

CAPRICORN MUNICIPAL DEVELOPMENT GUIDELINES

STORMWATER DRAINAGE DESIGN

D5

DESIGN GUIDELINES

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Keeping the Capricorn Municipal Development Guidelines up-to-date

The Capricorn Municipal Development Guidelines are living documents which reflect progress of municipal works in the Capricorn Region. To maintain a high level of currency that reflects the current municipal environment, all guidelines are periodically reviewed with new editions published and the possibility of some editions to be removed. Between the publishing of these editions, amendments may be issued. It is important that readers assure themselves they are using the current guideline, which should include any amendments which may have been published since the guideline was printed. A guideline will be deemed current at the date of development approval for construction works.

GENERAL

D05.01. SCOPE

D05.01.01. This section sets out the guidelines for the design of stormwater drainage systems for urban and rural areas.

D05.01.02. The following order of priority for interpretation of documents will apply: (Please note that reference to a Guideline or Standard, is reference to the latest version of the relevant document, unless specifically a version number is specifically stated)

***Order of
Priority***

1. CMDG D5 Stormwater Design Specification
2. Queensland Urban Drainage Manual (QUDM)
3. AUSTROADS
4. DTMR Specifications and Standard Drawings
5. Australia Rainfall and Runoff
6. Australian Standards

D05.02. OBJECTIVES

D05.02.01. The objectives of stormwater drainage design are as described in the Queensland Urban Drainage Manual (QUDM).

D05.03. REFERENCE AND SOURCE DOCUMENTS

(a) CMDG Specifications

- | | | |
|------|---|-------------------------------------|
| C220 | - | Stormwater Drainage - General |
| C221 | - | Pipe Drainage |
| C222 | - | Precast Box Culverts |
| C223 | - | Drainage Structures |
| C224 | - | Open Drains including Kerb & Gutter |

(b) Australian Standards

- AS/NZS 1254 - PVC-U pipes and fittings for stormwater and surface water applications.
- AS/NZS 2032 - Installation of PVC pipe systems.
- AS/NZS 3725 - Design for installation of buried concrete pipes.
- AS/NZS 4058 - Precast concrete pipes (pressure and non-pressure).
- AS/ NZS 4139 - Fibre reinforced concrete pipes and fittings.
- AS/ NZS 5065 - Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications
- AS/NZS 2566.1 - Buried flexible pipelines – Structural design
- AS/NZS 2566.2 - Buried flexible pipelines – Installation
- AS1597.1 - Precast reinforced concrete box culverts - Small culverts (not exceeding 1200mm span and 1200mm height).
- AS1597.2 - Precast reinforced concrete box culverts - Large culverts (exceeding 1200mm span or 1200mm height and up to and including 4200mm span and 4200mm height).
- AS/NZS 3500.3 - Plumbing and drainage - Stormwater drainage.

(c) Other

- Queensland Government
 - Land Act 1994
 - Land Title Act 1994
- Department of Energy and Water Supply
 - Queensland Urban Drainage Manual (QUDM), latest edition.
- Department of Environment and Heritage Protection
 - Queensland Water Quality Guidelines 2009
- Department of Infrastructure, Local Government and Planning
 - State Planning Policy 2017
- Department of Transport and Main Roads.
 - Manual Road Drainage (2015)
 - Standard Drawings
- Geoscience Australia
 - Australian Rainfall and Runoff (ARR) 2016.
- AUSTROADS
 - Guide to Bridge Technology series
 - Guide to Road Design
 - Part 5: Drainage - General and Hydrology Considerations
 - Part 5A: Drainage - Road Surface, Networks, Basins and Subsurface.
 - Part 5B: Drainage - Open Channels, Culverts and Floodways
- Engineers Australia
 - Australian Runoff Quality - A Guide to Water Sensitive Urban Design.
- Institute of Public Works Engineering Australasia, QLD Division.
 - Standard Drawings, 2013
- Healthy Waterways
 - MUSIC Modelling Guidelines

- Practice Note - MUSIC Modelling of Bioretention Systems with Infiltration
- Bioretention Technical Design Guidelines
- Concept Design Guidelines for Water Sensitive Urban Design.
- WSUD Technical Design Guidelines for South East Queensland.
- Deemed to Comply Solutions - Stormwater Quality Management
- Construction and Establishment Guidelines: Swales, Bioretention systems and Wetlands International Erosion Control Association
- Best Practice Erosion and Sediment Control document

Concrete Pipe Association of Australia

- Hydraulics of Precast Concrete Conduits.
- Colebrook White Charts

Australian National Conference On Large Dams, Leederville WA.

- ANCOLD 1986, Guidelines on Design Floods for Dams.

HYDROLOGY

D05.04. DESIGN RAINFALL DATA

D05.04.01. Design rainfall shall be determined in accordance with Book 2 of Australian Rainfall & Runoff (ARR) - A Guide to Flood Estimation (2016). Intensity-Frequency-Duration (I-F-D) data is to be derived from information obtained within the Bureau of Meteorology (BOM) website. The assessment must be based on latitude and longitude of the location under design. Refer to www.bom.gov.au/water/designRainfalls

I-F-D Data

D05.04.02. Design Annual Exceedance Probability (AEP) for the Minor System shall be in accordance with Table D05.04.1

ARI and AEP**Table D05.04.1 - Design Annual Exceedance Probabilities – Minor System (QUDM 2017)**

Development Category ⁴		Minor System	
		ARI (yrs)	AEP (%)
Central Business & Commercial		10	10
Industrial		2	39
Urban Residential (High Density – greater than 20 dwelling units/ha)		10	10
Urban Residential (Low Density – 6 & up to 20 dwelling units/ha)		2	39
Rural Residential – 2 to 5 dwelling units/ha		2	39
Open Space – Parks, etc.		1	63
Major Road ⁶	Kerb and channel flow	10 ¹	10
	Cross drainage (culverts)	50	2
Minor road ⁶	Kerb and channel flow ⁴		
	Cross drainage (culverts)	10	10

Notes:

1. The design AEP for the minor drainage system in a major road shall be that indicated for the major road, not that for the Development Category of the adjacent area.
2. Cross drainages should be designed to accept the flow for the minor system AEP shown. In addition, the designer must ensure that the major system backwater does not enter properties upstream. 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 AEP design storm to ensure flooding of upstream properties does not occur. In addition, the downstream face of the causeway embankment may need protection where overtopping is likely to occur.
3. The terms used in this table are described in QUDM.
4. Local Government Authority specific or refer to development category in QUDM.
5. VDg, flow depth and width limitations are applicable in accordance with QUDM.
6. Refer to CMDG D1 Geometric Road Design for cross drainage design for the road hierarchy for individual Local Government Authority.

- D05.04.03. Design Annual Exceedance Probability (AEP) for the combined Minor/Major System shall be in accordance with Table D05.04.2. Order of priority should be: 1. LGA Planning Scheme, 2. CMDG, 3. QUDM.

Table D05.04.2 - Design Annual Exceedance Probabilities – Major System (QUDM 2017)

Development Category ¹	Major System	
	ARI (yrs)	AEP (%)
Reference flood for setting floor levels in hospitals, emergency services, flood evacuation buildings and Civil Defence HQ	500	0.2%
Reference flood for setting floor levels of emergency shelters, police facilities, museums, libraries, storage facilities for valuable records or item of historical or cultural significance, and housing for aged and those with impaired mobility; and the setting design levels for water and wastewater centres ² and critical utility services infrastructure ²	200	0.5%
Reference flood for setting habitable floor levels in residential buildings and floor levels in commercial/industrial buildings adjacent floodplains or overland flow paths ³	Note 4	Note 4
Design Storm for overland flowpaths	50 or 100	2% or 1%

Notes:

¹ The terms used in this table are described in the QUDM Glossary (Chapter 13).

² Refers to critical components of the system that are required to be flood-free in order to allow prompt and cost-effective recovery of services after a flood (e.g. electrical equipment).

³ Refer to relevant Local Government Authority for confirmation of design storm AEP. Fill, building and floor levels are usually set relative to the 1% AEP event even if the overland flow path design storm represents a 2% probability

⁴ Refer to relevant Local Government Authority planning scheme in the first instance, if not covered under the planning scheme then use 100 yrs ARI/ 1% AEP as per QUDM.

D05.05. CATCHMENT AREA

- D05.05.01. The catchment area of any point is defined by the limits from where surface runoff will make its way, either by natural or man-made paths, to this point. Consideration shall be given to likely changes to individual catchment areas due to the development of the overall catchment.
- D05.05.02. The catchment boundary shall be determined by using the most accurate information available subject to Local Government Authority approval. A catchment boundary plan shall be presented to the Local Government Authority on a contour map along with the source of the information.
- D05.05.03. Design discharge from a catchment area shall be based on a fully developed catchment in accordance with the current Planning Scheme or Strategic Plan and other available information on developments within the catchment. Developers need to obtain guidance from the Local Government Authority as to what flow conditions should be assumed for the fully developed upstream catchment.

**Catchment
Definition**

**Design
Discharge**

D05.06. HYDROLOGY AND HYDRAULICS

- D05.06.01. The Rational Method may be used for regular shaped catchments and as long as requirements for QUDM are met. Where catchments are an irregular shape or run-off characteristics vary considerably within the catchment, partial area calculations may be required to determine peak flows to be used in design. Rational Method calculations to determine flows shall be carried out in accordance with QUDM. **Rational Method**
- D05.06.02. All calculations shall be carried out by a qualified person experienced in hydrologic and hydraulic design under the supervision of a Registered Professional Engineer of Queensland (RPEQ) experienced in this field. **Qualified Person**
- D05.06.03. Coefficients of discharge shall be calculated in accordance with QUDM. Unless agreed otherwise with the Local Government Authority, the following Table D05.06.1 - Fraction Impervious for Development Categories shall be used to determine C_{10} . **Runoff Co-efficient**

Table D05.06.1 - Fraction Impervious for Development Categories

Zones	Fraction Impervious
Central business areas (including in the Principal centre zone and Major centre zone)	1.00
Industrial uses and other commercial uses (including in the District centre zone and Neighbourhood centre zone)	0.90
Significant paved areas (e.g. roads and car parks)	0.90
High Density Residential land uses (> 20 dwelling units per hectare)	
Townhouse type development	0.80
Multi-unit dwellings	0.85
High-rise residential development	0.90
Medium, Low-Medium, and Low density residential area (including roads)	
Average lot $\geq 750\text{m}^2$	0.60
Average lot $\geq 600\text{m}^2 < 750\text{m}^2$	0.75
Average lot $\geq 450\text{m}^2 < 600\text{m}^2$	0.80
Average lot $\geq 300\text{m}^2 < 450\text{m}^2$	0.85
Average lot $< 300\text{m}^2$	0.90
Medium, Low-Medium, and Low density residential area (infill subdivision excluding roads)	
Average lot $\geq 750\text{m}^2$	0.55
Average lot $\geq 600\text{m}^2 < 750\text{m}^2$	0.60
Average lot $\geq 450\text{m}^2 < 600\text{m}^2$	0.65
Average lot $\geq 300\text{m}^2 < 450\text{m}^2$	0.75
Average lot $< 300\text{m}^2$	0.80
Rural/ environmental protection areas (2-5 dwellings per ha)	0.20
Open space areas (e.g. parks with predominately vegetated surfaces)	0.20

- D05.06.04. Where the flow path is through areas having different flow characteristics or includes property and roadway, then the flow time of each portion of the flow path shall be calculated separately.
- D05.06.05. The maximum time of concentration in an urban area shall be 20 minutes unless sufficient evidence is provided to justify a greater time. **Time of Concentration**
- D05.06.06. The minimum time of concentration shall be 5 minutes for any catchment to its point of entry into the drainage network.

- D05.06.07. Flow paths to pits shall be representative of the fully developed catchment considering such things as fencing and the likely locations of buildings. Consideration shall be given to likely changes to individual flow paths due to the full development of the catchment.
- D05.06.08. Mannings 'n' surface roughness co-efficient shall be derived from information contained in QUDM. **Manning's 'n'**
- D05.06.09. For large and/or complex drainage situations, detention basins, situations nominated as important by a delegated officer from the Local Government Authority, and / or where the Rational Method is not suitable as described in QUDM, an appropriate computerised hydrological model shall be used to determine peak flow rate and peak volume utilising recognised software packages for runoff routing and drainage analysis. Book 5 of ARR shall be used for estimation of flood hydrograph and losses.
- D05.06.10. The full electronic files associated with any computerised modelling works shall be provided to the Local Government Authority as a part of Site Based Stormwater Management Plan. Computer model shall be prepared by a qualified person experienced in the use of the program and under the supervision of a Registered Professional Engineer of Queensland (RPEQ) experienced in this field. The accuracy of the model shall be verified by a RPEQ experienced in this field. The model shall be calibrated and a sensitivity analysis shall be completed. Acceptable software packages are identified in Table D05.06.02 – Acceptable Modelling Packages. The use of alternate software packages is subject to LGA approval.

Table D05.06.02 – Acceptable Modelling Packages

	Banana Shire	Central Highlands Regional	Gladstone Regional	Isaac Regional	Maranoa Regional	Livingstone Shire	Rockhampton Regional
Runoff Routing:	12d Model Drainage		XP-RAFTS/ TUFLOW		12d Model /XP-RAFTS/ TUFLOW		XP-RAFTS/ TUFLOW
Drainage Analysis:	Watercom DRAINS		Drains (ILSAX)/ PCDRAINS		Drains (ILSAX)/ PCDRAINS		Drains (ILSAX)/ PCDRAINS
Steady Flow	HEC-RAS		HEC-RAS		HEC-RAS		HEC-RAS
Unsteady flow	TUFLOW		MIKE 11/ XPSWIM/ TUFLOW		TUFLOW		MIKE 11/ XPSWIM/ TUFLOW
Water Quality	MUSIC/ MUSIC X		MUSIC/ MUSIC X		MUSIC/ MUSIC X		MUSIC/ MUSIC X

Computerised Models

HYDRAULICS

D05.07. HYDRAULIC GRADE LINE

- D05.07.01. Hydraulic calculations shall generally be carried out in accordance with QUDM and shall be undertaken by a qualified person experienced in hydrologic and hydraulic design and under the supervision of a RPEQ experienced in this field. **Qualified Person**

D05.07.02.	The hydraulic calculations shall substantiate the hydraulic grade line adopted for design of the system and shown on the drawings. Summaries of calculations are to be provided with the design including listings of all program input and output.	Calculations
D05.07.03.	The "major" system shall provide safe, well-defined overland flow paths for infrequent (for meanings, refer to Ch 3 of Book 2, Australian Rainfall and Runoff: A Guide to Flood Estimation) storm runoff events while the "minor" system shall be capable of carrying and controlling flows from frequent runoff events. Refer to Table D05.04.1 for major and minor storm event AEP's.	
D05.07.04.	Downstream water surface level requirements are given below: - <ul style="list-style-type: none"> (a) Known hydraulic grade line level from downstream calculations including pit losses at the starting pit in the design event. (b) Where the downstream starting point is a pit and the hydraulic grade line is unknown, a level of 0.15m below the invert of the pit inlet in the downstream pit is to be adopted. (c) Where the outlet is an open channel or natural watercourse, the tailwater level shall be established by calculation of the coincident rainfall event in the open channel or natural watercourse. 	Downstream Control
D05.07.05.	The water surface in drainage pits shall be no higher than 0.15m below the gutter invert for inlet pits and 0.15m below the underside of the lid for junction pits.	Water Surface Limits
D05.08.	PIPES / BOX CULVERTS	
D05.08.01.	Minimum culvert sizes are given below: <ul style="list-style-type: none"> • The minimum pipe size shall be 375mm diameter. • The minimum box culvert size shall be 600mm wide x 300mm high. 	Minimum Culvert Sizes
D05.08.02.	Minimum cover to pipes shall be in accordance with the manufacturer's specifications, wherever possible a minimum cover of 600mm is preferred.	
D05.08.03.	Maximum box culvert width/ pipe diameter to be located beneath the kerb alignment is 600mm. Box culverts and pipes above this size are required to be located within the road carriageway.	Maximum Culvert Size
D05.08.04.	Culvert classes shall be determined in accordance with manufacturer's recommendations. Appropriate consideration should be taken for loadings from construction traffic when determining culvert class.	Culvert Classes
D05.08.05.	Maximum construction loads for each compaction layer of stormwater trench must be nominated and included on design (Intended to avoid cracking of concrete structures).	Maximum Compaction Loadings
D05.08.06.	The minimum vertical and horizontal clearance between stormwater culverts and other services is to be 0.3m except for sewer that requires 0.3m and 0.6m respectively.	Clearance
D05.08.07.	In areas where any part of the pipe is below AHD RL 5.0, exposed to saltwater or aggressive soil, culverts shall have cover to reinforcement in accordance with AS3600, AS3735 and AS5100.5.	Exposure Classification & Clear Cover to Reinforcement

D05.09. PITS

D05.09.01. Inlet Pits shall be spaced so that the gutter flow width is limited to be in accordance with QUDM and so that the inlet efficiency is not affected by adjacent inlet openings. Preference shall be given to the location of drainage pits at the upstream side of allotments.

Spacing

D05.09.02. Access chambers shall be provided in accordance with QUDM.

D05.09.03. Gully inlets shall be Local Government Authority approved proprietary inlet structures. Current approved products are stormwater gully inlet from "C-M Concrete Products. Alternative products may be utilised subject to approval by the Local Government Authority.

Gully Inlet Capacity

D05.09.04. Lip-in-Line gully inlets are to be utilised.

D05.09.05. Inflow capacities shall be in accordance with the manufacturer's specifications with Blockage Factor applied in accordance with QUDM.

D05.10. OVERLAND FLOW

D05.10.01. The major system shall be designed generally in accordance with QUDM. Where overland flow is to be transferred from the road network into drainage reserve, open space or parkland, dedicated drainage flow paths must be provided in accordance with QUDM with a minimum width of 5m. For unlined flow path or channel, it shall be designed to allow access to facilitate maintenance activities. The widths of the access and maintenance berms are required to be a minimum of 4.5m. The transfer of overland flow from road reserve to open space shall not be permitted within private property.

Overland Flow

D05.10.02. Overland flow paths shall be located in accordance with QUDM.

D05.10.03. Drainage flow paths do not generally count as useful park contribution areas. Refer to the relevant Local Government Authority planning scheme policies for this information.

D05.11. OPEN CHANNELS

D05.11.01. Open channels shall be designed to have smooth transitions with adequate access provisions for maintenance and cleaning. Where the Local Government Authority permits the use of an open channel to convey flows from a development site to the receiving water body, such a channel shall comply with the requirements of this Guideline, QUDM and Australian Rainfall and Runoff (ARR).

D05.11.02. Safety fencing shall be provided at dangerous sections in accordance with CMDG specification and standard drawings, and QUDM, AS1926.1, and AS1926.2. Fence height of 1.2m is considered to be appropriate.

Safety

D05.11.03. Where the product of average velocity and average flow depth at the design flow rate is greater than 0.4m²/s, the design will be required to specifically provide for the safety of persons who may enter the channel.

D05.11.04. Design of open channels shall be generally in accordance with QUDM. Open channels will be designed to contain the major system flow for 1% AEP (100 year ARI) less any flow that is contained in the minor system (if applicable), with an appropriate freeboard for open channel and allowance for blockage of the minor system in accordance with QUDM. Freeboard requirements

Design Flow and Freeboard Access and Maintenance berm

shall be in accordance with QUDM. Access and maintenance berms are to be provided in accordance with Section D05.10 of the specification.

D05.11.05. A minimum longitudinal grade for an open channel shall be based on the minimum permissible velocity. The minimum permissible velocity shall be such that it prevents deposition of the sediment. 0.5% applies for open channels. **Minimum Grade / velocity**

D05.11.06. Friction losses in open channels shall be determined using Mannings "n" values given below: - **Channel Roughness**

Mannings "n" Roughness Coefficients for open channels shall generally be derived from information in Chapter 2 of Book 6, Australian Rainfall & Runoff 2019.

Table D05.11.01: Values of Roughness Coefficient n for different channel conditions (Sellin 1961)

Description of Channel	Manning's "n"		
	Minimum	Normal	Maximum
Glass, plastic, machined metal	0.009	0.010	0.013
Fabricated steel channels	0.011	0.012	0.017
Planed timber, joints flush	0.010	0.012	0.014
Sawn timber, joints uneven	0.011	0.013	0.015
Concrete, trowel finished	0.011	0.013	0.015
Concrete, shuttering	0.012	0.014	0.017
Brickwork	0.012	0.015	0.018
*Excavated Channels:			
Earth, clean	0.016	0.022	0.030
Gravel	0.022	0.025	0.030
Rock cut, smooth	0.025	0.035	0.040
Rock cut, jagged	0.035	0.040	0.060
*Natural Channels			
Clean, regular section	0.025	0.030	0.040
Some stones and weeds	0.030	0.035	0.045
Some rocks and/or brushwood	0.050	0.070	0.080
Very rocky or with standing timber	0.075	0.100	0.150
Flood Plains:			
Short grass pasture	0.025	0.030	0.035
Mature crops	0.025	0.035	0.045
Brushwood	0.035	0.050	0.070
Heavy timber or other obstacles	0.050	0.100	0.160

Table D05.11.01 reproduced from ARR 2019 Book 2 Section 2.5.2

*Mannings 'n' values for Landscaped open channels shall be determined on an individual basis subject to approval by the Local Government Authority

D05.11.07.	Maximum side slopes on grassed lined open channels shall be 1(V) in 4(H) for maintenance purposes, unless otherwise approved by the Local Government Authority. Channel inverts shall generally have minimum cross slopes of 1 in 20.	Side Slopes
D05.11.08.	Low flow provisions in open channels (man-made or altered channels) will require low flows to be contained within a pipe system, or low flow channel at the invert of the main channel. In the case of low flow pipe, a minimum size of 375mm is required. Scouring velocities in the pipe shall be obtained at AEP 39% (2 year ARI). Channels shall be designed to prevent waterlogging of the channel bed. The width of the invert shall be sufficient to accommodate the full width of a tractor and slasher. Local Government Authority approval is required for situations where low flow pipes are not required and subsoil drainage will suffice.	Low Flows
D05.11.09.	Channels shall be designed for sub-critical flow. Transitions in channel slopes are to be designed to avoid any hydraulic jumps due to the nature of the transition.	Hydraulic Jumps
D05.11.10.	Armouring shall be provided in accordance with the requirements of QUDM and shall be designed to suit the design flow velocity. Refer to the CMDG Standard Drawing	Armouring
D05.11.11.	The preferred solutions for open channel treatments are natural treatments including the use of rock lining, vegetation treatments and soft engineering solutions.	
D05.12.	MAJOR STRUCTURES	
D05.12.01.	Refer to D3 STRUCTURES & BRIDGE DESIGN for the requirements on stormwater drainage design in relation to these structures.	Major and Minor Structures
D05.13.	WATER SENSITIVE URBAN DESIGN (WSUD)	
D05.13.01.	Water Sensitive Urban Design (WSUD) shall be implemented in accordance with the respective Local Government Authority's Planning Scheme and/or policy.	Implementation of WSUD
D05.13.02.	Design guidelines for implementing WSUD shall be in accordance with Australian Runoff Quality: Guide to Water Sensitive Urban Design by Engineers Australia and Water Sensitive Urban Design: Healthy Waterways WSUD Technical Design and Bioretention Technical Design Guidelines.	Design Guidelines
D05.13.03.	Bioretention Basins shall be designed in accordance with Bioretention Technical Design Guidelines by Healthy Waterways.	Bioretention Basin Design
D05.13.04.	Plant species for a bioretention basin shall be selected in accordance with Annexure D05A. Climatic regions are in accordance with State Planning Policy Interactive Mapping System, Department of Infrastructure, Local Government and Planning (known as SPP Interactive Mapping System), and Climate Classification of Australia (Köppen maps), BOM. Table D05.13.01 provides climatic region in accordance with SPP Interactive Mapping System for Local Government Authority areas. For lists of plants, refer to Annexure D05A.	Plant Species

Table D05.13.01: Climatic Regions for Local Government Authority Areas

Local Government Authority	Climatic Region
Banana Shire Council	Western Queensland
Central Highland Regional Council	Western Queensland
Gladstone Regional Council	Central Coast (South)
Isaac Regional Council	Site specific - Central Coast (South) and Western Queensland
Livingstone Shire Council	Site specific - Central Coast (South) and Western Queensland
Maranoa Regional Council	Western Queensland
Rockhampton Regional Council	Site specific - Central Coast (South) and Western Queensland

Table D05.13.02 shows a correlation between the State Planning Policy Interactive Mapping System, Köppen maps and the climatic regions specified in the Bioretention Technical Design Guidelines.

Detention and Retention Basin design.

Table D05.13.02: Correlation between Climatic Regions

Climatic Region in accordance with SPP Interactive Mapping System	Equivalent Climatic Region Köppen maps in accordance with Bureau of Meteorology	Regions as specified in Bioretention Technical Design Guidelines, v1.1 by Water by Design
South East Queensland	Subtropical	Subtropical (ST)
Central Queensland (North)	Subtropical	Subtropical (ST)
Central Queensland (South)	Subtropical	Subtropical (ST)
Dry Tropics	Tropical	Dry Tropics (DT)
Wet Tropics	Tropical	Wet Tropics (DT)
Cape York / Far North Queensland	Equatorial	Wet Tropics (WT)
Western Queensland	Grassland and Desert	Arid (A)

D05.13.05. Detention and retention Basins shall be designed in accordance with QUDM, Austroads Guide to Road Design - Part 5A.

D05.13.06. For all Stormwater Quality Improvement Devices (SQID), RPEQ certifications are required to be provided to the Local Government Authority for design, construction, and stormwater quality compliance.

Design and Installation of SQIDs

D05.13.07. The Manufacturer's supplied maintenance plan for proprietary devices and/or RPEQ certified maintenance plan for vegetated devices shall be submitted to the Local Government Authority.

Maintenance Plan for SQIDs

D05.13.08. Approved information signage shall be installed for all Stormwater Quality Improvement Devices that are to be LGA assets. Signage shall be educative and shall focus on both created and local habitat. Signage strategies should consider following key issues:

- Signage should be kept simple and easy to understand for general people.

- Location of signage should be selected such that it attracts attention;
- Location of signage should be at key areas requiring interpretation
- Signage materials need to be low maintenance and durable, resistant to UV and graffiti and easily installed.

D05.14. RURAL DEVELOPMENTS

D05.14.01. For developments in rural areas refer to “Queensland Department of Transport and Main Roads Manual: Road Drainage (2015) or Local Government Authority specific guidelines.

D05.15. LAWFUL POINT OF DISCHARGE

D05.15.01. All discharge points from developments are required to be a Lawful Point of Discharge (LPOD). A Lawful Point of Discharge shall be determined in accordance with the test as specified in QUDM.

Lawful point of discharge

D05.15.02. The maximum permissible piped discharge to the kerb and channel at any point must be limited to 30L/s. No greater than two 100mm diameter pipes (or approved equivalent) with approved kerb adapters shall be used at any single discharge location.

D05.15.03. All drainage pipes >150mm nominal diameter shall connect to below ground stormwater infrastructure or other location approved by the LGA.

D05.16. ALLOTMENT DRAINAGE

D05.16.01. Allotment drainage shall be provided to any lot where it cannot be satisfactorily demonstrated that roofwater drainage associated with building construction on that lot, could be reasonably connected directly to the kerb and channel. The allotment drainage system shall be in accordance with the QUDM Design Class set out in Table D05.16.1 – Roof and Allotment Drainage Requirements below.

Allotment Drainage Requirements (QUDM Design Classes)

Table D05.16.1 – Roof and Allotment Drainage Requirements

Local Government Authority	Low Density Residential QUDM Level (Note 3)	Application	Special Requirements
Banana Shire	II (Note 1)	Low Density Residential	Connection to main is permitted. No grated inlets - low density residential only.
Central Highlands Regional	II (Note 1)	Low Density Residential	
Gladstone Regional	III (Note 2)	Residential	Connections must be to pits.
Isaac Regional	II (Note 1)	Low Density Residential	Connection to main is permitted. No grated inlets - low density residential only.
Maranoa Regional	II (Note 1)	Low Density Residential	
Livingstone Shire	II (Note 1)	Low Density Residential	
Rockhampton Regional	II (Note 1)	Low Density Residential	

Note 1: Level III allotment drainage may be required by the Local Government Authority in some instances (e.g. steep slopes).

Note 2: GRC may consider level II allotment drainage in low-risk circumstances.

Note 3: For all other development categories – industrial, high density residential, commercial etc refer to QUDM

D05.16.02. Inter allotment drainage shall be provided where lands are developed such that;

- lots do not drain to Local Government Authority infrastructure,
- developing lands are located at the higher side and lower side is developed prior to higher side. Refer to figure D05.15.01 as an illustration:

**Inter
allotment
drainage**

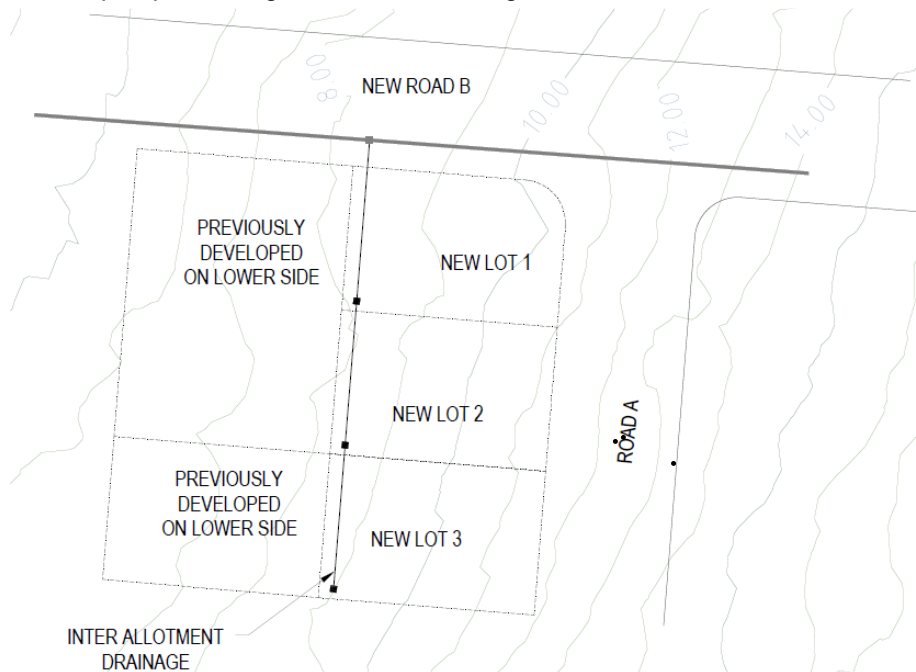


Figure: D05.15.01: Higher Side Development

- Developing lands are located at the lower and higher side is developed prior to lower side. Refer to figure D05.15.02 as an illustration: two choices either connect upstream existing roofwater to new pipe (level II) OR INSTALL LEVEL III DRAINAGE.

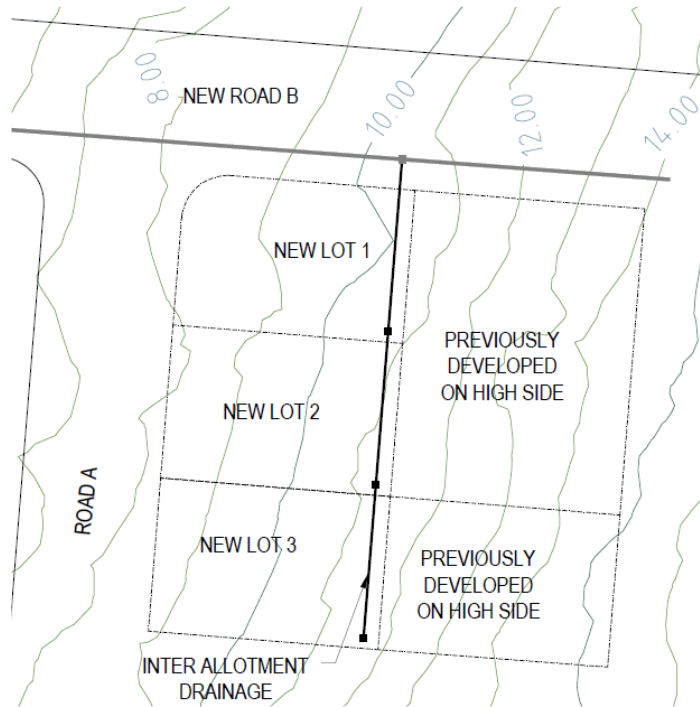


Figure: D05.15.01: Lower Side Development

- D05.16.03. All inter allotment drainage systems shall be covered by a drainage easement, in favour of the Local Government Authority, of a minimum width in accordance with Table D05.16.2. If the easement is to form part of an overland flow path for Level 3 inter allotment drainage, then the width of the easement must be extended to encompass the full flow width.

Drainage Easements

Table D05.16.2 - Inter Allotment Drainage Easements

Local Government Authority	Easement Widths (m) min ¹
Banana Shire	3
Central Highlands Regional	4
Gladstone Regional	4
Isaac Regional	4
Livingstone Shire	3
Maranoa Regional	4
Rockhampton Regional	3

¹ Easement widths mentioned in the above table are the minimum, as a wider easement may be required for larger drainage infrastructure, additional services, and for ease of maintenance.

D05.16.04.	The inter allotment drainage pipe shall be generally a minimum 1.0m clear of the outer edge of a pipe from the rear boundary of the allotment and shall be designed to accept the concentrated drainage from buildings on each allotment for flow rates having a design AEP (ARI) the same as the “minor” street drainage system.	Alignment
D05.16.05.	Inter allotment drainage pits shall be located at all changes of direction, horizontal and vertical. Pits should generally be a minimum of 1.0m clear from the outer edge to the side boundary. Pits shall be constructed of reinforced concrete (steel or fibre reinforcement). Pits shall be constructed with a concrete lid finished flush with the surface of works.	Pits
D05.16.06.	Inter allotment drainage pipes shall have a minimum longitudinal gradient of 0.5% or as required to achieve self-cleansing velocity, whichever is greater.	Grade
D05.16.07.	Where inter allotment drainage and sewer mains are laid adjacent to each other, a minimum horizontal clear distance of 0.60m and a minimum vertical clear distance of 0.30m, between the outer edges of pipes and / or pits shall be maintained.	Sewer
D05.16.08.	All drainage pipes within an easement shall maintain a minimum of 1.0m clear distance from the edge of the easement to the outer edge of the pipe.	

OTHER DESIGN ELEMENTS

D05.17. STORMWATER DISCHARGE

D05.17.01.	Scour protection at culvert or pipe system outlets shall be designed constructed to minimise erosion. Generally, erosion protection shall, as a minimum, be designed in accordance with QUDM. The design outlet flow velocity for an outlet scour protection shall be the design storm event for the subject culvert or pipe.	Scour
D05.17.02.	The discharge protection shall be subject to the performance standard such that the requirements of the Environment Protection Act with regard to water quality are fulfilled.	EPA

D05.18. PIPE MATERIAL

D05.18.01.	<p>The following pipe materials are approved subject to minimum cover and installation requirements stated by the manufacturer:</p> <ul style="list-style-type: none"> • Steel reinforced concrete pipe and culverts to AS4058; and • Fibre Reinforced pipes to AS4139.; and • Corrugated polypropylene pipes to AS/NZS 5065. Up to 600mm maximum diameter. For use in urban areas only. • Unplasticised Poly Vinyl Chloride (uPVC) pipes to AS/NZS 1254. • Other pipes will be considered subject to individual Local Government Authority approval. 	Pipe material
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D05.19. SUBSURFACE DRAINAGE

D05.19.01.	Subsurface drainage shall be designed in accordance with the D4 – Subsurface Drainage.	Subsoil Drain at Pits
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- D05.19.02. The upstream end of the subsoil drain shall be sealed with cement mortar and the downstream end shall discharge through the wall of the pit or headwall.

D05.20. EASEMENTS AND AGREEMENTS

- D05.20.01. All drainage infrastructure (including overland flow paths) within private property shall be encumbered by drainage easements. Each easement shall include a deed of agreement that outlines each party's rights as the grantor and the grantee.
- D05.20.02. Evidence of any Deed of Agreement necessary to be entered into as part of the drainage system will need to be submitted prior to any approval of the engineering plans. Easements are to be created prior to sealing of the survey plans.

***Easements
and
Agreements***

SITE BASED STORMWATER MANAGEMENT PLAN

D05.21. SITE BASED STORMWATER MANAGEMENT PLAN (SWMP)

- D05.21.01. Where required by the Local Government Authority, the developer is obliged to submit Site Based Stormwater Management Plan addressing Quantity and Quality aspects of stormwater management. The template provided in Annexure D05B should be utilised unless noted in Table D05.21.1.

Table D05.21.1 – Site Based Stormwater Management Plan Template

Local Government Authority	Annexure D05B Applies	Alternative
Banana Shire	Yes	
Central Highlands Regional	Yes	
Gladstone Regional	Yes	
Isaac Regional	Yes	
Maranoa Regional	Yes	
Livingstone Regional	Yes	
Rockhampton Regional	No	Refer to planning scheme

D05.22. STORMWATER QUALITY

- D05.22.01. The developer shall submit MUSIC model and output from MUSIC model as a part of Site Based Stormwater Management Plan demonstrating stormwater quality objective is achieved in accordance with State Planning Policy 2017.
- D05.22.02. A development is required to comply with the State Planning Policy 2017 in relation to Water Quality Objectives.
- D05.22.03. The developer shall submit Erosion and Sediment Control (ESC) plan as required by the Local Government Authority at the operational works stage. Plans are to be certified by an appropriate RPEQ experienced in this field or Certified Professional in Erosion and Sediment Control (CPESC). ESC plans are to be updated, certified and submitted to the Local Government Authority as construction works proceed.

ESC Plan

- D05.22.04. The developer is required to submit to the Local Government Authority on-maintenance and off-maintenance schedule for stormwater quality treatment devices. For bio-retention basins, wetlands, vegetated swales etc., guidelines published by Healthy Waterways should be used as primary documents. For other treatment devices, for example, Gross Pollutant Traps, the developer is required to submit manufacturer's maintenance schedule and instructions. **Water Quality**

D05.23. BIO-RETENTION SYSTEMS

- D05.23.01. Bio-retention systems are shallow depressions in the urban landscape designed to collect and treat stormwater by way of filtration through various media. Bio-retention systems shall be designed in accordance with Water by Design – Bio-retention Technical Design Guidelines (2014).

D05.24. VEGETATED STORMWATER ASSETS

- D05.24.01. All proposed vegetated stormwater assets (swales, bio-retention systems, constructed wetlands and sediment basins etc.) are to be designed to allow for efficient and effective maintenance. Refer to Water by Design - Maintaining Vegetated Stormwater Assets (2012) for typical maintenance activities.

- D05.24.02. An inspection and maintenance schedule shall be prepared and submitted for approval by the Local Government Authority. The Inspection and Maintenance Schedule should detail the following:

- a) Inspection Frequency
- b) What is to be inspected
- c) Normal maintenance procedures (removal of sediment build up, clearing of trash racks etc.)
- d) Frequency of maintenance procedures

Consultation with the Local Government Authority shall be carried out to determine acceptable inspection and maintenance frequencies once Contractor defects liability periods have expired.

ANNEXURE D05A

Table D05.22.1 - Core functional bio-retention plant species - Gladstone Regional Council

Species Name	Common Name	Type ³	Region
<i>Carex Appressa</i>	Tall Sedge	Groundcover Sedge	ST, WT
<i>Ficinia Nodosa</i>	Knobby Club-Sedge	Groundcover Sedge	ST
<i>Lepidosperma Laterale</i>	Variable Sword-Sedge	Groundcover Sedge	All
<i>Lomandra Hystrix</i>	River Mat-Rush	Groundcover Herb	ST, DT, WT
<i>Lomandra Longifolia</i>	Spiny-Headed Mat-Rush	Groundcover Herb	All
<i>Lomandra Leucocephala</i>	Woolly Mat-Rush	Groundcover Herb	DT, A
<i>Poa Labillardierei</i>	Common Tussock Grass	Groundcover Grass	ST, A
<i>Themeda Australis</i>	Kangaroo Grass	Groundcover Grass	All
<i>Callistemon Sieberi</i>	River Bottlebrush	Shrub	ST
<i>Leptospermum Liversidgei</i>	Olive Tea-Tree	Shrub	ST
<i>Melaleuca Thymifolia</i>	Thyme Honey Myrtle	Shrub	ST, DT
<i>Banksia Robur</i>	Swamp Banksia	Small Tree	ST
<i>Melaleuca Linariifolia</i>	Flax-Leaved Paperbark	Small Tree	ST
<i>Melaleuca Viridiflora</i>	Broad Leaved Tea-Tree	Small Tree	ST, WT, DT
<i>Casuarina Glauca</i>	Swamp Oak	Tree	ST, WT, DT
<i>Casuarina Cunninghamiana</i>	River Sheoak	Tree	ST
<i>Lophostemon Suaveolens</i>	Swamp Mahogany	Tree	ST, WT, DT
<i>Melaleuca Bracteata</i>	Black Tea-Tree	Tree	ST, WT, DT
<i>Melaleuca Quinquenervia</i>	Broad-Leaved Paperbark	Tree	ST, WT, DT

1. The list of core plant species has been derived from research conducted by FAWB (<http://www.monash.edu.au/fawb>), its successors, other research organisations and observations of healthy bioretention systems.
2. Pennisetum alopecuroides is strongly self-seeding. Local Government Authority advice should be sought regarding its use.

3. WT = wet tropics; DT = dry tropics; ST = subtropics; A = aridzones; All = occurs in all regions.

Table D05.22.1 - Supplementary bio-retention plant species - Gladstone Regional Council

Supplementary Species	Common Name	Type	Region ²
<i>Cymbopogon Refractus</i>	Barbed Wire Grass	Groundcover Grass	DT, WT, ST
<i>Fimbristylis Dichotoma</i>	Common Fringe Sedge	Groundcover Sedge	All
<i>Fimbristylis Ferruginea</i>	Rusty Fringe Sedge	Groundcover Sedge	All
<i>Fimbristylis Tristachya</i>	Fimbry	Groundcover Sedge	DT, WT, ST
<i>Fuirena Umbellata</i>	Yefen	Groundcover Sedge	DT, WT, ST
<i>Gahnia Aspera</i>	Saw Sedge	Groundcover Sedge	ST, WT, DT
<i>Gahnia Seiberiana</i>	Red-Fruit Saw-Sedge	Groundcover Sedge	ST, WT, DT
<i>Juncus Polyanthemus</i>	Striated Rush	Groundcover Sedge	DT, WT, ST
<i>Juncus Usitatus</i>	Common Rush	Groundcover Sedge	DT, WT, ST
<i>Lomandra Confertifolia</i>	Dwarf Mat Rush	Groundcover Sedge	ST
<i>Rhynchospora Corymbosa</i>	Matamat	Groundcover Sedge	All
<i>Alphitonia Excelsa</i>	Red Ash	Shrub	All
<i>Austromyrtus Dulcis</i>	Midgen Berry	Shrub	ST
<i>Breynia Oblongifolia</i>	False Coffee Bush	Shrub	All
<i>Cordyline Manners-Suttoniae</i>	Giant Palm Lily	Shrub	ST, WT
<i>Hibiscus Heterophyllus</i>	Native Rosella	Shrub	DT, WT, ST
<i>Leptospermum Polygalifolium</i>	Wild May	Shrub	DT, WT, ST
<i>Melastoma Malabathricum</i>	Blue Tongue	Shrub	ST, WT
<i>Myoporum Acuminatum</i>	Coastal Boobialla	Shrub	All
<i>Xanthorrhoea Fulva</i>	Swamp Grass Tree	Shrub	ST
<i>Casuarina Equisetifolia</i>	Coast She Oak	Tree	DT, WT, ST

<i>Callistemon Viminalis</i>	Weeping Bottle Brush	Tree	All
<i>Chionanthus Ramiflora</i>	Native Olive	Tree	DT, WT, ST
<i>Corymbia Tessellaris</i>	Moreton Bay Ash	Tree	DT, WT, ST
<i>Cupaniopsis Anacardioides</i>	Beach Tucker	Tree	DT, WT, ST
<i>Eucalyptus Tereticornis</i>	River Blue Gum	Tree	DT, WT, ST
<i>Eugenia Reinwardtiana</i>	Cedar Bay Cherry	Tree	DT, WT, ST
<i>Livistona Decora</i>	Weeping Cabbage Palm	Tree	DT, ST
<i>Melaleuca Dealbata</i>	Blue Leaved Paperbark	Tree	DT, WT, ST
<i>Waterhousea Floribunda</i>	Weeping Lily-Pilly	Tree	ST
<i>Bothriochloa Pertusa</i>	Indian Couch	Turf ¹	DT, ST
<i>Paspalum Distichum</i>	Water Couch	Turf ¹	DT, ST
<i>Paspalum Vaginaturn</i>	Salt Water Couch	Turf ¹	DT, ST, WT
<i>Sporobolus Virginicus</i>	Marine Couch	Turf ¹	DT, WT, ST
<i>Zoysia Macrantha</i>	Zoysia	Turf ¹	ST

1. Turf species are not as effective at stormwater treatment due to their shallower root systems and shoot length. If there is a landscape amenity objective that is driving the response, then plant with appropriate plant species (avoid dense canopies) for a deeper root distribution.
2. WT = wet tropics; DT = dry tropics; ST = subtropics; A = arid zones; All = occurs in all regions.

Planting density

PERFORMANCE OUTCOMES

Planting densities must:

- Provide rapid coverage to out-compete weeds
- Have a uniform root zone through the filter media
- Enable bio-retention performance objectives to be met
- Have 90% coverage in two growing seasons

RECOMMENDED APPROACH

High plant density in bio-retention systems is beneficial to:

- Facilitate rapid establishment of vegetation cover
- Exclude weeds
- Ensure a uniform root zone throughout the filter media
- Maintain filter media porosity
- Maximise pollutant removal

- Distribute flows evenly across the surface of the bio-retention system
- Prevent scour, establishment of preferred flow paths, and re-suspension of deposited sediments.

A suitable planting density should be used to ensure vegetation covers at least 90% of the bio-retention surface after the establishment period (i.e. <10% soil of much visible from above). The planting density to achieve this outcome will vary depending on the species used. Table 2 provided typical planting densities required to achieve 90% coverage rapidly. Over many years, as plants mature and expand, some plants may die. Densities may reduce, however the high initial densities will ensure that in the long term coverage is maintained.

Direct seeding may be useful alternative to the use of seedlings, particularly in large bio-retention systems where it is important to establish vegetation cover quickly to minimising weed ingress. Direct seeding is commonly used for establishing grass cover in bush reconstruction projects. It can be used to establish shrubs and trees.

As the success rate of direct seeding cannot be guaranteed, direct seeding should be used to complement planting seedlings.

Table D05.22.3: Typical Planting Densities Required to Achieve 90% Cover

Vegetation Type	Planting density
Groundcovers (including grasses, herbs and sedges)*	Six to eight plants per m ²
Shrubs**	One plant per 2 - 20 m ²
Trees**	One plant per 20 - 100 m ²

* Groundcover densities of up to 12 plants per m² may be required for bushland layouts

** Suitable plant densities for shrubs and trees depend on the size and form of individual plant species and overall landscape objectives sought

ANNEXURE D05B: Template – Site-based Stormwater Management Plan

Section	Contents
Cover Page	
Document Information Page	This page should outline information relevant to the authorship IWMP (ideally provided in Tabular Form), including document title (and reference number), document ownership (including names of personnel that have issued and checked the IWMP) and name of client (and client representative, if appropriate).
Summary	Concise summary of study methodology and findings.
Responses to Information Request	Details of how (if any) previous information requests from the Local Government Authority have been addressed.
Table of Contents	
1: Introduction	General description of the proposed development/ works, existing site, scope of the IWMP and names of the project team members.
2: Flood Impact Assessment	Assessment of flooding issues at the site of the proposed development (with supporting calculations) for the existing site conditions and 'ultimate development'.
2.1: Site Details	General description of the site and vicinity, including relevant hydrological/ drainage features and flood behaviour.
2.2: Methodology Used	General description of the methodology used in the flood impact assessment.
2.3: Hydrologic Model Establishment	Description of the hydrological modelling methodology, catchment delineation, input parameters and assumptions.
2.4: Hydraulic Model Establishment	Description of the hydraulic modelling methodology, catchment delineation, input parameters and assumptions.
2.5: Calibration & Validation	Description of the calibration and validation process.
2.6: Design Event Modelling	Description of the design event modelling, including critical duration analysis.
2.7: Sensitivity Analysis	Description of sensitivity analyses including climate change scenarios.
2.8: Predicted Impact Assessment	Description of proposed development scenarios including modelling results and proposed mitigation measures.
2.9: Conclusions of Flood Impact Assessment	
3: Stormwater Management Plan	Description of how it is possible for the development to meet given stormwater management targets.
3.1: Opportunities & Constraints for Stormwater Management	Description of the opportunities and constraints presented by the site for the application of stormwater quality and quantity controls (e.g. steep topography preventing the application of devices like swales).
3.2: Pollutants of Concern	Identification of pollutants likely to be generated during the (i) construction phase and (ii) operational phase of the proposed development.
3.3: Stormwater Management Objectives	Identification of stormwater management objectives for both the (i) construction phase and (ii) operational phase of the proposed development.
3.4: Design/ Modelling Approach	Description of design/ modelling methodology, including information on modelling parameters/ properties applied (e.g. source and treatment nodes, meteorological data)

3.5: Operational Phase Stormwater Management Options	Description of selected stormwater management options for the site for the operational phase of the development. This section should include modelling results and dimensions of stormwater treatment measures.
3.6: Life Cycle Costs	Life cycle costs of the proposed operational phase stormwater management options. (The life-cycle costing tool available in MUSIC (version 3 and later) may be utilised to provide indicative life-cycle costing information.
3.7: Asset Hand-Over	Identification of proposed organisation or person(s) who will be responsible for ongoing maintenance activities of the stormwater treatment measures (after the 'on maintenance' period).
3.8: Conclusion of Stormwater Management Plan	
4: Water Savings Plan	Description of the strategy (with supporting calculations and/or modelling, if necessary) proposed to satisfy given water savings targets.
5: References	
Appendix A: Modelling Files	Local Government Authority is to be provided with all modelling files and data to enable checking of all modelling calculations. Data transfer shall include a 'readme' text file, containing a description of the contents and details of any naming conventions used for model files.
Appendix B: Design Drawings	<p>For areas proposed for development, a layout plan must be provided to clearly illustrate the location/ extent of the proposed stormwater treatment measures and the direction of flow through these measures.</p> <p>A full layout plan and a section drawing (at least a longitudinal section and possibly a cross section) must be provided for each stormwater treatment measure showing integration with the existing or proposed drainage system, benching levels (and if appropriate standing water, extended detention and peak water levels), bunding, planting layouts and other conceptual features such as (but not limited to) maintenance access, monitoring access (if proposed) and safety precautions (e.g. fencing and/ or dense vegetation restricting public access). For sites with multiple small treatment devices (e.g. streetscape bioretention 'pods'), a full layout plan and a section drawing of a selected representative sample (e.g. two) of devices must be provided. Layout plans should consider the integration of the stormwater treatment measures into the surrounding landscape.</p> <p>These designs must be prepared as preliminary design drawings suitable for the subsequent preparation of detailed civil design drawings for construction.</p>
Appendix C: Design Checklists & Calculation Summaries	
Appendix D: Maintenance Plans	Maintenance Plans for all proposed stormwater treatment measures proposed for the site (Further information in relation to maintenance plans is provided in Appendix B of this guideline).
Appendix E: Erosion & Sediment Control Plan	An erosion and sediment control (ESC) plan prepared in accordance with "Best Practice Erosion and Sediment Control" (2008 or current version) by IECA, Local Government Authority Planning Scheme requirements and any other recognised industry guidelines.
Appendix F: Construction & Establishment Plan	Description of how each of the proposed stormwater treatment measures are to be constructed and established in accordance with Water by Design's (2009 or current version) "Construction and Establishment Guidelines" or similar guideline document.
Other Appendices	Any further supporting documentation, as required.