HANDBOOK OF STORMWATER DRAINAGE DESIGN

Aus-Spec Reference

D5 – Stormwater Drainage Design

AMENDMENT RECORD FOR THIS SPECIFICATION PART

This Specification is Council's edition of the AUS-SPEC generic specification part and includes Council's primary amendments.

Details are provided below outlining the clauses amended from the Council edition of this AUS-SPEC Specification Part. The clause numbering and context of each clause are preserved. New clauses are added towards the rear of the specification part as special requirements clauses. Project specific additional script is shown in the specification as italic font.

The amendment code indicated below is 'A' for additional script 'M' for modification to script and 'O' for omission of script. An additional code 'P' is included when the amendment is project specific.

Amendment Sequence No.	Key Topic addressed in amendment	Clause No.	Amend Code	Author Initials	Amend Date
1	Version 2 July 2010	All	AMO	ID	July 2010
2	Flow Capture Charts (Refer AUS-SPEC Drawings) Standard Drawings removed (Listed Only)	All	M	ID	July 2010
3	Table 2.1 Average replaced by Annual	2.2	M	ID	July 2010
4	Kinematic Wave description amended	4.2	M	ID	July 2010
5	Minor storage volume description 'or 100m^3 storage'	12.1.4	A	ID	July 2010
6	Added pre-cast culvert bases and steel pipe clauses	14.0.6 & 7	A	ID	July 2010
7	Outlet to be sized to convey 2 x orifice flow to next downstream structure (UPRCT documentation)	Appendix E2	M	ID	July 2010
8	Detention Volume and Undeveloped - Developed flow check formulae amended	Appendix E2	M	ID	July 2010
9	Appendix E3 source document references amended	Appendix E3	M	ID	July 2010
10	Flow Capture Charts used with BCC permission	Appendix F	M	ID	July 2010
11	Appendix G – Amendment Record	Appendix G	A	ID	July 2010
12	Orifice size 55mm	12.1.12	M	ID	February 2011
13	Use of FRC Pipe requires approval of Council	14.0.8	A	ID	June 2011
14	Add Stormwater Management Plan & WSUD clauses plus minor amendments and reference updates	1.1.7 to .14 added 1.2.6 moved to new Sect. 1.3 1.2.7 to .10 renumbered 1.2.10 deleted New Sect. 1.03 2.0 minor amend's, Update Sect. 18.0	AM	ID	August 2013
15	Page 15, section 12.01, point 14 and Appendix E added note below title	section 12.01 and Appendix E	AM	ID	August 2016
16	Typo in reference	7.2.f	M	MK	March 2018
17	Removal of Fibre Reinforced Pipes	14.8	M	MK	December 2019

Version 3b – December 2019

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1. INTRODUCTION

1.01 GENERAL

1. The Engineering Standards for the Northern Rivers Councils are the "Northern Rivers Local Government Development and Design Manual" and "Northern Rivers Local Government Construction Manual" (hereafter referred to as AUS-SPEC).
2. All external civil works shall be in accordance with and completed under the supervision of an engineer or surveyor approved by a delegated officer from Council's Engineering Section.
3. The purpose of this supplement is to provide additional information, expanding on the elements addressed in and the requirements of – 'Section D5 Stormwater Drainage Design'.
4. The supplement will be referred to as the 'Northern Rivers Local Government Handbook of Stormwater Drainage Design'.
5. Other relevant documentation (but not limited to) which shall be referenced and considered in preparing stormwater drainage designs for submission to Council are :
    - relevant Council DCP
    - Australian Rainfall & Runoff 1987 (AR&R 1987) – *(S18.1 ref 4)*
    - Queensland Urban Drainage Manual (QUDM) - *(S18.1 ref 2)*
6. Developers and consultants are encouraged to consult with Council to discuss applications and obtain an initial assessment of a development proposal
7. Development design will have regard to the existing natural soils, vegetation, topography and drainage paths of the site.
8. Information is required by the local government authority to enable proper assessment of an application for development that complies with Ecologically Sustainable Development (ESD) and Water Sensitive Urban Design (WSUD) principles.
9. The information and detail required may vary dependent for specific development projects, as determined by a delegated officer from Council, and where subject to the requirements of each Council's Development Control Plan (DCP)
10. Development application plans and documentation are to be sufficiently detailed to allow the feasibility of a Stormwater Management Plan (SWMP) to be assessed (refer Section 1.3).
11. Construction Certificate applications must contain all required engineering drawings and documentation to allow an approval of a SWMP to be issued.
12. Works which may impact on the quality and quantity of stormwater runoff discharging from a development site requires the preparation and submission for approval by the local government authority, of a SWMP that demonstrates how post-development flow volumes and stormwater quality are controlled to pre-development conditions by achieving neutral or beneficial effect (NorBE) on the natural environment and receiving constructed system, waters or wetlands.
13. If NorBE cannot be achieved an upgrade of the downstream drainage system will be required, subject to Council approval.
14. Development works include (but are not limited to) :
    - Subdivisions
    - Buildings and structures
    - Earthworks, dams, lakes, roadworks and drainage works
    - Siteworks, such as vehicular access roads, car parks, pedestrian / bicycle paths, landscaping, signage, fencing and other structures
    - Quarrying, mining and other industrial / commercial activities

1.02 CONDITIONS OF APPROVAL AND PRINCIPLES TO BE FOLLOWED BY DEVELOPMENTS

1. The developer, under the supervision of an approved engineer or surveyor, is responsible:
   a. for costs relating to alterations and extensions of existing roads, drainage and services for the purposes of the development
   b. to construct, at own cost, all works required for the development, in accordance with the Development Application Determination conditions and the Construction Certificate issued by Council
2. Three (3) full size A1 sets of the Engineering Drawings are to be submitted. One approved set will remain in Council's records and the other stamped sets returned to the Applicant. Council also requires a full set of plans at A3 size and electronic copies of drawing files in both pdf and autocad dxf or dwg format (or compatible).
3. The consultant is also to submit copies of all modeling data files in electronic format (e.g. DRAINS, PCDRAIN, RAFTS, HECRAS, MUSIC).
4. Approval of Engineering Plans will be current for a period of two years from the Construction Certificate approval by Council, after which time Council may require alteration to Engineering Design to comply with standards current at that date
5. All stormwater is to be collected within the property and discharged in accordance with Council's standards. Effective measures are to be undertaken to prevent the obstruction of surface drainage, the disruption of amenity, damage or deterioration of any other property. Retention of the natural stormwater system is desirable where possible.
6. CCTV inspection, including the provision of a detailed certified report and DVD by an appropriately qualified and experienced person, may be required on existing and newly constructed stormwater lines as directed by Council at the developers cost
7. Changes to design during construction may require the re-submission of design calculations and computer analysis
8. Undeveloped catchment design flows to the minor system may be used due to the requirements of relevant Development Control Plans, Water Sensitive Urban Design principles and the limiting of flows from a development to the pre-development conditions. This must be supported by design calculations which accurately model the system and a stormwater management plan which has been submitted to and approved by a delegated officer from Council's Engineering Section. Refer Section 12
9. Infiltration devices, swales and 'Water Sensitive Urban Design' components shall be designed in accordance with Council requirements. Accepted design guidelines may be sourced from Water-By-Design *(S18.1 ref 17)*. The following requirements apply to infiltration systems :
   a. to be wholly located within the development and an adequate distance, as approved by a delegated officer from Council's engineering section, from adjacent property or structures
   b. to be discharged to a swale, piped stormwater system or other location as approved by a delegated officer from Council's Engineering Section
   c. to be designed by a consultant approved by a delegated officer from Council's engineering section
   d. Site testing is to be undertaken to determine soil permeability and water table depth

1.03 STORMWATER MANAGEMENT PLANS

1. A full and detailed stormwater management plan for the site, satisfactory to Council, is to be submitted for approval prior to the issue of the construction certificate. The plan may need to include (but not limited to) :

2. Analysis of the upstream contributing area and overland flowpaths considering all impacted drainage flows, adjacent and/or downstream properties, structures, infrastructure and downstream receiving systems

    a. Sensitivity Analysis to consider reasonable performance criteria over the lifetime of a stormwater system (to consider such issues as variable mannings 'n', determination of time of concentration *(S18.1 ref 9,10)*, hydraulic jumps, link lags).

    b. Documentation of inflow rates at all contributing points

    c. Consideration of floods greater than the design flood *(S18.1 ref 4,5,6)*

    d. Consideration of the capacity of any downstream system (the developer may be required to upgrade downstream facilities at their cost where the development impacts directly on the facility even though the post development flow does not exceed pre development flow. Each case will be considered on its merits).

    e. Identification of the 1 in 100 year ARI flood flow lines

    f. Post-development peak flows leaving the development are not to exceed the pre-development peak flow rates for the required design storm event unless required otherwise by Council

    g. Provision of overland flowpaths (natural and diverted) for the development considering proposed development flows and adjacent / downstream property. Easements may be required.

    h. Control of stormwater volume & quality leaving the site and Control / protection against Erosion *(S18.1 ref 11)*

    i. Minimization of the depth of table drains by the use of box / cross drainage culverts

    j. Where overtopping of the road pavement is expected for the design ARI event or lesser return period, the road shoulder is to have a concrete apron both sides and / or concrete pavement for the extent of overtopping as a result of the design ARI event to prevent erosion of the shoulder and damage to the pavement *(S18.1 ref 7,9,10)*

    k. The road reservation is to be widened where necessary, due to the width of drainage swales, to ensure footpaths have a minimum of 2.4m width suitable for use by pedestrians and the provision of services.

    l. Maximum cross-falls on drainage swales of 1 in 6 is preferred.

    m. Show capacity, flow rates and velocities at pertinent points in drainage swales and for access pipes at critical points

    n. Details of proposed detention basins and associated works

    o. Public safety, amenity and maintenance considerations

    p. Fencing considerations

    q. Effluent disposal areas

3. Both major (1 in 100 year ARI) and minor system (determined by zoning / use) stormwater flows upstream of, adjacent to, within, through and flowing from the development site are to be considered by the SWMP.

4. The SWMP should include the following information with justification of any assumptions and / or decisions made (where appropriate but not limited to) :

   a. Site and catchment description :

      - Site location
      - Contour plan (identifying all contributing catchments)
      - Description of contributing catchments and land uses (existing &
      - future)
      - Available water supplies
      - Geology and soil types (including permeability, erodibility, ASS)
      - Hydrology
      - Stormwater discharge locations
      - Downstream waterways, wetlands and ecosystems
      - Tidal influences
      - Water table and groundwater effects
      - Vegetated buffer zones

   b. A risk assessment of the proposed development drainage system considering site location (ecosystems, wetlands, waterway, floodway, floodplain, zoning, surrounding development / structures, existing overhead and underground services) with regard to the safety and protection of persons and property. This may include consideration of construction, maintenance and 'handover' phases of a project.

   c. Summary of WSUD design objectives / performance criteria

      - Apply DCP requirements for water quality
      - Infiltration capability of in-situ soils
      - Comply with NSW Environmental Protection Authority (EPA) requirements
      - for water quality

   d. Maintenance Measures and Life Cycle Costing (does apply if dual reticulation re-use system is installed)

      - Estimate of required maintenance measures (i.e. type & frequency)
      - Assessment of annualised maintenance cost

   e. Potable water consumption :

      - Water consumption assumptions
      - Description of proposed water management measures
      - WSUD components and measures used
      - Details of water balance analysis to demonstrate compliance

   f. Stormwater quality :

      - Water quality objectives
      - Description of proposed water management measures
      - WSUD components and measures used
      - Details of stormwater quality modelling to demonstrate compliance

   g. Stormwater quantity (discharge frequency, flow rate and volume)

      - Description of proposed water management measures
      - Details of hydraulic structures
      - WSUD components and measures used
      - Details of hydrologic / hydraulic analyses to demonstrate compliance

   h. Computer modelling results ('DRAINS', 'MUSIC' or other Council accepted software)

   i. Ecological protection and management including details of strategies proposed to protect / enhance identified ecological habitats or species

   j. Details of road reservation widths in accordance with the 'Northern Rivers Development, Design and Construction Manuals', plus additional width to contain proposed WSUD components, as approved by the local authority

k. Details of management plan/s identifying the qualifications, responsibilities and roles of consultants, contractors and project managers. The plans are to indicate project timelines, staging, supervision, construction, inspection, testing, establishment, maintenance, commissioning (including but not limited to) :

- WSUD management components and measures (separate maintenance / staging plans may be required
- Proposed methods for transferring responsibility of WSUD components located on private property to the property owners (if applicable)
- Proposed methods for transferring responsibility of WSUD components to Council (if applicable)

l. To assist the assessment process, designers and consultants may include other design information in the SWMP. The detail required for a SWMP may also vary according to type, location, size, complexity, staging and other relevant factors for a specific development project application.

1.04 WATER SENSITIVE URBAN DESIGN (WSUD)

1. Water Sensitive Urban Design (WSUD) is the application of 'Best Practice' stormwater management principles to maintain, protect and improve waterway health and mitigate the impact of development on the natural water cycle. This shall achieve neutral or beneficial effect (NorBE) on the natural environment, adjoining property or infrastructure and the receiving constructed system, waters or wetlands.
2. Stormwater flows from development projects may cause pollution, erosion and sedimentation in wetlands and waterways, including increased frequency and magnitude of flooding. Impermeable surfaces (roads, buildings and driveways) reduce soil infiltration.
3. Planning, design and construction of built environments should result in healthy ecosystems through the management of water quality and quantity, minimising impact on the natural water cycle.
4. Traditional stormwater management involves piped discharge from development projects and provision of stormwater detention for flood mitigation and drainage asset protection purposes. By contrast, management of the urban water cycle considers stormwater as a resource for re-use ensuring the appropriate treatment and attenuation of stormwater flows, prior to discharging into receiving waters.
5. 'WSUD' utilises on-site collection, treatment and harvesting of stormwater flows as part of an integrated 'treatment train'. It provides opportunity for detention and harvesting of stormwater, reducing potable water demand, discharge volume and pollutant load of stormwater discharge.
6. 'BASIX' *(S18.1 ref 18)* is a web-based design tool that ensures residential developments meet the NSW Government's targets for reductions in water consumption and greenhouse gas emissions. Proposed stormwater management detention volumes are to be in addition to that required for 'BASIX'.
7. Each local government authority in the Northern Rivers Group of Councils (NRG) requires the use of their applicable Development Control Plans, sustainability requirements and the following guidelines in the design and construction of WSUD drainage systems for development projects and subdivisions :

   a. The Queensland 'Water-By-Design' (WbD) program provides guidelines *(S18.1 ref 18)*, complying development examples and fact sheets to assist with the design and delivery of WSUD. These technical guidelines and objectives for water conservation and stormwater management are based on Queensland government legislation and are to be considered with respect to the requirements of NSW legislation

   b. Prior to preparing any development or construction certificate applications the developer should obtain advice from a delegated officer representing the local government authority regarding the use and application of the WbD information

c. The Sydney Catchment Management Authority's 'Interim Reference Guidelines *(S18.1 ref 19)* for the 'South East Queensland Concept Design Guidelines for WSUD' provide advice on the differences between NSW and Qld legislation / terms.

d. The Soils and Construction 'Blue Book' Guidelines from the NSW Department of Environment & Heritage *(S18.1 ref 11)* WSUD provide reference material applicable to New South Wales.

1.05 OBJECTIVES OF SMWP'S AND WSUD

1. The objectives of stormwater management are to :

   a. ensure traditional and/or WSUD principles (as approved by Council) are applied to the design and construction of development projects

   b. reduce demand for potable water from the town water supply

   c. ensure stormwater discharge from development projects is controlled to mitigate adverse impact of volumetric discharge and water quality to achieve 'NorBE' – neutral or beneficial effect on the natural environment, adjoining property or infrastructure and the receiving constructed system, waters or wetlands

   d. utilise natural flowpaths and incorporate on-site treatment

   e. ensure water management is a key consideration in the urban design process to maximise opportunities for water reuse and ensure stormwater management infrastructure is integrated within the surrounding environment

   f. protect and maintain ecosystems, property and infrastructure within, adjacent to and downstream of the development site

2. ensure the purpose of the stormwater drainage and flood protection elements are not compromised and that buildings and infrastructure are protected from flooding or damage by construction of incompatible or inappropriate stormwater systems.

1.06 STORMWATER QUALITY IMPROVEMENT DEVICES (SQIDS)

1. All SQIDS for subdivisions and development projects are to be sized to treat a minimum of a 1 in 3 month rainfall event, or as determined by a delegated officer from Council. They are to be designed with overflow / bypass arrangements that accommodate a 1 in 100 year ARI storm event without causing erosion, scouring or structural damage in accordance with the technical design guidelines.

2. They may not be required where :

   a. the total development area is < 150 m² or as determined by the local authority DCP

   b. no impervious areas, road works or drainage works are proposed

   c. A risk assessment is provided demonstrating they are not required

3. Stormwater treatment devices that utilise soft engineering treatment solutions that can be contained within either existing or proposed public reserves are preferred. Treatment areas within private lands will be considered subject to registration of appropriate land title encumbrances, approved by Council, upon the private land. A Maintenance Management Plan is required to be submitted to the local government authority for approval.

4. All proposals should provide sufficient information to demonstrate :

   a. proper consideration of public safety

   b. proposed infrastructure design levels and grades will fit within existing site contours and,

   c. maintenance of proposed infrastructure can economically and feasibly be undertaken

5. Solutions that propose provision of publicly owned hard engineering treatment devices that can fail due to insufficient maintenance levels or that require the use of specialist equipment for maintenance that may not be available locally, are generally not supported.

2. AVERAGE RECURRENCE INTERVAL (ARI) & ANNUAL EXCEEDANCE PROBABILITY (AEP)

1. The average recurrence interval is known as the return period, this is the mean time between occurrences of some event, such as a flood or rainfall event. It is used as the foundation of many design procedures based on acceptable frequencies of occurrence. For urban stormwater drainage design the "event" will be the exceedance of some rainfall intensity and quantity over time and the resulting stormwater flows.
2. In general, the ARI can be considered to be the inverse of the probability of exceedance. If the ARI is in years, the corresponding probability is in terms of the event occurring in an annual period (i.e. a 20 year ARI is equivalent to a 1 in 20 year event or 5% AEP).

Table 2.1

AVERAGE RECURRENCE INTERVAL ARI yrs	ANNUAL EXCEEDANCE PROBABILITY AEP %
100	1
50	2
20	5
10	10
5	20
2	50
1	100

3. In Council's Development Control Plans, the general term '1 in x years' will be used to define particular events, e.g., 1 in 100 year flood event, 1 in 10 year rainfall event. In each case these terms relate to the statistical terminology above.

3. DESIGN IFD RAINFALL (D5.04)

1. Design Intensity-Frequency-Duration (IFD) Rainfall relationships shall be derived in accordance with Australian Rainfall & Runoff 1987. The consultant shall provide the rainfall figures and parameters used if they differ from those provided in Appendix A – IFD Data. The ARIs for Local Environmental Plan Zonings are as follows :

Table 3.1

DESCRIPTION	(ARI 1 in X years)	Lismore City Council
MAJOR SYSTEM (ARI 1 in X years)	100	100
MINOR SYSTEM (ARI 1 in X years)		
Parks & Reserves	1	1
Rural Residential	5	10
Urban Residential	5	10
Commercial / Industrial	10	20
MAJOR ROAD (Sub-arterial)		
Kerb & Gutter	10	10
Cross Drainage – Culverts, Bridges etc.	50	50
MINOR ROAD (Collector & Local)		
Kerb & Gutter	As per zoning	
Cross Drainage – Culverts, Bridges etc.	20	20

2. The above Design ARI's are subject to the following conditions :
   a. The design ARI for the minor drainage system in a major road / traffic route shall be that nominated for the major road, not the zoning of the adjacent area.
   b. Culverts under roads should be designed to accept the full flow for the minor system ARI shown and the minimum freeboard permitted shall be up to the subgrade level. In addition the consultant must ensure that the 100 year ARI backwater does not enter adjacent or upstream properties. If upstream properties are at a relatively low elevation

it may be necessary to install culverts of capacity greater than that for the minor system ARI design storm to ensure flooding of upstream properties does not occur. In addition causeway embankments may need scour protection where overtopping is likely to occur

c. Notwithstanding, Council may require a higher recurrence interval based on particular locality considerations that may generally include:

- Ability to accommodate the major event
- RMS or other authority's flood requirements
- Afflux considerations
- Future strategic planning considerations
- Counter disaster planning considerations
- Historical records of flood events
- Safety considerations in flood events
- The ability to access isolated or single entry communities

d. Consideration must be given to the overland flowpath, should the capacity of any drainage system be exceeded. A design-controlled overland flowpath is to be provided, together with the necessary easements / restrictions 'as-to-user', to ensure that the overland flowpath is not blocked by residents.

4. RUNOFF COEFFICIENTS & TIME OF CONCENTRATION (D5.06)

4.01 RUNOFF COEFFICIENTS

1. Council may determine that an investigation of the Runoff Coefficient and time of concentration for a particular development / location is necessary due to development type, strategic planning or zoning requirements. They shall not be less than the values determined for the existing catchment conditions and must take into account future planning. In these cases the designer shall provide calculations to determine the fraction impervious for those developments. Partial area effects and Peak flows must be considered.

2. Consultants may provide calculations to determine the fraction impervious and coefficients of runoff (refer QUDM) to the satisfaction of a delegated officer from Council's Engineering Section. The following table lists acceptable Ten Year Runoff Coefficients versus Zoning with consideration of existing landform :

Table 4.1

ZONING / TYPE	TEN YEAR RUNOFF COEFFICIENT C_{10}		
	Ground Slope		
	<1%	1% - 5%	>5%
Rural Residential			
Bare Rock	0.82	0.88	0.94
Rocky/Clay Soils	0.68	0.78	0.90
Open Forest/Grass/Crops	0.47	0.62	0.80
Average to Heavily Timbered	0.30	0.40	0.58
Cleared Sand Soils #	0.15	0.25	0.40
Urban Residential			
<600m^2	0.80	0.85	0.90
600m^2 to 1000m^2	0.75	0.80	0.85
>1000m^2	0.65	0.70	0.75
Industrial / Commercial	0.95	0.95	0.95
Parks / Reserves	0.55	0.65	0.75

Note 1. Existing Water table and groundwater conditions are to be considered

3. For events of an ARI other than ten years the following frequency factors shall be used:

Table 4.2

ARI	Fy
1	0.8
2	0.85
5	0.95
10	1
20	1.05
50	1.15
100	1.2

4. Unless otherwise approved the design rainfall used for the sizing of pollution control devices is to be based on IFD data and the following table.

Table 4.3

Design ARI (months)	1	2	3	4	6	9
Proportion of 1 in 1 year ARI	0.25	0.40	0.50	0.60	0.75	0.9

5. An assessment of the capacity of the downstream receiving system or waterway, to accept a pollutant load, and an investigation of the hydraulics of the drainage system is required.

4.02 TIME OF CONCENTRATION

1. The minimum time of concentration for a catchment shall be five minutes.
2. The maximum time of concentration used in an urban area shall be 20 minutes unless a greater time can be justified by calculations acceptable to a delegated officer from Council's Engineering Section.
3. The suggested method of calculating time of concentration for certain scenarios is listed below. It is up to the consultant to select an appropriate method (which may not be listed, but is documented and considered accepted engineering practice). Determination and calculation of time of concentration is to be acceptable to a delegated officer from Council's Engineering Section.
4. Time of concentration may be calculated using :
   a. The ***Probabilistic Method*** (for Rural Catchments up to 250km^2 in area) may be used to estimate time of concentration for a catchment.

$$tc = 0.76A0.38 \text{ (hours)}$$

Where A is in km^2

   b. **Modified Friend's Equation** may be used for shallow sheet flow over plane surfaces up to 200m length in rural areas and up to 50m length in urban areas. Thereafter an assessment of concentrated flow time by an approved standard method, supported by calculation shall be carried out.

$$tc = (107nL^{0.333}) / S^{0.2} \quad \text{(minutes)}$$

Table 4.4

LANDUSE	n
Paved Surface	0.015
Bare Soil	0.0275
Poorly Grassed	0.035
Average Grassed	0.045
Densely Grassed	0.060

   c. The **Kinematic Wave Method** may be used for planes of flow in homogenous catchments similar in nature, slope and roughness (such as paved areas) and shall not

be applied to large heterogeneous catchments dissimilar in nature, slope and roughness

(ref AR&R Technical Note 3(i))

$$tc = 6.94\ (Ln)^{0.6}) / I^{0.4}\ S^{0.3} \qquad (minutes)$$

5. Acceptable Roughness / Retardance Coefficient 'n' values (similar to but not identical to mannings 'n') are as follows :

Table 4.5

LANDUSE	n
Parkland	0.350
Rural Residential	0.300
Urban Residential	0.210
Medium Density Urban Residential	0.110
Industrial	0.060
Commercial	0.040
Paved Area	0.010
Asphalt Roadway	0.020
Gravel Areas	0.020

5. HYDROLOGICAL & HYDRAULIC CALCULATIONS (D5.07 & D5.08)

1. Hydrological and hydraulic calculations shall be based on the methods outlined in QUDM. Results shall be provided in accordance with requirements of AR&R 1987 and QUDM (refer Appendix E).
2. All information, including determination of pit pressure change co-efficients and other relevant calculations, computer analysis program outputs and manual calculations, should be provided in a clear, concise format that allows Council to carry out any necessary design assessment in a timely manner
3. Computer analysis outputs must be consistent with the information shown on the plans and additional information (sketches and/or calculations) may be requested to fully describe the proposed system and it's operation for assessment purposes
4. Electronic copies of computer models are required if they are in a format that council possesses the software for. If not, the consultant may have to conduct a demonstration of the modelling with their computer's and software at Council nominated premises
5. **Tailwater Levels** to be adopted are as follows (refer Appendix D for River Tidal Gradients for effected Councils) :
   a. Pipe obvert for free outfalls
   b. Design ARI flood level or River Half-Tide Levels (refer Appendix D) for receiving / tidal waters
   c. 150mm below kerb invert for existing systems with unknown HGL
   d. Surcharge height for surcharge outlet
   e. A nominal minimum freeboard of 150mm should be achieved between surface level and water surface elevation, determined by a hydraulic grade line design, in a stormwater structure
   f. The use of reinforced concrete box culverts should be considered in low flat areas

6. COMPUTER MODELLING

1. Where catchments are large, complex or nominated as important by a delegated officer from Council's Engineering Section for strategic planning or other purposes, accurate levels of flow rate prediction shall be made and peak flow rates shall be determined using a recognised runoff routing computer model. Council's preferred models are RORB, RAFTS-XP or DRAINS
2. The use of industry standard computer models by Professional Engineers for stormwater design is supported by Council. Designers should be aware of the need for model calibration (refer Appendix B) and sensitivity analysis. Council will advise on the modeling software they prefer. To enable timely assessment by Council the following industry standard modeling software is acceptable :
   a. Runoff Routing Hydrological - RORB
      RAFTS-XP
      DRAINS (ILSAX)
   b. Drainage Analysis Hydraulics - DRAINS (ILSAX)
      PCDRAIN
      XPSTORM
   c. Steady State Hydraulics - HEC-RAS
   d. Unsteady Flow Hydraulics - MIKE-11
   e. Water quality - MUSIC
      AQUALM-XP
3. Should Consultants wish to use a program not listed, details are to be submitted to Council prior to use. As a minimum the submission should be accompanied by :
   a. Basic parameters
   b. Input data files
   c. Output Summary files
   d. Relevant documentation relating to the program to enable deciphering and interpretation of input and output data
   e. Verification of models using industry standard techniques such as checking peak discharge using the rational method or checking peak flood levels with HEC-RAS
4. Computer modeling shall be compatible with the latest version of the program
5. A clear & concise report is to be submitted stating all the parameters used and assumptions made, including but not limited to :
   a. Rainfall loss values
   b. Sub-catchment fraction imperviousness
   c. Flow velocity estimates
   d. Manning's 'n' roughness values
   e. Flow contraction and expansion coefficients
   f. Structure hydraulic headloss coefficients (software default values must be checked and certified by the designer)
   g. Other hydraulic head losses
6. Hardcopy is to be submitted to Council. Electronic copies of final input and output computer files together with accompanying catchment and layout plans, for hydrological, hydraulic and water quality models must be provided for Council's records at the time of lodging detailed engineering plans for Construction Certificate approval.

7. MINOR SYSTEM CRITERIA (D5.09)

1. The Minor System comprises kerb & gutter, road table drains, gully pits, underground pipes manholes and outlets. The Major system (refer Section 9 – Major System Criteria) refers to overland flow paths designed to convey storm flows in excess of the minor system capacity. These systems are designed in accordance with Section 3 – Design IFD Rainfall
2. Criteria are as follows :
   a. Designs shall consider the convenience and safety of pedestrians and vehicles, construction and maintenance issues and freeboard to buildings for all types of development
   b. Kerb & gutter flow widths shall not exceed 2.5m nor over-top the kerb
   c. Designs shall consider table drain and driveway culvert capacities and minimization of erosion and sediment transport
   d. Designs shall consider layback kerb / driveway levels for gutter capacity where there is a low level footpath
   e. Total flow for minor flood events shall be contained within easements and/or drainage reserves.
   f. Velocity x Depth product requirements apply as for the Major System (refer Section 9 – Major System Criteria).
   g. Longitudinal table and swale drains with grades greater than 4% and less than 0.7% are to be lined with an appropriate treatment having regard to the application. Examples may include but are not limited to:
      - reinforced turf
      - spraycrete
      - hydromulch
      - rock
      - concrete
   h. Low flow pipelines / inverts should be considered in channels of very flat grades

8. PIT CAPACITIES - SYSTEM INLETS / OUTLETS (D5.10 & D5.11)

1. Inlet and outlet structures shall be provided in accordance with Council's standard drawings () and flow capture charts as included in Appendix F – Flow Capture Charts
2. Hydraulic losses shall be calculated in accordance with the charts and methods described in QUDM or other approved documentation acceptable to a delegated officer from Council's Engineering Section
3. Maximum pit by-pass flow shall be 30 l/s
4. Maximum spacing between directly connected pits shall be 80m
5. No trapped low points will be permitted
6. Structures are to incorporate safety measures, be low maintenance and fit within the amenity of the surrounding area. Non-standard structures will require the approval of a delegated officer from Council's Engineering Section

9. MAJOR SYSTEM CRITERIA (D5.12)

1. The Major system refers to overland flow paths comprising open space, floodway channels, road reserve, pavement areas, detention basins and lagoons, designed to convey storm flows in excess of the minor system capacity. These systems are designed in accordance with Section 3 – Design IFD Rainfall
2. Velocity x Depth product requirements within road reserve (and footpath) are as follows :
    - Maximum depth of water 0.20m
    - Velocity x depth product – pedestrian safety < 0.4 m^2/s
    - Velocity x depth product – vehicle safety only < 0.6 m^2/s
3. Major channels must address safety requirements.
4. Freeboard between the 100 year ARI flood level and floor levels on structures and entrances to underground carparks shall be as presented in Section D5.12 of
5. Where roads are in fill or overtopping of kerbs and flow through property may occur, a 0.100m freeboard shall be provided between the ponding level of water in the road and the high point in the footpath. This shall be considered in the construction of driveways.
6. A Capacity Reduction Factor, F = 0.8, shall be applied in the calculation of flows within the roadway. Manning's 'n' values are as follows :
    - Concrete 0.012
    - Hot Mix 0.014
    - Flush Seal 0.018
7. The 100 year ARI flow path through a development, from any upstream catchments to an acceptable downstream flowpath i.e. an 'escape route' for major system flood flows, must be demonstrated.
8. The **Probable Maximum Flood (PMF)** is defined as the peak flood derived from routing the Probable Maximum Precipitation (PMP) through the stormwater system. Safe passage of the PMF must be demonstrated on major systems where there is risk to property and / or life *(S18.1 ref 4,5,6)*. Investigation is required for (but not limited to)
    - Detention basins / dams and spillways
    - Bridges / major culverts
    - Public infrastructure such as hospitals

10. OPEN CHANNELS (D5.13)

1. Approval by Council for the inclusion of open channels in a development is required. Safety issues and the maintenance of channels and associated low flow systems shall be considered.
2. Sensitivity analysis to consider such issues as variable mannings 'n' and well-maintained / re-vegetated state may be required by Council (S18.1 ref 9,10). Generally acceptable Manning's 'n' Roughness Coefficient values are as follows :

Table 10.1

DESCRIPTION	n
Concrete Pipe or Box	0.011
Concrete (trowel finish)	0.014
Concrete (formed & unfinished)	0.016
Spraycrete (gunite)	0.018
Bitumen Seal	0.018
Brick or paved	0.015
Pitched / dressed stone in mortar	0.016
Rubble Masonry / Random stone in mortar	0.028
Rock lining / Rip Rap	0.028
Corrugated Metal	0.027
Earth (clear)	0.022
Earth (weeds & gravel)	0.028
Rock	0.038
Short Grass	0.033
Long Grass	0.043

11. MAJOR STRUCTURES (D5.14)

9. Major structures are those that are designed to take flows in excess of the minor system capacity or a major road cross culvert or bridge. A delegated officer from Council's Engineering Section may determine that a structure outside this definition warrants consideration as a major structure.
10. Culverts and Floodways shall be designed in accordance with 'Austroads Waterway Design' (S18.1 ref 7,9,10) and consider the requirements of any relevant authorities such as the Roads & Transport Authority.
11. A minimum freeboard of 300mm from the design ARI event to the underside of all structures is required (debris / blockage).
12. All major structures are to be designed for a 1 in 100 year ARI event without afflux. Some afflux and upstream inundation may be permitted provided calculations, to the satisfaction of a delegated officer from Council's Engineering Section, can demonstrate the effect is minimal and that private property is not affected.
13. Certified structural design is required on bridges, major culverts and other structures as determined by a delegated officer from Council's Engineering Section.

12. RETARDATION / DETENTION BASINS (D5.15 & 16)

12.01 MINOR STORAGE VOLUMES

1. For development projects larger than dual occupancy and for multi-unit, commercial and industrial developments, on-site detention (OSD) of stormwater is required

2. Permissible Site Discharge (PSD) is the maximum discharge from the post-development site and shall not exceed the pre-developed flows for all storm events up to the 1 in 100 years ARI
3. Concentrated flows must be managed to the satisfaction of Council
4. The methods to determine required storage volume may be a non-time translation hydrograph method (e.g. Wollongong method or Swinburne method) if the catchment area is no greater than 2500m^2 or 100m^3 storage otherwise a time translation hydrograph method (e.g.. Runoff Routing method) shall be used. **For both cases, the capacity of the existing drainage system must be checked to ensure no increase in flows occurs**
5. PSD shall be determined considering the capacity of the existing system
6. The method of OSD shall be approved by a delegated officer from Council's Engineering Section, subject to the requirements / conditions of a particular development
7. The provision of OSD for a development shall address issues including (but not limited to) control of discharge, relief overflow, water re-use, dedicated detention volume, access, maintenance, ventilation, & safety. Methods of detention may include :
    - In-ground tanks
    - Above-ground storages (car parks / driveways)
    - Above-ground storages (landscaped areas)
    - Rainwater Tanks
8. All OSD's shall be fitted with an overflow which drains to a legal point of discharge. Overflows shall be designed for the 1 in 100 year event without inundation of any floor levels or exceeding appropriate flow depths / velocities
9. OSD's shall be clearly marked by a suitable plate in a prominent position stating *'On Site Detention System – Do not reduce volume or interfere with orifice plate'*, or similar
10. The OSD storage is to be located clear of any overland flow paths
11. Wherever possible, the runoff from the whole development site is to be directed to the OSD storage
12. The preferred orifice diameter shall be 55 mm and is to be protected by a screening device to minimise blockage.
13. Minimum slope on storage areas are to be no less than 1% for turf areas and 0.5 % paved areas
14. Catchment areas, flows and storage details must be indicated on the drawings. Tabulated design calculations shall be provided. Refer Appendix E 'Sample OSD Calculation Sheet' *(Refer Byron Shire Council DCP 2002 – Part N5)*. Note: This method cannot be used in the Ballina Shire (refer to Ballina Councils DCP for the acceptable calculation methodologies).
15. Floor level freeboards from water surface levels shall be provided in accordance with Council requirements
16. Overflows shall be designed to cater for the 1 in 100 year ARI storm in accordance with Council requirements
17. Individual councils shall be consulted regarding specific requirements for stormwater / rainwater tanks

12.02 MAJOR STORAGE VOLUMES

1. When Detention or Retention Basins are used to mitigate the impact of developed flows for developments with catchment areas greater than 2500m^2, or as determined by a delegated officer from Council's Engineering Section, a time translation hydrograph method such as a runoff routing method shall be used to determine required storage volume.
2. A detailed hydrological and hydraulic analysis is required.

3. Computer software used is to be 'recognized industry standard', acceptable to a delegated officer from Council's Engineering Section. A comprehensive list of 'set-up' parameters used to obtain results from the program is to be provided to Council (refer Section 6).
4. All computer analysis results shall be submitted in a clear, concise format that allows Council to carry out any necessary design checks. Explanatory sketches and notes may be required
5. Basins shall be designed so that the peak flow from the proposed development for the 5, 10, 20, 50 and 100 year ARI events, for durations from 5 minutes to 3 hours, does not exceed the existing peak flow from the site i.e. post-development flows must not exceed pre-development flows
6. Peak flows (pre and post-development) are to be calculated using the same methodology
7. Dedication of land to Council and / or easements in favour of Council for stormwater purposes are required over basins including a minimum 5m buffer to surrounding property / infrastructure
8. Off-Line basins may reduce the risk of sequential over-topping
9. The consultant is to provide confirmation of the submission and assessment of the design plans for any proposed basins by the New South Wales Dam Safety Committee *(S18.1 ref 8)*
10. Design and installation of stormwater detention / retention is required on development sites in all areas where under-capacity drainage systems exist downstream of the site or where the proposed development will result in the existing infrastructure surcharging
11. A documented strategy plan for the maintenance of basins, acceptable to Council, is to be provided. This is to include consideration of the design and construction of the basin base and the top of the wall.
12. Public Safety Issues are to be considered and documented, including :
    a. Maximum water depth shall be 1.2m in the 1 in 100 year ARI event
    b. Side slopes steeper than 6 H to 1 V are to have appropriate security / safety fencing
    c. Internal basin side slopes shall be 6H to 1V as a preferred maximum slope
    d. Internal basin side slopes of 4H to 1V shall be permitted as an absolute maximum subject to the approval of a delegated officer from the Council's Engineering Section
    e. Internal basin side slopes steeper than 6H to 1V shall require safety / security fencing
    f. Maximum velocity through the basin during the 1 in 1 year ARI event should not exceed 0.3 m/s
    g. Inlet / Outlet structures shall be located at extreme ends of the basin with short-circuit of flow further minimized by use of baffles
    h. Appropriate hazard / safety signage and depth indicators are to be installed
    i. Flow intakes to be protected considering blockage and safety issues
13. The high level outlet to a basin shall have the capacity to contain a minimum of the ARI 1 in 100 year flood event. Additional spillway capacity may be required. Spillway design shall be in accordance with the requirements for open channels (refer sections 9, 10 & 11)
14. Low flow pipe systems shall be rubber ring jointed (lifting holes appropriately sealed) and designed considering appropriate factors such as permeability, seepage and cut-off walls. Intakes shall be protected against blockage
15. Minimum basin floor slope shall be 1 %
16. Basins shall be designed, where possible, as water quality improvement facilities to meet the requirements of Australian Rainfall Quality (ARQ), Environmental Protection Authority (EPA), appropriate Council DCP's and relevant authorities controlling receiving waters.

17. Any detention basin design must consider any worsening of upstream or downstream conditions due to :
    a. Backwater effects and possible raised upstream flood levels
    b. Extended periods of flow for minor ARI events
    c. Creation of flood peaks which occur at the same time as downstream tributary flood peaks

13. INTER-ALLOTMENT DRAINAGE (D5.17)

1. Inter-allotment drainage systems shall be designed to accept flow from buildings and impervious areas in accordance with the following conditions or as directed by a delegated officer from Council's Engineering Section
2. Pipe sizes shall be a minimum of :
    a. 150mm diameter for up to and including a maximum 2 lots
    b. 225mm diameter up to a maximum 375 diameter for greater than 2 lots in accordance with QUDM Level III (QUDM Table 5.18.6)
    c. For pipe sizes greater than 375mm diameter design is to be in accordance with minor system criteria and QUDM Level IV (QUDM Table 5.18.4)
3. Design of any inter-allotment drain shall consider the existing receiving system
4. Inter-allotment drainage shall be provided for every allotment which does not drain directly to:
    - a street frontage or
    - existing pipeline of adequate capacity to accept additional flow or
    - natural watercourse.
5. Flooding effects shall be considered and allowed for in a design.
6. One residential lot only will be permitted to connect directly to the street. Connection to an underground system is preferred. Refer to Section 16 in this manual for guidance with respect to the provision of Section 88B easements.
7. In rural and rural / residential areas inter-allotment drainage may be omitted if it can be demonstrated that there will be no adverse affects on downstream properties.

14. CONDUITS (D5.18)

1. Supply and installation of all Conduits shall conform with the appropriate Australian Standards *(S18.2)*
2. Where pre-cast concrete pipes shall be subject to tidal influence, salt water concrete cover (Exposure Classification B2 or C) shall be specified
3. Pipe bedding shall be in accordance with the manufacturers recommendations
4. Class of pipe shall be in accordance with the design depth, ground conditions, manufacturers recommendations and shall also consider construction loading
5. Spigot and socket rubber ring jointed pipes shall be used for all pipe sizes.
6. Precast box culvert units shall be installed on cast in-place concrete slabs in accordance with AS1597.2.
7. Steel stormwater pipes shall not be used.
8. Fibre reinforced stormwater pipes shall not be used.

15. PIT DESIGN & STANDARDS (D5.19)

1. Standard drawings for stormwater infrastructure may be accessed via the Lismore City Council web-site. Non-standard structures will require the approval of a delegated officer from Council's Engineering Section.
2. For a list of relevant Australian Standards refer Section 18.2
3. Road Gully Pits are to be aligned with property boundaries where possible and are to be clear of existing services, other infrastructure and driveways.
4. Desirable lintel size is 2.4m (S) being 1.8m opening
5. Stormwater pits are to be as follows :
   a. Structure sizes must increase with increased pipe sizes / configuration - design details may be required
   b. Step-irons are required over 1.2m depth
   c. Rectangular manholes are preferred
   d. Grated road gully pits greater than 1.5m deep and / or constructed over 600mm or greater diameter pipes are to be structurally designed and detailed and shall be certified as structurally adequate for the anticipated service design loads by a professional structural engineer.

Table 15.1

DEPTH (to invert mm)	MINIMUM INTERNAL SIZE mm		
	RECTANGULAR		CIRCULAR
	Width mm	Length mm	Diameter mm
d <= 600	450	450	600
600 < d <= 900	600	600	900
900 < d <= 1200	600	900	1050
d > 1200	900	900	1050

(source AS/NZ3500)

16. STORMWATER DISCHARGE & EASEMENTS (D5.20 & 21)

1. In any proposed development, especially those involving filling, consideration needs to be given to the existing and proposed overland flowpaths in the design. New or re-configured stormwater easements may be required
2. Roof, surface and piped stormwater flows from a development must be designed and directed to a legal point of discharge and be subject to landowners agreements, easements, 'restrictions as to user', dissipation of concentrated flow, water quality assessment and protection of adjoining / downstream property.
3. Any design solution must be acceptable to Council.
4. Section 88B instruments creating easements and 'restrictions as to user' must be drafted, checked by a surveyor and shall be submitted to Council for approval.
5. Written evidence of approval of a 'Legal Point of Discharge' must accompany the design submission for an approval to be given by Council. Negotiations with the appropriate landowner or controlling authority are the responsibility of the developer and / or their representatives. Legal Points of Discharge include (but are not limited to) :
   a. existing Council infrastructure such as kerb & gutter, open channel or stormwater pipeline
   b. unformed road reserve
   c. public stormwater infrastructure via private property in an existing stormwater easement
   d. defined natural waterway controlled by the NSW Department of Natural Resources

6. All drainage structures must be contained within the relevant easement. Easements shall be a minimum width of 3m, or 2m plus the underground conduit width, or the area of influence of the trench, whichever is the greater. For private interallotment drainage lines 225mm in diameter or smaller, the easement width may be reduced to 1.5m (2m LCC) notwithstanding the requirements for the area of influence of the trench.
7. Easements are to be provided over:
    a. private roof water / inter-allotment drainage lines, in favour of upstream owners
    b. inter-allotment drainage lines that receive flows from external public property (such as roads or reserves), in favour of Council
    c. overland flow paths through private property and open channels to contain the 1 in 100 year ARI flood flow plus a minimum 150mm freeboard (considering safety and maintenance access), in favour of Council
8. A 'Restriction As to User' that identifies the natural waterway line and contains the 1 in 100 year ARI flood flow line may require an additional buffer of up to ten metres (10m) either side of the flow line. This shall be accurately identified by survey and noted on the survey plans to prevent the erection of structures or any other obstacle in overland flow paths
9. Fencing is not to interfere with or inhibit overland flows
10. Building platforms and effluent disposal are to be located at least 300mm above the 1 in 100 year ARI flood flow line.
11. Any form of development, the planting of trees, use as an effluent disposal area and the construction of structures is prohibited within the 1 in 100 year overland flow path
12. The development of the site is not to adversely affect adjacent properties or local drainage patterns (in particular detention basins). Provision is to be made for the free passage of surface stormwater away from affected sites.
13. Scour protection shall be provided at the outlet of all conduits and channels in accordance with the Landcom 'Soils and Construction – Volume 1, Chapter 5. Energy dissipators for major culverts shall be in accordance with the New South Wales Roads and Traffic Authority Road Design Guidelines *(S18.1 ref 9,10,11)*.
14. All natural creeks and waterways are to be retained and any works must comply with the requirements of the relevant state authorities (Section 3A Permit)
15. The above requirements do not apply to flood prone lands (i.e. land which is regularly inundated by river flooding events). These locations are covered by the requirements of the relevant Council DCPs, and flood management plans within individual Council areas

17. RURAL RESIDENTIAL DESIGN CONSIDERATIONS

1. The following criteria shall be included in the design of any proposed rural residential development as a minimum requirement :
    a. longitudinal piped drainage
    b. general wider road reservation to facilitate drainage and other infrastructure
    c. localised wider road reservation
    d. offset pavement
    e. box culverts
    f. driveway and culvert arrangement and location
2. Pipe or precast concrete box culverts, bridges or concrete causeways should be located at road crossings of all natural watercourses and extend to the limits of the road formation.
3. Depth of flow indicators and delineator posts shall be used to better define the areas of more frequent inundation

4. Cross drainage design shall take into account the possible debris load from the catchment and in this regard the provision of reinforced concrete box culverts is Council's preferred option.
5. Easements shall be provided on both sides of the road reserve to allow for necessary scour protection works to be undertaken and for future maintenance works as required. These easements shall :
    a. extend to a point where the outlet flow dissipates and spreads to sheet flow or to the natural watercourse flow regime
    b. encapsulate the water course and allow machine access to either side of the watercourse from the road reserve

18. REFERENCES :

18.01 DESIGN GUIDELINES & REPORTS *(web sites last accessed 27 August 2013)*

1	The Northern Rivers Local Government Development & Design Manual – Section D5 Stormwater Drainage Design	
2	Queensland Urban Drainage Manual 2013 (provisional)	http://www.nrm.qld.gov.au/water/regulation/flood_risk_management.html
3	Maclean Shire Council – Stormwater Drainage Design Handbook 1998	
4	Australian Rainfall & Runoff 1987	http://www.ncwe.org.au/arr/index.html
5	The Estimation of Probable Maximum Precipitation in Australia : Generalised Short Duration Method' - Commonwealth Bureau of Meteorology	www.bom.gov.au/water/designRainfalls/pmp/document/GSDM.pdf
6	Floodplain Development Manual 2005 – NSW Department of Infrastructure, Planning and Natural Resources	http://www.environment.nsw.gov.au/floodplains/manual.htm
7	Austroads Guide to Road Design - Drainage	http://www.austroads.com.au/road-design
8	NSW Dam Safety committee	http://www.damsafety.nsw.gov.au/default.shtm
9	RMS NSW Road Design Guidelines	http://www.rta.nsw.gov.au/doingbusinesswithus/lgr/downloads/information/roaddesign-engineering.html
10	Queensland Department of Transport & Main Roads – Technical Guides	http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications.aspx
11	Soils & Construction Manual Department of Environment & Heritage NSW	http://www.environment.nsw.gov.au/stormwater/publications.htm
12	Blacktown City Council – Engineering Guidelines for Development	http://www.blacktown.nsw.gov.au/Planning_and_Development/Plans_and_Guidelines/Engineering_Guidelines_for_Development
13	Campbelltown City Council – Engineering Guidelines for Development	http://www.campbelltown.nsw.gov.au/CampbelltownSustainableCityDevelopmentControlPlan2012?searchTerms[]=engineering&searchTerms[]=guidelines
14	Brisbane City Council (BCC) –Subdivision & Development and Water Sensitive Urban Design Guidelines	http://www.brisbane.qld.gov.au/planning-building/planning-guidelines-and-tools/guidelines/subdivision-development-guidelines/BCC_232
15	Gold Coast City Council (GCCC) – Land Development Guidelines	http://www.goldcoast.qld.gov.au/gcplanningscheme_0509/policy_11.html
16	Gold Coast City Council (GCCC) – Report 990 Full Scale Hydraulic Testing of Lip in Line Gullies (jointly funded by BCC, GCCC & Queensland Department of Main Roads)	
17	Queensland 'Water-By-Design' Guidelines	*http://waterbydesign.com.au/TechGuide/*
18	NSW Department of Planning & Infrastructure 'BASIX' Guidelines	*https://www.basix.nsw.gov.au/basixcms/*
19	Sydney Catchment Authority WSUD reference Guidelines	*http://www.wsud.org/resources-examples/tools-resources/reference-guidelines/wsud-reference-guidelines/*
20	'AUSIFD' software by Dr Graham A. Jenkins, School of Environmental Engineering, Griffith University Queensland	
21	IPWEA NSW Practical Design of Stormwater Retention Basins	

18.2 AUSTRALIAN STANDARDS

AS1141	Methods of sampling and testing aggregates
AS1254	uPVC Pipes
AS1260	PVC Pipes and Fittings for Drain Waste and Vent Applications (sewer grade)
AS1289	Method of Testing Soils for Engineering Purposes
AS1303	Steel Reinforcing Bars for Concrete
AS1379	The specification and Manufacture of Concrete
AS1597	Small Precast Reinforced Concrete Box Culverts (Part 1)
AS1597	Large Precast Reinforced Concrete Box Culverts (Part 2)
AS1646	Elastomeric Seals for Waterworks purposes
AS1830	Iron Castings - Grey Cast Iron
AS2032	Installation of uPVC Pipe Systems
AS2758	Aggregates and rock for engineering purposes
AS/NZ 3500	Plumbing & Drainage (Stormwater Drainage)
AS3600	Concrete Structures
AS3678	Structural Steel - Hot-rolled Plates, Floor-plates and Slabs
AS3725	Loads on Buried Concrete Pipes
AS3996	Metal Access Covers, Road Grates and Frames
AS4058	Precast Concrete Pipes
AS4139	Fibre Reinforced Concrete Pipes and Fittings
AS4680	Hot-dipped Galvanised Coatings on Ferrous Articles

APPENDIX A - IFD DATA

A1 Ballina Shire Council

Alstonville Tropical Fruit Research Station

Regression Coefficients for equation $lnY = A + B(lnX) + C(lnX)^2 + D(lnX)^3 + E(lnX)^4 + F(lnX)^5 + G(lnX)^6$							
ARI	A	B	C	D	E	F	G
1	3.69751406	-0.62069011	-0.02822695	0.02243838	-0.00029868	-0.00155427	0.00018425
2	3.94088745	-0.59440136	-0.01530109	0.01702103	-0.00148988	-0.00095462	0.00012911
5	4.1718359	-0.52329373	0.02018766	0.00255938	-0.00479284	0.00064334	-0.00001374
10	4.28226662	-0.48608595	0.03875091	-0.00500981	-0.0065179	0.00148056	-0.00008903
20	4.42118597	-0.45370162	0.05491292	-0.01160961	-0.00802081	0.00220853	-0.00015433
50	4.56237173	-0.4208357	0.07129901	-0.01831237	-0.00954606	0.00294782	-0.00022088
100	4.66038227	-0.39778441	0.08279558	-0.02299482	-0.01061589	0.00346738	-0.00026705

Duration (mins)	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
	1	**2**	**5**	**10**	**20**	**50**	**100**
6	124.31	157.56	195.22	216.12	246.49	281.72	309.01
7	116.88	148.88	186.98	208.46	239.22	275.11	303.09
8	110.94	141.6	178.75	199.82	229.84	264.95	292.4
9	105.97	135.29	170.93	191.17	219.96	253.66	280.02
10	101.66	129.73	163.66	182.91	210.32	242.38	267.44
11	97.85	124.75	156.98	175.21	201.23	231.63	255.38
12	94.42	120.24	150.86	168.1	192.81	221.62	244.11
13	91.31	116.14	145.25	161.59	185.07	212.42	233.73
14	88.45	112.37	140.11	155.62	177.98	203.99	224.24
15	85.81	108.9	135.39	150.15	171.5	196.3	215.58
16	83.36	105.69	131.05	145.14	165.57	189.29	207.7
17	81.07	102.7	127.04	140.53	160.14	182.87	200.51
18	78.93	99.92	123.34	136.28	155.15	177	193.94
19	76.93	97.31	119.9	132.36	150.56	171.62	187.93
20	75.04	94.86	116.71	128.73	146.32	166.67	182.42
30	60.76	76.68	93.9	103.31	117.18	133.18	145.55
45	48.1	60.96	75.49	83.54	95.25	108.82	119.36
60	40.35	51.46	64.83	72.4	83.19	95.81	105.68
120	26.07	34.01	45.54	52.51	62.04	73.48	82.67
180	20.26	26.8	37.29	43.86	52.73	63.58	72.42
240	17.03	22.72	32.38	38.57	46.87	57.14	65.59
300	14.93	20.04	29	34.82	42.61	52.32	60.36
360	13.44	18.1	26.46	31.95	39.28	48.46	56.09
480	11.42	15.44	22.83	27.73	34.27	42.49	49.36
540	10.69	14.48	21.46	26.1	32.3	40.1	46.63
720	9.11	12.35	18.36	22.37	27.71	34.44	40.09
1080	7.26	9.82	14.54	17.67	21.85	27.09	31.5
1440	6.14	8.29	12.19	14.75	18.18	22.46	26.06
2160	4.79	6.43	9.34	11.23	13.76	16.9	19.55
2880	3.96	5.3	7.64	9.16	11.17	13.67	15.78
3600	3.38	4.53	6.5	7.77	9.46	11.54	13.32
4320	2.96	3.96	5.68	6.78	8.24	10.04	11.59

A2 Byron Shire Council *(Reference BSC Development Control Plan 2002 – Part N5)*

Byron Bay & Bangalow

Duration	LPIII Intensity (mm/hr) for Average Recurrence Interval (Years)						
	1	2	5	10	20	50	100
5 min	128	160	190	215	240	260	300
6 min	120	150	180	200	222	250	280
10 min	98	125	150	165	180	210	235
20 min	72	90	110	125	140	155	170
30 min	60	75	90	100	115	130	140
1 hr	40	50	63	70	80	90	100
2 hrs	26	34	42	47	54	62	78
3 hrs	20	26	34	38	43	50	54
6 hrs	12	16	21	24	28	32	34
12 hrs	8	10	14	15	18	21	22
24 hrs	5.5	7.7	9	10.5	12.5	14.5	16
48 hrs	3.5	4.6	6.5	7.5	8.7	10.8	12
72 hrs	2.7	3.6	5.1	6	7.2	9.2	10.5

Ocean Shores, Brunswick Heads & Mullumbimby

Duration	LPIII Intensity (mm/hr) for Average Recurrence Interval (Years)						
	1	2	5	10	20	50	100
5 min	130	161	200	220	245	285	305
6 min	120	151	186	210	230	270	290
10 min	100	125	155	170	190	225	240
20 min	72	90	115	130	145	170	185
30 min	59	74	94	105	120	140	153
1 hr	40	50	65	75	85	100	110
2 hrs	27	34	44	51	60	70	76
3 hrs	21.5	27	35	40	47	55	60
6 hrs	14	17.5	23	26	30	36	40
12 hrs	9.2	11.7	15.2	17.5	20	24	26
24 hrs	6	7.8	10.3	11.8	13.8	16	18
48 hrs	4	5	6.7	8	9.2	11	13.5
72 hrs	3	3.8	5.3	6.4	7.5	9.2	12.1

Huonbrook, Wilsons Creek & Main Arm

Duration	LPIII Intensity (mm/hr) for Average Recurrence Interval (Years)						
	1	2	5	10	20	50	100
5 min	121	160	198	220	245	290	320
6 min	115	150	185	208	233	275	300
10 min	93	122	150	170	190	222	250
20 min	68	90	112	127	144	160	185
30 min	55	73	93	105	120	140	155
1 hr	38	50	65	74	85	102	111
2 hrs	23	34	45	53	59	71	79
3 hrs	21.3	27.5	36	42	46.5	57	63
6 hrs	14.7	19	25.5	30	32	40	44
12 hrs	10	13	17	21.7	22.1	28	30.9
24 hrs	7	9	11.7	15	16	20	23
48 hrs	4.8	6.3	8.3	10.4	11.8	14.9	16.7
72 hrs	3.7	5	7	8.5	9.8	12	13.6

A3 Clarence Valley Council *(Source - AR&R, AusIFD ver 2.0.1 (2005) Dr. G. A. Jenkins)*

GRAFTON (Latitude 29.68° Longitude 152.93°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
40.35	7.9	2.44	70	15.94	5.11	0.11	4.38	16.61

Duration (mins)	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
	1	**2**	**5**	**10**	**20**	**50**	**100**
5	102	129	159	177	200	231	255
6	96	121	149	165	188	217	239
7	90	115	141	156	177	205	225
8	86	109	134	148	168	194	214
9	82	104	128	141	160	185	204
10	78	99	122	135	154	177	195
11	75	95	117	130	147	170	187
12	72	92	113	125	142	164	181
13	70	89	109	121	137	158	174
14	68	86	105	117	132	153	168
15	65	83	102	113	128	148	163
16	64	81	99	110	124	144	158
17	62	78	96	107	121	140	154
18	60	76	94	104	118	136	150
19	58	74	91	101	115	132	146
20	57	72	89	99	112	129	142
25	51	65	80	88	100	115	127
30	46	59	72	80	91	105	115
45	37	47	58	64	73	84	93
60	32	40	49	55	62	71	79
120	20	26	32	36	41	48	53
180	15	20	25	28	32	37	42
240	13	16	21	23	27	32	35
300	11	14	18	20	23	28	31
360	10	12	16	18	21	25	28
420	9	11	15	16	19	23	25
480	8	10	13	15	18	21	23
540	7	9	12	14	16	19	22
600	7	9	12	13	15	18	20
660	6	8	11	12	14	17	19
720	6	8	10	12	14	16	18
840	5	7	9	11	13	15	17
960	5	7	9	10	12	14	16
1080	5	6	8	9	11	13	14
1200	4	6	8	9	10	12	14
1320	4	5	7	8	10	11	13
1440	4	5	7	8	9	11	12
2160	3	4	5	6	7	8	9
2880	2	3	4	5	6	7	8
3600	2	3	4	4	5	6	7
4320	2	2	3	4	4	5	6

YAMBA (Latitude 29.45° Longitude 153.48°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
41.8	8.2	2.65	82.5	16.3	5.85	0.05	4.39	16.78
Yamba, Angourie, Iluka, Maclean, Townsend, Ashby, Woombah, Brooms Head, Chatsworth I., Palmers I., & East of Maclean								

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	105	134	170	191	218	255	282
6	98	126	160	179	205	239	265
7	93	119	151	169	194	227	251
8	88	113	143	161	185	216	239
9	84	108	137	154	176	206	229
10	80	103	131	147	169	198	220
11	77	99	126	142	163	190	211
12	74	95	121	137	157	184	204
13	72	92	117	132	152	177	197
14	69	89	113	128	147	172	191
15	67	86	110	124	142	167	185
16	65	84	107	120	138	162	180
17	63	81	104	117	135	158	175
18	62	79	101	114	131	154	171
19	60	77	99	111	128	150	167
20	58	75	96	108	125	146	163
25	52	67	86	97	112	131	146
30	47	61	78	89	102	120	134
45	38	49	63	72	83	97	109
60	32	42	54	61	71	83	93
120	21	27	35	39	45	53	60
180	16	20	26	30	35	41	46
240	13	17	22	25	29	34	38
300	11	15	19	21	25	29	33
360	10	13	17	19	22	26	29
420	9	12	15	17	20	24	26
480	8	11	14	16	18	22	24
540	8	10	13	15	17	20	22
600	7	9	12	14	16	19	21
660	7	9	11	13	15	17	20
720	6	8	11	12	14	17	18
840	6	7	10	11	13	15	17
960	5	7	9	10	12	14	16
1080	5	6	8	10	11	13	15
1200	5	6	8	9	11	13	14
1320	4	6	8	9	10	12	13
1440	4	5	7	8	10	11	13
2160	3	4	6	6	8	9	10
2880	3	4	5	5	6	8	9
3600	2	3	4	5	6	7	8
4320	2	3	4	4	5	6	7

BRUSHGROVE (Latitude 29.49° Longitude 153.08°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
40.74	8	2.5	77	15.94	5.18	0.08	4.38	16.69
Brushgrove, Ulmarra, Tucabia, Illarwill, Gulmarrad, Lawrence & West of Maclean								

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	102	131	164	184	210	245	271
6	96	123	154	172	197	230	254
7	90	116	146	163	186	217	241
8	86	110	138	155	177	206	229
9	82	105	132	148	169	197	219
10	78	100	126	142	162	189	210
11	75	96	121	136	156	182	201
12	72	93	117	131	150	175	194
13	70	90	113	127	145	169	188
14	68	87	109	122	140	164	182
15	66	84	106	119	136	159	176
16	64	81	103	115	132	154	171
17	62	79	100	112	128	150	166
18	60	77	97	109	125	146	162
19	59	75	95	106	122	142	158
20	57	73	92	104	119	139	154
25	51	65	83	93	107	125	138
30	46	59	75	85	97	114	126
45	37	48	61	68	78	92	102
60	32	41	52	58	67	78	87
120	20	26	33	38	43	51	57
180	15	20	26	29	33	39	44
240	13	16	21	24	28	33	37
300	11	14	18	21	24	28	32
360	10	13	16	18	21	25	28
420	9	11	15	17	19	23	26
480	8	10	14	15	18	21	24
540	7	10	13	14	16	20	22
600	7	9	12	13	15	18	20
660	7	8	11	13	15	17	19
720	6	8	10	12	14	16	18
840	6	7	9	11	13	15	17
960	5	7	9	10	12	14	15
1080	5	6	8	9	11	13	14
1200	4	6	8	9	10	12	14
1320	4	5	7	8	10	11	13
1440	4	5	7	8	9	11	12
2160	3	4	5	6	7	8	9
2880	3	3	4	5	6	7	8
3600	2	3	4	4	5	6	7
4320	2	2	3	4	4	5	6

A4 Kyogle Shire Council *(Source – AR&R, AusIFD ver 2.0.1 (2005) Dr. G. A. Jenkins)*

KYOGLE (Latitude 28.62° Longitude 153.12°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
40.74	8	2.5	77	15.94	5.18	0.08	4.38	16.69

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	99	127	158	176	201	235	260
6	93	119	148	165	188	220	243
7	88	112	139	156	178	207	229
8	83	106	132	148	169	196	218
9	79	101	126	141	161	187	207
10	76	97	121	135	154	179	198
11	73	93	116	129	147	171	190
12	70	90	111	124	142	165	183
13	68	86	108	120	137	159	176
14	66	84	104	116	132	154	170
15	64	81	101	112	128	149	165
16	62	79	98	109	124	144	160
17	60	76	95	106	120	140	155
18	58	74	92	103	117	136	151
19	57	72	90	100	114	133	147
20	55	71	88	98	111	129	143
25	50	63	78	87	99	115	127
30	45	57	71	79	90	104	116
45	36	46	57	63	72	83	92
60	31	39	48	53	61	71	78
120	20	26	32	36	41	47	52
180	16	20	25	28	32	37	41
240	13	17	21	24	27	31	35
300	12	15	19	21	24	28	31
360	10	13	17	19	21	25	27
420	9	12	15	17	19	23	25
480	9	11	14	16	18	21	23
540	8	10	13	15	17	20	22
600	8	10	12	14	16	18	20
660	7	9	12	13	15	17	19
720	7	9	11	12	14	16	18
840	6	8	10	11	13	15	17
960	6	7	9	11	12	14	16
1080	5	7	9	10	11	13	15
1200	5	6	8	9	11	13	14
1320	5	6	8	9	10	12	13
1440	5	6	7	8	10	11	13
2160	4	5	6	7	8	9	10
2880	3	4	5	6	6	8	8
3600	3	3	4	5	6	7	7
4320	2	3	4	4	5	6	7

WOODENBONG (Latitude 28.4° Longitude 152.6°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
40.0	7.0	2.4	70.0	14.0	4.7	0.25	4.38	16.85

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	100	127	159	178	205	241	269
6	93	119	149	167	192	225	252
7	88	113	141	158	181	213	237
8	84	107	134	150	172	202	225
9	80	102	127	143	164	192	215
10	76	98	122	137	157	184	205
11	73	94	117	131	150	176	197
12	71	90	113	126	145	170	189
13	68	87	109	122	140	164	183
14	66	84	105	118	135	158	177
15	64	82	102	114	131	153	171
16	62	79	99	110	127	149	166
17	60	77	96	107	123	144	161
18	59	75	93	104	120	140	157
19	57	73	91	102	117	137	152
20	56	71	89	99	114	133	149
25	50	64	79	89	101	119	133
30	45	58	72	80	92	108	120
45	36	46	58	64	74	86	96
60	31	40	49	55	63	73	81
120	19	25	31	35	40	47	53
180	14	18	23	26	31	36	41
240	12	15	19	22	25	30	34
300	10	13	16	19	22	26	29
360	9	11	15	17	19	23	26
420	8	10	13	15	17	21	24
480	7	9	12	14	16	19	22
540	6	8	11	13	15	18	20
600	6	8	10	12	14	17	19
660	6	7	10	11	13	16	18
720	5	7	9	10	12	15	17
840	5	6	8	10	11	14	15
960	4	6	8	9	10	13	14
1080	4	5	7	8	10	12	13
1200	4	5	7	8	9	11	13
1320	4	5	6	7	9	10	12
1440	4	5	6	7	8	10	11
2160	3	4	5	6	7	9	10
2880	3	4	5	6	6	8	9
3600	2	3	4	5	5	6	7
4320	2	3	3	4	5	6	6

LOADSTONE (Latitude 28.4° Longitude 152.98°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
42.0	8.8	3	75.0	16.0	6.0	0.15	4.39	16.95

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	105	134	167	186	213	248	275
6	99	126	157	175	199	232	258
7	93	119	148	165	188	219	243
8	88	113	140	157	179	208	231
9	84	108	134	149	171	199	220
10	81	103	128	143	163	190	211
11	78	99	123	137	157	183	203
12	75	95	119	132	151	176	195
13	72	92	114	128	146	170	188
14	70	89	111	123	141	164	182
15	67	86	107	120	137	159	176
16	65	84	104	116	133	154	171
17	64	81	101	113	129	150	166
18	62	79	98	110	125	146	162
19	60	77	96	107	122	142	158
20	59	75	94	104	119	139	154
25	53	67	84	93	107	124	138
30	48	61	76	85	97	113	125
45	38	49	61	68	78	91	101
60	33	42	52	58	66	77	85
120	21	27	34	38	43	50	56
180	16	21	26	29	34	39	44
240	14	18	22	25	28	33	36
300	12	15	19	21	24	28	32
360	11	14	17	19	22	25	28
420	10	12	15	17	20	23	26
480	9	11	14	16	18	21	24
540	8	11	13	15	17	20	22
600	8	10	12	14	16	18	21
660	7	9	12	13	15	17	19
720	7	9	11	12	14	17	18
840	6	8	10	11	13	15	17
960	6	7	9	11	12	14	16
1080	5	7	9	10	11	13	15
1200	5	7	8	9	11	13	14
1320	5	6	8	9	10	12	14
1440	5	6	8	8	10	12	13
2160	4	5	6	7	8	9	10
2880	3	4	5	6	7	8	9
3600	3	3	4	5	6	7	8
4320	2	3	4	4	5	6	7

TOONUMBAR (Latitude 28.56° Longitude 152.75°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
40.0	8.0	2.5	66.5	16.05	5.7	0.20	4.39	16.85

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	101	128	158	175	199	231	256
6	95	120	148	164	186	216	239
7	89	113	139	154	176	204	226
8	85	108	132	146	167	193	214
9	81	103	126	140	159	184	203
10	77	98	120	133	152	176	194
11	74	94	116	128	145	169	186
12	72	91	111	123	140	162	179
13	69	88	107	119	135	156	173
14	67	85	104	115	130	151	167
15	65	82	100	111	126	146	161
16	63	80	97	108	122	142	156
17	61	77	95	105	119	137	152
18	59	75	92	102	115	134	148
19	58	73	90	99	112	130	144
20	56	72	87	97	110	127	140
25	50	64	78	86	98	113	124
30	46	58	71	78	89	102	113
45	37	47	57	62	71	81	90
60	31	40	48	53	60	69	76
120	20	26	32	35	40	47	52
180	15	20	25	28	32	37	41
240	13	16	21	23	27	31	35
300	11	14	18	20	23	28	31
360	10	12	16	18	21	25	28
420	9	11	15	17	19	23	26
480	8	10	13	15	18	21	24
540	7	10	12	14	17	20	22
600	7	9	12	13	16	19	21
660	6	8	11	13	15	18	20
720	6	8	10	12	14	17	19
840	6	7	9	11	13	15	18
960	5	7	9	10	12	14	16
1080	5	6	8	9	11	14	15
1200	4	6	8	9	11	13	15
1320	4	5	7	8	10	12	14
1440	4	5	7	8	9	12	13
2160	3	4	5	6	7	9	11
2880	2	3	4	5	6	8	9
3600	2	3	4	5	5	7	8
4320	2	2	3	4	5	6	7

BONALBO (Latitude 28.9° Longitude 152.6°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
35.0	7.5	2.4	61.5	13.5	4.6	0.24	4.38	16.7

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	88	113	143	162	187	222	249
6	82	106	134	151	175	207	232
7	78	100	126	143	165	195	218
8	74	95	120	135	156	184	206
9	70	90	114	129	148	175	196
10	67	86	109	123	142	167	187
11	65	83	105	118	136	160	180
12	62	80	101	113	131	154	172
13	60	77	97	109	126	148	166
14	58	74	94	105	122	143	160
15	56	72	91	102	118	138	155
16	55	70	88	99	114	134	150
17	53	68	85	96	111	130	146
18	52	66	83	93	107	126	141
19	50	64	81	91	104	123	137
20	49	63	79	88	102	120	134
25	44	56	70	79	91	106	119
30	40	51	64	71	82	96	107
45	32	41	51	57	65	76	85
60	27	35	43	48	55	64	71
120	18	23	28	32	36	42	47
180	14	18	22	25	28	33	37
240	12	15	18	21	24	28	31
300	10	13	16	18	21	24	27
360	9	11	14	16	18	22	24
420	8	10	13	15	17	20	22
480	7	10	12	13	15	18	20
540	7	9	11	12	14	17	19
600	6	8	10	12	13	16	18
660	6	8	10	11	13	15	17
720	6	7	9	10	12	14	16
840	5	7	8	10	11	13	15
960	5	6	8	9	10	12	13
1080	5	6	7	8	10	11	13
1200	4	5	7	8	9	11	12
1320	4	5	7	7	8	10	11
1440	4	5	6	7	8	10	11
2160	3	4	5	5	6	8	8
2880	2	3	4	5	5	6	7
3600	2	3	3	4	5	5	6
4320	2	2	3	3	4	5	5

DYRAABA (Latitude 28.7° Longitude 152.85°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
40.6	8.1	2.5	65.0	16.0	5.3	0.18	4.39	16.8

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	103	130	158	174	197	227	249
6	96	122	148	163	184	212	233
7	91	115	140	153	173	199	219
8	87	109	132	146	164	189	208
9	83	104	126	139	156	180	198
10	79	100	121	133	150	172	189
11	76	96	116	127	143	165	181
12	73	92	111	122	138	158	174
13	71	89	107	118	133	153	168
14	68	86	104	114	128	147	162
15	66	83	101	110	124	143	157
16	64	81	98	107	121	138	152
17	62	79	95	104	117	134	147
18	61	77	92	101	114	130	143
19	59	75	90	98	111	127	139
20	58	73	87	96	108	124	136
25	52	65	78	85	96	110	121
30	47	59	71	77	87	100	109
45	38	47	57	62	69	79	87
60	32	40	48	52	59	67	73
120	20	26	32	35	40	46	50
180	16	20	25	27	31	36	40
240	13	16	21	23	26	31	34
300	11	14	18	20	23	27	30
360	10	13	16	18	21	25	27
420	9	11	15	16	19	23	25
480	8	10	13	15	18	21	23
540	7	10	12	14	16	20	22
600	7	9	12	13	16	18	21
660	7	8	11	13	15	17	20
720	6	8	10	12	14	17	19
840	6	7	10	11	13	15	17
960	5	7	9	10	12	14	16
1080	5	6	8	9	11	13	15
1200	4	6	8	9	10	12	14
1320	4	6	7	8	10	12	13
1440	4	5	7	8	9	11	13
2160	3	4	5	6	7	9	10
2880	3	3	4	5	6	7	8
3600	2	3	4	4	5	6	7
4320	2	2	3	4	5	6	6

TABULAM (Latitude 28.9° Longitude 152.55°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
34.0	6.9	1.96	60.7	12.5	3.75	0.24	4.38	16.7

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	85	110	141	160	185	220	248
6	80	103	132	149	173	205	231
7	75	97	124	140	163	193	217
8	72	92	118	133	154	183	206
9	68	88	112	127	147	174	195
10	65	84	107	121	140	166	187
11	63	81	103	116	134	159	179
12	60	78	99	112	129	153	172
13	58	75	95	107	124	147	165
14	56	72	92	104	120	142	159
15	55	70	89	100	116	137	154
16	53	68	86	97	112	133	149
17	51	66	84	94	109	129	145
18	50	64	81	92	106	125	140
19	49	63	79	89	103	122	137
20	48	61	77	87	100	119	133
25	42	54	69	77	89	105	118
30	39	50	62	70	81	95	107
45	31	40	50	56	64	75	84
60	26	34	42	47	54	63	71
120	17	22	27	30	35	41	46
180	13	17	21	24	27	32	36
240	11	14	17	20	22	26	30
300	9	12	15	17	19	23	26
360	8	11	13	15	17	20	23
420	8	10	12	14	16	18	21
480	7	9	11	13	14	17	19
540	6	8	10	12	13	16	18
600	6	8	10	11	13	15	16
660	6	7	9	10	12	14	15
720	5	7	9	10	11	13	15
840	5	6	8	9	10	12	13
960	4	6	7	8	9	11	12
1080	4	5	7	7	9	10	11
1200	4	5	6	7	8	9	11
1320	4	5	6	7	8	9	10
1440	3	4	5	6	7	8	9
2160	3	3	4	5	5	6	7
2880	2	3	3	4	4	5	6
3600	2	2	3	3	4	5	5
4320	1	2	2	3	3	4	4

MUMMULGUM (Latitude 28.85° Longitude 152.8°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
40.4	8.7	2.7	63	16.4	6.2	0.2	4.39	16.8

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years))**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	103	129	156	172	194	223	245
6	96	121	146	161	181	208	229
7	91	115	138	151	171	196	215
8	86	109	131	144	162	186	204
9	82	104	125	137	154	177	194
10	79	99	119	131	147	169	185
11	76	95	114	125	141	162	177
12	73	92	110	120	136	155	170
13	70	89	106	116	131	150	164
14	68	86	103	112	126	144	158
15	66	83	99	109	122	140	153
16	64	80	96	105	118	135	148
17	62	78	94	102	115	131	144
18	61	76	91	99	112	128	140
19	59	74	89	97	109	124	136
20	58	72	86	94	106	121	132
25	51	65	77	84	94	107	117
30	47	59	70	76	85	97	106
45	38	47	56	61	68	77	84
60	32	40	47	51	57	65	71
120	21	26	32	35	39	45	49
180	16	20	25	28	31	36	40
240	13	17	21	23	27	31	34
300	12	15	18	21	24	27	30
360	10	13	17	19	21	25	28
420	9	12	15	17	19	23	25
480	9	11	14	16	18	21	24
540	8	10	13	15	17	20	22
600	7	10	12	14	16	19	21
660	7	9	12	13	15	18	20
720	7	9	11	12	14	17	19
840	6	8	10	11	13	16	18
960	6	7	9	11	12	15	17
1080	5	7	9	10	12	14	16
1200	5	6	8	9	11	13	15
1320	5	6	8	9	10	13	14
1440	4	6	7	8	10	12	14
2160	3	4	6	7	8	10	11
2880	3	4	5	6	7	8	10
3600	2	3	4	5	6	7	8
4320	2	3	4	4	5	7	8

A5 Lismore City Council *(Engineering Guidelines Section 2.1)*

Lismore Urban Area / Goonellabah AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
44.80	9.37	3.06	83.30	17.70	6.12	0.05	4.40	16.94

Duration	**LPIII Intensity (mm/hr) for Average Recurrence Interval (Years))**						
	1	**2**	**5**	**10**	**20**	**50**	**100**
5 mins	113	144	178	197	222	256	283
6 mins	106	135	167	185	209	241	266
10 mins	86.8	111	137	152	172	199	220
20 mins	63.3	80.7	101	112	127	147	162
30 mins	51.5	65.6	82.0	91.4	104	120	133
1 hr	35.1	44.8	56.3	62.9	71.7	83.3	92.2
2 hr	22.8	29.2	36.7	41.1	46.9	54.5	60.3
3 hr	17.7	22.6	28.4	31.8	36.3	42.3	46.8
6 hr	11.4	14.5	18.3	20.5	23.4	27.3	30.2
12 hr	7.32	9.37	11.8	13.3	15.2	17.7	19.6
24 hr	4.85	6.23	7.93	8.93	10.3	12.0	13.4
48 hr	3.14	4.04	5.20	5.88	6.78	7.97	8.89
72 hr	2.37	3.06	3.96	4.49	5.19	6.12	6.84

Overland flow travel time aid Table of $txI^{0.4}$ values for use in conjunction with Technical Note 3 page 300 ARR 1987

ARI Duration	**1 Years**	**10 Years**	**20 Years**	**100 Years**
5 min	33	41	43	48
6 min	39	48	51	56
7 min	44	55	58	64
8 min	49	62	65	72
9 min	55	68	72	79
10 min	60	75	78	86
12 min	69	86	91	101
14 min	79	99	104	114
16 min	88	110	116	128
18 min	97	121	130	140
20 min	105	132	139	153

Nimbin Village AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
45.00	11.00	3.80	82.00	22.00	9.50	0.08	4.40	16.95

Duration	**LPIII Intensity (mm/hr) for Average Recurrence Interval (Years)**						
	1	**2**	**5**	**10**	**20**	**50**	**100**
5 mins	113	144	177	196	223	257	283
6 mins	106	135	166.	184	209	242	266
10 mins	86.7	110	137	152	172	199	220
20 mins	63.8	80.5	100	111	127	147	162
30 mins	51.3	65.5	81.7	91.0	104	120	133
1 hr	35.0	44.8	56.1	62.7	71.5	83.2	92.1
2 hr	23.7	30.4	38.5	43.3	49.6	58.0	64.5
3 hr	18.8	24.1	30.8	34.7	39.9	46.8	52.1
6 hr	12.5	16.2	20.9	23.7	27.4	35.2	36.1
12 hr	8.43	10.9	14.2	16.2	18.8	22.4	25.1
24 hr	5.65	7.42	10.0	11.6	13.7	16.5	18.7
48 hr	3.71	4.92	6.87	8.13	9.74	11.9	13.7
72 hr	2.82	3.78	5.40	6.46	7.82	9.71	11.2

Overland flow travel time aid, Table of $txI^{0.4}$ values for use in conjunction with Technical Note 3 page 300 ARR 1987

ARI Duration	**1 Years**	**10 Years**	**20 Years**	**100 Years**
5 min	33	41	43	48
6 min	39	48	51	56
7 min	44	55	58	64
8 min	49	62	65	72
9 min	55	68	72	79
10 min	60	75	78	86
12 min	69	86	91	101
14 min	79	99	104	114
16 min	88	110	116	128
18 min	97	121	130	140
20 min	105	132	139	153

A6 Richmond Valley Council *(Reference CSC Standard Drawing CC4.1)*

Casino

Duration	Intensity (mm/hr) for Average Recurrence Interval (Years))						
	1	2	5	10	20	50	100
5 mins	95.9	122.8	154.4	173.0	198.3	231.7	257.4
6 mins	89.9	115.1	144.7	162.0	185.7	216.9	241.0
7 mins	84.9	108.6	136.5	152.8	175.1	204.5	227.1
8 mins	80.6	103.1	129.5	144.9	166.0	193.9	215.3
9 mins	76.8	98.3	123.4	138.1	158.2	184.7	205.1
10 mins	73.5	94.1	118.1	132.1	151.3	176.6	196.0
11 mins	70.6	90.3	113.3	126.8	145.1	169.4	188.0
12 mins	68.0	86.9	109.0	122.0	139.6	162.9	180.8
13 mins	65.6	83.9	105.2	117.6	134.6	157.1	174.4
14 mins	63.4	81.1	101.6	113.7	130.1	151.8	168.4
15 mins	61.4	78.5	98.4	110.1	125.9	146.9	163.0
16 mins	59.6	76.2	95.5	106.7	122.1	142.4	158.1
17 mins	57.9	74.0	92.7	103.7	118.6	138.3	153.5
18 mins	56.3	72.0	90.2	100.8	115.3	134.5	149.2
19 mins	54.9	70.1	87.8	98.2	112.3	130.9	145.2
20 mins	53.5	68.4	85.6	95.7	109.4	127.6	141.5
21 mins	52.2	66.7	83.5	93.4	106.8	124.5	138.0
22 mins	51.0	65.2	81.6	91.2	104.3	121.5	134.8
23 mins	49.9	63.8	79.8	89.1	101.9	118.8	131.7
24 mins	48.8	62.4	78.0	87.2	99.7	116.2	128.8
25 mins	47.8	61.1	76.4	85.3	97.6	113.7	126.1
26 mins	46.9	59.9	74.9	83.6	95.6	111.4	123.5
27 mins	45.9	58.7	73.4	82.0	93.7	109.2	121.0
28 mins	45.1	57.6	72.0	80.4	91.9	107.1	118.7
29 mins	44.3	56.5	70.7	78.9	90.2	105.0	116.5
30 mins	43.5	55.5	69.4	77.5	88.5	103.1	114.3
45 mins	34.8	44.5	55.5	61.9	70.7	82.2	91.1
60 mins	29.6	37.7	47.0	52.4	59.8	69.6	77.0
90 mins	22.8	29.2	36.6	41.0	46.9	54.8	60.8
2 hrs	18.9	24.3	30.6	34.3	39.4	46.1	51.3
3 Hrs	14.5	18.6	23.7	26.7	30.7	36.0	40.2
6 hrs	9.2	11.8	15.2	17.3	20.0	23.6	26.4
12 hrs	5.8	7.5	9.8	11.2	13.0	15.5	17.4
24 hrs	3.8	4.9	6.4	7.3	8.6	10.2	11.5
48 hrs	2.4	3.1	4.1	4.7	5.5	6.6	7.4
72 hrs	1.8	2.3	3.1	3.5	4.1	4.9	5.6

Evans Head (Latitude 29.07° Longitude 153.25°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
45.00	8.60	3.10	83.00	16.20	6.20	0.04	4.39	16.82

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years)**						
	1	**2**	**5**	**10**	**20**	**50**	**100**
5 mins	113.38	143.80	177.38	196.15	222.04	255.46	280.62
6 mins	106.26	134.83	166.49	184.21	208.63	240.16	263.91
10 mins	86.98	110.50	136.91	151.74	172.10	198.44	218.30
12 mins	80.43	102.23	126.82	140.66	159.62	184.17	202.68
15 mins	72.73	92.50	114.94	127.59	144.9	167.32	184.24
18 mins	66.73	84.92	105.66	117.38	133.39	154.14	169.81
20 mins	63.39	80.70	100.50	111.70	126.97	146.78	161.75
25 mins	56.67	72.20	90.08	100.21	114.01	131.92	145.46
30 mins	51.54	65.70	82.10	91.42	104.07	120.51	132.95
45 mins	41.35	52.78	66.20	73.85	84.21	97.69	107.90
1 hr	35.13	44.89	56.46	63.07	72.00	83.63	92.46
1.5 hr	26.99	34.51	43.46	48.59	55.50	64.51	71.36
2 hr	22.30	28.53	35.96	40.22	45.96	53.45	59.14
3 hr	16.99	21.74	27.45	30.72	35.13	40.89	45.26
4.5 hr	12.93	16.55	20.93	23.44	26.82	31.24	34.59
6 hr	10.65	13.64	17.26	19.35	22.15	25.81	28.59
9 hr	8.11	10.40	13.18	14.78	16.93	19.74	21.88
12 hr	6.69	8.58	10.88	12.21	14.00	16.33	18.10
18 hr	5.38	6.91	8.81	9.91	11.38	13.31	14.79
24 hr	4.59	5.91	7.56	8.53	9.81	11.50	12.79
30 hr	4.06	5.22	6.71	7.57	8.73	10.24	11.40
36 hr	3.66	4.71	6.07	6.86	7.91	9.30	10.36
48 hr	3.09	3.98	5.15	5.84	6.74	7.94	8.85
72 hr	2.39	3.09	4.02	4.57	5.29	6.25	6.99

Coraki / Woodburn (Latitude 28.59° Longitude 153.17°) AR&R V2 Map Coefficients								
1 hr 2 yr	**12 hr 2 Yr**	**72 hr 2 Yr**	**1 hr 50 yr**	**12 hr 50 yr**	**72 hr 50 yr**	**Skew**	**F2**	**F50**
44.00	8.80	2.80	78.00	15.50	5.70	0.06	4.40	16.94

Duration	**Intensity (mm/hr) for Average Recurrence Interval (Years)**						
	1	**2**	**5**	**10**	**20**	**50**	**100**
5 mins	111.14	140.86	173.23	191.37	216.53	249.08	273.63
6 mins	104.18	132.06	162.46	179.51	203.14	233.72	256.79
10 mins	85.31	108.18	133.24	147.31	166.79	192.01	211.04
12 mins	78.89	100.06	123.30	136.36	154.42	177.80	195.46
15 mins	71.35	90.51	111.60	123.45	139.84	161.07	177.10
18 mins	65.47	83.08	102.48	113.39	128.47	148.01	162.77
20 mins	62.20	78.94	97.40	107.80	122.15	140.75	154.79
25 mins	55.62	70.60	87.17	96.51	109.39	126.08	138.70
30 mins	50.60	64.24	79.36	87.88	99.63	114.87	126.39
45 mins	40.61	51.58	63.80	70.70	80.20	92.53	101.84
1 hr	34.51	43.85	54.29	60.20	68.31	78.85	86.82
1.5 hr	26.73	33.96	42.02	46.58	52.85	60.99	67.14
2 hr	22.21	28.21	34.91	38.69	43.89	50.64	55.74
3 hr	17.06	21.67	26.80	29.69	33.68	38.85	42.76
4.5 hr	13.09	16.62	20.54	22.76	25.81	29.76	32.75
6 hr	10.85	13.77	17.02	18.85	21.37	24.64	27.12
9 hr	8.33	10.57	13.06	14.46	16.40	18.90	20.80
12 hr	6.91	8.77	10.83	11.99	13.59	15.67	17.23
18 hr	5.39	6.87	8.60	9.58	10.92	12.67	14.00
24 hr	4.51	5.77	7.28	8.16	9.34	10.88	12.06
30 hr	3.91	5.02	6.39	7.18	8.25	9.64	10.71
36 hr	3.48	4.48	5.73	6.46	7.43	8.72	9.71
48 hr	2.87	3.71	4.79	5.43	6.28	7.40	8.26
72 hr	2.15	2.79	3.66	4.18	4.86	5.77	6.48

APPENDIX B - STANDARD COMPUTER MODEL PARAMETERS & ASSUMPTIONS

• PARAMETERS TO BE USED IN RAFTS MODELLING

1. The use of RAFTS (Runoff Analysis & Flow Training Simulation) is permissible for catchment wide / detention basin analysis but not recommended for urban areas
2. Where a range of values is given, use of the value selected needs to be justified.
3. Where there is any possibility of variation in values, multiple runs to test sensitivity will be required.
4. RAFTS runs are to be carried out for a range of storms including (as a minimum) 2yr, 5yr, 10yr, 20yr, 50yr, 100yr ARI and PMP
5. A range of storm durations for each of these recurrence intervals must be modelled sufficiently to show that the peak flows at each sub-catchment node peak flows have been identified.
6. The fraction impervious is to be in accordance with QUDM Table 5.04.1 or other recognized reference and must be verified by site inspection. The value identified by site inspection will be the minimum value to use in any sensitivity analysis.
7. If the Initial and Continuing loss model is used :
   a. Impervious area losses are to be IL=1.5mm and CL=0mm/hr
   b. Pervious area losses are to be IL=15 mm and CL=2.5mm/hr
   c. PMF pervious and impervious areas losses are to be IL=0mm and CL=0mm/hr
8. ARBM (Australian Representatives Basin Model) water balance model parameters are given below. Use of values other than those given must be justified
9. PERN (Population-Environment Research Network) factors used to adjust the catchment routing factor to allow for catchment roughness values must be justified. Typical Values are as tabulated below :

PERN VALUE	DESCRIPTION
0.015	Impervious Area
0.025	Urban Pervious Area
0.05 – 0.07	Rural Pastures
0.10	Forested Catchments

10. The Old Urban option is not to be used.
11. BX =1.0 (Calibration factor similar to RORB's k_c)
12. Appropriate lags are to be calculated based on the type of catchment or channel routing is to be used.
13. Basins must be modelled by Stage-Storage and Stage-Discharge relationships
14. The split catchment option is to be used for separately modelling the pervious and impervious fractions of the catchment.

ARBM parameters			
Parameter	Description	Value	Unit
CAPIMP	Capacity of Impervious Area Storage	1.5	mm
ISC	Interception Storage Capacity	1.5	mm
DSC	Depression Storage Capacity	5	mm
USC	Capacity – Upper Soil Zone Storage	25	mm
LSC	Capacity – Lower Soil Zone Storage	100	mm
UH	Maximum Potential Evapo-transpiration from Upper Soil Zone	10	mm/day

LH	Maximum Potential Evapo-transpiration from Lower Soil Zone	10	mm/day
ER	Proportion of Evapo-transpiration from USC	0.7	
IDS	Initial Impervious Area Storage	0.5	mm
IS	Initial Interception Storage	0.5	mm
DS	Initial Depression Storage (pervious)	0	mm
US	Initial Upper Soil Zone Storage	20	mm
LS	Initial Lower Soil Zone Storage	80	mm
GS	Initial Groundwater Storage	0	mm
GN	Groundwater Recession Factor	1	mm
SO	Sorptivity of Dry Soil	3.0	mm/min
Ko	Saturated Hydraulic Conductivity	0.33	mm/min
LDF	Lower Soil Drainage Factor	0.05	
KG	Constant Rate Groundwater Recession Factor	0.94	
ECOR	Rate of Potential Evaporation from "A" Class Pan	0.70	
IAR	Proportion of Rainfall intercepted by Vegetation	0.70	

• PARAMETERS TO BE USED IN DRAINS MODELLING

1. Use of values other than those listed here requires the approval of a delegated officer from Council's Engineering Section.
2. Where a range of values is given, use of the value selected needs to be justified
3. Where there is any possibility of variation in values, multiple runs to test sensitivity will be required
4. Drains runs are to be carried out for an range of storms depending on the ARI of the minor system

DRAINS Model Parameters			
Parameter	Description	Value	Unit
	Model for Design and Analysis run	Rational Method	
	Rational Method Procedure	ARR87	
	Soil Type - Normal	3.0	
	Paved (Impervious) Area Depression Storage	1	mm
	Supplementary Area Depression Storage	1	mm
	Grassed (Pervious) Area Depression Storage	5	mm
AMC	Antecedent Moisture Condition (ARI = 1-5 years)	2.5	
AMC	Antecedent Moisture Condition (ARI = 10-20 years)	3.0	
AMC	Antecedent Moisture Condition (ARI = 50-100 years)	3.5	
	Sag Pit Blocking Factor (Major systems)	(refer charts & AUS-SPEC)	
	On Grade Pit Blocking Factor (Major Systems)		
	Inlet Pit Capacity	(refer charts & AUS-SPEC)	
	Minimum Pit freeboard	150	mm

APPENDIX C - DESIGN SUBMISSION CHECKLIST

NOTE :

1.0 The checklist is not limited to the listed items

2.0 Consultants are expected to apply engineering 'best practice' and sound engineering judgement in the provision of information for development project applications and the submission of engineering design drawings

3.0 Reports / Plans / Calculations are to be certified by Specialist Consultant, Engineer or approved Surveyor, to the satisfaction of a delegated officer from Council's Engineering Section

PROJECT :
COUNCIL FILE No. :
LOCATION :
CONSULTANT :

A. DESIGN

NOTE : Report / Plans / Calculations to be certified

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Stormwater Calculations submitted on standard forms to Council requirements as per AR&R or QUDM for Major & Minor systems		
2	Manual calculations provided in clear, concise format		
3	Computer files / Setup Parameters List provided		
4	Hydrologic and hydraulic models / results checked and verified by qualified person		
5	Locality Plan		
6	Catchment Plan to scale		
7	Hydraulic model plans, showing location and extent of model cross-sections.		
8	Existing and Proposed site plan including staging		
9	Associated buildings, structures and landscape plans / sections.		
10	Data in reports / plans matches calculations		
11	Legal point of discharge identified		
12	Downstream discharge landowner's agreements obtained (public & private)		
13	Public amenity, safety & aesthetics considered		
14	Sedimentation & Erosion Control Plans (to be consistent with Stormwater Design and Council requirements)		
15	Water Quality models / results checked and verified by qualified person		
16	Structural Certifications		
17	Survey by licensed surveyor		
18	Show lot and DP numbers		
19	Show DA numbers applicable		
20	Show adjacent developments where known		
21	All levels (survey, design and drawing) to Australian Height Datum		

2. Hydrology / Hydraulics

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Approved design methodology		
2	Coefficient of Runoff		
3	Time of concentration		
4	Overland Flow paths		
5	Catchment area		
6	Partial area effects		
7	Flow velocities (flowpaths, channels, outlets etc.)		
8	Storm surge & tidal effects		
9	Calculations for Major / Minor systems		
10	Blockage factors applied to catchpits		
11	Coincident flowpaths (flooding)		
12	Bridges, culverts, channels, structures, etc.		
13	Road flood immunity and trafficability		
14	Complies with AR&R / QUDM / Council DCP's		
15	Approvals from other relevant authorities (RMS etc.)		
16	Setback / Buffer from existing watercourse / floodway		
17	Loss of flood storage		
18	Loss of conveyance area		
19	Compensation cut / fill earthworks plan & sections		

3. Open Channels and Watercourses

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Roughness (values, sensitivity, vegetated buffer)		
2	Geometry (alignment, batters, grades, low-flow provision)		
3	Capacity		
4	Impact on flood levels of surrounding properties		
5	Tailwater levels		
6	Tidal effects		
7	Freeboard		
8	Maximum velocities and scour protection		
9	Minimum velocities and siltation		
10	Impact on vegetation and wildlife		
11	Effect of landscaping		
12	Maintenance and safety berms (provision and access)		
13	Energy losses (including bends and drops)		

4. Overland Flowpaths

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Depth (max 0.200m)		
2	Velocity (d x v product)		
3	Concentration of flows (capture, scour, re-direction)		
4	Freeboard		
5	Roughness (values, sensitivity, vegetated buffer)		
6	Impact on flood levels of surrounding properties		
7	Tailwater levels		
8	Easement		

5. Retention, Detention and Sedimentation Basins

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Safety (bank slope & depths, inlet / outlet works, structural integrity, Dam Safety Committee)		
2	Referral to the NSW Dam Safety Committee		
3	Sizing		
4	Outflows		
5	Spillway		
6	Scour protection		
7	Maintenance (sediment basins)		
8	Freeboard		
9	Water quality		
10	Effect on catchment runoff hydrograph		
11	Batter slopes		
12	Minor flood flows		
13	Maximum flooded depth		
14	inlet / outlet structures		
15	Earthworks		
16	landscaping		

6. Bridges and Culverts

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Flood immunity (afflux and impact on property)		
2	Velocity and scour (u/s and d/s)		
3	Effect of overtopping and d/s flood levels		
4	Effect of road furniture (guardrail etc.)		
5	Tailwater level		
6	Allowance for fauna movement (wet and dry periods)		
7	Energy dissipation		
8	Maintenance		
9	Safety		

7. Pipe Outlets

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Velocity and scour (u/s and d/s)		
2	Energy dissipation		
3	Tailwater Level		
4	Configuration, location and skew		

B. DESIGN DRAWINGS

NOTE : Report / Plans / Calculations to be certified

1. Catchment Plan

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	North Point and scale		
2	Road Names		
3	Development boundary and lot / road boundaries, lot & DP numbers		
4	Numbering as per calculations (areas and system)		
5	Catchment boundaries in bold line and clearly shown		
6	Existing and proposed contours, clearly shown		
7	Watershed direction (indicate longest time of concentration)		
8	Stormwater reticulation system clearly shown		
9	External catchments and details		
10	TO SCALE		

2. Detail Plans

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	North Point and scale		
2	Road Names		
3	Development boundary		
4	System Numbering		
5	Existing and proposed contours, clearly shown		
6	Pipe size, type and class		
7	Location (co-ordinate, road centreline chainage / offset, bdy offset)		
8	Structure type, details		
9	Lengths and grades		
10	Inter-allotment drainage		
11	Easements		
12	100 year ARI floodlines (existing and design) and buffers		
13	100 year ARI flowpaths and easements		
14	Invert levels, surface levels		
15	PREFERRED SCALE 1: 500		

3. Long Sections - Pipelines and channels

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	System Numbering		
2	Pipe grade %, size, type and class		
3	Design ARI event and hydraulic grade line plotted		
4	Control HGL / Receiving Waters Water Surface Level		
5	Flows (actual & capacity) and velocities (structure to structure)		
6	Structure type, details and Junction line reference		
7	Existing and design surface level profiles		
8	Chainages, lengths and grades (structure to structure)		
9	Invert levels, surface levels, depths & HGL levels		
10	Utility Service crossing details		
11	Open Drain and Basin Details		
12	Inlet / Outlet structure and lead-out / tail-in details		
13	Other Structures (drop, energy dissipator etc.)		
14	**PREFERRED SCALE 1: 500 hor. / 1 : 50 vert.**		

4. Open Drains

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	System Numbering		
2	Design ARI event and hydraulic grade line		
3	Flows and velocities		
4	Cross sections at nominal 20m intervals		
5	Other Structures (drop, energy dissipator etc.)		
6	Existing and design surface level profiles		
7	Chainages, lengths and grades		
8	Invert levels, surface levels, depths		
9	Inlet / Outlet structure details		
10	Batter slopes and treatment		

5. Detention Basins

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Plan		
2	Sections		
3	Details of Basin Wall		
4	Details of structures		
5	Extent of permanent storage (if any)		
6	Maximum storage level		
7	Spillway details		
8	Energy dissipation works and Scour protection		
9	Landscaping		
10	Earthworks		
11	Maintenance and access Plan		

6. Water Quality & Water Sensitive Urban Design Measures

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Details of proprietary devices		
2	Details of non-proprietary devices		
3	Calculations and details of performance showing compliance with Council's requirements		
4	Maintenance Plan, costings & details considering access and safety		
5	Work Method statements for installed devices		

APPENDIX D - TIDAL GRADIENTS

- **CLARENCE RIVER TIDAL GRADIENT (Figure 1A)**

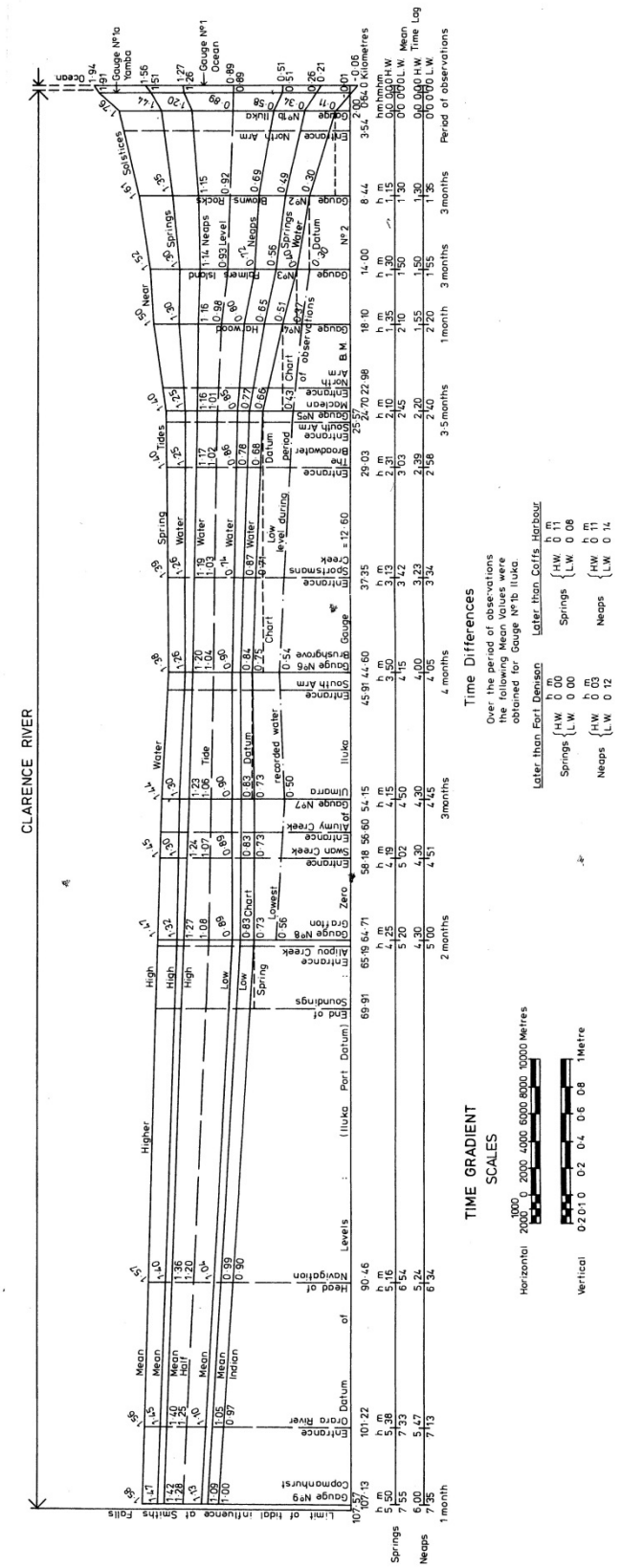

FIGURE 1A – CLARENCE RIVER TIDAL GRADIENT

NOTES

1. **Level Datum – Iluka Port Datum (Zero Iluka Gauge = 12.60 BM N°.2). Subtract 0.91m for AHD values**
2. **Source – NSW PWD Clarence River Waterway Planning Study 1976 (Soros Longworth & McKenzie) Figure 11a**
   ISBN 7240 2675 4
   PWD 78006

D2 CLARENCE RIVER PLAN (Figure 1B)

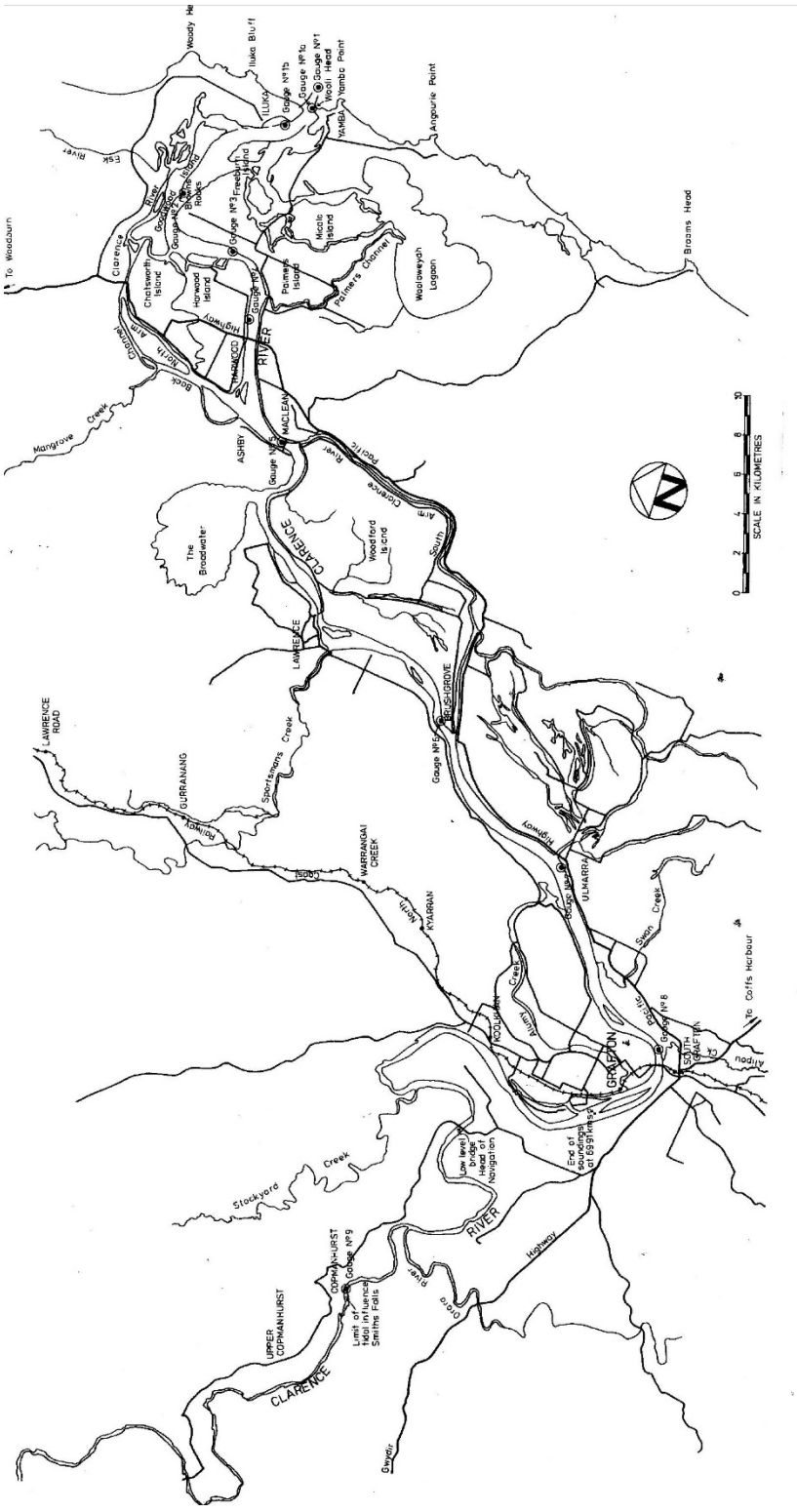

FIGURE 1B – CLARENCE RIVER PLAN

APPENDIX E - SAMPLE DETAILS & TABULATIONS

E1 CATCHMENT PLAN & HYDROLOGICAL - HYDRAULIC CALCULATION TABLE

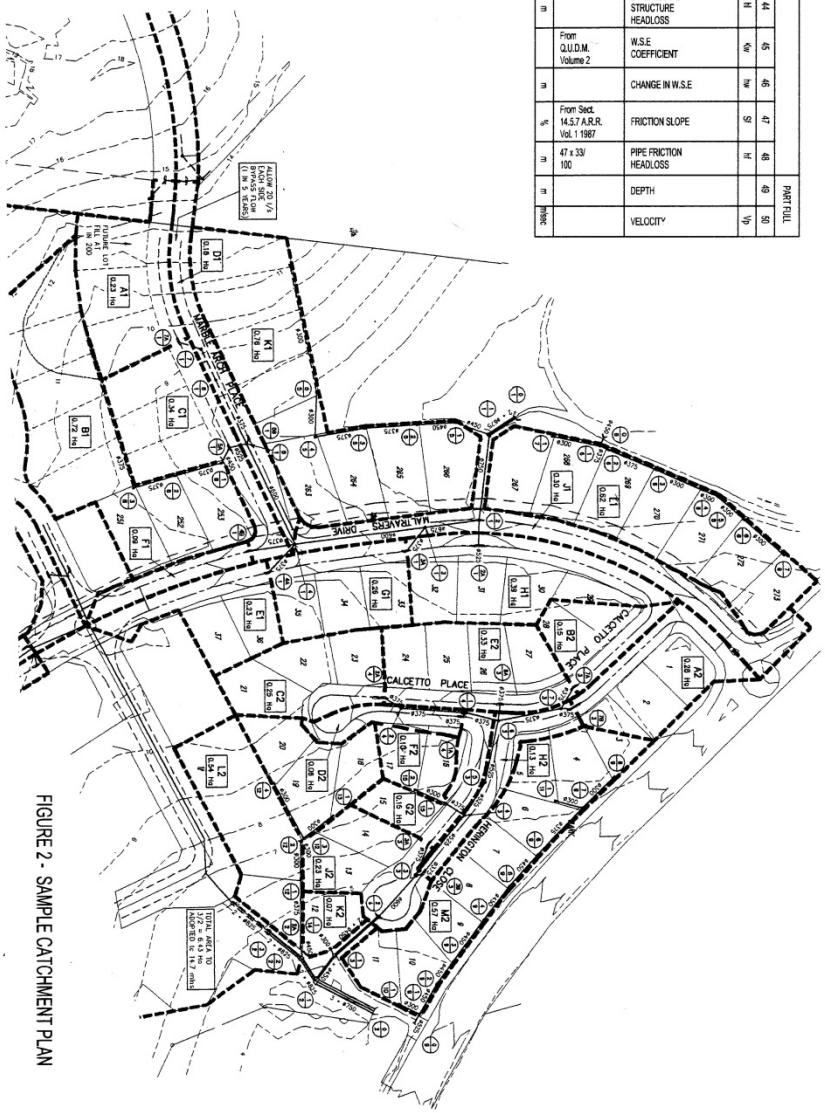

FIGURE 2 - SAMPLE CATCHMENT PLAN

		DESIGN LEVELS	51		
m	U/S RL D/S RL	OBVERT LEVELS	51		
m	U/S RL D/S RL	DRAIN SECTION H.G.L.	52		
m		U/S H.G.L.	53		
m		LATERAL H.G.L.	54		
m		W.S.E.	55		
m		SURFACE OR K&C INVERT LEVEL	56		
m		FREEBOARD	57		
		STRUCTURE No.	58		

		HEADLOSSES	40		
	FROM Q.U.D.M. CHARTS VOLUME 2	STRUCTURE RATIOS FOR 'K' VALUE CALCULATIONS	38, 39		
m	36x36/2g	VELOCITY HEAD	V2/2g	40	
	From Q.U.D.M. Volume 2	U/S HEADLOSS COEFFICIENT	Ku	41	
m	40 x 41	U/S PIPE STRUCTURE HEADLOSS	hu	42	
	From Q.U.D.M. Volume 2	LATERAL HEADLOSS COEFFICIENT	Kl	43	
m		LATERAL PIPE STRUCTURE HEADLOSS	hl	44	
	From Q.U.D.M. Volume 2	W.S.E COEFFICIENT	Kw	45	
m		CHANGE IN W.S.E	hw	46	
%	From Sect. 14.5.7 A.R.R. Vol. 1 1987	FRICTION SLOPE	Sf	47	
m	47 x 33/ 100	PIPE FRICTION HEADLOSS	hf	48	
m		DEPTH		49	PART FULL
m/sec		VELOCITY	Vp	50	

years		DESIGN A.R.I.		1	LOCATION
		STRUCTURE NO.		2	
		DRAIN SECTION		3	
		SUB-CATCHMENTS CONTRIBUTING		4	
		SURFACE CONDITION (LAND USE)		5	TIME
%		SLOPE OF CATCHMENT		6	
min		SUB-CATCHMENT TIME OF CONCENTRATION	tc	7	
mm/h	From Intensity Chart	RAINFALL INTENSITY	I	8	SUB-CATCHMENT RUNOFF
		COEFFICIENT OF RUNOFF	C	9	
ha		SUB-CATCHMENT AREA	A	10	
ha	9 x 10	EQUIVALENT AREA	(CA)	11	
ha	sum 11	SUM OF CONTRIBUTING EQUIVALENT AREAS	Σ(CA)	12	
cumec	(8x12)/360	SUB-CATCHMENT DISCHARGE	Q	13	
cumec	sum 25	FLOW PAST PREVIOUS GULLIES		14	
cumec	13 + 14	FLOW IN K&C (INCLUDING BYPASS)		15	INLET DESIGN
%		ROAD GRADE AT INLET		16	
m		K - K' WIDTH		17	
m		FLOW WIDTH	W	18	
m		FLOW DEPTH AT INVERT	dg	19	
m/sec		GUTTER FLOW VELOCITY	Vg	20	
m2/s	20 x 19	dg x Vg		21	
		INLET NUMBER		22	
	From Std. Drg.	INLET TYPE		23	
cumec	From Charts	FLOW INTO INLET	Qg	24	
cumec	15 - 24	BYPASS FLOW		25	
min		CRITICAL TIME OF CONCENTRATION	tc	26	DRAIN DESIGN
mm/h	From Intensity Chart	RAINFALL INTENSITY	I	27	
ha	sum of U/S 12	TOTAL CONTRIBUTING EQUIVALENT AREA	Σ(CA)	28	
cumec		MAJOR TOTAL FLOW	Qt	29	
cumec		MAJOR SURFACE FLOW CAPACITY	Qm	30	
cumec		MAJOR SURFACE FLOW	Qs	31	
cumec		FLOW IN PIPE	Qp	32	
m		REACH LENGTH	L	33	
%		PIPE GRADE	S	34	
mm		PIPE / BOX DIMENSIONS		35	
m/sec	32/Area of Sect	FLOW VELOCITY FULL (PIPE GRADE VELOCITY)	V	36	
min	33/ (36x60)	TIME OF FLOW IN REACH	T	37	

FIGURE 1 - SAMPLE HYDRAULIC GRADE LINE CALCULATION SHEET

E2 SAMPLE OSD CALCULATION SHEET

Note: This method cannot be used in the Ballina Shire (refer to Ballina Councils DCP for the acceptable calculation methodologies).

On -site Stormwater Detention Design Summary Sheet

Developed Area = m^2

Pre Development

Catchment Areas (Must be shown on engineering drawings)

Roof Area (A_r) = m^2

Paved Area (A_p) = m^2

Vegetated Area (A_v) = m^2

Total Area = m^2 (Must equal post development area)

Stormwater Flows (For 5 year storm event)

Duration = 5 min n

Rainfall Intensity ($^5I_5$) = mm/hr (select from rainfall intensity charts)

Stormwater flow (Q_5) = $(A_r c_r + A_p c_p + A_v c_v) \times {}^5I_5 / 3600$

= l/s

Post Development

Catchment Areas (Must be shown on engineering drawings)

Roof Area (A_r) = m^2

Paved Area (A_p) = m^2

Vegetated Area (A_v) = m^2

Total Area = m^2 (Must equal pre development area)

Stormwater Flows (For 20 year storm event)

Duration = 5 min n

Rainfall Intensity ($^{20}I_5$) = mm/hr (select from rainfall intensity charts)

Stormwater flow (Q_{20}) = $(A_r c_r + A_p c_p + A_v c_v) \times {}^{20}I_5 / 3600$

= l/s

Stormwater Detention Requirements

Storage Volume = $(Q_{20} - Q_5) \times 5 \times 60 / 1000$

= m^3

PSD = l/s (Permissible Site Discharge = Q_5)

Orifice Plate Controlled Discharge (N/A if using choke pipe)

Head (H) = m (max. water level to orifice centre)

Orifice Diameter = $1000 \times \sqrt{[(0.464 \times Q_5 / 1000) / \sqrt{H}]}$

= mm

Outlet Pipe Diameter = mm ~~(min. 3 x orifice diameter)~~

Outlet to be sized to convey 2 x orifice flow to next downstream structure.

Choke Pipe Controlled Discharge (N/A if using orifice plate)

Calculate by trial & error using the following formulas

Q_d (pipe capacity) = $1000 A_p \sqrt{[2 \times 9.8 (H/K_t)]}$ (l/s)

Where,

- A_p = Cross-sectional area of pipe (m^2)
- H = Head of water (m) from max. water level to tailwater level
- K_t = $K_f + K_p$
- K_f = L/(50 D)
- L = Length of pipe (m)
- D = Diameter of pipe (m)
- K_p = $\sum$ pipe component head losses (Pipe entry = 0.5, Pipe Exit = 1.0, 45° Bend = 0.35 & 90° Bend = 0.9)

Storage Provided

Storage Volume = m^3 A separate sheet is to be attached showing all workings for the storage volumes proposed on the engineering drawings.

NOTE : Confirmation for the application of the above method shall be obtained from a delegated officer from Council's Engineering Section prior to it's use. Calculation of inflow to the OSD shall be based on the 1 in 20 year ARI storm for the developed site. The maximum outflow from the OSD shall be based on the 1 in 5 year ARI storm for the undeveloped site.

$$\textit{Detention Volume } (m^3) = (Q^{20}_{dev} - Q^{5}_{undev}) \times t^{c}_{20\ dev} \times (60/1000)$$

(where Q is in l/s, t^c is in minutes)

The 1 in 100 year ARI developed flow from the site shall be checked to ensure it does not exceed the 1 in 100 year ARI undeveloped flow from the site, i.e.

$$Q^{100}_{dev} - Q^{20}_{dev} + \textit{Detention Outflow } (= Q^{5}_{undev}) \leq Q^{100}_{undev}$$

E3 OSD ORIFICE DIAMETER, DEPTH OF PONDING AND PSD

ORIFICE DIAMETER (mm)

RELATIVE TO DEPTH OF PONDING AND PERMISSIBLE SITE DISCHARGE

PSD l / s	DEPTH ABOVE CENTRELINE OF ORIFICE (m)																				
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	
2.0	55																				
3.0	67	56	51																		
4.0	77	65	59	55	52																
5.0	86	73	66	61	58	55	53	51	50												
6.0	95	80	72	67	63	60	58	56	55	53	52	51	50								
7.0	102	86	78	72	68	65	63	61	59	57	56	55	54	53	52	51	50	50			
8.0	109	92	83	77	73	70	67	65	63	61	60	59	58	56	55	55	54	53	52	52	
9.0	116	97	88	82	77	74	71	69	67	65	64	62	61	60	59	58	57	56	55	55	
10.0	122	103	93	86	82	78	75	73	70	69	67	66	64	63	62	61	60	59	58	58	
11.0	128	108	97	91	86	82	79	76	74	72	70	69	67	66	65	64	63	62	61	61	
12.0	134	112	102	95	89	85	82	80	77	75	73	72	70	69	68	67	66	65	64	63	
13.0	139	117	106	98	93	89	86	83	80	78	76	75	73	72	71	70	69	68	67	66	
14.0	144	121	110	102	97	92	89	86	83	81	79	78	76	75	73	72	71	70	69	68	150
15.0	150	126	114	106	100	96	92	89	86	84	82	80	79	77	76	75	74	73	72	71	dia
16.0	154	130	117	109	103	99	95	92	89	87	85	83	81	80	78	77	76	75	74	73	
17.0	159	134	121	113	106	102	98	95	92	90	87	86	84	82	81	80	78	77	76	75	
18.0	164	138	124	116	110	105	101	97	95	92	90	88	86	85	83	82	81	80	78	77	
19.0	168	141	128	119	113	108	103	100	97	95	92	90	89	87	86	84	83	82	81	80	
20.0	173	145	131	122	115	110	106	103	100	97	95	93	91	89	88	86	85	84	83	82	
21.0		149	134	125	118	113	109	105	102	99	97	95	93	91	90	88	87	86	85	84	
22.0		152	138	128	121	116	111	108	105	102	99	97	95	94	92	91	89	88	87	86	
23.0		156	141	131	124	118	114	110	107	104	102	99	97	96	94	93	91	90	89	88	
24.0		159	144	134	126	121	116	112	109	106	104	102	100	98	96	95	93	92	91	89	
25.0		162	147	136	129	123	119	115	111	109	106	104	102	100	98	97	95	94	92	91	
26.0		166	150	139	132	126	121	117	114	111	108	106	104	102	100	98	97	96	94	93	
27.0		169	152	142	134	128	123	119	116	113	110	108	106	104	102	100	99	97	96	95	
28.0		172	155	144	137	131	126	121	118	115	112	110	108	106	104	102	101	99	98	97	
29.0			158	147	139	133	128	124	120	117	114	112	109	107	106	104	102	101	100	98	
30.0			161	150	141	135	130	126	122	119	116	114	111	109	107	106	104	103	101	100	
31.0			163	152	144	137	132	128	124	121	118	115	113	111	109	107	106	104	103	102	
32.0			166	154	146	140	134	130	126	123	120	117	115	113	111	109	108	106	105	103	225
33.0			168	157	148	142	136	132	128	125	122	119	117	115	113	111	109	108	106	105	dia
34.0			171	159	151	144	138	134	130	127	124	121	119	116	114	113	111	109	108	106	
35.0				161	153	146	140	136	132	128	125	123	120	118	116	114	112	111	109	108	
36.0				164	155	148	142	138	134	130	127	124	122	120	118	116	114	112	111	110	
37.0				166	157	150	144	140	136	132	129	126	124	121	119	117	116	114	112	111	
38.0				168	159	152	146	141	137	134	131	128	125	123	121	119	117	116	114	113	
39.0				170	161	154	148	143	139	136	132	130	127	125	122	121	119	117	115	114	
Minimum Discharge Pipe Diameter				300 dia									225 dia								

Note : Linear interpolation between values is permitted

(Source Newcastle City Council DCP50 Appendix 3 & Lake Macquarie City Council Handbook of Drainage Design Criteria March 2004 & Byron Shire Council DCP2002 – Part N)

APPENDIX F - FLOW CAPTURE CHARTS (Refer AUS-SPEC std. Dwgs.)

NOTES :

1. The adopted hydraulic flow capture charts are from Brisbane City Council (BCC) and based on BCC standard 'Lip-in-Line' Gully Pits, Grates and Lintels. They have been used with the permission of Brisbane City Council *(ref AUS-SPEC Std Dwgs SW-07, 08 & 09)*
2. Data for the charts was based on testing undertaken at the Urban Resource Centre, University of South Australia for Brisbane City Council, Gold Coast City Council, and Queensland Department of Main Roads in March 2001 and November 2002. No extrapolation beyond the limits of the charts should be undertaken
3. 2.4m (Small), 3.6m(Medium) and 4.8m(Large) are the industry standard overall lintel lengths (**NOT** the opening size)
4. Appropriate use of bicycle-safe grates shall be considered in gully pit grate selection
5. **Bicycle-safe grates, smaller standard lintels or proprietary grates / pre-cast lintel and grate units may be accepted by a delegated officer from the Council's Engineering Section, subject to the provision of acceptable gully pit flow capture charts**
6. Road crossfall, longitudinal grade and side-entry opening size are considered the major influence on gully pit inlet capture
7. Design flow heights should not exceed side-entry opening heights
8. The AUS-SPEC standard kerb and gutter profiles are similar to BCC kerb and channel Types 'D' (drive-over) and 'E' (upright) profiles.