DEVELOPMENT DESIGN SPECIFICATION

D5

SUBDIVISION DRAINAGE DESIGN

5. 1 INTRODUCTION

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5.1.1 Objectives

This document is intended to provide guidance to developers and their consultants so that the following objectives are met in all stormwater designs for land subdivisions within the Shellharbour & Kiama Council area;

* provide safety for the public,
* minimise and control, nuisance flooding and to provide for the safe passage of less frequent flood events
* protect property,
* enhance the urban landscape,
* maximise the land area available for dwellings,
* minimise the environmental impact of urban runoff.

The system shall be planned and designed so as to generally conform with natural drainage patterns and discharge to natural drainage paths in the catchment.

5.1.2 Major/Minor System

5.1.2.1 Definition

The **minor drainage** system consists of kerb and gutter, table drains, swales, pits, and underground pipelines (including interallotment drainage) designed to fully contain and convey a design flow of specified Average Recurrence Interval (ARI).

The **major drainage** system consists of pavements, roadway reserves, dedicated floodways, detention basins, and natural watercourses which convey a design flood in excess the capacity of the minor drainage system.

5.1.2.2 Provision for Failure

It is important to ensure that the combined system can cope with surcharge due to blockages and flows in excess of the design ARI. If failure of the system occurs the risk to life and property can be significantly increased. All designs must incorporate fail-safe features.

The use of the hydraulic gradeline design method is important as some entry sumps may actually surcharge when the design capacity of the pipe system is exceeded.

In establishing the layout of the drainage system, designers shall ensure flows will not encroach onto private property during floods less than or equal to the 100 Years ARI flood.

5.1.3 Flood Attenuation

Designers shall ensure that discharges from new urban developments, do not exceed the capacity of the downstream stormwater systems nor result in additional scour and instability of natural creek and river systems and artificial channels.

While the general design consideration is to limit discharges from a site to pre-development levels designers should fully investigate the impact of post development discharges to determine whether attenuation measures are warranted.

5.1.4 Water Quality Control

5.1.4.1 General Strategy

Urban development will generally result in an increased level of export of a wide range of non-point source pollutants. To protect the quality of local streams and receiving waters the stormwater system shall incorporate water quality measures in accordance with the development consent.

5.1.5 Easements

The stormwater drainage system should avoid impacting upon private property. The lot layout shall ensure that the stormwater drainage system does not encroach upon land intended as private lots so that drainage easements, other than for interallotment drainage, are not required.

Drainage easements shall be provided within land intended to be dedicated as Public Reserve where this water drains directly from private property.

The major drainage system shall be located completely within public land.

5.1.6 Public Safety

Designers shall give detailed consideration to public safety consequences of their proposed stormwater systems and shall incorporate measures to ensure public safety.

5.1.7 Maintenance

Designers shall give detailed consideration to the operation and continuing maintenance of the stormwater system.

Any design incorporating the need for special or unusual equipment for operation and maintenance should not be prepared without the prior written approval of the Council.

Provision for maintenance and equipment access must be incorporated in the design of the stormwater system.

5.2 HYDROLOGY

Tables

Maps

5.2.1 Design Principles

Design methods and data shall be derived from the latest edition of Australian Rainfall and Runoff, (I.E.Aust) unless otherwise required by this document.

For catchment areas greater than 50 hectares, design discharge for components of the major drainage system shall be estimated by two recognised flow methods.

5.2.2 Average Recurrence Intervals (ARI)

The minor stormwater system design ARI shall be selected in accordance with Table 5.2.1.

The major stormwater system of floodways and overland flowpaths shall be designed to ensure that all private land is protected against inundation from flood flows up to and including the 100 Year ARI flood.

The design analysis shall take into account the possibility of property damage or danger to life which might occur in specific situations.

Table 5.2.1
Design ARI

Drainage System	Minor System ARI (years)	Major System ARI (years)
Collector, Access Street, Access Place, Accessway	5	100
Major Collector	20	100
Relief of low point draining through private property [1]	100	100
Relief of low point through public open space	5	100
Dual use floodways (passive open space) [2]	25% of 1 year flow	100
Detention Basins (passive open space)	25% of 1 year flow	100
Detention Basins (active open space) [2,3]	1	100

Notes:
1. Relief of a low point through private property will only be considered where the designer can demonstrate that there is no other possible solution. Adequate provision shall be made for the passage of overflows caused by pit and pipe blockage
2. Spillways shall be designed to safely pass the PMF without danger to downstream property
3. Subsoil drainage systems shall be installed to prevent waterlogging

5.2.3 Rational Method

The following procedures shall be adopted when using the Rational Method for drainage design in urban catchments in the Shellharbour and Kiama local government area. Partial area effects shall be taken into account in determining peak flow rates.

5.2.3.1 Time of Concentration

The time of concentration may be estimated using the so called Kinematic Wave Equation using a value of “n” determined from Table 5.2.2;

$$t = \frac{6.94(L \cdot n^{*})^{0.6}}{I^{0.4} \cdot S^{0.3}} \qquad \text{[eqn 5.2.1]}$$

Where:
t = time of concentration (min)
L = flow path length (m)
n^* = retardance coefficient
S = slope (m/m)
I = rainfall intensity (mm/h)

Table 5.2.2
Retardance Coefficients

Surface Type	'n' value
Concrete or asphalt	0.012
Bare sand	0.013
Gravelled surface	0.02
Bare clay/loam soil (eroded)	0.025
Sparse vegetation	0.09
Short grass / lawns	0.15

5.2.3.2 Runoff Coefficent

The runoff co-efficient shall be determined using the procedure outlined in Chapter 14 of Australian Rainfall and Runoff 1987 (ARR87).

Table 5.2.3
Runoff Coefficient

Impervious Fraction %	C_{10}
100	0.9
0	0.7

Table 5.2.4
Frequency Factors for Rational Method Coefficients

ARI (years)	Frequency Factor Fy
1	0.80
2	0.85
5	0.95
10	1.00
20	1.05
50	1.15
100	1.20

In the absence of detailed evidence impervious areas shall be taken from Table 5.2.5

Table 5.2.5
Impervious Area Estimates

Landuse Type	Percentage Impervious
Single Dwelling Residential	45% (min 200m^2 per lot)
Road Reserve	70%
Medium Density Residential	80%
Commercial	100%
Industrial	100%
Public Recreation Areas	10%

5.2.4 DRAINS / ILSAX

(a) *Rainfall Loss Rates*

In the absence of calibrated data the parameter values given in Table 5.2.6 shall be adopted.

Table 5.2.6
DRAINS / ILSAX Rainfall Loss Parameters

Parameter	Value
Impervious (paved) depression	1mm
Pervious (grassed) depression	5mm
Soil Type	3.0
AMC	3.0

(b) *Time of Concentration*

The time of entry for sub-catchments shall be calculated using equation 5.2.1.

The time of entry for all impervious areas shall be taken as 5 minutes.

5.2.5 WBNM

Designers are to use the guidance outlined within the WBNM user guide to establish the model parameters.

Local evidence indicates that the **lag parameter** should fall within the range 1.3 to 1.8.

In the absence of detailed evidence the **impervious lag factor** should be set at 0.10

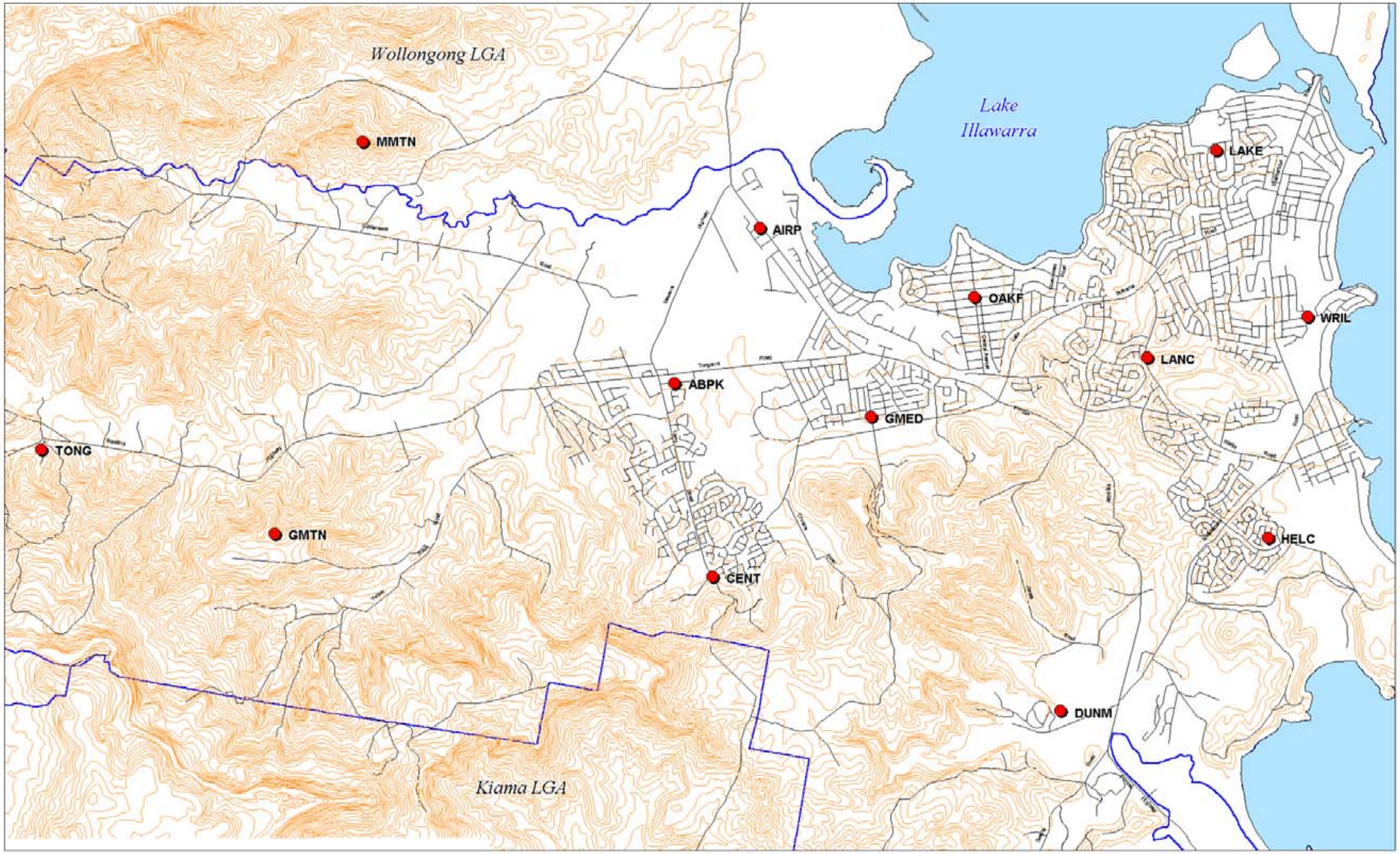
5.2.6 Rainfall Data

The catchment locations for basic Intensity-Frequency-Duration data calculations for Shellharbour are shown on the Map 1.

The catchment locations for basic Intensity-Frequency-Duration data calculations for Kiama are shown on the Map 2.

Table 5.2.7
Shellharbour IFD Data

Data Station	Elev (m)	$^{i}2_{1}$	$^{i}2_{12}$	$^{i}2_{72}$	$^{i}50_{1}$	$^{i}50_{12}$	$^{i}50_{72}$	FF2	FF50	G
Albion Park	10	46.00	9.60	2.88	100.00	21.80	7.00	4.28	15.80	0.00
Green Meadows	25	44.40	9.25	2.56	88.75	19.95	6.59	4.28	15.80	0.00
Dunmore	10	44.50	8.90	2.38	88.00	19.20	6.46	4.28	15.80	0.00
Centenary	100	46.00	9.84	3.00	100.00	21.00	7.00	4.28	15.80	0.00
Warilla	10	42.90	8.58	2.31	84.40	18.50	6.00	4.28	15.80	0.00
Oakflats	10	43.93	8.88	2.46	87.00	19.63	6.36	4.28	15.80	0.00
Lake Illawarra	10	43.72	8.59	2.40	84.00	18.90	6.27	4.28	15.80	0.00
Landcom	10	43.30	8.70	2.34	84.75	18.70	5.90	4.28	15.80	0.00
Airport	10	44.54	9.30	2.88	95.00	20.00	7.28	4.28	15.80	0.00
Shellcove	10	42.80	8.54	2.27	84.74	18.76	6.01	4.28	15.80	0.00
Tongarra	60	55.00	13.00	4.25	124.00	32.00	11.00	4.28	15.80	0.00
Mount Murray	760	47.00	13.00	4.60	110.00	32.50	12.00	4.28	15.80	0.00
Marshall Mount	224	48.00	11.00	3.75	113.00	23.75	8.80	4.28	15.80	0.00
Green Mountain	60	50.00	11.30	3.75	118.00	26.25	9.20	4.28	15.80	0.00



Rainfall Data Stations

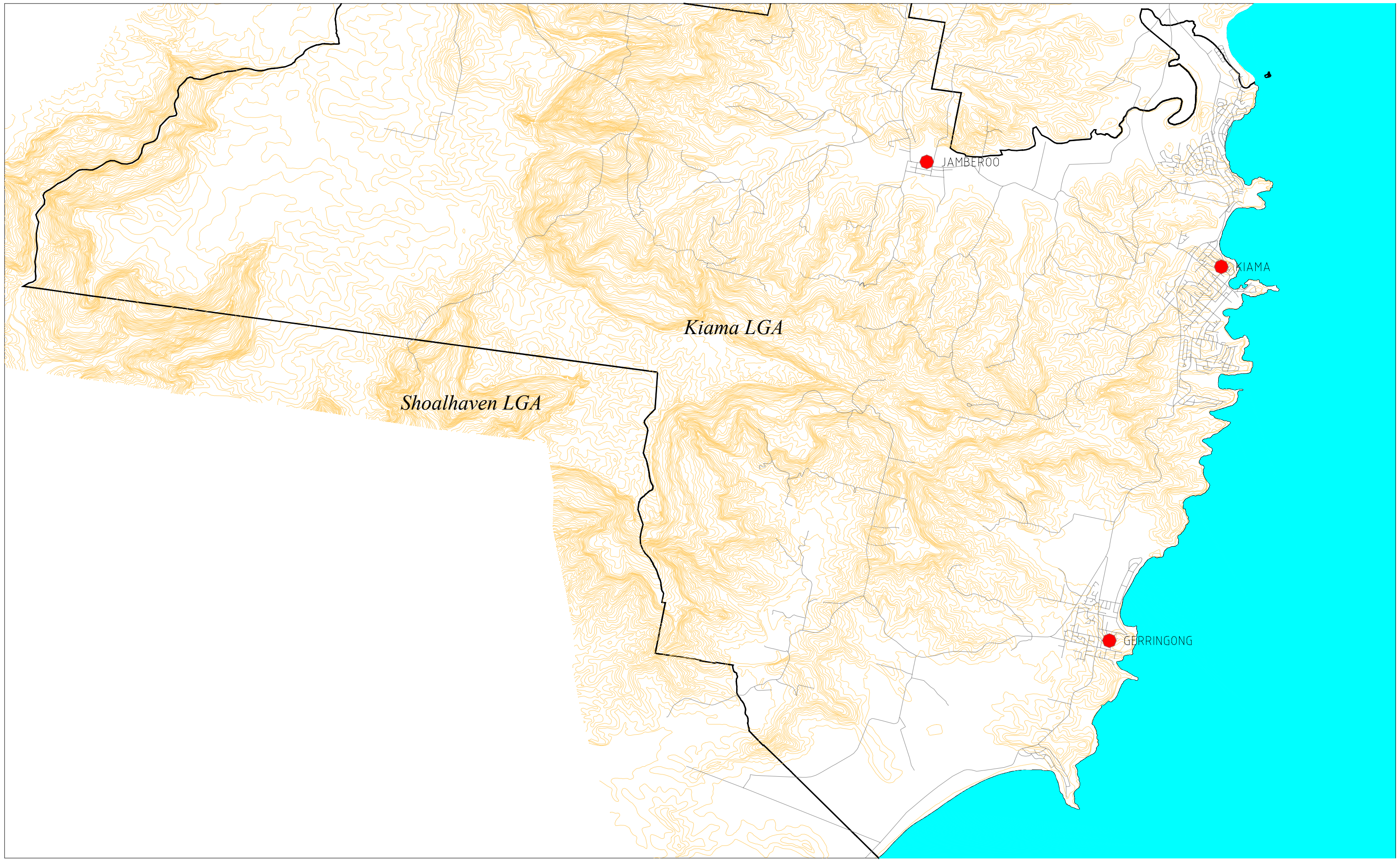
Map prepared by:
Lisa Hart
GIS Section
Shellharbour City Council
29-November-2008
j:\GIS\Workspace\RainfallDataStations.WOR

N

Scale 1:45,000

Table 5.2.8
Kiama IFD Data

Data Station	Elev (m)	$^{i}2_{1}$	$^{i}2_{12}$	$^{i}2_{72}$	$^{i}50_{1}$	$^{i}50_{12}$	$^{i}50_{72}$	FF2	FF50	G
Kiama	10	46.00	9.60	2.80	100.00	20.50	7.00	4.27	15.80	0.00
Jamberoo	25	46.00	9.70	2.50	95.00	20.00	7.00	4.27	15.80	0.00
Gerringong	10	45.00	9.50	2.45	90.00	19.80	6.80	4.27	15.80	0.00



Rainfall Data Stations

Map prepared by
Department of Engineering & Works
Kiama Municipal Council
August 2003

5.3 ROAD & PROPERTY DRAINAGE

5.3.1 Road and Property Network

5.3.2 Major Traffic Routes

5.3.3 Pit Capacities

5.3.4 Pit Inlet Lengths

Charts

Chart 5.3.1	Kerb Inlet Pit Capacity
Chart 5.3.2	Gutter Flow Width
Chart 5.3.3	Roadway Capacity 6 m Road (SCC)
	Roadway Capacity 8 m Road (SCC)
Chart 5.3.4	Roadway Capacity 5.5 m Road (KMC)

5.3.1 Road and Property Drainage Network

The minor drainage system shall be designed in accordance with the following requirements:

a. Maximum width of gutter flow for the critical design rainfall burst event shall be 2.45 m.

b. Water depth in gutter shall not exceed 0.2 m for the critical 100 year ARI design rainfall burst.

c. Bypass flow at a pit shall not exceed 20% of the approach flow for the critical design rainfall burst.

d. The minimum pipe size within or draining public property shall be 375 mm dia.

e. Minimum interallotment drainage pipe size shall be 150 mm dia.

f. Maximum water level in a kerb inlet pit shall be 150 mm below gutter level for the critical design rainfall burst.

g. Maximum water level in a junction pit or surface inlet pit shall be 150 mm below finished surface level for the critical design rainfall burst.

h. Maximum spacing of kerb inlet pits, junction pits or inspection pits in roads and public reserves shall be 80 m.

i. Maximum spacing of interallotment drainage pits shall be 60 m or 3 lots.

j. Minimum velocity in pipe shall be 0.6 m/s. Maximum velocity in pipe shall be 8 m/s

k. Velocity x depth product shall not exceed 0.4 m^2/s for flows other than those in pipelines and designated floodways. Note that a public road is not a designated floodway.

l. Medium density, commercial and industrial developments shall be provided with a direct connection to the underground piped system.

5.3.2 Major Traffic Routes

Major traffic routes shall remain trafficable during major storm events. Major traffic routes are collectors, major collectors and higher order roads.

5.3.2.1 Major Drainage Crossings

Bridges and culverts over major floodways and natural waterways shall be designed in accordance with the provisions of the AUSTROADS Bridge Design Code and the AUSTROADS Bridge Waterway Code.

Weir flow over the roadway may be permitted in some cases. Where weir flow is permitted the following parameters shall be met:

- velocity x depth product shall not exceed $0.4m^2/s$,
- depth of flow over the roadway shall not exceed 0.25 m,

- guide posts shall be provided to clearly indicate the carriageway,
- freeboard of not less than 0.5 m shall be provided at the upstream face of the crossing for the minor design storm,
- no inundation of upstream roads or property due to floods up to and including the PMF.

5.3.2 Pit Capacities

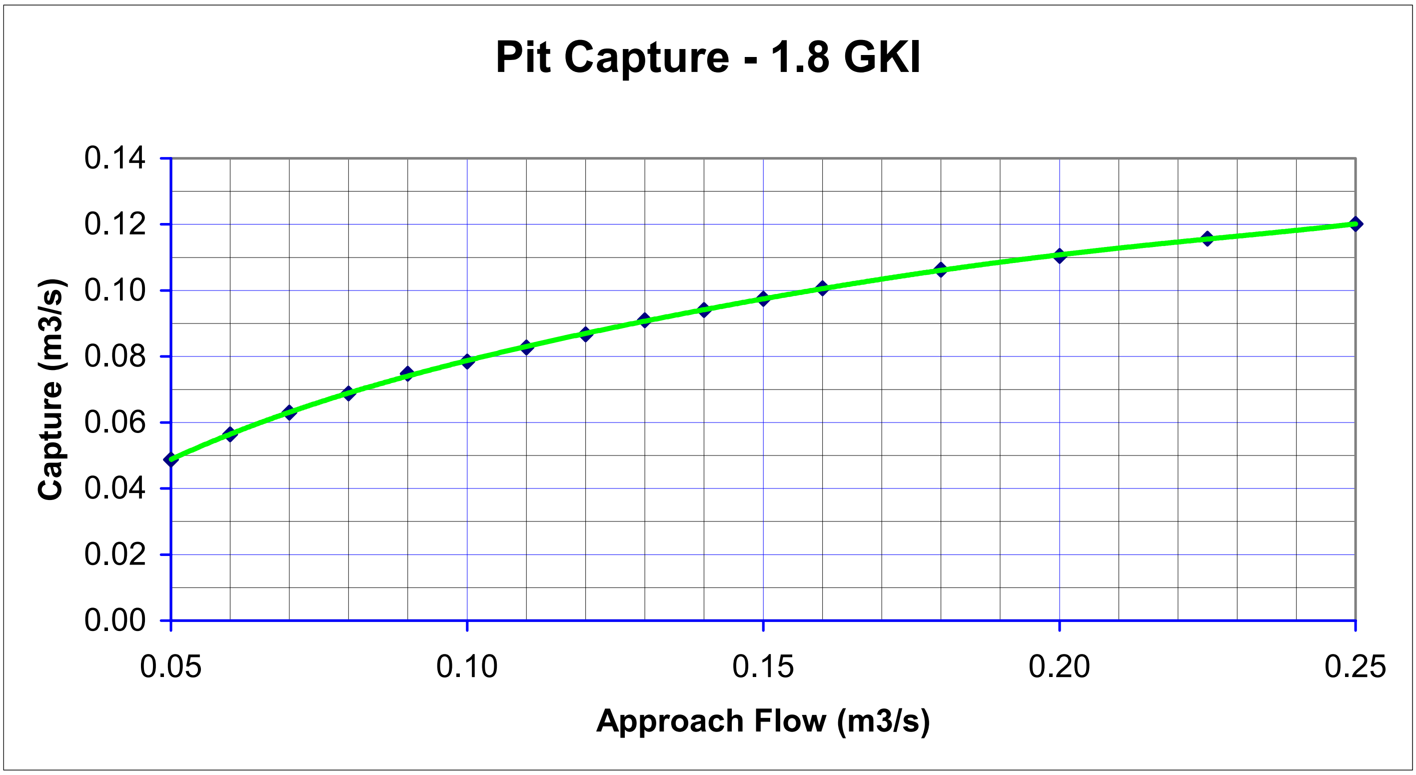
The standard kerb inlet pit shall be the Housing Commission type RM10. Inlet capacities shall be as set out in chart 5.3.1. Chart 5.3.1 is adapted from the Department of Housing Road Manual.

5.3.2 Pit Inlet Lengths

The standard inlet pit shall have a nominal opening of 1.8 m, however pits with openings of 2.4 metres and 3.0 metres may be used.

The designer shall minimise the use of pits requiring inlet opening exceeding 2.4 metres.

Chart 5.3.1
Pit Capture Inflow



Adapted from Department of Housing Road Manual

Chart 5.3.2a
Limiting Gutter Flow Rate for 2.45 m Flow Width (150 kerb & gutter @ 3% crossfall)

Gutter Slope (%)	Flow Rate (l/s)		Gutter Slope (%)	Flow Rate (l/s)
0.5	61		5.5	201
0.6	67		6.0	210
0.7	72		6.5	219
0.8	77		7.0	227
0.9	81		7.5	235
1.0	86		8.0	243
1.25	96		8.5	250
1.5	105		9.0	258
1.75	114		9.5	265
2.0	121		10.0	272
2.5	136		11.0	285
3.0	149		12.0	297
3.5	161		13.0	310
4.0	172		14.0	321
4.5	182		15.0	333
5.0	192		16.0	343

Adapted from Figure 14.9 AR&R 1987

Chart 5.3.2b
Limiting Gutter Flow Rate for
2.45 m Flow Width
(roll kerb & gutter @ 3% crossfall)

Gutter Slope (%)	Flow Rate (l/s)	Gutter Slope (%)	Flow Rate (l/s)
0.5	46	5.5	152
0.6	50	6.0	159
0.7	54	6.5	165
0.8	58	7.0	171
0.9	61	7.5	177
1.0	65	8.0	183
1.25	72	8.5	189
1.5	79	9.0	194
1.75	86	9.5	199
2.0	92	10.0	105
2.5	102	11.0	215
3.0	112	12.0	224
3.5	121	13.0	233
4.0	129	14.0	242
4.5	137	15.0	251
5.0	145	16.0	259

Chart 5.3.3
Roadway Capacity
(3% crossfall and v*d < 0.4)

Gutter Slope (%)	150 Kerb & Gutter (l/s)			Roll Kerb & Gutter (l/s)			Gutter Slope (%)
	6 Wide	8 Wide	> 8 Wide	6 Wide	8 Wide	> 8 Wide	
0.25	333	327	318	289	283	271	0.25
0.5	471	462	450	408	400	384	0.5
0.75	577	566	551	500	490	470	0.75
1	667	654	636	577	566	543	1
1.5	817	801	779	707	693	665	1.5
2	943	925	900	817	800	768	2
2.5	1054	1034	1006	914	894	858	2.5
3	1155	1132	1102	1001	980	940	3
3.5	1247	1223	1191	1082	1058	1016	3.5
4	1268	1308	1273	1098	1131	1086	4
4.5	1240	1387	1350	1074	1200	1152	4.5
5	1213	1351	1359	1050	1265	1214	5
5.5	1187	1312	1312	1028	1135	1135	5.5
6	1163	1253	1253	1007	1084	1084	6
6.5	1144	1218	1218	991	1054	1054	6.5
7	1123	1205	1205	973	1042	1042	7
7.5	1106	1161	1161	958	1004	1004	7.5
8	1089	1141	1141	943	987	987	8
8.5	1071	1119	1119	926	968	968	8.5
9	1057	1067	1067	915	923	923	9
9.5	1040	1054	1054	901	912	912	9.5
10	1028	1039	1039	890	899	899	10
10.5	1017	1009	1009	881	873	873	10.5
11	1004	977	977	869	845	845	11
11.5	972	972	972	842	842	842	11.5
12	938	938	938	812	812	812	12
12.5	931	931	931	806	806	806	12.5
13	922	922	922	798	798	798	13
13.5	912	912	912	790	790	790	13.5
14	899	899	899	779	779	779	14
14.5	888	888	888	769	769	769	14.5
15	874	874	874	757	757	757	15
15.5	861	861	861	746	746	746	15.5
16	849	849	849	735	735	735	16
16.5	840	840	840	727	727	727	16.5
17	829	829	829	718	718	718	17

5.4 PIPELINES

5.4.1 Materials

5.4.1.1 Pipe Types

5.4.1.2 Pipe Design

5.4.1.3 Jointing

5.4.2 Locations

5.4.2.1 Carriageway & Road Reserve

5.4.2.2 Interallotment Drainage

5.4.3 Drainage Easements

5.4.4 Hydraulic Design

5.4.4.1 Design Criteria

5.4.4.2 Design Principles

5.4.5 Grades

5.4.6 Structural Design

5.4.6.1 Minimum Depth

5.4.6.2 Maximum Depth

5.4.6.3 Bedding & Backfill

5.4.6.4 Pipe Class

5.4.7 Curved Pipelines

5.4.8 Clearance from Other Services

5.4.9 Culverts

5.4.1 Materials

5.4.1.1 Pipe Types

Stormwater pipelines in roads, Council easements and public reserves shall be constructed of either;

* Fibre Reinforced Cement Pipes (FRC), or
* Steel Reinforced Concrete pipes (RCP)

Interallotment pipelines in private property shall be constructed of either;

* Fibre Reinforced Cement Pipes (FRC),
* Steel Reinforced Concrete pipes (RCP),
* Sewer Grade Unplasticised Polyvinyl Chloride Pipes (SH - uPVC),
* Vitrified Clay Pipes (VCP), or
* High density polyethylene (HDPE).

The use of two or more types of pipe material on a single reach of pipeline is not acceptable.

Proposals for the use of other materials shall be referred to the Council prior to detailed design. Such a proposal without proper documentation will be rejected.

5.4.1.2 Pipe Design

FRC pipes shall comply with the latest edition of AS 4139.

RCP pipes shall comply with the latest editions of AS 4058 and AS 3725.

uPVC pipes shall comply with the latest editions of AS 1260 and AS 2566.

5.4.1.3 Jointing

Pipe joints shall be rubber ring joint.

The maximum allowable head for all pipes shall be in accordance with the appropriate Australian Standard.

5.4.2 Locations

5.4.2.1 Carriageway & Road Reserve

Stormwater pipelines should generally be located on the high side of carriageways to intercept subsurface water.

Curved pipe alignments are permitted. Designs should minimise the extent of pipe within the carriageway.

5.4.2.2 Interallotment Drainage

Interallotment drainage pipelines and easements shall be provided to all lots which cannot reasonably drain to the street to which the lot fronts. The depth of interallotment drainage system shall be designed to be able to service the whole of the area of the lot.

Minimum interallotment drainage easement widths shall be in accordance with Table 5.4.1.

Interallotment drainage pipelines shall not exceed 525 mm dia.

Table 5.4.1
Minimum Interallotment Easement Widths

Pipe Diameter (mm)	Easement Width (m)
150 & 225	1.2
300 to 450	1.5
525	3.0

Note: Table 5.4.1 applies for depth to invert less than 3 m

Each lot shall be individually connected to the interallotment drainage system via a slope junction or a direct connection to a pit. The connection shall be wholly within the property to be serviced and be located at a distance of 1.0 m from the downstream boundary of the lot.

Where a lot is connected directly to a pit, the connection angle shall be between 45 and 90 degrees.

5.4.3 Drainage Easements

The layout of the subdivision is to be such that drainage easements are avoided. Drainage easements will only be approved where there is no other means of draining the site and the provision of public land such as a road or pathway is not practical.

Drainage easements shall be wide enough to wholly contain the pipe and pits and shall also provide working space on each side of the pipe for maintenance. Minimum drainage easement widths shall be in accordance with Table 5.4.2.

Pipelines 600 mm diameter and larger shall be located within public open space.

Minimum drainage easements widths shall be in accordance with Table 5.4.2.

Table 5.4.2
Minimum Drainage Easement Widths

Pipe Depth (m)	**Drainage Easement Width (m)**
Up to 3.0	3.0
3.0 - 6.0	4.0

5.4.4 Hydraulic Design

5.4.4.1 Design Criteria

Pipelines shall be designed by a "hydraulic grade line" (HGL) method using appropriate pipe roughness factors and pit head loss co-efficients.

Pit head loss co-efficients shall be determined by one of the following methods:

- Sangster et al. - The University of Missouri - 1958, or
- Hare, C. - Civ. Eng Transactions, Institution of Engineers Aust 1981 Vol CE25, No.1 1983.

Actual pipe diameters, shall be used for hydraulic calculations.

Pipe roughness values should be selected from Table 5.4.3.

Table 5.4.3
Pipe Roughness Values

Pipe Material	**n**	**k** (mm)
Spun Precast Concrete	0.012	0.6
Fibre Reinforced Cement	0.010	0.15
Vitrified Clay	0.013	0.6
UPVC	0.009	0.06

5.4.4.2 Design Principles

At an outfall to a floodway or watercourse the following parameters shall apply:

Minor Drainage System Design & Checking
Controlling HGL shall be set as the higher of the pipe obvert for a free outfall or the water surface level in the floodway for the minor system design ARI flood.

Major Drainage System Design & Checking
Controlling HGL shall be set at the water surface level in the floodway for the 100 years ARI flood.

Pipelines at pits should be located such that the projected area of the upstream pipe is wholly contained within the area of the downstream pipe.

5.4.5 Grades

The longitudinal grade of the pipeline between drainage pits or structures shall be calculated from centerline to centerline of such structures.

An absolute minimum grade of 0.5% may be acceptable where steeper grades are not practical.

Maximum grade will be such that the velocity of flow in the pipe does not exceed 8.0 m/s.

Where pipe grades exceed 12% concrete anchor blocks shall be installed at every second pipe.

Where pipeline grades are steeper than 7%, scour stops shall be installed at every second pipe.

5.4.6 Structural Design

5.4.6.1 Minimum Depth

Minimum cover for IAD pipes shall be 450 mm to pipe collar.

Minimum cover over pipelines in roads and public reserves shall be such as to withstand the maximum load combination from construction plant or in-service traffic.

The absolute minimum cover for any pipe in a road or public reserve shall be 450 mm from top of pipe collar to finished surface level.

For pipelines under road pavements, the required cover shall be measured from top of pipe to pavement subgrade level. In the absence of detailed pavement design the pavement depth should be assumed to be not less than 450 mm.

5.4.6.2 Maximum Depth

The maximum depth to invert of stormwater pipelines shall be 6 m.

The maximum depth to invert for interallotment drainage pipelines shall be 3 m.

5.4.6.3 Bedding & Backfill

Pipe bedding shall be in accordance HS3.

5.4.6.4 Pipe Class

Pipe class shall be selected to provide adequate strength to meet overburden and traffic loads. Pipe loadings shall be determined in accordance with the relevant Australian Standard for the pipe material in question.

5.4.7 Curved Pipelines

Curved stormwater pipelines may be utilised wherever there are significant advantages in their use. Where curved pipelines are proposed the following requirements shall be met:

a. Ad hoc curving of piplines to avoid obstacles such as trees, services, etc is not permitted.

b. Curved pipelines shall have a constant radius and constant grade. An inlet or junction pit shall be provided at curve TP and changes of grade.

c. Radius of curvature complies strictly with the manufacturers detail.

d. Engineering drawings are to be fully detailed showing the curve radius and the manufactures minimum radius.

Indicative curvature details are outlined in Table 5.4.4 and Table 5.4.5.

Table 5.4.4
Minimum Radius for Fibre Reinforced Pipe

Nom Diameter (mm)	ADCOL			SUPERTITE		
	Rotation (degrees)	Deflection (mm)	Min Radius (m)	Rotation (degrees)	Deflection (mm)	Min Radius (m)
150	2.0	140	115	5.0	349	46
225	2.0	140	115	4.0	279	57
300	2.0	140	115	4.0	279	57
375	1.5	105	153	2.5	174	92
450	1.5	105	153	2.0	140	115
525	1.5	105	153	1.5	105	153
600	1.0	70	229	1.0	70	229
675	1.0	70	229	1.0	70	229
750	1.0	70	229	1.0	70	229

Source: FRC Stormwater Pipeline Systems TECHNICAL MANUAL, James Hardie

Table 5.4.5
Minimum Radius for Reinforced Concrete Pipe

Nom Diameter (mm)	Normal Pipe		Special	
	Rotation (degrees)	Min Radius (m)	Rotation (degrees)	Min Radius (m)
150	5.3	20	-	-
225	2.2	64	4.9	21
300	1.6	89	3.8	36
375	1.3	107	3.4	41
450	1.5	94	2.4	49
525	1.1	128	2.3	61
600	0.4	375	2.4	58
675	0.5	279	2.1	67
750	0.6	199	1.8	77
825	1.6	86	-	-
900	1.4	98	-	-
1050	1.4	95	-	-
1200	1.4	103	-	-
1350	1.2	121	-	-
1500	1.1	126	-	-
1650	1.0	145	-	-

Source: Reinforced Concrete Drainage Pipe - User's Guide, Rocla Pipeline Products, Amatek Limited Apr 92

5.4.8 Clearance from Other Services

Minimum clearances have been established to reduce the likelihood of damage to stormwater pipelines or other services, and to protect personnel during construction or maintenance work.

Under no circumstances shall stormwater pipelines be;

* cranked to avoid other services or obstacles.

* located longitudinally directly above or below other underground services in the same trench

Where stormwater pipeline crosses or is constructed adjacent to an existing service, the design shall be based on the work-as-executed location and level of service. The design documents shall direct the Contractor to verify the location and level of existing service prior to constructing the stormwater pipeline in question.

Minimum clearances between stormwater pipelines and other services shall be in accordance with Table 5.4.4. Clearance shall be calculated from the outside of the pipe collar.

Table 5.4.4 Minimum Clearances

Service	Horrizontal Clearance (mm)	Vertical Clearance (mm)
Sewers	500	50
Water Mains	500	150
Telephone	500	75
High Pressure Gas	500	300
Low Pressure Gas	500	150
High Voltage Elect	500	300
Low Voltage	500	150

5.4.9 Culverts

5.4.9.1 General

Box culverts may be designed in accordance with the latest edition of AS1597.

Box culverts have a tendency to accumulate silt during low flow periods, especially where multiple cells are used. A means of concentrating low flows shall be provided.

Access for maintenance shall be provided to the apron of all inlet and outlet headwalls.

The joints of box culverts located under roadways shall be sealed against possible loss of fines under the road surface. The method of sealing shall be in accordance with the Manufacturers recommendations and clearly shown on the design plans.

Designers must also consider the requirements of DLWC and NSW Fisheries in relation to providing a satisfactory accessibility for aquatic fauna (eg fish & amphibians).

5.4.9.2 Minor System

Box culverts may be permitted as part of the minor stormwater system where availability of cover or minimal water depths make the use of pipes unsuitable.

5.4.9.3 Major Systems

Box or pipe culverts may be used as part of the major stormwater system in floodways and other waterways for road crossings.

Culvert crossings shall be designed for a 100 years ARI flow with an upstream freeboard of at least 0.6 m.

Calculations justifying the adopted culvert size shall be submitted with the plans.

Entrance loss co-efficients shall be in accordance with Table 5.4.5.

Table 5.4.5
Culvert Entrance Loss Coefficients

ENTRANCE CONDITION	k_{en}
Concrete Pipe Projecting from fill - no headwall	
Socket end of pipe	0.2
Square cut end of pipe	0.5
Concrete Pipe with Headwall or Headwall and Wingwalls	
Socket end of pipe	0.2
Square cut end of pipe	0.5
Rounded entrance to 1/12 diameter	0.2
Concrete Pipe	
Mitred to Conform with Fill Slope	0.7
End section conformed to fill slope	0.5
Beveled edges 33 or 45 degree bevels	0.2
Side slope tapered inlet	0.2
Box Culvert Headwall Parallel to Embankment - no wingwalls	
Square edge on three edges	0.5
Three edges rounded to 1/12 of barel dimension	0.2
Wingwalls at 30 to 75 Degrees to barrel	
Square edge at crown	0.4
Top corner rounded to radius = 1/12 barrel dimension	0.2
Wingwalls at 10 to 25 Degrees to Barrel	
Square edge at crown	0.5
Wingwalls parellel (extension of sides)	
Square edge at crown	0.7
Side or slope tapered inlet	0.2

5.5 FLOODWAYS

5.5.1 General

5.5.2 Location

5.5.3 Freeboard

5.5.4 Landscaping

5.5.1 General

A **floodway** is defined as either a natural watercourse or artificial channel which conveys concentrated flow with v*d > 0.4. Note that the major stormwater system conveying the 100 year ARI is not a floodway.

Floodways shall be designed to cater for flows up to and including 100 Years ARI.

An **overland flow path** is part of the major/minor system as is defined as a flow path over public land where the v*d shall be < 0.4 m^2/s

5.5.2 Location

Continuous designated overland flow paths shall be provided from the top of the catchment through the entire urban area.

Floodways shall be provided along the alignment of existing watercourses and drainage depressions. Diversion of floodways away from their natural paths **will not** be permitted other than with the written concurrence of DLWC and Council.

Floodways with development site shall be designated as public open space.

5.5.3 Freeboard

The minimum freeboard to habitable floor levels shall be 500 mm above the 100 Year ARI flood.

5.5.4 Landscaping

Designers shall consult closely with DLWC guidelines in relation to riparian corridor planting.

5.6 DIVERSION DRAINS

5.6.1 General Requirements

5.6.1 General Requirements

Where the development consent requires diversion drains to be installed they shall be installed in accordance with the following:

a. Diversion drains shall be sized for flows up to and including 100 Year ARI,

b. Diversion drains shall divert surface runoff to discharge into the nearest natural watercourse, floodway or overland flow path,

c. Diversion drains shall be located adjacent boundaries,

d. Discharge points shall be provided at intervals not exceeding 200 m,

e. Longitudinal grades shall be not less than 0.5% to minimise the likelihood of ponding and siltation within the drain,

f. The maximum longitudinal grade shall be selected such that the average flow velocity in the drain does not exceed the following values under any operating conditions;

  * 2m/s for unlined drains,

  * 4m/s for lined drains.

g. The maximum side slopes shall be in accordance with the following table;

	Private Land	**Public Land**
slope in fill	1 v:2h	1v : 4h
slope in cut	1 v:2h	1v : 4h
rock 1 in 0.25	1v : 0.25h	1v : 0.25h

h. Diversion drains shall be designed to allow for ease of maintenance, including ready access for maintenance machinery. In general, cut-off drains shall be designed so that mechanical grass cutting equipment (ie. motor mowers or tractor mounted mowers) can be used to control grass and weed growth. Maintenance of the drain cross section should be possible using conventional earthmoving equipment such as backhoes, front-end loaders, and trucks. Where conditions do not permit ready access, diversion drains shall be designed for minimum maintenance by providing such measures as concrete lining or stone pitching.

5.7 FLOOD DETENTION BASINS

5.7.1 General

5.7.2 Analysis

5.7.3 Outlet Design

5.7.3.1 Primary Outlet

5.7.3.2 Secondary Outlet

5.7.4 Grades

5.7.5 Safety

5.7.6 Maintenance

5.7.1 General

Detention storage may be provided as an integral part of a the major drainage system in new development areas to either;

- increase the lot yield and reduce development costs by reducing downstream flowrates in order to minimise the land take for floodways, or
- meet a specific planning requirement that downstream flowrates not exceed pre-development levels for a given range of ARIs.
- to reproduce existing or predeveloped flow characteristics in natural channels.

Detention storage shall be planned, designed and analysed by investigating the total catchment area and interaction of other detention basins within the catchment.

Detention storage basins should be designed for multi-purpose use wherever possible. Recreational uses such as sporting fields and passive open space are considered most suitable. Sporting fields can be provided with local drainage and low flow by-pass for the minor drainage system.

Embankments shall be designed and constructed such that they will not breach under any operating conditions for all flows up to and including the Probable Maximum Flood (PMF).

Detention storage structures shall not cause flood waters due to the 100 years ARI flood or PMF to inundate upstream roads or property.

5.7.2 Design and Analysis

A range of 'design' storms or a long term record of rainfall shall be used to determine the maximum storage requirements and the size of outlets for the detention storage structure. As a minimum the following design storms shall be used in the preliminary design and analysis of the basin:

Table 5.7.1
Minimum Design Storm Bursts

Basin Capacity Secondary Outlet & Emergency Weir	Check for Upstream and Downstream Flooding
100 year ARI 1 hr design burst	2,5,10,20,50 year ARI 30 min design burst
100 year ARI 2 hr design burst	2, 5,10,20,50 year ARI 1 hr design burst
100 year ARI 3 hr design burst	2, 5,10,20,50 year ARI 2 hr design burst
100 year ARI 6 hr design burst	2, 5,10,20,50 year ARI 3 hr design burst
100 year ARI 12 hr design burst	2, 5,10,20,50 year ARI 6 hr design burst
100 year ARI 24 hr design burst	2, 5,10,20,50 year ARI 12 hr design burst
100 year ARI 72 hr design burst	2, 5,10,20,50 year ARI 24 hr design burst
PMF	PMF

A recognised and widely used hydrograph estimation technique shall be used to estimate inflow hydrographs. Inflow hydrographs shall be routed through the basin using full reservoir routing calculations to determine the outflow hydrograph.

The designer shall test the design using an **embedded storm** to check the effect of the basin being partially full during the critical design burst.

The hydraulic and detail design of detention basins shall be subject to the following requirements;

a. Discharge from the basin shall generally not exceed the pre developed discharge hydrograph from the catchment for all flood events up to and including the 100 year ARI flood.

b. No increase in flooding downstream. The designer shall consider the coincidence of flow peaks from other basins within the catchment.

c. No increse in flood levels upstream.

d. The embankment shall have a freeboard of not less than 500 mm above the 1 in 100 year flood level.

e. The embankment shall have a freeboard of not less than 300 mm above the PMF flood level

f. The spillway shall be designed to safely pass the PMF.

g. Internal batters shall not exceed a slope of 1 in 6.

h. External batters shall not exceed a slope of 1 in 6.

i. The requirement for the outlet structure to be fitted with trash racks to prevent blockage or for safety shall be discussed with Council.

j. The basin floor shall be designed to be free draining and to prevent waterlogging.

k. The designer shall seek advice from the NSW Dams Safety Committee to determine if the detention basin is or is likely to be classified as a prescribed dam. Where the basin is or is likely to be classified as a prescribed dam, the designer shall be submit the design and all necessary documentation to the NSW Dams Safety Committee for approval prior to submitting the design to Council.

l. A geotechnical engineer's report/specification for the basin embankment shall be submitted to Council.

5.7.3 Outlet Design

5.7.3.1 Primary Outlet

A primary outlet system shall be provided to manage discharge up to the critical duration 100 year ARI event.

The primary outlet shall be designed to minimize the risk and consequences of blocking.

The consequences of partial blockage of the primary outlet shall be investigated and accounted for in the basin design.

An anti-vortex device should be considered to maximise hydraulic efficiency. The need for venting of the outlet should also be investigated.

Safety fencing shall be provided at entry and exit headwalls.

Energy dissipation and/or scour protection shall be provided at the downstream end of the primary outlet.

5.7.3.2 Secondary Outlet

A secondary outlet to allow a non-catastrophic means of passing flood larger than the 100 years ARI event shall be provided.

Spillway design criteria shall be based on the Australian National Committee of Large Dams (ANCOLD) document, "Guidelines on Design Floods for Dams", 1986 and NSW Dams Safety Committee requirements and technical notes.

The spillway shall be designed to eliminate the possibility of embankment failure by scour.

Adequate erosion protection shall be provided for the weir crest and downstream spillway area. Grass cover shall be acceptable for spillway velocities up to 4m/s.

The primary outlet shall be assumed to be fully blocked for the purposes of secondary outlet design and analysis.

5.7.4 Embankment Grades

Embankment slopes shall have a maximum batter of 1 in 6. Slopes of up to 1 in 5 may be approved in extenuating circumstances.

The floor of the basin shall be designed with a minimum fall of 1 in 50 in order to promote free draining and minimise ponding.

5.7.5 Safety

Retarding basins shall be provided with adequate and clear signs indicating their purpose and their potential danger during storms.

5.7.6 Maintenance

Retarding basins shall be provided with adequate access for maintenance machinery to remove silt or debris from the floor of the basin. Access for maintenance shall also be provided to the primary and secondary outlets.

5.8 REFERENCES

1. Urban Stormwater Edition 1, Standard Engineering Practices, ACT Department of Urban Services.

2. Australian Rainfall and Runoff, IE Aust 1987.

3. Department of Housing Road Manual, 1987.

4. Sangster et al. The University of Missouri - 1958.

5. Hare, C. Civil Engineering Transactions, Institution of Engineers Aust, Vol CE25, No1 1983.

6. NSW Dams Safety Committee Information Sheets DSC 1 Apr 98, DSC 2 Apr 98, DSC 3 Apr 98, DSC 5 Aug 96, DSC 13 Oct 92, DSC 14 Jul 96.

7. Boyd, M.J. etal, WBNM 2000 User documentation, Nov 2000.

8. US Army Corps of Engineers, HEC-RAS Hydraulic Reference Manual V2.0 April 1997.