14	6	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
Pipe28	2.82	7.7	4.18	4.16	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	19.03	2	0	4.68	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
		2.2	17.57	4.36	
		1.1	73.2	4.18	
CK1b	25.51	0.6	0	4.16	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
		1.3	62.3	4.1	
		1.7	125.6	3.71	
		1	179.4	3.43	
		2.4	216.5	2.85	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	3.44	3.44	1.93	0.17	0.58	11.15	3.41	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
OF7	11.85	11.85	2.25	0.17	2.08	10.48	12.23	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
OF70	12.11	12.11	2.25	0.17	2.12	10.48	12.49	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
OF16	2.97	2.97	0.25	0.3	0.92	6.41	3.1	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
OF13	5.55	5.55	1.25	0.71	1.77	5.28	2.48	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
OF26	3.87	3.87	1.81	0.28	1.17	4	4.14	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

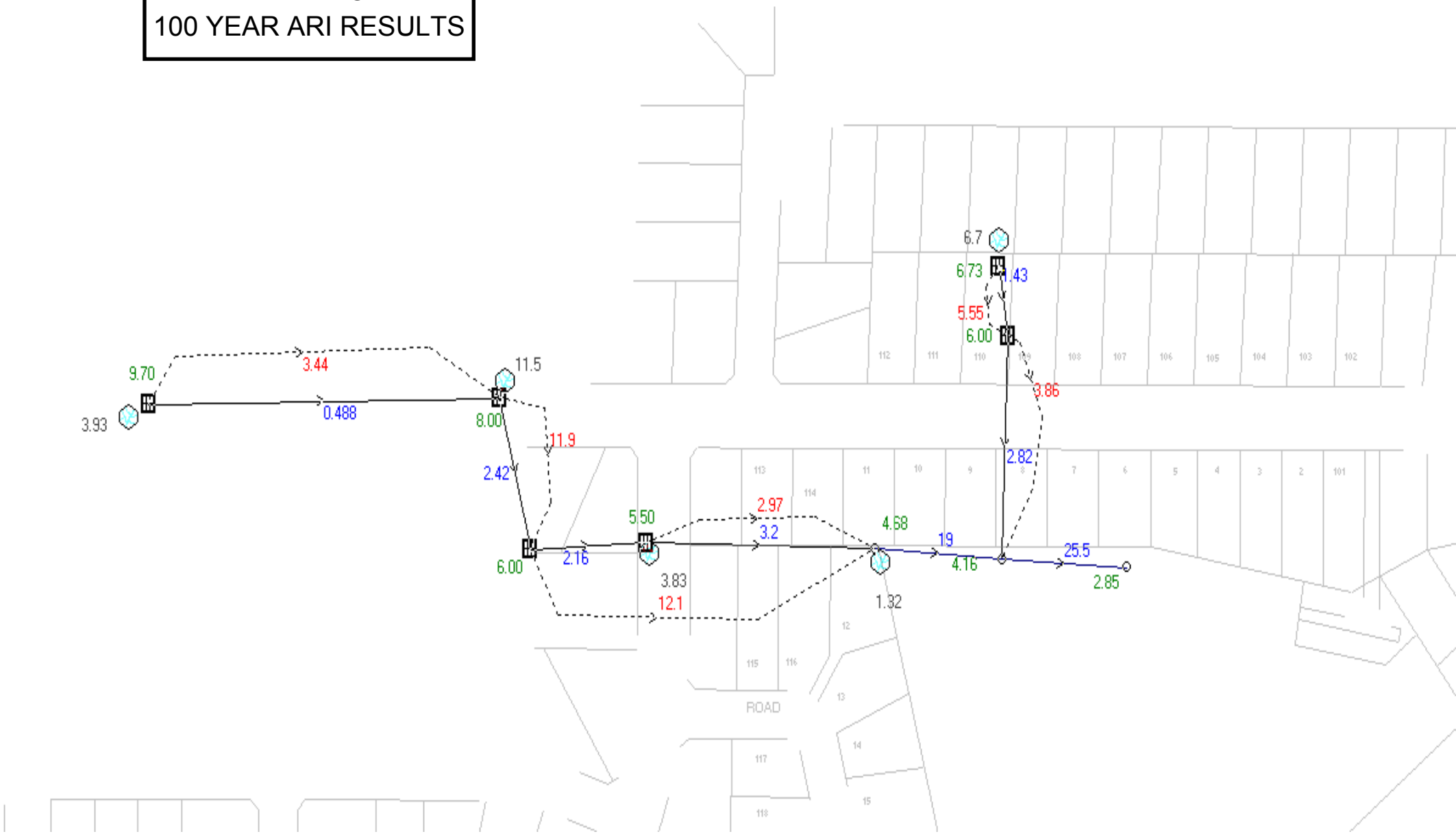
CONTINUITY CHECK for AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	6498.9	6498.9	0	0
P1a	36764.03	36764	0	0
Pit100	36763.89	36772.9	0	0
P1c	17178.7	17231.77	0	-0.3
N109139	47595.84	47595.85	0	0
N122	60998.13	60997.92	0	0
N164	60997.92	60997.92	0	0
P2a	13401.13	13401.13	0	0
P4	13401.14	13402.06	0	0

Run Log for Whole catchment PRE2.drn run at 11:29:33 on 25/3/2008

Water spilled (upwelling) from Pit100
Freeboard was less than 0.15m at P4, P2a, P1c, P1a, P1b
The maximum flow exceeded the safe value in the following overflow routes: OF70, OF26, OF16, OF13, OF9, OF7

PRE DEVELOPED □
100 YEAR ARI RESULTS



EXISTING DEVELOPMENT DATA

PIT / NODE DETAILS Version 9

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor	x	y	Bolt-down lid	id	Part Full Shock Loss
P1b	OnGrade	Dummy	DUMMY FULL CAPTURE		4	9.7		0	0	-257.94	21.16	No	1438	1 x Ku
P1a	OnGrade	Dummy	DUMMY FULL CAPTURE		4.4	8		0	0	-122.26	23.13	No	1450	0.5 x Ku
Pit100	Sag	Dummy	DUMMY FULL CAPTURE	500	4.4	5.7	0.3	0	0	-110.24	-24.16	No	3247366	0.5 x Ku
P1c	OnGrade	Dummy	DUMMY FULL CAPTURE		2.6	5.5		0	0	-65.58	-22.13	No	1464	0.3 x Ku
N109139	Node					5.1		0		22.95	-23.83		8124709	
N122	Node					5.5		0		72.05	-27.29		1475	
N164	Node							0		120.39	-29.81		2339934	
P2a	OnGrade	Dummy	DUMMY FULL CAPTURE		4	6.73		0	0	70.72	64.4	No	270089	1 x Ku
P4	OnGrade	Dummy	DUMMY FULL CAPTURE		3.3	6		0	0	74.34	42.68	No	270109	1 x Ku

DETENTION BASIN DETAILS

Name	Elev	Volume	Init Vol. (cu.m)	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type	x	y	HED	Crest RL	Crest Length(m)	id

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)	Grass Length (m)	Supp Length (m)	Paved Slope(%) %	Grass Slope %	Supp Slope %	Paved Rough	Grass Rough	Supp Rough	Lag Time or Factor
C1b	P1b	7.46	45	55	0	5	2	0	5	70	0	3	7	0	0.08	0.21	0	0
C1a	P1a	34.35	9	91	0	5	15	0	3	120	0	3	4	0	0.08	0.3	0	0
C1c	P1c	9.02	17	83	0	8	2	0	3	170	0	3	6	0	0.08	0.3	0	0
Cat3	N109139	3.44	5	95	0	5	1	0	3	160	0	3	2.5	0	0.08	0.3	0	0
C2a	P2a	15.48	45	55	0	15	10	0	3	100	0	3	9	0	0.08	0.3	0	0

PIPE DETAILS

Name	From	To	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)	Rough	Pipe Is	No. Pipes	Chg From	At Chg	Chg (m)	Rl (m)	Chg (m)	RL (m)
P1b-1a	P1b	P1a	250	8.57	6.12	0.98	Concrete, under roads	1050	1070	0.3	New	1	P1b	0				
P1a-1c	P1a	Pit100	37.5	6.12	4.28	4.91	Concrete, not under roads	1050	1070	0.3	New	1	P1a	0				
P110	Pit100	P1c	56.6	4.28	3.6	1.2	Concrete, not under roads	1050	1070	0.3	New	1	Pit100	0				
Pipe54	P1c	N109139	38.72	3.6	3.49	0.28	Concrete, not under roads	1350	1370	0.3	New	1	P1c	0				
N2a-N4	P2a	P4	46.85	4.8	3.75	2.24	Concrete, under roads	900	900	0.3	New	1	P2a	0				
Pipe28	P4	N122	1	3.75	3.7	5	Concrete, under roads	1200	1200	0.3	New	1	P4	0				

DETAILS of SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of Service (m)	Chg (m)	Bottom Elev (m)	Height of Service (m)	Chg (m)	Bottom Elev (m)	Height of Service (m)	etc	etc

CHANNEL DETAILS

Name	From	To	Type	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Base Width (m)	L.B. Slope (1:?)	R.B. Slope (1:?)	Manning n	Depth (m)	Roofed
Crk1a	N109139	N122	Irregular	90.77									
CK1b	N122	N164	Irregular	216.5									

OVERFLOW ROUTE DETAILS

Name	From	To	Travel Time (min)	Spill Level (m)	Crest Length (m)	Weir Coeff. C	Cross Section	Safe Depth Major Storms (m)	SafeDepth Minor Storms (m)	Safe DxV (sq.m/sec)	Bed Slope (%)	D/S Area Contributing %	id
OF9	P1b	P1a	5				Full width 6m Road, Layback Kerb, 2m footpath @4%	0.15	0.09	0.6	3	0	232717
OF7	P1a	Pit100	4				6m road, roll kerb, 2m ftpth @6.0%, FULL WIDTH	0.16	0.11	0.6	3	0	1473
OF70	Pit100	N109139	4				6m road, roll kerb, 2m ftpth @6.0%, FULL WIDTH	0.16	0.11	0.6	3	0	3409687
OF16	P1c	N109139	3				8m wide road	0.14	0.14	0.6	1	0	1296351
OF13	P2a	P4	6				Grassed Swale 1m base 1:3 sides	0.4	0.4	0.6	2.5	0	270116
OF26	P4	N122	4				Pathway 4m wide	0.3	0.3	0.6	3	0	2444813

EXISTING DEVELOPMENT 1 YEAR PEAK STORM RESULTS

DRAINS results prepared 21 April, 2008 from Version 2006.23

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		1.07		0	0.58	Outlet System
P1a	7.93		1.83		0.07	0	None
Pit100	6	6	0	405	-0.3	0.31	Outlet System
P1c	5.17		0.6		0.33	0	None
N109139	4.24		0.44				
N122	3.44		0				
N164	2.06		0				
P2a	6.73		1.57		0	0.14	Outlet System
P4	5.28		0.14		0.72	0	None

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	1.07	0.84	0.29	7.41	18.27	0	AR&R 1 year, 30 minutes storm, average 49.2 mm/h, Zone 1
C1a	1.46	0.78	0.85	6.78	47.94	0	AR&R 1 year, 30 minutes storm, average 49.2 mm/h, Zone 1
C1c	0.6	0.38	0.23	9.64	35.2	0	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
Cat3	0.13	0.04	0.12	7.45	63.08	0	AR&R 1 year, 2 hours storm, average 22.1 mm/h, Zone 1
C2a	1.57	1.29	0.44	17.07	36.93	0	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P1b-1a	0.49	0.9	9.19	7.93	AR&R 1 year, 10 minutes storm, average 82 mm/h, Zone 1
P1a-1c	2.31	7.2	6.53	6	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
P110	1.76	2	5.47	5.18	AR&R 1 year, 2 hours storm, average 22.1 mm/h, Zone 1
Pipe54	3.26	2.9	4.9	4.45	AR&R 1 year, 30 minutes storm, average 49.2 mm/h, Zone 1
N2a-N4	1.43	2.8	5.48	5.28	AR&R 1 year, 45 minutes storm, average 39.6 mm/h, Zone 1
Pipe28	1.57	6.9	4.06	4.01	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	3.36	1.8	0	4.24	AR&R 1 year, 30 minutes storm, average 49.2 mm/h, Zone 1
		1.7	17.57	3.79	
		0.8	73.2	3.51	
CK1b	4.54	0.6	0	3.44	AR&R 1 year, 30 minutes storm, average 49.2 mm/h, Zone 1
		1.3	62.3	3.21	
		0.8	125.6	2.89	
		0.9	179.4	2.61	
		2.1	216.5	2.06	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	0.58	0.58	0.46	0.1	0.17	7.56	1.69	AR&R 1 year, 30 minutes storm, average 49.2 mm/h, Zone
OF7	0	0	0.77	0	0	0	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF70	0.31	0.31	0.77	0.08	0.12	5.37	1.51	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1
OF16	0	0	0.25	0	0	0	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF13	0.14	0.14	1.25	0.12	0.11	1.7	0.91	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1
OF26	0	0	1.81	0	0	0	0	AR&R 5 year, 2 hours storm, average 39.5 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

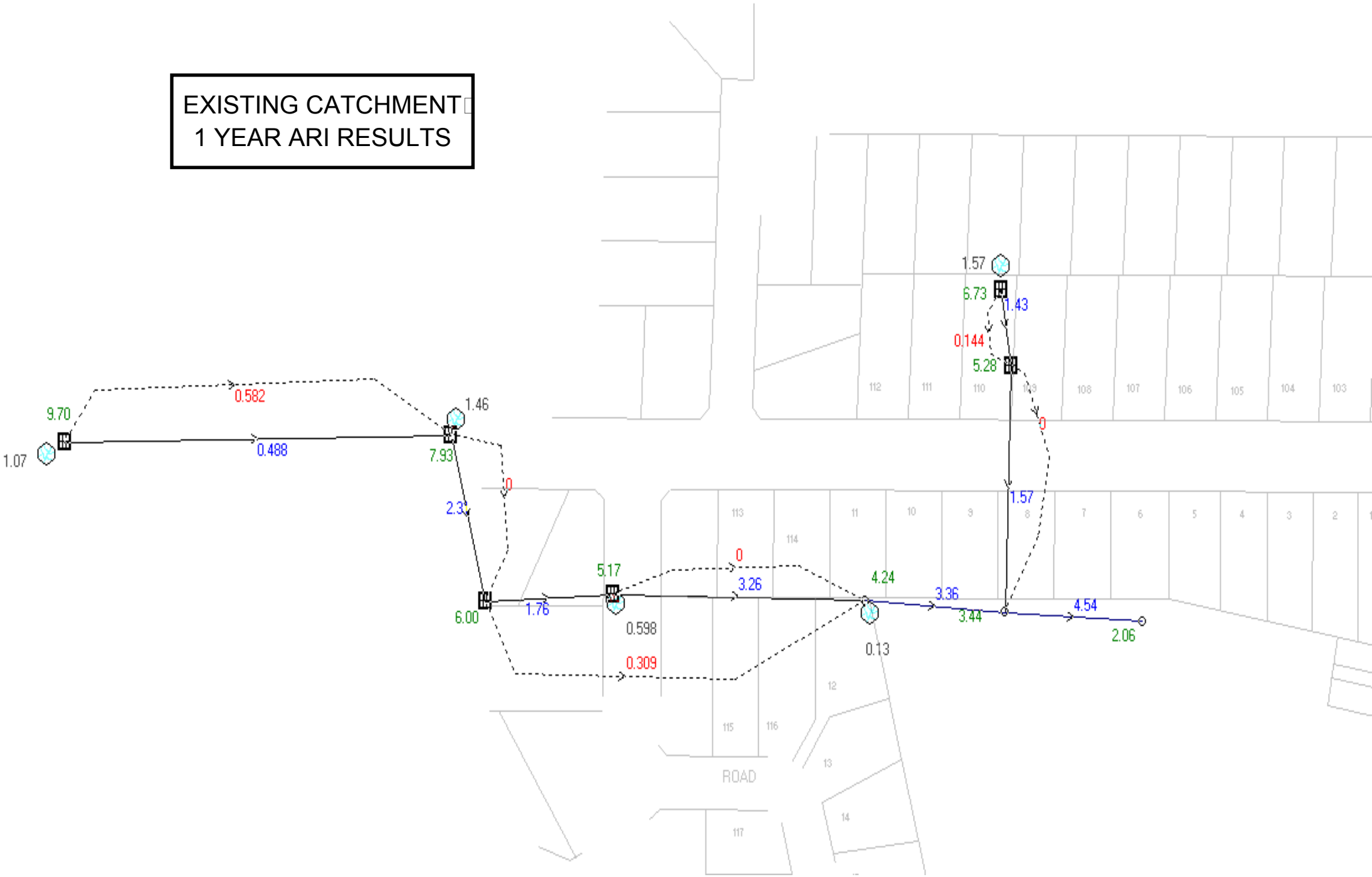
CONTINUITY CHECK for AR&R 1 year, 30 minutes storm, average 49.2 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	1089.21	1089.21	0	0
P1a	3475.78	3550.05	0	-2.1
Pit100	3550.05	3558.63	0	-0.2
P1c	4373.17	4445.22	0	-1.6
N109139	4663.12	4663.13	0	0
N122	6862.9	6862.89	0	0
N164	6862.89	6862.89	0	0
P2a	2187.58	2187.58	0	0
P4	2187.58	2199.77	0	-0.6

Run Log for Whole catchment EXIST.drn run at 16:50:35 on 21/4/2008

Water spilled (upwelling) from Pit100
Freeboard was less than 0.15m at P2a, P1a, P1b
The maximum flow exceeded the safe value in the following overflow routes: OF9

EXISTING CATCHMENT
1 YEAR ARI RESULTS



EXISTING DEVELOPMENT 5 YEAR PEAK STORM RESULTS

DRAINS results prepared 25 March, 2008 from Version 2006.23

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		2.41		0	1.92	Outlet System
P1a	8		5.89		0	3.96	Outlet System
Pit100	6	6	3.96	500	-0.3	4.69	Outlet System
P1c	5.5		1.49		0	0.55	Outlet System
N109139	4.58		5.67				
N122	3.75		0.53				
N164	2.51		0				
P2a	6.73		3.39		0	2.26	Outlet System
P4	6		2.26		0	0.53	Outlet System

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	2.41	1.38	1.04	7.46	18.57	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
C1a	4.55	1.32	4.29	6.81	48.55	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
C1c	1.49	0.61	1.18	9.94	41.25	0	AR&R 5 year, 2 hours storm, average 39.5 mm/h, Zone 1
Cat3	0.48	0.07	0.47	6.64	42.64	0	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
C2a	3.39	2.31	1.56	16.64	31.38	0	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P1b-1a	0.49	0.9	9.19	8	AR&R 5 year, 5 minutes storm, average 174 mm/h, Zone 1
P1a-1c	2.42	7.4	6.54	6	AR&R 5 year, 5 minutes storm, average 174 mm/h, Zone 1
P110	2.16	2.4	5.74	5.5	AR&R 5 year, 20 minutes storm, average 102 mm/h, Zone 1
Pipe54	3.22	2.6	4.95	4.58	AR&R 5 year, 30 minutes storm, average 85 mm/h, Zone 1
N2a-N4	1.43	2.2	6.13	6	AR&R 5 year, 10 minutes storm, average 137 mm/h, Zone 1
Pipe28	2.82	7.7	4.18	4.13	AR&R 5 year, 20 minutes storm, average 102 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	8.68	2	0	4.58	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
		2.2	17.57	4.22	
		1	73.2	3.84	
CK1b	11.9	0.6	0	3.75	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
		1.3	62.3	3.62	
		1.2	125.6	3.3	
		0.9	179.4	3.03	
		2.2	216.5	2.51	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	1.92	1.92	0.46	0.15	0.36	10.13	2.43	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF7	3.96	3.96	0.77	0.17	0.69	10.48	4.09	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF70	4.69	4.69	0.77	0.17	0.82	10.48	4.83	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
OF16	0.55	0.55	0.25	0.18	0.26	4	1.48	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
OF13	2.26	2.26	1.25	0.47	0.93	3.84	1.96	AR&R 5 year, 2 hours storm, average 39.5 mm/h, Zone 1
OF26	0.53	0.53	1.81	0.12	0.23	4	1.94	AR&R 5 year, 2 hours storm, average 39.5 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

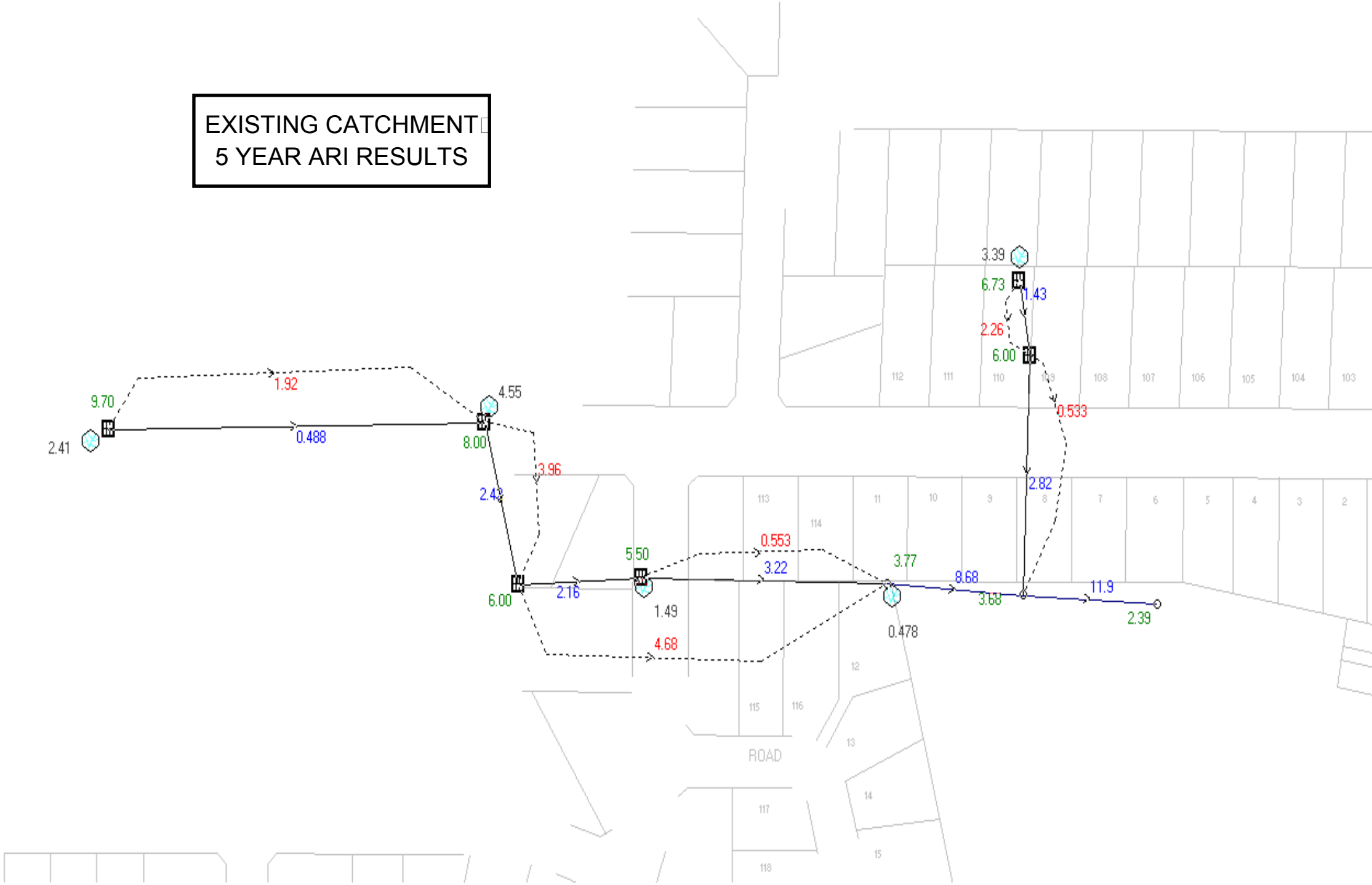
CONTINUITY CHECK for AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	3483.84	3483.84	0	0
P1a	16402.55	16461.76	0	-0.4
Pit100	16461.69	16469.7	0	0
P1c	11118.71	11177.21	0	-0.5
N109139	21389.98	21389.99	0	0
N122	28585.38	28585.38	0	0
N164	28585.38	28585.38	0	0
P2a	7183.7	7183.71	0	0
P4	7183.7	7195.38	0	-0.2

Run Log for Whole catchment EXIST.drn run at 14:55:41 on 25/3/2008

Water spilled (upwelling) from Pit100
Freeboard was less than 0.15m at P4, P2a, P1c, P1a, P1b
The maximum flow exceeded the safe value in the following overflow routes: OF70, OF16, OF13, OF9, OF7

EXISTING CATCHMENT
5 YEAR ARI RESULTS



EXISTING DEVELOPMENT 100 YEAR PEAK STORM RESULTS

DRAINS results prepared 25 March, 2008 from Version 2006.23

PIT / NODE DETAILS

Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		4.66		0	4.17	Outlet System
P1a	8		14.03		0	12.1	Outlet System
Pit100	6	6	12.1	500	-0.3	12.35	Outlet System
P1c	5.5		3.7		0	2.84	Outlet System
N109139	4.68		16.25				
N122	4.18		4.29				
N164	2.86		0				
P2a	6.73		7.15		0	5.98	Outlet System
P4	6		5.98		0	4.29	Outlet System

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	4.66	2.43	2.25	6.54	12.36	0	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
C1a	11.47	2.25	10.92	6.28	38.79	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
C1c	3.7	0.97	3.18	9.28	27.96	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
Cat3	1.29	0.13	1.25	6.28	33.55	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
C2a	7.15	4.11	3.69	16.28	26.72	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P1b-1a	0.49	0.9	9.19	8	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
P1a-1c	2.42	7.4	6.54	6	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
P110	2.16	2.4	5.74	5.5	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
Pipe54	3.26	2.4	4.95	4.68	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
N2a-N4	1.43	2.2	6.14	6	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
Pipe28	2.82	7.7	4.18	4.18	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	19.27	2	0	4.68	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
		2.2	17.57	4.36	
		1	73.2	4.2	
CK1b	26.28	0.6	0	4.18	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
		1.3	62.3	4.12	
		1.7	125.6	3.72	
		1	179.4	3.45	
		2.4	216.5	2.86	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	4.17	4.17	1.93	0.17	0.7	11.15	4.14	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zon
OF7	12.1	12.1	2.25	0.17	2.12	10.48	12.49	AR&R 100 year, 2 hours storm, average 74 mm/h, Zone 1
OF70	12.35	12.35	2.25	0.17	2.17	10.48	12.74	AR&R 100 year, 2 hours storm, average 74 mm/h, Zone 1
OF16	2.84	2.84	0.25	0.3	0.88	6.41	2.96	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
OF13	5.98	5.98	1.25	0.74	1.86	5.43	2.52	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
OF26	4.29	4.29	1.81	0.3	1.29	4	4.29	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

CONTINUITY CHECK for AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	7272.77	7272.77	0	0
P1a	37537.91	37596.92	0	-0.2
Pit100	37596.84	37605.54	0	0
P1c	17769.9	17823.29	0	-0.3
N109139	48829.85	48829.78	0	0
N122	63870.68	63870.39	0	0
N164	63870.39	63870.39	0	0
P2a	15033.22	15033.22	0	0
P4	15033.22	15040.63	0	0

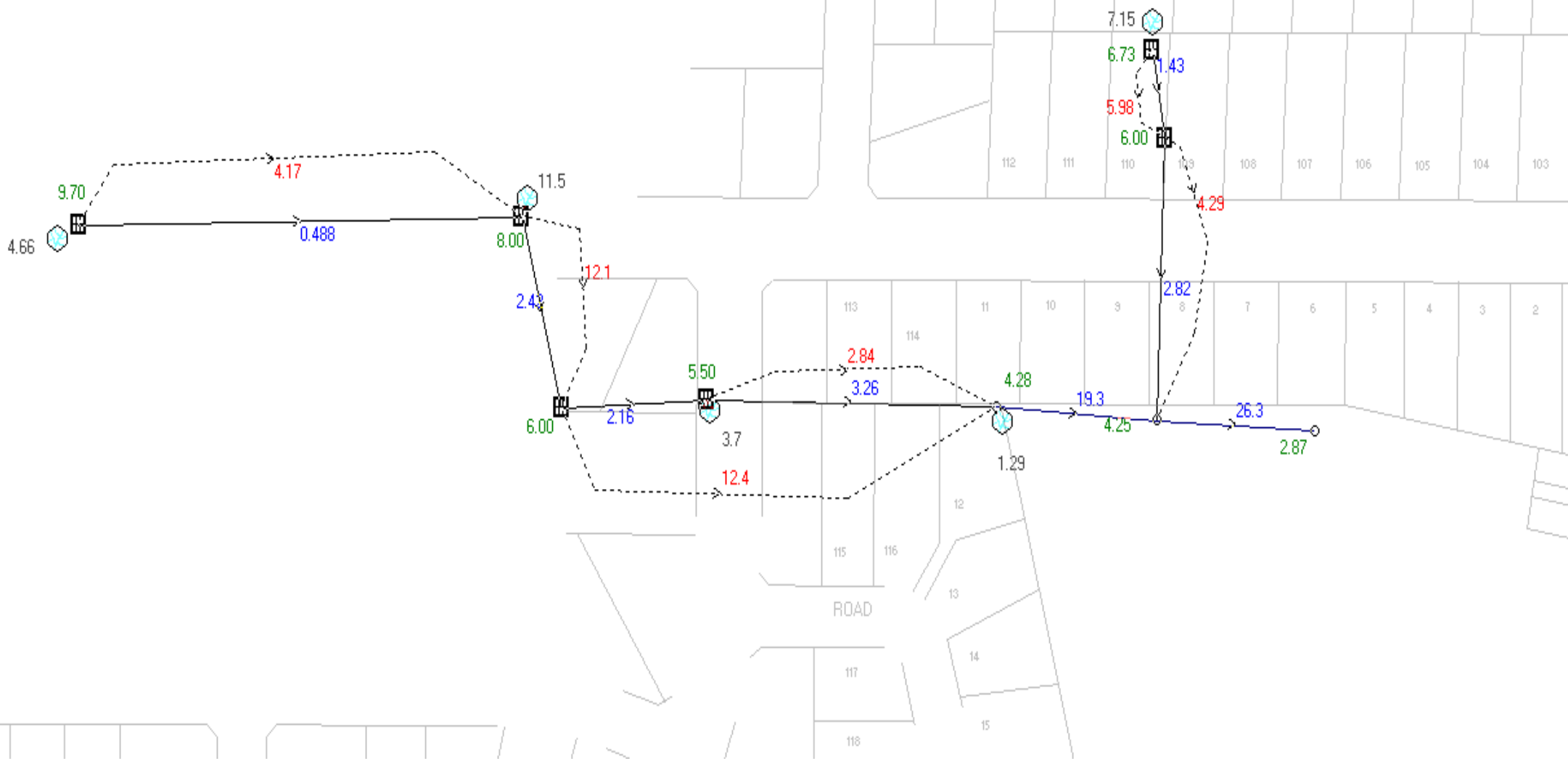
Run Log for Whole catchment EXIST.drn run at 15:06:42 on 25/3/2008

Water spilled (upwelling) from Pit100

Freeboard was less than 0.15m at P4, P2a, P1c, P1a, P1b

The maximum flow exceeded the safe value in the following overflow routes: OF70, OF26, OF16, OF13, OF9, OF7

EXISTING CATCHMENT
100 YEAR ARI RESULTS



POST-DEVELOPED DATA

PIT / NODE DETAILS Version 9

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor	x	y	Bolt-down lid	id	Part Full Shock Loss
P1b	OnGrade	Dummy	DUMMY FULL CAPTURE		4	9.7		0	0	-257.94	21.16	No	1438	1 x Ku
P1a	OnGrade	Dummy	DUMMY FULL CAPTURE		4.4	8		0	0	-122.26	23.13	No	1450	0.5 x Ku
Pit100	Sag	Dummy	DUMMY FULL CAPTURE	500	4.4	5.7	0.3	0	0	-110.24	-24.16	No	3247366	0.5 x Ku
P1c	OnGrade	Dummy	DUMMY FULL CAPTURE		2.6	5.5		0	0	-65.58	-22.13	No	1464	0.3 x Ku
N109139	Node					5.1		0		22.95	-23.83		8124709	
N122	Node					5.5		0		72.05	-27.29		1475	
N164	Node							0		120.39	-29.81		2339934	
P2a	OnGrade	Dummy	DUMMY FULL CAPTURE		4	6.73		0	0	70.72	64.4	No	270089	1 x Ku
P4	OnGrade	Dummy	DUMMY FULL CAPTURE		3.3	6		0	0	74.34	42.68	No	270109	1 x Ku

DETENTION BASIN DETAILS

Name	Elev	Volume	Init Vol. (cu.m)	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type	x	y	HED	Crest RL	Crest Length(m)	id

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)	Grass Length (m)	Supp Length (m)	Paved Slope(%) %	Grass Slope %	Supp Slope %	Paved Rough	Grass Rough	Supp Rough	Lag Time or Factor	Gutter Length (m)	Gutter Slope %	Gutter FlowFactor
C1b	P1b	7.46	45	55	0	5	2	0	5	70	0	3	7	0	0.08	0.21	0	0			
C1a	P1a	34.35	9	91	0	5	15	0	3	120	0	3	4	0	0.08	0.3	0	0			
C1c	P1c	9.02	45	55	0	8	2	0	3	170	0	3	6	0	0.08	0.3	0	0			
Cat3	N109139	3.44	40	60	0	5	1	0	3	160	0	3	2.5	0	0.08	0.3	0	0			
C2a	P2a	15.48	45	55	0	15	10	0	3	100	0	3	9	0	0.08	0.3	0	0			

PIPE DETAILS

Name	From	To	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)	Rough	Pipe Is	No. Pipes	Chg From	At Chg	Chg (m)	Rl (m)	Chg (m)	RL (m)	etc (m)
P1b-1a	P1b	P1a	250	8.57	6.12	0.98	Concrete, under roads	1050	1070	0.3	New	1	P1b	0					
P1a-1c	P1a	Pit100	37.5	6.12	4.28	4.91	Concrete, not under roads	1050	1070	0.3	New	1	P1a	0					
P110	Pit100	P1c	56.6	4.28	3.6	1.2	Concrete, not under roads	1050	1070	0.3	New	1	Pit100	0					
Pipe54	P1c	N109139	38.72	3.6	3.49	0.28	Concrete, not under roads	1350	1370	0.3	New	1	P1c	0					
N2a-N4	P2a	P4	46.85	4.8	3.75	2.24	Concrete, under roads	900	900	0.3	New	1	P2a	0					
Pipe28	P4	N122	1	3.75	3.7	5	Concrete, under roads	1200	1200	0.3	New	1	P4	0					

DETAILS of SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of Service (m)	Chg (m)	Bottom Elev (m)	Height of Service (m)	Chg (m)	Bottom Elev (m)	Height of Service (m)	etc etc

CHANNEL DETAILS

Name	From	To	Type	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Base Width (m)	L.B. Slope (1:?)	R.B. Slope (1:?)	Manning n	Depth (m)	Roofed
Crk1a	N109139	N122	Irregular	90.77									
CK1b	N122	N164	Irregular	216.5									

OVERFLOW ROUTE DETAILS

Name	From	To	Travel Time (min)	Spill Level (m)	Crest Length (m)	Weir Coeff. C	Cross Section	Safe Depth Major Storms (m)	SafeDepth Minor Storms (m)	Safe DxV (sq.m/sec)	Bed Slope (%)	D/S Area Contributing %	id
OF9	P1b	P1a	5				Full width 6m Road, Layback Kerb, 2m footpath @4%	0.15	0.09	0.6	3	0	232717
OF7	P1a	Pit100	4				6m road, roll kerb, 2m ftpth @6.0%, FULL WIDTH	0.16	0.11	0.6	3	0	1473
OF70	Pit100	N109139	4				6m road, roll kerb, 2m ftpth @6.0%, FULL WIDTH	0.16	0.11	0.6	3	0	3409687
OF16	P1c	N109139	3				8m wide road	0.14	0.14	0.6	1	0	1296351
OF13	P2a	P4	6				Grassed Swale 1m base 1:3 sides	0.4	0.4	0.6	2.5	0	270116
OF26	P4	N122	4				Pathway 4m wide	0.3	0.3	0.6	3	0	2444813

POST-DEVELOPED 1 YEAR PEAK STORM RESULTS

DRAINS results prepared 18 April, 2008 from Version 2006.23

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		1.04		0	0.55	Outlet System
P1a	7.93		1.83		0.07	0	None
Pit100	6	6	0	374	-0.3	0.34	Outlet System
P1c	5.29		1.14		0.21	0	None
N109139	4.27		0.5				
N122	3.47		0				
N164	2.1		0				
P2a	6.73		1.57		0	0.14	Outlet System
P4	5.28		0.14		0.72	0	None

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	1.04	0.87	0.25	7.23	17.03	0	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
C1a	1.42	0.82	0.74	6.64	45.43	0	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
C1c	1.14	0.99	0.15	9.64	35.2	0	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
Cat3	0.4	0.37	0.05	6.64	42.64	0	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
C2a	1.57	1.29	0.44	17.07	36.93	0	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P1b-1a	0.49	0.9	9.19	7.93	AR&R 1 year, 10 minutes storm, average 82 mm/h, Zone 1
P1a-1c	2.31	7.2	6.53	6	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
P110	1.75	1.9	5.47	5.29	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1
Pipe54	3.4	3	4.92	4.47	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1
N2a-N4	1.43	2.9	5.46	5.28	AR&R 1 year, 45 minutes storm, average 39.6 mm/h, Zone 1
Pipe28	1.57	6.9	4.06	4.01	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	3.76	1.9	0	4.27	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
		1.8	17.57	3.8	
		0.9	73.2	3.53	
CK1b	5.12	0.6	0	3.47	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1
		1.3	62.3	3.26	
		0.8	125.6	2.95	
		0.9	179.4	2.66	
		2.2	216.5	2.1	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	0.55	0.55	0.46	0.1	0.16	7.33	1.67	AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1
OF7	0	0	0.77	0	0	0	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF70	0.34	0.34	0.77	0.08	0.13	5.7	1.53	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1
OF16	0	0	0.25	0	0	0	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF13	0.14	0.14	1.25	0.12	0.11	1.7	0.91	AR&R 1 year, 1 hour storm, average 33.7 mm/h, Zone 1
OF26	0	0	1.81	0	0	0	0	AR&R 5 year, 2 hours storm, average 39.5 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

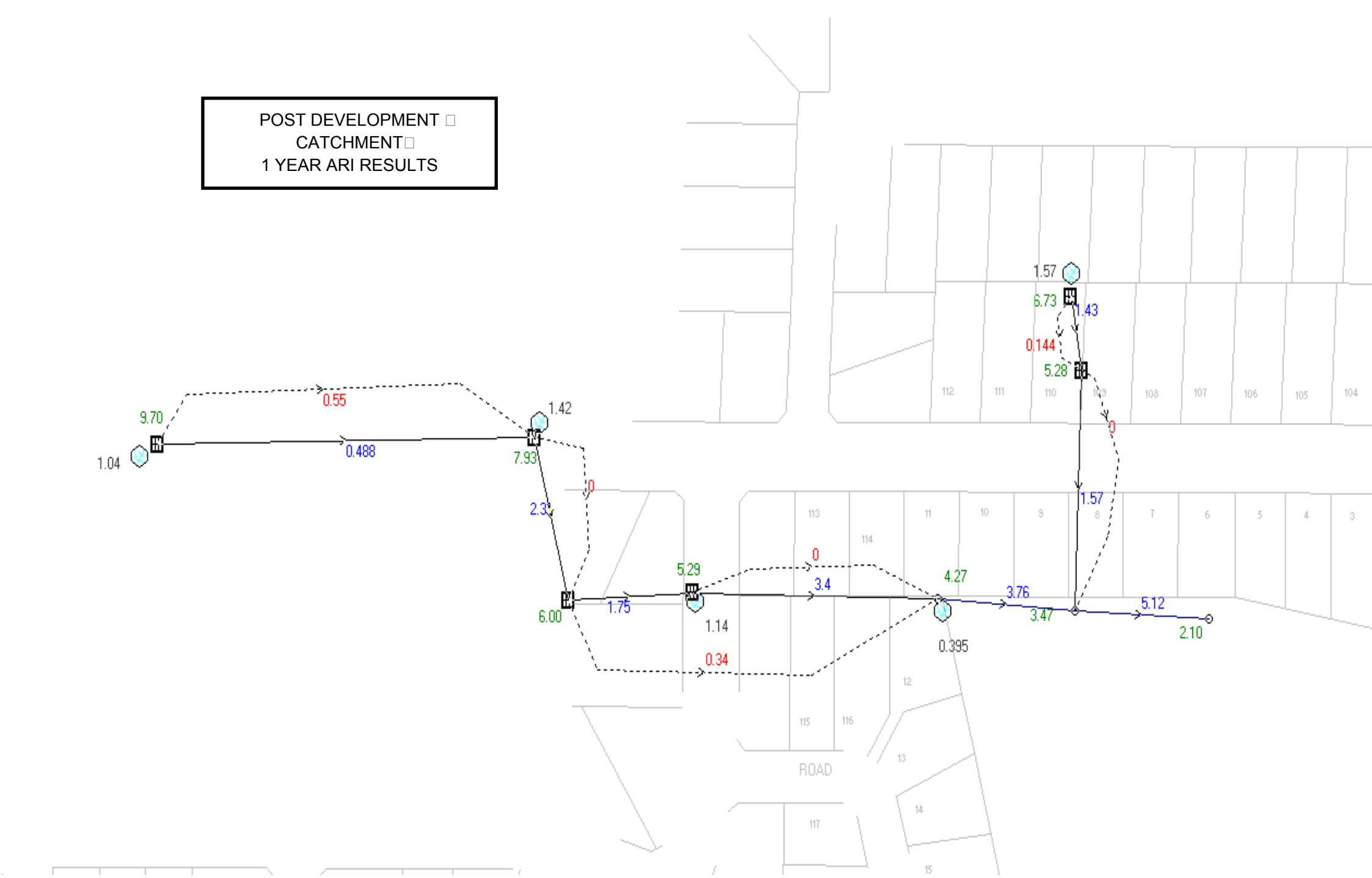
CONTINUITY CHECK for AR&R 1 year, 20 minutes storm, average 60 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	856	856	0	0
P1a	2293.53	2351.37	0	-2.5
Pit100	2351.37	2360.23	0	-0.4
P1c	3305.83	3343.78	0	-1.1
N109139	3665.3	3665.3	0	0
N122	5327.58	5327.57	0	0
N164	5327.57	5327.57	0	0
P2a	1653.69	1653.68	0	0
P4	1653.68	1662.27	0	-0.5

Run Log for Whole catchment POST.drn run at 07:33:36 on 18/4/2008

Water spilled (upwelling) from Pit100
Freeboard was less than 0.15m at P2a, P1a, P1b
The maximum flow exceeded the safe value in the following overflow routes: OF9

POST DEVELOPMENT
CATCHMENT
1 YEAR ARI RESULTS



POST-DEVELOPED 5 YEAR PEAK STORM RESULTS

DRAINS results prepared 25 March, 2008 from Version 2006.23

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		2.41		0	1.92	Outlet System
P1a	8		5.89		0	3.96	Outlet System
Pit100	6	6	3.96	500	-0.3	4.74	Outlet System
P1c	5.5		2.22		0	0.86	Outlet System
N109139	4.59		5.86				
N122	3.76		0.53				
N164	2.52		0				
P2a	6.73		3.39		0	2.26	Outlet System
P4	6		2.26		0	0.53	Outlet System

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	2.41	1.38	1.04	7.46	18.57	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
C1a	4.55	1.32	4.29	6.81	48.55	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
C1c	2.22	1.7	0.58	9.33	28.85	0	AR&R 5 year, 20 minutes storm, average 102 mm/h, Zone 1
Cat3	0.79	0.59	0.29	6.81	46.91	0	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
C2a	3.39	2.31	1.56	16.64	31.38	0	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P1b-1a	0.49	0.9	9.19	8	AR&R 5 year, 5 minutes storm, average 174 mm/h, Zone 1
P1a-1c	2.42	7.4	6.54	6	AR&R 5 year, 5 minutes storm, average 174 mm/h, Zone 1
P110	2.16	2.4	5.74	5.5	AR&R 5 year, 10 minutes storm, average 137 mm/h, Zone 1
Pipe54	3.3	2.6	4.95	4.59	AR&R 5 year, 5 minutes storm, average 174 mm/h, Zone 1
N2a-N4	1.43	2.2	6.13	6	AR&R 5 year, 10 minutes storm, average 137 mm/h, Zone 1
Pipe28	2.82	7.7	4.18	4.13	AR&R 5 year, 20 minutes storm, average 102 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	8.88	2	0	4.59	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
		2.2	17.57	4.23	
		0.9	73.2	3.84	
CK1b	12.08	0.6	0	3.76	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
		1.3	62.3	3.63	
		1.2	125.6	3.31	
		0.9	179.4	3.04	
		2.2	216.5	2.52	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	1.92	1.92	0.46	0.15	0.36	10.13	2.43	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF7	3.96	3.96	0.77	0.17	0.69	10.48	4.09	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF70	4.74	4.74	0.77	0.17	0.83	10.48	4.89	AR&R 5 year, 1 hour storm, average 60 mm/h, Zone 1
OF16	0.86	0.86	0.25	0.21	0.36	4.29	1.7	AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1
OF13	2.26	2.26	1.25	0.47	0.93	3.84	1.96	AR&R 5 year, 2 hours storm, average 39.5 mm/h, Zone 1
OF26	0.53	0.53	1.81	0.12	0.23	4	1.94	AR&R 5 year, 2 hours storm, average 39.5 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

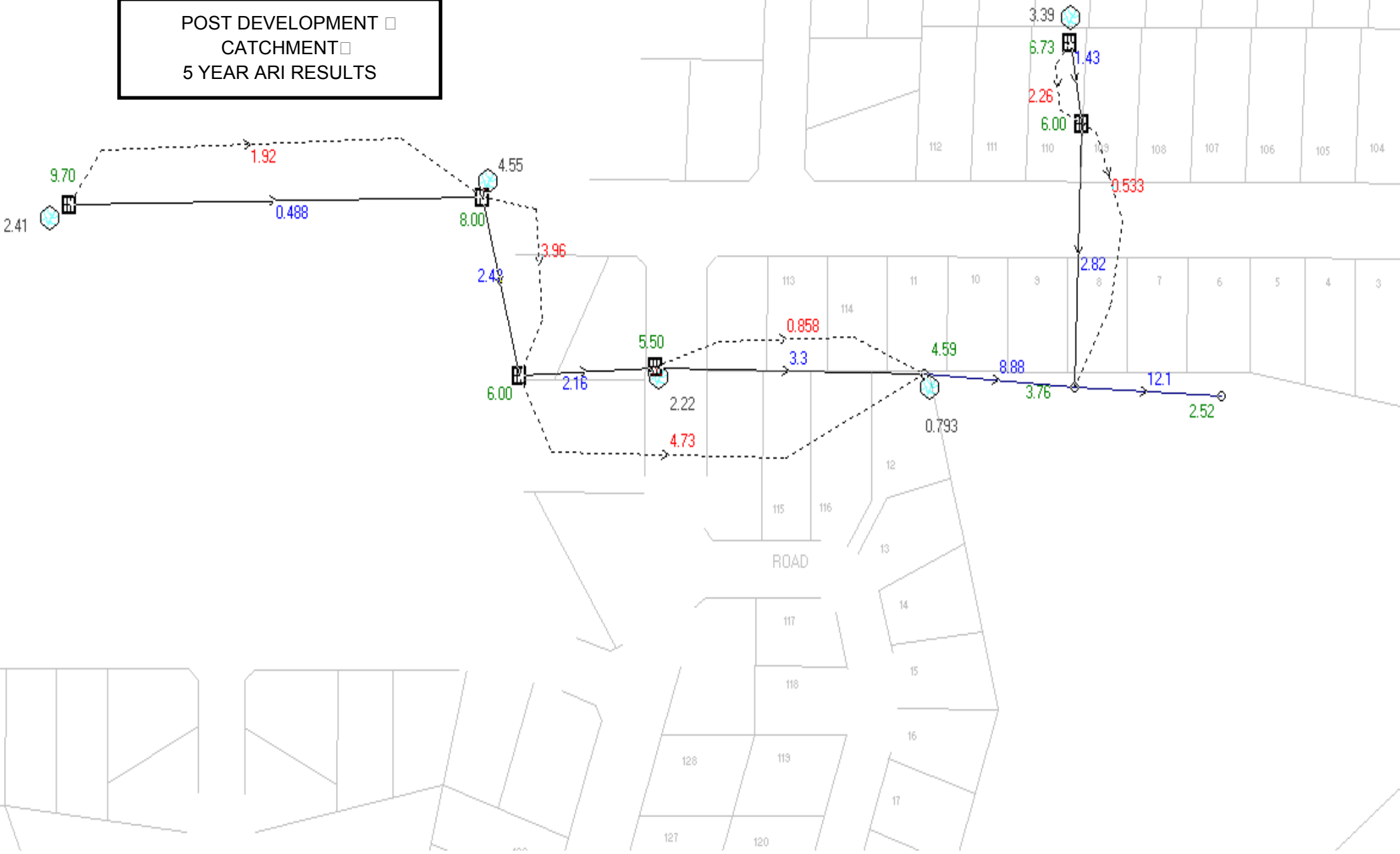
CONTINUITY CHECK for AR&R 5 year, 1.5 hours storm, average 47 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	4098.15	4098.15	0	0
P1a	19442.01	19489.62	0	-0.2
Pit100	19489.53	19497.86	0	0
P1c	14275.15	14305.83	0	-0.2
N109139	26287.7	26287.69	0	0
N122	34771.54	34771.55	0	0
N164	34771.55	34771.55	0	0
P2a	8473.81	8473.81	0	0
P4	8473.81	8483.85	0	-0.1

Run Log for Whole catchment POST.drn run at 14:03:58 on 25/3/2008

Water spilled (upwelling) from Pit100
Freeboard was less than 0.15m at P4, P2a, P1c, P1a, P1b
The maximum flow exceeded the safe value in the following overflow routes: OF70, OF16, OF13, OF9, OF7

POST DEVELOPMENT
CATCHMENT
5 YEAR ARI RESULTS



POST-DEVELOPED 100 YEAR PEAK STORM RESULTS

DRAINS results prepared 25 March, 2008 from Version 2006.23

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		4.66		0	4.17	Outlet System
P1a	8		14.03		0	12.1	Outlet System
Pit100	6	6	12.1	500	-0.3	12.35	Outlet System
P1c	5.5		4.56		0	3.69	Outlet System
N109139	4.68		15.97				
N122	4.17		4.29				
N164	2.86		0				
P2a	6.73		7.15		0	5.98	Outlet System
P4	6		5.98		0	4.29	Outlet System

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	4.66	2.43	2.25	6.54	12.36	0	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
C1a	11.47	2.25	10.92	6.28	38.79	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
C1c	4.56	2.87	1.83	9.51	32.53	0	AR&R 100 year, 2 hours storm, average 74 mm/h, Zone 1
Cat3	1.65	1.05	0.74	6.41	36.72	0	AR&R 100 year, 1.5 hours storm, average 88 mm/h, Zone 1
C2a	7.15	4.11	3.69	16.28	26.72	0	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P1b-1a	0.49	0.9	9.19	8	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
P1a-1c	2.42	7.4	6.54	6	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
P110	2.16	2.4	5.74	5.5	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
Pipe54	3.36	2.5	4.95	4.68	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
N2a-N4	1.43	2.2	6.14	6	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1
Pipe28	2.82	7.7	4.18	4.17	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	18.99	2	0	4.68	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
		2.2	17.57	4.36	
		0.9	73.2	4.19	
CK1b	26	0.6	0	4.17	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
		1.3	62.3	4.11	
		1.7	125.6	3.72	
		1	179.4	3.44	
		2.4	216.5	2.86	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	4.17	4.17	1.93	0.17	0.7	11.15	4.14	AR&R 100 year, 30 minutes storm, average 152 mm/h, Zon
OF7	12.1	12.1	2.25	0.17	2.12	10.48	12.49	AR&R 100 year, 2 hours storm, average 74 mm/h, Zone 1
OF70	12.35	12.35	2.25	0.17	2.17	10.48	12.74	AR&R 100 year, 2 hours storm, average 74 mm/h, Zone 1
OF16	3.69	3.69	0.25	0.3	1.14	6.41	3.85	AR&R 100 year, 2 hours storm, average 74 mm/h, Zone 1
OF13	5.98	5.98	1.25	0.74	1.86	5.43	2.52	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1
OF26	4.29	4.29	1.81	0.3	1.29	4	4.29	AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

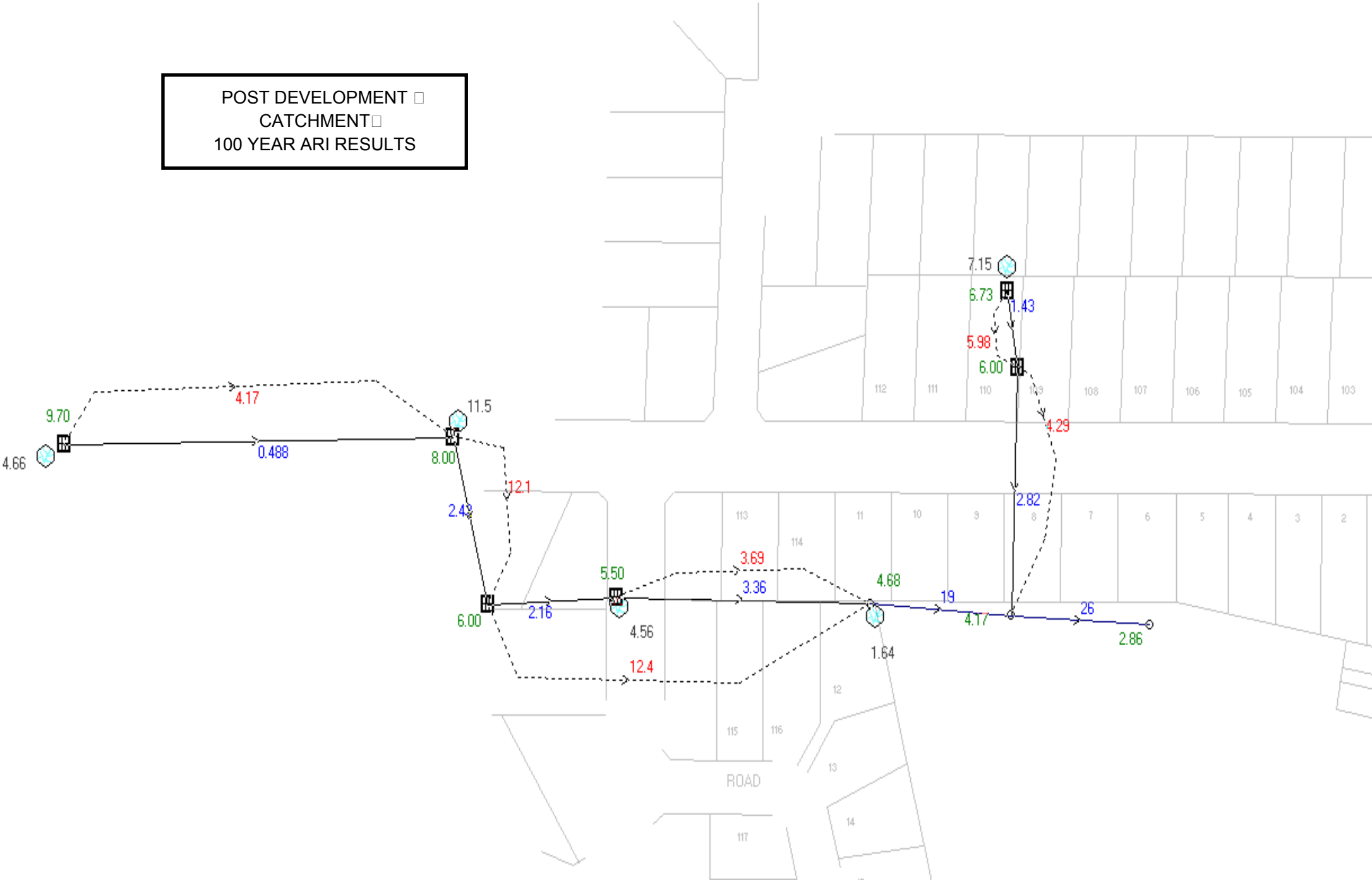
CONTINUITY CHECK for AR&R 100 year, 1 hour storm, average 111 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	7272.77	7272.77	0	0
P1a	37537.91	37596.92	0	-0.2
Pit100	37596.84	37605.54	0	0
P1c	18304.06	18351.97	0	-0.3
N109139	49703.67	49703.68	0	0
N122	64744.57	64744.33	0	0
N164	64744.33	64744.33	0	0
P2a	15033.22	15033.22	0	0
P4	15033.22	15040.63	0	0

Run Log for Whole catchment POST.drn run at 14:16:03 on 25/3/2008

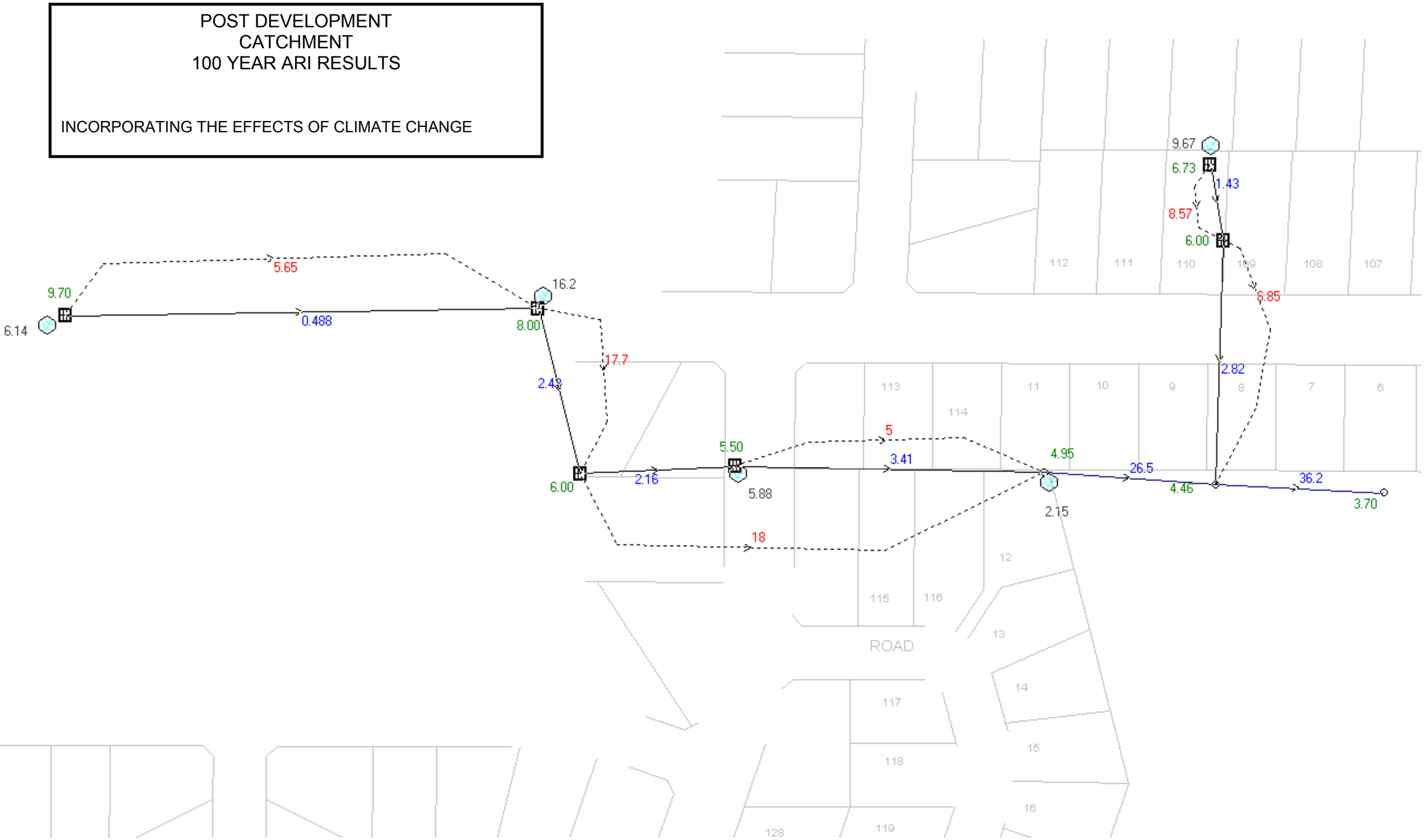
Water spilled (upwelling) from Pit100
Freeboard was less than 0.15m at P4, P2a, P1c, P1a, P1b
The maximum flow exceeded the safe value in the following overflow routes: OF70, OF26, OF16, OF13, OF9, OF7

POST DEVELOPMENT
CATCHMENT
100 YEAR ARI RESULTS



POST DEVELOPMENT
CATCHMENT
100 YEAR ARI RESULTS

INCORPORATING THE EFFECTS OF CLIMATE CHANGE



DRAINS results Post Development Catchment 100 Year ARI Results
Including the Effects Of Climate Change prepared 06 July, 2009 from
Version 2006.23

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
P1b	9.7		6.137		0	5.65	Outlet System
P1a	8		19.637		0	17.709	Outlet System
Pit100	6	6	17.709	500	-0.3	17.961	Outlet System
P1c	5.5		5.881		0	5.003	Outlet System
N109139	4.95		23.705				
N122	4.46		6.852				
N164	3.7		0				
P2a	6.73		9.675		0	8.57	Outlet System
P4	6		8.57		0	6.852	Outlet System

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C1b	6.137	3.114	3.024	6.57	12.58	0	ARR 100 Year + 30% Increase due to Climate Change
C1a	16.201	2.945	15.361	6.16	36.42	0	ARR 100 Year + 30% Increase due to Climate Change
C1c	5.881	3.341	2.954	9.16	25.37	0	ARR 100 Year + 30% Increase due to Climate Change
Cat3	2.147	1.311	1.125	6.16	30.31	0	ARR 100 Year + 30% Increase due to Climate Change
C2a	9.675	5.354	5.105	16.16	25.05	0	ARR 100 Year + 30% Increase due to Climate Change

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm

P1b-1a	0.488	0.9	9.19	8	ARR 100 Year + 30% Increase due to Climate Change
P1a-1c	2.416	7.4	6.541	6	ARR 100 Year + 30% Increase due to Climate Change
P110	2.164	2.4	5.749	5.5	ARR 100 Year + 30% Increase due to Climate Change
Pipe54	3.409	2.3	5.024	4.949	ARR 100 Year + 30% Increase due to Climate Change
N2a-N4	1.429	2.2	6.139	6	ARR 100 Year + 30% Increase due to Climate Change
Pipe28	2.824	7.7	4.184	4.458	ARR 100 Year + 30% Increase due to Climate Change

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Crk1a	26.523	2	0	4.949	ARR 100 Year + 30% Increase due to Climate Change
		2.2	17.57	4.413	
		0.3	73.2	4.471	
CK1b	36.165	0.4	0	4.458	ARR 100 Year + 30% Increase due to Climate Change
		0.3	62.3	4.421	
		1.8	125.6	4	
		0.9	179.4	3.844	
		1	216.5	3.7	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF9	5.65	5.65	1.934	0.17	0.95	11.15	5.61	ARR 100 Year + 30% Increase due to Climate Change
OF7	17.709	17.709	2.245	0.17	3.11	10.48	18.27	ARR 100 Year + 30% Increase due to Climate Change
OF70	17.961	17.961	2.245	0.17	3.15	10.48	18.53	ARR 100 Year + 30% Increase due to Climate Change
OF16	5.003	5.003	0.251	0.296	1.54	6.41	5.22	ARR 100 Year + 30% Increase due to Climate Change
OF13	8.57	8.57	1.249	0.863	2.39	6.18	2.77	ARR 100 Year + 30% Increase due to Climate Change
OF26	6.852	6.852	1.805	0.386	1.97	4	5.09	ARR 100 Year + 30% Increase due to Climate Change

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

CONTINUITY CHECK for ARR 100 Year + 30% Increase due to Climate Change

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
P1b	9759.97	9759.97	0	0
P1a	51468.18	51513.18	0	-0.1
Pit100	51513.06	51519.46	0	0
P1c	21723.55	21785.02	0	-0.3
N109139	67786.53	67786.53	0	0
N122	87983.77	87983.86	0	0
N164	87983.86	87983.86	0	0
P2a	20191.81	20191.79	0	0
P4	20191.79	20197.38	0	0

Run Log for Whole catchment POST plus 10% Climate Change.drn run at 17:05:01 on 6/7/2009

Water spilled (upwelling) from Pit100
Freeboard was less than 0.15m at P4, P2a, P1c, P1a, P1b
The maximum flow exceeded the safe value in the following overflow routes: OF70, OF26, OF16, OF13, OF9, OF7

APPENDIX E

Mannings Analysis of Overflows Upstream of Creek

OVERLAND FLOW UPSTREAM OF CREEK

ARI 1

Q = 1/nAR2/3So1/2

Description: **Section -2 (Manyana Dr)**

ne = [Sum(Pini3/2)/Sum(Pi)]2/3

Water RL Step for Depth Calc 0.01 m Design Flow 0.34 m^3/s

Channel Slope 2 %

Display Start Calc WL m (optional & set for desired WL)

X-Dist	RL	Description	Mannings n	RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m^3/s)	V_{avg} (m/s)
0	5.92		n/a							
1	5.86	Asphalt	0.011							
2	5.79		0.011							
3	5.72		0.011							
4	5.64		0.011	5.53	0	#DIV/0!	#DIV/0!	#DIV/0!		
5	5.61		0.011	5.54	0.01	0.108	17.600	0.011	0.05	0.43
6	5.63		0.011	5.55	0.02	0.298	20.563	0.011	0.23	0.76
7	5.64		0.011	5.56	0.03	0.518	23.438	0.011	0.52	1.01
8	5.66		0.011	5.57	0.04	0.766	26.334	0.011	0.93	1.22
8.99	5.68		0.011	5.58	0.05	1.045	29.250	0.011	1.46	1.39
9	5.68		0.011	5.59	0.06	1.353	32.226	0.011	2.1	1.55
10	5.68		0.011	5.6	0.07	1.690	35.267	0.011	2.87	1.7
11	5.69		0.011	5.61	0.08	2.066	39.184	0.011	3.73	1.81
12	5.7		0.011	5.62	0.09	2.471	41.937	0.011	4.81	1.95
13	5.7		0.011	5.63	0.1	2.905	44.933	0.011	6.02	2.07
14	5.71		0.011	5.64	0.11	3.370	48.131	0.011	7.36	2.18
15	5.72		0.011	5.65	0.12	3.873	52.245	0.011	8.79	2.27
16	5.72		0.011	5.66	0.13	4.412	56.014	0.011	10.42	2.36
17	5.7		0.011	5.67	0.14	4.992	60.114	0.011	12.22	2.45
18	5.69		0.011	5.68	0.15	5.614	64.353	0.011	14.2	2.53
19	5.67		0.011	5.69	0.16	6.284	69.475	0.011	16.28	2.59
20	5.66		0.011	5.7	0.17	7.006	74.852	0.011	18.57	2.65
21	5.65		0.011	5.71	0.18	7.771	78.200	0.011	21.44	2.76
22	5.64		0.011	5.72	0.19	8.571	82.131	0.011	24.43	2.85
23	5.63		0.011	5.73	0.2	9.398	83.355	0.011	28.2	3
24	5.63		0.011	5.74	0.21	10.238	84.491	0.011	32.23	3.15
25	5.62		0.011	5.75	0.22	11.09	85.63	0.01	36.49	3.29
26	5.61		0.011	5.76	0.23	11.95	86.78	0.01	40.97	3.43
27	5.61		0.011	5.77	0.24	12.82	88.07	0.01	45.63	3.56
28	5.6		0.011	5.78	0.25	13.71	89.67	0.01	50.41	3.68
29	5.6		0.011	5.79	0.26	14.61	90.66	0.01	55.65	3.81
30	5.6		0.011	5.8	0.27	15.53	92.43	0.01	60.78	3.91
31	5.59		0.011	5.81	0.28	16.46	94.57	0.01	65.99	4.01

Description: **Section -1 (Through Lots 115 & 116)**

Water RL Step for Depth Calc 0.01 m Design Flow 0.34 m^3/s

Channel Slope 2 %

Display Start Calc WL 5 m (optional & set for desired WL)

X-Dist	RL	Description	Mannings n	RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m^3/s)	V_{avg} (m/s)
0	5.7		n/a							
12.3	5.1	Light bush	0.080							
21.6	5.2		0.080							
24.5	5.12		0.080	5.02	0	0.000	0.000	#DIV/0!		
25.9	5.07		0.080	5.03	0.01	0.029	5.745	0.080	0	0.05
28.4	5.2		0.080	5.04	0.02	0.108	10.155	0.080	0.01	0.09
31.3	5.19		0.080	5.05	0.03	0.232	14.565	0.080	0.03	0.11
37.8	5.24		0.080	5.06	0.04	0.400	18.975	0.080	0.05	0.13
46.09	5.07		0.080	5.07	0.05	0.621	25.252	0.080	0.09	0.15
59.03	5.03		0.080	5.08	0.06	0.893	29.254	0.080	0.15	0.17
63.6	5.02		0.080	5.09	0.07	1.206	33.257	0.080	0.23	0.19
73	5.1		0.080	5.1	0.08	1.558	37.259	0.080	0.33	0.21
84.9	5.14		0.080	5.11	0.09	1.966	44.197	0.080	0.44	0.22
96.1	5.06		0.080	5.12	0.1	2.442	51.134	0.080	0.57	0.23
121.3	5.6		0.080	5.13	0.11	2.989	58.154	0.080	0.73	0.24
				5.14	0.12	3.605	65.175	0.080	0.93	0.26
				5.15	0.13	4.270	67.820	0.080	1.19	0.28
				5.16	0.14	4.961	70.465	0.080	1.5	0.3
				5.17	0.15	5.679	73.110	0.080	1.83	0.32
				5.18	0.16	6.423	75.755	0.080	2.19	0.34
				5.19	0.17	7.194	78.400	0.080	2.59	0.36
				5.2	0.18	8.012	85.245	0.080	2.93	0.37
				5.21	0.19	8.877	87.705	0.080	3.41	0.38
				5.22	0.2	9.766	90.164	0.080	3.92	0.4
				5.23	0.21	10.680	92.624	0.080	4.47	0.42
				5.24	0.22	11.618	95.084	0.080	5.06	0.44
				5.25	0.23	12.572	95.756	0.080	5.74	0.46
				5.26	0.24	13.533	96.428	0.080	6.46	0.48
				5.27	0.25	14.501	97.100	0.080	7.22	0.5
				5.28	0.26	15.475	97.772	0.080	8	0.52
				5.29	0.27	16.456	98.444	0.080	8.83	0.54
				5.3	0.28	17.443	99.116	0.080	9.68	0.56
				5.31	0.29	18.438	99.788	0.080	10.57	0.57

SUNSET STRIP FLOW CAPACITY

ARI 1

Description: **Sunset Strip roadway (Typical Capacity -6m wide std kerb, 4m verge at 3%)**

Water RL Step for Depth Calc 0.01 m Design Flow 0.34 m³/s

X-Dist	RL	Description	Mannings n	Channel Slope 2 %
0	5.12		n/a	Display Start Calc WL m (optional & set for desired WL)
4	5	Verge	0.030	
4.15	5	Kerb	0.011	
4.18	4.85		0.011	
4.45	4.89		0.011	
7.15	4.97	Asphalt	0.013	
9.67	4.89	Kerb	0.013	
10.12	4.85		0.011	
10.15	5		0.011	
10.3	5		0.011	
14.3	5.12	Verge	0.030	

RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m³/s)	V_{avg} (m/s)
4.85	0	0.000	0.000	#DIV/0!		
4.86	0.01	0.001	0.202	0.011	0	0.35
4.87	0.02	0.004	0.403	0.011	0	0.56
4.88	0.03	0.008	0.605	0.011	0.01	0.74
4.89	0.04	0.015	0.806	0.011	0.01	0.89
4.9	0.05	0.025	1.480	0.012	0.02	0.79
4.91	0.06	0.043	2.153	0.012	0.04	0.85
4.92	0.07	0.066	2.826	0.012	0.06	0.93
4.93	0.08	0.097	3.499	0.013	0.1	1.03
4.94	0.09	0.134	4.172	0.013	0.15	1.13
4.95	0.1	0.177	4.846	0.013	0.22	1.23
4.96	0.11	0.227	5.519	0.013	0.3	1.33
4.97	0.12	0.284	6.192	0.013	0.4	1.43
4.98	0.13	0.344	6.212	0.013	0.56	1.62
4.99	0.14	0.404	6.233	0.013	0.73	1.8
5	0.15	0.463	6.253	0.013	0.91	1.97
5.01	0.16	0.529	7.158	0.014	0.91	1.72
5.02	0.17	0.601	7.831	0.016	0.96	1.59
5.03	0.18	0.681	8.504	0.017	1.03	1.52
5.04	0.19	0.766	9.176	0.018	1.13	1.47
5.05	0.2	0.859	9.849	0.019	1.24	1.44
5.06	0.21	0.958	10.521	0.020	1.37	1.43
5.07	0.22	1.064	11.194	0.021	1.51	1.42
5.08	0.23	1.177	11.866	0.021	1.67	1.42
5.09	0.24	1.297	12.539	0.022	1.85	1.43
5.1	0.25	1.423	13.212	0.022	2.05	1.44
5.11	0.26	1.556	13.884	0.023	2.26	1.45
5.12	0.27	1.695	14.557	0.023	2.48	1.46

Description: **Sunset Strip roadway (Typical Capacity -8m wide std kerb, 4m verge at 3%)**

Water RL Step for Depth Calc 0.01 m Design Flow 0.34 m³/s

X-Dist	RL	Description	Mannings n	Channel Slope 2 %
0	5.12		n/a	Display Start Calc WL m (optional & set for desired WL)
4	5	Verge	0.030	
4.15	5	Kerb	0.011	
4.18	4.85		0.011	
4.45	4.89		0.011	
8.15	5	Asphalt	0.013	
11.67	4.89	Kerb	0.013	
12.12	4.85		0.011	
12.15	5		0.011	
12.3	5		0.011	
16.3	5.12	Verge	0.030	

RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m³/s)	V_{avg} (m/s)
4.85	0	0	0	#DIV/0!		
4.86	0.01	0	0.2	0.01	0	0.35
4.87	0.02	0	0.4	0.01	0	0.56
4.88	0.03	0.01	0.6	0.01	0.01	0.74
4.89	0.04	0.01	0.81	0.01	0.01	0.89
4.9	0.05	0.03	1.48	0.01	0.02	0.79
4.91	0.06	0.04	2.16	0.01	0.04	0.84
4.92	0.07	0.07	2.84	0.01	0.06	0.93
4.93	0.08	0.1	3.51	0.01	0.1	1.03
4.94	0.09	0.13	4.19	0.01	0.15	1.13
4.95	0.1	0.18	4.87	0.01	0.22	1.23
4.96	0.11	0.23	5.55	0.01	0.3	1.33
4.97	0.12	0.28	6.22	0.01	0.41	1.43
4.98	0.13	0.35	6.9	0.01	0.53	1.52
4.99	0.14	0.42	7.58	0.01	0.67	1.61
5	0.15	0.5	8.25	0.01	0.84	1.7
5.01	0.16	0.58	9.16	0.01	0.92	1.59
5.02	0.17	0.67	9.83	0.02	1.03	1.53
5.03	0.18	0.77	10.5	0.02	1.16	1.5
5.04	0.19	0.88	11.18	0.02	1.3	1.48
5.05	0.2	0.99	11.85	0.02	1.46	1.48
5.06	0.21	1.11	12.52	0.02	1.64	1.48
5.07	0.22	1.24	13.19	0.02	1.83	1.48
5.08	0.23	1.37	13.87	0.02	2.05	1.49
5.09	0.24	1.51	14.54	0.02	2.27	1.51
5.1	0.25	1.65	15.21	0.02	2.52	1.52
5.11	0.26	1.81	15.88	0.02	2.78	1.54
5.12	0.27	1.97	16.56	0.02	3.06	1.56

OVERLAND FLOW UPSTREAM OF CREEK

ARI 5

Q = 1/nAR2/3So1/2

Description: **Section -2 (Manyana Dr)**

ne = [Sum(Pini3/2)/Sum(Pi)]2/3

Water RL Step for Depth Calc 0.01 m Design Flow 5.6 m^3/s

Channel Slope 2 %

Display Start Calc WL m (optional & set for desired WL)

X-Dist	RL	Description	Mannings n	RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m^3/s)	V_{avg} (m/s)
0	5.92		n/a							
1	5.86	Asphalt	0.011							
2	5.79		0.011							
3	5.72		0.011							
4	5.64		0.011	5.53	0	#DIV/0!	#DIV/0!	#DIV/0!		
5	5.61		0.011	5.54	0.01	0.108	17.600	0.011	0.05	0.43
6	5.63		0.011	5.55	0.02	0.298	20.563	0.011	0.23	0.76
7	5.64		0.011	5.56	0.03	0.518	23.438	0.011	0.52	1.01
8	5.66		0.011	5.57	0.04	0.766	26.334	0.011	0.93	1.22
8.99	5.68		0.011	5.58	0.05	1.045	29.250	0.011	1.46	1.39
9	5.68		0.011	5.59	0.06	1.353	32.226	0.011	2.1	1.55
10	5.68		0.011	5.6	0.07	1.690	35.267	0.011	2.87	1.7
11	5.69		0.011	5.61	0.08	2.066	39.184	0.011	3.73	1.81
12	5.7		0.011	5.62	0.09	2.471	41.937	0.011	4.81	1.95
13	5.7		0.011	5.63	0.1	2.905	44.933	0.011	6.02	2.07
14	5.71		0.011	5.64	0.11	3.370	48.131	0.011	7.36	2.18
15	5.72		0.011	5.65	0.12	3.873	52.245	0.011	8.79	2.27
16	5.72		0.011	5.66	0.13	4.412	56.014	0.011	10.42	2.36
17	5.7		0.011	5.67	0.14	4.992	60.114	0.011	12.22	2.45
18	5.69		0.011	5.68	0.15	5.614	64.353	0.011	14.2	2.53
19	5.67		0.011	5.69	0.16	6.284	69.475	0.011	16.28	2.59
20	5.66		0.011	5.7	0.17	7.006	74.852	0.011	18.57	2.65
21	5.65		0.011	5.71	0.18	7.771	78.200	0.011	21.44	2.76
22	5.64		0.011	5.72	0.19	8.571	82.131	0.011	24.43	2.85
23	5.63		0.011	5.73	0.2	9.398	83.355	0.011	28.2	3
24	5.63		0.011	5.74	0.21	10.238	84.491	0.011	32.23	3.15
25	5.62		0.011	5.75	0.22	11.09	85.63	0.01	36.49	3.29
26	5.61		0.011	5.76	0.23	11.95	86.78	0.01	40.97	3.43
27	5.61		0.011	5.77	0.24	12.82	88.07	0.01	45.63	3.56
28	5.6		0.011	5.78	0.25	13.71	89.67	0.01	50.41	3.68
29	5.6		0.011	5.79	0.26	14.61	90.66	0.01	55.65	3.81
30	5.6		0.011	5.8	0.27	15.53	92.43	0.01	60.78	3.91
31	5.59		0.011	5.81	0.28	16.46	94.57	0.01	65.99	4.01

Description: **Section -1 (Through Lots 115 & 116)**

Water RL Step for Depth Calc 0.01 m Design Flow 5.6 m^3/s

Channel Slope 2 %

Display Start Calc WL 5.2 m (optional & set for desired WL)

X-Dist	RL	Description	Mannings n	RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m^3/s)	V_{avg} (m/s)
0	5.7		n/a							
12.3	5.1	Light bush	0.080							
21.6	5.2		0.080							
24.5	5.12		0.080	5.2	0.18	8.012	85.245	0.080		
25.9	5.07		0.080	5.21	0.19	8.877	87.705	0.079	3.47	0.39
28.4	5.2		0.080	5.22	0.2	9.766	90.164	0.080	3.92	0.4
31.3	5.19		0.080	5.23	0.21	10.680	92.624	0.080	4.47	0.42
37.8	5.24		0.080	5.24	0.22	11.618	95.084	0.078	5.16	0.44
46.09	5.07		0.080	5.25	0.23	12.572	95.756	0.078	5.87	0.47
59.03	5.03		0.080	5.26	0.24	13.533	96.428	0.078	6.61	0.49
63.6	5.02		0.080	5.27	0.25	14.501	97.100	0.078	7.39	0.51
73	5.1		0.080	5.28	0.26	15.475	97.772	0.080	8	0.52
84.9	5.14		0.080	5.29	0.27	16.456	98.444	0.080	8.83	0.54
96.1	5.06		0.080	5.3	0.28	17.443	99.116	0.080	9.68	0.56
121.3	5.6		0.080	5.31	0.29	18.438	99.788	0.080	10.57	0.57
				5.32	0.3	19.439	100.460	0.080	11.5	0.59
				5.33	0.31	20.447	101.132	0.080	12.45	0.61
				5.34	0.32	21.461	101.804	0.080	13.44	0.63
				5.35	0.33	22.482	102.476	0.080	14.46	0.64
				5.36	0.34	23.510	103.148	0.080	15.51	0.66
				5.37	0.35	24.545	103.820	0.080	16.59	0.68
				5.38	0.36	25.586	104.492	0.080	17.7	0.69
				5.39	0.37	26.634	105.164	0.080	18.85	0.71
				5.4	0.38	27.689	105.836	0.080	20.02	0.72
				5.41	0.39	28.751	106.508	0.080	21.23	0.74
				5.42	0.4	29.819	107.180	0.080	22.46	0.75
				5.43	0.41	30.894	107.852	0.080	23.73	0.77
				5.44	0.42	31.976	108.524	0.080	25.03	0.78
				5.45	0.43	33.064	109.196	0.080	26.36	0.8
				5.46	0.44	34.159	109.868	0.080	27.71	0.81
				5.47	0.45	35.261	110.540	0.080	29.1	0.83
				5.48	0.46	36.369	111.212	0.080	30.52	0.84
				5.49	0.47	37.485	111.884	0.080	31.96	0.85

OVERLAND FLOW UPSTREAM OF CREEK

ARI 100

Q = 1/nAR2/3So1/2

Description: **Section -2 (Manyana Dr)**

ne = [Sum(Pini3/2)/Sum(Pi)]2/3

Water RL Step for Depth Calc 0.01 m Design Flow 16.1 m^3/s

Channel Slope 2 %

Display Start Calc WL m (optional & set for desired WL)

X-Dist	RL	Description	Mannings n	RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m^3/s)	V_{avg} (m/s)
0	5.92		n/a							
1	5.86	Asphalt	0.011							
2	5.79		0.011							
3	5.72		0.011							
4	5.64		0.011	5.53	0	#DIV/0!	#DIV/0!	#DIV/0!		
5	5.61		0.011	5.54	0.01	0.108	17.600	0.011	0.05	0.43
6	5.63		0.011	5.55	0.02	0.298	20.563	0.011	0.23	0.76
7	5.64		0.011	5.56	0.03	0.518	23.438	0.011	0.52	1.01
8	5.66		0.011	5.57	0.04	0.766	26.334	0.011	0.93	1.22
8.99	5.68		0.011	5.58	0.05	1.045	29.250	0.011	1.46	1.39
9	5.68		0.011	5.59	0.06	1.353	32.226	0.011	2.1	1.55
10	5.68		0.011	5.6	0.07	1.690	35.267	0.011	2.87	1.7
11	5.69		0.011	5.61	0.08	2.066	39.184	0.011	3.73	1.81
12	5.7		0.011	5.62	0.09	2.471	41.937	0.011	4.81	1.95
13	5.7		0.011	5.63	0.1	2.905	44.933	0.011	6.02	2.07
14	5.71		0.011	5.64	0.11	3.370	48.131	0.011	7.36	2.18
15	5.72		0.011	5.65	0.12	3.873	52.245	0.011	8.79	2.27
16	5.72		0.011	5.66	0.13	4.412	56.014	0.011	10.42	2.36
17	5.7		0.011	5.67	0.14	4.992	60.114	0.011	12.22	2.45
18	5.69		0.011	5.68	0.15	5.614	64.353	0.011	14.2	2.53
19	5.67		0.011	5.69	0.16	6.284	69.475	0.011	16.28	2.59
20	5.66		0.011	5.7	0.17	7.006	74.852	0.011	18.57	2.65
21	5.65		0.011	5.71	0.18	7.771	78.200	0.011	21.44	2.76
22	5.64		0.011	5.72	0.19	8.571	82.131	0.011	24.43	2.85
23	5.63		0.011	5.73	0.2	9.398	83.355	0.011	28.2	3
24	5.63		0.011	5.74	0.21	10.238	84.491	0.011	32.23	3.15
25	5.62		0.011	5.75	0.22	11.09	85.63	0.01	36.49	3.29
26	5.61		0.011	5.76	0.23	11.95	86.78	0.01	40.97	3.43
27	5.61		0.011	5.77	0.24	12.82	88.07	0.01	45.63	3.56
28	5.6		0.011	5.78	0.25	13.71	89.67	0.01	50.41	3.68
29	5.6		0.011	5.79	0.26	14.61	90.66	0.01	55.65	3.81
30	5.6		0.011	5.8	0.27	15.53	92.43	0.01	60.78	3.91
31	5.59		0.011							

Description: **Section -1 (Through Lots 115 & 116)**

Water RL Step for Depth Calc 0.01 m Design Flow 16.1 m^3/s

Channel Slope 2 %

Display Start Calc WL 5.2 m (optional & set for desired WL)

X-Dist	RL	Description	Mannings n	RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m^3/s)	V_{avg} (m/s)
0	5.7		n/a							
12.3	5.1	Light bush	0.080							
21.6	5.2		0.080							
24.5	5.12		0.080	5.2	0.18	8.012	85.245	0.080		
25.9	5.07		0.080	5.21	0.19	8.877	87.705	0.079	3.47	0.39
28.4	5.2		0.080	5.22	0.2	9.766	90.164	0.080	3.92	0.4
31.3	5.19		0.080	5.23	0.21	10.680	92.624	0.080	4.47	0.42
37.8	5.24		0.080	5.24	0.22	11.618	95.084	0.078	5.16	0.44
46.09	5.07		0.080	5.25	0.23	12.572	95.756	0.078	5.87	0.47
59.03	5.03		0.080	5.26	0.24	13.533	96.428	0.078	6.61	0.49
63.6	5.02		0.080	5.27	0.25	14.501	97.100	0.078	7.39	0.51
73	5.1		0.080	5.28	0.26	15.475	97.772	0.080	8	0.52
84.9	5.14		0.080	5.29	0.27	16.456	98.444	0.080	8.83	0.54
96.1	5.06		0.080	5.3	0.28	17.443	99.116	0.080	9.68	0.56
121.3	5.6		0.080	5.31	0.29	18.438	99.788	0.080	10.57	0.57
				5.32	0.3	19.439	100.460	0.080	11.5	0.59
				5.33	0.31	20.447	101.132	0.080	12.45	0.61
				5.34	0.32	21.461	101.804	0.080	13.44	0.63
				5.35	0.33	22.482	102.476	0.080	14.46	0.64
				5.36	0.34	23.510	103.148	0.080	15.51	0.66
				5.37	0.35	24.545	103.820	0.080	16.59	0.68
				5.38	0.36	25.586	104.492	0.080	17.7	0.69
				5.39	0.37	26.634	105.164	0.080	18.85	0.71
				5.4	0.38	27.689	105.836	0.080	20.02	0.72
				5.41	0.39	28.751	106.508	0.080	21.23	0.74
				5.42	0.4	29.819	107.180	0.080	22.46	0.75
				5.43	0.41	30.894	107.852	0.080	23.73	0.77
				5.44	0.42	31.976	108.524	0.080	25.03	0.78
				5.45	0.43	33.064	109.196	0.080	26.36	0.8
				5.46	0.44	34.159	109.868	0.080	27.71	0.81
				5.47	0.45	35.261	110.540	0.080	29.1	0.83
				5.48	0.46	36.369	111.212	0.080	30.52	0.84
				5.49	0.47	37.485	111.884	0.080	31.96	0.85

OVERLAND FLOW UPSTREAM OF CREEK

ARI 100 +30% Climate Change

Description: **Section -2 (Manyana Dr)**

Q = 1/nAR2/3So1/2

*Water RL*ne = [Sum(Pini3/2)/Sum(Pi)]2/3

X-Dist	RL	Description	Mannings n								
0	5.921		n/a								
1	5.856	Asphalt	0.011	Step for Depth Calc		0.01	m	Design Flow	23	m^3/s	
2	5.79		0.011	Channel Slope		2	%				
3	5.716		0.011	Display Start Calc WL			m (optional & set for desired WL)				
4	5.641		0.011								
5	5.608		0.011	RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m^3/s)	V_{avg} (m/s)	
6	5.625		0.011	5.527	0	#DIV/0!	#DIV/0!	#DIV/0!			
7	5.641		0.011	5.537	0.01	0.108	17.600	0.011	0.046396	0.430386	
8	5.658		0.011	5.547	0.02	0.298	20.563	0.011	0.227775	0.764265	
8.993	5.675		0.011	5.557	0.03	0.518	23.438	0.011	0.52432	1.012384	
9	5.675		0.011	5.567	0.04	0.766	26.334	0.011	0.932131	1.216352	
10	5.681		0.011	5.577	0.05	1.045	29.250	0.011	1.456468	1.39425	
11	5.688		0.011	5.587	0.06	1.353	32.226	0.011	2.100055	1.552692	
12	5.695		0.011	5.597	0.07	1.690	35.267	0.011	2.865179	1.69584	
13	5.701		0.011	5.607	0.08	2.066	39.184	0.011	3.734137	1.807613	
14	5.708		0.011	5.617	0.09	2.471	41.937	0.011	4.809656	1.946611	
15	5.715		0.011	5.627	0.1	2.905	44.933	0.011	6.015995	2.070953	
16	5.716		0.011	5.637	0.11	3.370	48.131	0.011	7.3602	2.184041	
17	5.702		0.011	5.647	0.12	3.873	52.245	0.011	8.786133	2.268692	
18	5.687		0.011	5.657	0.13	4.412	56.014	0.011	10.42422	2.362494	
19	5.673		0.011	5.667	0.14	4.992	60.114	0.011	12.21736	2.447229	
20	5.659		0.011	5.677	0.15	5.614	64.353	0.011	14.19749	2.528894	
21	5.645		0.011	5.687	0.16	6.284	69.475	0.011	16.27747	2.590461	
22	5.64		0.011	5.697	0.17	7.006	74.852	0.011	18.56857	2.650357	
23	5.634		0.011	5.707	0.18	7.771	78.200	0.011	21.43679	2.758387	
24	5.627		0.011	5.717	0.19	8.571	82.131	0.011	24.42522	2.849751	
25	5.62		0.011	5.727	0.2	9.398	83.355	0.011	28.20085	3.000583	
26	5.613		0.011	5.737	0.21	10.238	84.491	0.011	32.22913	3.148107	
27	5.605		0.011	5.747	0.22	11.08813	85.62612	0.011	36.4879	3.290716	
28	5.601		0.011	5.757	0.23	11.95002	86.78389	0.011	40.96793	3.428273	
29	5.599		0.011	5.767	0.24	12.82408	88.07222	0.011	45.63239	3.558337	
30	5.597		0.011	5.777	0.25	13.71217	89.66609	0.011	50.41351	3.676553	
31	5.593		0.011	5.787	0.26	14.61412	90.66063	0.011	55.64986	3.807953	

Description: **Section -1 (Through Lots 115 & 116)**

*Water RL*Step for Depth Calc 0.01 m Design Flow 23 m^3/s

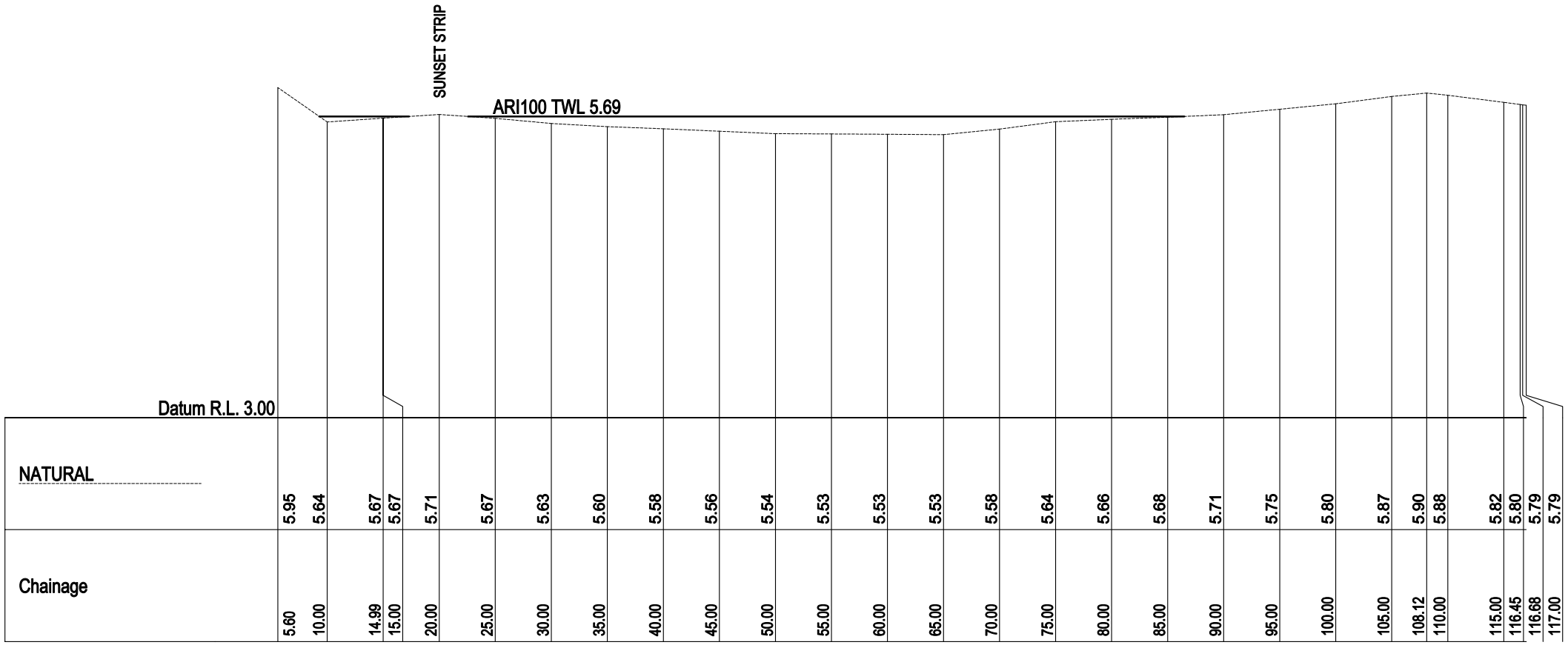
Channel Slope 2%

Display Start Calc WL 5.2 m (optional & set for desired WL)

X-Dist	RL	Description	Mannings n							
0	5.7		n/a							
12.3	5.1	Light bush	0.080							
21.6	5.2		0.080	RL WL	Max Depth	Flow Area	Wett Perim	n_e	Q (m^3/s)	V_{avg} (m/s)
24.5	5.12		0.080	5.2	0.18	8.012	85.245	0.080		
25.9	5.07		0.080	5.21	0.19	8.877	87.705	0.079	3.467787	0.390659
28.4	5.2		0.080	5.22	0.2	9.766	90.164	0.080	3.922792	0.401679
31.3	5.19		0.080	5.23	0.21	10.680	92.624	0.080	4.472467	0.418778
37.8	5.24		0.080	5.24	0.22	11.618	95.084	0.078	5.161818	0.444287
46.09	5.07		0.080	5.25	0.23	12.572	95.756	0.078	5.867658	0.466715
59.03	5.03		0.080	5.26	0.24	13.533	96.428	0.078	6.611703	0.48856
63.6	5.02		0.080	5.27	0.25	14.501	97.100	0.078	7.393448	0.509874
73	5.1		0.080	5.28	0.26	15.475	97.772	0.080	8.004248	0.517246
84.9	5.14		0.080	5.29	0.27	16.456	98.444	0.080	8.827223	0.536425
96.1	5.06		0.080	5.3	0.28	17.443	99.116	0.080	9.683745	0.555156
121.3	5.6		0.080	5.31	0.29	18.438	99.788	0.080	10.57342	0.573469
				5.32	0.3	19.439	100.460	0.080	11.49589	0.591391
				5.33	0.31	20.447	101.132	0.080	12.45082	0.608946
				5.34	0.32	21.461	101.804	0.080	13.43793	0.626155
				5.35	0.33	22.482	102.476	0.080	14.45694	0.643038
				5.36	0.34	23.510	103.148	0.080	15.5076	0.659611
				5.37	0.35	24.545	103.820	0.080	16.58968	0.675892
				5.38	0.36	25.586	104.492	0.080	17.70298	0.691895
				5.39	0.37	26.634	105.164	0.080	18.8473	0.707632
				5.4	0.38	27.689	105.836	0.080	20.02247	0.723117
				5.41	0.39	28.751	106.508	0.080	21.22833	0.73836
				5.42	0.4	29.819	107.180	0.080	22.46472	0.753372
				5.43	0.41	30.894	107.852	0.080	23.73152	0.768163
				5.44	0.42	31.976	108.524	0.080	25.0286	0.782742
				5.45	0.43	33.064	109.196	0.080	26.35585	0.797118
				5.46	0.44	34.159	109.868	0.080	27.71315	0.811298
				5.47	0.45	35.261	110.540	0.080	29.10042	0.825289

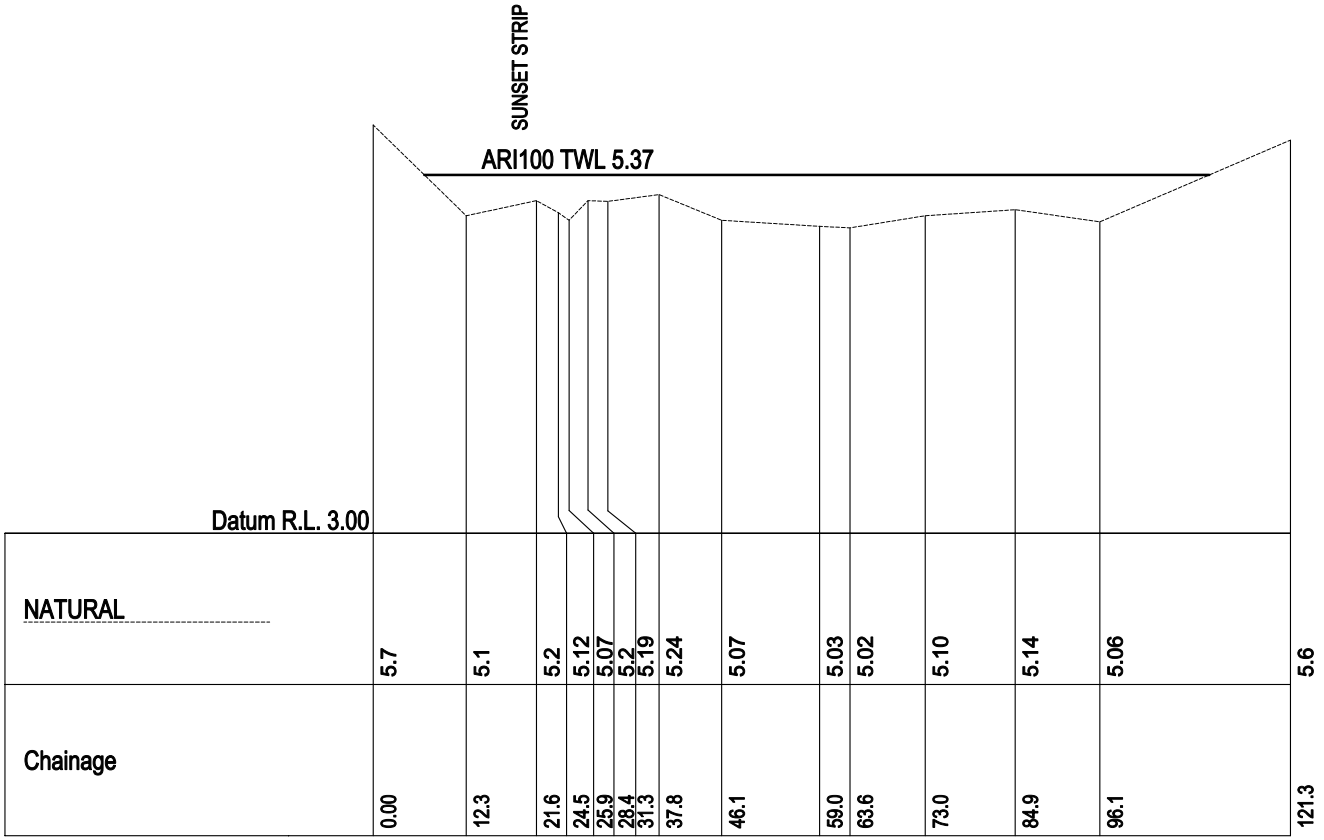
APPENDIX F

Flood Path and Creek Cross Sections



Scale Horizontal 1:500 Vertical 1:50

MANYANA DR SECTION CH-71.1

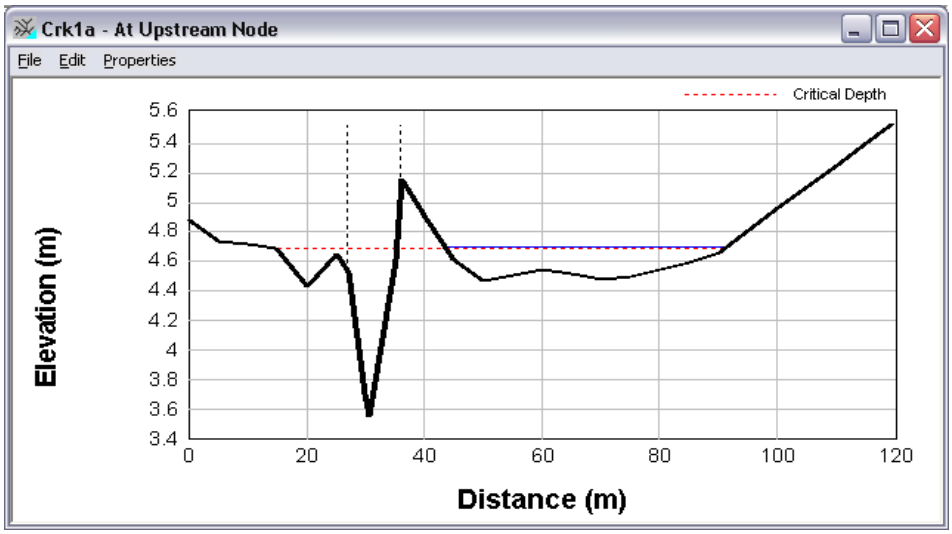


Scale Horizontal 1:500 Vertical 1:50

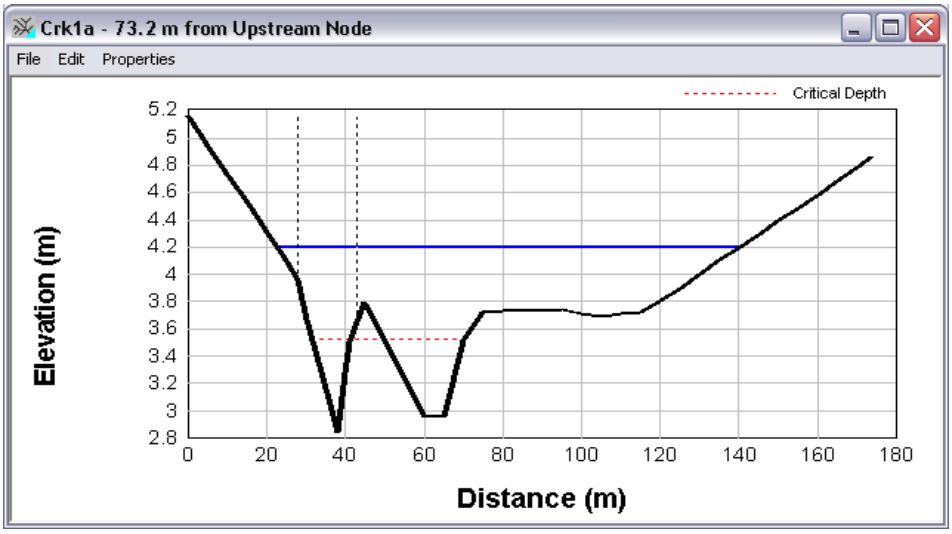
MANYANA DR SECTION THROUGH LOTS 115 & 116 CH-43.9

CREEK SECTIONS WITH DRAINS 100 YEAR ARI PEAK WATER LEVELS

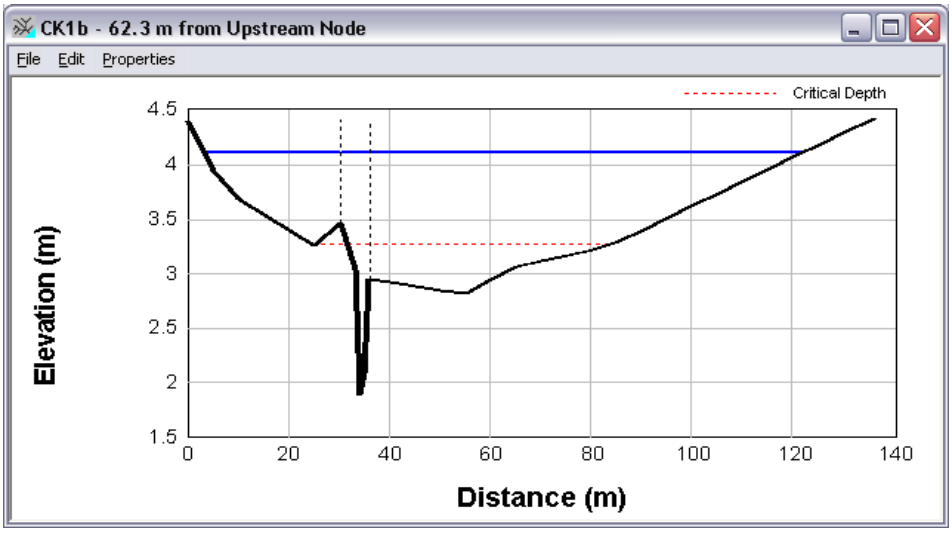
Creek Section 3 CH0.0



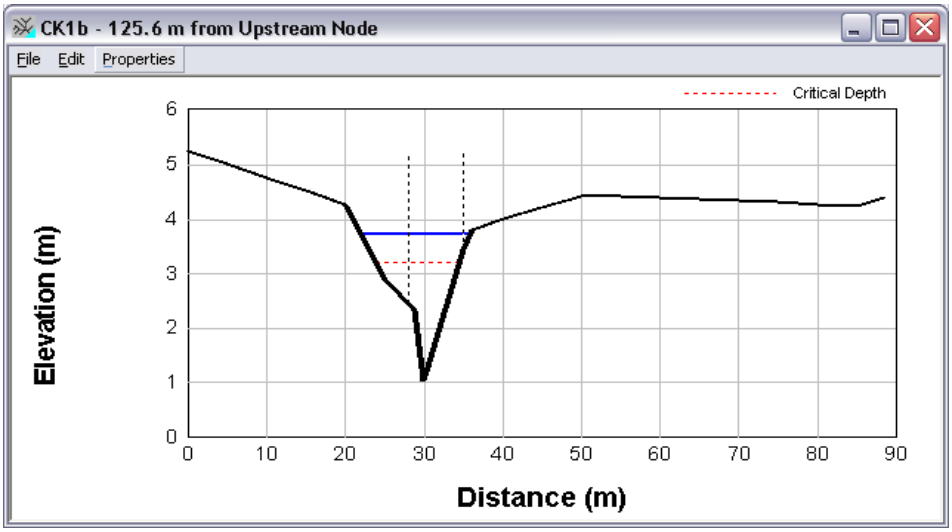
Creek Section 4 CH90.8



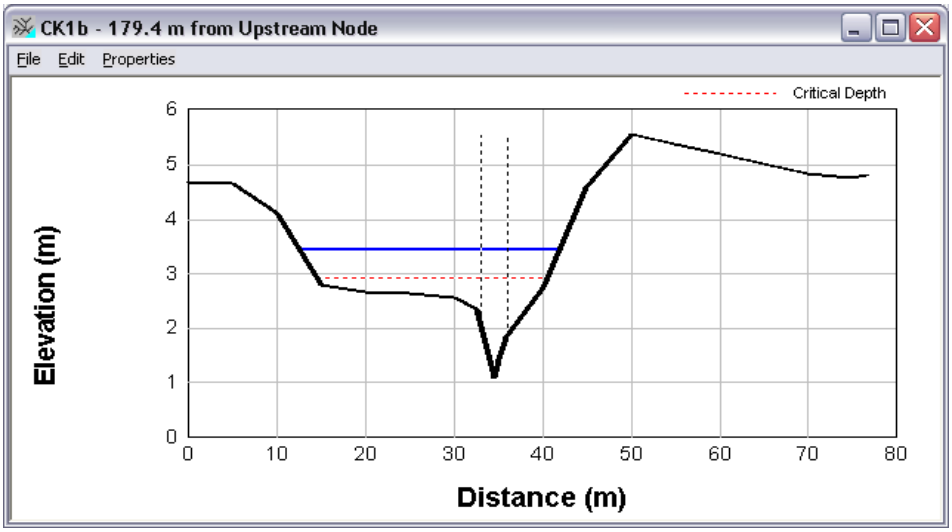
Creek Section 5 CH135.5



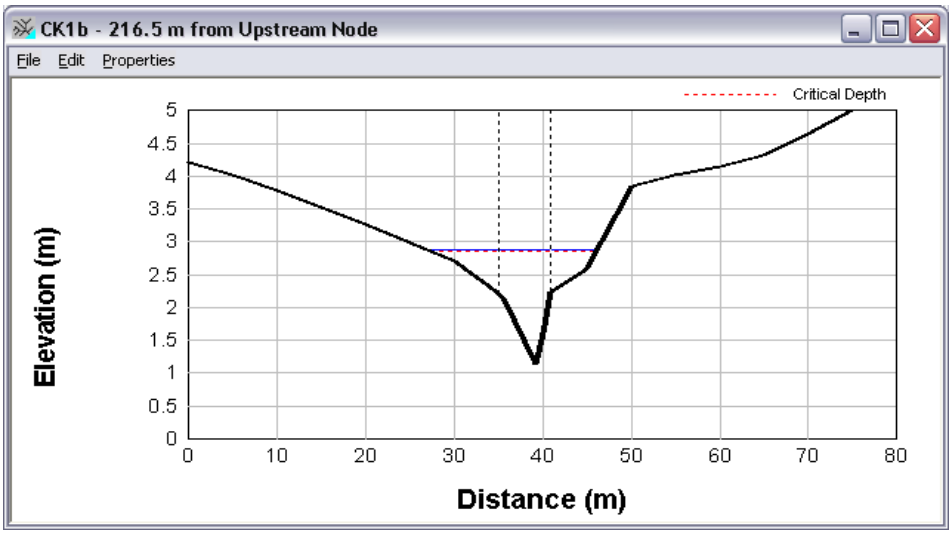
Creek Section 6 CH198.8



Creek Section 7 CH252.6

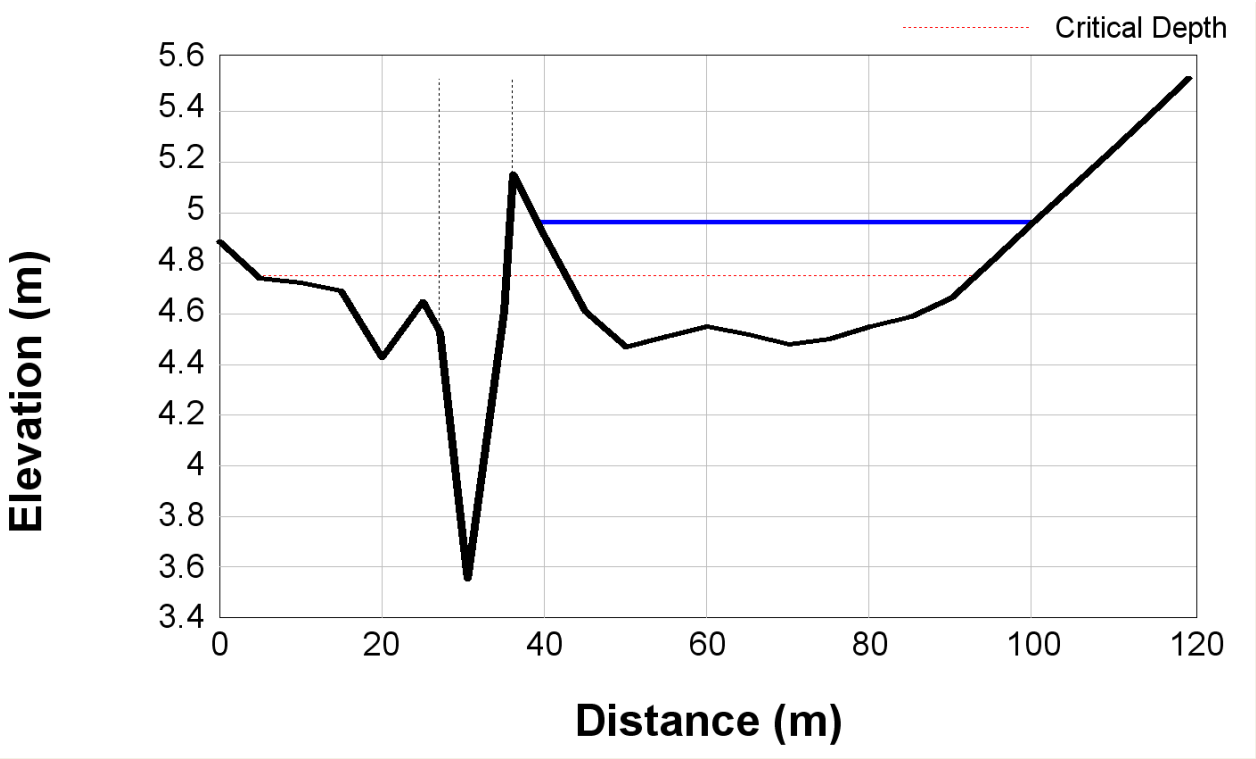


Creek Section 8 CH289.7

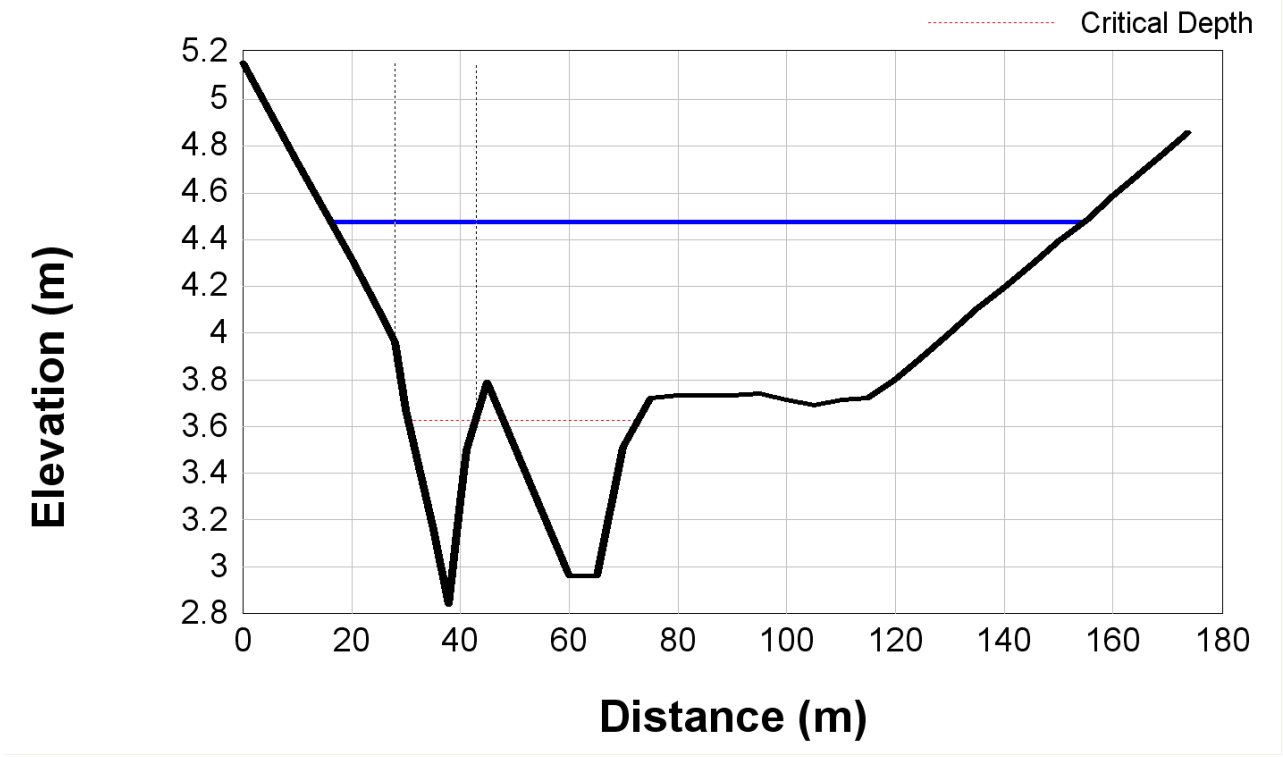


CREEK SECTIONS WITH DRAINS 100 YEAR ARI INCORPORATING THE EFFECTS OF CLIMATE CHANGE

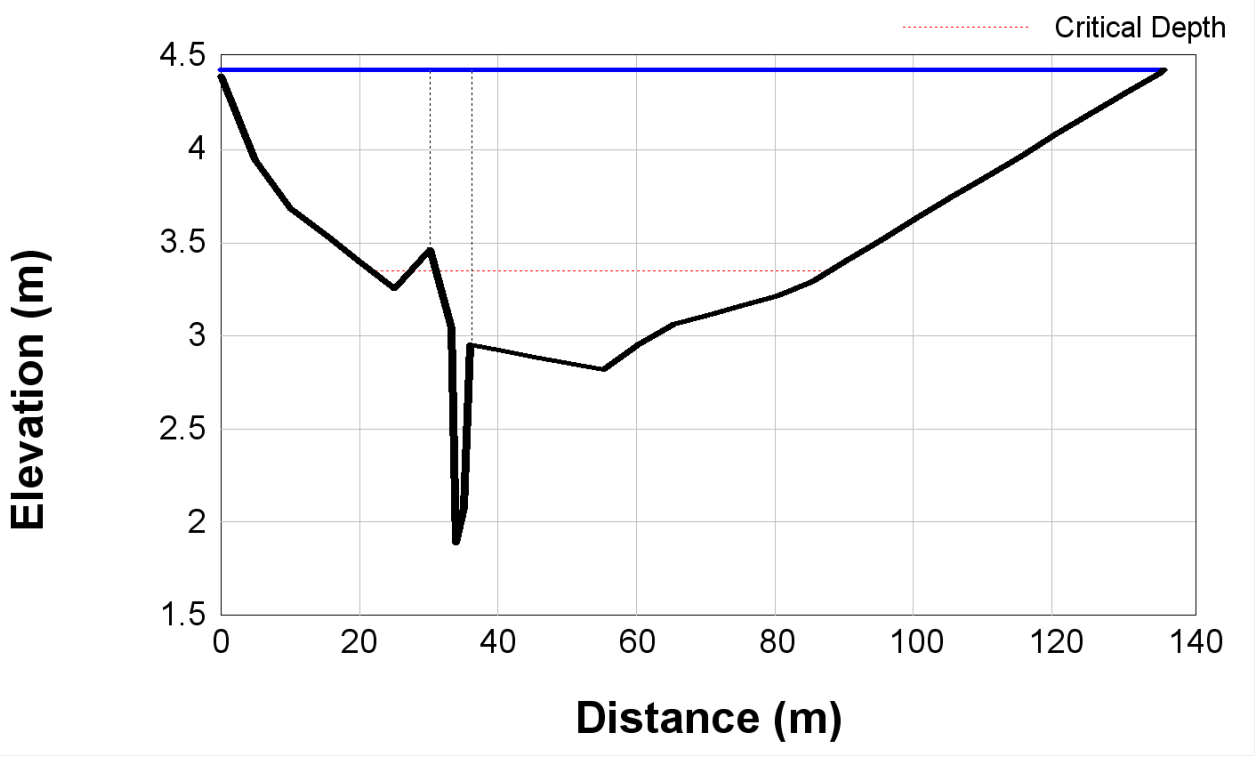
Creek Section 3 CH0.0



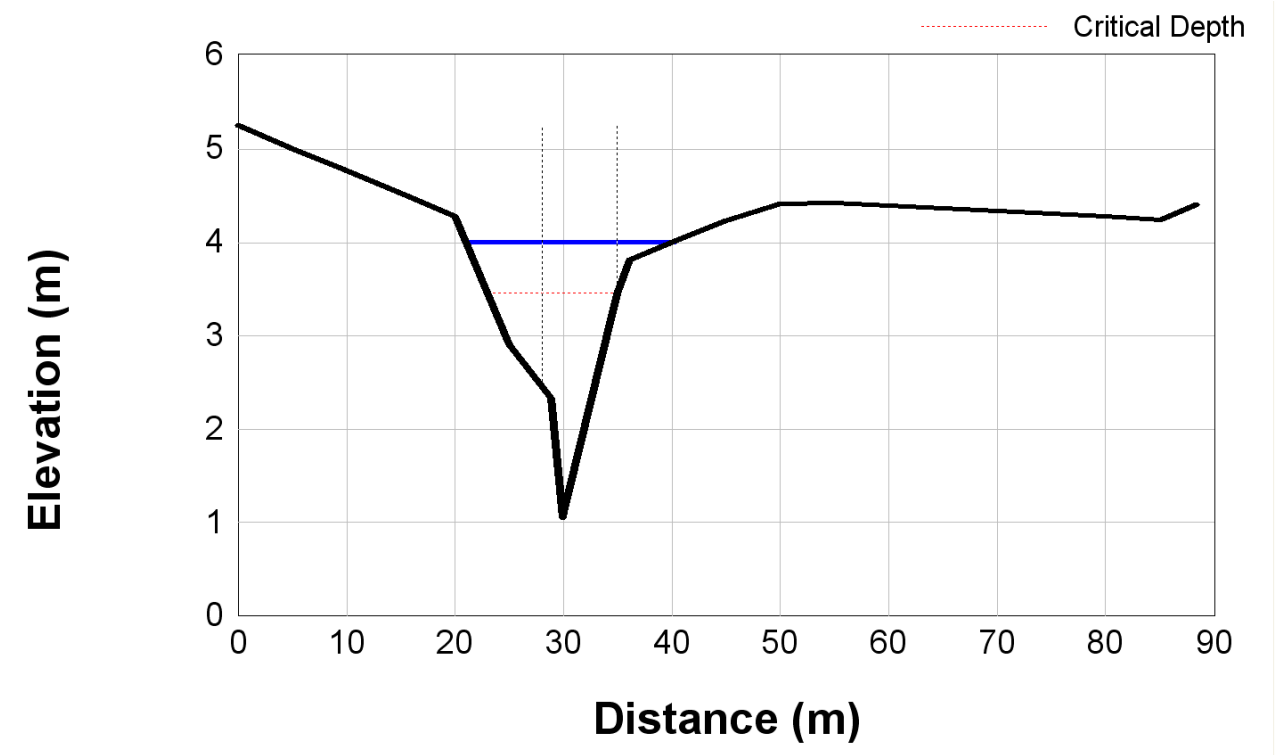
Creek Section 4 CH90.8



Creek Section 5 CH135.5



Creek Section 6 CH198.8



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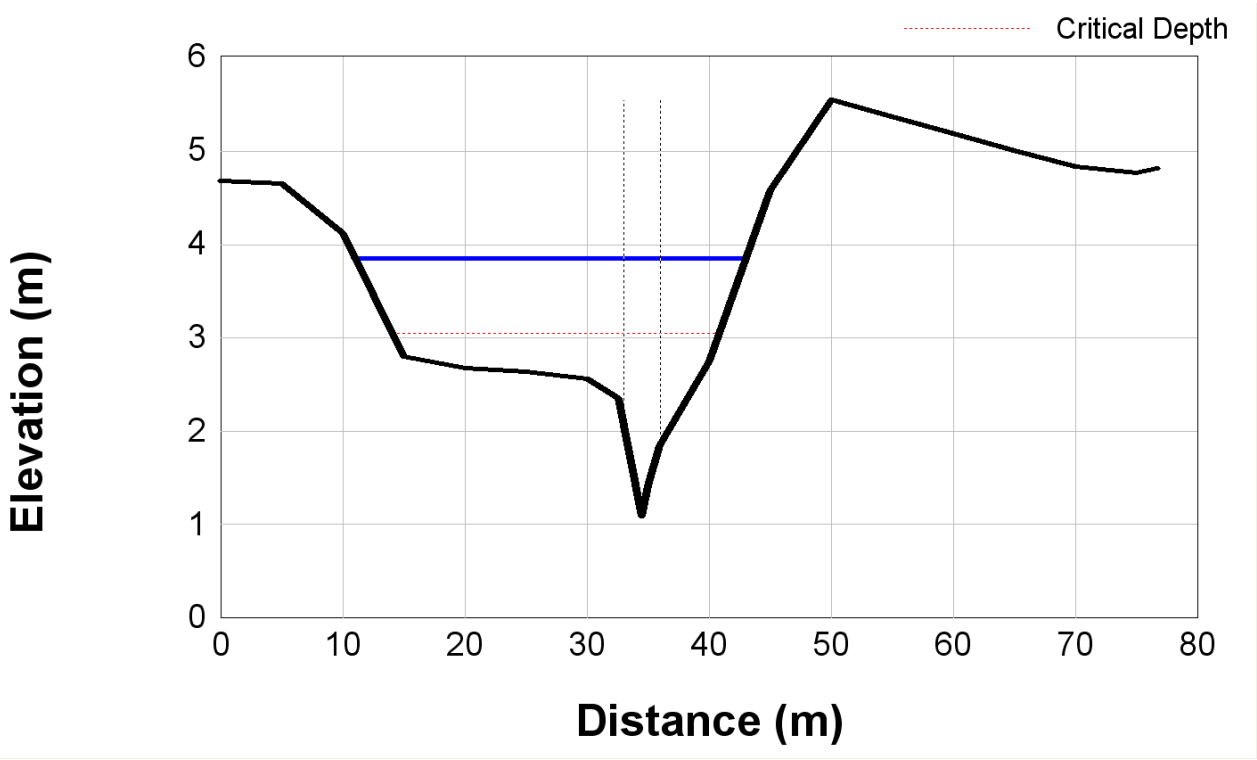

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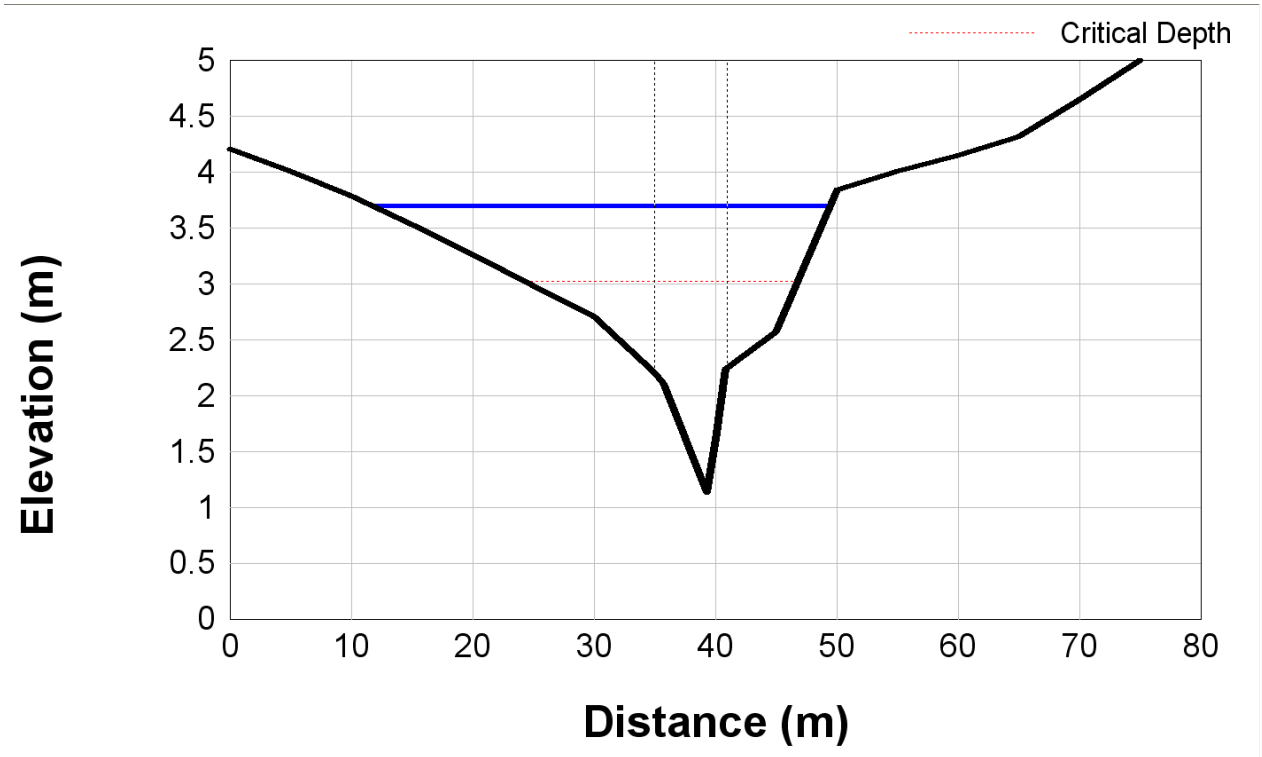
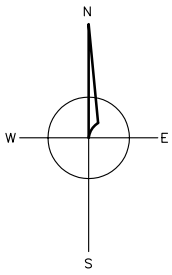


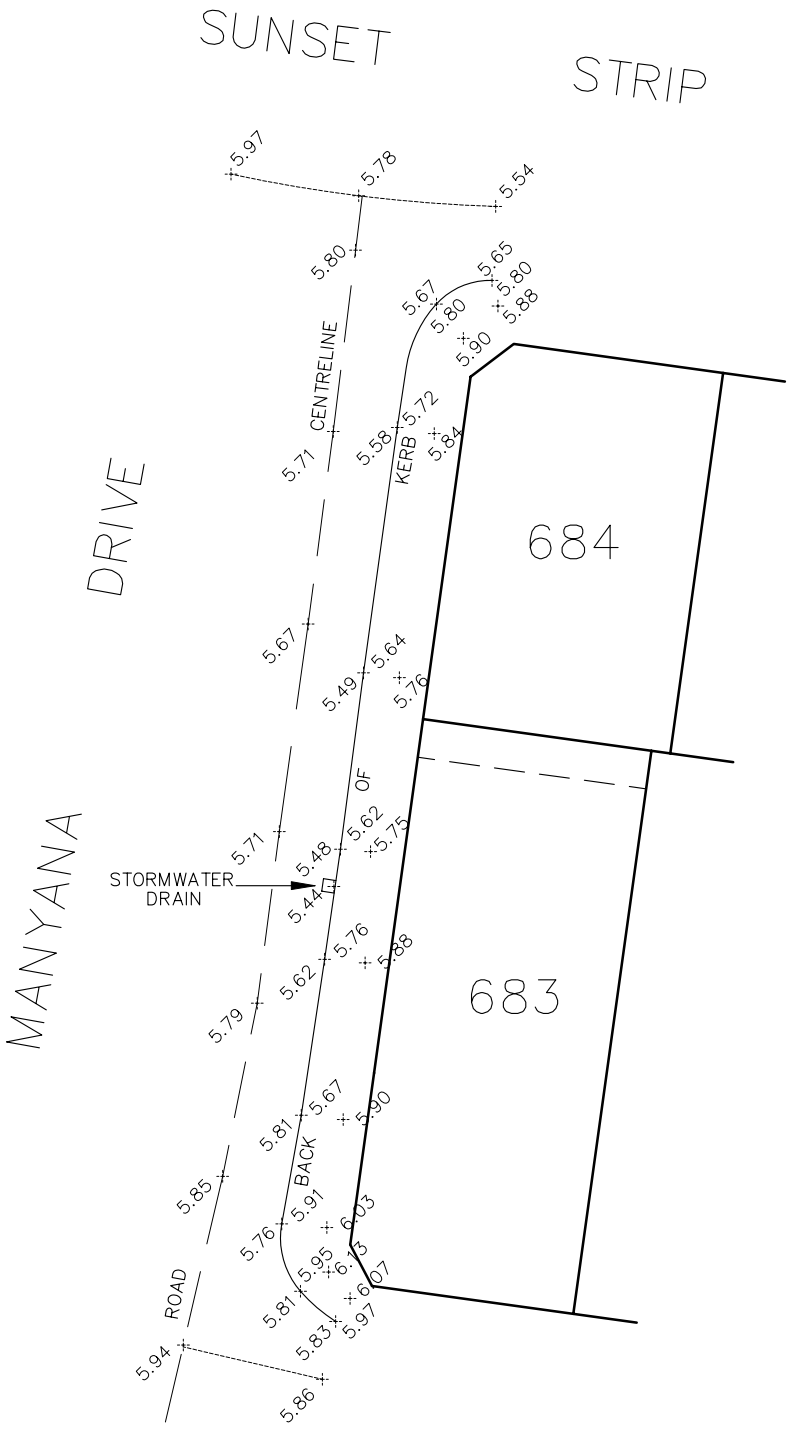
APPENDIX G

Manyana Drive Detail Survey

REF. No. 101662/15

SKETCH PLAN
SHOWING SAG ON MANYANA DRIVE
FOR STORM WATER CONCEPT PLAN
REDUCTION RATIO 1:600 AT A4 SIZE





WATKINSON APPERLEY PTY LIMITED
SURVEYORS, ENGINEERS & TOWN PLANNERS
51 GRAHAM STREET NOWRA 2541
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Email: mail@watapp.com.au

Date – 20th SEPTEMBER 2007

APPENDIX H

MUSIC Model
Input and Output Data

Source nodes								
Location	New Urban 1	New Urban 2	New Urban 3f	New Urban 4h1	Sub 1 Roof	Sub 2 Roof	Sub 2 dev road	Sub 1 dev road
ID	2	3	4	5	6	7	8	9
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	1.77	0.1	0.34	0.19	1.05	0.03	0.03	1.55
Area Impervious (ha)	0.36	0.02	0.06	0.04	1.05	0.03	0.03	1.55
Area Pervious (ha)	1.41	0.08	0.28	0.16	0.00	0.00	0.00	0.00
Field Capacity (mm)	80	80	80	80	80	80	80	80
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	120	120	120	120	120	120	120	120
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.15	2.15	2.15	2.15	1.3	1.3	2.43	2.43
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.6	-0.6	-0.6	-0.6	-0.89	-0.89	-0.82	-0.82
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.3	0.3	0.3	0.3	0.3	0.3	0.34	0.34
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	1.2	1.2	1.2	1.2	-2	-2	-2	-2
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-0.85	-0.85	-0.85	-0.85	-2	-2	-2	-2
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	0.11	0.11	0.11	0.11	-2	-2	-2	-2
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	7.62	0.45	1.41	0.84	9.34	0.22	0.29	13.8
OUT - TSS Mean Annual Load (kg/yr)	1.06E+03	56.3	174	112	252	5.9	104	4.83E+03
OUT - TP Mean Annual Load (kg/yr)	1.96	0.11	0.35	0.21	1.47	3.46E-02	5.34E-02	2.44
OUT - TN Mean Annual Load (kg/yr)	14.7	0.85	2.71	1.64	20.5	0.49	0.71	33.4
OUT - Gross Pollutant Mean Annual Load (kg/yr)	152	8.87	26.7	16.7	230	5.47	7.22	340

Source nodes							
Location	Sub 3 dev road within 80m	Sub 4 dev road within 80m	Old urban 1	Old urban 4	Old urban 2	Sub 3 remian dev road	Old urban 3
ID	10	11	12	13	14	15	19
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	0.16	0.16	26.51	6.21	31.46	0.04	6.03
Area Impervious (ha)	0.16	0.16	5.39	1.26	6.39	0.04	1.23
Area Pervious (ha)	0.00	0.00	21.12	4.95	25.07	0.00	4.81
Field Capacity (mm)	80	80	80	80	80	80	80
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	120	120	120	120	120	120	120
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.43	2.43	2.15	2.15	2.15	2.14	2.15
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.82	-0.82	-0.6	-0.6	-0.6	-0.82	-0.6
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.34	0.34	0.3	0.3	0.3	0.34	0.3
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	-2	-2	1.2	1.2	1.2	-2	1.2
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-2	-2	-0.85	-0.85	-0.85	-2	-0.85
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	-2	-2	0.11	0.11	0.11	-2	0.11
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	1.42	1.43	114	26.8	136	0.32	26.1
OUT - TSS Mean Annual Load (kg/yr)	499	501	1.54E+04	3.57E+03	1.82E+04	59.3	3.41E+03
OUT - TP Mean Annual Load (kg/yr)	0.25	0.25	29.2	6.68	34.2	5.71E-02	6.62
OUT - TN Mean Annual Load (kg/yr)	3.39	3.43	222	51.2	265	0.78	51
OUT - Gross Pollutant Mean Annual Load (kg/yr)	35	35.2	2.28E+03	535	2.71E+03	7.88	520

Source nodes								
Location	Sub 4 remian dev road	New Urban 3g	New Urban 4i2	New Urban 4i1	Sub 3g Roofs	Sub 4h1 Roofs	Sub 4i1 Roofs	Sub i2 Roofs
ID	20	21	22	23	24	25	26	27
Node Type	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode	UrbanSourceNode
Total Area (ha)	0.1	0.14	0.35	0.13	0.11	0.1	0.1	0.06
Area Impervious (ha)	0.10	0.03	0.07	0.03	0.11	0.10	0.10	0.06
Area Pervious (ha)	0.00	0.11	0.28	0.10	0.00	0.00	0.00	0.00
Field Capacity (mm)	80	80	80	80	80	80	80	80
Pervious Area Infiltration Capacity coefficient - a	200	200	200	200	200	200	200	200
Pervious Area Infiltration Capacity exponent - b	1	1	1	1	1	1	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1	1	1	1	1	1	1
Pervious Area Soil Storage Capacity (mm)	120	120	120	120	120	120	120	120
Pervious Area Soil Initial Storage (% of Capacity)	30	30	30	30	30	30	30	30
Groundwater Initial Depth (mm)	10	10	10	10	10	10	10	10
Groundwater Daily Recharge Rate (%)	25	25	25	25	25	25	25	25
Groundwater Daily Baseflow Rate (%)	5	5	5	5	5	5	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0	0	0	0	0	0	0
Stormflow Total Suspended Solids Mean (log mg/L)	2.14	2.15	2.15	2.15	1.3	1.3	1.3	1.3
Stormflow Total Suspended Solids Standard Deviation (log mg/L)	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Stormflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0
Stormflow Total Phosphorus Mean (log mg/L)	-0.82	-0.6	-0.6	-0.6	-0.89	-0.89	-0.89	-0.89
Stormflow Total Phosphorus Standard Deviation (log mg/L)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Stormflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0
Stormflow Total Nitrogen Mean (log mg/L)	0.34	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Stormflow Total Nitrogen Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Stormflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Stormflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Suspended Solids Mean (log mg/L)	-2	1.2	1.2	1.2	-2	-2	-2	-2
Baseflow Total Suspended Solids Standard Deviation (log mg/L)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Baseflow Total Suspended Solids Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Suspended Solids Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Phosphorus Mean (log mg/L)	-2	-0.85	-0.85	-0.85	-2	-2	-2	-2
Baseflow Total Phosphorus Standard Deviation (log mg/L)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Baseflow Total Phosphorus Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Phosphorus Serial Correlation	0	0	0	0	0	0	0	0
Baseflow Total Nitrogen Mean (log mg/L)	-2	0.11	0.11	0.11	-2	-2	-2	-2
Baseflow Total Nitrogen Standard Deviation (log mg/L)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Baseflow Total Nitrogen Estimation Method	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic	Stochastic
Baseflow Total Nitrogen Serial Correlation	0	0	0	0	0	0	0	0
OUT - Mean Annual Flow (ML/yr)	0.93	0.62	1.51	0.55	1	0.89	0.89	0.56
OUT - TSS Mean Annual Load (kg/yr)	163	78.3	204	71.8	27	22.8	23.2	14.8
OUT - TP Mean Annual Load (kg/yr)	0.16	0.15	0.38	0.14	0.16	0.13	0.14	8.61E-02
OUT - TN Mean Annual Load (kg/yr)	2.25	1.2	2.92	1.05	2.22	1.96	1.93	1.22
OUT - Gross Pollutant Mean Annual Load (kg/yr)	22.8	12.4	30.2	10.9	24.7	21.9	21.9	13.8

USTM treatment nodes						
Location	Wetland	Bio-Retention north	Bio-Retention south	Buffer 4i2	Swale	Swale
ID	17	18	28	29	30	31
Node Type	WetlandNode	BioRetentionNode	BioRetentionNode	BufferNode	SwaleNode	SwaleNode
Lo-flow bypass rate (cum/sec)	0	0	0		0	0
Hi-flow bypass rate (cum/sec)	100	2	2			
Inlet pond volume	200					
Area (sqm)	300	19	19	355.60		
Extended detention depth (m)	0.5	0.2	0.2		0.5	0.5
Permanent pool volume (cum)	200					
Proportion vegetated	0.5					
Equivalent pipe diameter (mm)	100					
Overflow weir width (m)	5	4	4			
Notional Detention Time (hrs)	2.53					
Orifice discharge coefficient	0.6					
Weir coefficient	1.7	1.7	1.7			
Number of CSTR cells	5	3	3		10	10
Total Suspended Solids k (m/yr)	1500	8000	8000		8000	8000
Total Suspended Solids C* (mg/L)	6	20	20		20	20
Total Suspended Solids C** (mg/L)	6				14	14
Total Phosphorus k (m/yr)	1000	6000	6000		6000	6000
Total Phosphorus C* (mg/L)	0.06	0.13	0.13		0.13	0.13
Total Phosphorus C** (mg/L)	0.06				0.13	0.13
Total Nitrogen k (m/yr)	150	500	500		500	500
Total Nitrogen C* (mg/L)	1	1.4	1.4		1.4	1.4
Total Nitrogen C** (mg/L)	1				1.4	1.4
Threshold hydraulic loading for C** (m/yr)	3500				3500	3500
Extraction for Re-use	Off	Off	Off	Off	Off	Off
Annual Re-use Demand - scaled by daily PET (ML)						
Constant Daily Re-use Demand (kL)						
User-defined Annual Re-use Demand (ML)						
Percentage of User-defined Annual Re-use Demand Jan						
Filter area (sqm)		18	18			
Filter depth (m)		1	1			
Filter median particle diameter (mm)		5	5			
Saturated hydraulic conductivity (mm/hr)		100	100			
Voids ratio		0.3	0.3			
Length (m)					44	44
Bed slope					0.03	0.03
Base Width (m)					1	1
Top width (m)					5	5
Vegetation height (m)					0.25	0.25
Proportion of upstream impervious area treated				1		
Seepage Rate (mm/hr)	0	3.6	3.6	10	10	10
Evap Loss as proportion of PET	1.25					
Depth in metres below the drain pipe		0	0			
IN - Mean Annual Flow (ML/yr)	282	4.56	5.06	1.51	27.7	26.4
IN - TSS Mean Annual Load (kg/yr)	4.84E+03	808	716	204	3.73E+03	3.46E+03
IN - TP Mean Annual Load (kg/yr)	49.4	0.95	0.92	0.38	6.84	6.68
IN - TN Mean Annual Load (kg/yr)	491	9.71	11.1	2.92	53.4	51.8
IN - Gross Pollutant Mean Annual Load (kg/yr)	64.9	100	119	30.2	558	528
OUT - Mean Annual Flow (ML/yr)	282	4.29	4.82	0.61	25.6	24.3
OUT - TSS Mean Annual Load (kg/yr)	5.17E+03	332	326	34.7	1.95E+03	1.77E+03
OUT - TP Mean Annual Load (kg/yr)	43.9	0.6	0.64	0.1	4.88	4.72
OUT - TN Mean Annual Load (kg/yr)	479	7.59	8.98	1	48.8	47
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0	0	0	12.3	0	0

Generic treatment nodes	
Location	Gross Pollutant Trap
ID	16
Node Type	GPTNode
Lo-flow bypass rate (cum/sec)	0
Hi-flow bypass rate (cum/sec)	5
Flow Transfer Function	
Input (cum/sec)	0
Output (cum/sec)	0
Input (cum/sec)	10
Output (cum/sec)	10
Gross Pollutant Transfer Function	
Input (kg/ML)	0
Output (kg/ML)	0
Input (kg/ML)	14.99
Output (kg/ML)	0.03
Total Nitrogen Transfer Function	
Input (mg/L)	0
Output (mg/L)	0
Input (mg/L)	49.59
Output (mg/L)	43.48
Total Phosphorus Transfer Function	
Input (mg/L)	0
Output (mg/L)	0
Input (mg/L)	5.04
Output (mg/L)	3.54
Total Suspended Solids Transfer Function	
Input (mg/L)	0
Output (mg/L)	0
Input (mg/L)	1000.49
Output (mg/L)	89.8
IN - Mean Annual Flow (ML/yr)	282
IN - TSS Mean Annual Load (kg/yr)	4.00E+04
IN - TP Mean Annual Load (kg/yr)	69.5
IN - TN Mean Annual Load (kg/yr)	558
IN - Gross Pollutant Mean Annual Load (kg/yr)	5.74E+03
OUT - Mean Annual Flow (ML/yr)	282
OUT - TSS Mean Annual Load (kg/yr)	4.84E+03
OUT - TP Mean Annual Load (kg/yr)	49.4
OUT - TN Mean Annual Load (kg/yr)	491
OUT - Gross Pollutant Mean Annual Load (kg/yr)	64.9

Other nodes	
Location	Creek
ID	1
Node Type	ReceivingNode
IN - Mean Annual Flow (ML/yr)	341
IN - TSS Mean Annual Load (kg/yr)	9.59E+03
IN - TP Mean Annual Load (kg/yr)	54.8
IN - TN Mean Annual Load (kg/yr)	592
IN - Gross Pollutant Mean Annual Load (kg/yr)	12.3
OUT - Mean Annual Flow (ML/yr)	0
OUT - TSS Mean Annual Load (kg/yr)	0
OUT - TP Mean Annual Load (kg/yr)	0
OUT - TN Mean Annual Load (kg/yr)	0
OUT - Gross Pollutant Mean Annual Load (kg/yr)	0

Links							
Location	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link
Source node ID	16	17	18	7	14	3	8
Target node ID	17	1	1	16	16	16	16
Muskingum-Cunge Routing	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed
Muskingum K							
Muskingum theta							
IN - Mean Annual Flow (ML/yr)	282	282	4.29	0.22	136	0.45	0.29
IN - TSS Mean Annual Load (kg/yr)	4.84E+03	5.17E+03	332	5.9	1.82E+04	56.3	104
IN - TP Mean Annual Load (kg/yr)	49.4	43.9	0.6	3.46E-02	34.2	0.11	5.34E-02
IN - TN Mean Annual Load (kg/yr)	491	479	7.59	0.49	265	0.85	0.71
IN - Gross Pollutant Mean Annual Load (kg/yr)	64.9	0	0	5.47	2.71E+03	8.87	7.22
OUT - Mean Annual Flow (ML/yr)	282	282	4.29	0.22	136	0.45	0.29
OUT - TSS Mean Annual Load (kg/yr)	4.84E+03	5.17E+03	332	5.9	1.82E+04	56.3	104
OUT - TP Mean Annual Load (kg/yr)	49.4	43.9	0.6	3.46E-02	34.2	0.11	5.34E-02
OUT - TN Mean Annual Load (kg/yr)	491	479	7.59	0.49	265	0.85	0.71
OUT - Gross Pollutant Mean Annual Load (kg/yr)	64.9	0	0	5.47	2.71E+03	8.87	7.22

Location	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link
Source node ID	9	12	6	10	4	5	25
Target node ID	16	16	16	18	18	18	18
Muskingum-Cunge Routing	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed
Muskingum K							
Muskingum theta							
IN - Mean Annual Flow (ML/yr)	13.8	114	9.34	1.42	1.41	0.84	0.89
IN - TSS Mean Annual Load (kg/yr)	4.83E+03	1.54E+04	252	499	174	112	22.8
IN - TP Mean Annual Load (kg/yr)	2.44	29.2	1.47	0.25	0.35	0.21	0.13
IN - TN Mean Annual Load (kg/yr)	33.4	222	20.5	3.39	2.71	1.64	1.96
IN - Gross Pollutant Mean Annual Load (kg/yr)	340	2.28E+03	230	35	26.7	16.7	21.9
OUT - Mean Annual Flow (ML/yr)	13.8	114	9.34	1.42	1.41	0.84	0.89
OUT - TSS Mean Annual Load (kg/yr)	4.83E+03	1.54E+04	252	499	174	112	22.8
OUT - TP Mean Annual Load (kg/yr)	2.44	29.2	1.47	0.25	0.35	0.21	0.13
OUT - TN Mean Annual Load (kg/yr)	33.4	222	20.5	3.39	2.71	1.64	1.96
OUT - Gross Pollutant Mean Annual Load (kg/yr)	340	2.28E+03	230	35	26.7	16.7	21.9

Location	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link
Source node ID	26	23	21	24	11	28	27
Target node ID	28	28	28	28	28	1	28
Muskingum-Cunge Routing	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed
Muskingum K							
Muskingum theta							
IN - Mean Annual Flow (ML/yr)	0.89	0.55	0.62	1	1.43	4.82	0.56
IN - TSS Mean Annual Load (kg/yr)	23.2	71.8	78.3	27	501	326	14.8
IN - TP Mean Annual Load (kg/yr)	0.14	0.14	0.15	0.16	0.25	0.64	8.61E-02
IN - TN Mean Annual Load (kg/yr)	1.93	1.05	1.2	2.22	3.43	8.98	1.22
IN - Gross Pollutant Mean Annual Load (kg/yr)	21.9	10.9	12.4	24.7	35.2	0	13.8
OUT - Mean Annual Flow (ML/yr)	0.89	0.55	0.62	1	1.43	4.82	0.56
OUT - TSS Mean Annual Load (kg/yr)	23.2	71.8	78.3	27	501	326	14.8
OUT - TP Mean Annual Load (kg/yr)	0.14	0.14	0.15	0.16	0.25	0.64	8.61E-02
OUT - TN Mean Annual Load (kg/yr)	1.93	1.05	1.2	2.22	3.43	8.98	1.22
OUT - Gross Pollutant Mean Annual Load (kg/yr)	21.9	10.9	12.4	24.7	35.2	0	13.8

Location	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link	Drainage Link
Source node ID	29	13	30	19	15	31	20
Target node ID	1	30	1	31	31	1	30
Muskingum-Cunge Routing	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed	Not Routed
Muskingum K							
Muskingum theta							
IN - Mean Annual Flow (ML/yr)	0.61	26.8	25.6	26.1	0.32	24.3	0.93
IN - TSS Mean Annual Load (kg/yr)	34.7	3.57E+03	1.95E+03	3.41E+03	59.3	1.77E+03	163
IN - TP Mean Annual Load (kg/yr)	0.1	6.68	4.88	6.62	5.71E-02	4.72	0.16
IN - TN Mean Annual Load (kg/yr)	1	51.2	48.8	51	0.78	47	2.25
IN - Gross Pollutant Mean Annual Load (kg/yr)	12.3	535	0	520	7.88	0	22.8
OUT - Mean Annual Flow (ML/yr)	0.61	26.8	25.6	26.1	0.32	24.3	0.93
OUT - TSS Mean Annual Load (kg/yr)	34.7	3.57E+03	1.95E+03	3.41E+03	59.3	1.77E+03	163
OUT - TP Mean Annual Load (kg/yr)	0.1	6.68	4.88	6.62	5.71E-02	4.72	0.16
OUT - TN Mean Annual Load (kg/yr)	1	51.2	48.8	51	0.78	47	2.25
OUT - Gross Pollutant Mean Annual Load (kg/yr)	12.3	535	0	520	7.88	0	22.8

Links		
Location	Drainage Link	Drainage Link
Source node ID	2	22
Target node ID	16	29
Muskingum-Cunge Routing	Not Routed	Not Routed
Muskingum K		
Muskingum theta		
IN - Mean Annual Flow (ML/yr)	7.62	1.51
IN - TSS Mean Annual Load (kg/yr)	1.06E+03	204
IN - TP Mean Annual Load (kg/yr)	1.96	0.38
IN - TN Mean Annual Load (kg/yr)	14.7	2.92
IN - Gross Pollutant Mean Annual Load (kg/yr)	152	30.2
OUT - Mean Annual Flow (ML/yr)	7.62	1.51
OUT - TSS Mean Annual Load (kg/yr)	1.06E+03	204
OUT - TP Mean Annual Load (kg/yr)	1.96	0.38
OUT - TN Mean Annual Load (kg/yr)	14.7	2.92
OUT - Gross Pollutant Mean Annual Load (kg/yr)	152	30.2