STORMWATER MANAGEMENT PLAN REPORT

FOR

MAKHALEMPONGO CHICKENS PORTION 40 OF FARM KILLARNEY

REVISION 0

July 2022

NTUSA CONSULTING
ENGINEERS PTY LTD

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Contents

1. Introduction

Ntusa Consulting Engineers was appointed by Makhalempongo Chickens to prepare a stormwater management plan (SWMP) for the proposed addition of two chicken broilers at the Makhalempongo Chickens portion 40 of farm killarney located within the Cato Ridge area under the eThekwini Local Municipality.

In accordance with the National Environmental Management Act, Water Act and National Building Regulations, a stormwater management plan is required in order to ascertain reasonable water control, conservation and management of the environment. The Stormwater Management prescribes that the stormwater discharge from privately owned or commercial site be controlled and limited to the predevelopment scenario.

2. Overview

Land development can dramatically alter the hydrologic cycle of a site and, ultimately, an entire watershed. Prior to development, native vegetation can either directly intercept precipitation or draw that portion that has infiltrated into the ground and return it to the atmosphere through evapotranspiration. Development can remove this beneficial vegetation and replace it with lawn or impervious cover, reducing the sites evapotranspiration and infiltration rates.

Clearing and grading a site can remove depressions that store rainfall. Construction activities may also compact the soil and diminish its infiltration ability, resulting in increased volumes and rates of stormwater runoff from the site. Impervious areas that are connected to each other through gutters, channels, and storm sewers can transport runoff more quickly than natural areas. This shortening of the transport or travel time quickens the rainfall runoff response of the drainage area, causing flow in downstream waterways to peak faster and higher than natural conditions. These increases can create new and aggravate existing downstream flooding. Increased peak flows produce greater fluctuations between normal and storm flow rates, which can increase erosion and greatly exceed the required flow in the Municipal stormwater drainage system.

The key objectives of the stormwater Management Plan for the Development are to define measures to:

- Ensure compatibility of the site with relevant regulations and by-laws from the stormwater perspective;
- Protect all life and property from damage by stormwater floods;
- Prevent erosion of soil by wind and water, and
- Develop a conceptual Surface Water Management Plan for the site during construction and post development when compared to pre-development.

3. Project Description

The site is located at **29°47'53.55"S, 30°34'38.04''E** at the Cato Ridge (Killarney) Area. The site consists of 7 broiler houses, bio security area, manager's resident and a storage area. There are existing stormwater management facilities that were built for the mentioned structures.

The proposed development comprises of additional 2 broiler houses with an area of 1674m² and 1854m² and a roundabout for trucks. The proposed additional developed area contributes **4.24 percent** of the site area.

4. Proposed stormwater management system

The broad ideals of the stormwater management philosophy account for the following:

- Reuse of the existing downstream drainage system;
- Compliance with the standard and specific conditions of Authorisation of the Department of Agriculture & Environmental Affairs Record of Decision once available;
- Compliance with the relevant Municipal stormwater management policy;
- Compliance with the National Water Act (Act no.36, 1998); and
- Current national and international best management practices.

5. Site impact assessment

Without appropriately designed stormwater intervention measures, the proposed development plan could have the following detrimental effects:

Physical impacts

- Hydrologic regime alterations – increase in discharge rate (volume per unit time) due to increases in flow velocities along existing engineered channels and conduits;
- Hydraulic regime alterations – increase in discharge volume due to decreases in depression storage and infiltration;
- Thermal – increased water temperatures of storm flows at the pipe outfalls, due to runoff from discharge from attenuation ponds, could impact temperature sensitive biota; and
- Other – and attenuation of trash and debris could result in loss of visual amenity and possibly impact sensitive biota.

6. Stormwater Management Assessment

6.1 Design Standards

The following general design standards have been adopted.

Guidelines for Human Settlement Planning and Design

In general, the proposed stormwater management system is designed in accordance with the Guidelines for Human Settlement and Design, compiled by CSIR Building and Construction Technology & Department of Housing.

eThekwini Municipality Stormwater Management Policy

Stormwater management policy is driven by the eThekwini Municipality Coastal Engineering, Stormwater and Catchment Management Department, in conjunction with the Environmental Management Department and essentially falls under the following categories:

- *Water quality*

  Policy dictates that adequate measures be instituted during the construction phase to minimise transportation and deposition of silt from the construction site during storm events.

  Each development is individually assessed for other pollutants and toxicants, based on proposed land use, and site specific requirements are prescribed.

  Policy dictates that storm flows stemming from new developments shall not exceed the flows prior to such development having taken place. To this end, the 1:10 and 1:50 storm recurrence intervals have been defined as the two benchmarks.

- *Dual drainage system*

  Policy dictates the application of a dual drainage system, with the minor system (e.g. closed conduit systems) catering for frequent storm events and major system (e.g. overland flow routes) for less frequent but severe storm events.

- *Department of Water Affairs and Forestry*

  In general, the proposed stormwater attenuation dams are designed in accordance with the National Water Act (Act 36 of 1998), Section 39, General Authorizations, as published in Government Notice 26/28 no.399, dated 26 March 2004. The general Authorisation mitigates impact and risk by limiting the maximum storage of dams on a site to 50000m^3 and the maximum wall height of any structure to 5m.

The design standard applicable for stormwater modeling prescribes that the stormwater outflow from the site be limited to the predevelopment discharge for the 10 and 50-year recurrence interval storms. Attenuation measures must provide for the difference between the pre-development 1:50 year and post development 1:50 year storms or pre-development 1:50 year and 1:10 year post development. The values that yields higher flow is adopted as indicated in the calculations set out below.

Furthermore, the rate of outflow from the attenuation structure must exceed the pre-development 1:10 year peak rate until the 1:50 year storage is reached.

6.2 Hydrology

6.2.1 Catchment area

The proposed development is shown on the site plan. The total site area for calculations, as per Architectural Plans and post development characteristics are shown as follows:

SCHEDULE OF AREAS:			
Description	**Area**		**Percentage**
Pre-development			
Undeveloped	m²	97716	86.44
Post-development			
Proposed building	m²	3528	3.61
Roundabout	m²	615.75	0.63
Undeveloped	m²	93572.25	82.77
Total proposed development	m²	4143.75	4.24

6.2.2 Runoff coefficients

For the calculation of coefficients of runoff for both the pre and post development. These coefficients have been calculated based on the soil conditions, topography and finished surface volume types.

The difference between the pre and post development coefficients of runoff determines the volume to be attenuated.

6.2.3 Time of concentration

The time of concentration is calculated using hydrological estimates. Using the Bransby Williams Formula for flow lengths greater than 200m, the time of concentration, Tc is calculated from the following equation:

$$Tc = 60(0.87\ x\ L^2 \div 10^9 \div S)\wedge 0.385$$

The surface reduction factor (r.) is as follows:

Surface Reduction Factor	
Type of Surface	**Factor (r)**
Smooth paving	0.02
Clean soil	0.1
Sparse grass	0.3
Mod grass	0.4
Thick bush/grass	0.8

For pre-development scenario, r = 0.4

For post development scenario, r = 0.02

The minimum allowable time of concentration for design is guided by the following table:

TIME OF CONCENTRATION	
Thick vegetation	15min
Cultivated areas/Parks	15min
Residential Areas	15min
Fully developed	10min

6.2.4 Rainfall data

The rainfall data for the site recorded for the nearest rain gauge is as follows:

RAINFALL DATA						
Return Period	Storm Duration					
	5min	**10min**	**15min**	**30min**	**45min**	**60min**
2	11.4	15.2	18.1	22.8	26.2	28.8
5	16.6	22.2	26.3	33.3	38.2	42.1
10	21.0	28.0	33.2	42.0	48.2	53.1
20	26.0	34.7	41.1	52.0	59.7	65.8
50	34.0	45.4	53.8	68.1	78.1	86.1
100	41.3	55.2	65.4	82.7	94.9	104.6
200	50.0	66.8	79.1	100.1	114.8	126.6

6.2.5 Storm discharge

The design calculations for predevelopment and post development scenarios are as follows:

RATIONAL METHOD							
Description of Catchment			Makhalempongo Chicken Poultry				
River Detail							
Calculated by		N. Mkhwanazi			**Date**	31/07/2022	
Physical characteristic							
Size of catchment (A)			0.11305	km²	Rainfall region		Summer
Longest watercourse (L)			0.4	km	**Area distribution factors**		
Average slope (S_{av})			1.528	m/m	Rural	Urban	Lakes
Dolomite area ($D_{\%}$)			0	%	100	0	0
Mean annual precipitation (MAP)			966	mm			
Rural (1)					**Urban** (2)		
Surface slopes	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C_2**
Vleis and pans	0	0.05	0	**Lawns**			
Flat area	45	0.11	4.95	Sandy, flat (<2%)	0	0.08	0
Hilly	45	0.2	9	Sandy, steep (>7%)	0	0.18	0
Steep area	10	0.3	3	Heavy soil, flat (<2%)	0	0.15	0
Total	**100**	-	0.1695	Heavy, soil, steep (>7%)	10	0.3	3
Permeability	**%**	**Factor**	**Cp**	**Residential areas**			
Very permeable	0	0.05	0	Houses	0	0.5	0
Permeable	60	0.1	6	Flat	0	0.6	0
Semi-permeable	20	0.2	4	**Industry**			
Impermeable	20	0.3	6	Light industry	0	0.65	0
Total	**100**	-	0.16	Heavy industry	0	0.7	0

Vegetation	%	Factor	Cv	Business			
Thick bush and plantation	70	0.05	3.5	City centre	0	0.6	0
Light bush and farm-lands	15	0.15	2.25	Suburban	0	0.85	0
Grasslands	15	0.25	3.75	Streets	90	0.95	85.5
No vegetation	0	0.3	0	Maximum flood	0	1	0
Total	**100**	-	0.095	Total (C_2)	100	-	0.885
Time of concentration (Tc)				**Notes:**			
Overland (3)		Defined watercourse		Manuals : SANRAL Drainage Manual and Geometric Design			
$T_C = 0{,}604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0{,}467}$		$T_C = \left(\frac{0{,}87L^2}{1000S_{av}}\right)^{0{,}385}$		Notes			
	hours	0.232	hours				

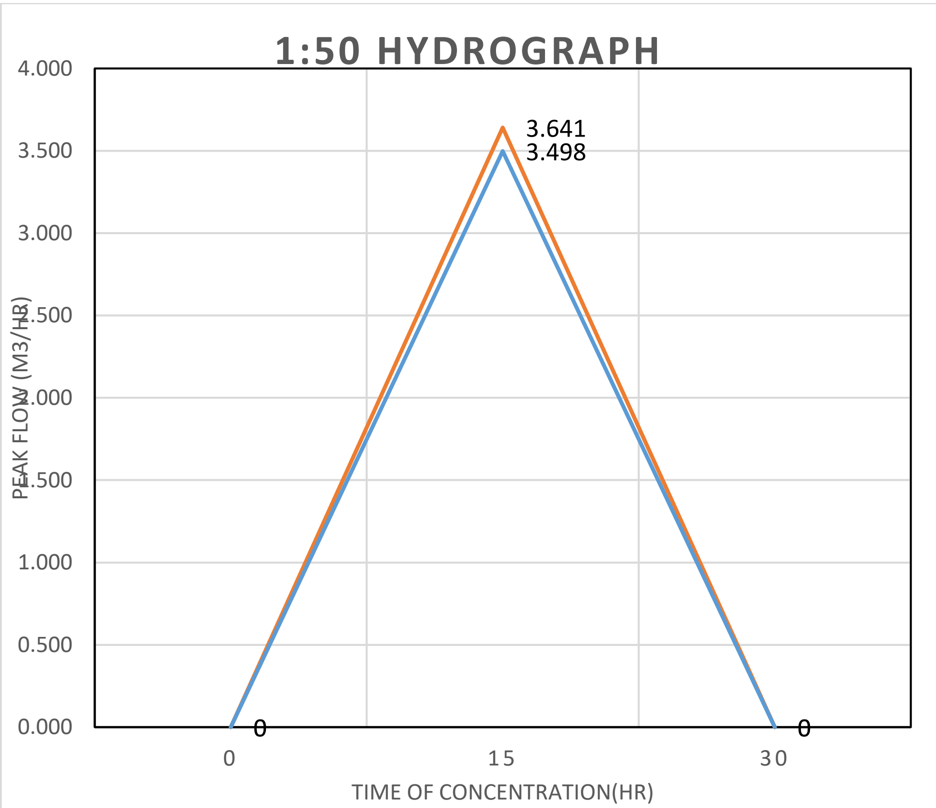
Run-off coefficient - Predevelopment							
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 ($C_1 = C_s + C_p + C_v$)	0.4245	0.4245	0.4245	0.4245	0.4245	0.4245	
Adjusted for dolomite areas, C_{1D} = (C_1(1-D%)+(C1D%(SUM(Dfactor X Cs%) (4)							
Adjustment factor for initial saturation, Ft (5)	1	1	1	1	1	1	
Adjustment run-off coefficient, C_T	0.4245	0.4245	0.4245	0.4245	0.4245	0.4245	

Rainfall							
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point precipitation (mm) Pt	12	18	20	25	32	40	
Point intensity (mm/hr), Pi = Pt/Tc	51.72414	77.5862069	86.2068966	107.7586207	137.931	172.41379	
Area reduction factor ARF_T (7)	0.75	0.8	0.85	0.9	0.95	1	
Average intensity (mm/hr), I_T = Pi x ARF_T	38.7931	62.06896552	73.2758621	96.98275862	131.0345	172.41379	
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3,6}$	**0.517131**	**0.827409052**	**0.97680235**	**1.292826643**	**1.746752**	**2.2983585**	
Run-off coefficient - Post development							
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Run-off coefficient, C_1 (C_1 = Cs + Cp + Cv)	0.885	0.885	0.885	0.885	0.885	0.885	
Adjusted for dolomite areas, C_{1D} = (C_1(1-D%)+(C1D%(SUM(Dfactor X Cs%) (4)							
Adjustment factor for initial saturation, Ft (5)	1	1	1	1	1	1	
Adjustment run-off coefficient, C_T	0.885	0.885	0.885	0.885	0.885	0.885	
Rainfall							
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point precipitation (mm) Pt	12	18	20	25	32	40	
Point intensity (mm/hr), Pi = Pt/Tc	51.72414	77.5862069	86.2068966	107.7586207	137.931	172.41379	
Area reduction factor ARF_T (7)	0.75	0.8	0.85	0.9	0.95	1	
Average intensity (mm/hr), I_T = Pi x ARF_T	38.7931	62.06896552	73.2758621	96.98275862	131.0345	172.41379	
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3,6}$	**1.078117**	**1.724987069**	**2.03644307**	**2.695292295**	**3.641639**	**4.7916307**	

The design discharge, Q, corresponding to the allowable time of concentration for both the predevelopment and post development scenarios is as in the table below and the following graph showing the run-off hydrograph:

Storm Recurrence interval (yr)	Pre-development Q (m3/s)	Post-development Q (m3/s)
10	0.977	2.036
50	3.498	3.641

6.2.6 Attenuation Volume



6.2.7 Attenuation structure

From the calculations, the total volume required for storage is based on the 1:50 year peak storm discharge, V = 8.58m³. This is the total volume of water to be detained on the site.

There is an existing stormwater retention pond / attenuation tank that was designed to detain the runoff from the proposed hardened areas. The dimensions of the existing storage pond is: 45m x 23m x 1m. The resultant runoff from the proposed two additional broiler houses will be accounted for in the existing storage system. Therefore, there will be no need to construct a new storage system. If there is a need to construct a new system for the additional runoff volume, then the following should be noted.

The attenuation stormwater volume is not to be less than 8.58m³

The recommended size of the tank is 4.00m long x 2.15m wide x 1.0m deep = 8.6m³

This allows the tank to have a:

- 0.15mm freeboard in the event of minor blockages and siltation in the tank.
- Attenuate the volume required.

7. Execution of stormwater Management Plan

This strormwater management plan seeks to mitigate the adverse effects of development on downstream receiving waters and/or built environment through effective and sustainable runoff, sediment and pollutant control measures during construction of the civil works, the ensuring construction of the broiler houses and finally upon completion of all construction.

7.1 Construction – Civil infrastructure

7.1.1 Attenuation Structures

The attenuation structures, storage ponds or grassed swales shall be constructed prior to construction of the two additional broiler houses and roundabout or once pipe systems are functional in this catchment.

7.1.2 Site clearance

Site clearance must be carried out with due care and attention to the effect, whether short-term or long-term, that this removal will have on erosion potential.

7.1.3 Filter barriers

Precautionary filter barriers such as silt fencing, straw bale barriers shall be installed on the site at all times to contain soil erosion and prevent any eroded material from being transported.

7.1.4 Forming of embankments

Where embankments have to be formed, stabilization and erosion control measures shall be implemented without delay.

7.1.5 Trench excavation

Trenching for services shall be programmed to commence immediately preceding installation of the services and said trenches shall be backfilled and compacted, to a density at least equivalent to the density of the adjacent in-situ soils, immediately thereafter. Where it is unavoidable that trenches remain open and unattended temporary check dams shall be constructed in the invert of the trench.

7.1.6 Re-establishment of vegetation

Landscaping and re-vegetation of areas not occupied by impervious surfaces shall be programmed to commence immediately after civil works have been completed, or have reached a stage where newly established ground cover is not at risk from construction activities.

7.2 Construction – Top structures

The discharge from the roof area and hardened areas will be collected in a piped network and directed to the attenuation tank or ponds as indicated on the site plan. Annexure A. There is no access to municipal stormwater in the vicinity of the site therefore discharge will be attenuated by means of a soak away or retention pond.

8. Conclusion

The earthworks operation must be carried out by a suitably qualified contractor. The specifications with respect to the following will be issued on the bulk earthworks drawings and details upon appointment of a contractor.

- Material utilization plan in terms of the platform cutting and filling.
- Extents of the cutting and filling. Specifications of the platform and required compaction. The controls and procedures.
- Stormwater Management for the pre and post scenarios.

Measures must be introduced during the construction phase which will mitigate environmental impacts.

These will be in the form of the following construction methods and procedures.

- Earth drains to the top of cut embankments.
- Temporary v-drains
- Silt curtains along drains and cut and fill embankments – to mitigate erosion and prevent excessive discharge of latent soil elements into the environmental sensitive areas boundary.
- The use of shade clothes strategically positioned along the environmental sensitive areas so that no contamination with respect to dust and litter enter this boundary.

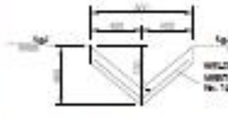
Yours Faithfully

Ntuthuko Mkhwanazi (Pr. Tech. Eng.)

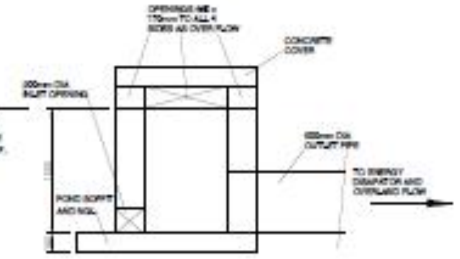
076 647 8979

9. ANNEXURE A

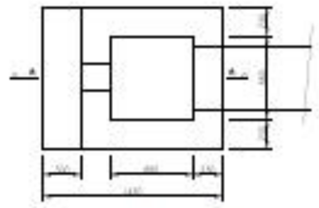
SWMP PLAN LAYOUT



CONCRETE LINED V-DRAIN



SECTION A - A



OUTLET MANHOLE PLAN LAYOUT

DESIGN PHILOSOPHY

1. ALL STORMWATER FLOW TO BE DIRECTED TO ATTENUATION POND
2. DISCHARGE TO BE LIMITED TO PREDEVELOPED DISCHARGE RATE PER METER OF BOUNDARY ALONG BOUNDARY LENGTH INFLUENCED BY POND LIMIT.
3. DISCHARGE BY CALCULATION:

PRE DEVELOPMENT DISCHARGE	[illegible]
BOUNDARY LENGTH AFFECTED BY POND DISCHARGE [illegible] METERS	
PERMITTED FLOW	[illegible]
PIPE FLOW [illegible]mm DIA	[illegible] CUMECS
NUMBER OF DISCHARGE PIPES REQUIRED	[illegible] No. EQUALLY SPACED ALONG POND
THEORETICAL DRAIN TIME	[illegible] MINUTES

4. POND DIMENSIONS

DEPTH	= 1000mm
VOLUME	= [illegible] CUMECS MINIMUM
LENGTH	= [illegible]m AT BOTTOM
WIDTH	= [illegible]m AT BOTTOM

[illegible] CONSULTING ENGINEERS

STORMWATER MANAGEMENT	CALCULATIONS
ASSESSMENT METHOD	RATIONAL METHOD
PROJECT No.	
TOTAL SITE AREA	[illegible]
HARDENED AREA	[illegible]
UNHARDENED AREA	[illegible]
HARDENED RUNOFF COEFFICIENT	[illegible] DEVELOPED
UNHARDENED RUNOFF COEFFICIENT	[illegible] UNDEVELOPED
EFFECTIVE COEFFICIENT DEVELOPED STATE	[illegible]
RAINFALL INTENSITY	[illegible]
1:50 PREDEVELOPED FLOW	[illegible]
1:50 DEVELOPED FLOW	[illegible]
BALANCE TO BE ATTENUATED	[illegible]
VOLUME REQUIRED	[illegible]
VOLUME REQUIRED	[illegible]
PERMITTED FLOW	[illegible]
PIPE DIAMETER	[illegible]
PIPE AREA	[illegible]
WATER DEPTH (AVERAGE)	1000mm
PIPE FLOW	[illegible]
AREA OF POND	[illegible]
AREA OF POND	[illegible]

STORMWATER MANAGEMENT PLAN

PREDEVELOPMENT FLOW DURING CONSTRUCTION: [illegible]

POST DEVELOPMENT / CONSTRUCTION: [illegible]

SCHEDULE OF AREAS:

HOUSE No. [illegible] = [illegible]

HOUSE No. [illegible] = [illegible]

TOTAL ADDED AREA = [illegible]

KILLARNEY FARM

STORMWATER_MANAGEMENT_PLAN

10. ANNEXURE B

CALCULATIONS

CATCHMENT ANALYSIS PRE - POST DEVELOPMENT VER 1.1 Jan 2021

Site:	Makhalempongo Chicken Poultry Farm (Killarney)
	PRE and POST development
Descr:	lat 29°47'53.55" long 30°34'38.04
Anal. by:	N. MKHWANAZI
Date:	31-Jul-22

Site Area (m^2)	Tc pre (min)	Tc post (mins)
113050.00	15.00	15.00

RI (yrs)	RI Reduction factor ft	CT PRE d	CT POST d	RAIN DATA mm/hr 15	RAIN DATA mm/hr 30	Ipre 15.0	Ipost 15.0	Q PRE	Q POST	Reqd Storage 2xTc	Total hardened area runoff	mean runoff	area1	area2	area2 alt	area 3	inter y2'/y1	inter y2'/y1'
2	0.75	0.32	0.66	51.72	51.72	51.7	51.7	0.517	1.078	505	505	673	505	0	0	0	20	30
5	0.8	0.34	0.71	77.59	77.59	77.6	77.6	0.827	1.725	808	808	1010	808	0	0	0	20	30
10	0.85	0.36	0.75	86.21	86.21	86.2	86.2	0.977	2.037	954	954	1122	954	0	0	0	20	30
20	0.9	0.38	0.80	107.76	107.76	107.8	107.8	1.293	2.695	1262	1262	1402	1262	0	0	0	20	30
50	0.95	0.40	0.84	137.93	137.93	137.9	137.9	1.747	3.642	1705	1795	1795	1705	0	0	0	20	30
100	1	0.42	0.89	172.41	172.41	172.4	172.4	2.298	4.792	2244	2244	2244	2244	0	0	0	20	30

DWA METHOD

PRE/RURAL Runoff Coefficient			**POST/URBAN Runoff Coefficient**		
Catchment MAP		MAP	**URBAN**	%	
Catchment Slope CS	%	**> 900mm**	Lawn sandy<2%	0	0.08
< 3%	0	0.05	Lawn sandy>7%	0	0.18
3-10 %	45	0.11	Lawn heavy<2%	0	0.15
10 - 30 %	45	0.20	Lawn heavy>7%	10	0.30
> 30 %	10	0.30	Residential single	0	0.50
	100	0.17	Flats/dense townships	0	0.60
Soil Permeability Cp	%		Industry , light	0	0.65
Very perm (Dunes)	0	0.05	Industry , heavy	0	0.70
Perm (light soil)	60	0.10	Business local	0	0.60
Semi (most soils)	20	0.20	Business CBD	0	0.85
Imperm (rock, paving)	20	0.30	Streets/roofs	90	0.95
	100	0.16		100	0.89
Vegetal growth Cv	%				
Dense bush, forest	70	0.05	AREA WEIGHTING FACTORS		
Cult land, sparse bush	15	0.15		%	DWA
Grassland	15	0.25	RURAL	0.00	0.42
Bare Surface	0	0.30	URBAN	100.00	0.89
	100	0.10	LAKES	0	0.00
Rural Catchment coeff	Ct =	0.42	Cdesign	100	0.89

Tc Rational METHOD "KERBY" FORMULA

Overland flow T(mins) = $36(rD/1000/S^{0.5})^{0.467}$

Dist (m)		r factor	
400.00	smooth paving	0.02	
Slope	clean soil	0.10	
1.53	sparse grass	0.30	
	mod grass	0.40	**NOTE**:
	thick bush/gra	0.80	distance
	choose r	0.40	used should
T overland (mins)		13.86	not exceed
Velocity (m/s)		0.48	200m

Q, Vel, Time of concentration - defined watercourse/open channel/pipe/box culv

INPUT		**OUTPUT**				n values
Manning n	0.011	**SHAPE**	Qunif=VA	Vel V	Tc mins	smooth concr.012
Slope (m/m)	0.025	Trapezoid	0.27	2.74	0.912	earth.018
Width (m)	1.000	rectangle	0.27	2.74	0.912	nat.stream.05
Depth (m) not	0.1	FullBoxCulv	0.18	1.83	1.366	Conc canal .02
path/distance	150	Triangle	0.00	0.02	128.149	asph.016
side slope 1:?	0.001	Gutter	0.00	0.01	203.424	grass.03
pipe dia (m)	0.45	FullPipeCulv	0.53	3.35	0.746	bushy.05
		NB Pipe is assumed full				

SHORT STEEP BOX CULVERTS

HEAD H (m)	span B	depth D	H/D	INLET COEFF C SQUARE E	ROUND
5	0.8	0.80	6.25	0.9	1.0
$Q=2/3CBH(2/3gH)^{0.5}$ for H/D<1.2			m^3/s	H/D>!.2	H/D>1.2
				0.6	0.8
$Q=CBD(2g(H-CD))^{0.5}$ for H/D>1.2			m^3/s	3.616	4.735

SHORT STEEP PIPE CULVERTS <= 250 mm dia

	HEAD H	DIA D (m)	H/D	slope	
	1	0.35	2.85714286	0.01	0.01
$Q=0.35g^{0.5}d^{.361}H^{1.639}$		m^3/s	H/D>1.28	H/D<=1.28	
$Q=0.43g^{0.5}d^{1.683}H^{0.817}$		m^3/s	0.23012801	H/D>=1.28<4	

	0.40	
sloped culverts		
0<h/d<0.8	H/D>0.8	q=D2xsqrt(gD)x0.48(S/0.4)0.05*(H/D)1.9
0.8<H/D<=1.2	0.8>H/D>	q=D2xsqrt(gD)x0.44(S/0.4)0.05*(H/D)1.5
h/d>>1.2	0.2557	q=0.6pi*d2/4sqrt(2gh)