CLIENTS | PEOPLE | PERFORMANCE

Narrandera Shire Council

Engineering Guidelines for Subdivisions and Development Standards

Part 3 - Stormwater Drainage Design

February 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

1. Introduction

This section of the Engineering Guidelines for Subdivisions and Developments outlines Council's recommended practice for the design of stormwater and drainage systems. It is in no way a comprehensive "Design Manual" and it is to be read in conjunction with and as a supplement to referenced standards.

The Subdivision and Development Guidelines comprise:

Part 1	-	General Requirements
Part 2	-	Guidelines for Design of Roads
Part 3	**-**	**Guidelines for Design of Drainage**
Part 4	-	Guidelines for Design of Water Reticulation
Part 5	-	Guidelines for Design of Sewers
Part 6	-	Guidelines for Landscaping and Measures for Erosion, Sedimentation and Pollution Control
Part 7	-	Guidelines for Testing.

2. General

Stormwater drainage design is to be based on the current version of Australian Rainfall and Runoff. The aims and principles of the Australian Rainfall and Runoff (AR&R) outline" *that the main purpose of the urban stormwater drainage system is to collect and can convey stormwater to receiving waters, with minimal nuisance, danger or damage."* Other objectives are listed as:

- Limitation of pollutants entering receiving waters and other adverse impacts of urbanisation, such as erosion and sedimentation;
- Water conservation; and
- Integration of large-scale drainage works into town planning schemes, with multiple use of land for drainage, recreation or transportation.

AR&R then lists the following four (4) fundamental guiding principles:

1. Descriptions and analysis of stormwater drainage systems should be based on measured or observed real system behaviour;
2. Drainage systems must be viewed in relation to the total urban system;
3. Drainage systems should be designed and operated to maximise benefits to the community; and
4. Designers should be influenced by professional considerations such as ethics, standardisation and innovation.

The objectives and guiding principles are important considerations that must be taken into account when determining stormwater drainage strategies and plans for subdivisional development. This signals a change in emphasis from the original approach where *" the main purpose of the urban stormwater drainage system was to collect and can convey stormwater to receiving waters, with minimal nuisance, danger or damage". Council* strongly supports this approach, based on a hierarchical consideration of planning strategies as follows.

- The Planning Scheme;
- Land-Use Strategies;
- Precinct Strategies;
- Stormwater Management Plan For City (Water Quality);
- Stormwater Strategy (Citywide Master Plan);
- Stormwater Catchment Plans;
- Stormwater Studies And Investigations;
- Overall Subdivision Drainage Master Plan; and
- Specific Subdivision Stage Drainage Plans.

As infrastructure planning for Councils is evolving Councils will have the strategies developed to varying extents. In the absence of a detailed strategy the intention is that Council will work with a Developer to encourage subdivision and development works that are consistent with an holistic approval to stormwater drainage, water quality and water sensitive urban design principles.

3. Water Sensitive Urban Design (WSUD)

Stormwater drainage design is to include the principles of Water Sensitive Urban Design in subdivisional works. Include in the inception meeting with Council officers, discussion and agreement on Water Sensitive Urban Design and the extent to which these principles can be incorporated into the subdivision master planning and urban landscaping. Integrate the management of the urban water cycle with urban planning and design. Urban stormwater is to be managed as both a resource and for protection of receiving waters. Encourage outcomes that promote the retention of water on site.

3.1 Water Sensitive Urban Design

Water Sensitive Urban Design includes:

- The sustainable management of the Water Cycle;
- Principles of water consumption;
- Water recycling;
- Waste minimisation; and
- Environmental protection.

3.2 Environmental Benefits

The Environmental Benefits Include:

- Improving the urban landscape;
- Reduction of the export of pollution from the site;
- Retardation of storm flows; and
- Reduced irrigation requirements.

3.3 Context

Council's consideration of water sensitive urban design elements into subdivision design will consider:

- Lifecycle cost implications on the maintenance of the infrastructure;
- The maintenance period and the success of the initial establishment;
- Community safety and the safety of maintenance staff;
- The provision of consistent citywide themes that recognise individuality of each locality; and
- Focus on larger systems rather then high maintenance smaller systems.

3.4 References

Water Sensitive Urban Design is to be undertaken in accordance with the general principals outlined in the following references.

- Water Sensitive Urban Design

  Melbourne Water 2005

  WSUD Engineering Procedures

  CSIRO publishing

- Urban Stormwater

  Best practice

  Environmental Management Guidelines

  Victorian Stormwater Committee 1999

- Australian Runoff Quality

  A guide to water sensitive urban design

The purpose of these references is to assist designers and referral authorities in the checking of designs. These documents are not intended to be decision making guides for the selection, integration and locating WSUD elements, which are covered in Australian Runoff Quality Guidelines.

4. Stormwater Drainage Calculations

All drainage design calculations shall be undertaken in accordance with the current version of Australian Rainfall and Runoff. The most appropriate method of calculation should be selected, having regard to the magnitude of flows and the potential for flooding.

Typically the RATIONAL METHOD is the best known method for urban drainage design and is suited to small subdivisional design where larger flows are not anticipated. The Rational Method is not suited for flood modelling. The formula is as follows:

$$Q = CIA/360$$

Where:

Q is design flow rate cubic metres per second

C is coefficient of runoff (also Cy, Cy*).

I is rainfall intensity mm/hr

A is area in ha

Rational assumptions are based on statistical analysis of data to produce a “standard” design flow rate or discharge

4.1 Factors Effecting Estimates of Flowrates

There is an inherent variability in rainfall and runoff values as this data is obtained from fitted statistical distributions. Council has adopted a major/minor drainage network philosophy for street drainage in accordance with Australian Rainfall and Runoff.

4.2 Catchment Discharge

Developments shall be designed such that the rate of discharge will not increase as a result of development, unless otherwise approved by Council in accordance with an integrated catchment wide drainage strategy. This shall consider events that include the 1% ARI event.

4.3 Design Recurrence Interval

The pipe drainage network shall be designed for average recurrence interval flows as follows.

Table 1 Design Recurrence Intervals, Narrandera Specific

Type of Development	Design Average Recurrence interval
Residential Areas	1:10 ARI
Industrial and Commercial Areas	1:20 ARI

4.4 Standards of Performance

There are a range of performance levels that need to be designed that include:

- Maintenance requirements (frequent event);
- A convenience or nuisance reduction requirement (infrequent event);
- A flood damage prevention requirement (severe or rare event); and
- A disaster management requirement (extreme event).

It is emphasised that there is inherent variability in rainfall or run off values obtained from fitted statistical distributions. Designers must allow for stormwater events larger then that calculated as part of the design process, to occur without causing damage to property or life.

4.5 Property Drainage

Account for the following in drainage design:

- Roof drainage systems are to be sized by rules based on a simplified Rational Method applied to roof surfaces. (AR&R makes reference Refer to Publications of the National Building Technology Centre.) Adopt concrete pits as a joint issue;
- Provide minimum 450 mm concrete pit with metal grate connected to Council pipe system with 100 mm connection. Approved precast pits are acceptable;
- Provide easements in rear of block drainage that are in favour of Council;
- Individual properties may drain to the kerb and gutter or alternatively to a piped underground drainage system where provided; and
- Identify and protect overland flow path with easements and the provision of uninterrupted flow.

4.6 Pipe System Drainage

When considering street drainage and the major/minor concept, major drainage is not to be confused with trunk drainage. The concept relates to drainage systems operating during storms of large magnitude. The minor system is the gutter and pipe network capable of carrying runoff from minor storms. Pipes are sized to carry flows low ARI to prevent nuisance flooding of streets. Overflows are then routed along streets and drainage reserves. Hydraulic capacities of flow paths are to be checked for 100 year ARI events. Overflow calculations need to determine the route for these overflow quantities ensuring hazardous situations do not arise on streets and footpaths, and that buildings are protected from floodwaters. Refer to example shown in Figure 1.

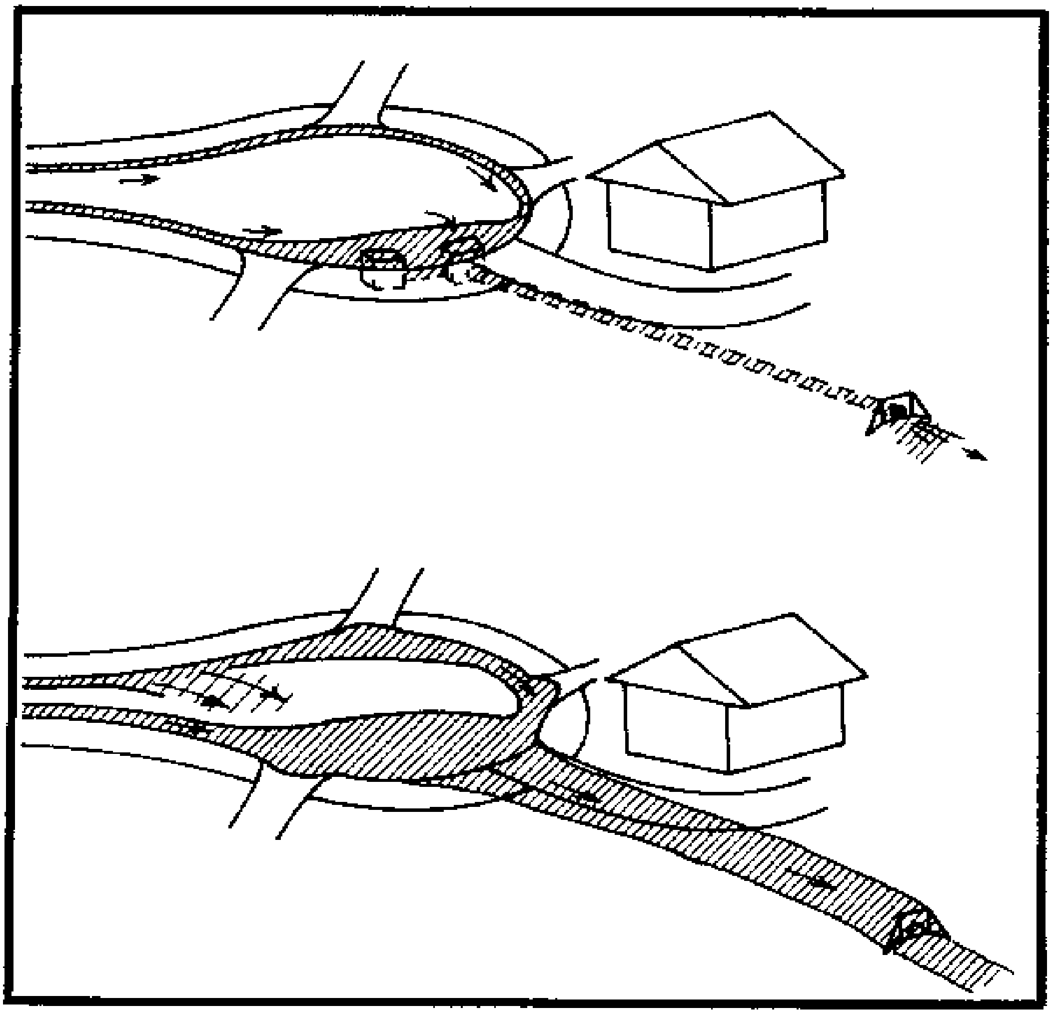


Figure 1 Example from AR&R

4.7 Stormwater Drainage Pits

4.7.1 Location

Provide stormwater drainage pits at spacings to limit gutter flow spread to 2 to 2.5m on any section of road other than a kerb return where the width is limited to 1 metre.

The maximum spacing between pits is approximately 90 metres subject to hydraulic calculations demonstrating acceptable flow widths and stormwater velocity.

Provide extended double grated gully pits at sag points.

Check inlet capacity of stormwater drainage pits match or exceed design pipe inflow.

4.7.2 Drainage Pit Design

Key requirements in relation to Drainage Pit Design are:

- Standard pits should be provided in drainage lines at all changes in grade, level or direction and at all pipe junctions;
- The minimum clearance from the top of the manhole to the design water level in the pit should be 150 mm;
- Pipe junctions where the deflection angle of the major flow exceeds 90º should be avoided;
- Pipe grading across pits shall be as follows:
  - No change in direction or diameter – minimum 50 mm;
  - No change in diameter but direction change – minimum 70 mm;
- Changes in diameter shall be graded obvert to obvert;
- Every endeavour is to be made to maintain flow velocities through pits and excessive drops will not be permitted;
- Pits are to be located and constructed in accordance with Standard drawings (subject to availability). Precast pits are acceptable subject to prior Council approval to the type and design; and
- Minimum size drainage pits that require physical access are to be 1050 mm.

4.8 Surface Runoff and Travel Times

4.8.1 Kinematic Wave Equation

Stormwater design shall account for overland flow prior to discharge to the pipe network.

The recommended formula to determine time of overland flow is the "Kinematic Wave" equation.

There are restrictions on the use of this formula as this expression applies to planar or sheet flow of water. The maximum length applicable should not exceed 60 metres. Consider a supposedly flat playing field, where water would concentrate into rivulets. A surface roughness or retardance coefficient "n*" is used which is not to be confused with Manning's "n". The equation is as follows:

$$t = 6.94\ (L.n^*)^{0.6\,/}\ I^{0.4}\ .\ S^{0.30} \quad \text{(14.2 AR\&R 1987)}$$

where:

t is overland flow time (minutes);

L is flow path length (m);

n* is a surface roughness or retardance coefficient;

I is rainfall intensity (mm/h); nd

S is slope (m/m).

Note: The lower the value of n*, the more conservative or the greater the flows. n* is normally taken as varying for 0.15 to 0.20 for residential overload flow.

Table 2 Surface Roughness or Retardance Factors

Surface Roughness or Retardance Factors	
Surface Type	*Roughness Coefficient n**
Concrete or Asphalt	0.010 - 0.013
Bare Sand	0.010 - 0.016
Gravelled Surface	0.012 - 0.030
Bare clay-Loam Soil (eroded)	0.012 - 0.033
Sparse Vegetation	0.053 - 0.130
Short Grass Prairie	0.100 - 0.200
Lawns	0.170 -0.480

Where overland flow is concentrated, naturally or by design, into an earth or grass lined channel, Manning's Formula for open channel flows can be used to estimate flow times and characteristics:

$$Q = A.V = AR^{2/3} S^{1/2}/n$$

Where:

Q is flowrate (m^3/s);

A is the cross-sectional area of flow (m^2);

V is velocity (m/s);

P is the wetted perimeter of flow (m);

R is hydraulic radius (m), equal to A divided by P;

S is longitudinal slope (m/m);and

n is a roughness coefficient (Table 2).

Alternatively gutter flow times can be estimated from design aids.

Estimates of overland flow times are not highly accurate and gutter flow times added to these flow times need not be calculated precisely.

In applying the Rational Method note that the minimum duration for which rainfall intensity data applies is five minutes.

Consider a typical residential block with a 2% fall from the rear to the front. The Kinematic Wave equation would indicate that the travel time over the block would be 15 minutes.

Table 3 Manning's Roughness Coefficients

Manning's Roughness Coefficients "n" for Open Channels	
Surface Type	*Suggested n Values*
Concrete Pipes or Box Sections	0.011 - 0.012
Concrete (trowel finish)	0.012 - 0.015
Concrete (formed, without finishing)	0.013 - 0.018
Sprayed Concrete (gunite)	0.016 - 0.020
Bricks	0.014 - 0.016
Pitchers or Dressed Stone in Mortar	0.015 - 0.017
Random Stones in Mortar or Rubble Masonry	0.020 - 0.035
Rock Lining or Rip-Rap	0.025 - 0.030
Corrugated Metal (depending on size)	0.020 - 0.033
Earth (clear)	0.018 - 0.025
Earth (with weeds or gravel)	0.025 - 0.035
Rock Cut	0.035 - 0.040
Short Grass	0.030 - 0.035
Long Grass	0.035 - 0.050

4.9 Dimension of Flow

Key requirements in relation to Dimensions of flow are:

- Limit flow width to 2 to 2.5 metres, along kerb and gutter and 1 metre around kerb returns for a 1:10 year ARI storm;
- Gutter flows are not to overtop the kerb;
- Free board for floor levels of habitable rooms in properties 300 mm;
- Product of depth and velocity $0.4m^2/s$ for safety of pedestrians or 0.6 to 0.7 m^2/s for the stability of parked vehicles; and
- Bypass flows shall not exceed 15% of total pit flow.

4.10 Pit Entry Capacities

Hydraulic design calculations must demonstrate adequate capacity of the stormwater drainage network to accept the design flows.

4.11 Estimation of Flowrates by the Rational Method

A peak flowrate for a particular time of concentration is calculated. While this is adequate for design, the model is unsuitable for the simulation of drainage system behaviour in actual storms.

4.12 Partial Area Effects

The time of concentration most commonly used is the full area time, which is the travel time for runoff from the longest flow path. Partial area calculations may be approximated by obvious partial catchment areas and for partial areas based on the concentration times of impervious zones directly connected to the pipe system.

4.13 Runoff Coefficients "C"

In the current version of Australian Rainfall and Runoff, a "probabilistic" interpretation of the value of C is used. This represents the ratio of runoff to rainfall frequency curves. It does not represent the ratio between runoff and rainfall volume nor the ratio of their peak rates. The probabilistic interpretation covers the whole range of events involving different combinations of rainfalls and antecedent conditions using the equation below, which determines a runoff coefficient for the catchment for any ARI based on the 10-year ARI runoff coefficient for the entire catchment (C_{10}) and a conversion factor known as a 'frequency factor' (F) for that ARI.

$$C_y = F_y \times C_{10}$$

Where:

$C_y =$ y-year ARI runoff coefficient for the entire catchment;

$F_y =$ y-year ARI frequency factor (Table 4);

$C_{10} =$ 10-year ARI runoff coefficient for the entire catchment.

Table 4: Urban Frequency Factors

ARI (Years)	*Frequency Factor (Fy)*
1	0.8
2	0.85
5	0.95
10	1.0
20	1.05
50	1.15
100	1.2

Given this, in order to determine the runoff coefficient for the entire catchment it is necessary to use the following equations to determine the 10-year ARI runoff coefficient (C_{10}). This value is determined by combining the runoff coefficient of the pervious and impervious areas of the catchment, and is as such largely dependant on the fraction impervious (f).

$$C_{10} = (0.9 \times f) + \left[C^1{}_{10} \times (1 - f)\right]$$

$$C^1{}_{10} = 0.1 + \left[0.0133 \times \left({}^{10}I_1 - 25\right)\right]$$

Where:

C_{10} = 10-year ARI runoff coefficient for the entire catchment;

f = Impervious fraction of the catcment (value must be between 0.0 and 1.0);

$C^1{}_{10}$ = 10-year ARI pervious area runoff coefficient; and

${}^{10}I_1$ = 10-year ARI,1-hour rainfall intensity for the location (obtained from locations IFD data).

4.14 Fraction Impervious

Typical fractions for impervious areas are shown in Table 5.

Table 5 Typical fractions for impervious aeas

Situation	**f**
Open Space/Parkland	0.00
Residential Areas (Ultimate Development)	0.35
Normal House Block	0.42
Duplex Block	0.57
Road Reserve Including Roads and Footpath	0.85

In situations where more accurate estimates of impervious area fractions can be determined the accurate estimates should be used in preference to the typical fractions given above.

4.15 Rainfall Data and Intensity

The Rational Method uses uniform rainfall patterns taken from Intensity Frequency Duration (IFD) relationships. Refer to Appendix.

4.16 Pipe System Hydraulics

Hydraulic grade calculations may be used for the design of pipe systems in accordance with examples provided in AR&R. This model is preferred, as it is better able to model real behaviour, and allows for surcharging of pits, and pressure flows and to produce more efficient designs.

4.16.1 Limiting Velocities

The minimum allowable velocity for design is normally taken as 1m/s.

The absolute minimum allowable velocity is 0.6 m/s to provide self-cleansing velocities.

This hydraulic requirement is a different approach to the minimum grade approach. The basis of the minimum grade approach relates to construction problems and tolerances. Minimum grades of 1/300 are acceptable for normal pipeline design.

4.16.2 Calculation of Pipe Friction

The Colebrook-White Equation (Table 6) is recognised as the best relationship for the full range of turbulent pipe flows. It follows the curved lines shown on the Moody Diagram. Manning's formula is valid in the completely turbulent section only; but prone to error in the transition zone. Subject to approval by Council Mannings calculations may be accepted.

The Colebrook-White Equation:

$$V = -0.87\sqrt{(2g.D.S)}\ \log_e \left[{}^{k}/3.7\ D + {}^{2.51v}/D\sqrt{(2g.D.S)}\right]$$

Where:

g is gravitational acceleration (m/s^2);

D is diameter (m);

S is energy line slope (m/m);

k is pipe wall roughness (m), sometimes given as "e"; and

v is the kinematic viscosity (m^2/s) - normally 1.0×10^{-6}.

Table 6 Colebrook-White Equation Pipe Friction

Pipe Material	**Hydraulics Research Recommendations k Value (mm) for Pipe Conditions:**			**SAA Recommendations k Value (mm) for pipes concentrically**
	Good	***Normal***	***Poor***	**Jointed and clean**
Concrete				
Spun precast, "0" Ring Joints	0.06	0.15	0.3	0.03 to 0.15
Monolithic construction against rough forms	0.06	1.5	-	
Asbestos Cement	0.015	0.03	-	0.015 to 0.06
uPVC				
With Chemically Cemented Joints	-	0.03	-	
with Spigot and Socket Joints	-	0.06	-	0.003 to 0.015

Design wall roughness should reflect conditions well into the service life of the pipe. Thus for concrete pipes a value of K = 0.3 mm is suitable, i.e. somewhere between “good” and “poor”.

4.17 Pipe Construction

Pipes are to be reinforced concrete pipe (RCP) rubber ring jointed with a minimum diameter of 300 mm.

The minimum cover under road pavements is 300 mm below subgrade level or 600 mm below pavement surface level whichever is greatest.

The minimum diameter of interallotment drainage pipes is 225 mm with the exception of one lot where 150 mm pipes may be provided. Interallotment drainage pipe materials may be other then concrete but are subject to Council approval.

The minimum cover over interallotment drainage is 300 mm.

No reduction in pipe diameter is allowed for pipe reaches progressing down stream.

Council will consider other materials on a case-by-case basis.

4.18 Drawings

Table 7 Standard Drawings, Narrandera

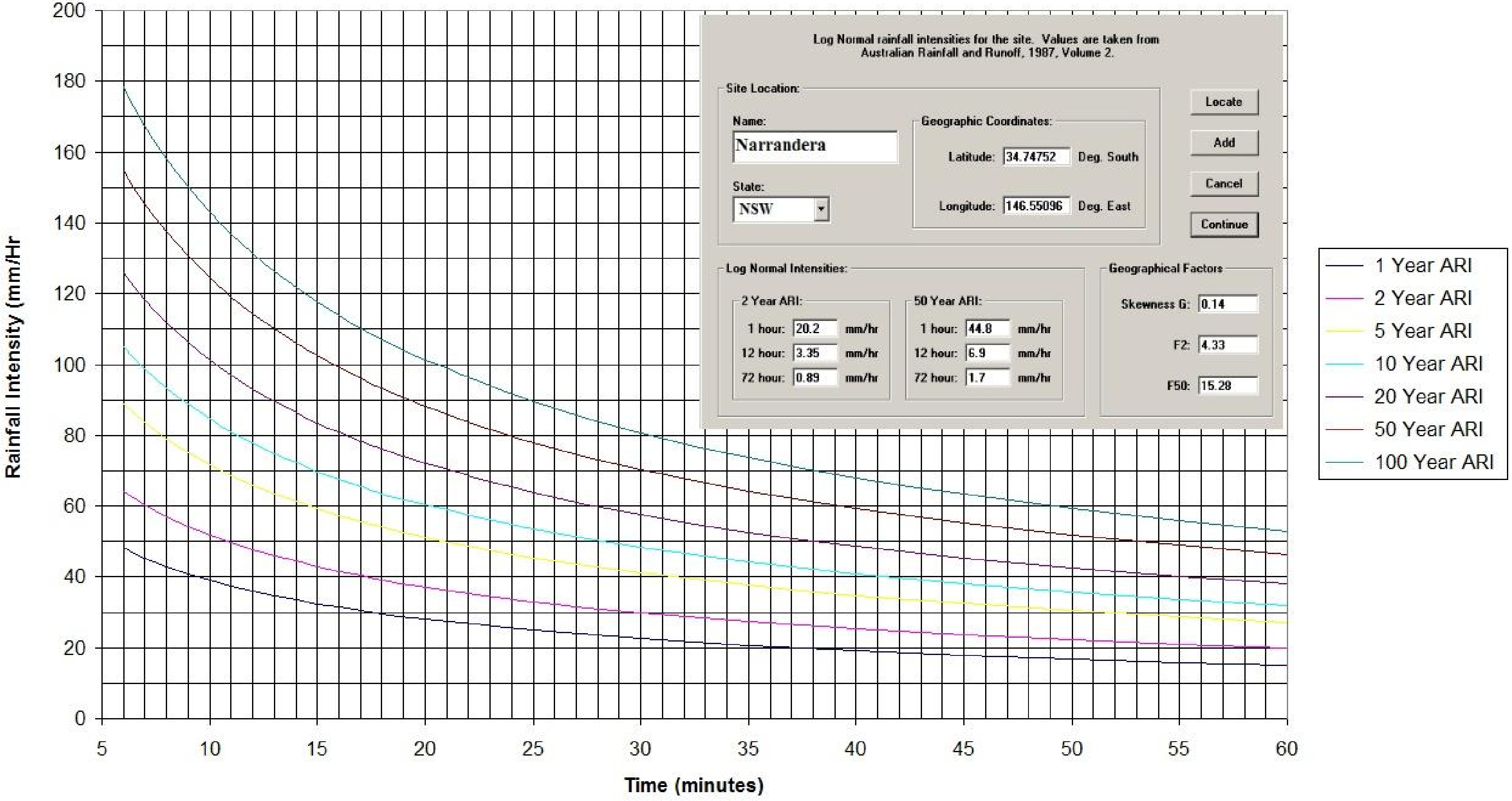
Item	Description	Drawing No.
1	Grated Gully Pits	
2	Grated Gully Pits in Semi Mountable Kerb and Gutter	
3	Standard Side Entry Pits	
4	Special Side Entry Pits for Standard Kerb and Gutter	
5	Special Side Entry Pits for Semi-Mountable Kerb and Gutter	
6	Grates and Frames for Grated Gully Pits	
7	Standard Drainage Manhole	
8	Property Inlet Pits	
9	Surface Inlet Pit	
10	House Connection to Pipes Under Kerb and Gutter	
11	Standard Concrete Headwalls for 300 to 900 Diameter Pipes	
12	Standard Subsoil Drainage	
13	Standard Trench Details	

(Council Standard drawings are subject to availability and development)

Appendix A

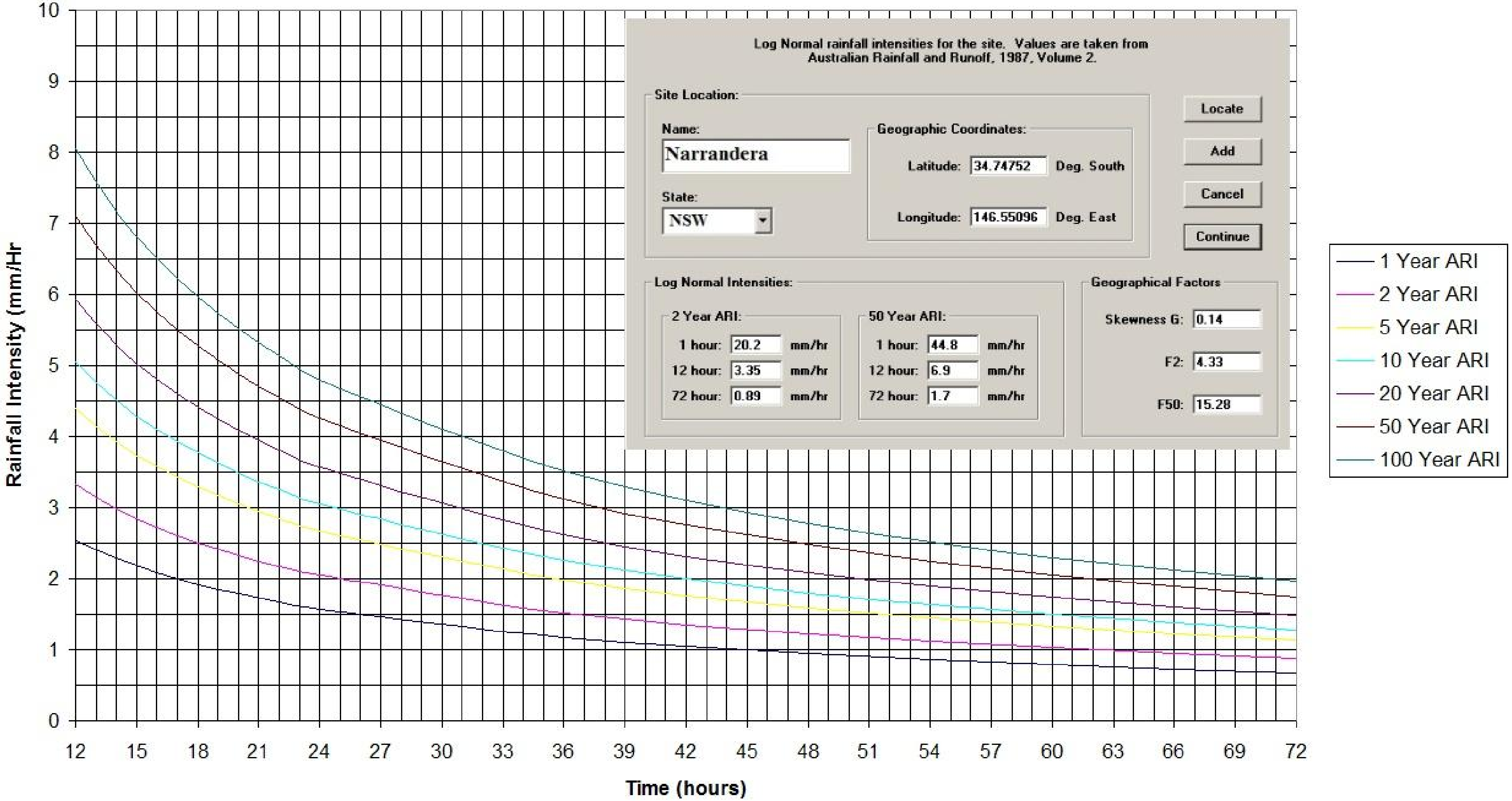
IFD Analysis based on Australian Rainfall and Runoff (1987)

Narrandera - Rainfall Intensity Frequency Duration Curves (6 minutes to 60 minutes)

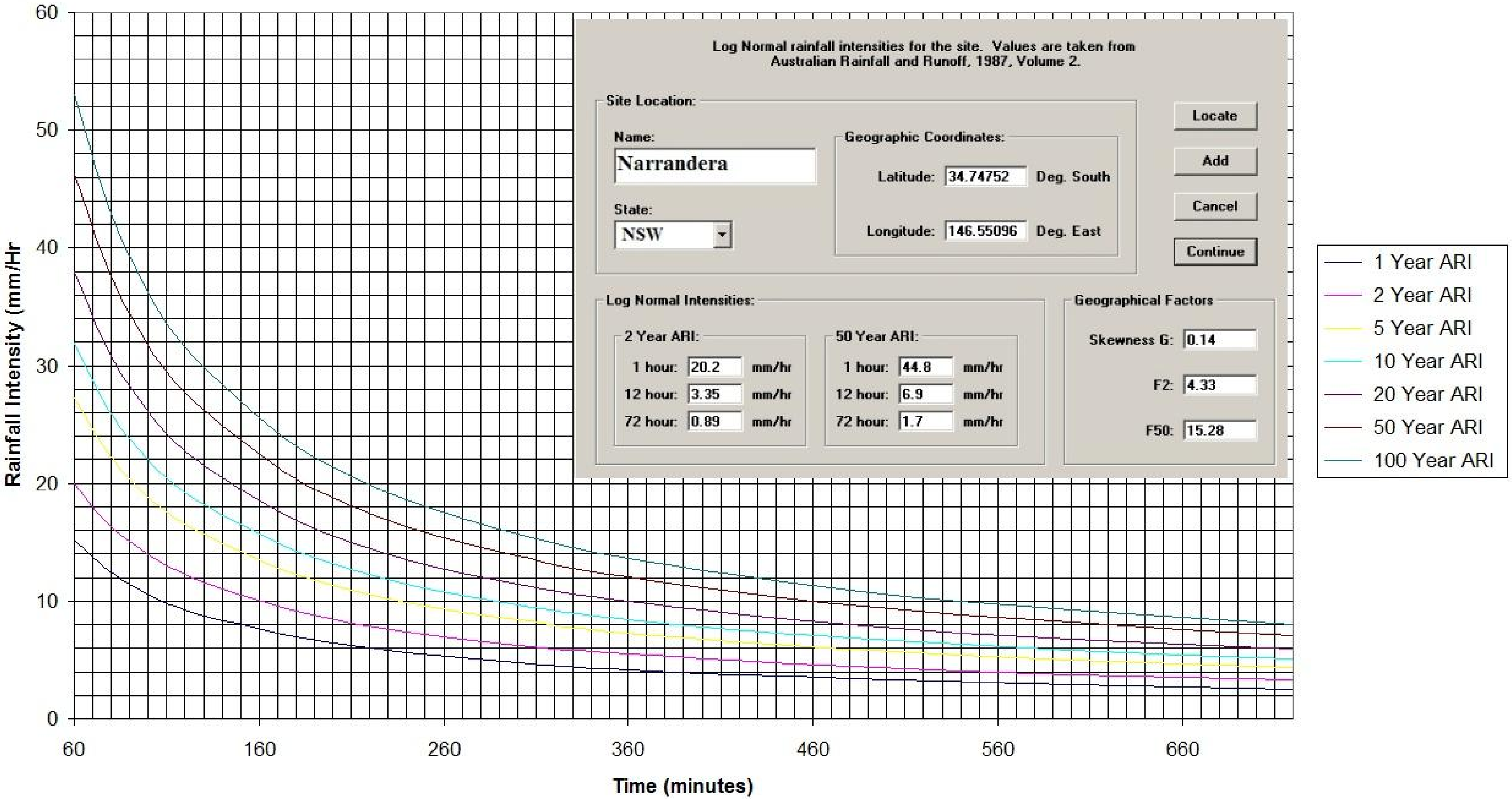


31/27125/5375

Narrandera - Rainfall Intensity Frequency Duration Curves (12 hours to 72 hours)



Narrandera - Rainfall Intensity Frequency Duration Curves (60 minutes to 720 minutes)



Narrandera – Rainfall Intensity Frequency Duration Table (6 minutes to 60 minutes)

Duration	1 Year ARI	2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI
(mins)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)
6	48.48	64.06	88.84	104.97	125.84	154.87	178.24
7	45.37	60.3	83.55	98.68	118.24	145.46	167.35
8	42.97	57.1	79.06	93.32	111.79	137.46	158.11
9	40.9	54.33	75.16	88.69	106.21	130.55	150.12
10	39.07	51.89	71.74	84.63	101.31	124.48	143.11
11	37.45	49.72	68.71	81.02	96.96	119.11	136.9
12	36	47.78	65.99	77.79	93.07	114.29	131.34
13	34.69	46.03	63.63	74.88	89.56	109.95	126.33
14	33.49	44.44	61.3	72.23	86.37	106.01	121.78
15	32.4	42.98	59.26	69.81	83.46	102.41	117.62
16	31.4	41.64	57.39	67.58	80.79	99.1	113.8
17	30.47	40.41	55.66	65.53	78.32	96.05	110.29
18	29.61	39.26	54.06	63.63	76.03	93.23	107.03
20	28.06	37.2	51.18	60.22	71.93	88.16	101.18
25	24.96	33.06	45.41	53.38	63.71	78.02	89.49
30	22.6	29.92	41.04	48.2	57.49	70.35	80.65
35	20.73	27.44	37.58	44.11	52.59	64.31	73.69
40	19.21	25.41	34.78	40.79	48.6	59.4	68.04
45	17.95	23.73	32.44	38.03	45.29	55.32	63.35
50	16.87	22.3	30.45	35.68	42.48	51.87	59.37
55	15.94	21.07	28.75	33.67	40.07	48.9	55.96
60	15.13	19.99	27.26	31.91	37.96	46.31	52.99

Narrandera – Rainfall Intensity Frequency Duration Table (60 minutes to 720 minutes)

Duration (mins)	1 Year ARI (mm/hour)	2 Year ARI (mm/hour)	5 Year ARI (mm/hour)	10 Year ARI (mm/hour)	20 Year ARI (mm/hour)	50 Year ARI (mm/hour)	100 Year ARI (mm/hour)
60	15.13	19.99	27.26	31.91	37.96	46.31	52.99
75	12.96	17.1	23.26	27.19	32.31	39.36	44.98
90	11.4	15.03	20.39	23.81	28.26	34.39	39.27
120	9.28	12.22	16.52	19.26	22.82	27.72	31.62
180	6.93	9.1	12.24	14.23	16.83	20.38	23.21
240	5.62	7.38	9.89	11.47	13.54	16.37	18.62
300	4.78	6.27	8.38	9.71	11.44	13.82	15.7
360	4.19	5.49	7.32	8.47	9.97	12.03	13.65
480	3.4	4.45	5.92	6.83	8.03	9.67	10.96
600	2.9	3.79	5.02	5.79	6.79	8.17	9.25
720	2.54	3.32	4.39	5.05	5.93	7.11	8.05

Narrandera – Rainfall Intensity Frequency Duration Table (12 hours to 72 hours)

Duration	1 Year ARI	2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI
(hours)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)	(mm/hour)
12	2.54	3.32	4.39	5.05	5.93	7.11	8.05
14	2.29	2.98	3.93	4.52	5.3	6.35	7.18
16	2.09	2.72	3.58	4.11	4.81	5.76	6.51
18	1.92	2.5	3.29	3.77	4.41	5.28	5.96
20	1.79	2.33	3.05	3.49	4.08	4.88	5.51
22	1.67	2.17	2.85	3.26	3.81	4.55	5.13
24	1.57	2.05	2.67	3.06	3.57	4.26	4.8
36	1.18	1.52	1.98	2.26	2.62	3.12	3.51
48	0.95	1.23	1.58	1.8	2.09	2.48	2.78
60	0.8	1.03	1.32	1.5	1.74	2.05	2.3
72	0.68	0.88	1.13	1.28	1.48	1.75	1.96

GHD

105 Hume Street
Wodonga VIC 3690 Australia
T: 61 2 6043 8700   F: 61 2 6043 8711   E: abxmail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	J Ellwood	C Elliott		C Elliott		10/2/11