

SC6.4.3 Design standards

SC6.4.3.2 Building over or adjacent to services

SC6.4.3.2.1 Introduction

(1) Purpose

This sub-section outlines council's standards and guidelines for building over or adjacent to council's services. This document will supplement the Queensland Development Code *Mandatory Part 1.4 – "Building over or near relevant infrastructure"* and identifies and provides additional guidance about any information that may be required to support a development application. This section does not replace or override any aspect of the QDC.

(2) Scope

This sub-section applies to all building work proposed to be carried out over or near to a council service or underground asset.

(3) Principles

The construction and erection of a structure or the creation of a residential allotment over or near to a council service must be carried out in a way that ensures that:

- (a) the function of the service is not adversely affected;
- (b) no additional load is placed on the service without council approval; and
- (c) maintenance access (at all times) to the service is not interfered with or restricted.

SC6.4.3.2.2 Restricted development

(1) Without exception, council will not permit building a structure over or near to:

- (a) sewer pressure mains and overflow pipework; or
- (b) gravity sewer trunk mains; or
- (c) sanitary drainage connection points; or
- (d) water supply mains; or
- (e) stormwater drainage conduits (pipes or culverts) with a capacity of less than 2% average exceedence probability (AEP) or stormwater pipelines with an internal diameter of less than 375 mm; or
- (f) open drainage channels or overland drainage paths.

SC6.4.3.2.3 Allowable development over or adjacent to sewerage services

(1) Council may permit building a structure over or near to the following sewerage services:

- (a) gravity sewer mains, other than gravity trunk mains excluded under section SC6.4.3.2.2. The applicant is to carry out an internal closed-circuit television inspection of the main and submit it to council, prior to commencing any construction activities over or adjacent to the sewer.

If the main is assessed to be in poor condition or liable to damage from the proposed construction, the applicant may be required to replace the main to the satisfaction of council prior to commencement of any construction activities over or adjacent to the sewer; and

- (b) sewer maintenance holes in commercial or industrial buildings:

If approved, the chamber is to be raised to the floor level of the building. Maintenance holes must be sealed against gas leaks, bolted down and kept clear of obstructions for maintenance access by council at all times.

SC6.4.3.2.4 Allowable development over or adjacent to stormwater services

(1) Council may permit building a structure over or near to the following stormwater services:

- (a) drainage conduit with a minimum 2% AEP and with an internal diameter greater than 375 mm. The applicant must carry out an internal closed-circuit television inspection of the stormwater conduit and submit it to council, prior to commencing any construction activities over or adjacent to the stormwater conduit. If the stormwater conduit is assessed to be in poor condition or liable to damage from the proposed construction, the applicant may be required to replace the main to the satisfaction of council

prior to commencement of any construction activities over or adjacent to the stormwater conduit. Council may permit a driveway or temporary or light steel framed structure to be constructed over a storm water drain where:

- (i) maintenance access to the drain can be retained;
- (ii) the drain does not also form part of an overland flow path; and
- (iii) no other option is available.

SC6.4.3.2.5 Clearances

The following minimum clearances apply for structures permitted to be built over or adjacent to a service:

- (1) a minimum clearance of 250 mm must be maintained between the outside edge of the service footprint and the nearest projection of the foundation of the proposed structure, excluding swimming pools. Swimming pools must be located to achieve a minimum clearance of 600 mm vertically and 1 m horizontally to the outer edge of the service footprint;
- (2) a minimum horizontal clearance of 1.2 m must be maintained between the outer face of the service and the nearest point of the foundation of the structure;
- (3) the foundation of any structure, excluding a swimming pool, located within the zone of influence must extend a minimum of 150 mm below the projected zone or on solid rock. Pier and beam footings are generally acceptable;

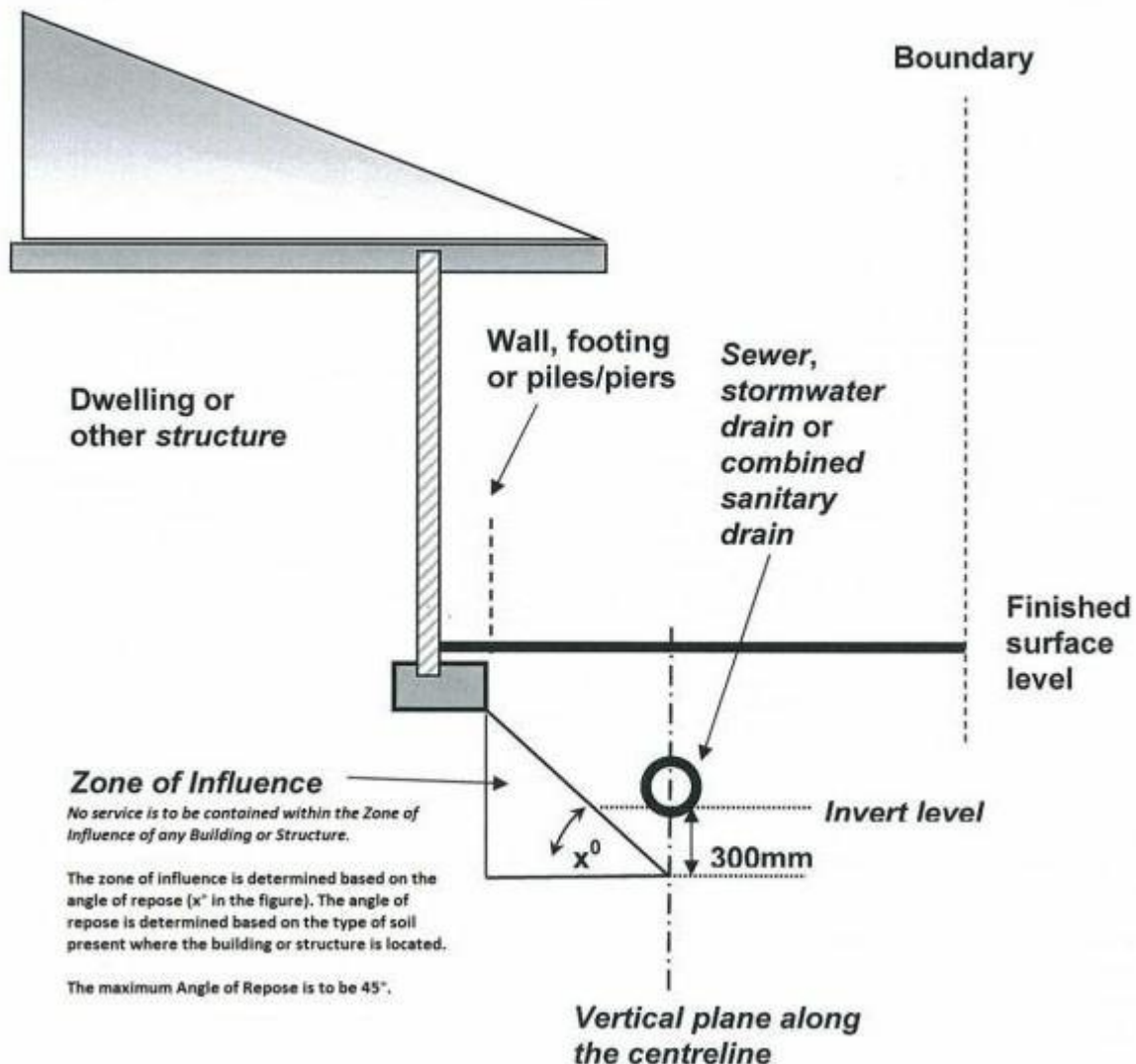


Figure SC6.4.3.2.1 Zone of influence

- (4) a minimum clear vertical space above a sewer manhole of 2.4 m must be maintained above the finished ground

surface level for access purposes;

- (5) a minimum horizontal clear space of 2.0 m must be maintained between structure and connection point on sewer, connection point on sewer refers to oblique branch (OB), vertical jump-up (VJU) and sewer maintenance structure; and
- (6) a minimum horizontal clear space of 2.0 m must be maintained between structure and outside face of gravity trunk sewer.

SC6.4.3.2.6 Relocation of services

- (1) Council will require that a service is relocated at the developer's expense where:
 - (a) no other site is reasonably available for the location of the proposed structure;
 - (b) the proposed structure is in conflict with, or likely to cause damage to, a council service.
- (2) If council in its absolute discretion considers it necessary for a service to be relocated as a consequence of a proposed development, the re-design must consider:
 - (a) the feasibility of redesign or relocation;
 - (b) terrain;
 - (c) cost;
 - (d) importance of the service; and
 - (e) suitability for future maintenance access.

SC6.4.3.3 Footpath treatment policy

SC6.4.3.3.1 Purpose

- (1) The purpose of the Footpath treatment policy is to achieve an appropriate footpath treatment and installation to achieve consistency of surfacing material located in key areas across Townsville, commensurate with the streetscape intent having regard to:
 - (a) the projected level of usage in a given location, such as shared-use or heavy traffic movements;
 - (b) activities anticipated to occur within the verge at the given location and safety requirements; and
 - (c) the desired streetscape character of the location, giving particular attention to the relevant zone code.

Editor's note—refer to SC6.4.3.3.7 Footpath treatment location maps for locations of treatments.

- (2) Reference and source documents:
 - (a) This subsection should be read in conjunction with other sections of the Townsville City Plan and Development manual planning scheme policy including, but not limited to:
 - Part 4 Priority infrastructure plan
 - Part 9.3.3 Landscape code
 - Part 9.3.4 Reconfiguring a lot code
 - Part 9.3.6 Works code
 - SC6.4.2 Development application guidelines
 - SC6.4.3.4 Outdoor dining design
 - SC6.4.3.6 Landscape policy
 - SC6.4.3.20 Public lighting and utility services
 - SC6.4.4.1 Geometric road design
 - SC6.4.4.2 Pavement design
 - SC6.4.4.7 Bicycle, pedestrian and shared path design
 - SC6.4.6 Construction standards
 - (b) The following Australian Standards are also referenced and should be read in conjunction with this subsection:
 - AS/NZS 1158.3.1 Lighting for roads and public spaces
 - AS 1170 Structural design actions (set)
 - AS 1428 Design for access and mobility (set)
 - AS 2890.3 Parking facilities – Bicycle parking facilities
 - AS 3996 Access covers and grates
 - AS 3727 Guide to residential pavements
 - AS/NZS 4586:2004 Slip resistance classification of new pedestrian surface materials
 - (c) Other:
 - The following documents are also referenced and should be read in conjunction with this subsection:
 - Austrroads, Guide to Road Design (Set):
 - Aust Roads – Road Design Part 4 Intersections and Crossings, section 8 Pedestrian Crossings
 - Aust Roads – Road Design Part 4 Intersections and Crossings, section 9 Cyclist Crossings
 - Aust Roads – Road Design Part 6A Pedestrian and Cyclist Paths
 - Department of Transport and Main Roads, Manual of uniform traffic control devices (MUTCD), Queensland.
 - Department of Transport and Main Roads, Traffic and Road Use Management Manual, Volume 1 – Part 6: Intersections, Interchanges and Crossings, Section 3.4-1 Pedestrian crossing facility guidelines and prioritisation system user guide Queensland Government, Crime Prevention through Environmental Design, Guidelines for Queensland, Parts A and B, 2007.

SC6.4.3.3.2 Footpath treatment

- (1) The standards and requirements of this policy sub-section will achieve compliance with Townsville City Plan where the planning scheme code notes this policy as providing compliance.

Editor's note—Part 9.3.3 Landscape Code, Part 9.3.4 Reconfiguring a lot code and Part 9.3.6 Works Code each have outcomes that can be achieved by this policy sub-section, in addition to the relevant zone code.

- (2) The locations where footpath treatment standards of this policy are to be met are shown in SC6.4.3.3.7 Footpath treatment location maps. In general, the following locations require footpath treatment in accordance with this policy sub-section:
- (a) the Principal central (CBD) and key development areas supporting the CBD;
 - (b) other key activity centres (generally those in the Centre zones category and Specialised centre zone), in particular along the supporting roads and streets where attractive pedestrian streetscapes are intended by the zone and precinct;
 - (c) key infill areas, including medium density and higher density residential areas where there is an emphasis on creating attractive and pedestrian-oriented streetscapes;
 - (d) facilities with high levels of public use warranting improved footpath treatment such as: educational establishments (schools, TAFE colleges), places of worship etc., the finish of the footpath treatment shall be at the discretion of the Townsville City Council;
 - (e) mixed use areas that have frequent pedestrian use have a highly visible frontage or where attractive pedestrian environments are intended by the zone and precinct;
 - (f) special footpath type areas such as Magnetic Island, The Strand, Palmer Street and Sir Leslie Thiess Drive; and
 - (g) any new centres, commercial, mixed use and community uses that are not identified in SC6.4.3.3.7 Footpath treatment location maps. In such instances, the above criteria shall be used to determine the most similar development to inform the particular treatment to be applied.

Editor's note—for any other areas not covered by SC6.4.3.3.7 Footpath treatment location maps see SC6.4.4.7 Bicycle, pedestrian and shared path design.

Editor's note—refer to SC6.4.3.3.7 Footpath treatment location maps for location of proposed treatments.

Editor's note—for land with the Townsville City Waterfront Priority Development Area (PDA) additional criteria applies, see the Townsville City Waterfront Priority Development Area Development Scheme.

SC6.4.3.3.3 Footpath treatment standards

- (1) Footpath treatment standards for each of the nominated locations identified in SC6.4.3.3.7 Footpath treatment location maps are set out in the following Tables.

Editor's note—refer to SC6.4.3.3.7 Footpath treatment location maps for locations of proposed treatments.

FT1 – Footpath Treatment 1	
Statement of intent - FT1	
Footpath treatment 1 serves the core retail and entertainment areas of the Principal centre (CBD). The treatment provides the highest finish intended to support high levels of pedestrian use and may provide for on street dining, and informal and formal recreational and civic spaces.	
Body of footpath and driveway crossings: FT1	
Description:	• footpath treatment FT1 shall be full width from building line to the road kerb alignment. • two kinds of stone pavers of varying length and width set in mortar on mass concrete base (see SC6.4.6.14 Mass concrete sub-base and SC6.4.6.18 Segmental paving) • facing: split face finish to top (saw cut other edges) • image: refer to Figure SC6.4.3.3.2 Image FT1.

Pattern:	- staggered pattern as shown in Figure SC6.4.3.3.1 Conceptual diagram: FT1, and Figure SC6.4.3.3.2 Image FT1. - pavers shall be laid alternatively 200mm and 100mm wide with the basalt (darker) paver towards the building line and the granite (lighter) paver towards the kerb. - a staggered transition between the pavement types shall occur at approximately 70 per cent basalt 30 per cent granite, see Figure SC6.4.3.3.1 Conceptual diagram FT1.
Grout:	- product: CTA Polyblend G15 or approved equal. - colour: 'Mid Grey'.
Pavers:	- basalt: 100% grey range (darker stone in Figure SC6.4.3.3.1 Conceptual diagram FT1) - granite: 'Sindoor Brown' (lighter stone in Figure SC6.4.3.3.1 Conceptual diagram FT1) - width: 200 mm or 100 mm (refer varying widths in Figure SC6.4.3.3.1 Conceptual diagram FT1) - length: 300 mm or 500 mm - depth: 40 mm

Driveway and pedestrian crossing point

Description:	- driveway access through footpath shall be monolithic poured colored concrete slabs, colour to be matched to the basalt paver, with saw cut detailing to match adjacent paver pattern (scoring cuts only 5mm deep). See Figure SC6.4.3.3.3 Image FT1 driveway option. - driveway crossover shall be "plain natural" concrete with surface : broom finish. - pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish.

Figure SC6.4.3.3.1 Conceptual diagram: FT1

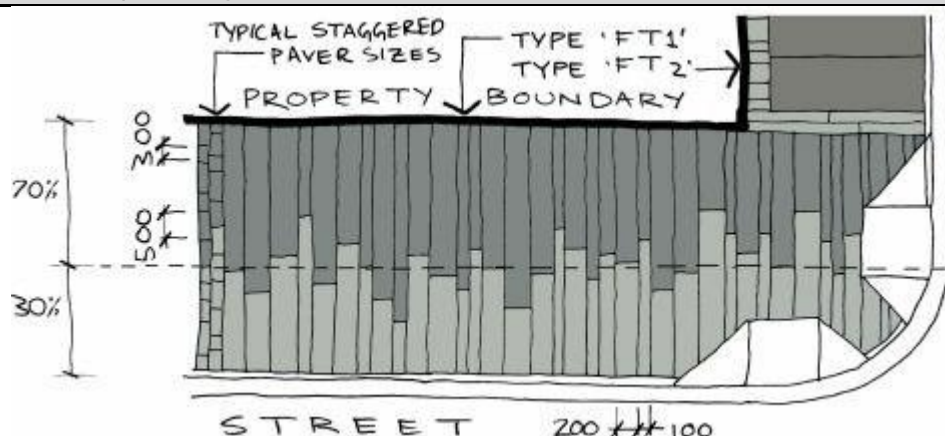


Figure SC6.4.3.3.2 Image: FT1



Figure SC6.4.3.3.3 Image FT1 driveway option



Editor's note—refer to SC6.4.3.3.7 Footpath treatment location maps for locations of proposed treatments.

FT2 – Footpath Treatment 2	
Statement of intent	
Footpath treatment 2 serves the remainder of the Principal centre (CBD), key areas which support the CBD and areas intended for medium and higher residential densities nearby the CBD. The treatment provides a nexus with FT1 and is of a high quality to support high levels of pedestrian use and may provide for the integration of civic spaces. A reduced width option may be permitted in the medium density residential areas as indicated on SC6.4.3.3.7 Footpath treatment location maps.	
Body of footpath: FT2	
Description:	• footpath treatment FT2 shall be full width from building line to the road kerb alignment. • monolithic poured concrete slabs in approximately 5 m lengths with decorative scoring pattern and perimeter stone paver banding on mass concrete base, see SC6.4.6.14, Figure SC6.4.3.3.4 Conceptual diagram: FT2, and Figure SC6.4.3.3.5 Conceptual diagram FT2, and Figure SC6.4.3.3.5 Image: FT2. • finish: 'light wash' 1 mm – 2 mm deep (2 mm max) using a water-based chemical retarder, see Figure SC6.4.3.3.8, Figure SC6.4.3.3.9, and Figure SC6.4.3.3.10. • standard drawings as noted in SC6.4.3.3.3(b). • decorative scoring, see Figure SC6.4.3.3.4, Figure SC6.4.3.3.5, and noted in SC6.4.3.3.3(3) and SC6.4.3.3.3(i). Editor's note—refer to Figure SC6.4.3.3.8 for maximum acceptable aggregate exposure and Figure SC6.4.3.3.9 and Figure SC6.4.3.3.10 for unacceptable, under and over, aggregate exposure.
Description reduced width option areas:	• reduced width which allows for a planting zone from back of curb and/or property boundary see Figure SC6.4.3.3.7 Conceptual diagram FT2 – Reduced width option. • monolithic poured concrete slabs with decorative scoring pattern and stone paver banding at approximately 5m intervals on a mass concrete base, see Figure SC6.4.3.3.7. • finish: 'light wash' 1 mm – 2 mm deep (2 mm max) using a water based chemical retarder, see Figure SC6.4.3.3.8, Figure SC6.4.3.3.9, and Figure SC6.4.3.3.10. • standard drawings as noted in SC6.4.3.3.3(b). • decorative scoring: see Figure SC6.4.3.3.7, and noted in SC6.4.3.3.3(3) and SC6.4.3.3.3(i). Editor's note—refer to Figure SC6.4.3.3.8 for maximum acceptable aggregate exposure and Figure SC6.4.3.3.9 and Figure SC6.4.3.3.10 for unacceptable, under and over, aggregate exposure.

Pattern:	see Figure SC6.4.3.3.4 Conceptual diagram FT2 and Figure SC6.4.3.3.5 Conceptual diagram F2 and Figure SC6.4.3.3.7 Conceptual diagram F2 reduced width option for saw cut pattern.
Colour:	- concrete colour: CCS "Onyx" at 4% dose in a grey cement base. - aggregate: Hanson "salt and pepper" or approved equivalent.
Banding: FT2	
Description:	- granite stone pavers of varying length and width on mass concrete base, see SC6.4.6.14 Mass concrete sub-base and SC6.4.6.18 Segmental paving, SC6.4.3.3.5 Banding details. - facing: split face to top, saw cut finish to all other sides. - standard drawings as listed in SC6.4.3.3.3(b).
Pattern:	staggered pattern as shown in Figure SC6.4.3.3.4 Conceptual diagram FT2, Figure SC6.4.3.3.5 Conceptual diagram FT2, Figure SC6.4.3.3.6 Image FT2 and Figure SC6.4.3.3.7 Conceptual diagram FT2 reduced width option.
Grout:	- product: Polyblend G15 sanded grout from Construction Technologies Australia or approved equal. - colour: "Mid Grey".
Pavers:	- granite: "Sindoor Brown". - width: 200 mm or 100mm. - length: 300 mm or 500mm. - depth: 40 mm.
Driveway and pedestrian crossing points: FT2	
Description:	- driveway access through footpath shall be monolithic poured concrete slabs with decorative scoring, see Figure SC6.4.3.3.3. - finish: light wash finish 1 mm – 2 mm deep (2 mm max), using a water-based chemical retarder (CCS "reveal" 1 mm or approved equal, do not use sugar), see Figure SC6.4.3.3.5, Figure SC6.4.3.3.9, and Figure SC6.4.3.3.10. - driveway crossover shall be "plain natural" concrete with surface: broom finish. - pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish. - standard drawings: as noted in SC6.4.3.3.3(b)
Pattern:	see Figure SC6.4.3.3.4 Conceptual diagram: FT2 and Figure SC6.4.3.3.5 Conceptual diagram: FT2 for sample crossover layout and decorative scoring pattern.
Colour:	- concrete colour: CCS "Onyx" at 4% dose in a grey cement base. - aggregate: Hanson "salt and pepper" aggregate or approved equivalent.

Figure SC6.4.3.3.4 Conceptual diagram: FT2

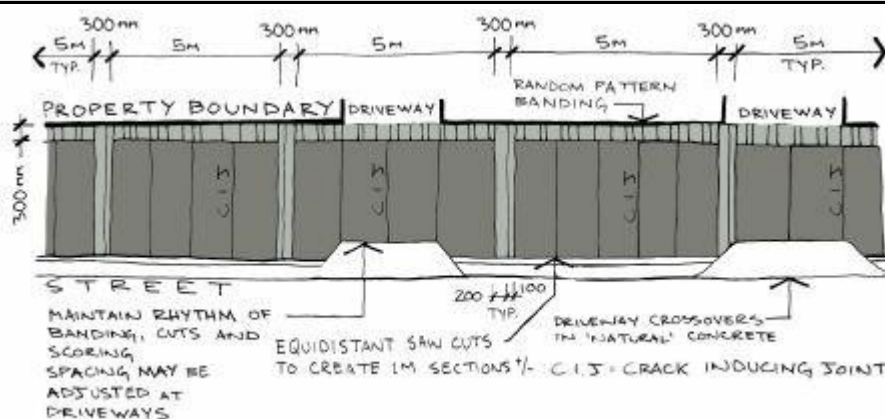


Figure SC6.4.3.3.5 Conceptual diagram: FT2

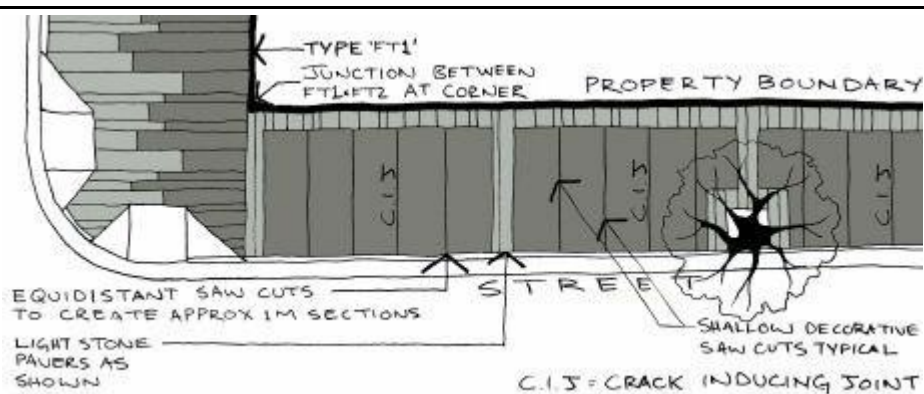


Figure SC6.4.3.3.6 Image FT2



Figure SC6.4.3.3.7 Conceptual diagram FT2 reduced width option

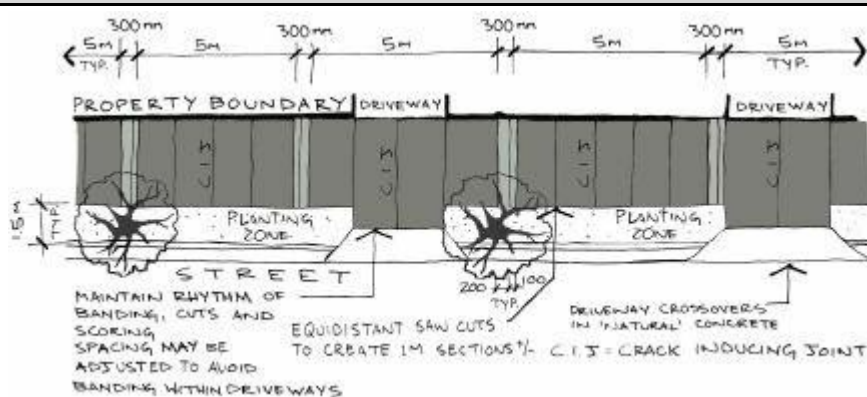


Figure SC6.4.3.3.8 Image FT2 (2 mm maximum exposure acceptable)



Figure SC6.4.3.3.9 Image FT2 (1 mm exposure - unacceptable - underexposed)



Figure SC6.4.3.3.10 Image FT2 (3 mm exposure – unacceptable - overexposed)



Editor's note—refer to SC6.4.3.3.7 - Footpath treatment location maps for locations of proposed treatments.

FT3 – Footpath Treatment 3

Statement of intent

Footpath treatment 3 serves many of the city activity centre areas, including major, district and local centres and some neighborhood centres, mixed use areas and specialised centres, where regular pedestrian use is anticipated for commercial and recreational purposes

Body of footpath: FT3

Description:	- footpath treatment FT3 shall be full width from building line to the road kerb alignment. - monolithic poured coloured concrete slabs in 5 m lengths with decorative scoring and perimeter cobble banding. - conceptual image: see Figure SC6.4.3.3.11 Conceptual diagram FT3. - finish: broom finish. - standard drawings: as noted in SC6.4.3.3.3(b). Editor's note —for decorative scoring, see SC6.4.3.3.4, SC6.4.3.3.3(g), and SC6.4.3.3.3(i).
Description reduced width option areas:	- reduced width which allows for a planting zone from back of kerb and/or property boundary see Figure SC6.4.3.3.13 Conceptual diagram FT3 Reduced width option. - monolithic poured coloured concrete slabs with decorative scoring and cobble banding at approximately 5m intervals on a mass concrete base. - conceptual image: see Figure SC6.4.3.3.13 Conceptual diagram FT3 Reduced width option. - finish: broom finish. - standard drawings: as noted in SC6.4.3.3.3(b). Editor's note—for decorative scoring, see SC6.4.3.3.4, SC6.4.3.3.3(g), and SC6.4.3.3.3(i).
Pattern:	- conceptual scoring pattern: see Figure SC6.4.3.3.11 and Figure SC6.4.3.3.13, - for variations such as corners, trees, doorways etc, refer: Figure SC6.4.3.3.22, Figure SC6.4.3.3.23, Figure SC6.4.3.3.24, Figure SC6.4.3.3.25, Figure SC6.4.3.3.26 and Figure SC6.4.3.3.27, - align scoring pattern with adjacent footpath scoring and/or saw cuts where applicable Editor's note —for decorative scoring, see SC6.4.3.3.4, SC6.4.3.3.3(g), and SC6.4.3.3.3(i)
Colour:	CCS "paperbark" at 4% dose in a grey cement base
Banding: FT3	
Description:	- pressed concrete cobbles set in mortar on mass concrete base (see SC6.4.6.14 Mass concrete subbase, SC6.4.6.18 - Segmental Paving and SC6.4.3.3.5 Banding details) - finish: proprietary non-slip finish

Pattern:	- cobbles 3x wide in stack bond pattern - conceptual image: see Figure SC6.4.3.3.11 and Figure SC6.4.3.3.13,. - for variations such as corners, trees, doorways etc. refer: Figure SC6.4.3.3.22, Figure SC6.4.3.3.23, Figure SC6.4.3.3.24, Figure SC6.4.3.3.25, Figure SC6.4.3.3.26, Figure SC6.4.3.3.27, and Figure SC6.4.3.3.29.
Colour:	CCS "ghost gum".
Pavers:	100mm x 100mm square x 60 mm to 65 mm deep.
Driveway and pedestrian crossing points: FT3	
Description:	- driveway access through footpath shall be monolithic poured coloured concrete slabs. - driveway crossover shall be "plain natural" concrete with surface: broom finish, see Figure SC6.4.3.3.24. - pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish. - standard drawings: as noted in SC6.4.3.3.3(b). Editor's note —for decorative scoring, see SC6.4.3.3.4, SC6.4.3.3.3(g), SC6.4.3.3.3(i).
Pattern:	- for pattern integration of driveways, refer: Figure SC6.4.3.3.24. - align driveway scoring pattern with adjacent footpath decorative scoring and/or crack control saw cuts. Editor's note —for decorative scoring, see SC6.4.3.3.4, SC6.4.3.3.3(g), SC6.4.3.3.3(i).
Colour:	CCS "paperbark" at 4% dose in a grey cement base, kerb transition: "natural" concrete colour.

Figure SC6.4.3.3.11 Conceptual diagram FT3

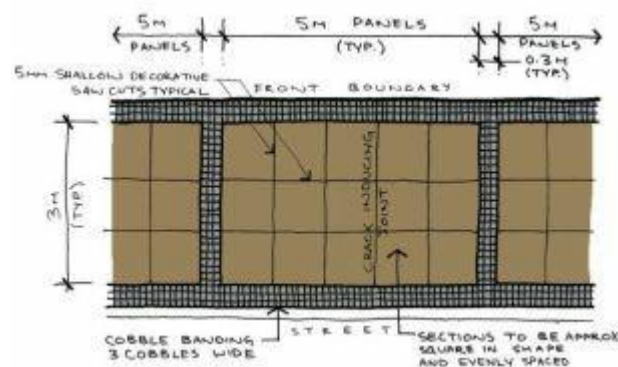


Figure SC6.4.3.3.12 Image: FT3



Figure SC6.4.3.3.13 Conceptual diagram FT3 reduced width option

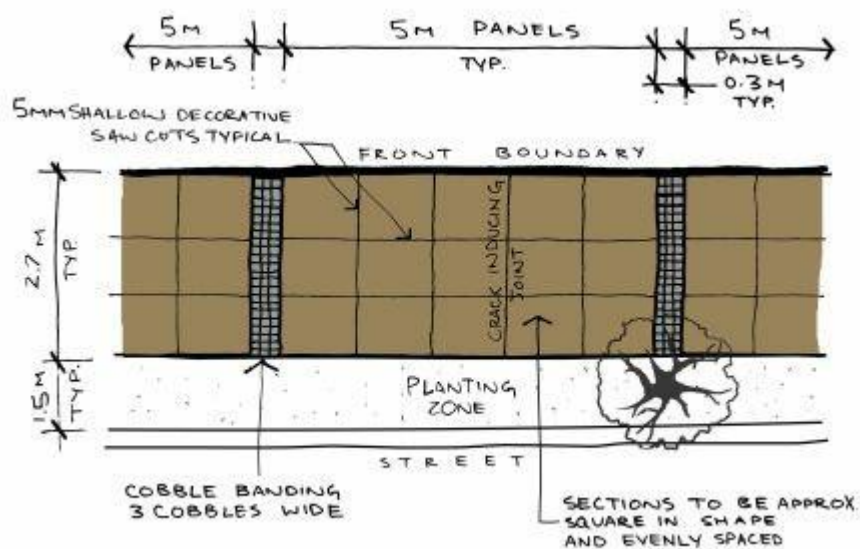


Figure SC6.4.3.3.14 Image FT3 reduced width option



Editor's note—refer to SC6.4.3.3.7 - Footpath treatment location maps for locations of proposed treatments.

FT4 – Footpath Treatment 4

Statement on intent

Footpath treatment 4 serves many of the city's lower order activity centre areas, mixed use areas, key corridors and key infill areas intended for increased residential densities and attractive streetscape.

Body of footpath: FT4

Description:	- Footpath treatment FT4 shall be full width from building line to the road kerb alignment. - monolithic, poured, full depth coloured concrete finish: broom finish. - standard drawings: see standard drawings noted in SC6.4.3.3.3(3)(b).
Description reduced width option areas:	- Reduced width which allows for a planting zone from back of kerb and/or property boundary. - monolithic, poured, full depth coloured concrete finish: broom finish. - standard drawings: see standard drawings noted in SC6.4.3.3.3(3)(b).
Colour:	CCS "paperbark" at 4% dose in a grey cement base.
Pattern	divided by crack control joints as required and decorative scoring into equal sections of approximately 1 m wide throughout the length of the footpath.

Driveway and pedestrian crossing points: FT4

Description:	- driveway access through footpath shall be monolithic, poured, full depth coloured concrete. - driveway crossover shall be "plain natural" concrete with surface broom finish, see Figure SC6.4.3.3.24. - pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish. - standard drawings: see standard drawings noted in SC6.4.3.3.3(b)
Colour:	CCS "paperbark" at 4% dose in a grey cement base.

FT5 – Footpath Treatment 5

Statement of intent

Footpath treatment 5 is a specialised treatment which serves the Palmer Street dining area.

Body of footpath: FT5

Description:	- footpath treatment FT5 shall be full width from building line to the road kerb alignment. "Bluestone" stone pavers set in mortar on mass concrete base, see SC6.4.6.14 Mass concrete subbase and SC6.4.6.18 Segmental paving - Pattern: staggered pattern, see Figure SC6.4.3.3.15 and Figure SC6.4.4.3.16 facing: split face finish to top surface (all other sides sawn). - standard drawings: as noted in SC6.4.3.3.3(b).
Pavers:	- stone type: "Bluestone" - size 1: 750 mm x 495 mm. - size 2: 495 mm x 495 mm. - size 3: 495 mm x 245 mm. - size 4: 495 mm x 155 mm. - depth: 40 mm.
Colour:	natural stone colour.
Grout:	product: CTA Polyblend G15 or approved equal colour: "Mid Grey".

Driveway and pedestrian crossing points: FT5

Description:	- driveway access through footpath shall be 'Bluestone' cobble pavers set in mortar on mass concrete base see SC6.4.6.14 Mass concrete subbase and SC6.4.6.18 Segmental paving. - facing: split face finish to top with all other sides sawn. - pattern: continuous staggered pattern, see Figure SC6.4.3.3.15 and Figure SC6.4.3.3.16. - driveway crossover shall be "plain natural" concrete with surface: broom finish, see Figure SC6.4.3.3.24. - pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish.
Pavers:	100 mm x 100 mm square x 60 mm to 65 mm deep.
Colour:	natural "Bluestone" colour.
Grout:	- product: Polyblend G15 sanded grout from Construction Technologies Australia or approved equal. - colour: "Mid Grey".

Figure SC6.4.3.3.15 Pattern FT5

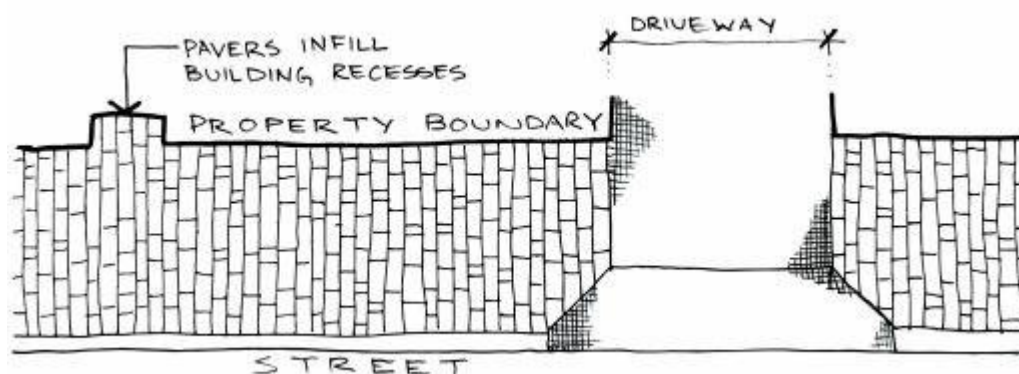
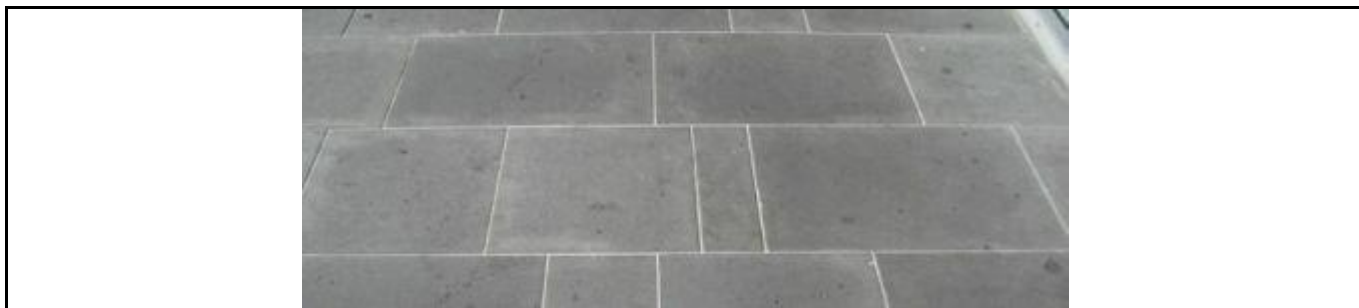


Figure SC6.4.3.3.16 Image FT5 body of footpath



Editor's note—refer to SC6.4.3.3.7 Footpath treatment location maps for locations of proposed treatments.

FT6 – Footpath Treatment 6	
Statement on intent	
Footpath treatment 6 is a specialised treatment area which serves the southern side of The Strand through to Ross Creek.	
Body of footpath and driveway crossings: FT6	
Description:	- footpath treatment FT6 shall be full width from building line to the road kerb alignment. - pressed concrete pavers set in stack bond pattern in mortar on mass concrete base see SC6.4.6.14 Mass concrete sub-base and SC6.4.6.18 Segmental paving. - image: see Figure SC6.4.3.3.18 - standard drawings: as noted in SC6.4.3.3.3(b). - for property boundaries not parallel to kerb refer: Figure SC6.4.3.3.28
Pattern	laid in stack bond parallel to the kerb line, see Figure SC6.4.3.3.17, and Figure SC6.4.3.3.18
Pavers:	- Havenpave 50. - width: 200mm. - length: 200mm. - depth: 50mm. - colour: "Charcoal"
Banding to footpath: FT6	
Description:	- pressed concrete pavers in soldier course pattern set in mortar on mass concrete base, see SC6.4.6.14 Mass concrete sub-base and SC6.4.6.18 Segmental paving. - for property boundaries not parallel to kerb refer: Figure SC6.4.3.3.28
Pattern:	laid in soldier course perpendicular to the kerb line, see Figure SC6.4.3.3.17 and Figure SC6.4.3.3.18 below.
Pavers:	- Havenbrick 50. - length: 200 mm - width: 100 mm - depth: 50 mm - colour: CCS "Sunstone".
Driveway and Pedestrian Crossing Points: FT6	
Description:	- driveway access through footpath shall be pressed concrete pavers set in stack bond pattern in mortar on mass concrete base see SC6.4.6.14 Mass concrete subbase and SC6.4.6.18 Segmental paving. - Standard drawings: as noted in SC6.4.3.3.3(b). - driveway crossover shall be "plain natural" concrete with surface: broom finish, see Figure SC6.4.3.3.24. - pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish.
Figure SC6.4.3.3.17 Pattern: FT6	

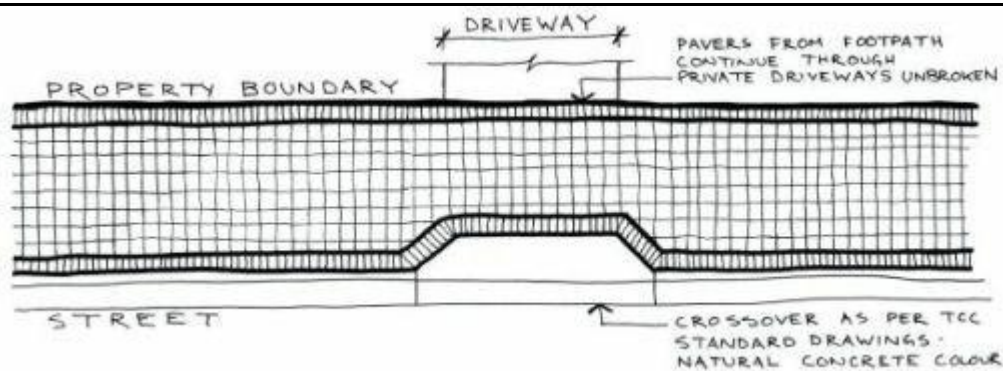


Figure SC6.4.3.3.18 Image FT6



Editor's note—refer to SC6.4.3.3.7 - Footpath treatment location maps for locations of proposed treatments

FT7 – Footpath Treatment 7

Statement of intent

Footpath treatment 7 is a specialised treatment area which serves the Sir Leslie Thiess Drive area and the east end of the southern side of The Strand.

Body of footpath: FT7

Description:	- monolithic poured concrete slabs in 5 m lengths - finish: lightly exposed aggregate, refer texture only of Figure SC6.4.3.3.8 - image: see Figure SC6.4.3.3.19. - standard drawings: refer to the standard drawings noted in SC6.4.3.3.3(3)(b).
Colour:	- CCS "Coco" 4% dose in a grey cement base - aggregate: Hanson "Burdekin Red" or approved equivalent.

Driveway and Pedestrian Crossing Points: FT7

Description:	- driveway access through footpath shall be monolithic poured coloured concrete slabs. - driveway crossover shall be "plain natural" concrete with surface: broom finish, see Figure SC6.4.3.3.24. - pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish.

Figure SC6.4.3.3.19 Image FT7



Editor's note—refer to SC6.4.3.3.7 - Footpath treatment location maps for locations of proposed treatments

Editor's note—FT8 – Footpath Treatment 8 table describes the existing treatment, as noted on SC6.4.3.3.7 Footpath treatment location

maps this area is an investigation area. An alternate treatment is under development.

FT8 – Footpath Treatment 8	
Statement on intent	
Footpath treatment 8 is a specialised treatment area which serves the Gregory Street area in North Ward.	
Body of footpath: FT8	
Description:	- footpath treatment FT8 shall be full width from building line to the road kerb alignment. - pressed concrete pavers set in mortar on mass concrete base with perimeter banding, see SC6.4.6.14 Mass concrete sub-base and SC6.4.6.18 Segmental paving - for property boundaries not parallel to kerb refer: Figure SC6.4.3.3.28 image: see Figure SC6.4.3.3.20. - finish: proprietary non-slip finish. - sealant: two coats of penetrating sealer.
Pattern:	- stack bond as per existing adjacent pattern with alternating bands of coloured pavers separated by a 350 mm band of "natural" concrete - image: see Figure SC6.4.3.3.20.
Pavers:	- width: 400 mm. - length: 400 mm. - depth: 40 mm. - colours: CCS "Morocco", CCS "Onyx 21"
Banding: FT8	
Description:	pressed concrete pavers set in mortar on mass concrete base see SC6.4.6.14 Mass concrete subbase and SC6.4.6.18 Segmental paving.
Pattern:	1x wide soldier course, see Figure SC6.4.3.3.20 - stack bond as per existing adjacent pattern with alternating bands of coloured pavers separated by a 350 mm band of "natural" concrete.
Colour:	colour of banding pavers match colour of banded square pavers colours: CCS "Morocco", CCS "Onyx 21", natural grey concrete.
Pavers:	- length: 220 mm. - width: 110 mm. - depth: 40 mm.
Supplier:	Boral or approved equal.
Driveway and Pedestrian Crossing Points: FT8	
Description:	- Driveway access through footpath shall be pressed concrete pavers set in mortar on mass concrete base with perimeter banding, see SC6.4.6.14 Mass concrete sub-base and SC6.4.6.18 Segmental paving. - Driveway crossover shall be "plain natural" concrete, with surface broom finish, see Figure SC6.4.3.3.24. - Pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish.
Figure SC6.4.3.3.20 Image FT8	
	

Editor's note—refer to SC6.4.3.3.7 - Footpath treatment location maps for locations of proposed treatments

FT9 – Footpath Treatment 9	
Statement of intent	
Footpath treatment 9 is a specialised treatment occurring only on Magnetic Island.	
Body of footpath: FT9	
Description:	- monolithic poured coloured concrete slabs. - primarily in eucalypt with the secondary colour black used to highlight special features such as premises entries, dining areas, etc. - finish: 'light wash' 1 mm – 2 mm deep (2 mm max) using a water-based chemical retarder. - standard drawings: as noted in SC6.4.3.3.3(b). Editor's note—refer to Figure SC6.4.3.3.8 for maximum acceptable aggregate exposure and Figure SC6.4.3.3.9 and Figure SC6.4.3.3.10 for unacceptable, under and over, aggregate exposure.
Description reduced width area:	- reduced width which allows for a planting zone from back of kerb and/or property boundary. - monolithic poured coloured concrete slabs. - primarily in eucalypt with the secondary colour black used to highlight special features such as premises entries, dining areas etc. - finish: 'light wash' 1 mm – 2 mm deep (2 mm max) using a water based chemical retarder. - standard drawings: as noted in SC6.4.3.3.3(b). Editor's note—refer to Figure SC6.4.3.3.8 for maximum acceptable aggregate exposure and Figure SC6.4.3.3.9 and Figure SC6.4.3.3.10 for unacceptable, under and over, aggregate exposure.
Colour:	- primary - CCS "eucalypt" at 4% dose in a grey cement base Figure SC6.4.3.3.21 Image FT9. - secondary - CCS "black" at 4% dose in a grey cement base Figure SC6.4.3.3.21 Image FT9. - aggregate: Hanson "salt and pepper" or approved equivalent.
Pattern:	divided by crack control joints as required.
Driveway and Pedestrian crossing Points: FT9	
Description:	- driveway access through footpath shall be monolithic poured coloured concrete slab. - driveway crossover shall be "plain natural" concrete with surface: broom finish, see Figure SC6.4.3.3.24. - pedestrian kerb ramp shall be "plain natural" concrete with surface: broom finish.
Colour:	- primary - CCS "eucalypt" at 4% dose in a grey cement base see Figure SC6.4.3.3.21 Image FT9. - Secondary - CCS "black" at 4% dose in a grey cement base Figure SC6.4.3.3.21 Image FT9. - aggregate: Hanson "salt and pepper" or approved equivalent.
Figure SC6.4.3.3.21 Image FT9	



- (2) All concrete cobbles (border banding) and field pavers are to have a:
- (a) depth of 60 mm to 65 mm for cobbles, 40mm for field pavers;
 - (b) compressive strength of 32 MPa for concrete cobbles and pavers;
 - (c) mass concrete subbase integral with adjacent concrete, see SC6.4.6.14 Mass concrete subbase;
 - (d) slip resistance in accordance with AS/NZS 3661.1, Table 5;
 - (e) 3 mm chamfer on the surface edges with a pressed finish for concrete pavers and cobbles; and be in accordance with AS1428.1 – Construction tolerances for abutment of surfaces;
 - (f) two coats of low VOC, water-based, 7-15 year recoat penetrating sealer system designed to repel grease and oil stains;
 - (g) cobbles and pavers are to be placed on concrete mortar; and
 - (h) edge of paver banding shall be filled with 10mm thick compressible filler board for full depth of slab and 20mm polyurethane based sealant.
- (3) All concrete slabs shall be:
- (a) integrally coloured for the full depth of the slab where colouring is noted in SC6.4.3.3.3 Footpath treatment standards;
 - (b) Engineer Certified design drawings must be submitted to council for acceptance prior to approval being given showing site specific construction details of paver band designs and integrated construction joints at intervals that are generally in accordance with TCC Standard drawing SD-070. Pavements are to be constructed as per SC6.4.4.8 Standard drawings:
 SD-015: Verge Service Corridors General Type Sections;
 SD-020: Concrete Kerbing;
 SD-025: Kerb Ramp;
 SD-030: Driveway Access Urban Residential Properties;
 SD-031: Driveway Access Commercial and Industrial Properties;
 SD-032: Driveway Crossovers Urban Residential Properties;
 SD-055: Road Crossing and Footpath Reinstatement for Trench Laid Services;
 SD-060: Traffic Sign Installation;
 SD-065: Street Name Sign and Installation Details;
 SD-070: Concrete Pathway Reinforced Concrete (Mesh) Alternative;
 SD-075: Concrete Pathway Reinforced Concrete (Fibre) Alternative; and
 SD-500: Standard Bus Shelter and Footing Details,

- (c) sealed with two coats of low VOC, water-based, 7-15 year recoat penetrating sealer system designed to repel grease and oil stains;
- (d) proportioned in terms of 'width to length' as '1 to 1.5' between crack control joints as per standard drawings listed in SC6.4.3.3.3(b);
- (e) laid in accordance with standard drawings listed in SC6.4.3.3.3(b);
- (f) constructed so that all runoff, slurry and excess materials must be captured and disposed of appropriately, and all surrounding surfaces are protected from staining;
- (g) constructed so that all decorative scoring cuts are five mm deep for the full length of the slab continuous through the end of the slab;
- (h) constructed so that all crack inducing saw cuts are continuous through to the end of the slab;
- (i) constructed so that all saw cuts:
 - (i) are made approximately 24 hours after finishing (preferably the morning after the pour);
 - (ii) are cut with a "Early Cut Saw" only;
 - (iii) are cut with a "Dry Cut" method only (this requirement is to override conflicting specifications on standard drawing SD-070 (for coloured concrete only);
 - (iv) are aligned where possible with any service penetrations, on at least one side of the penetration, or services to be located wholly within one saw cut square (see Figure SC6.4.3.3.32);
 - (v) are constructed in accordance with standard drawings listed in SC6.4.3.3.3(b) with the exception of SC6.4.3.3.3(i)(iii);
 - (vi) for footpath treatment type FT3, create a pattern comprised of:
 - (A) both decorative scoring and crack inducing joints (as required) to create sub-panels approximately 1x1 m square or otherwise closely proportioned rectangular shapes evenly spaced throughout the panel (see Figure SC6.4.3.3.22);
 - (B) minimum sub-panel dimensions of 0.8 m either width or length, generally creating rectangular, regularly spaced sub-panels evenly spaced through the primary panel; and
 - (C) maximum sub-panel dimensions of 1.2 m either width or length, generally creating rectangular, regularly spaced sub-panels evenly spaced through the primary panel.
 - (vii) for footpath treatment type FT2, create patterns comprised of both decorative scoring and crack inducing joints (as required) creating sub-panels approximately 1 m wide (4 cuts in 5 m lengths) evenly spaced throughout the panel (see Figure SC6.4.3.3.22, Figure SC6.4.3.3.23 and Figure SC6.4.3.3.24).
- (j) coloured concrete slabs shall be grade S32 minimum. Where concrete is located in an aggressive environment (e.g. salt exposure, aggressive soils, etc.), concrete strength design shall be in accordance with AS3600;
- (k) fibre reinforced concrete footing under banding shall be grade S20 minimum;
- (l) concrete slab thickness shall be 100mm minimum. In areas where maintenance vehicular loading is expected, concrete thickness shall be 125mm minimum;
- (m) concrete cover to steel reinforcement shall be 40mm unless otherwise noted;
- (n) concrete shall be laid on minimum 50mm of compacted crusher dust / sand bedding with moisture barrier;
- (o) all concrete shall be cured in accordance with the following:
 - (i) AS3600;
 - (ii) aliphatic alcohol must be used. The aliphatic alcohol shall be applied after screeding & and bull floating operations;
 - (iii) no water shall be added to concrete;
 - (iv) an impermeable membrane shall be applied. All joints in membrane are to be taped and the edges secured to prevent the ingress of air;
 - (v) minimum curing period shall be not less than 7 days for strength grade S32 and not less than 4 days for high early strength concrete;

- (p) exposed edges of formed concrete elements shall have a 20mm chamfer unless otherwise noted;
 - (q) all concrete shall be mechanically vibrated. Hand held vibrators must be held upright. Concrete must not be spread using vibrator; and
 - (r) all other requirements shall be in accordance with SC6.4.6.28 Minor concrete works.
- (4) Tactile ground surface indicators (TGSi) where required shall:
- (a) be stainless steel studs (CTA SureSteel or approved equal) with bright yellow plastic insert for type FT1, FT2, FT5 installed as per AS/NZS1428.4.1 providing slip resistance of R13 (wet/oil ramp);
 - (b) all other types not covered by SC6.4.3.3(4)(a) shall be yellow Polyurethane tactile indicator studs (warning tactiles), and bars (directional tactiles), drill and lock installation; and
 - (c) be supplied and installed in accordance with AS/NZS1428.4.1 providing correct illuminance contrast, and AS1428.1 and AS4586 Slip Resistance of Pedestrian Surfaces, and as per manufacturers specifications and in accordance with AS1884. Also to be in accordance with SC6.4.4.7(4) Bicycle, pedestrian and shared path design.
- (5) footpath treatment shall not impede into private property.
- (6) for all footpath treatment types the ground surface on the continuous accessible path of travel – construction tolerances for abutment of surface shall be in accordance with AS 1428.1. to eliminate the possibility of tripping hazards and non-compliance levels of abutting surfaces occurring.

SC6.4.3.3.4 General guidelines

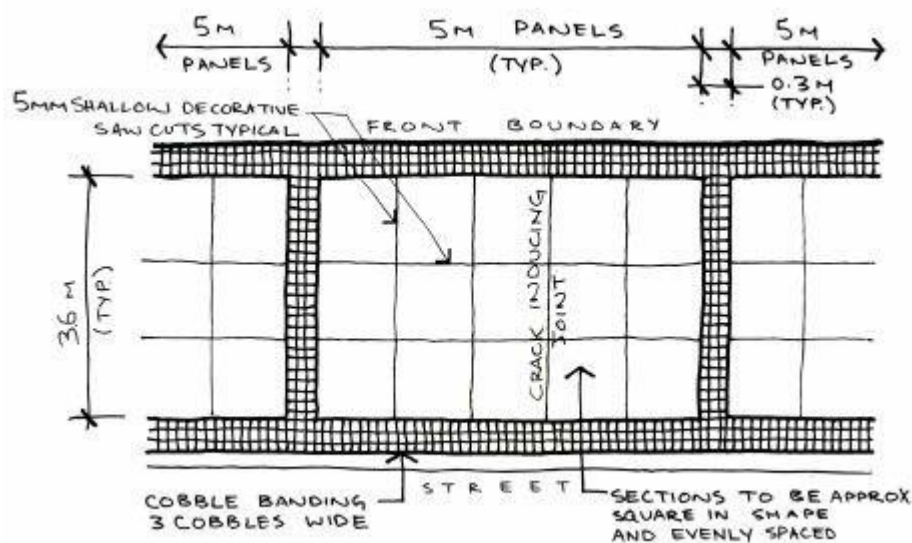


Figure SC6.4.3.3.22 Typical footpath treatment FT3

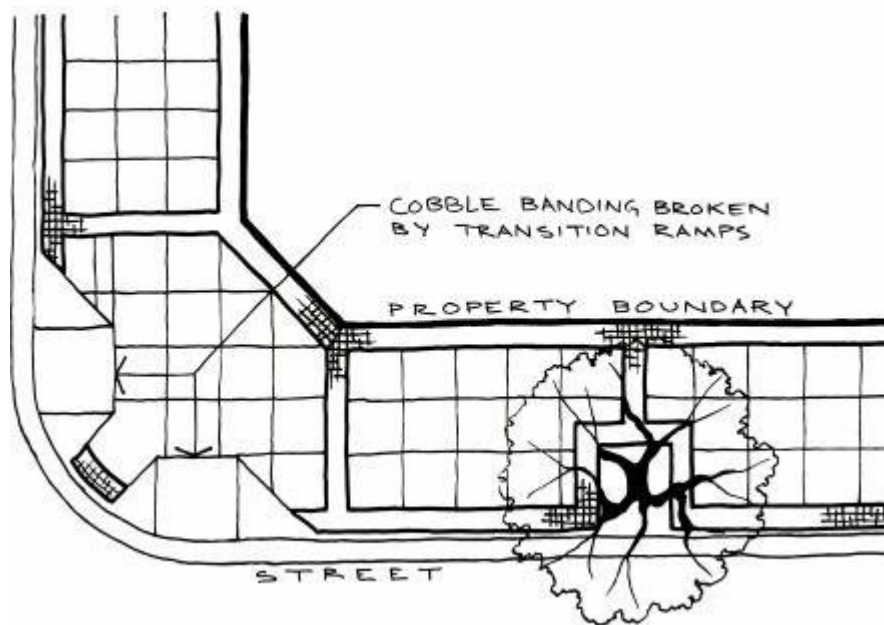


Figure SC6.4.3.3.23 Typical footpath treatment at street corners - banding is broken by kerb ramps

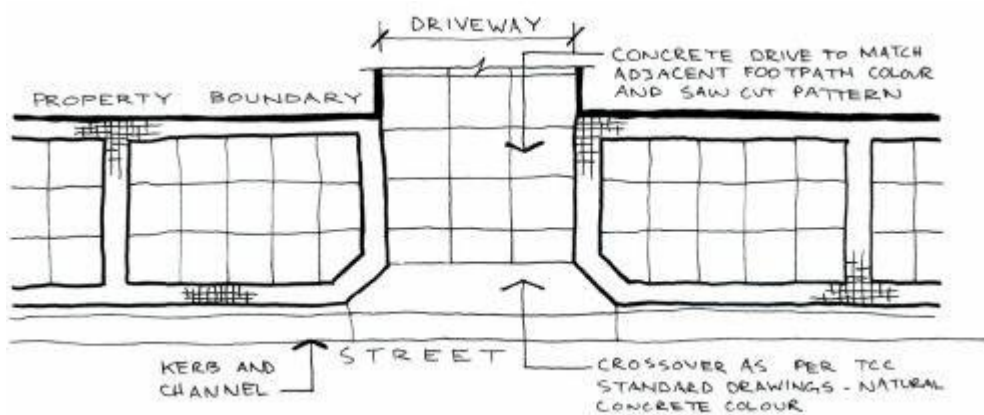


Figure SC6.4.3.3.24 Typical driveway treatment - banding to match angle of crossover

SC6.4.3.3.5 Banding details

- (1) Banding is to be:
 - (a) continuous across tenancy or property boundaries at regular 5 m intervals (see Figure SC6.4.3.3.21 and Figure SC6.4.3.3.22) and is to retain a rectilinear alignment as illustrated in Figure SC6.4.3.3.25, Figure SC6.4.3.3.27 and Figure SC6.4.3.3.28;
 - (b) broken by minor built form intrusions, allowed to infill minor built form recesses, (see Figure SC6.4.3.3.25;
 - (c) continued around existing streetscape and landscape elements (see Figure SC6.4.3.3.26); and
 - (d) run parallel to property boundaries and kerb where property boundaries are not parallel to kerb, with cross-banding remaining perpendicular to line of kerb (see Figure SC6.4.3.3.27 and Figure SC6.4.3.3.28).
- (2) Where banding is broken by driveways in footpath treatment types FT2, FT3, FT6 and, banding returns to the property line as per Figure SC6.4.3.3.24, Figure SC4.4.3.3.34 and Figure SC6.4.3.3.35.



Figure SC6.4.3.3.25 Continuous footpath at uneven building lines

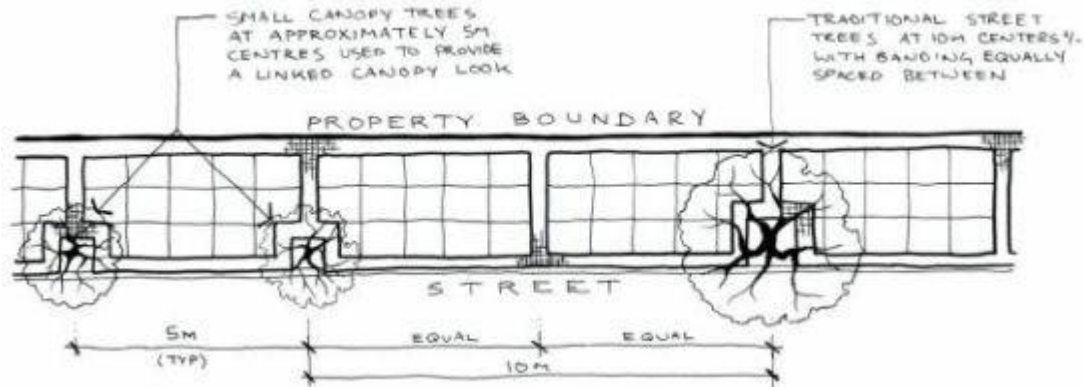


Figure SC6.4.3.3.26 Banding around landscape element

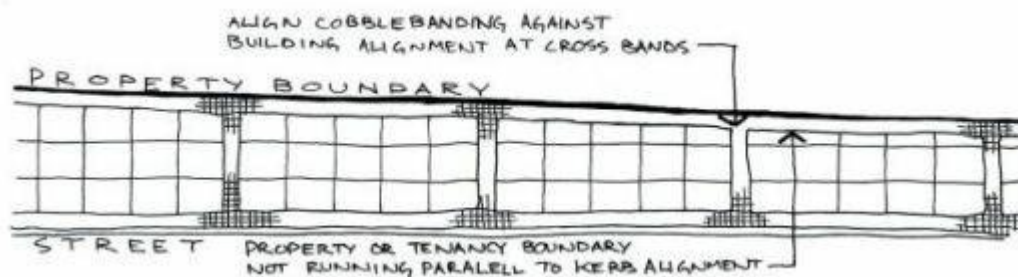


Figure SC6.4.3.3.27 Banding around poured concrete against property boundary where property boundary is not parallel to line of kerb

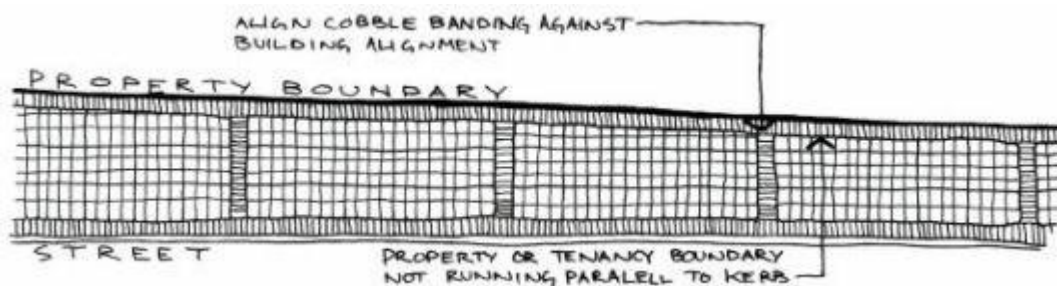


Figure SC6.4.3.3.28 Banding around pavers against property boundary where property boundary is not parallel to line of kerb

SC6.4.3.3.6 Footpath details

- (1) Joint lines and trim courses are to be straight and as continuous as is practical along the footpath length regardless of individual property boundaries (see Figure SC6.4.3.3.29). Protect existing buildings as per Figure SC6.4.3.3.29.

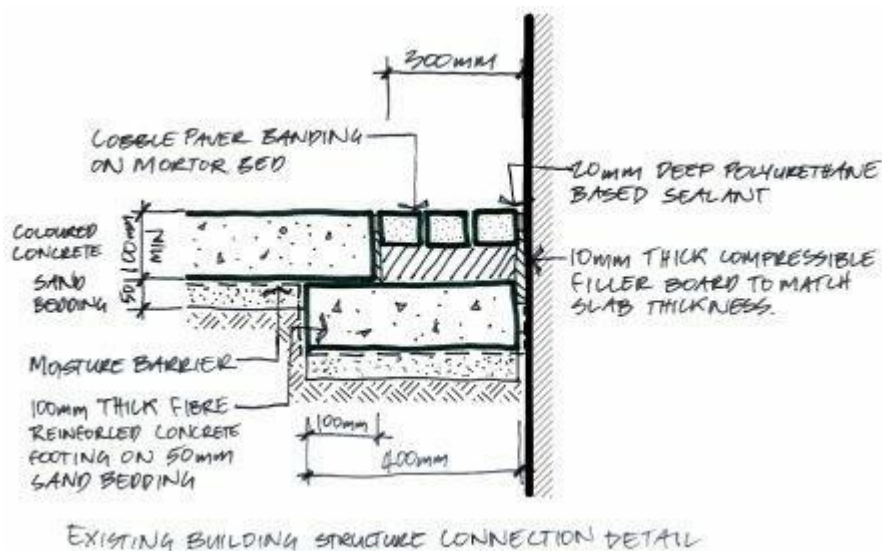


Figure SC6.4.3.3.29 Existing building structure connection detail

- (2) Service access lids and inspection pits:
- (a) installed within the footpath zone shall be finished and matched to the finished surface levels of the footpath treatment;
 - (b) which are manufactured shall be installed in accordance with manufacturer's installation instructions, having regard to the footpath pattern of the selected footpath treatment type;
 - (c) in footpath treatment areas FT1, FT5:
 - (i) be housed within an angle surround frame, which enables adjacent footpath treatments to be placed to the edge of the service penetration. The lid is to allow for matched pavers to be placed within, matching the adjacent paver material, colours and patterns flush with the top of the adjacent treatment (see Figure SC6.4.3.3.31);
 - (d) in footpath treatments FT2, FT3, FT6, FT7 and FT8, have their perimeter supports resting on concrete slabs that are integral with the adjacent concrete slab without a separate surround (see Figure SC6.4.3.3.30):
 - (i) be housed within an angle surround frame, which enables concrete to be laid to the edge of the service penetration;
 - (ii) be located in and integrated with adjacent concrete slabs so service access structures limit or control cracking in surrounding concrete (see Figure SC6.4.3.3.32); and
 - (iii) are located where possible so future replacement or alteration of service access structures minimises disruption to adjacent concrete panels, and are aligned with existing or proposed concrete crack control saw cuts where possible, or are located wholly fully within the saw-cut panel (see Figure SC6.4.3.3.32); and
 - (e) when penetrating a cobbled area of FT3, be installed such that the cobbles continue to the edge of the new service access lids and inspection pits (see Figure SC6.4.3.3.31).

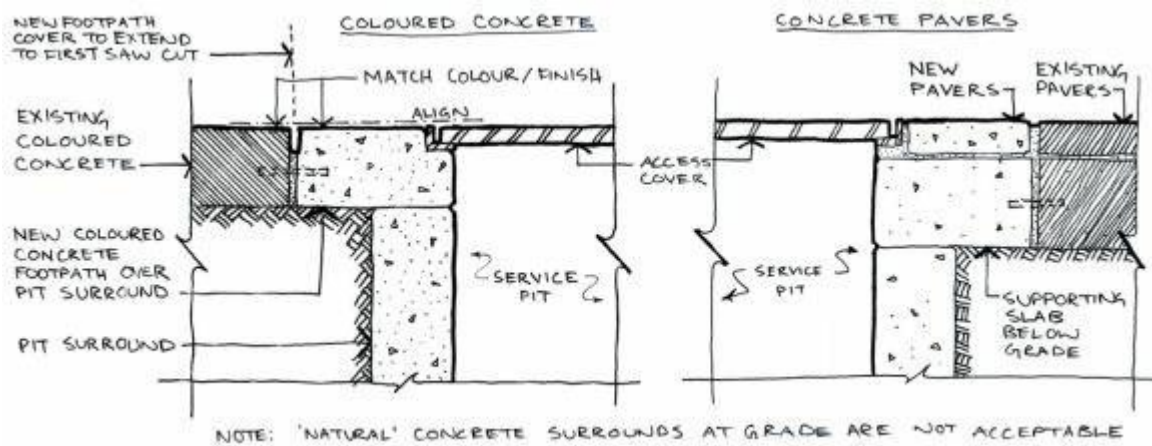


Figure SC6.4.3.30 Edge treatments to service access lids and inspection pits for footpath treatment areas FT2, FT3, FT4, FT6, FT7 and FT8

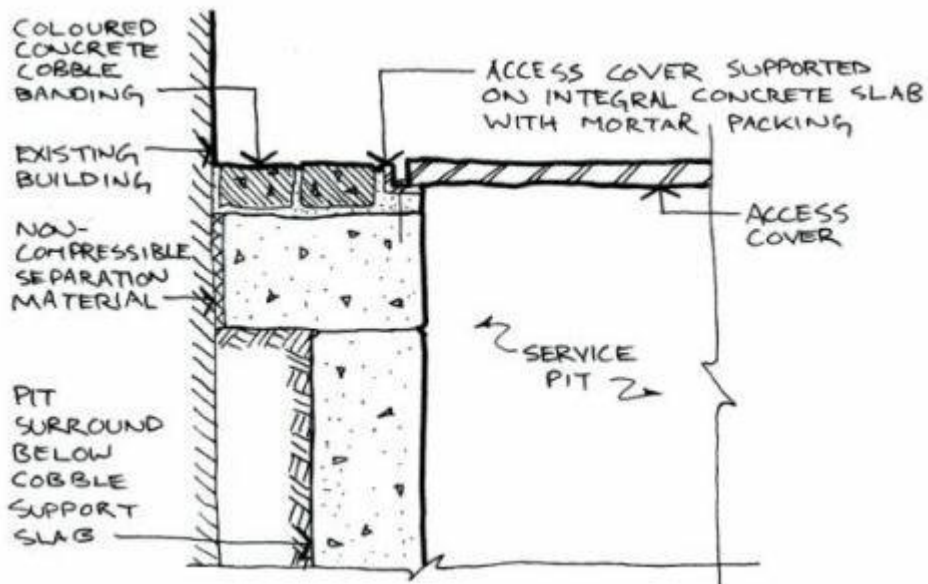
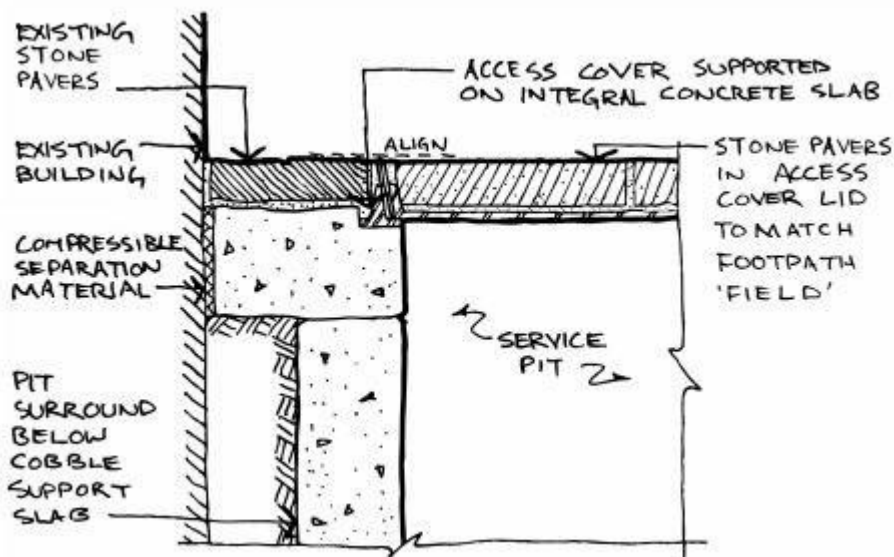


Figure SC6.4.3.31 Edge treatment to service access lid and inspection pits adjacent to pavers for type FT1 and FT5



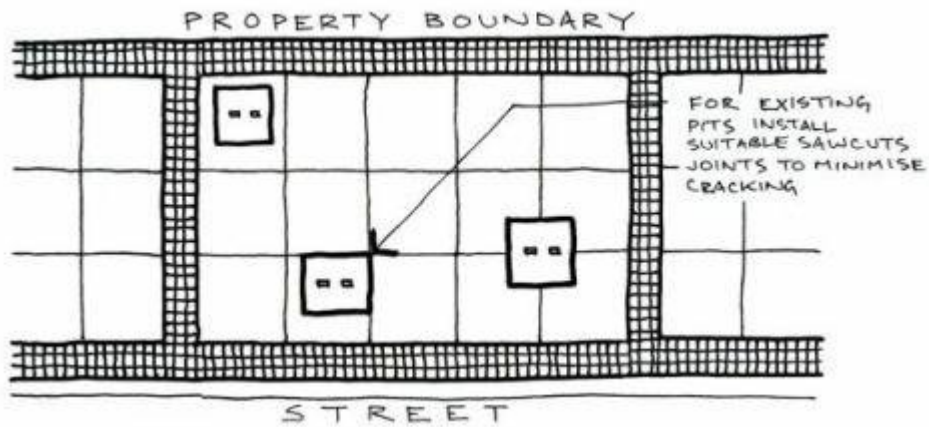


Figure SC6.4.3.32 Incorporate service access lids and inspection pits into decorative saw cut pattern

- (3) All footpaths (see Figure SC6.4.3.3.33) shall have maximum:
- (a) cross fall of 1:40 (for cross fall greater than 1:40 liaise with council); and
 - (b) slope of 1:20 (for slopes greater than 1:20 liaise with council).
- (4) Kerb and channelling is to be provided if not currently installed for all footpath treatments covered by this policy, and shall be constructed in accordance with standard drawings listed in SC6.4.3.3.3(b).

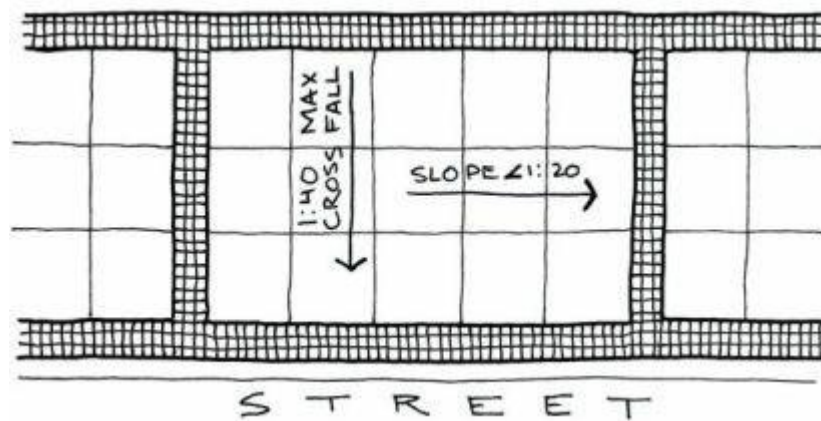


Figure SC6.4.3.33 Slope and cross fall

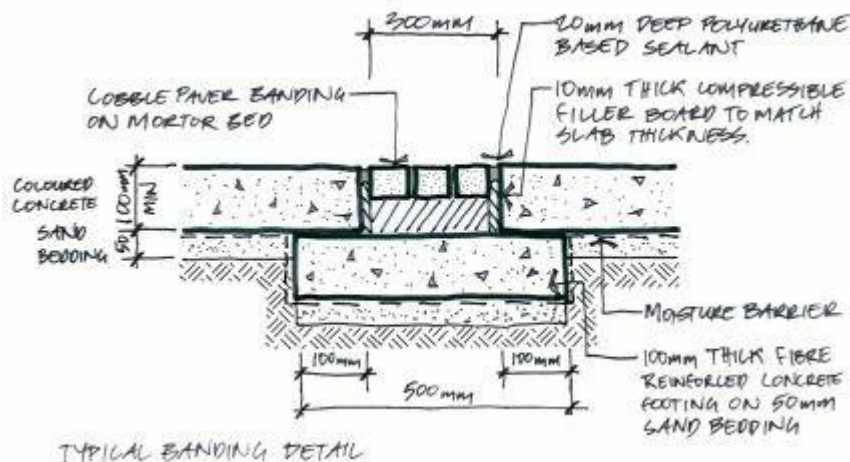


Figure SC6.4.3.34 Typical banding details

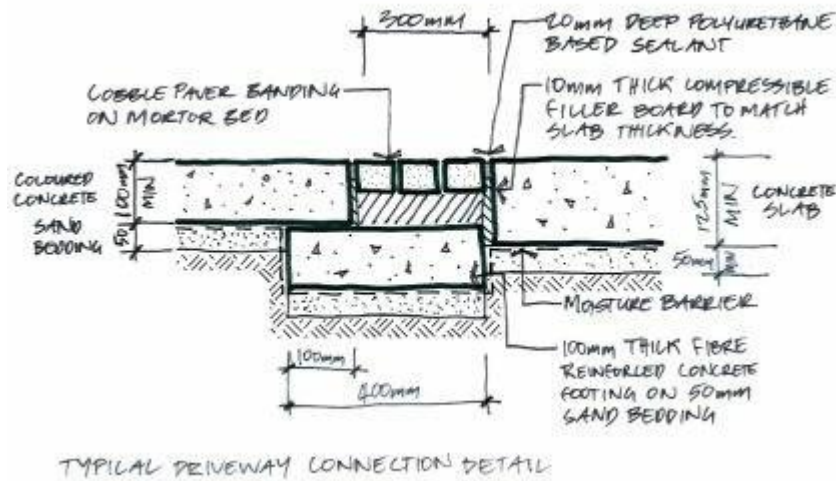


Figure SC6.4.3.35 Typical driveway connection detail

- (5) Kerb ramps are to be:
- (a) in accordance with the standard drawings see SC6.4.3.3.3(b) - SD025 – Kerb Ramp,
 - (b) in accordance with AS1428.1 *Design for Access and Mobility, Part 1: General requirements for access – New Building Works*;
 - (c) installed facing the direction of travel and aligned parallel and perpendicular with opposite kerb ramp;
 - (d) located to suit the flow of pedestrian traffic and the position of the signal button;
 - (e) constructed of surface broom finished plain natural concrete;
 - (f) installed with sharp transitions between adjacent surfaces (top and bottom); and
 - (g) installed with Tactile Ground Surface Indicators (TGSIK) in accordance with AS/NZS1428.4.1 *Design for Access and Mobility Part 4.1: Means to assist the orientation of people with vision impairment – Tactile ground surfaces indicators*.
- (6) Where the existing kerb edge is uneven:
- (a) the cobble banding is to be set along a straight line. A cementitious infill material shall be used to make up for the irregularities of the kerb, as indicated in Figure SC6.4.3.3.36;
 - (b) ensure suitable concrete admixture (Fosroc Renderoc or approved equal) is used to create a straight and true edge if irregularity in kerb is less than 50 mm deep, see Figure SC6.4.3.3.36 and standard drawing SD-020: Concrete Kerbing; and
 - (c) infill is not to be formed so a tripping hazard occurs. In accordance with AS1428.1 *Construction tolerances for abutment of surfaces*.

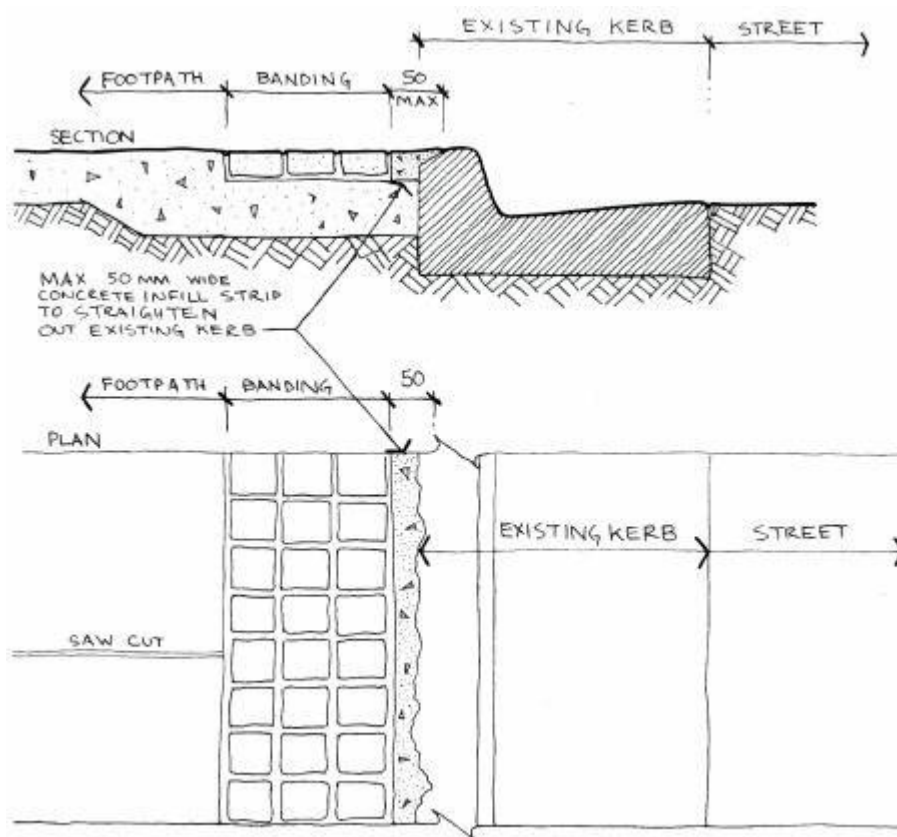


Figure SC6.4.3.36 Concrete infill strip for uneven existing kerb lines

- (7) When providing reinstatement from trenching:
- (a) where trench passes through segmented paver footpath treatment areas:
 - (i) remove intact pavers and store securely and safely on site;
 - (ii) allow for replacement and installation of any broken, cut or otherwise damaged pavers or deteriorated;
 - (iii) ensure paving support slabs removed for trenching purposes are reinstated in accordance with standard drawings noted in SC6.4.3.3.3(b) flush with adjacent support slabs to allow level reinstatement of pavers over; and
 - (iv) replace original and/or new pavers over reinstated slab.
 - (b) where trench passes through concrete footpath treatment areas:
 - (i) reinstate new concrete in accordance with standard drawings listed in SC6.4.3.3.3(b) flush with adjacent support surface/slabs to allow level reinstatement;;
 - (ii) ensure new concrete matches adjacent slab colour: refer to relevant footpath type in Tables SC6.4.3.3.3, for concrete colour, aggregate, finish, etc. for types as identified in SC6.4.3.3.7 - Footpath treatment location maps; and
 - (iii) allow for replacement and installation of any broken, cut or deteriorated or otherwise damaged footpath treatment caused by the removal.
- (8) When incorporating existing trees into new works, installing new trees, or other landscape features:
- (a) incorporate elements into the paving pattern, as shown in Figure SC6.4.3.3.37;
 - (b) modify installation where practical in accordance with the construction detail indicated in Figure SC6.4.3.3.38; and
 - (c) refer to SC6.4.3.6 Landscape policy for street tree spacing, selection, root barrier treatments, root development zone, tree grates or other tree surround treatments and lighting.

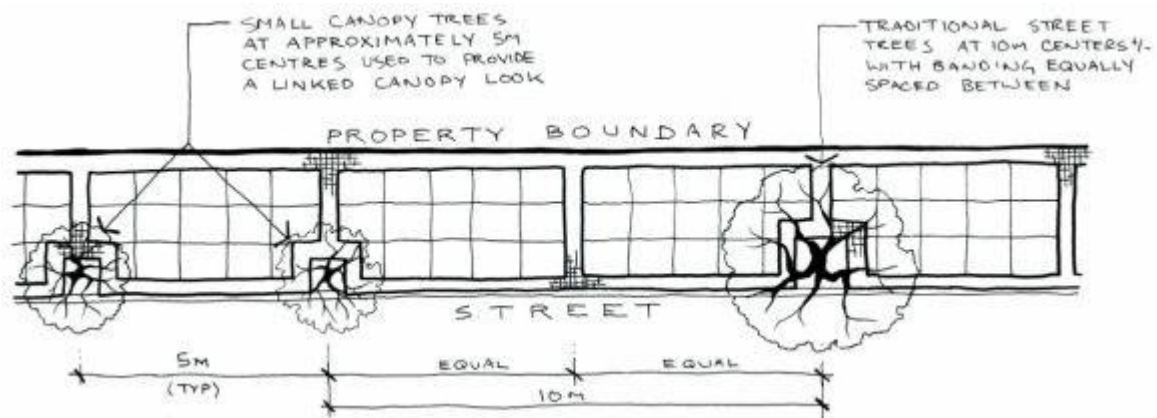


Figure SC6.4.3.3.37 Banding around tree planting

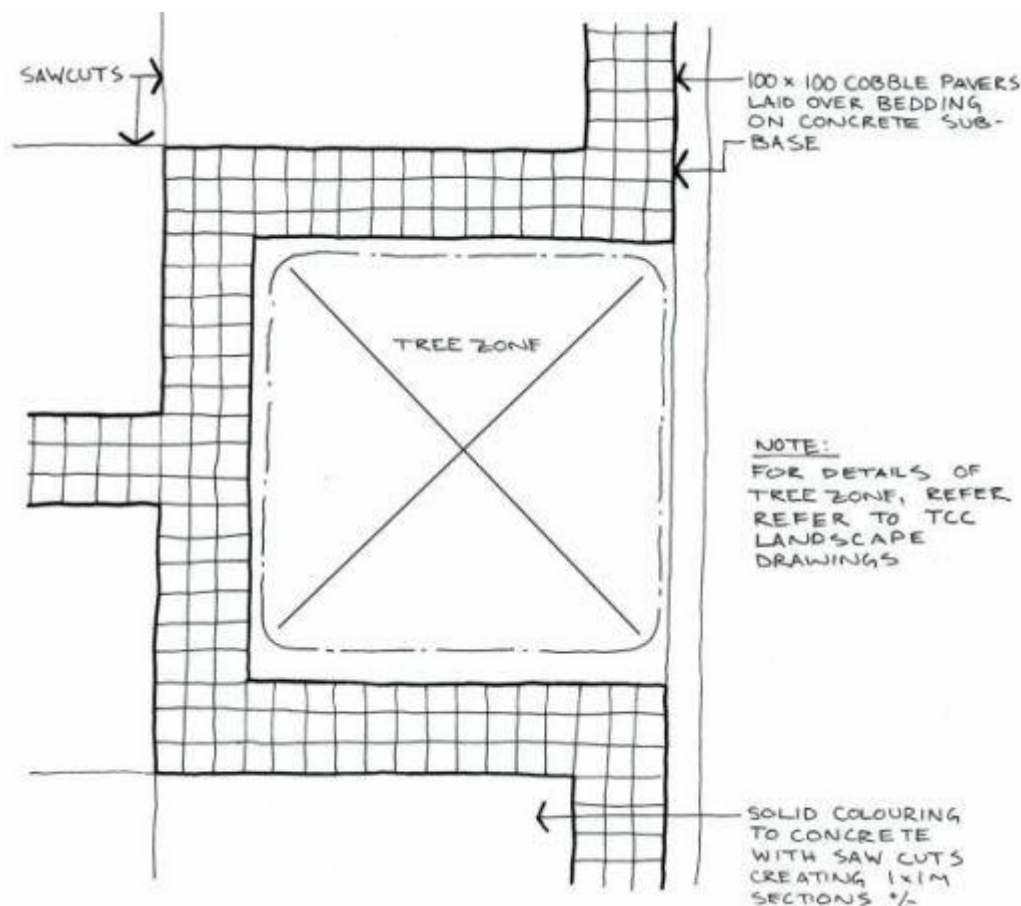
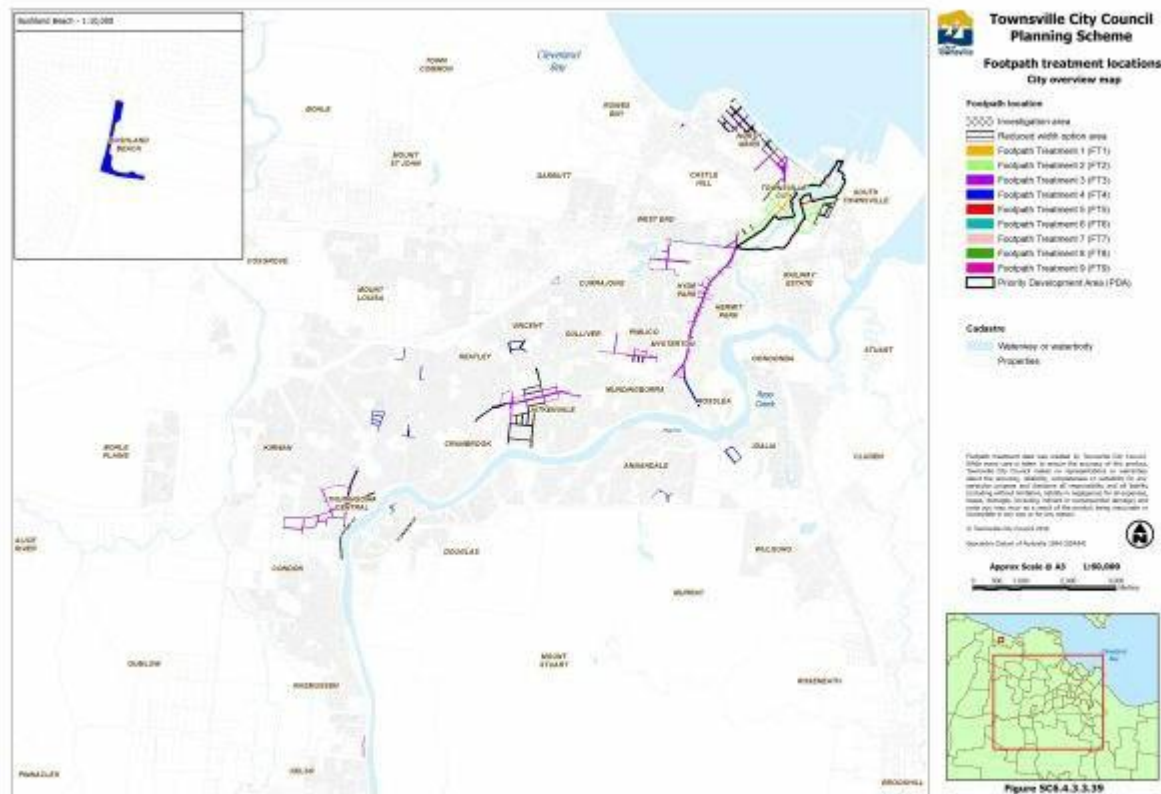


Figure SC6.4.3.3.38 Paver banding plan at tree surround

- (9) When incorporating existing road transport- related infrastructure (such as bus stops, street signs and traffic signals) or providing for the placement of new road related infrastructure into any of the footpath treatment types:
- safety and visibility requirements shall be in accordance with the Manual of Uniform Traffic Control Devices (MUTCD) for the placement of new such infrastructure;
 - footpath treatments and patterns shall be modified around existing elements in order to reduce disturbance to established infrastructure;.
 - bus stops shall be in accordance with standard drawings listed in SC6.4.3.3.3.(3)(b). Bus stop concrete slab is a reinforced solid object supporting a large size structure, therefore required to be one whole slab undisturbed. Footpath treatment to be made flush with adjacent support slabs to allow level reinstatement;
 - street signs and traffic signals shall be in accordance with Australian Standards and guidelines; and
 - street signs shall be in accordance with standard drawings listed in SC6.4.3.3.3.(3)(b).

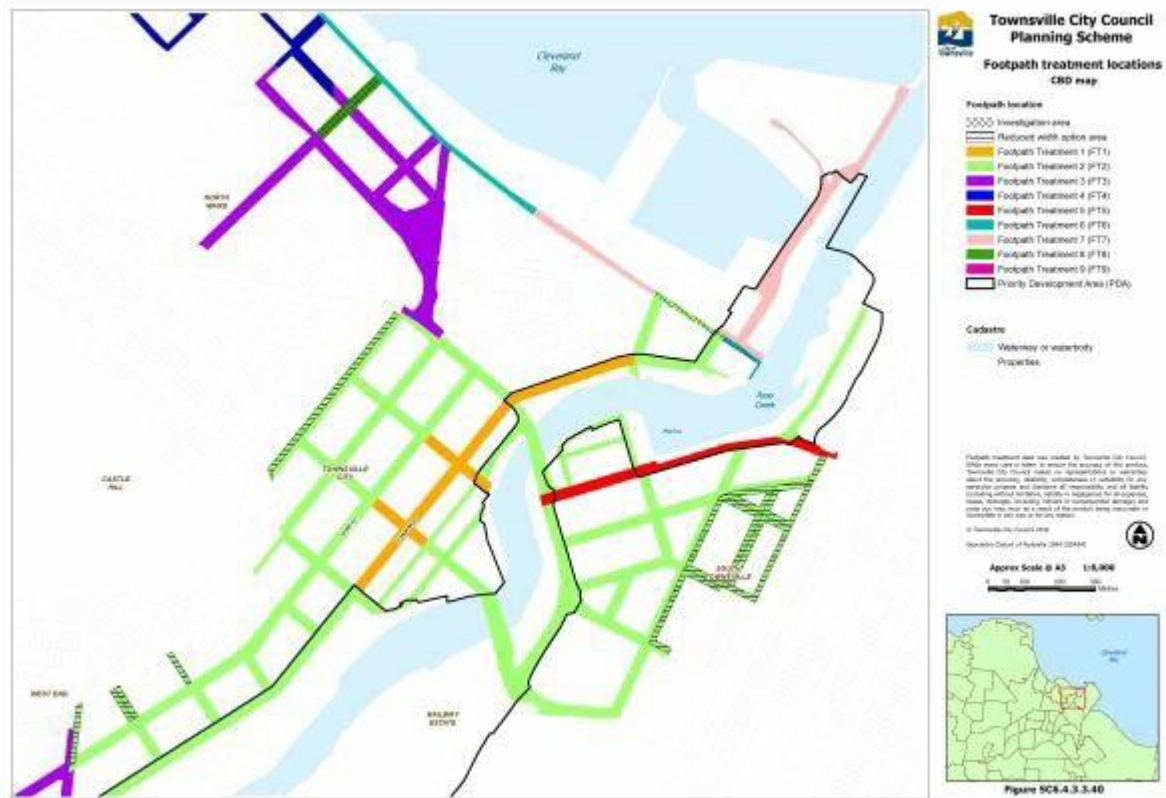
- (10) When incorporating the placement of street furniture (such as , seating, rubbish bins and bollards) :
- installation should not impede pedestrian movement along the footpath. There shall be a 1800mm minimum clear width for the continuous accessible path of travel along the building property line, building façade and fence lines for pedestrians, especially people with a vision impairment, .in accordance with AS2890.3; and
 - the placement of street furniture shall give consideration to minimizing the disturbance to the footpath treatment type and paving patterns.

SC6.4.3.3.7 Footpath treatment location maps



[Click here to view PDF high resolution map.](#)

Figure SC6.4.3.3.39 City overview map



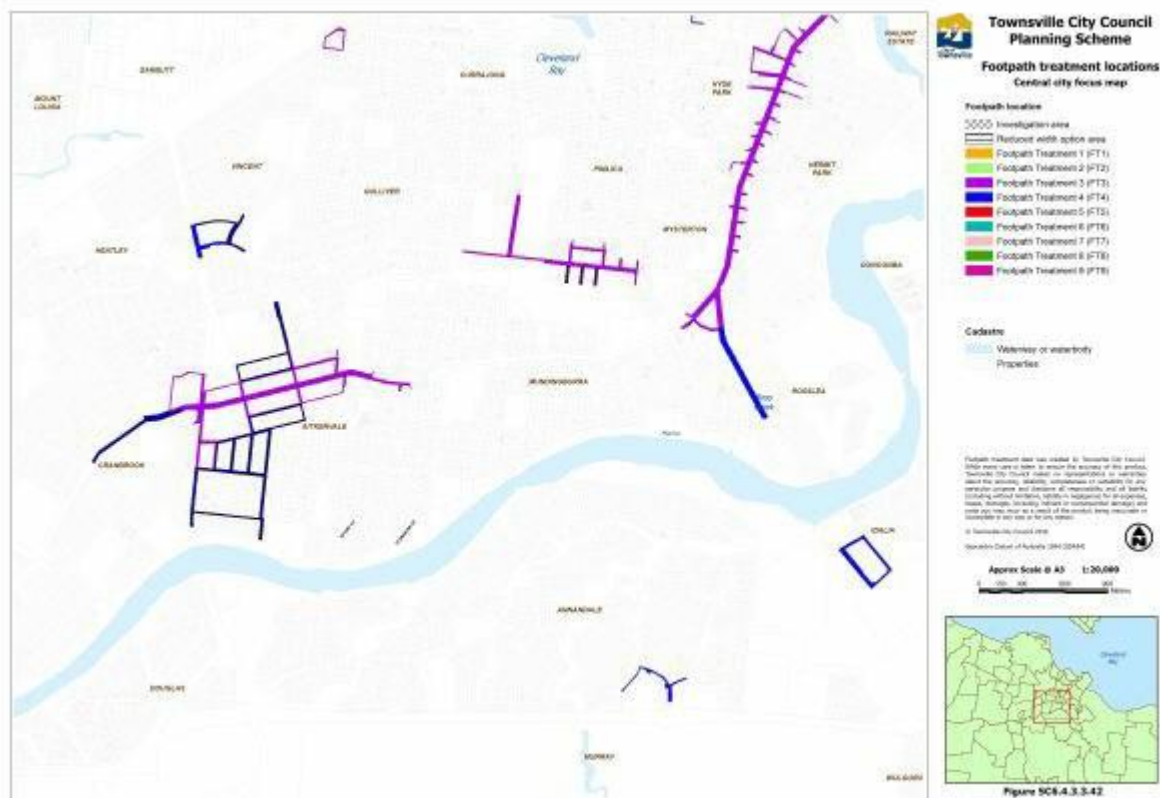
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Figure SC6.4.3.3.40 CBD map



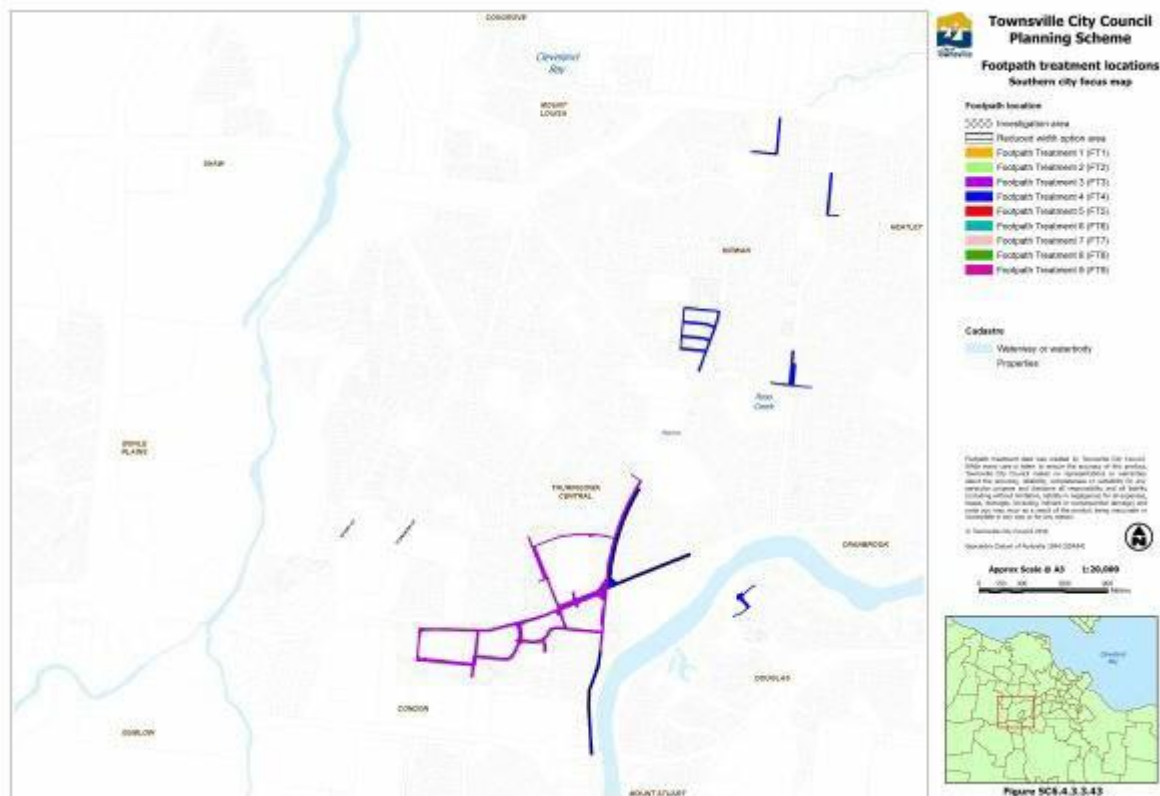
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Figure SC6.4.3.3.41 Northern city focus map



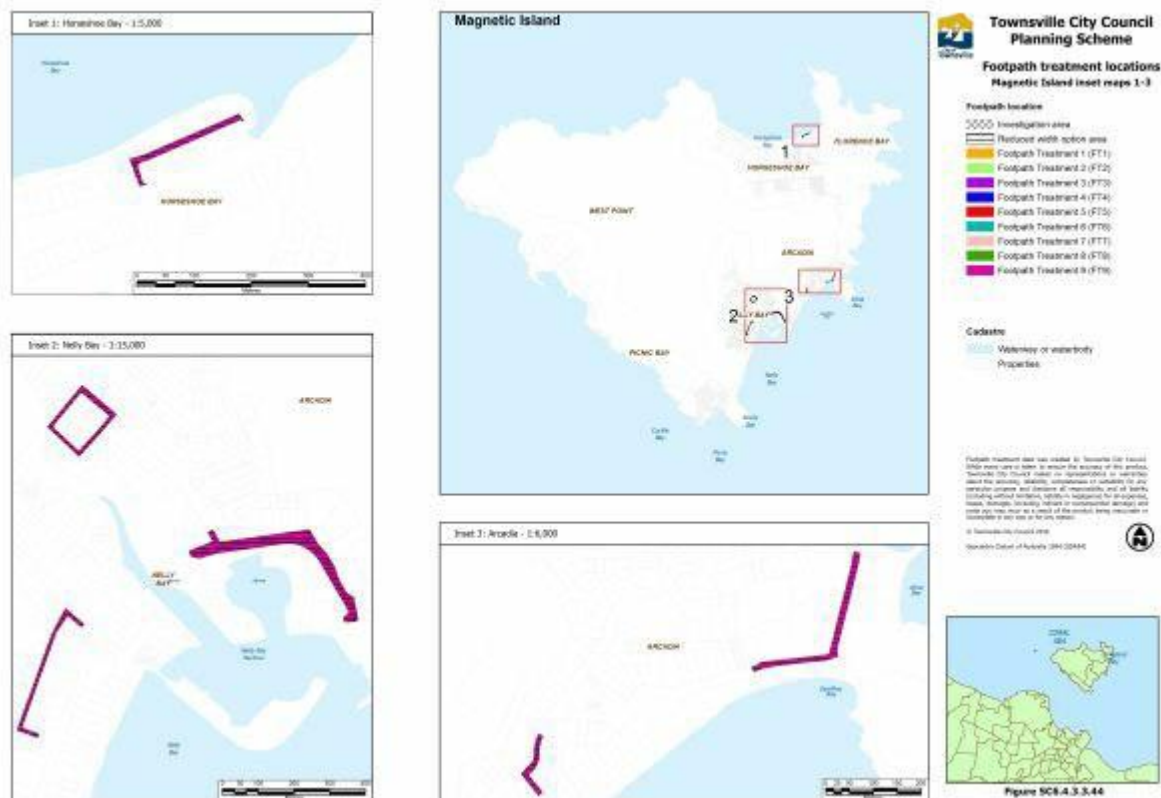
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Figure SC6.4.3.3.42 Central city focus map



[Click here to view PDF high resolution map.](#)

Figure SC6.4.3.3.43 Southern city focus map



[Click here to view PDF high resolution map.](#)

Figure SC6.4.3.3.44 Magnetic Island inset maps 1 - 4

SC6.4.3.4 Outdoor dining design

SC6.4.3.4.1 Introduction

(1) Purpose

- (a) To protect pedestrian traffic by the introduction of shared footpath management guidelines for the purpose of providing for improved use of the area and business opportunity.
- (b) To effectively address risk management issues to facilitate which relate to the introduction of additional uses, cross pedestrian traffic, and items of infrastructure or street furniture, as well as the potential interaction with vehicles as outlined in SC6.4.3.4.2.

(2) Scope

- (a) When assessing an application involving outdoor dining, council will consider all relevant issues, including, but not limited to:
 - (i) whether the proposed outdoor dining area is located immediately adjacent to the applicant's existing premises and/or connectedness to the development;
 - (ii) pedestrian usage of the area, including safety and passage;
 - (iii) vehicular usage of the area, including separation and safety matters;
 - (iv) the general safety of patrons of the proposed outdoor area;
 - (v) the contribution towards a high amenity area and creation of active and integrated spaces and places as identified by the relevant zone code; and
 - (vi) how the outdoor dining integrates with the character of the locality/zone and existing or intended streetscape, including specific footpath treatments.

Editor's note—Applicants should also refer to section 9.4.1 Advertising devices code of the Townsville City Plan for additional design requirements and Table 5.8.2 Operational work being placing an advertising device on premises for application requirements regarding the control of advertising devices in outdoor dining spaces.

Editor's note—Applicants should also be aware that there may be additional related approvals required, including Outdoor Dining Licence Applications from Townsville City Council (Subordinate Local Law No. 1.2 (Commercial Use of Local Government Controlled Areas and Roads) 2011), Food Premises Licence and any liquor licencing requirements required by the Queensland Government office of Liquor, Gaming and Racing and if the outdoor dining area is on state controlled land, including road, that the applicant shall lodge other necessary documentation to the required entity.

Editor's note— Any person wishing to use any council-controlled land for outdoor dining must lodge an application for an outdoor dining licence under council's Outdoor Dining Policy, which can be found on council's website.

- (b) Outdoor dining is considered to include the following:
 - (i) the use of the council-controlled public land for the purpose of extending the services of premises whose main function is the provision of food and/or beverages to the public; and
 - (ii) premises may include restaurants, cafes, bars, deli and other food outlets, but does not include roadside stalls.

(3) Terminology

Back of kerb

The point of the kerb profile away from the road, as illustrated in Figure SC6.4.3.3.6.

Crash barrier	A longitudinal or roadside barrier that has the primary function of preventing penetration by a vehicle and for which the primary purpose is to prevent or reduce the injury to occupants of an errant vehicle and restaurant patrons by safely redirecting an errant vehicle away from a roadside hazard. All roadside crash barriers must be designed to meet AS3845:1999.
Kerbside zone	The area between the trading zone and the back of kerb.
Kerbside use zone	The area between the back of kerb and the vehicle through lane. Uses within the kerbside use zone may include parking, accessible parking, bus bays, taxi ranks, drop-off zones, loading zones, no standing zones, shoulders and bike lanes. Fencing legs should not create a tripping hazard.
Pedestrian fence	A fence provided to restrict the movement of pedestrians and restaurant patrons. This can include a permanent structure or may be a portable café-style fence. Pedestrian fences must be: • A minimum height of 800 mm; • Designed and constructed so that the fence does not present a spearing hazard and is of a level of quality and design acceptable to council.
Pedestrian zone	A 1.8m wide section of footpath for the through movement of pedestrians located adjacent to the property building line (shoreline).
Trading zone	The formally defined area within which outdoor dining is permitted by council. All furniture and commercial activities relating to outdoor dining must occur within this area. Pavement markers will be installed by council to define the extents of the approved dining area (trading zone).
Traffic lane	The area of the road that is used for the through passage of vehicles in normal driving conditions. The traffic lane does not include the shoulder, parking lane or other kerbside use area.

The relationship between the key terms above is shown in Figure SC6.4.3.4.1 - Summary of guidelines and requirements.

SC6.4.3.4.2 Risk considerations associated with outdoor dining

With respect to outdoor dining, risk is increased by four significant events. Risk management through design guidelines is provided for the following four risk events:

- (1) a vehicle running off road when diners are present, without sufficient separation to allow the driver of the vehicle to recover (or for diners to react and clear the path of the vehicle);
- (2) a vehicle running off road when diners are not present, without sufficient separation to allow the driver of the vehicle to recover, and the outdoor dining furniture penetrates the vehicle causing injury to vehicle occupants;
- (3) a vehicle running off road at a location where a crash barrier has been provided for the specific purpose of protecting footpath diners, and the crash barrier has not been designed to safely and effectively redirect the impact of a vehicle, causing either injury to outdoor diners or injury of the vehicle occupants; and
- (4) a diner/staff stepping or falling onto path of vehicle due to proximity of trading zone to the traffic lane (with no fence or barrier in place), for example due to placement of a chair too close to the kerb.

SC6.4.3.4.3 Design guidelines for kerbside risk management and use

In addition to risk management issues, the guidelines include recommendations for the separation of the trading zone to accommodate the various roadside elements such as parking, and access to public infrastructure and services.

Table SC6.4.3.4.1 below summarises the content of these guidelines.

Table SC6.4.3.4.1 Summary of guidelines and requirements

Guidelines	Requirements
Speed zones	See Table SC6.4.3.4.2
Barriers and fences	See Table SC6.4.3.4.3
Intersection corner	Outdoor dining should not occur within an intersection corner as defined in Figure SC6.4.3.5
Kerbside uses	See Table SC6.4.3.4.4, Figure SC6.4.3.6
Public infrastructure clearances	In general, 1 m clearance from public infrastructure unless demonstrated otherwise. See SC6.4.3.4.8
Pedestrian access though trading zone to access kerbside uses	See clause SC6.4.3.4.7

SC6.4.3.4.4 Design guidelines for risk management

Because of the increase in risk associated with higher speed limits, different levels of outdoor dining protection and separation have been recommended to manage risk appropriately. In some speed zones, outdoor dining is generally not appropriate. In lower speed zones, outdoor dining is generally always appropriate provided suitable measures are taken to separate diners from traffic by distance or a physical barrier or fence. Table SC6.4.3.4.2 below summarises the recommendations for risk management in different speed zones.

Table SC6.4.3.4.2 Summary of recommendations for risk management

Speed zone (km/h)	Appropriate for outdoor dining	Provide crash barrier guidelines	Provide pedestrian fencing guidelines
Above 60	No	-	-
60	Yes	Yes	Yes
50	Yes	Yes	Yes
40	Yes	No	Yes

Table SC6.4.3.4.3 provides the detailed design guidelines for different speed zones. Note that in the majority of cases, the need for a crash barrier can be avoided by increasing the separation distance between the trading zone and traffic. Figures SC6.4.3.4.2 – SC6.4.3.4.4 illustrate these design guidelines.

Table SC6.4.3.4.3 Guideline for crash barriers, pedestrian fencing and separation distance

Speed zone (kph)	Trading zone 3m or more from traffic lane	Trading zone 1.2m to 3m from traffic lane	Trading zone less than 1.2m from traffic lane
Above 60	Not recommended for outdoor dining	Not recommended for outdoor dining	Not recommended for outdoor dining
60	No crash barrier or pedestrian fence required	Pedestrian fence required	Crash barrier required
50	No crash barrier or pedestrian fence required	Pedestrian fence required	Crash barrier required
40	No crash barrier or pedestrian fence required	No crash barrier or pedestrian fence required	Pedestrian fence required

SC6.4.3.4.5 Design guidelines for trading zones at an intersection

In general, outdoor dining is not appropriate in the vicinity of an intersection corner. This allows corners to be used by pedestrians and cyclists, and allows access to public infrastructure and services to be maintained at all times. In some circumstances it may however be appropriate to support the zone intent and specific demonstration for intersection driving will be required.

Figure SC6.4.3.4.5 shows the area at a corner that should not be used for a trading zone.

SC6.4.3.4.6 Trading zone setbacks for kerbside use

Different kerbside uses have different spatial requirements to facilitate the movement of vehicles and pedestrians. Table SC6.4.3.4.4 summarises the recommended separation distance between the back of kerb and the trading zone for each kerbside use. Figure SC6.4.3.6 illustrates these distances.

Table SC6.4.3.4.4 Setbacks for kerbside use

Kerbside use	Minimum setback from back of kerb
No Standing/traffic lane	0.3m (if no pedestrian fence provided)
Parking - angle	0.8m
Parking - Parallel	0.8 m
Accessible Parking (Parallel)	1.5m

SC6.4.3.4.7 Pedestrian access to kerbside use and through trading zones

The design of a trading zone and any required pedestrian fencing should accommodate access through or around the trading zone for pedestrians, including persons with a disability. Where a pathway is required through the trading zone, a minimum width of 1.2 m is required. Where the kerbside use has an accessible parking bay and kerb ramp to access vehicles in the kerbside zone, a 1.5 m wide access through the trading zone must be provided. In addition, the design should consider the need for the crossing of pedestrians where the proposed outdoor dining facility is not within 20 m of a pedestrian crossing or intersection. A minimum width of pedestrian zone of 1.8 m is recommended located adjacent to the property building line. This width should be increased to a minimum of 2.4 m at locations where high pedestrian volumes are expected.

SC6.4.3.4.8 Clearances to public infrastructure

It is recommended that with the exception of service pits, in general a clearance of 1 m is desirable from all public infrastructure with the following exceptions:

- (1) where a pedestrian fence is provided which separates the infrastructure and the trading zone; or
- (2) where the owner of the public infrastructure asset (including council) provides written permission to relax the minimum clearance requirement.

In the case of service pits, a minimum clearance is not specified. However, it is recommended that the applicant obtains the permission of the asset owner if the applicant wishes to install outdoor dining furniture over or in the immediate vicinity of the service pit.

SC6.4.3.4.9 Risk assessment for non-conforming designs

Outdoor dining proposed within a speed zone higher than 60 km/h, or if the applicant believes that the requirements of the design guidelines are not applicable to the specific location, a risk assessment will be required by council.

The risk assessment must be prepared by a person considered by the council to have appropriate expertise in traffic engineering, and will need to demonstrate that the proposed design meets the intent of this sub-section and the relevant provisions of the Townsville City Plan, particularly the relevant zone code.

SC6.4.3.4.10 Permanent outdoor dining structures

In the case where a permanent structure (for example concrete walls, decking, awnings) are proposed, details are to be provided on plans submitted for approval.

Structures, and associated services, must be designed and constructed by suitably qualified persons in accordance with the relevant Australian Standards and the requirements of the Townsville City Plan (i.e. relevant zone code) to maintain public safety, good amenity and ease of cleaning and maintenance.

Electrical supply should have an isolating switchboard to enable the operator of the outdoor dining service to isolate the electrical supply.

Editor's note—Works within council's road reserve will require separate approvals under the relevant local laws (e.g. Road Work Permit).

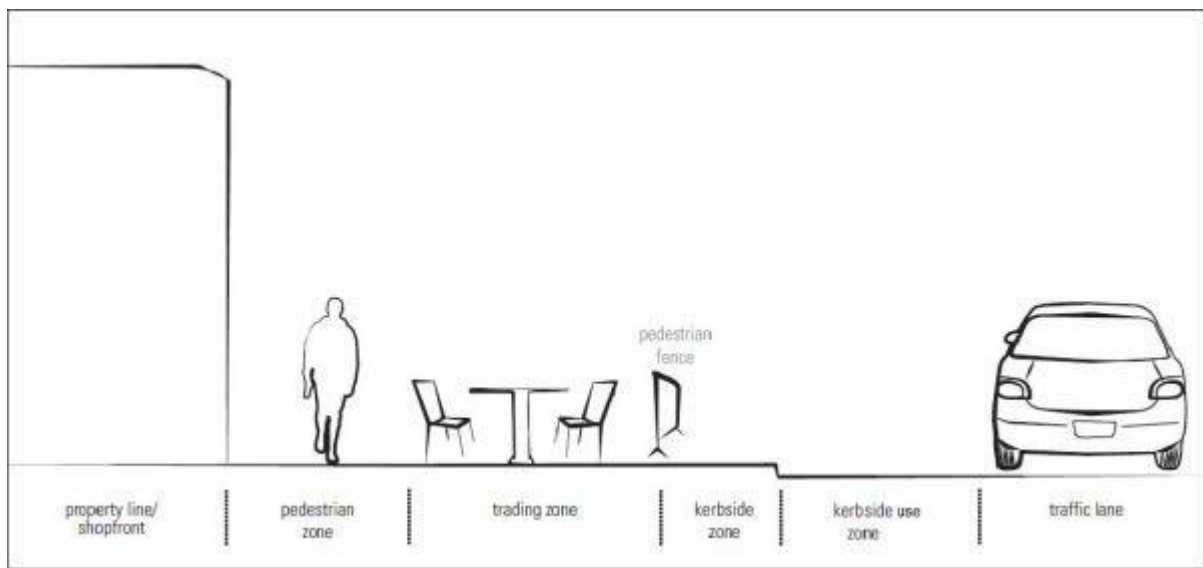


Figure SC6.4.3.4.1 Trading zone definitions

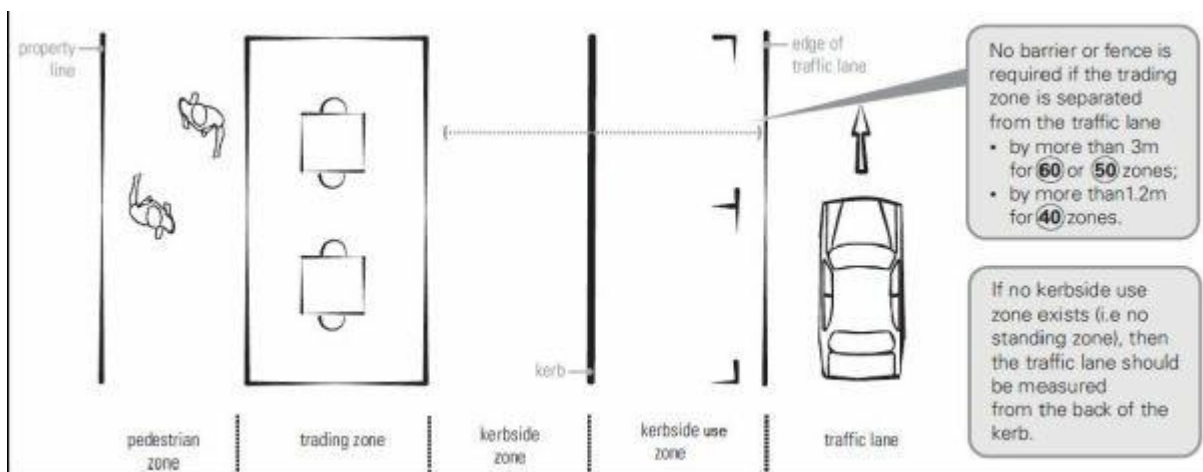


Figure SC6.4.3.4.2 Separation requirements (no barrier or pedestrian fence)

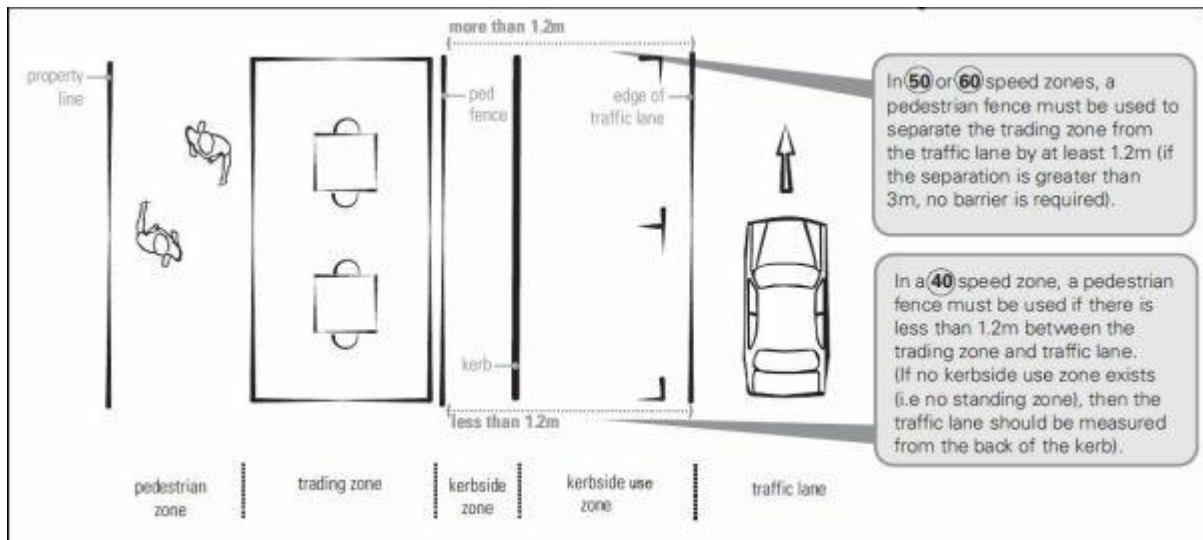


Figure SC6.4.3.4.3 Pedestrian fence requirements

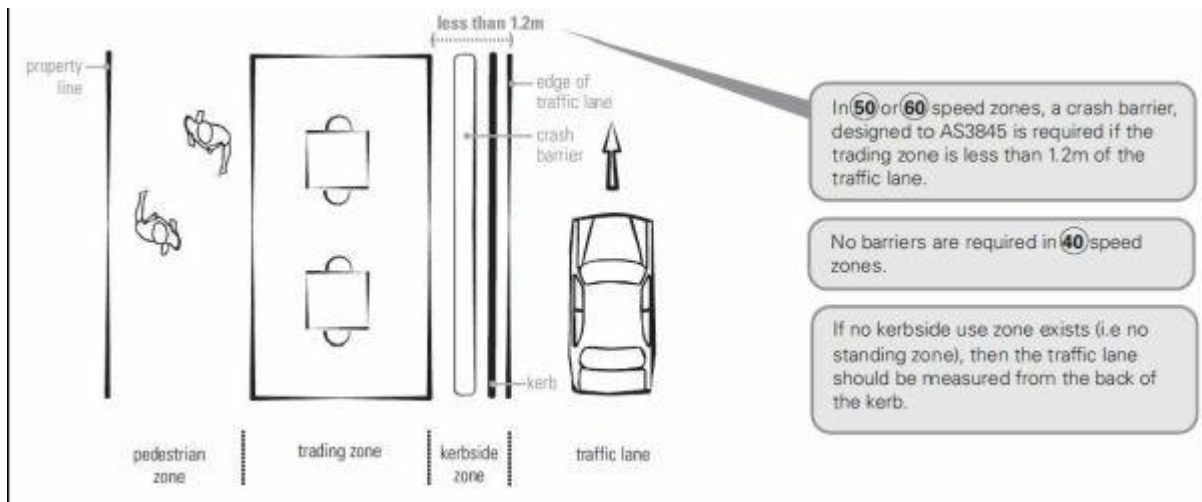


Figure SC6.4.3.4.4 Crash barrier requirements

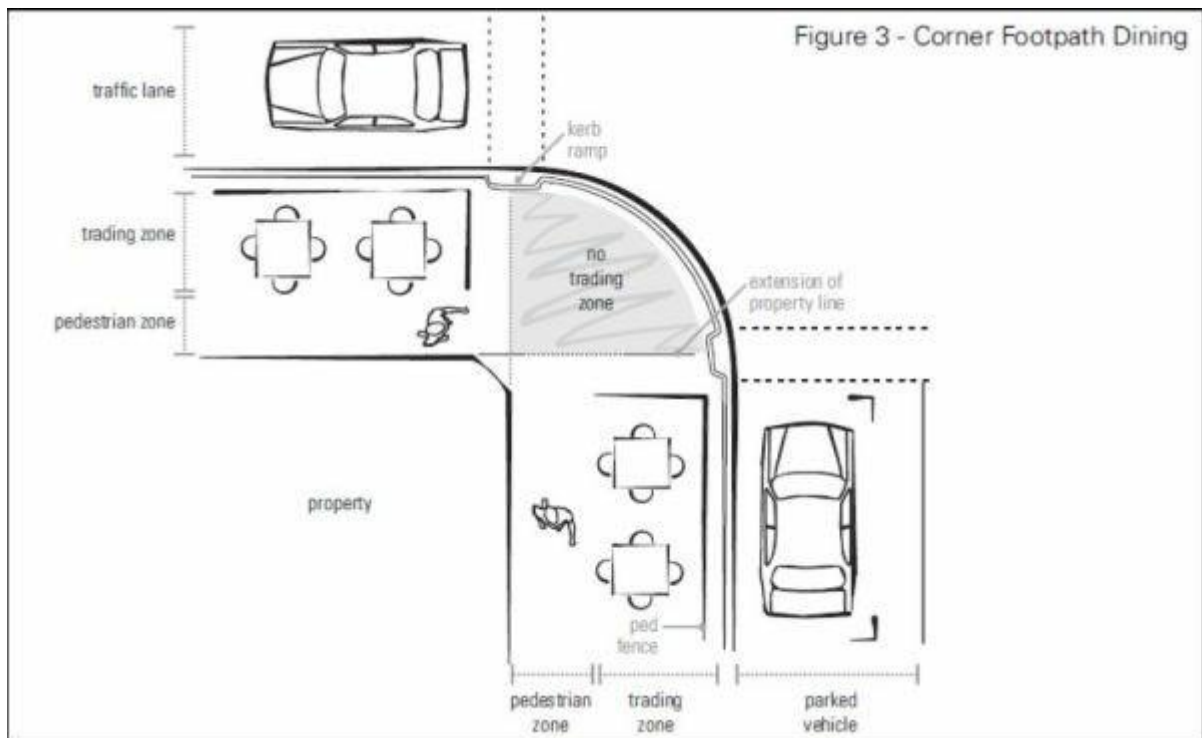


Figure SC6.4.3.4.5 Outdoor dining at intersections

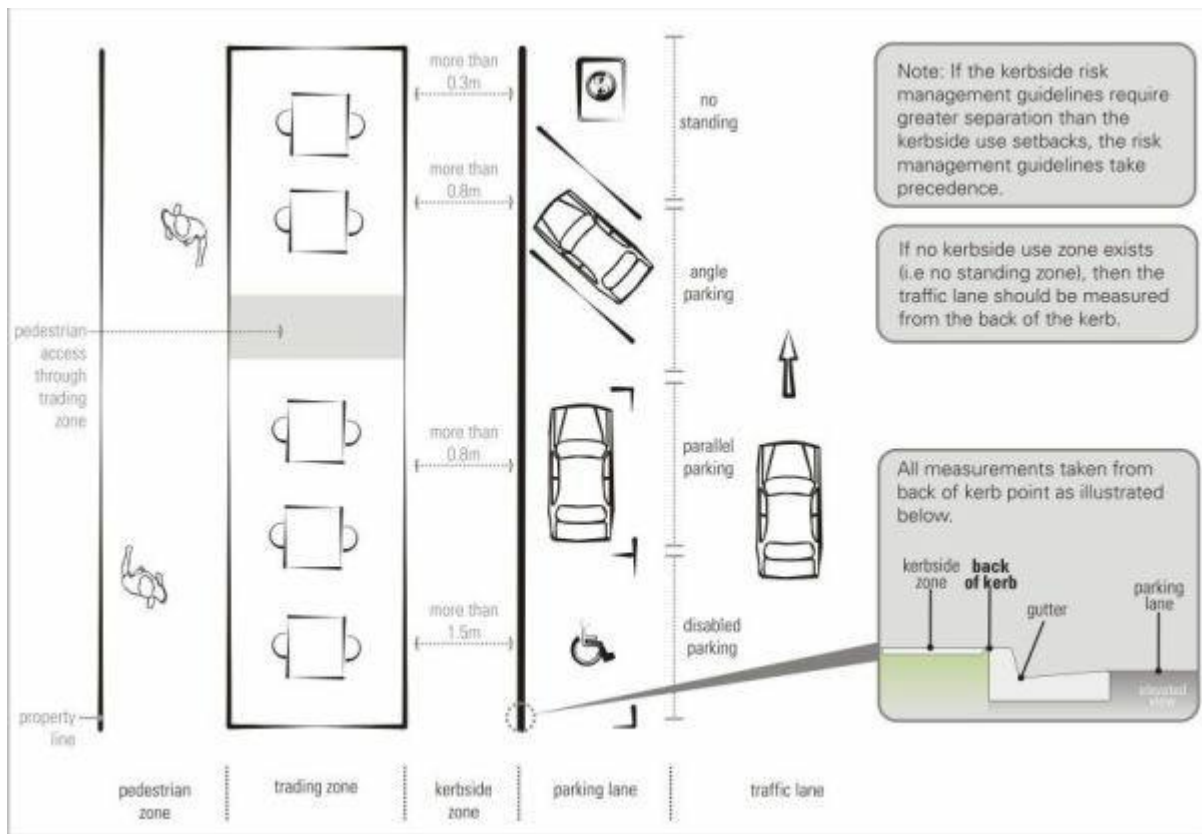


Figure SC6.4.3.4.6 Kerbside use setback requirements

SC6.4.3.4.11 Design and layout principles

- (1) To ensure the safety of patrons using the indoor and outdoor areas of the business.
- (2) To ensure safety and convenient passage of all pedestrians when using public footpaths.
- (3) To ensure the maintenance of clear sight lines for both pedestrians and motorists, particularly near pedestrian crossings, street corners and key intersections as sought by the relevant zone code.
- (4) To provide an active and integrated street front.
- (5) To ensure adjoining premises are not adversely affected by any business use of footpath areas.

SC6.4.3.4.12 Plan of layout

- (1) For any application involving outdoor dining, the applicant is required to provide a layout plan identifying the zones nominated in SC6.4.3.4.1(3) Terminology (and Figure SC6.4.3.4.1) above to a scale of 1:100.

The plan of layout must clearly identify the following:

- (a) pedestrian zone - a clear pedestrian thoroughfare of not less than 1.8 m in width adjacent to the property building line;
- (b) trading zone – an outline of the area intended to be used, including its dimensions;
- (c) kerbside zone – area between trading zone and back of kerb;
- (d) kerbside use zone – area between back of kerb and traveled path of vehicle;
- (e) traffic lane – area of the road used for through passage of vehicles;
- (f) any pedestrian fences that are proposed to be used;
- (g) any crash barriers that are proposed to be installed;
- (h) the access and exit points of the building near the intended outdoor dining area;
- (i) details of any loading zones, bus zones, trees, planter boxes, fire hydrants, transformers, telephone booths, mail boxes, bus stops, bus seats and shelters, rubbish bins, pillars, posts and other obstructions; and
- (j) If any structures are proposed the structures and, the location of any underground services (such as

water, electricity, etc.).

- (2) In addition to submitting a plan of layout, the applicant is also required to submit:
 - (a) a colour photograph of the site frontage of the area; and
 - (b) details of all proposed signage and advertising.

SC6.4.3.4.13 Access guidelines

Outdoor dining should enrich the pedestrian experience and public life and support the purpose of the relevant zone. It is therefore important that they present an open, inviting image and are easily accessible from the public way. The layout and access must be ergonomically designed to allow safe operation of outdoor dining.

The streetscape must provide safe, equitable and dignified access for all, enabling all people to move around independently, safely and without restriction within an outdoor space. The edge of the building permits people who are visually impaired to easily locate entrances to buildings without encountering hazards. Hence, where possible and practical, the trading zone should be located on the kerb-side of the footpath, and the pedestrian zone should be located on the building side of the footpath adjacent to the property building line to provide a continuous accessible path of travel for all pedestrians.

In some locations, conditions may make siting of the trading zone on the kerb-side impractical, seriously disadvantageous or an unreasonable impediment to pedestrian traffic. In such situations, council will consider allowing the location of the trading zone adjacent to the building rather than against the kerb.

In all locations, an outdoor dining area must stay within the area identified as trading zone on the approved layout plan.

Details of required clearances to public infrastructure are provided in SC6.4.3.4.11.

Outdoor dining areas must be easily accessible from the footpath and must present an open and inviting image to entice participation. Pedestrians should not be forced onto the roadway by outdoor dining activities or other non-permanent items/structures on the footpath.

SC6.4.3.4.14 Furniture guidelines

Permanent outdoor furniture should make a positive contribution to the street environment. A furniture style that is practical and integrates well with the surrounding cityscape is encouraged.

- (1) Outdoor furniture should enhance the character of the street.
- (2) Outdoor furniture should be robust to withstand the wear and tear of outdoor commercial usage.
- (3) Outdoor furniture should be safe in its design, compliant with Australian Standards, and not cause any hazards to the patrons, shopkeepers or pedestrians.
- (4) Barricades, safety rails, bollards etc. may be required for safety reasons. All such barriers must be provided and maintained in accordance with this sub-section.
- (5) The use of framed fabric or any other style of low-height barriers, including planter boxes, within public domain must be carefully designed and selected to ensure minimal impact on the use, enjoyment and safety of pedestrians and patrons.
- (6) Removable furniture are to be removed when business is not open.
- (7) No part of the footpath is to be used for storage.

SC6.4.3.4.15 Umbrellas/shade structure guidelines

- (1) Fixtures that penetrate or damage the pavement on public footpaths will generally not be permitted. However, assessments will be undertaken on a case-by-case basis.

- (2) In some cases, the applicant may wish to undertake streetscape works to accommodate an outdoor café. Such works may include footpath widening, paving, street tree planting, installation of permanent umbrellas/shade structures, pedestrian lighting and where such works are in support of the relevant zone code of the Townsville City Plan.
- (3) Umbrellas and other shade structures should not encroach upon, nor interfere with pedestrian movement or services.
- (4) Umbrellas and other shade structures must have not less than 2.5 m clearance above the footpath within the obstruction free zone (AS1742.2 – 2009) from the lowest point of the extended arms (spokes) and not cause a hazard to pedestrians within a pedestrian zone.
- (5) Umbrellas and other shade structures must be maintained in sound and aesthetically acceptable condition to the council's satisfaction.
- (6) Umbrellas and other shade structures must be secured against high winds.
- (7) Umbrellas and other shade structures must be removed when the outdoor seating area is not in use.
- (8) Any advertising on umbrellas and other shade structures must comply with section 9.4.1 Advertising devices code (any relevant approval obtained for the placement of an Advertising device) and the relevant local law (*Local Law No. 1.4 Installation of advertising devices 2011*).

SC6.4.3.4.16 Advertising guidelines

The Advertising devices code found in section 9.4.1 of the Townsville City Plan provides applicants with information regarding the placement of advertising devices. In some instances, separate approval for operational works for the placement of an advertising device may be required. Refer to Table 5.8.2 of the Townsville City Plan to determine levels of assessment for the placement of an advertising device.

SC6.4.3.4.17 Lighting

Any outdoor dining establishment approved to operate outside daylight hours must provide adequate lighting to Australian Standards, to ensure the safety and amenity of patrons and the general public. The use or reliance on council infrastructure is not permitted and the cost of maintaining, running and installing the lighting shall be the responsibility of the applicant/operator of the outdoor dining space. Any outdoor lighting must also comply with any light spillage requirements so as not to cause nuisance to adjoining properties or traffic movement areas. Lighting shall be safe and not cause obstruction or pose a hazard to pedestrians or traffic.

SC6.4.3.5 Car parking and public transport facilities

SC6.4.3.5.1 Introduction

(1) Purpose

This sub-section provides advice, guidance and standards with respect to car parking and public transport facilities to support an integrated safe, efficient and sustainable transport network.

(2) Scope

This sub-section includes the consideration of:

(a) transport impacts, including:

- (i) demands for private and public transport, pedestrian and cycle usage;
- (ii) impacts of future development on existing transport networks and infrastructure and the need for any improvements; and
- (iii) assessment of the public transport services and the provision of facilities both on and off-site and specific high generator needs;

(b) pedestrian and cycle facilities integration with existing networks and for the provision of facilities both on and off-site;

(c) site access - accesses and driveways;

(d) parking area design provision of adequate and appropriately designed parking and circulation areas; and

(e) servicing - provision of appropriate loading/unloading facilities and manoeuvring areas both on and off-site and provision for emergency and service vehicle access.

(3) Relationship to codes

(a) Where a development application is assessable against Part 9.4.6 Transport impact, access and parking code, the application of this sub-section will assist the applicant to address the performance outcomes and acceptable solutions of that code as it contains advice, guidelines and standards.

(b) This sub-section can also be used as guidance and advice for other assessment criteria and codes including Part 9.4.4 Reconfiguring a lot code, Part 9.4.7 Works code, Part 9.4.5 Accepted works requirements code and Part [9.4.39.3.3](#) Landscape code.

(4) Reference and source documents that must be read in conjunction with this sub-section are as follows:

(a) Development manual planning scheme policy sub-sections

SC6.4.3.3 Footpath treatment policy

SC6.4.3.4 Outdoor dining design

SC6.4.3.6 Landscape policy

SC6.4.3.14 Traffic impact assessment guidelines

SC6.4.3.13 Townsville road hierarchy

SC6.4.3.20 Public lighting and utility services

SC6.4.3.22 Waste management guidelines

SC6.4.4.1 Geometric road design

SC6.4.4.2 Pavement design

SC6.4.4.3 Bridges and other structures

SC6.4.4.7 Bicycle, pedestrian and shared path design

SC6.4.4.8 Standard drawings

(b) SC6.10 Parking rates planning scheme policy

(c) Australian Standards

AS/NZS 2890 set *Parking Facilities*

AS1428 set *Design for Access and Mobility*

(d) Department of Transport and Main Roads Queensland
Manual of Uniform Traffic Control Devices (MUTCD)

Traffic and Road Use Management Manual (TRUM)
Guidelines for Assessment of Road Impacts of Developments, 2006
Road planning and design manual
Transport Planning and Coordination Regulation 2005
Planning for Safe Transport Infrastructure at Schools, April 2011
 Public Transport Infrastructure Manual (PTIM) - TransLink Division

- (e) Austroads Guides
 - Austroads Design Vehicles and Turning Path Templates Guide*
 - Guide to Road Design* – set
 - Guide to Traffic Management* – set
 - Cycling Aspects of Austroads Guides AP-G88-14 and Quick Reference*
- (f) Other
 - Australian Government, *Disability Standards for Accessible Public Transport 2002 (DSAPT)*
 - Australian Government, *Disability Standards for Accessible Public Transport Guidelines*
 - Australian Government, *Disability (Access to Premises - Buildings) Standards 2010 Premises Standards*
 - Disability Discrimination Act 1992 (DDA)
 - Australian Building Codes Board, *National Construction Code (NCC)*
 - Queensland Government, *Crime Prevention through Environmental Design: Guidelines for Queensland (CPTED)*
 - Institute of Public Works Engineering Australia, Qld Division, *Complete Streets – Guidelines for Urban Street Design*, 2010
 - Queensland Government, *Queensland Development Code (QDC)*

SC6.4.3.5.2 Public transport

- (1) Transport network impact
 - (a) Applicants should assess the additional transport demands generated by the development and the capacity of the infrastructure to accommodate the additional demands by way of a traffic impact assessment report where all impacts, upgrades and alterations to the road infrastructure, including line marking and signage are identified.
 - (b) SC6.4.3.14 Traffic impact assessment guidelines must then be applied to the extent outlined in that report and information and plans provided on any new infrastructure or the proposed alterations/additions to the existing infrastructure for the consideration/approval of council which may be required as a result of this development. Provision should be made for the utilisation or extension of existing networks and services where required. The recommendations of the traffic impact assessment must be implemented with regard to the advice, guidance and standards identified in this sub-section. End of Trip facilities (on-site or off-site) must be provided as part of the development where identified by the relevant code and must take account of the particular characteristics of the user and service provider.
- (2) Public transport
 - (a) Public transport demands should be assessed and consideration given to upgrading the existing transport network, services and facilities in accordance with the current and future demands.
 - (b) The developer is to provide council with a comprehensive assessment of the current and projected public transport demands for any new facility to be constructed as part of these works. This assessment is to be in the form of a detailed transport report and will include the particulars of any proposed upgrade to the existing transport services, routes and systems that adjoin the proposed project development. Taxi services are also considered a form of public transport and are to be considered in the model assessment of the site (if applicable). Taxi services should be integrated with other transport node facilities wherever it is possible to do so.
 - (c) Information and guidelines for providing public transport are provided in SC6.4.3.5 Attachment A of this sub-section. SC6.4.3.5 Attachment B of this sub-section provides advice on the consultation process with the necessary statutory authorities and service providers.
- (3) Major developments
 - (a) Major developments which will result in high levels of public transport demand should give particular consideration to the provision and integration of services and the detail design of associated facilities on

or near the site. Facilities should be designed so as to be convenient and encourage public transport, walking or cycling. Generators may include uses such as schools, hospitals, event venues, shopping or employment centres, and high-density residential developments, aged care facilities, medical centres and retirement villages.

- (b) If a development is a high level generator under SC6.4.3.14 Traffic impact assessment guidelines, a modal interchange should be provided which may include taxis. A set-back from the main road/route should be provided to ensure the site is serviced safely and directly for these facilities. Developments should present an active frontage to the transport interchange facility with wide footpaths and no conflicting vehicular accesses to ensure pedestrian and user safety is a priority.

SC6.4.3.5.3 Driveways

- (1) Developments must provide for safe effective vehicular site access to and from the site, appropriate for the volume, frequency and type of vehicle usage and the function and characteristics of the surrounding road network. Separate, and clearly distinguishable, access for pedestrians should be provided where practicable.
- (2) The location and characteristics of the access should be in accordance with the following documents:
 - (a) SC6.4.4.1 Geometric road design
 - (b) SC6.4.3.17 Driveways
 - (c) SC6.4.4.8 Standard drawings
 - (d) SC6.4.6 Construction specifications
 - (e) AS 2890 - *Parking Facilities Set*
 - (f) Austroads Guides
- (3) The location and capacity of accesses must provide for safe and efficient pedestrian, cyclist and vehicular movement on adjacent and nearby road, and be appropriately designed so as to consider sight distances, grades, queuing, manoeuvring requirements, drainage and services. Any access must be structurally sound and built of aesthetically appealing materials for the circumstance. The impact of the access on neighbouring properties in terms of safety, streetscape and noise should also be considered.

SC6.4.3.5.4 Pedestrians and cyclists

- (1) Developments are to make appropriate provision for the safe and convenient movement of pedestrians and cyclists, both on-site and to and from surrounding networks. Design should include the provision of suitable routes and end-of-trip facilities so as to encourage and facilitate these forms of movement.
- (2) Major developments should provide end-of-trip facilities in accordance with the QDC Mandatory Part 4.1 *Sustainable Buildings* within the building or on-site.
- (3) As well as to ensuring the safety of pedestrians, cyclists and other transport users, the design of pathways, roads, car parks and associated infrastructure (including lighting, landscaping etc) should in turn encourage overall public safety. The principles found in *Crime Prevention through Environmental Design Guidelines (Queensland)* must be given appropriate consideration for the specific development circumstances in addition to requirements of the relevant code.

SC6.4.3.5.5 Parking

- (1) Parking on-site
 - (a) On-site parking must be provided to meet the demands of the development, including open space areas and meet the minimum rates set out in SC6.10 Parking Rates planning scheme policy (Table SC6.10.2.1 Parking rates). SC6.4.3.6 Landscaping policy provides further direction on the provision of parking to service open space areas.
 - (b) Any associated change to existing on-street parking controls or loading bays must also be appropriately addressed by the development. A parking layout plan must be submitted for the approval of council which accounts for the loss of any existing on-street parking bays to accommodate loading zones, bus

stops, taxi ranks or driveways required for the orderly operation of the proposed development.

- (c) The design of the car park, its accesses and associated aisles are to be in accordance with AS/NZS 2890.
- (d) Accesses must be designed in accordance with SC6.4.3.17 Driveways and SC6.4.4.8 Standard drawings.
- (e) Where car parks are accessed through security barriers, doors or lifts, sufficient queuing space must be provided on site to accommodate all expected traffic during peak demand periods.
- (f) Access ways adjacent to car park entries should have sufficient internal queuing space to prevent vehicles queuing into the street whilst waiting for a vehicle to manoeuvre into-out of a parking bay.
- (g) Turning paths for cars and service vehicles must be provided in accordance with the Austroads' *Design Vehicles and Turning Path Template Guide*. Council may require the preparation of plans that demonstrate adequate turning paths in accordance with Austroads.
- (h) Pavements must be sealed, line marked and constructed to a design appropriate for the anticipated vehicular loading.
- (i) Parking for schools must comply with *Planning for Safe Transport Infrastructure at Schools*.
- (j) Car parks must provide adequate manoeuvring and parking areas for the type of vehicles and functions served. They must be clearly signed and marked, accessible, safe and contribute aesthetically to the internal user and the streetscape character. Landscaping associated with parking facilities must be in accordance with the Landscape Code and with SC6.4.3.6 Landscape policy.
- (k) All car parking spaces for people with a disability must be designed in accordance with AS/NZS 2890-6. Car parking spaces for people with a disability are to be largely located as close as possible to the point of entry into the proposed development. Provision for off-site parking may also be required. In this circumstance, the ability to safely provide this within the road reserve must also be demonstrated.
- (l) Pedestrian access and movements within the car park should be separate from vehicular access and should be appropriately marked and signed and accessible by all abilities.
- (m) Carwash bays must be clearly marked and signed, even though this may also be utilised as a visitor space. Run-off from the car washing bay must not discharge into the stormwater drainage system. Stormwater quality treatment for the car park run-off must be considered as part of the treatment for the whole site.
- (n) Bicycle storage racks must be provided on-site in accordance with AS/NZS 2890.3.
- (o) Provision of lighting in off-street car parks is to comply with AS1158.

(2) Parking on-street

- (a) Developers must undertake all works identified in the traffic impact assessment report required in SC6.4.3.5.2(1) Transport network impact.
- (b) If a new driveway is to be constructed in a street where parallel parking exists and it is necessary to remove parking bays and install a driveway, the remaining parallel parking bays must be remarked such that at least 3 m is left clear from the edge of the driveway on the approach side of the driveway and at least 2 m is left clear on the other side of the driveway. Remarketing of the remaining on street bays and any relocation/alteration to parking control signs must be undertaken as part of this works. A parking layout plan must be submitted for the approval of council.
- (c) Where a loading zone, bus stop or a taxi zone is required as a result of a development, the infrastructure, line marking and signage must be provided by the developer. The design must be submitted to council for approval prior to works commencing on site.

Editor's note—a loss of parking may occur due to access requirements by Queensland Fire and Rescue at hydrant boosters.

SC6.4.3.5.6 Servicing

- (1) The development must make adequate on-site provision for the access, loading, unloading and manoeuvring of service vehicles sufficient to cater for the demand generated by the development and the service vehicles

utilised. The design must ensure the safety of other vehicles, pedestrians and cyclists and that other users are not inconvenienced. The design must also consider any adverse effect on the amenity of the development and its surroundings including the effects of visual amenity, operating hours, the generation of noise odour and dust, and proximity to sensitive uses. The design of this layout must conform to AS 2890.2.

- (2) The development must make adequate internal provision within the site to allow all vehicles servicing the development to enter and exit the site in a forward direction only. In demonstration of this requirement, council may request a turning path plan to show how the intended vehicle types that are expected to use the development can enter and exit the site in a forward gear.
- (3) Entry of B-double or other multi-combination vehicles servicing a proposed development will be considered by council on a case-by-case basis. In making this assessment, council will:
 - (a) assess the status of the roadway fronting the development;
 - (b) consider the zoning of the adjoining properties;
 - (c) design particulars of the vehicle entry and exit layout – with particular attention to the footway/verge crossing details;
 - (d) the internal manoeuvring capacity of the development site; and
 - (e) safety implications to the public and other road users.

Editor's note—road manager consent is required for travel on the road network. Applications are coordinated by the National Heavy Vehicle Regulator.

- (4) Provision for refuse collection must be in accordance with SC6.4.3.22 Waste management guidelines.

SC6.4.3.5 Attachment A: Information and guidelines for public transport

- (1) Bus routes are preferred along the shortest route, or up to 120% of the shortest length, between destinations.
- (2) Preferred bus routes are generally located along arterial, sub-arterial and collector roads. Passenger bus services will not service an estate with only one entry/exit; as existing passengers are taken on a tourist trip through the estate without getting closer to their destination.
- (3) The main criteria in determining the location of a bus route is that no more than 10% of residents should have to walk more than 400m to catch a bus within the urban area. Council may request a public transport route plan as part of the development to demonstrate this requirement. Bus services operate to a published timetable, so routes with minimal delays at intersections are preferred; routes with multiple traffic signals can cause delays to timetable service.
- (4) To minimise resident objection to the placement of bus stops in front of houses, any public open space (e.g. drainage or recreational reserve) should be considered to accommodate a bus stop. This is particularly pertinent if the public open space contains a pathway. Other options include high-density residential or commercial developments where off-street parking is a component of the development. It is most desirable to establish the location of future bus stops during the design process to ensure that future development proposals recognise the implications of this infrastructure and its location. A layout plan showing the proposed locations must be submitted for the approval of council.
- (5) New bus stops will be one of four standards:
 - (a) Minimum boarding point - bus stop sign with timetable displays (TDC), platform with tactile ground surface indicators (TGSI); or
 - (b) regular stop - bus stop sign with TDC, platform with (TGSI) and seat (inbound definite, outbound optional); or
 - (c) intermediate stop - bus stop sign with TDC, platform with TGSI and shelter with seat (inbound definite, outbound optional) – site specific; or

- (d) premium stop - generally limited to high route volume locations and stops at shopping centres. As per intermediate stop, with greater care to the infrastructure finish standards and capacity requirements.
- (6) New regular and intermediate bus stops are to be designed and constructed in accordance with council's standard drawings (SC6.4.4.8 Standard drawings) and meeting disability compliance standards (DSAPT and Premises Standards) or set out under the Disability Discrimination Act 1992.
- (7) Bus stops should be located where there is no conflict with the location of (drainage pits/surrounds, poles, items of street furniture), street trees or driveways to properties. Drainage pits must be located away from the bus platform (concrete slab) to avoid creating a safety hazard. They are generally located in residential areas at side boundaries of adjoining properties to avoid resident concerns about loss of amenity and view, by having a stop directly in front of their property. Bus stops are generally preferred to include a location near an intersection to pick up passenger from the side streets; however, it should not impact on intersection functionality or operation. Bus stops are preferred on the departure side of intersections and major driveways.
- Bus stop facilities within private property must comply with the DSAPT and associated guidelines, the Premises Standards or under the DDA. The developer must provide documentation to demonstrate consultation with the Department of Transport and Main Roads and the all impacted bus operators about future passenger bus routes servicing the facility during the design phase. A layout plan showing the proposed location with details must be submitted for the approval of council.
- (8) Pathways servicing bus stops must form an integral part of a pathway network servicing the entire estate, and not just be a short connection to the corner of the nearest street.
- (9) The in-bound and out-bound bus stops along the same route should be in proximity to each other on opposite sides of the street, although the bus stops do not have to be directly opposite each other (especially at intersections).
- (10) All new bus stops being constructed must comply with the requirements of the DSAPT and associated guidelines (including any bus stop relocations), the Premises Standards or under the DDA. It must also have a clear continuous accessible path of travel; that is be serviced by a smooth, level and impervious surface with a 1500mm minimum width. One aspect of compliance is that the preferred cross-fall on the bus stop platform slab is 2%, and absolute maximum of 2.5%. School bus stops (mostly in a rural environment) do not need to comply with this requirement at this time.
- (11) A standard bus stop is 3 m wide by 12 m long, (see SC6.4.4.8 Standard Drawings) plus entry/exit tapers on roads with a posted speed limit of 60km/h or less. A bus bay (with associated parking restrictions) is approximately 42m long (allowing for a 15m in taper and 15m egress taper). These dimensions can vary and may severely impact on the required street width (especially where no indents are to be provided), driveway access to properties and the availability of visitor/customer parking.
- (12) Consideration must be also given as to how elderly and young passengers (especially school children) will safely cross the street to access the bus service. This may require the installation of a nearby refuge crossing or traffic signals, or similar measures.
- (13) Bus routes should avoid having vertical or horizontal deflection traffic calming measures along the route. Any vertical deflection devices that are to be used by a bus service intended to operate in high pedestrian environment must be flat-top road humps. Council may support a bus route where speed cushions are installed.
- (14) Any roundabout along a bus route must be able to accommodate a turning bus without mounting the kerb and channel or encroaching onto any landscaping on the centre island, including during a right hand turn.
- (15) The developer is to prepare a draft Master Plan for the proposed development together with a traffic impact

- (16) The Master Plan will identify (as a minimum):
- (a) proposed residential development lot sizes and densities;
 - (b) any proposed commercial development, including approx. GFA;
 - (c) any proposed education facility or other significant bus passenger service attractor (e.g. retirement village, hospital etc.);
 - (d) location, type and hierarchy of open spaces areas;
 - (e) the proposed road hierarchy for the development, and how it connects to the existing road network;
 - (f) the location of proposed footpaths and shared paths and bicycle paths throughout the development, and how they connect to the existing, and future, networks; and
 - (g) the route of all existing passenger bus routes within 1 km of the proposed development and through the development; and
 - (h) The Master Plan must be submitted for the approval of council.
- (17) As part of the information required in obtaining a development approval, the developer must provide evidence of feedback from consultation with all the following stakeholders on the feasibility of potential passenger bus service route/major bus corridor through the new development:
- (a) Department of Transport and Main Roads (TransLink Division);
 - (b) Department of Transport and Main Roads (Northern Region);
 - (c) local contract bus operator (Sunbus Townsville) and if necessary school bus operator/s;
 - (d) local taxi operator (Townsville Taxis); and
 - (e) council's Infrastructure Services Division.
- (18) The outcome from the engagement with the stakeholders will be:
- (a) advice if the development is ever likely to be serviced by a passenger bus service or school bus service;
 - (b) agreement of the most likely route(s) through, or servicing, the proposed development;
 - (c) the need and likely location of bus stops necessary to service the development;
 - (d) general agreement on the location and route of footpaths and shared paths servicing any future bus service along the agreed bus routes;
 - (e) advice on the need for any bus stop to be constructed as part of any proposed commercial centre, and the likely required standard of the facility; and
 - (f) the need for the developer to provide any other additional facilities to ensure the operation of an efficient and effective public transport services, including taxis. This may include required intersection treatment, bus stop locations, the possibility of joint use bus stops and the like.

SC6.4.3.5 Attachment B: Guidelines - Authority consultation for public transport, taxis, buses and school buses

- (1) Taxi operations
Contact the Department of Transport and Main Roads Northern Region and the local taxi operator about taxi service operations.
- (2) Taxi infrastructure
- (a) Contact Townsville City Council about existing and proposed taxi rank infrastructure in the area.
 - (b) Any existing or new infrastructure undergoing substantial refurbishment or alteration must comply with the *Disability Standards for Accessible Public Transport 2002* and associated guidelines, the Premises Standards or under the DDA, and be in accordance with SC6.4.4.8 Standard drawings at the time of the refurbishment or alteration. It must have clear continuous accessible path of travel; that is, be serviced by a smooth, level and impervious surface.

- (3) Bus routes
 - (a) Contact the Department of Transport and Main Roads Northern Region and the local bus operator (Service Contract holder) about current and future passenger bus routes.
 - (b) The developer will need to be aware of, and make provision for, future bus routes as determined through the consultation process with DTMR, council and the local bus operators.
- (4) Bus stop infrastructure
 - (a) Contact Townsville City Council in the first instance about existing and proposed bus stop infrastructure on the road reserve, then contact the Department of Transport and Main Roads about interchange-type infrastructure.
 - (b) Any existing or new infrastructure undergoing substantial refurbishment or alteration must comply with the DSAPT and guidelines, the Premises Standards or under the DDA, and be in accordance with SC6.4.4.8 Standard drawings at the time of the refurbishment or alteration.
 - (c) Townsville City Council has prepared standard drawings for bus stop infrastructure. Also, new or relocated bus stops must have the specified branding (J Pole/ Blade signing), an identifying name approved by council's Technical Services Unit and be in accordance with SC6.4.4.8 Standard drawings and the bus stop position identified by easting and northing.
- (5) School buses services

Contact the Department of Transport and Main Roads Northern Region and the local bus operator about current and future school bus route operations.
- (6) School bus stop infrastructure

Contact Townsville City Council about existing and proposed school bus stop infrastructure on the road reserve.
- (7) Intercity buses (long distance)

Contact Townsville City Council about existing and proposed intercity bus stop infrastructure on the road reserve, but also contact the Department of Transport and Main Roads TransLink Division about bus stop infrastructure and bus stop operations.

SC6.4.3.6 Landscape policy

SC6.4.3.6.1 Introduction

(1) Purpose

The purpose of this sub-section is to:

- (a) support the purpose of Part 9.3.3 Landscape code and other elements of the Townsville City Plan and Development manual planning scheme policy;
- (b) identify the application of this sub-section to landscape and irrigation design across all types of open space; and
- (c) provide detailed design and construction standards, advice and guidelines for landscaping on private and public land ensuring a high standard, strong contribution to the city image and local character that are suited to site and climatic conditions and will remain fit for purpose over the long-term.

(2) Scope

This sub-section provides direction on landscape and irrigation design within open space, both within the public and private realm.

The scope of this sub-section includes:

- (a) overarching design, sustainability and management principles that should be applied to open space development including:
 - (i) general design principles, master plans and identified design outcomes;
 - (ii) principles of sustainability economic, environmental, and social; and
 - (iii) management frameworks for public open space Public Open Space (POS) Hierarchy, Public Open Space Management (POSM) Framework and Irrigation Profile Level (IPL) Framework;
- (b) the types, functions and development objectives for open space:
 - (i) private open space;
 - (ii) streetscapes; and
 - (iii) public open space recreation parks, sporting parks and other public open space; and
- (c) design and embellishment guidelines for application in open space development.

(3) Reference and source documents

- (a) This sub-section should be read in conjunction with other sections of the Townsville City Plan and Development manual planning scheme policy including, but not limited to:

Part 4 – Priority infrastructure plan

Part 8.2.5 – Natural assets code

Part 9.3.3 – Landscape code

Part 9.3.4 – Reconfiguring a lot code

SC6.4.3.3 – Footpath treatment policy

SC6.4.3.4 – Outdoor dining design

SC6.4.4.1 – Geometric road design

SC6.4.4.7 – Bicycle, pedestrian and shared path design

SC6.4.3.20 – Public lighting and utility services

SC6.9 Natural assets planning scheme policy

- (b) The following Australian Standards are also referenced and should be read in conjunction with this sub-section:

AS/NZS 1158.3.1 *Lighting for roads and public spaces*

AS 1170 *Structural design actions (set)*

AS 1428 *Design for access and mobility (set)*

AS 1926.1 *Swimming pool safety – safety barriers for swimming pools*

AS 2156 *Walking tracks*

AS 2890.3	<i>Parking facilities – Bicycle parking facilities</i>
AS 3996	<i>Access covers and grates</i>
AS 4373	<i>Pruning of amenity trees</i>
AS 4422.2016	<i>Playground surfacing – Specifications, requirements and test methods</i>
AS/NZS 4486.1	<i>Playgrounds and playground equipment – Development, installation, inspection, maintenance and operation</i>
AS 4685.1	<i>Playground equipment – General safety requirements and test methods (and Amendment 1 – 2006, and Amendment 2 – 2008)</i>
AS 4685.2	<i>Playground equipment – Particular safety requirements and test methods for swings (and Amendments 1- 2006 and 2 - 2008)</i>
AS 4685.3	<i>Playground equipment – Particular safety requirements and test methods for slides (and Amendment 1- 2006)</i>
AS 4685.4	<i>Playground equipment – Particular safety requirements and test methods for runways</i>
AS 4685.5	<i>Playground equipment – Particular safety requirements and test methods for carousels (and Amendment 1 – 2006)</i>
AS 4685.6	<i>Playground equipment – Particular safety requirements and test methods for rocking equipment (and Amendment 1 – 2008)</i>
AS 4685.11	<i>Playground equipment – Additional specific safety requirements and test methods for spatial network</i>
AS/NZS 4456.9	<i>Masonry units and segmental pavers and flags – Methods of test – Determining abrasion resistance</i>
AS/NZS 4586	<i>Slip resistance classification of new pedestrian surface materials</i>

(c) Other

The following documents are also referenced and should be read in conjunction with this sub-section:

Austrorads, *Guide to Road Design* (Set)

Building Code of Australia

Department of Transport and Main Roads, *Road landscape manual*, 2013

Department of Transport and Main Roads, *Manual of uniform traffic control devices* (MUTCD), Queensland

Department of Transport and Main Roads, *Traffic and Road Use Management Manual*, Volume 3.13: *Pedestrian Cross Facility Guidelines and Prioritisation system User Guide*.

Queensland Government, *Crime Prevention through Environmental Design, Guidelines for Queensland*, Parts A and B, 2007

Queensland Government, *Census of the Queensland Flora*, 2013, edited by Peter D. Bostock and Alisa E. Holland.

Western Australian Department of Sport and Recreation, *Sports Dimensions Guide for Playing Areas*

SC6.4.3.6.2 Landscape design

(1) Introduction

Landscape and irrigation outcomes should demonstrate consideration and application of the overarching principles, as described within this sub-section, Part 9.3.3 Landscape Code and other parts of the Townsville City Plan.

Alignment with applicable principles should be expressed in the landscape and irrigation design outcomes and addressed in the “Landscape Statement of Intent”, as detailed in Section SC6.4.2 Development application guidelines.

(2) Master plans

For certain sites or localities, council may formally adopt Master Plans that identify specific strategies and plans to deliver key design and construction outcomes in the built environment.

At sites or locations where these Master Plans apply, any landscape design outcomes must be in accordance with the requirements for that site or area.

The following plans contain site specific outcomes that must be complied with:

- (a) Thuringowa Riverway Master Plan (2003); and
- (b) Riverway Sustainable Development Policy (2003).

Editor's note—applicants should refer to all applicable sub-sections within the Development manual planning scheme policy which identify specific design principles and outcomes required across individual open space typologies as well as other infrastructure.

Editor's note—outcomes identified in an adopted master plan take precedence over all other design guidelines, unless approved otherwise. Where proposals deviate from the desired outcomes of the adopted master plan, applicants must justify this deviation for council's assessment and approval.

- (3) Identifiable character and/or identified design outcomes
For key sites or localities where council has **not** formally adopted area specific plans and strategies but there is an identifiable character and/or desired design outcome, planning and design for new open space development in these areas should seek to be consistent or complementary to this established direction.

Identifiable character and/or design outcomes may include:

- (a) an established colour or furniture palette;
- (b) a dominant tree, plant species or planting style;
- (c) heritage features or an identifiable character;
- (d) significant natural features, materials, or environmental setting (e.g. natural bushland or coastal settings); and
- (e) a consistent, hierarchical-based landscape design style (e.g. all “main roads” to be developed in “tropical boulevard” style).

Editor's note—statements pertaining to identifiable character or design outcomes for particular locations or land uses are contained within Townsville City Plan. Where applicable, landscape design outcomes are to comply with these statements and must be addressed within the “Landscape Statement of Intent”. Where proposals will deviate from the desired outcomes, applicants must justify this deviation for further assessment and approval by council.

SC6.4.3.6.3 Economic sustainability

Landscape and irrigation outcomes should demonstrate consideration and application of economic sustainability principles, as described within this sub-section, Part 9.3.3 Landscape code and other areas of the Townsville City Plan.

Alignment with applicable principles should be expressed in the landscape and irrigation design outcomes and addressed in the “Landscape Statement of Intent”, as detailed in Section SC6.4.2 Development application guidelines.

- (1) General principles
Principles for consideration should include, but are not limited to:
- (a) promoting opportunities for business and investments by:
 - (i) designing quality streetscapes that promote local business and attract patrons; and
 - (ii) creating opportunities for marketing initiatives such as festivals, events and community based activities (e.g. provision of event spaces within public open space areas);
 - (b) developing and implementing an integrated and strategic approach to the long term provision of open space infrastructure by:
 - (i) aligning new public open space development with council's Public Open Space Embellishment Framework and priority infrastructure plans; and
 - (ii) designing and developing new infrastructure and open space that improves the quality and value of the built environment within both the public and private realm (e.g. creating more liveable spaces that promote the city as an attractive place to live and invest); and
 - (c) establishing economically sustainable infrastructure outcomes by:
 - (i) identifying the lifecycle costs of open space infrastructure (e.g. the costs to plan, develop,

- maintain, replace and demolish a recreational facility are established); and
- (ii) identifying and developing new infrastructure with consideration of the ongoing operational requirements (e.g. identify and design a new open space development in line with defined maintenance resources).

(2) Lifecycle costing

Editor's note—currently, no framework or standard format for establishing lifecycle costs is developed. Applicants requested to submit lifecycle costing information should refer to best-practice examples until a formal framework is established.

(3) Ongoing operational requirements

- (a) Where requested, applicants are required to identify the ongoing operational requirements in a maintenance plan, as detailed in Section SC6.4.2 Development application guidelines.
- (b) For public open space, maintenance plans should be aligned with Public Open Space Management (POSM) Framework, as outlined in SC6.4.3.6.9(2)(b) POSM Framework and developed with consideration of the Public Open Space Embellishment Framework, as per Table SC6.4.3.6.1.

SC6.4.3.6.4 Environmental sustainability

Landscape and irrigation outcomes should demonstrate consideration and application of environmental sustainability principles, as described within this sub-section, Part 9.3.3 Landscape Code, other areas of the Townsville City Plan and council's Corporate Plan.

Alignment with applicable principles should be expressed in the landscape and irrigation design outcomes and addressed in the "Landscape Statement of Intent", as detailed in Section SC6.4.2 Development application guidelines.

Editor's note—currently, no framework has been developed for identifying and documenting outcomes against the environmental sustainability objectives listed. Until a formal framework or best-practice examples are identified, applications will be considered on a case by case basis. This includes recognition of independent certification under incentive-based branding and certification frameworks (e.g. EnviroDevelopment) designed to increased sustainability in developments.

(1) Principles for consideration should include, but are not limited to:

- (a) conservation and substitution of non-renewable resources, by:
 - (i) responsible use of finite resources; and
 - (ii) implementation of efficiency mechanisms and strategies, (e.g. reduction of potable water use through water wise landscape and irrigation design);
- (b) efficient and sustainable use of renewable resources, such as:
 - (i) prioritising and promoting innovative use of new, renewable materials or substitutes (e.g. plantation timber); and
 - (ii) transitioning to renewable energy sources and infrastructure where practicable (e.g. solar powered lighting);
- (c) direct and indirect reduction in resource consumption and waste generation, by:
 - (i) implementing opportunities for waste reduction and reuse (e.g. concrete recycling for gabion walls);
 - (ii) prioritising and promoting use of recycled materials (e.g. recycled plastic composites);
 - (iii) promoting means for reducing carbon emissions and improving opportunities for carbon offsets and sequestration (e.g. reducing land clearing by promoting protection of existing trees and vegetation areas and incorporation of natural areas into public open space design); and
 - (iv) promoting environmentally sustainable design principles to directly and indirectly reduce resource consumption (e.g. increased street tree plantings to support passive cooling of streetscapes and buildings whilst improving amenity to promote pedestrian and cyclist activity); and

- (d) protection, rehabilitation or enhancement of existing natural assets and systems through methods such as:
 - (i) responsive planting design and species selection;
 - (ii) protection of remnant vegetation, significant trees and habitat areas;
 - (iii) promotion of ecological design and responsible urban forestry management; and
 - (iv) implementation of integrated water cycle management practices.

(2) Responsive planting design principles and species selection

The following are provided as general guidelines for responsive planting design and species selection for all types of open space.

(a) Aesthetic requirements

- (i) Planting design principles such as scale, proportion, repetition, balance, contrast, focal points and transition should be applied in the development of all planting designs.
- (ii) The design qualities of the plant species including size, scale, form, line, texture and colour should be considered and maximised through the planting design process.
- (iii) Plant selection and design should promote urban landscapes that reflect Townsville's climate, its natural environment, the existing local character, and any specific vegetation themes of a local area.

(b) Suitability and functional requirements

- (i) Plant selection based on the biophysical attributes of the plant, the ideal growing conditions of the species and its appropriateness for the site conditions and the region's dry tropics climate.
- (ii) The intended function and location of the plant species should be appropriate to its growing habit, size and other design qualities, in particular ensuring the expected size of the mature specimen can be supported in the available planting space.
- (iii) The quantity and density of planting proposed should consider the expected mature plant size, the density required to achieve the desired effect, account for expected die out during establishment, and avoid any foreseeable maintenance issues.
- (iv) Planting location and/or species selection should not create any foreseeable, adverse impacts on access, circulation or critical sightlines.
- (v) Plant habit and location should not have any foreseeable, adverse impact on adjacent properties, built assets, services, roads, drainage or other infrastructure.
- (vi) The irrigation, maintenance and other resource inputs necessary to maintain the functionality and longevity of planting design outcomes and species should be sustainable, cost-effective and analogous with the available resources.

(c) Ecological requirements

- (i) Plant selection and design should promote the use of local native and non-invasive introduced plant species.
- (ii) Additional considerations and specifications applicable to plantings are detailed in sub-section SC6.4.6.26 Landscaping and other requirements of this sub-section.

(3) Retention of remnant vegetation and significant trees

(a) Site planning and landscape design should be used to protect and integrate significant vegetation or trees of the site including, but not limited to:

- (i) large, existing mature trees;
- (ii) vegetation in intact natural areas;
- (iii) trees or vegetation protected by heritage listing;
- (iv) trees or vegetation not formally protected by heritage listing but where the size and/or quantity present has a significant character impact;
- (v) marine plants including mangroves;

- (vi) vegetation in riparian zones or on slopes, especially where the vegetation is performing a stabilisation role; and
 - (vii) vegetation external to the development site but where activities within the site may impact its long-term sustainability.
- (b) Where species/areas are identified as significant, all applicable tree and vegetation protection requirements are to be implemented, as per clause SC6.4.5.2(16) Work adjacent to trees and protection of environmentally significant vegetation.
 - (c) Additional detail on how the retained species will be protected and integrated into the proposed landscape works may need to be addressed in a vegetation protection plan, the “Landscape Statement of Intent” and included on the associated landscape plans.

Editor’s note—refer Section SC6.4.2 Development application guidelines and clause SC6.4.5.2(14) Work adjacent to trees and protection of environmentally significant vegetation.

(4) Ecological buffers

- (a) All buffer works to environmentally significant areas should be provided in accordance with Part 8.2.5 Natural assets code and SC6.9 Natural assets planning scheme policy.
- (b) All buffers and ecological designs should be prepared in consultation with an appropriate specialist for the local region.

Editor’s note—due to the variable nature of ecological design, no further guidelines or specifications are currently developed for the establishment of ecological buffers within open space. Proposals will be considered on a case-by-case basis in accordance with all necessary requirements defined by all applicable ecological, landscape and irrigation standards, legislation, and council’s overarching design and management principles. Engagement and approval from other stakeholders/authorities may additionally be required as part of any development proposal of this nature.

(5) Integrated water cycle management and water efficiency

Editor’s note—currently, no framework or standard principles for establishing integrated water cycle management and water efficiency objectives are developed specifically for open space. Applicants should refer to other requirements within the planning scheme, this sub-section and other sub-sections of the Development manual planning scheme policy.

SC6.4.3.6.5 Social sustainability

Landscape and irrigation outcomes should demonstrate consideration and application of social sustainability principles, as described within this sub-section, Part 9.3.3 Landscape Code and other areas of the Townsville City Plan.

Alignment with applicable principles should be expressed in the landscape and irrigation design outcomes and addressed in the “Landscape Statement of Intent”, as detailed in Section SC6.4.2 Development application guidelines.

(1) General principles

Principles for consideration should include, but are not limited to:

- (a) community development principles, such as:
 - (i) promoting social interaction and inclusion (e.g. well-designed civic spaces that promote social activities and community gatherings);
 - (ii) design for universal access where possible (e.g. applying universal design principles in the design and construction of recreation facilities to promote inclusion of users of different abilities);
 - (iii) equitable distribution of open space opportunities and resources (e.g. equitable distribution of different open space facilities throughout the city);
 - (iv) designing for community diversity (e.g. promoting open space design that responds to the varying needs of the community and creates a diversity of experiences suitable for different cultures and demographics); and

- (v) engaging with the community on design proposals (e.g. working with the local community/groups in the design or development of facilities within open space); and
- (b) public health and safety principles, such as:
 - (i) creating opportunities for community health and well-being activities (e.g. provision of outdoor activity elements that promote physical activity for all ages through structured or unstructured recreation);
 - (ii) applying principles for crime prevention through environmental design (CPTED), refer to SC6.4.3.6.6 Crime prevention through environmental design; and
 - (iii) complying with all standards and safety requirements to ensure safe open space for the community and maintenance personnel.

(2) Universal access

Unless not practicable or cost prohibitive, open space development, embellishment provision and location must cater for accessibility and mobility requirements in accordance with AS 1428 Design for access and mobility (Set of standards), and as required by Part 9.3.3 Landscape Code. This should include, but is not limited to:

- (a) providing an appropriate number of certified accessible items at key activity areas/locations;
- (b) providing appropriate surface treatments that enhance safety, mobility and accessibility, whilst also being aesthetically pleasing and promoting sensory stimulation where required;
- (c) providing appropriately sized concrete slabs that are designed to facilitate wheelchair and pram access around open space furniture and other infrastructure items;
- (d) providing all ancillary infrastructure such as ramps and pathways to ensure access and compliance with applicable standards; and
- (e) incorporation of all other universal design principles, as applicable.

SC6.4.3.6.6 Crime prevention through environmental design

Crime Prevention Through Environmental Design (CPTED) provides a common-sense approach to designing environments (new or redevelopment) in ways that help to create safer spaces and reduce crime. CPTED may be applied to any built environment or facility. For example, parks, toilet blocks, public areas, shopping centres, car parks and even residential dwellings. Implementing CPTED principles will not always eliminate crime but it is one of many different techniques that Council employs in a holistic approach to reduce and prevent criminal activity.

The design and landscaping associated with development for, parks, gardens, streetscapes or other public open space areas, shall be considered against the key CPTED elements.

Editor's note—further guidance on implementing CPTED principles can be found in the following locations: Queensland Government, *Crime Prevention through Environmental Design, Guidelines for Queensland, Parts A and B*, 2007 and CPTED Association website.

SC6.4.3.6.7 Private open space

Private open space is considered to be a usable outdoor area within a private development. It may include back and front yards, courtyards, gardens, balconies, terraces, decks, and communal areas in multi-unit developments. These spaces provide important private places for residents and other users to play, entertain, relax or seek respite from urban living.

Landscaping and irrigation within private open spaces assists in creating a shaded and attractive setting that is comfortable and usable, whilst also improving residential amenity and character. The significant environmental benefits of private open space are also recognised, noting the potential positive contribution of the spaces to reducing runoff, increasing biodiversity, heat amelioration and passive cooling.

Private open space does not include fully enclosed spaces, vehicle parking areas and verges. Open space contribution from roof gardens and vertical gardens will be assessed on a case-by-case basis and with consideration of other on-site open space and landscaping provision.

Editor's note—further details of design outcomes for private open space are contained within the relevant development codes of the

SC6.4.3.6.8 Streetscapes

Streetscapes refer to the street or road landscape including all public open space within the road reserve. The design and development of streetscapes will vary according to the road or street hierarchy, its associated function, as well as the surrounding land use and built environment.

Editor's note - Applicants should refer to SC6.4.4.1 Geometric road design for more information.

It is noted, however, that there is interdependency between elements within the private realm and the overall streetscape. Critically, elements with the private realm (e.g. residential or commercial frontages) contribute to the appearance and function of a streetscape. It is important, therefore, that any streetscape design proposal is integrated and responsive to the surrounding context.

SC6.4.3.6.9 Public open space

The landscape and character design outcomes associated with the development of public open space are required to demonstrate alignment with the standards set out in this sub-section and addressed in accordance with Section SC6.4.2 Development Application Guidelines.

(1) General

Public open space includes all areas of open space that are publically owned and/or accessible. Public open space includes parks and land that has been reserved for the purpose of sport and recreation, ecological function and natural environment protection, infrastructure corridors and stormwater management and the general provision of green space.

Public open space and the provision of dedicated parks contribute significantly to community well-being, urban place-making and the general amenity and liveability of a city. Parks and other open space typologies also perform dual or multifunctional roles. This includes supporting the provision and buffering of roadways, detention basins and other infrastructure networks such as bikeways, and utility services, particularly within corridor parks.

Public open space excludes open space not publically accessible, not for community use or within the road reserve. However there are some areas that are designated Special Use Parks or Facilities, these parks provide specialised recreation use. This includes where the nature of the recreation activity only allows controlled access and precludes free, unrestricted access to members of the public, or where the land and facility result in a single use activity.

(2) Public Open Space Frameworks

(a) Public Open Space (POS) Hierarchy

The public open space hierarchy refers to the size, form and function of public open space which will vary significantly across different park types and other public open space typologies. As such, public open space networks are usually defined by various open space typologies that are rationalised, planned and designed against a "Public Open Space Hierarchy".

This approach ensures the distribution, development and management of public open space occurs in a strategic and structured manner that reflects the differing classifications and importance of the each open space typology

Group and individual typologies within the Public Open Space Hierarchy reflect the diversity of functions and uses between different open space typologies within the city. Council's open space hierarchy has been divided into three functional groups:

- (i) recreation parks;
- (ii) sports parks; and
- (iii) other public open space.

Importantly, it should be recognised that one area of public open space may contain more than one open space typology function across the different functional groups.

For example, a park may contain two formalised sports fields (district sporting function), a local recreation node (local park function) and a drainage corridor (utility function). In instances such as this, the public open space may be:

- classified based on the most dominant function (e.g. classified a district sports park, with the presence of a local recreation node recognised but not separately designated), or
- split into different functional areas, where each area is separately recognised and designated.

Classification of public open space against the hierarchy is reached through a strategic audit and evaluation of the open space, its characteristics and the standards of embellishment. Profile, accessibility and usage catchments are also a key determinant in hierarchy classifications, with typologies generally being categorised on a local, district or regional basis.

The POSM classifications subsequently inform council's management, development and all future planning for the public open space and the wider open space network.

To support these classifications, council has developed a Public Open Space Embellishment Framework that defines what level of embellishment and infrastructure is "essential" to different public open space typologies. The purpose of this framework is to support equitable, cost-effective and sustainable development of public open space that is functional and meets the needs of the community.

The Public Open Space (POS) Embellishment Framework is further defined in Table SC6.4.3.6.1 Open space embellishments and the balance of this sub-section.

Editor's note—Open Spaces classified as being of District or Regional significance have been determined as priority trunk infrastructure. (Refer Part 4 Priority infrastructure plan of the Townsville City Plan).

The proposed landscape design and character outcomes associated with the development of public open space are required to demonstrate alignment with the standards set out in this sub-section and address this through landscape design outcomes and in the "Landscape Statement of Intent", as detailed in Section SC6.4.2 Development application guidelines.

(b) Public Open Space Management (POSM) Framework

A key objective of the Public open space management and associated levels of service is to ensure that the level of embellishment is consistent and sustainable with the available resources to maintain them.

Associated with the Public Open Space Hierarchy, council has developed a Public Open Space Management (POSM) Framework that specifies acceptable maintenance levels of service against different open space typologies. This POSM Framework and associated levels of service are also applied against the road hierarchy.

In order for council to properly assess future POSM requirements for each public open space development proposal, council may request the provision of a maintenance plan for maintenance activities not already detailed in the POSM Framework, as detailed in Section SC6.4.2 Development application guidelines. Where requested, this maintenance plan should seek to demonstrate alignment with the adopted POS Embellishment and POSM Frameworks.

Maintenance levels of service under the POSM Framework are defined by the public open space or road hierarchy classification and the frequency of maintenance services required. Associated with this, maintenance activities and frequencies are assigned, based on the public open space or road hierarchy classification and/or embellishments present.

A key objective of both the POS Embellishment and POSM Frameworks is to ensure that the level of embellishment is consistent and sustainable with the available resources to maintain them. As such, infrastructure must not be provided where the necessary maintenance required exceeds the allocated

maintenance level of service in order to ensure the public open space or items remain serviceable and safe for public use (e.g. dynamic fitness equipment that requires weekly safety inspections or electric barbecues that require daily cleaning to remain hygienic should not be installed in a park that has assigned fortnightly maintenance service). Further, the cost to establish, maintain and ultimately renew the infrastructure must be sustainable and cost effective for council and the community in the long-term.

In order for council to properly assess future POSM requirements for each public open space development proposal, council may request the provision of a maintenance plan, as detailed in Section SC6.4.2 Development application guidelines. Where requested, this maintenance plan should seek to demonstrate alignment with the adopted POS Embellishment and POSM Frameworks.

Editor's note—the POSM Framework is currently under review to align the maintenance frequency with the (POS) hierarchy review and further development. As such, detailed specifications relating to maintenance activities and frequency are not available at the present. Enquiries relating to this should be directed to Construction and Maintenance Operations.

(c) **Irrigation Profile Level (IPL) Framework**

As part of council's commitment to efficient, cost effective and responsible use of natural resources, council has developed an Irrigation Profile Level (IPL) Framework to categorise and define irrigation water usage within public open space.

The IPL Hierarchy identifies and defines a number of “profile levels” based on the level of irrigation applied, an indicative “functional application” based on open space typologies, and the performance indicators associated with each irrigation application rate. Refer to SC6.4.3.6 Attachment C for IPL Hierarchy.

Supporting this, the IPL Matrix identifies a number of criteria and “influences” used in the determination of an assigned IPL. Refer to SC6.4.3.6 Attachment D for the IPL Matrix.

Importantly, it must be recognised that the level of irrigation required is directly dependent upon the landscaping which it must support. As such, in the development of new public open space, the landscaping should be designed with consideration of the typical IPL classification for the public open space typology as well as the extent of landscaping and irrigation defined by the POS embellishment standards. Additional requirements are identified in SC6.4.3.6.34 Irrigation design and system requirements.

For existing public open space, the IPL classification must be based upon the required irrigation application rate necessary to support the health and longevity of the existing landscaping. Where a change to the IPL is proposed, this must include consideration of the open space typology, the intended use of the open space area and the impacts of reduced water application rate on existing plant specimens and include changes to the landscaping plantings where required.

Critically, an area of public open space may have more than one IPL (e.g. “high” IPL level around the activity node or within the minimum usable space, and then a “medium” or “low” profile for the balance of the open space). To achieve this in an efficient and effective manner, however, the associated landscaping and irrigation systems must be purpose-designed for this outcome (i.e. separate irrigation systems consistent with species selection and placement based on principles of hydro-zoning).

SC6.4.3.6.10 Recreation parks

Recreation parks includes the following:

- (1) **pocket parks:** are small open space parklands that offer a limited range of recreational activities for local residents. Pocket parks are generally associated with specific urban design outcomes, e.g. to support small lot housing.
- (2) **local recreation parks:** are moderately small open space parklands that offer local residents a communal open space to complement their own backyards. Local recreation parks are ideally located within 400m walking distance from residential properties and are generally accessed by non-motorised transport. These parks contain only basic infrastructure for recreational use, refer to the embellishment table for details.

- (3) district recreation parks: are much bigger than local sized parks that can service several suburbs, or a whole community and or a community event. The parks provide for a variety of passive and active recreation and/or contain facilities to cater for a wider user group of all age and levels of ability. The parks are well known destinations for those people living within their catchment, enabling the park to become a significant social hub.
- (4) regional recreation parks: are large open space parklands that offer a wide variety of both active and passive recreation opportunities to a broad section of the community.. The park area is capable of hosting large community events such as festivals, and unique functions. These parks have major embellishments features designed to attract visitation from a wider catchment area and encourage extended stay. It provides unique recreational experiences and is a major landmark and/or destination where people may spend (4+hours) in these parks.
- (5) recreation corridors: are usually a linear open space that follows creeks, drainage channels, service corridors or green belts. Corridor parks traditionally have a dual functionality and may include opportunities for cycling, walking and other recreational activities. It can also provide an important ecological link for flora and fauna. Corridor parks are intended to provide a safe connection between two or more destination points.

Editor's note—currently, further definitions and intent statements are not developed for all individual recreation park typologies. Refer Part 4 Local government infrastructure plan of the Townsville City Plan for definitions, distribution and land areas relating to trunk recreation parks.

SC6.4.3.6.11 Sporting parks

Sporting parks includes the following:

- (1) district sporting parks: are large sized open space parks that provide facilities that are suitable for the practicing and playing of structured or organised sports. These parks may not have the quality of playing surface or amenities of a regional sports park. The park generally contains a good level of embellishment provision. To service a wider user group the sporting areas are often lit, spectator facilities may include a club house, toilets, change rooms and off- street car parking. These parks may also include a limited range of informal recreation activities to cater for unstructured recreation.
- (2) regional sporting parks: are large quality sports parklands that meet state regulations for the sport and can comfortably host either regional (or State competitions). Generally these sports parks cater to a large number of sporting organisation's and spectators who share the site. People may spend (4+hours) in these parks. The playing field may be lit to the required standard for the dedicated sport. Regional Sports parks also have a high level of player and spectator facilities, including clubhouse, canteen, toilets, change rooms, off-road car parking. The park may also include a limited range of informal recreation activities for other park users such as playgrounds and BBQ areas.
- (3) special use parks or facilities; are specialised recreational use and facility spaces where the nature of the activity precludes free, unrestricted access to members of the public, or where the land and facility result in a single use activity. These park spaces may be controlled by either Council or private organisation's (User Pays). Specialised use parks include (but are not limited to); Water parks/Private Owned or Leased Swimming Pools, Equestrian, Archery/Bow hunting/Sport Shooting, Golf, Tennis, Lawn bowls, Model Planes and Motor Vehicle Sports.

Editor's note—Refer Part 4 Local government infrastructure plan of the Townsville City Plan for definitions, distribution and land areas relating to trunk sports parks.

SC6.4.3.6.12 Other public open space

Other public open space includes the following:

- (1) amenity parks: are small landscaped areas with a strong focus on visual. Traditionally Amenity parks may include monuments, memorials or gateway treatments. The park area may also include opportunities for passive recreation such as seating areas. An example of an Amenity Park is Garbutt Park, Garbutt, which acts as an entrance statement welcoming visitors and residents to Townsville.
- (2) civic parks and spaces: are relatively small areas generally associated with a high level of built infrastructure. While recreation use is minimal they provide landscape and amenity values for the general community. Civic parks provide an urban respite for social interaction and community gatherings. Often characterized by hard surface treatments associated with its setting and high activity use levels, these spaces may be used for social events such as community markets.

- (3) natural and bushland areas: are set aside primarily for conservation purposes to protect and retain natural vegetation and habitat areas. Size may range from small to large areas that reflect the importance of the environmental value. These parks may also provide opportunities for outdoor recreation activities such as bushwalking, trail running, mountain biking, nature viewing and appreciation. Embellishment improvements are generally limited infrastructure associated with the above activities such as seating, lookouts and signage. Some of the park areas may also include cleared areas intended to be rehabilitated to improve habitat corridors.
- (4) utility spaces: are areas that are often owned or maintained by council, for specific utility services such as electrical transmission, telecommunications, water and sewerage pump stations or other infrastructure purposes. These spaces may offer some dual functionality for recreation activities such as walking, cycling or civic amenity.
- (5) unallocated open space: may be any reserve area of land and/or water reserve which has not been named or developed at present, but which has been deemed important enough to be set aside for future park development. The park area is usually substantially undeveloped with no built infrastructure and only minor improvements such as rural fencing.
- (6) cemeteries: are an area under the control of council that is dedicated for the burial of the dead, or containing graves, tombs, funeral urns and interment of ashes.

Editor's note—currently definitions and intent statements are not developed for individual typologies within other public open space hierarchy categories.

SC6.4.3.6.13 Open space embellishments

(1) General requirements

A key objective of the POS Embellishment and POSM Framework is to ensure that the level of embellishment is consistent and sustainable.

As such, infrastructure must not be provided where the necessary maintenance required exceeds the allocated maintenance level of service. This is to ensure that the public open space or items remain serviceable and safe for public use (e.g. dynamic fitness equipment that requires weekly safety inspections or electric barbecues that require daily cleaning to remain hygienic should not be installed in a park that has assigned fortnightly maintenance service intervention). Further, the cost to establish, maintain and ultimately renew the infrastructure must be sustainable and cost effective for council and the community in the long-term.

- (a) Open space embellishment levels should be consistent with the assigned public open space typology (refer Table SC6.4.3.6.1 public open space embellishment framework) and / or road hierarchy classification or the characteristics of the associated land use.
- (b) Where private open space is associated with development, the private open space shall be considered on a case-by-case basis with consideration of the design points set out below.
- (c) The quantity and amount of the embellishment level will be dependent on the available area of open space and the spatial requirements of the selected embellishment facility.
- (d) The following key characteristics should be considered in the design process when selecting the level of embellishment:
 - (i) comply with any adopted master plan, environmental, heritage and character requirements;
 - (ii) consider the context, functionality and purpose for use (e.g. particular open space usage patterns for the site such as regular use for community events, or shared usage by multiple tenants in a large residential complex);
 - (iii) consider the setting, durability and aesthetic requirements for the intended area (e.g. specific materiality requirements for areas with a risk of vandalism, or more ornate detailing for intimate private courtyard space);
 - (iv) cater for the expected usage rates, demographic/s and their associated needs (e.g. reduced intervals between accessible bench seats along a pathway at a location with large senior user group);
 - (v) be located at appropriate locations or intervals, clustered near activity nodes and/or to

- complement any distinguishing site features (e.g. seating situated to maximise a vista or allow surveillance of a play area by carers);
- (vi) be climatically appropriate and consider localised conditions of the site (e.g. dynamic activity elements in coastal areas are not located in areas exposed to high onshore winds and salt spray);
- (vii) ideally be located under natural or built shade to allow day long use through reduced exposure, glare and heat absorption, particularly on metal or dark coloured surfaces (e.g. metal playground slides to be shaded and/or swapped for plastic slides, or, communal gathering areas located under shelters in private unit complex);
- (viii) complement natural materials or features and/or incorporate these where possible (e.g. grass mounding for seating; feature rock retaining walls consistent with local geology);
- (ix) be vandal resistant;
- (x) be installed on an appropriate surface material, on well drained ground and with an appropriate level of flood immunity (e.g. playgrounds not installed in an area surrounded by a retention basin); and
- (xi) prioritise use of recycled, sustainable materials where practicable and available (e.g. decking to be constructed of recycled plastic and composite fibre supports).

(2) Public open space and streetscape embellishment standards

- (a) Within public open space, embellishment selection must be in accordance with council's Public Open Space Embellishment Standards Framework, as detailed in Table SC6.4.3.6.1.
- (b) For streetscapes, landscape treatments shall be provided per SC6.4.3.6.31 Streetscape design and landscape treatments.
- (c) For public open space and streetscapes, embellishment standards must:
 - (i) be analogous to the Public Open Space Hierarchy, road hierarchy, or centre classification;
 - (ii) be consistent with any overarching design and embellishment strategy (e.g. adopted furniture suite against Public Open Space/Road Hierarchy);

Editor's note—other than landscape treatments as noted above, currently, detailed standards and specifications are not developed for other infrastructure items (e.g. shelters and seating) within streetscapes. Applications will therefore be assessed on a case-by-case basis and with consideration of the principles and standards outlined in this sub-section, and other sections of the Townsville City Plan. Refer to SC6.4.3.3 Footpath treatment policy and SC6.4.3.4 Outdoor dining design guidelines for requirements specific to these elements of a streetscape.

- (iii) complement those facilities in nearby precincts or parks, ideally providing diversity in the facilities available to the community;
- (iv) be consistent with any an existing style that is already established unless approved otherwise;
- (v) only include high quality, fit for purpose, proprietary items for which replacement parts are readily available from an Australian distributor;
- (vi) for district and regional level parks, custom suites or items may be permitted at particular sites, where the profile and location of the park warrants it. The decision will be made on a case by case basis at the discretion of council with consideration of the individual site characteristics and public open space classification

Editor's note—this decision will be made on a case-by-case basis, at the discretion of council and with consideration of the individual site characteristics and public open space classification

- (vii) minimise the use of timber elements unless approved otherwise. Where timber is permitted for use, only hardwood timber or painted pine should be used and all furniture items should ideally be undercover, protected from direct exposure to the sunlight and other elements;
- (viii) utilise high quality finishes that will reduced ongoing maintenance requirements and/or frequency (e.g. 2PAC epoxy paint in lieu of powder coating where items are not easily dissembled or repainted); and

- (ix) for all foreshore locations and other locations subject to salt spray or prolonged wet conditions, embellishments must be constructed of marine grade materials, including 316L stainless steel fittings, to ensure improved asset longevity and lifecycle cost reduction.

Editor's note—the above are provide as guidelines to be considered in the course of public open space and streetscape development. Additional areas within this sub-section provide specifications for individual open space infrastructure types and for landscape treatments in streetscapes.

SC6.4.3.6.1 Public Open Space Embellishment Framework

		RECREATION PARKS					SPORTS PARKS			OTHER PUBLIC OPEN SPACE				
		POCKET	LOCAL	DISTRICT	REGIONAL	CORRIDOR	DISTRICT	REGIONAL	SPECIALISED	AMENITY	CIVIC SPACES	NATURAL /BUSHLAND	UTILITY	UNALLOCATED
CATEGORY	EMBELLISHMENT TYPE													
Activity elements	Outdoor fitness equipment			Expected (Max 6 Pieces)	Expected (Min 6 Pieces)	Desirable (Max 6 Pieces)				Embellishment standards not defined due to custom nature of specific sport activity and facility requirements - to be assessed on a case by case basis				
	Informal sports/courts (e.g. basketball half court; table tennis table)		Desirable (Max 1 informal sport facility)	Expected (Max 2 informal sports facilities)	Expected (Max 2 informal sports facilities)		Desirable (Max 2 informal sport facility)							
	Playground (all abilities)				Desirable (Max 1 play facility)									
	Playground (mixed ages)	Desirable (Max 1 Combination unit)	Expected (Max 1- 3 Pieces)	Expected (Min 3-5 Pieces)	Expected (Min 6-10 Pieces suitable for the catchment)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)								
	Skate facilities			Desirable (Max 1500 sqm, Suitable to meet the catchment zone, approved on a case by case basis)	Desirable (Min 3000 sqm, Suitable to meet the catchment zone, approved on a case by case basis)									
	Water-play				Desirable (Appropriate facility suitable to meet the needs of the catchment zone, approved on a case by case basis)									
Electrical	3 phase power (events usage)			Desirable (Max 1 unit)	Expected (Min 2 Units)		Expected (Max 1 Unit)	Expected (Min 2 Unit)			Expected (Min 1 Unit)			

	Activity node lighting		Expected (Max 1 Lighting node as required for the activity)	Expected (Min 2 Lighting nodes as required for the selected activity areas)	Expected (Multiple lighting nodes as required for selected activity areas)	Desirable (Min Lighting nodes as required for CEPTED along pathway links)	Expected (Min 2 Lighting nodes as required for the selected activity areas)	Expected (Multiple lighting nodes as required for selected activity areas)			Expected (Multiple lighting nodes as required for selected activity areas)			
	Pathway lighting (ex. designated bikeways/shared pathways)			Desirable (Multiple lighting nodes as per ASNZ 1158.3.14_2005 - Lighting for roads and public spaces)	Expected (Multiple lighting nodes as per ASNZ 1158.3.14_2005 - Lighting for roads and public spaces)	Desirable (Multiple lighting nodes as per ASNZ 1158.3.14_2005 - Lighting for roads and public spaces)	Desirable (Multiple lighting nodes as per ASNZ 1158.3.14_2005 - Lighting for roads and public spaces)	Expected (Multiple lighting nodes as per ASNZ 1158.3.14_2005 - Lighting for roads and public spaces)		Desirable (Fit for Purpose, as required - will be considered on a case by case basis)	Expected (Multiple lighting nodes as per ASNZ 1158.3.14_2005 - Lighting for roads and public spaces)			
	Sports field/court lighting						Expected (Multiple lighting nodes as per AS2560 Sporting Facilities Manual - Part 1 Sports Lighting)	Expected (Multiple lighting nodes as per AS2560 Sporting Facilities Manual - Part 1 Sports Lighting)						
Fencing	Fencing (inc. bollards; post and rail; panels)	Expected (To adequately deter unauthorised vehicles from entering the Park Space)	Expected (To adequately deter unauthorised vehicles from entering the Park Space)	Expected (To adequately deter unauthorised vehicles from entering the Park Space)	Expected (To adequately deter unauthorised vehicles from entering the Park Space)	Expected (To adequately deter unauthorised vehicles from entering the Park Space)	Expected (To adequately deter unauthorised vehicles from entering the Park Space)	Expected (To adequately deter unauthorised vehicles from entering the Park Space)		Expected (To adequately deter unauthorised vehicles from entering the Park Space)	Essential (To adequately deter unauthorised vehicles from entering the Park Space)	Expected Min RURAL FENCING TYPE (To adequately deter unauthorised vehicles from entering the Park Space)	Expected Min RURAL FENCING TYPE (To adequately deter unauthorised vehicles from entering the Park Space)	Expected Min RURAL FENCING TYPE (To adequately deter unauthorised vehicles from entering the Park Space)
	Maintenance access gate	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)		Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)	Expected (To provide adequate access for Maintenance requirements)
Furniture	Bench seats	Desirable (Max 1 Park bench seat)	Expected (Max 2 Park bench seat)	Expected (Min 4 Park bench seat)	Expected (Min 8 Park bench seat)	Expected (Min 2 park bench seats, or number as required spaced at approx. 400m intervals along pathway links)	Expected (Min 4 Park bench seat)	Expected (Min 8 Park bench seat)		Expected (Max 2 Park bench seat)	Expected (Min 8 Park bench seat)	Expected (Min 2 park bench seats, or number as required spaced at approx. 400m intervals along pathway links)		

	Barbeques (electric)			Expected (Max 2 Double Plate BBQ Units)	Expected (Min 4 Double Plate BBQ Units)									
	Bins	Desirable (Max 1 Bin unit)	Expected (Max 1 Bin unit)	Expected (Min 2 Bin units)	Expected (Min 4 Bins, or adequate number of Bins to meet anticipated demand - Including recycling bins)	Desirable (Min 2bins, or number as required spaced at approx. 800m intervals along pathway links)	Expected (Min 2 Bin units)	Expected (Min 4 Bins, or adequate number of Bins to meet anticipated demand - Including recycling bins)		Desirable (Max 1 Bin unit)	Expected (Min 2 Bins, or adequate number of Bins to meet anticipated demand - Including recycling bins)			
	End of trip facilities (e.g. bicycle racks)			Expected (Min 1 bike rack unit)	Expected (Max 2 bike rack units)		Expected (Min 1 bike rack unit)	Expected (Max 2 bike rack units)			Expected (Min 1 bike rack unit)			
	Picnic tables and seats	Desirable (Max 1 Picnic Table Set)	Desirable (Min 2 Picnic Table Sets)	Expected (Min 4 Picnic Table sets)	Expected (Min 6 Picnic Table sets, or number to meet anticipated demand)	Desirable (Min 2 picnic table sets, or number as required spaced at approx. 800m intervals along pathway links)	Expected (Min 2 Picnic Table sets)	Expected (Min 6 Picnic Table sets, or number to meet anticipated demand)		Desirable (Max 1 Picnic Table Set)	Expected (Min 6 Picnic Table sets, or number to meet anticipated demand)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)		
	Water bubbler/tap (inc. connection; drainage inlet; soakage well)	Desirable (Max 1 Drinking Fountain - must be disability compliant and include dog drinking outlet as well)	Expected (Max 1 Drinking Fountain - must be disability compliant and include dog drinking outlet as well)	Expected (Max 2 Drinking Fountain - must be disability compliant and include dog drinking outlet as well)	Expected (Min 2 Drinking Fountain - must be disability compliant and include dog drinking outlet as well)	Desirable (Max 1 Drinking Fountain along pathway link- must be disability compliant and include dog drinking outlet as well)	Expected (Max 2 Drinking Fountain - must be disability compliant and include dog drinking outlet as well)	Expected (Min 2 Drinking Fountain - must be disability compliant and include dog drinking outlet as well)			Expected (Min 2 Drinking Fountain - must be disability compliant and include dog drinking outlet as well)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)		
Irrigation	Irrigation	Desirable (May have natural areas that are not irrigated, provide adequate irrigation to cover key activity high use areas. To be considered on a case by case basis)	Desirable (May have natural areas that are not irrigated, provide adequate irrigation to cover key activity high use areas. To be considered on a case by case basis)	Expected (May have natural areas that are not irrigated, provide adequate irrigation to cover key activity high use areas. To be considered on a case by case basis)	Expected (May have natural areas that are not irrigated. Provision of required irrigation to ensure all key activity high use areas are covered. To be considered on a case by case basis)	Desirable (May have natural areas that are not irrigated, provide adequate irrigation to cover key activity high use areas. To be considered on a case by case basis)	Expected (Provision of appropriate irrigation to be considered on a case by case basis, to ensure adequate coverage of key sporting and high activity use areas. designated playing fields to be irrigated at 100 % of field coverage)	Expected (Provision of required irrigation to be considered on a case by case basis, to ensure adequate coverage of key sporting and high activity use areas. designated playing fields to be irrigated at 100 % of field coverage)		Desirable (Provide adequate irrigation to cover key activity high use areas. To be considered on a case by case basis)	Expected (May have natural areas that are not irrigated. Provision of required irrigation to ensure all key activity high use areas are covered. To be considered on a case by case basis)			

Landscaping and surfacing	Earthworks (e.g. grassed mounds)	Desirable (Min 1 Mound, suitable mounding for play space relief and considered on a case by case basis)	Desirable (Min 1 Mound, suitable mounding for play space relief and considered on a case by case basis)	Desirable (Min 1 Mound, suitable mounding for play space relief and considered on a case by case basis)	Desirable (Min 2 Mound, suitable mounding for play space relief and considered on a case by case basis)		Expected (Min 2 Mounds, suitable mounding for Spectator viewing and considered on a case by case basis)	Expected (Min 2 Mounds, suitable mounding for Spectator viewing and considered on a case by case basis)			Desirable (Min 2 Mound, suitable mounding for play space relief and considered on a case by case basis)			
	Garden beds (excluding natural vegetation areas)	Desirable (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)	Desirable (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)	Expected (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)	Expected (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)	Desirable (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)	Desirable (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)	Expected (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)			Desirable (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)	Expected (Min 5% gardens cover. Extent and levels will be dependent on the park typology and considered on a case by case basis)		
	Shade trees	Expected (The desirable natural shade coverage outcome for recreational parks shall be min 35% coverage. With the shade coverage focused around park activity nodes)	Expected (The desirable natural shade coverage outcome for recreational parks shall be min 35% coverage. With the shade coverage focused around park activity nodes)	Expected (The desirable natural shade coverage outcome for recreational parks shall be min 35% coverage. With the shade coverage focused around park activity nodes, where this cannot be achieved supplementary man-made shade cover must be considered)	Expected (The desirable natural shade coverage outcome for recreational parks shall be min 35% coverage. With the shade coverage focused around park activity nodes, where this cannot be achieved supplementary man-made shade cover must be considered)	Expected (The desirable natural shade coverage outcome for corridor parks shall be min 35% coverage along pathway linkage alignments)	Expected (The desirable natural shade coverage outcome for recreational parks shall be min 20% coverage. With the shade coverage focused around park activity nodes, where this cannot be achieved supplementary man-made shade cover must be considered)	Expected (The desirable natural shade coverage outcome for recreational parks shall be min 20% coverage. With the shade coverage focused around park activity nodes, where this cannot be achieved supplementary man-made shade cover must be considered)			Expected (The desirable natural shade coverage outcome for recreational parks shall be min 35% coverage. With the shade coverage focused around park activity nodes, where this cannot be achieved supplementary man-made shade cover must be considered)	Expected (The desirable natural shade coverage outcome for recreational parks shall be min 35% coverage. With the shade coverage focused around park activity nodes, where this cannot be achieved supplementary man-made shade cover must be considered)	Desirable (The desirable natural shade coverage will consist of the predominant existing natural vegetation cover)	Desirable (Shade Trees should not impact on operation of services or facility structure)

	Turf areas (inc. events/activity lawns)	Desirable (The desirable turf coverage outcome shall be min 60% coverage of park area, with adequate turf coverage to meet the intended usage and anticipated demand)	Expected (The desirable turf coverage outcome shall be min 60% coverage of park area, with adequate turf coverage to meet the intended usage and anticipated demand)	Expected (The desirable turf coverage outcome shall be min 60% coverage of park area, with adequate turf coverage to meet the intended usage and anticipated demand)	Expected (The desirable turf coverage outcome shall be min 60% coverage of park area, with adequate turf coverage to meet the intended usage and anticipated demand)	Expected (The desirable turf coverage outcome shall be min 60% coverage of park area, with adequate turf coverage to meet the intended usage and anticipated demand)	Expected (The desirable turf coverage outcome shall be min 70% coverage of park area, including a 100% cover of the playing fields. The turf coverage shall be adequate to meet the intended usage and anticipated demand)	Expected (The desirable turf coverage outcome shall be min 70% coverage of park area, including a 100% cover of the playing fields. The turf coverage shall be adequate to meet the intended usage and anticipated demand)		Desirable (The desirable turf coverage outcome shall be min 60% coverage of park area, with adequate turf coverage to meet the intended usage and anticipated demand)	Expected (The desirable turf coverage outcome shall be min 60% coverage of park area, with adequate turf coverage to meet the intended usage and anticipated demand)			
Signage	Park name sign	Expected (1 Park Name Sign near the predominant park entry access)	Expected (1 Park Name Sign near the predominant park entry access)	Expected (1 Park Name Sign near the predominant park entry access, for larger parks with multiple entry access entry points - additional park name signs shall be considered on a case by case basis)	Expected (1 Park Name Sign near the predominant park entry access, for larger parks with multiple entry access entry points - additional park name signs shall be considered on a case by case basis)	Expected (1 Park Name Sign near the predominant park entry access, for larger parks with multiple entry access entry points - additional park name signs shall be considered on a case by case basis)	Expected (1 Park Name Sign near the predominant park entry access, for larger parks with multiple entry access entry points - additional park name signs shall be considered on a case by case basis)	Expected (1 Park Name Sign near the predominant park entry access, for larger parks with multiple entry access entry points - additional park name signs shall be considered on a case by case basis)		Expected (1 Park Name Sign near the predominant park entry access)	Expected (1 Park Name Sign near the predominant park entry access, for larger parks with multiple entry access entry points - additional park name signs shall be considered on a case by case basis)	Expected (1 Park Name Sign near the predominant park entry access)		
	Information signage (inc. regulatory, directional and interpretive signage)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)	Expected (Fit for Purpose, as required - will be considered on a case by case basis)	Expected (Fit for Purpose, as required - will be considered on a case by case basis)	Expected (Fit for Purpose, as required - will be considered on a case by case basis)	Expected (Fit for Purpose, as required - will be considered on a case by case basis)	Expected (Fit for Purpose, as required - will be considered on a case by case basis)		Desirable (Fit for Purpose, as required - will be considered on a case by case basis)	Expected (Fit for Purpose, as required - will be considered on a case by case basis)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)
Sporting	Indoor sport and recreation facility						Desirable (Fit for Purpose, as required - will be considered on a case by case basis)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)						
	Outdoor spectator facilities						Expected (Min 20 Spectator Seat Capacity)	Expected (Min 100 Spectator Seat Capacity)						

	Motorised sports facilities						Desirable (Fit for Purpose, as required - will be considered on a case by case basis)	Desirable (Fit for Purpose, as required - will be considered on a case by case basis)						
	Sports courts/fields (formal)						Expected (Min number of formal courts or fields required to undertake the sport, will be considered on a case by case Basis)	Expected (Min number of formal courts or fields required to undertake the sport, will be considered on a case by case Basis)						
Structures and buildings	Picnic shelters/gazebos		Desirable (Max 1 Picnic Shelter or gazebo)	Desirable (Max 2 Picnic Shelter or gazebo)	Expected (Min 2 Picnic Shelter or gazebo, or adequate number to meet anticipated demand)	Desirable (Max 1 Picnic Shelter or gazebo, generally kept to a minimum)	Desirable (Max 2 Picnic Shelter or gazebo)	Expected (Min 2 Picnic Shelter or gazebo, or adequate number to meet anticipated demand)		Desirable (Max 1 Picnic Shelter or gazebo, generally kept to a minimum)	Expected (Min 2 Picnic Shelter or gazebo, or adequate number to meet anticipated demand)			
	Clubhouse/change rooms/canteens						Desirable (Adequate developable land of a min 200 sq m. for approved clubs to develop their relevant facility requirements for their respective club)	Desirable (Adequate developable land of a min 200 sq m. for approved clubs to develop their relevant facility requirements for their respective club)						

	Community buildings			Desirable (Within the available park space adequate total developable land to a max 200 sq m. (includes space for toilets etc.) to develop relevant facility requirements for the park space)	Desirable (Within the available park space adequate total developable land to a max 400 sq m. (includes space for toilets etc.) to develop relevant facility requirements for the park space)		Desirable (within the available park space an allowance for total developable land to a maximum 400 sq m. (includes clubhouse/change room 200 sq m) of a minimum 200 sq m. for approved clubs to develop their relevant facility requirements for their respective club)	Desirable (within the available park space an allowance for total developable land to a maximum 800 sq m. (includes clubhouse/change room 400 sq m) of a minimum 400 sq m. for approved clubs to develop their relevant facility requirements for their respective club)			Desirable (Within the available park space adequate total developable land to a max 400 sq m. (includes space for toilets etc.) to develop relevant facility requirements for the park space)			
	Commercial facilities				Desirable (must fit within available Park space and not at the expense of available public open space, to be considered on a case by case basis)			Desirable (must fit within available Park space and not at the expense of available public open space, to be considered on a case by case basis)			Desirable (must fit within available Park space and not at the expense of available public open space, to be considered on a case by case basis)			
	Shade sails		Desirable (Shall only be considered for use where there is not enough natural shade cover over prescribed park facilities, particularly playgrounds)	Desirable (Shall only be considered for use where there is not enough natural shade cover over prescribed park facilities, particularly playgrounds)	Expected (Shall only be considered for use where there is not enough natural shade cover over prescribed park facilities, particularly playgrounds)		Desirable (Shall only be considered for use where there is not enough natural shade cover over prescribed park facilities, particularly playgrounds)	Expected (Shall only be considered for use where there is not enough natural shade cover over prescribed park facilities, particularly playgrounds)			Desirable (Shall only be considered for use where there is not enough natural shade cover over prescribed park facilities, particularly playgrounds)			

	Toilet block			Desirable (Max 1 toilet facility, to be considered on a case by case basis)	Expected (Max 2 toilet facility, to be considered on a case by case basis)		Desirable (Max 1 toilet facility, to be considered on a case by case basis)	Expected (Max 2 toilet facility, to be considered on a case by case basis)			Expected (Max 2 toilet facility, to be considered on a case by case basis)			
Transport and access infrastructure	Car parking (off-street)			Expected (Minimum 20 car parking bays, , or adequate number of car parking spaces to meet anticipated demand shall be considered on case by case basis)	Expected (Minimum 30 car parking bays, or adequate number of car parking spaces to meet anticipated demand shall be considered on case by case basis)		Expected (Minimum of 125 car parking bays – total on and off street. Minimum of 50% to be off-street parking bays. Parking may be angled or at 90 degree, including allowance for additional space for bus parking, turnaround and pull out zone)	Expected (Minimum of 300 car parking bays – total on and off street. Minimum of 50% to be off-street parking bays. Parking may be angled or at 90 degree, including allowance for additional space for bus parking, turnaround and pull out zone)			Desirable (Minimum 20 car parking bays. May be angled or 90 degrees, or adequate number of car parking spaces to meet anticipated demand shall be considered on case by case basis)			
	Car parking (on-street)	Expected (Minimum 5 car parking bays, kerbside external only. May be parallel or indented at 90 degrees)	Expected (Minimum 15 car parking bays, kerbside external only. May be parallel or indented at 90 degrees)	Expected (Minimum 20 car parking bays kerbside external only. May be parallel or indented at 90 degrees)	Expected (Minimum 50 car parking bays. May be parallel or indented at 90 degrees - including allowance for additional space for bus stop parking and pull out zones.)	Expected (Minimum 10 car parking bays, kerbside external only. May be parallel or indented at 90 degrees)	Expected (Maximum 75 parking bays. May be parallel or indented at 90 degrees - including allowance for additional space for bus stop parking and pull out zones.)	Expected (Maximum 150 parking bays. May be parallel or indented at 90 degrees - including allowance for additional space for bus stop parking and pull out zones.)			Desirable (Minimum 15 car parking bays, kerbside external only. May be parallel or indented at 90 degrees)	Expected (Minimum 20 car parking bays. May be angled or indented at 90 degree, or adequate number of car parking spaces to meet anticipated demand shall be considered on case by case basis. Including space for bus pull out zone where required)	Desirable (Minimum 5 car parking bays, kerbside external only. May be parallel or indented at 90 degrees)	

	Drainage and service connections	Desirable (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Expected (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Expected (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Expected (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Expected (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)		Desirable (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Expected (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (As required shall be considered on a case by case basis where there is a demonstrated need for such a facility)	
	Internal concrete pathways (min. 1.5m wide)	Desirable (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)	Desirable (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)	Expected (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)	Expected (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)	Desirable (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)	Expected (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)	Expected (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)		Desirable (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)	Expected (Min length Pathways should provide connection from the park entrance access point to the key park activity elements)			
	Internal roads/vehicle access pathways			Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Expected (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Expected (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)			Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	
	Walking tracks (dirt)				Desirable (Will only be considered on a case by case basis, where a demonstrated need for the facility has been identified)							Desirable (Will only be considered on a case by case basis, where a demonstrated need for the facility has been identified)		

Other Infrastructure	Dog off leash park (fenced)			Desirable (Shall only be developed in accordance with Councils adopted Dog off-leash strategy. (Refer to SC6.4.3.6.24 Dog Off-leash facilities).	Desirable (Shall only be developed in accordance with Councils adopted Dog off-leash strategy. (Refer to SC6.4.3.6.24 Dog Off-leash facilities).	Desirable (Shall only be developed in accordance with Councils adopted Dog off-leash strategy. (Refer to SC6.4.3.6.24 Dog Off-leash facilities).								
	Fishing platform/pontoons/boat ramps and Jetty's			Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)								
	Lookout platforms			Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)	Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)							Desirable (Shall be considered on a case by case basis where there is a demonstrated need for such a facility)		
	Public art			Desirable (Will only be considered on a case by case basis, in accordance with the Public Art - policy and strategies)	Expected (Will only be considered on a case by case basis, in accordance with the Public Art - policy and strategies)			Desirable (Will only be considered on a case by case basis, in accordance with the Public Art - policy and strategies)			Desirable (Will only be considered on a case by case basis, in accordance with the Public Art - policy and strategies)	Expected (Will only be considered on a case by case basis, in accordance with the Public Art - policy and strategies)		
	Swimming pools						Desirable (Will only be considered on a case by case basis, where a demonstrated need for the service has been identified)	Desirable (Will only be considered on a case by case basis, where a demonstrated need for the service has been identified)						

	Water features				Desirable (To be kept to a minimum and considered on a case by case basis)						Desirable (To be kept to a minimum and considered on a case by case basis)			

Expected infrastructure – critical to the intended function of the open space classification.

Desirable infrastructure – not considered essential but may compliment the function of the park space and is dependent on location, need and adjacency to other infrastructure/services.

Indoor and aquatic sports facilities are not included in the Public Open Space Hierarchy, largely due to the enclosed, custom nature and high level of built form.

Editor's note—Table SC6.4.3.6.1 indicates items that are considered “essential” to the function of each open space typology and therefore should be provided with the development of that type of public open space. Importantly, the embellishment standard set for each typology is considered an “average” standard and therefore variation between locations with the same hierarchy classification may occur. However, whilst some locations may include less or additional infrastructure items, the overall level of embellishment cannot exceed the “average” to the point where the location would be delivering a standard equivalent to another typology. (e.g. a local park embellished to the standard of an district park). Items considered “desirable” and/or “conditional” are to be considered on a case-by-case basis, and provided as required, dependent on location, need, affordability and adjacency to other infrastructure/services. Where there is a co-location of open space typologies with the one open space area, embellishment infrastructure can be “shared” between the two functional areas.

SC6.4.3.6.14 Activity elements

(1) General requirements

- (a) Activity elements may include, but are not limited to the following:
 - (i) outdoor fitness equipment;
 - (ii) play spaces and play equipment;
 - (iii) softfall surfacing;
 - (iv) skate and parkour elements and facilities; and
 - (v) informal sporting facilities.
- (b) All activity elements must be of a high standard, being designed, constructed and installed in accordance with:
 - (i) the provisions within the planning scheme, planning scheme policies and this sub section of the Development manual planning scheme policy;
 - (ii) manufacturer specifications;
 - (iii) all applicable Australian Standards and legislation;
 - (iv) all applicable council local laws; and
 - (v) council's approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for activity elements.

(2) Outdoor fitness equipment

- (a) Outdoor fitness equipment may include a combination of:
 - (i) static fitness equipment such as step ups, hurdles and sit up benches; and
 - (ii) dynamic fitness equipment such as bench presses, leg presses and pull downs.
- (b) Within public open space, outdoor fitness equipment shall only be provided at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1.

Editor's note—currently no further guidelines and standards are developed for the provision of outdoor fitness equipment across the public open space network. Inclusion of fitness equipment within public open space will be considered on a case-by-case basis and with consideration of the Public Open Space Hierarchy and Embellishment Frameworks. Where council develops and adopts a strategic plan for the provision of outdoor fitness equipment, all development proposals will be assessed against the provisions within that plan.

(c) Fitness equipment selection

- (i) All fitness equipment shall be designed, manufactured, installed, certified and maintained in accordance with all applicable Australian Standards, including:
 - (A) AS4685 – *Playground equipment – General safety requirements and test methods*;
 - (B) AS2555 – *Supervised adventure playground – Guide to establishment and administration*;
 - (C) AS4422 – *Playground Surfacing – Specification, requirements and test methods*; and
 - (D) AS4486.1 – *Playgrounds and playground equipment – Development, installation, inspection*,

- (ii) Equipment selection should take into account the existing demographics and cater for multiple age groups, subject to the population profile within the local area. Projected changes to the local demographic and/or aging of the original groups that will utilise the equipment should also be considered.
- (iii) A diversity of exercise activities should be developed within the site.
- (iv) Future inspection and maintenance requirements of the fitness equipment must be considered and the more onerous, dynamic equipment must be limited to district or regional level public open spaces only.
- (v) Longevity of materials must be considered, particularly within the context of the local conditions (e.g. only include equipment of a high quality design and materials, particularly for moving parts and where intense usage is anticipated).

(d) Fitness equipment siting

- (i) Fitness equipment should be located away from play spaces to reduce the temptation for children to play on the equipment.
- (ii) Ideally, the equipment should be located along or in close proximity to a primary access path, with the fitness units to be offset from this for the comfort of users.
- (iii) Individual units may be clustered together or spaced separately in a circuit along a pathway, dependent on the equipment, design and usage intent.
- (iv) All fitness equipment is to have concrete slabs, all required shock pads, and wet-pour rubber surfacing in accordance with AS/NZS 4422 *Playground Surfacing – Specifications, requirements and test method*.

(3) Play spaces and play equipment

(a) Play spaces are to be provided in order to:

- (i) provide a wide range of quality play opportunities that meet the needs of the local children and young people alike;
- (ii) aid children's development by providing spaces and elements for physical coordination activities such as balancing, climbing, jumping, crawling and running;
- (iii) assist in the development of social skills such as sharing and cooperation;
- (iv) promote children's use of their imagination and development of problem solving skills; and
- (v) provide a place for meeting and socialising amongst children, parents and other care givers.

(b) Play spaces shall include a combination of:

- (i) active, equipment based play structures (e.g. swings);
- (ii) active, non-structured play areas (e.g. kick-around areas or grass mounding);
- (iii) imaginative and creative play areas (e.g. trees or natural "cubby" areas);
- (iv) a parent or care-givers area (e.g. picnic settings or bench seats); and
- (v) special features that cater for children and young people of all abilities (at select locations only).

(c) Within public open space, play spaces and play equipment shall only be provided at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1.

(d) Playground equipment selection

- (i) All playground equipment shall designed, manufactured, installed, certified and maintained in accordance with all applicable Australian Standards, including:
 - (A) AS 4685 – *Playground equipment – General safety requirements and test methods, including AS 4685 parts 1- 6 and part 11*;
 - (B) AS 4486 – *Playgrounds and playground equipment – Development, installation, inspection, maintenance and operation*; and

- (C) AS/NZS 4422 – *Playground surfacing – Specifications, requirements, and test method.*
 - (ii) Equipment selection should take into account the existing demographics and cater for multiple age groups, subject to the population profile within the local area and the likely park users. Projected changes to the local demographic and/or aging of the original groups that will utilise the equipment should also be considered.
 - (iii) Diversity of play experiences between sites within the local area should be provided where possible.
 - (iv) Future inspection and maintenance requirements of the play facilities must be considered and elaborate, more complicated equipment limited to locations with a higher maintenance level of service.
 - (v) Longevity of materials must be considered, particularly within the context of the local conditions (e.g. plastic coated chains are to be avoided due to accelerated deterioration in North Queensland sun).
 - (vi) Equipment selection and orientation should take into account the potential for vandalism. As such, equipment with significant amounts of hard, non-transparent panels should be avoided, except where this can be mediated through orientation and casual surveillance opportunities.
 - (e) Playground equipment siting
 - (i) Active and passive play areas should be integrated but physically separated to promote more cohesive use of the space and facilitate quiet areas for creative and imaginative play activities.
 - (ii) Play spaces, particularly toddler areas, should be sited within close proximity to the main activity node to maximise accessibility and casual surveillance from parents, carers and adjacent users.
 - (iii) Play spaces should ideally be located within close proximity to the main access path. Care should be taken, however, to not create a point of conflict by locating a busy activity area on a main thoroughfare of the open space, as per below.
 - (iv) Play spaces should be located away from potential safety hazards such as car parks or trafficable areas, watercourses or steep slopes.
 - (v) Play spaces should be located away from adjacent properties to limit potential nuisance from ongoing noise. A minimum buffer of 15 m from adjacent property boundaries should be applied.
 - (vi) Sun safety and protection opportunities including natural and built shade options should be addressed in accordance with SC6.4.3.6.19 Shelters and shading devices. Shading opportunities should consider sun orientation and ensure that shading of the equipment is maximised during the highest UV risk period of the day and over the highest need elements (e.g. metal slides).
 - (vii) Natural elements such as turf mounding, trees, shrubs and rocks should be safely integrated into the play space where possible.
 - (viii) Fencing of the play space is to be considered on a case-by-case basis and established as required, in accordance with SC6.4.3.6.16 Fencing.
 - (ix) At larger playgrounds of a district or regional level, consideration should be given to the location of public toilets within short walking distance of the play space.
- Editor's note**—public toilets should be installed at select locations only. Refer SC6.4.3.6.21(2) Public toilets for further details.
- (x) Large, purpose built, “all-abilities” play areas are to be considered on a case by case basis and established as required.
 - (f) All playground equipment must be installed in accordance with the manufacturer's specifications. Certification of the equipment must also be provided.

(4) Softfall surfacing

- (a) Softfall surfacing shall be provided in order to:
 - (i) create a safe, impact absorbing surface underneath activity elements; and

- (ii) provide textual stimulation through different surfacing types (e.g. sand and rubber softfall).
- (b) Softfall surfacing may include a combination of:
 - (i) wet-pour rubber softfall or approved rubber alternatives, including shock pads beneath;
 - (ii) astro turf, including shock pads beneath; and
 - (iii) certified softfall sand.
- (c) Softfall surfacing shall be installed under all play spaces/equipment where a fall zone has been identified. Within public open space, the provision of equipment, and therefore softfall surfacing shall be at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1.
- (d) Organic softfall surfacing such as woodchips is not considered an acceptable softfall outcome.
- (e) Rubber softfall surfacing
 - (i) Rubber softfall must be installed in accordance with the equipment fall zone requirements, manufacturer's specifications and council approved standard drawings. Certification of the softfall installation must also be provided.
 - (ii) Shockpads shall be installed under all rubber softfall layers, as required by the applicable Australian Standards.
 - (iii) Rubber softfall colour selection shall minimise large areas of bright colours prone to fading in the sun. Rubber softfall mixes shall contain a minimum 70% EPDM rubber due to higher UV rating of this product.
 - (iv) Small, narrow and intricate designs (e.g. less than 300 mm in width) within the rubber softfall should be avoided due to ongoing deterioration of such designs.
 - (v) Rubber softfall shall be prioritised to areas requiring higher levels of accessibility or underneath high wear items.

Editor's note—currently, no standard drawings are formally adopted for rubber softfall surfacing.

- (5) Informal sporting facilities
Informal sporting facilities may include but are not limited to:
 - (a) basketball half courts;
 - (b) outdoor table tennis tables; and
 - (c) handball courts or rebound walls.

Editor's note—currently no specific requirement relating to informal sporting facilities are developed.

- (6) Skate facilities and parkour practice areas

Editor's note—currently no specific requirement relating to skate facilities and parkour practice areas are developed.

SC6.4.3.6.15 Electrical and lighting

- (1) Lighting
 - (a) All lighting must be of a high standard, being designed, constructed and installed in accordance with:
 - (i) the provisions within the planning scheme, planning scheme policies and this sub-section of the Development manual planning scheme policy;
 - (ii) manufacturer specifications;
 - (iii) all applicable Australian Standards and legislation;
 - (iv) all applicable council local laws; and
 - (v) council's approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for lighting.

- (b) Lighting requirements within public open space will be advised by council in accordance with the hierarchy classification of the public open space or pathways involved.
- (c) Power supply options (mains or solar) will be considered on a case-by-case basis, subject to the nature of the proposal, the existing supply opportunities and the site context.
- (d) All lighting works must be undertaken in accordance with SC6.4.3.20 Public lighting and utility services.
- (e) Pathway lighting
Bicycle paths or pedestrian paths within public open space that require lighting shall be lit to the applicable pathway lighting category, as per AS 1158 Lighting for roads and public spaces and SC6.4.3.20.2(c) Lighting for bicycle, pedestrian and shared paths.
- (f) Activity node lighting
Pathways within public open space that require lighting shall be lit to the applicable pathway lighting category, as per AS 1158 Lighting for roads and public spaces and SC6.4.3.20.2 Public lighting (urban and rural).

Editor's note—currently, no further standards are set for lighting of activity nodes. Council will negotiate these requirements on a case-by case basis until formal standards are set.

- (g) Sports field and court lighting in accordance with SC6.4.3.20.2(e) Lighting for sports grounds and sports complexes .

Editor's note—currently, no further standards are set for lighting of sports fields and courts. Council will negotiate these requirements on a case-by case basis until formal standards are set. Guidance on the recommended levels of illumination for each sport can be found in external references such as the Western Australian Department of Sport and Recreation Sports Dimensions Guide for Playing Areas.

(2) Electrical

All electrical works must be undertaken in accordance with SC6.4.3.20 Public lighting and utility services, all applicable Australian Standards and legislative requirements.

SC6.4.3.6.16 Fencing

(1) General requirements

- (a) Fencing may include, but is not limited to the following:
 - (i) fencing panels;
 - (ii) bollards;
 - (iii) post and rail systems;
 - (iv) rural type fencing; and
 - (v) other crash barriers.
- (b) Fencing is to be provided in order to:
 - (i) provide a legible definition of the open space boundaries and limits;
 - (ii) provide enclosure of a space appropriate to its function (e.g. fenced playgrounds);
 - (iii) prevent encroachment into open space by adjacent private properties;
 - (iv) prevent unwanted vehicle access by the provision of barriers along the road frontage, including into drainage reserves, parks and other public open spaces; and
 - (v) restrict access to unsafe locations or private property.
- (c) All fencing must be of a high standard, and designed, constructed and installed in accordance with:
 - (i) the provisions within the planning scheme, planning scheme policies and this sub-section of the Development manual planning scheme policy;
 - (ii) manufacturer specifications;

- (iii) all applicable Australian Standards and legislation;
- (iv) all applicable council local laws; and
- (v) council's approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for fencing.

- (d) Fencing materials, design and location
 - (i) Fencing materials, design and location should not unreasonably hinder pedestrian circulation through open space, with sufficient pedestrian access points to be provided.
 - (ii) Where vehicle access prevention is required along pathways or bikeways, bicycle deflections rails are the preferred method and removable bollards should be avoided. Refer to SD-066 - Miscellaneous traffic details – bicycle path terminal treatments deflection rail and intersection at side street.
 - (iii) For public open space or streetscapes, proposals should seek to be consistent with any existing fencing style that is already established unless approved otherwise.
 - (iv) Fencing materials, design and location should be considered in the context, functionality and purpose for fencing use (e.g. post and rail installed where prevention of vehicle access, including motorbikes, is required).
 - (v) Public playground area and pool fencing must be in accordance with AS1926.1 *Swimming pool safety – safety barriers for swimming pools*.
 - (vi) Where appropriate, use of plants to screen or soften the fencing is recommended, except where this will conflict with CPTED requirements.
- (e) Within public open space and streetscapes, fencing alignment and type shall include consideration of ongoing maintenance requirements and ensure:
 - (i) access for maintenance and other authorised vehicles shall be provided through a lockable gate or removable bollard, including provision of a kerb ramp or crossover at a safe location acceptable for council;
 - (ii) where provided in turf, a minimum 2 m wide clearance to other infrastructure (including trees) shall be maintained on either side of the fencing alignment to allow efficient mowing activities;
 - (iii) where bollards are provided in concrete, construction joints shall be provided to minimise damage to concrete slabs due to collisions, and allow ease of removal and replacement to damaged bollards; and
 - (iv) fencing is to be located within the surveyed boundary of the open space allotment; or
 - (v) where open space borders private property, fencing is to be located within the surveyed boundary of the private allotment.

SC6.4.3.6.17 Furniture

- (1) General requirements
 - (a) Furniture may include, but is not limited to the following:
 - (i) barbeques (gas, electric and wood-fired);
 - (ii) benches, seats and picnic settings;
 - (iii) refuse bins;
 - (iv) bicycle parking facilities;
 - (v) water bubblers and taps; and
 - (vi) tree grates and guards.
 - (b) All furniture must be of a high standard, being designed, constructed and installed in accordance with:
 - (i) the provisions within the planning scheme, planning scheme policies and this sub section of the Development manual planning scheme policy;
 - (ii) manufacturer specifications;

- (iii) all applicable Australian Standards and legislation;
- (iv) all applicable council local laws; and
- (v) council's approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for furniture.

(2) Electrical and gas barbeques

- (a) Within public open space, gas and electric barbeques are to only be provided at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1 Public Open Space Embellishment Framework.

Editor's note—Deviation from council's Public Open Space Embellishment Framework provisions for barbeques may only be considered where sufficient benefit to the wider community is demonstrated and supplementary conditions are satisfied. Proposed deviations must be discussed with council at preliminary approval stage and will only be approved where all community expectations have been considered; an extended maintenance period has been successfully negotiated and all other conditions are satisfied.

Editor's note—currently, no standard drawings are formally adopted for electrical and gas barbeques.

- (b) Where permitted, gas and electric barbeques must be provided in accordance with council approved standard drawings.
- (c) The following are the preferred specifications for outdoor gas and electric barbeques:
 - (i) cooktops to be all stainless steel construction, including high efficiency mono pressed stainless steel hotplate with laminated heat dispersion coating, high contact heating element and all stainless clamp plate;
 - (ii) timing, ignition and temperature control functions should feature on all hotplates to ensure optimum cooking temperature is constantly maintained and to maximise performance and efficiency. Visual and audible indication of operation and mode change should also be a key feature;
 - (iii) safety push button/stop systems are a mandatory requirement. These should ideally be located above the bench top, out of reach of children and fitted with a safety delay feature to ensure units cannot be inadvertently turned on;
 - (iv) hotplates are to be enclosed in a raised hob elevated and isolated above the bench top and with a minimum 100 mm protection zone. Benches should be designed without protrusions or ledges that may assist climbing;
 - (v) hotplates should be non-porous with no welds, creases or deep corners to trap food and bacteria. An automatic pre-heat mode should also feature and deliver minimum sterilising temperature;
 - (vi) enclosure frames are to consist of high strength, powder-coated aluminium extrusions. Cladding to be 18 mm compressed fibre cement backing panels with 0.55 mm stainless steel decorative fascia panels or approved similar. All doors to be stainless steel powder-coated or brushed stainless steel and fitted with a door lock matching council's preferred security key system;
 - (vii) barbeques are to be ideally located underneath a shelter, mounted on a concrete slab with minimum 450 mm clearance around the bench top on all sides;
 - (viii) units should be fitted with a fat collection tray and unobstructed access through fat tray access doors. Components should be designed to be easily unbolted and lifted out for maintenance and easy replacement;
 - (ix) electric components to be all fully sealed and power requirements are to be 240 volt A.C., 3.6 Kw, per plate or approved similar. All electrical works to be undertaken by a qualified electrician and in accordance with all relevant Australian Standards and legislation;
 - (x) gas barbeques may only be permitted by council where electricity power supply is restricted or

where connection to an electrical supply is cost prohibitive. Gas supply to be installed by a qualified plumber and in accordance with all relevant Australian Standards and legislation;

- (xi) a water tap should be readily accessible to the barbeque cooking and eating area for ease of use during barbeque operation and cleaning; and
- (xii) a minimum 2 year warranty must be provided with all barbeques installed within public open space.

(3) Wood fire barbeques and open fire areas

- (a) Wood fire barbeques or open fire areas are NOT to be provided unless approved by council.
- (b) "Natural settings" will be the only exception where wood fire barbeques or open fire areas may be permitted. Adequate environmental, fire and other safety measures must be included as part of any provision proposal to council.
- (c) Where permitted, wood fire barbeques must be provided in accordance with council approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for wood fire barbeques and open fire areas.

(4) Benches, seats and picnic settings

- (a) Where provided, benches, seats and picnic settings must be provided in accordance with council approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for benches, seats and picnic settings.

- (b) All benches, seats and picnic settings are to be flange mounted on an appropriately sized concrete slab unless approved otherwise.
- (c) Where within public open space or streetscapes, furniture should be consistent with any existing or adopted furniture suite for the public open space or streetscape, unless approved otherwise.

Editor's note—currently, no city-wide adopted furniture suite is developed. Some individual locations do, however, have formally adopted furniture suites and colour schemes. Others have informally established suites and colour schemes that have developed over the years. In both instances, new furniture selection should be consistent with these suites unless reasonable justification for deviating from the palette can be established.

(5) Refuse bins

- (a) Where provided, refuse bins must be provided in accordance with council approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for refuse bins.

- (b) For district and regional level parks, civic spaces and amenity parks, acceptable bin provision includes 240 L rubbish and recycling wheelie bins, with single or dual bin enclosures, mounted on a concrete slab. Cigarette Butt bins may be attached where deemed appropriate.
- (c) For local recreation parks and all other public open space, acceptable bin provision is restricted to 240 L rubbish and recycling wheelie bins, mounted on a concrete slab with a metal security bin stand unless approved otherwise.

Editor's note—refuse bin style and design for streetscapes will be considered on a case by case basis until further standards and design guidelines are developed.

- (d) For all public open space and streetscapes where bin enclosures are provided, these must be fitted with a door lock matching council's preferred security key system.
- (e) For all public open space, variations to size and quantity standards may be approved, as required to

support the associated waste collection requirements, particularly at locations of high usage or where sporting and community clubs are co-located.

- (f) All bins and enclosures are to be appropriately screened and located to ensure ease of accessibility for use and waste collection, without compromising the amenity of the public open space or adjacent land uses.
 - (g) All bins and enclosures are of a design, construction and location that minimises any likely impacts, or the risk of hazards due to vandalism or fire.
- (6) Bicycle parking facilities
Bicycle parking facilities are to be provided in accordance with AS 2890.3 *Parking facilities – Bicycle parking facilities*.

Editor's note—refer also SC6.4.4.7 Bicycle, pedestrian and shared path design

- (7) Water fountains and taps
- (a) For all public open space, ready access to a potable water source is to be provided as part of any open space development, including at activity nodes and at reasonable intervals along corridor parks or recreational pathways.
 - (b) All water fountains and taps should be located near existing services and water supply points wherever possible, focused around activity nodes or areas of high use.
 - (c) Dog bowls should be included as part of water fountain provision where necessary. Separate stand-alone units may be required where anticipated usage will be very high (e.g. in dog off-leash area).
 - (d) All water fountains should be installed on a concrete slab, above a drainage well and with adequate surface drainage inlets to prevent water pooling on adjacent surfaces.
 - (e) For all public open space, water fountains and taps should be designed, constructed and installed as per council specifications detailed in SC6.4.6.27 Irrigation. Each water fountain/tap is to have a water meter connected.

SC6.4.3.6.18 Signage

Signage may include, but is not limited to the following:

- (1) park name signs;
- (2) information signs;
- (3) directional signs;
- (4) regulatory signs; and
- (5) entry statements (private developments and public statements).

Editor's note—currently no specific requirements relating to signage are developed. For signage within public open space, consideration should be given to the Public Open Space Embellishment Framework and council's corporate branding requirements, as detailed in council's Graphic Standards Manual (GSM). Signs within streetscapes should be as per requirements detailed in sub-section SC6.4.6.24 Signposting.

SC6.4.3.6.19 Shelters and shading devices

- (1) General requirements
- (a) Shelters and shading devices may include, but is not limited to the following:
 - (i) awnings;
 - (ii) picnic shelters or gazebos; and
 - (iii) shade sails.
 - (b) All shelters and shading devices must be of a high standard, being designed, constructed and installed in accordance with:
 - (i) the provisions within the planning scheme, planning scheme policies and this sub-section of the Development manual planning scheme policy;
 - (ii) manufacturer specifications;

- (iii) all applicable Australian Standards and legislation;
- (iv) all applicable council local laws; and
- (v) council's approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for shelters and shading devices.

(2) Awnings

Editor's note—due to the place-specific, custom nature of awnings, no standard specifications are currently developed. Proposals will be considered on a case-by-case basis in accordance with all applicable building and engineering requirements, Australian Standards and council's overarching design and management principles. Applicants should refer to SC6.4.3.4 Outdoor dining design for shading requirements applicable in this situation.

(3) Shade sails

(a) All shade sails are to be:

- (i) designed, engineered, built and certified against Building Code of Australia, C2 wind rating requirements as per AS1170 *Structural design actions* and all other applicable standards;
- (ii) located with consideration of shading requirements, sun orientation and natural shading opportunities on site. As such, provision must be considered on a case-by-case basis, and account for the existing versus desired extent and daily duration of shade cover (natural and built); and
- (iii) provided in public car parking areas as a substitute to natural shading when there is insufficient available planting space or shade sails are deemed a more practicable and/or cost effective shading system.

Editor's note— Refer SC6.4.3.6.32 Car park plantings and shading for additional information

(b) All shade sails within public open space are to:

- (i) be provided at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in SC6.4.3.6.13 Open space embellishments, unless approved otherwise;

Editor's note—currently no further guidelines and standards are developed for the provision of shade sails across the public open space network. Inclusion of shade sails will be considered on a case-by-case basis and with consideration of the Public Open Space Hierarchy and Embellishment Frameworks. Where council develops and adopts a strategic plan for the provision of shade sails, all development proposals will be assessed against the provisions within that plan.

- (ii) be primarily provided over high use activity elements, where practicable and not cost prohibitive. Demand and need for shade sails is likely to be higher in greenfield sites or where there are minimal mature shade trees. In these instances, shade sail provision should be supplemented by ancillary shade tree plantings to ensure both natural and built shade are developed in the long term;
- (iii) be located to minimise proximity to trees that may increase maintenance due to leaf drop or pose a risk to the sail structure from falling limbs during storm events;
- (iv) have a 2.5 m minimum clearance between the highest accessible standing point of the shaded equipment/item and the lowest point of the shade sail. Access opportunities from adjacent structures should also be avoided, in order to reduce potential vandalism and damage to the structure or sail;
- (v) within playground areas, all poles are to be located outside equipment fall zones and, where practicable, outside the softfall surfacing area provided this will not conflict with mowing activities or circulation;

- (vi) be of premium quality shade fabric made of 100% monofilament yarns with a 10 year fabric warranty unless approved otherwise;
- (vii) include hot-dipped galvanised and powder coated poles of a colour consistent with any existing colour palette or adjacent park infrastructure;
- (viii) pole profile and diameter should inhibit climbing of the poles or anti climbing devices should be installed;
- (ix) include marine grade fittings for all locations; and
- (x) include quick release mechanisms on all sails for ease of removal during storm events and all necessary edge reinforcement and hardware to ensure longevity of the shade sail.

(4) Shelters and gazebos

- (a) All shelter structures are to be designed, engineered, built and certified against Building Code of Australia, C2 wind rating requirements as per Australian Standard AS 1170.2 *Structural design actions – wind actions* and all other applicable standards.
- (b) All shelter installations within public open space are to:
 - (i) be provided at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1 Public Open Space Embellishment Framework;
 - (ii) have a minimum 300 mm clearance from the edge of the roofline to the edge of the slab to reduce erosion around the structure;
 - (iii) be design and installed without roof gutting systems unless specified otherwise;
 - (iv) have a frame constructed of oiled hardwood timber, painted pine or marine grade metal materials;
 - (v) include marine grade fittings for all locations; and
 - (vi) where painted, be of a colour consistent with any existing colour palette or accompanying furniture suite.

SC6.4.3.6.20 Outdoor sporting facilities

Outdoor sporting facilities may include, but is not limited to the following:

- (1) sports fields and courts;
- (2) outdoor spectator facilities;
- (3) specialised sports facilities;
- (4) motorised sports facilities;
- (5) aquatic facilities; and
- (6) equestrian facilities.

Editor's note—currently no further guidelines and standards are developed for the provision of outdoor sporting facilities across the public open space network. Inclusion of outdoor sporting facilities will be considered on a case-by-case basis and with consideration of the Public Open Space Hierarchy and Embellishment Frameworks and all other applicable sections of the Townsville City Plan and sub-sections of the Development manual planning scheme policy. Where council develops and adopts a strategic plan for the provision of outdoor sporting facilities, all development proposals will be assessed against the provisions within that plan.

SC6.4.3.6.21 Structure and buildings

(1) General requirements

Structures and buildings may include, but are not limited to the following:

- (a) public toilets;
- (b) community facilities;
- (c) commercial facilities;
- (d) clubhouses, change rooms or canteens; and
- (e) sheds and shipping containers.

Editor's note—currently no further guidelines and standards are developed for the provision of structures and buildings across the public open space network. Inclusion of structures and buildings will be considered on a case-by-case basis and with consideration of the Public Open Space Hierarchy and Embellishment Frameworks and all other applicable sections of the Townsville City Plan and sub-sections of the Development manual planning scheme policy. Where council develops and adopts a strategic plan for the provision of outdoor sporting facilities, all development proposals will be assessed against the provisions within that plan.

(2) Public toilets

Editor's note—currently no further guidelines and standards are developed for the provision of public toilets across the public open space network. Inclusion of public toilets will be considered on a case-by-case basis and with consideration of the Public Open Space Hierarchy and Embellishment Frameworks and all other applicable sections of the Townsville City Plan and sub-sections of the Development manual planning scheme policy. Where council develops and adopts a strategic plan or design guidelines for the provision of public toilets, all development proposals will be assessed against the provisions within these documents.

SC6.4.3.6.22 Surface treatments

Surface treatments within all open space are to be:

- (1) of an appropriate extent and material that will be durable under the local climatic and site conditions;
- (2) of an appropriate extent and material that will mitigate the effects of large areas of impervious surfaces on run-off infiltration;
- (3) fit for the intended purpose of the surface, its location, and the anticipated type and level of usage;
- (4) shaded wherever possible and not prone to excessive heat retention, reflectivity and glare;
- (5) not conducive to water pooling or slippery when wet;
- (6) designed and located with consideration of the need for softening of hard surfaces with plantings; and
- (7) be practical to maintain.

Editor's note—currently no further requirements relating to surface treatments are developed. Compliance with relevant sections of the Development manual planning scheme policy is required.

SC6.4.3.6.23 Transport and access infrastructure

(1) General requirements

- (a) Transport and access infrastructure within open space is considered to include:
 - (i) car parking, both on and off street, associated with the open space or facilities;
 - (ii) internal roadways;
 - (iii) pedestrian paths, bicycle paths, shared paths;
 - (iv) public transport facilities;
 - (v) end of trip facilities;
 - (vi) walking tracks; and
 - (vii) boat ramps.
- (b) All transport and access infrastructure within public open space must be designed, constructed and installed in accordance with:
 - (i) the provisions within the Townsville City Plan, planning scheme policies, sub-section SC6.4.4.7 Bicycle, pedestrian and shared path design and this sub-section of the Development manual planning scheme policy;
 - (ii) all applicable Australian Standards and legislation;
 - (iii) all applicable council local laws; and
 - (iv) council's approved standard drawings.

Editor's note—refer to SC6.4.3.6.31 Streetscape design and landscape treatments for requirements relating to areas of a designated road reserve.

- (c) Bicycle, pedestrian and shared paths within public open space are to connect to activity areas within the open space and to the on-street verge pathway network. Where a verge pathway network does not exist, consideration may be given towards the future design and establishment of such a network in order to establish the best outcome for connectivity.

Editor's note—refer to SC6.4.4.7 Bicycle, pedestrian and shared path design for design guidelines for consideration of the type of paths to be provided through/within public open space. Consideration should be given to connectivity of bicycle paths and pedestrian path networks.

- (d) All landscaping and irrigation associated with transport and access infrastructure is to be in accordance with the provisions of this sub-section, and sub-sections SC6.4.6.26 Landscaping and SC6.4.6.27 Irrigation.

Editor's note—with the exception of the below, currently no further guidelines and standards are developed for the provision of transport and access infrastructure specifically within open space. Proposals will be assessed against the policies and standards contained in the Townsville City Plan other sub-sections of and the Development manual planning scheme policy. Where proposals are within public open space, consideration of the Public Open Space Hierarchy and Embellishment Frameworks will be given. Refer clause SC6.4.3.6.9 Public open space.

(2) Walking tracks

Walking track provision is to:

- (a) be provided in accordance with infrastructure design requirements, track markers and signage, in accordance with AS 2156 *Walking tracks*;
- (b) be at select locations only, where construction of the walking track/s will not create any foreseeable adverse impacts including unsustainable maintenance requirements, public safety and liability concerns, habitat destruction, land slip or slope destabilisation; and
- (c) be provided in accordance with any council adopted walking track strategy.

Editor's note—currently no further guidelines and standards are developed for the provision of walking tracks within public open space. Inclusion of walking tracks will be considered on a case-by-case basis and with consideration of the Public Open Space Hierarchy and Embellishment Frameworks. Where council develops and adopts a strategic plan for the provision of walking tracks, all development proposals will be assessed against the provisions within that plan.

(3) Boat ramps

Boat ramp provision is to:

- (a) be permitted in limited circumstances only, at specific locations, and where all relevant considerations are reasonably satisfied; and
- (b) include engagement with, and approval from all relevant authorities and asset owner/s.

Editor's note—due to the place-specific, custom nature of boat ramps, no standard specifications are currently developed. Proposals will be considered on a case-by-case basis in accordance with all necessary requirements defined by all applicable engineering, water safety and transport standards, legislation, and council's overarching design and management principles.

SC6.4.3.6.24 Dog off-leash facilities

Dog off-leash facilities are designated spaces under council's local law where within an open space dogs can recreate with their owners. Dog off-leash areas provide a safe and fun environment for owners and their dogs to enjoy parks and open spaces.

Dog off-leash facilities are to be built to a high standard that meets community expectations. Facilities where proposed Dog off-leash areas are proposed to be established shall have due regard for;

(1) Site selection

- (a) within public open space, dog off-leash facilities shall only be provided at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1;
- (b) an appropriate sized large dog off-leash fenced facility should range between 2000 to 4000 m²;
- (c) an appropriate sized small dog off-leash fenced facility should range between 1000s m² to 1500 m². It should be noted that small dog off-leash fenced facilities will not be installed as stand-alone facilities by themselves;
- (d) dog off-leash facilities should have adequate drainage and should have reasonable flood immunity;
- (e) dog off-leash facilities should have cross fall drainage of at least 2%. This will ensure that water will not pond within the dog off-leash area;

Editor's note—the surface cover all dog off-leash facilities will primarily consist of turf. In most instances open turfed areas above 2000 m² should be considered as a minimum for dog off-leash areas. Turf cover shall consist of 25 mm depth of dense, well rooted, vigorous grass growth with a 25 mm depth of topsoil. The type of turf to be used will be selected from the SC.6.2.6.26 – Attachment A list of preferred plant species.

- (f) the use of native groundcovers, shrubs and trees should be incorporated into the overall design of the dog off-leash areas. The usage of existing established trees can provide visual amenity to the park and will provide protection from the wind and sun;
- (g) landscaping and plants add to the amenity of the park, but it is important to ensure that plants are non-toxic and non-irritating to dogs. Some plants may have seeds, stems, leaves, fruits or flowers that are irritating and/or toxic to dogs;
- (h) all dog off-leash enclosures are required to be irrigated with pop up sprinklers; and
- (i) all dog off-leash facilities must be of a high standard, being designed, constructed and installed in accordance with:
 - (i) the provisions within the Townsville City Plan and this sub-section;
 - (ii) manufacturer specifications;
 - (iii) all applicable Australian Standards and legislation;
 - (iv) all applicable council local laws; and
 - (v) council's approved standard drawings.

Editor's note—Currently there are no approved standard drawings for dog off-leash areas.

(2) Siting of dog off-leash facilities

- (a) dog off-leash facilities should be located away from play spaces to minimise the temptation for children to have unsupervised interaction with dogs;
- (b) dog off-leash facilities should also be located away from other non-congruent recreation activities (e.g. barbeque areas and fitness equipment). As a general guide it is recommended that a spatial buffer of approximately 40 m is considered appropriate. However, other factors such as site gradient and vegetation coverage can be utilised to lessen the spatial buffer;
- (c) dog off-leash areas should also be sited to minimise noise nuisance into residential areas. As a general guide it is recommended that a minimum spatial buffer of approximately 40 m is considered appropriate. However, other factors such as site gradient and vegetation coverage can be utilised to lessen the spatial buffer;
- (d) a variety of open and shaded spaces should be created within a dog off-leash facility. There should be enough space to include active running areas as well as quieter environments where dogs can sniff, play and interact with their owners. As a guide it is recommended that a dog off-leash area have shade coverage (both natural and artificial) of approximately 35 per cent;
- (e) effective dog off-leash areas disperse the dog and human traffic throughout the park, and spread the wear and tear on the underlying surface evenly across the facility;
- (f) in all instances dog off-leash facilities should be supported by sufficient car parking spaces to

accommodate the amount of vehicle traffic likely to be generated by the particular use of the site. Refer to Table SC6.4.3.6.1 Public Open Space Embellishment Framework;

- (g) to enhance site accessibility and convenience, locate dog off-leash areas in close proximity to the available car parking. Additionally, equitable access ramps and a connecting path from the car parking to the dog off-leash facility should also be installed; and
- (h) The placement of Dog off-leash facilities and planting treatments, shall take into account the maintenance requirements for maintaining such a facility (e.g. allow minimum 2m between perimeter fence and facility item such as a seat).

(3) Design - entry way

- (a) double-gated entry to prevent dog escapees is required at all access points. Consideration should be given to the installation of multiple access points, to minimise congestion.
- (b) access points are high wear areas and appropriate sized concrete pads will be installed. These concrete pads should cover the entire entrance areas and extend out past the arc of the gate openings.
- (c) gates should be fitted with self-closing child-proof locks to prevent dog escapees and unsupervised children from entering the facility.
- (d) a separate entry for a maintenance gate (which should be 3-3.5m wide) will be installed within the perimeter fence line. This should be located away from all the other user access points.
- (e) other physical structures to support amenity such as shelters, benches or drinking fountains should be located at a suitable distance away from the access points to discourage dogs and people from congregating.

(4) Design - fencing

- (a) secure perimeter fencing will be installed that discourages canines from escaping under, over or through the fence;
- (b) the fence alignment shall avoid acute angles that can result in entrapment issues for dogs and humans;
- (c) fencing around all Dog Off-Leash Facilities will be approximately 1.2m – 1.5m in height; and
- (d) fencing materials must provide good visibility so that park users can see activity inside and around the park. Standard powder coated fencing panels traditionally used in pool fencing should be utilised as fence panels.

Editor's note—Be aware that smaller dog breeds may be able to run through the gaps in the panels of traditional pool fencing. When designing small dog off-leash areas give consideration to the installation of alternatives or undertaking modifications to the fencing panels to ensure that the enclosure is fit for purpose.

(5) Design Amenities - Seating

- (a) as a minimum, four bench seats should be installed within the large dog off-leash areas, and two bench seats within small-dog off-leash areas;
- (b) seating should be placed in areas to maximise the benefit of any nearby shade;
- (c) seating should be aligned and in close proximity to the fencing of the off-leash area. This ensures that the majority of the dog activity will occur in front of where the owner is sitting. A mowing strip of 2 m should be allowed between the fence and the seating. Finally seating should be located away from entry/exit gates to avoid congestion;
- (d) the type of seating used within the dog off-leash will be consistent with any existing or adopted furniture suite within the nearby park open space;
- (e) however, consideration should also be given to the space between the slat sizes utilised on the bench seat. Minimum gaps should be utilised to avoid dog paws entrapment points; and
- (f) picnic tables should not be located inside dog off-leash areas as this encourages food to be brought into the facility.

(6) Design Amenities - Drink facilities

- (a) as a minimum, two drink fountains should be installed within dog off-leash areas. These fountains should be accessible by dogs and people, but should be located away from the main entry gates to discourage

congregation in high traffic areas;

- (b) dog water bowls should be fixed to the drink fountain and be hinged so that owners can tip water out of the bowl. Adequate drainage around the water bowl should be installed to ensure that water logging and muddy areas do not occur. All drinking fountains are required to be installed on a concrete slab, above a drainage well with adequate surface drainage inlets;
- (c) drinking fountains should be aligned and in close proximity to the fencing of the off-leash area. This ensures that drinking dogs are not impacting activity areas. A mowing strip of 2 m should be allowed between the fence and the drink fountains; and
- (d) water fountains and taps should be designed, constructed and installed as per council's specification, Drink Fountain and Water Tap (SC.6.4.6.27 Irrigation).

(7) Design Amenities - Waste facilities

- (a) as a minimum, two dog faeces bag dispensers should be installed within dog off-leash areas;
- (b) dog faeces bag dispensers should have a locking device to prevent bags being pulled continuously and scattered in the park. Dog faeces bag dispensers should be located in close proximity to the access points (but should also not impede access). However, dog faeces bag dispensers should also be located in positions that ensure an ease of refill, which does not require council staff to enter the enclosure;
- (c) two covered rubbish bins should be installed outside of the dog off-leash area, in close proximity to the main gate access point (but should also not impede access). Bin position should also ensure easy collection: and
- (d) generally, the acceptable bin provision will be a 240L rubbish wheelie bin, mounted on a concrete slab with a metal security bin stand. Variations to size and quantity standards may be approved, as required to support the associated waste collection requirements, particularly at locations of high usage.

(8) Design Amenities – Lighting

- (a) most dog off-leash facilities do not require lighting. In many instances one security light may be installed to link the entrance of the dog off-leash area to the adjacent car parking will be sufficient;
- (b) full lighting of dog off-leash facilities will be accepted where there is a demonstrated need and where the lighting will not have a negative impact on adjacent residential areas; and
- (c) all lighting shall be carried out to the applicable lighting category, as per the Australian Standard AS11580 – Lighting for roads and public spaces.

(9) Design - Agility Equipment / Separate Small Dog Area / Specialised Play

- (a) not all dog off-leash facilities require agility equipment or a dedicated small dog off-leash area. These facilities will only be supported where there is a demonstrated demand on a case-by-case basis;
- (b) if agility equipment is considered appropriate it should be located away from access points and high running areas. Consultation with agility dog groups should be undertaken prior to assist in the design of appropriate agility facilities within dog off-leash areas;
- (c) small dogs are considered to be dogs that weigh less than 8 kilograms or are less than 35cm in height when measured from the floor to the top of the dog's front shoulders;
- (d) small dog off-leash areas will not contain agility equipment; and
- (e) specialised canine recreation equipment will be considered on a case-by-case basis. Consideration of ongoing maintenance costs, asset replacement costs and any potential impacts on canine health will be the major considerations when determining the request to install specialised canine recreation equipment.

(10) Design - Signage

- (a) council information signs on dog off-leash area rules are required to be installed in close proximity to all access points;
- (b) council has standard information signs on dog off-leash and small dog off-leash areas for usage and behavioural requirements that shall be used at dog off-leash areas;
- (c) park name signage should be installed in close proximity to the dog off-leash area so that people utilising the facility are able to readily recognise the name of the facility. Generally, dog off-leash areas will not have a separate specialised park name; and

- (d) when dog off-leash facilities are not readily visible from the road frontage, directional signage from car parking facilities or areas of high visibility should be utilised.

Editor's note—For further information on the construction of dog off-leash facilities, refer to the detailed landscape specification standards as provided in SC6.4.6 Construction Standards, in particular SC6.4.6.26 Landscaping.

SC6.4.3.6.25 Drainage and service connections

Editor's note—currently no specific requirements relating to drainage within open space are developed. All drainage requirements should be determined in accordance with sub-section SC6.4.4.4 Stormwater drainage design along with the relevant construction specifications.

SC6.4.3.6.26 Landscape entry statements

- (1) Landscape entry statements may be of the following types:
 - (a) sign/graphics on a wall or acoustic fence;
 - (b) a structure;
 - (c) public art; and
 - (d) landscaping plantings only.
- (2) Landscape entry statements to public open space, residential or commercial estate developments are to meet the following requirements:
 - (a) landscape entry statements are to be suitably located to clearly identify the public open space, an individual neighbourhood or development, or area of distinctive character;
 - (b) landscape entry statements are to be of a high quality urban form that is easily maintained;
 - (c) landscape entry statements are to be of a scale appropriate for the hierarchy classification and surrounding landscape character;

Editor's note—refer to Table SC6.4.3.6.1 Public Open Space Embellishment Framework relating to entry statement and signage in public open space.

- (d) where involving a wall entry statement, the wall is to be located within the private property on the property boundary, unless relating to public open space or designated park;
 - (e) any private properties containing wall/s or other landscape entry statements require a covenant protecting the wall or feature and outlining maintenance responsibilities, and a Property Note in council's rates system to ensure owners are aware of the existence of the wall or feature;
 - (f) other entry statements of an alternative nature or located within the road reserve will be considered on merit and must meet requirements for visibility and frangibility;
 - (g) landscape entry statements for residential or commercial estates are to be provided and maintained by the developer for the life of the development (i.e. off maintenance of the final stage); and
 - (h) landscape entry statements will not include water features.
 - (3) Landscape entry statements are to be provided in accordance with the following hierarchy and requirements:
 - (a) "Suburb" level landscape entry statements:
 - (i) generally be located on public land and owned by council after completion of any applicable maintenance period; and
 - (ii) conform with corporate graphics standards;

Editor's note—refer to council's Graphics Standards Manual.

- (b) Estate" level landscape entry statement:
 - (i) walls or acoustic fence located within private property; and

- (ii) structures, public art or landscaping may be located on public land subject to operational works (landscaping) approval;

Editor's note—public art needs to be coordinated through the Manager Gallery Services in accordance with council's Public art policy.

- (c) Neighbourhood/village" level landscape entry statement:
 - (i) generally a sign wall located on private property; and
- (d) "Street" level landscape entry statement:
 - (i) generally not acceptable.

SC6.4.3.6.27 Lookout platforms and fishing pontoons

- (1) Lookout platforms and fishing pontoons will only be permitted in limited circumstances, at specific locations, and where all relevant considerations are reasonably satisfied.
- (2) Where the proposed lookout platforms or fishing pontoons are associated with public open space, council owned land or will involve potential future council assets, infrastructure may only be permitted at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1. Approval from the relevant council asset owner/s will also be required.
- (3) In order to properly assess any such proposals, council may request the provision of a maintenance plan as part of the development application, as per Section SC6.4.2 Development application guidelines.

Editor's note—due to the place-specific, custom nature of lookout platforms and fishing pontoons, no further standard specifications are currently developed. Proposals will be considered on a case-by-case basis in accordance with necessary requirements defined by all applicable engineering and water safety standards, legislation, and council's overarching design and management principles. Engagement and approval from other stakeholders/authorities may additionally be required as part of any development proposal.

SC6.4.3.6.28 Public art

- (1) Public art is considered to be "a concept or work created by an artist/s in any medium, permanent, temporary or ephemeral, which enables stimulation of one or more of the senses and is situated in a place of public access".
- (2) Public art will only be permitted in limited circumstances, at specific locations, and where all relevant considerations are reasonably satisfied.
- (3) All public art proposals must demonstrate alignment with any council adopted public art policy.

Editor's note—refer to council's Public art policy.

- (4) Where the proposed public art is associated with public open space, streetscapes, council owned land, or will involve potential future council assets, the public art may only be permitted at approved locations and where the following overall requirements are also satisfied:
 - (a) the provision of the public art adds interest to the public open space or streetscape, reinforces the unique identity of Townsville, and contributes significantly to the sense of place;
 - (b) the public art is used as a medium to interpret the social and cultural values of the community, reflecting Townsville's diverse heritage and cultural identity, as well as the social context of the site;
 - (c) the public art responds to the environmental context of the site, and is integrated into the overall landscape or streetscape, being well-chosen and appropriately sited;
 - (d) the provision of public art within public open space is in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1, unless approved otherwise;

Editor's note—where a public art strategy has been formally approved by council for a precinct or development, this may take

- (e) the provision of public art within streetscapes and at centres is aligned with the expected levels of embellishment and characteristics of the road or centre hierarchy classification;
- (f) all public art should not create a public safety risk to the community or council maintenance staff;
- (g) engagement and approval from the relevant council asset owner/s and other stakeholders is required;
- (h) for all public art proposals, council may request the provision of a concept statement and details including, but not limited to the following:
 - (i) concept images or models;
 - (ii) detailed description of the artwork/theme/concept;
 - (iii) materiality;
 - (iv) scale;
 - (v) structural detailing and footing designs;
 - (vi) public safety considerations;
 - (vii) ongoing maintenance requirements;
 - (viii) project budget/costs; and
 - (ix) previous works and references; and
- (i) for all public art proposals, council may request the provision of a maintenance plan as part of the development application, as per Section SC6.4.2 Development application guidelines.

Editor's note—due to the place-specific, custom nature of public art, no further specifications are currently developed. Proposals will be considered on a case-by-case basis in accordance with all necessary requirements defined by all applicable engineering and electrical standards, legislation, and council's overarching design and management principles.

SC6.4.3.6.29 Screening

Screening may include, but is not limited to the following:

- (1) acoustic screening;
- (2) vegetated visual screening; and
- (3) architectural visual screening.

Editor's note—currently no specific requirements relating to acoustic and visual screening has been developed. Reference should be made to Department of Transport and Main Roads' *Road landscape manual*. Per SC6.4.2 Development application guidelines, council may ask for a description of any ongoing maintenance requirements to ensure that the stated noise attenuation performance of the measure does not deteriorate with time.

SC6.4.3.6.30 Soft landscaping

- (1) General requirements

Soft landscaping may include, but is not limited to the following:

- (a) plant species selection;
- (b) earthworks and mounding;
- (c) garden beds;
- (d) shade trees; and
- (e) turf areas.

- (2) Plant species selection

- (a) Preferred plant species

- (i) Plant species used are to be those recommended in the Preferred plant species list in SC6.4.3.6 Attachment A – Plant species schedules.

Editor's note—the Preferred plant species list found in SC6.4.3.6 Attachment A has been prepared as an inclusive list that takes into account council's requirements and those of relevant service providers, and is acceptable for use in most circumstances. The species list does not account for frangibility requirements relating to street tree plantings in streets or roads. This, along with all other relevant considerations associated with the site context must be considered in the development of the landscape plan and species selection. Refer to sub-section SC6.4.6.26 Landscaping for further detail relating to planting construction specifications.

- (ii) Plant species are to be selected by a suitably qualified and experienced horticulturist, landscape architect or designer to suit each of the site's hydro zones, so that direct rainfall supplies all or most of their water needs.
- (b) Undesirable plant species
Plant species are not to include undesirable species listed in the undesirable plant species list.

Editor's note—currently, no undesirable plant species list has been developed.

- (c) Declared weed species
Plant species used are not to include prohibited species listed in any declared weeds list.

Editor's note—refer to the Department of Agriculture, Fishers and Forestry for a declared weed species list. Currently, no design guidelines relating to other soft landscaping elements are developed.

SC6.4.3.6.31 Streetscape plantings

- (1) General requirements
 - (a) Landscape treatments may include, but is not limited to the following:
 - (i) street trees;
 - (ii) planted and/or mulched garden areas;
 - (iii) turf areas;
 - (iv) irrigation;
 - (v) artificial turf;
 - (vi) stencil-crete;
 - (vii) concrete (plain or coloured); and
 - (viii) other associated hard landscape treatments.

Editor's note—refer to the streetscape requirements under SC 6.4.3.3 Footpath treatment policy.

- (b) All streetscapes must be of a high standard, being designed, constructed and planted in accordance with:
 - (i) the provisions within the Townsville City Plan, planning scheme policies and this sub-section of the Development manual planning scheme policy;
 - (ii) all applicable Australian Standards and legislation;
 - (iii) all applicable council local laws; and
 - (iv) all council approved standard drawings.

Editor's note—currently, no standard drawings are formally adopted for landscape treatments.

Editor's note—where streetscape outcomes are within roads managed by the Department of Transport and Main Roads, applicants should refer to the Department of Transport and Main Roads' *Landscape Design Manual* (2013). Requirements of the Department of Transport and Main Roads' Landscape Design Manual will take precedence in these instances. Engagement and

- (c) All streetscape outcomes should be underpinned by and contribute to the following strategic objectives:
- (i) safety – streetscapes do not introduce risk to road users, must contribute positively to a safe road environment and be safe to maintain and construct;
 - (ii) functionality – proposed outcomes are fit-for purpose and comply with landscape and road planning and design principles, appropriate to the road hierarchy and function;
 - (iii) environment - ecological and sustainable design principles are incorporated to mitigate the environmental impacts of the road and maintain or improve the intrinsic value of the streetscape;
 - (iv) aesthetics – streetscapes provide high visual amenity and are contextually sensitive to the character of the surrounding built and natural environment;
 - (v) community – proposed outcomes are responsive to the needs and concerns of stakeholders and maintain or improve the quality of life and liveability of communities; and
 - (vi) economic – streetscapes represent value for money and provide cost effective design outcomes that seek to minimise costs over whole of life cycle.

Editor's note—whilst the above strategic objectives are relating specifically to streetscape outcomes, these objectives are aligned with the overarching sustainability principles outlined at the beginning of this sub-section and within Part 9.3.3 Landscape code. Alignment with both the above strategic objectives and the overarching sustainability principles are to be expressed in the proposed streetscape design outcomes and detailed in the "Landscape statement of intent" per SC6.4.2 Development application guidelines.

(2) Safety

- (a) Streetscapes shall create a safe road environment by ensuring:
- (i) a safe system approach to road safety is used, as detailed by Austroads;
 - (ii) safe and efficient pedestrian, cyclist and vehicle movement is facilitated through the integration of all infrastructure and landscape elements within the road corridor;
 - (iii) hazards, safety or security risks are not introduced;
 - (iv) safe sight distances are applied and maintained as per Austroads Part 3 and Part 4. At intersections, use of Minimum Gap Sight Distance, and at roundabouts, criteria 1 and 2, are mandatory;
 - (v) clear zones and frangibility requirements are met in accordance with clear zone criteria as per Austroads Part 6;
 - (vi) setbacks and other clearances are met;
 - (vii) signage and other road furniture is not obscured;
 - (viii) safety and traffic management is enhanced through the functional use of landscape plantings;
 - (ix) surface treatments are slip-resistant and non-reflective;
 - (x) effects of glare and shadowing are minimised;
 - (xi) CPTED principles are incorporated into all streetscape designs; and
 - (xii) a safe work environment for maintenance personnel is achieved and requirements for traffic control are minimised.
- (b) Associated with the above, the following definitions apply.
- (i) "Frangible" vegetation - is plants (including trees) with a stem or trunk diameter equal to or less than 100 mm in diameter at maturity, measured from 300 mm above the finished ground level. Shrubs and ground covers are considered frangible except for shrubs that exceed 3.5 m in height.
 - (ii) "Non-frangible" vegetation - is plants (including trees) with a stem or trunk diameter greater than 100 mm in diameter at maturity, measured from 300 mm above the finished ground level. This includes shrubs greater than 3.5 m in height and most trees.
 - (iii) Setback - is the distance measured from the outer edge of the specified component to the centre

of the vegetation trunk.

- (iv) Clearance - is the distance measured from the edge of the specified component to the perimeter of the second component or vegetation.
- (v) Canopy clearance – is the vertical distance measured between the finished ground level and the underside of the tree canopy.

Editor's note—the above definitions are based on Austroads' *Guide to Road Design*, Part 6B: Roadside Environment (2009) and Department of Transport and Main Roads' *Landscape Design Manual* (2013) – Appendix 4.

(3) Functional

Streetscape outcomes must be fit-for-purpose and shall:

- (a) be supported by all other ancillary infrastructure requirements that are essential to the overall functionality and longevity of the streetscape, including but not limited to irrigation, subsoil drainage and root barrier; and

Editor's note—refer to sub-sections SC6.4.6.20 Subsoil, foundation and pavement drains, SC6.4.6.21 Subsurface drainage, SC6.4.4.1 Geometric road design, SC6.4.6.26 Landscaping and SC6.4.6.27 irrigation.

- (b) demonstrate sound application of design theories including legibility, form, function, connectivity, way-finding, accessibility and mobility, robustness, place-making and imaging.

Editor's note—where proposed streetscape outcomes deviate from the outlined requirements of this sub-section, the merit for this deviation must be detailed. Notes documenting how all safety, functional and operational requirements are satisfied by the design exception must be included for further consideration. Any variances will be assessed on a case by case basis relative to the situation. Approval will not be granted where the design exception opposes safety requirements or increases safety risk. All plans are required to be signed off by a RPEQ registered engineer.

(4) Environment

Ecological and sustainable design principles shall be incorporated by:

- (a) applying an appropriate planting approach such as: structured, naturalistic, and water sensitive planting; grass seeding; or turfing;
- (b) integrating street trees in the streetscape that will create shade for all users (including pedestrians and cyclists) and ameliorate the urban heat island effect;
- (c) providing a buffer between the road and surrounding land uses;
- (d) integrating the streetscape within natural areas through planting approaches with a natural appearance and naturalistic, informal distribution;
- (e) improving the health and resilience of the urban forest by establishing green corridors along streets or roads and providing habitat corridors within the urban matrix;
- (f) incorporating functional landscape components such as the use of vegetation to screen headlight glare;
- (g) using varied vegetation treatments to highlight progression or transition to a different speed environment;
- (h) designating feature areas or nodal points by creating a marker or landmark element at interchanges, intersections, major structures and entry gateways;
- (i) using vegetation and other components to maintain or frame views;
- (j) establishing economical ways to treat large areas;
- (k) assisting with integrated stormwater management by establishing vegetation that will reduce erosion and large expanses of impervious surface; and
- (l) incorporating vegetation and other treatments in ways that minimise maintenance in high risk areas, require reduced maintenance interventions and become self-sustaining over time.

(5) Aesthetics

Streetscapes shall be contextually sensitive and provide high visual amenity by:

- (a) establishing streetscape characters themes that address, retain, reflect and where possible enhance the local context of the project area (architectural themes, colours, visual heritage values etc.);
- (b) creating balance in term of scale and mass between new streetscape components and the existing natural features and urban building forms;
- (c) integrating natural elements that recognise and promote the value of the urban forest in all streetscapes;
- (d) establishing innovative approaches to providing functional, high amenity outcomes whilst maintaining and enhancing the safety and operational function of the road;
- (e) responding to changes in road conditions and promoting legibility under varied road conditions or different design speeds;
- (f) presenting a visually cohesive and unified suite of treatments that are simple, refined and without unnecessary, non-functional embellishment;
- (g) creating treatments that are visually recessive except where intended to be highly visible feature elements;
- (h) maintaining an uncluttered road environment with limited visual intrusion that will minimise risk of road user distraction and conflict with official traffic signs and signals; and
- (i) devising colouration and surface treatment solutions that shall mitigate the visual impact of dirt, staining and adhesion of other pollutants.

(6) Community

Proposed streetscaping shall be responsive to stakeholder needs and concerns by:

- (a) identifying and addressing community values and associated interests, perceptions and preferences as part of transport and road landscape planning and design process;
- (b) promoting participation and contribution by implementing effective community engagement processes;
- (c) enhancing public amenity for all users through improvements to user comfort, way finding and walkability;
- (d) promoting the health and well-being of the community by improving the useability of pedestrian networks through provision of shade or boulevard treatments;
- (e) improving accessibility, connectivity and security within the streetscape;
- (f) establishing streetscapes that are functional and facilitate equitable access to a variety of multi-modal transport systems;
- (g) seeking design outcomes that create a sense of community and reinforce local character, identity, and cultural heritage; and
- (h) improving experiences both for users traveling within the transport infrastructure corridor itself and the community beyond.

(7) Economic

Streetscapes will represent value for money and minimise costs over whole of life cycle by:

- (a) implementing appropriate designs that provide balanced outcomes across all strategic objectives;
- (b) creating iconic gateway entry statements, in strategic locations only, which emphasise the urban or regional identity and enhance tourism, business potential and associated economic benefits;
- (c) promoting increased usage and visitation to business and services through the provision of user friendly vehicular, pedestrian, cyclist and public transport networks which incorporate a high level of amenity and deliver a high quality experience;
- (d) ensuring the ongoing cost and level of service for operational requirements associated with the streetscape is appropriate for the hierarchy and profile of the road;
- (e) minimising the overall cost of operational activities through responsive design that reduces high cost, high risk, high frequency and high intensity activities;
- (f) creating designs that will evolve into a self-sustaining streetscape and have a progressive reduction in the number of maintenance interventions over the operational life of the corridor; and

- (g) promoting innovation in the development of alternative treatment types that achieve a balance between the desired aesthetic and reduce maintenance outcomes.
- (8) Streetscape treatment provision
- (a) Requirements relating to all safety objectives such as clear zones, sight distances and frangibility will take precedence and determine the placement and control of landscaping elements within the streetscape.
 - (b) All hard and soft landscape treatment construction must be in accordance with the specifications set out in sub-sections SC6.4.6.26 Landscaping and SC6.4.6.27 Irrigation.
 - (c) Kerb types will be as per SC6.4.4.8 Standard drawings (Typical Road Cross Sections SD-001, SD-002, SD-003, SD-004, SD-005, SD-006, SD-010), and SC6.4.4.1 Geometric road design.
 - (d) Where a zero object height is necessary, only hard landscape areas must be established, subject to meeting all other requirements within this sub-section and other sub-sections of the Development manual planning scheme policy.
 - (e) A minimum 1.2 m width of hard surface treatment (which may be inclusive of road pavement, kerb, concrete, mountable aprons etc.) must be provided between soft landscaping and the edge of the traffic lane, unless approved otherwise.
 - (f) In areas >70 km/hr, an increase to 3 m in width of hard surface treatment may be required between soft landscaping and the edge of the traffic lane, subject to assessment of the associated risks of the road environment.

Editor's note—the above widths are based on standard clearances between traffic lanes and work sites, as detailed in *Manual Uniform Traffic Control Devices (MUTCD)*, Queensland. These clearance requirements may be subject to reduction or increase dependent on the road speed environment being assessed and subject to council approval. The intention for all standard clearances is to ensure a safe work environment, reduced inconvenience to road users and reduced the reliance on traffic control and the associated costs.

- (g) Installation of decorative walls, entry signs, rocks or other fixed objects in the medians or central island of roundabouts will only be approved in select locations and where:
 - (i) the median or roundabout is larger than 10 m in width/diameter;
 - (ii) vehicles are not likely to run off the road;
 - (iii) placement of the fixed objects will not distract drivers;
 - (iv) maintenance or repairs to the fixed objects will not put maintenance personnel at risk;
 - (v) all requirements (including frangibility, clear zones, sight triangles etc.) per Austroads are satisfied; and
 - (vi) green walls or vine trellises shall only be provided in limited circumstances and where all design, construction, safety and maintenance conditions are satisfied.

Editor's note—due to the custom nature of green walls, vertical gardens and façade greening, no design and construction standards are provided. Each site will be assessed on a case-by-case basis. Generally the majority of these type of planting features are to be within private property and should be under the maintenance regime of the owner. All engineering and hydraulic certification must be provided with any structure proposed.

- (h) For medians, specific requirements apply being:
Streetscape treatments shall be provided in accordance with Table SC6.4.3.6.7 Treatment application based on median width and other requirements of this policy.

Table SC6.4.3.6.7 Treatment application based on median width

Treatment	Appropriateness of treatment application by median widths (including width of kerbs)				
	< 2.5 m	2.5 m – 3.5 m	3.5 m – 6.0 m	6.0 m – 10.0m	> 10.0m
Hard landscape (Stencil-crete, artificial turf, concrete or similar) ¹ where the width of hard landscape treatments may exceed 6.0m, a combination of hard and soft landscape treatments should be applied to avoid large expanses of hardscape, subject to satisfaction of all safety requirements	Yes	Yes	Yes	Yes ¹	Yes ¹
Turf (Zoysia spp. or approved alternative) ² may be approved in select locations only, minimum clearances may still apply subject to road speed environment. Unless approved otherwise, turf areas must be a minimum width of 2.0m to support an irrigation system in a safe and efficient manner and facilitate efficient operational maintenance. Turf areas greater than 6.0m in width should be combined with other hard and soft landscaping treatments	No	No ²	Yes	Yes	Yes
Garden areas (Shrubs/ground covers below 3.5m in height) <i>Frangible</i> ³ may be approved in select locations only, minimum garden area width and clearances may still apply subject to road speed environment, subject to satisfaction of all safety requirements	No	Yes ³	Yes	Yes	Yes
Small trees/ large shrubs (Mature canopy between 5.0 – 10.0m in height or large shrubs greater than 3.5m in height) <i>Frangible or Non – frangible</i>	No	No	Yes	Yes	Yes
Medium trees (Mature canopy between 10.0 – 15.0m in height) <i>Non – frangible</i>	No	No	No	Yes	Yes
Large tree (Mature canopy greater than 15.0m in height) <i>Non – frangible</i>	No	No	No	No	Yes
Palms <i>Frangible or Non – frangible</i> ⁴ select locations only, minimum setbacks may also apply subject to species selection and mitigation of risks associated with frond drop	No	No	No	Yes ⁴	Yes ⁴

Editor's note—appropriateness of treatment application is based on clearance and setback requirements in a 60 km/h speed environment. Council approval of design outcomes that deviate from the above may be granted at select locations, dependent on the road speed

environment being assessed and that all safety and operational requirements are satisfied. This includes requirements outlined in MUTCD (Queensland) relating to work sites, with the intention being to design streetscapes to minimise reliance on traffic control during regular, routine maintenance operations.

- (i) For the roundabouts, specific requirements apply being:
 - (i) streetscape treatments shall be provided in accordance with Table SC6.4.3.6.8 and other requirements of this sub-section;
 - (ii) splitter or blister islands should not accommodate any soft landscaping unless approved otherwise (generally, islands must be an average width of 6 m or greater and all safety and operational requirements must firstly be satisfied); and
 - (iii) where garden areas and trees are provided, plant species in the central islands of roundabouts should only consist of ground covers, low growing shrubs and/or mulched areas with clean trunked trees unless approved otherwise.

Table SC6.4.3.6.8 Treatment application based on roundabout diameter

Treatment	Treatments application by roundabout diameter (including width of kerbs and mountable apron)			
	< 7.0 m	7.0 m – 10.0 m	10.0 m – 14.0m	> 14.0m
Hardscape (Stencil-crete, artificial turf, concrete or similar) ¹ where the width of hardscape treatments may exceed 10.0 metres, a combination of hard and soft landscaping treatments must be applied to avoid large expanses of hardscape	Yes	Yes	Yes ¹	Yes ¹
Turf (Zoysia spp. or approved alternative) ² may be approved in select locations only, minimum clearances may still apply subject to road speed environment. Unless approved otherwise, turf areas must be a minimum width of 2.0m to support an irrigation system in a safe and efficient manner and facilitate efficient operational maintenance. Turf areas greater than 6.0m in width should be combined with other hard and soft landscaping treatments	No	No	Yes ²	Yes ²
Garden areas (Shrubs/ground covers below 3.5m in height) <i>Frangible</i> ³ may be approved in select locations only, minimum garden area width and clearances may still apply subject to road speed environment	No ³	Yes	Yes	Yes
Small trees/ large shrubs (Mature canopy between 5.0 – 10.0m in height or large shrubs greater than 3.5m in height) <i>Frangible or Non – frangible</i>	No	Yes	Yes	Yes
Medium trees (Mature canopy between 10.0 – 15.0m in height) <i>Non – frangible</i>	No	No	Yes	Yes
Large tree (Mature canopy greater than 15.0m in height) <i>Non – frangible</i>	No	No	No	Yes
Palms <i>Frangible or Non – frangible</i> ⁴ select locations only, minimum setbacks may also apply subject to species selection	No	No	Yes ⁴	Yes ⁴

(9) Hard landscape treatment requirements

(a) Hard landscape treatments must:

(i) comply with all requirements relating to:

- (A) appropriate abrasion resistance in accordance with test methods stipulated in AS/NZS 4456.9 - *Masonry units and segmental pavers and flags - Methods of test - Determining abrasion resistance*; and

(B) appropriate slip resistance capability as required by AS/NZS 4586 - *Slip resistance classification of new pedestrian surface materials*; and

(ii) be colour-fast, UV resistant and non-reflective.

(b) Where the width of hard landscape treatments may exceed 6 m, it is desirable that a combination of hard and soft landscape treatments is used to avoid large expanses of hard surface. This excludes roundabouts below 10 m in diameter.

(10) Turf area requirements

(a) Turf areas shall be in accordance with all applicable council approved standard drawings for turf areas.

Editor's note—currently, no standard drawings are formally adopted for streetscape treatments.

(b) Turf areas may form part of clear zones, provided all other requirements are satisfied.

(c) Turf areas must be a minimum 1.5 m **clear** width to allow for mowing access unless approved otherwise (noting minimum 2 m **total** widths are desirable for irrigation purposes).

(d) Where the width of the medians exceed 6 m, it is desirable that turf areas are combined with other hard and soft landscape treatments to provide balance against the median width.

(e) Turf species must be low maintenance and Empire Zoysia or an approved equivalent species.

(11) Garden area requirements

(a) Garden areas (planted or mulched only) shall be in accordance with all applicable council approved standard drawings for garden areas.

Editor's note—currently, no standard drawings are formally adopted for garden areas.

(b) All garden areas must be a minimum width of:

(i) 1 m where combined with other soft and hard landscaping treatment; and

(ii) 1.5 m where provided as full width planting.

(c) Where garden areas are **within** the sight triangle, plantings should only consist of ground covers and low shrubs with a maximum mature height of 600 mm or less in order to preserve sight lines.

(d) Where garden areas are **outside** the sight triangle, plantings expected to exceed 600 mm in mature height may be provided where all clear zone and frangibility requirements are satisfied and plantings are provided:

(i) as screen planting or buffers along fence lines or acoustic barriers;

(ii) for functional reasons such as a visual barrier for headlight glare, a windbreak or a physical barrier to human movement; and

(iii) where screening or accent planting is desired.

(e) Approval of full width planting may be provided:

(i) for strategic locations only;

(ii) where the garden area will be a minimum width of 1.5 m; and

(iii) where garden areas will be located behind road safety barrier system; or

(iv) where the road speed and required clearances between the edge of the traffic lane and the garden area complies with MUTCD (Queensland) requirements for work sites (Short-term Low Impact - Built Areas or Static Work Areas) and will not require the use of traffic control.

Editor's note—approval for full width planting will only be for select locations, subject to the satisfaction of all safety and operational maintenance requirements. Approved locations will generally be associated with central median screening or buffering plantings, key entry gateways or high profile roads, and/or associated with centres or commercial precincts. Where the road speed is 40 km/h or less, full width plantings may be provided in medians between 2.5-3.5 m, subject to achieving the

- (f) Where full width plantings are approved, plants must setback (from back of kerb) at least half the mature plant diameter, in order to mitigate potential encroachment into the roadway, reduce obstructions that compromise safety and increased maintenance requirements.
- (g) All species selection should have regard to aesthetic, suitability, functional and ecological selection criteria and include consideration of:
 - (i) appropriateness for the planting approach (e.g. structured or naturalistic);
 - (ii) mature spread dimension and required density, noting encroachment into road shoulder must be avoided;
 - (iii) mature height and compliance with sight triangle requirements, noting reliance on frequent maintenance to maintain sight lines must be avoided;
 - (iv) frangibility requirements;
 - (v) drought resistance/water requirements;
 - (vi) suitability for prevailing soil type;
 - (vii) lifespan, noting long-lived species are desired and annuals are not to be used unless approved otherwise;
 - (viii) salt tolerance;
 - (ix) pollution resistance;
 - (x) environmental and habitat value of particular species;
 - (xi) ongoing care and maintenance requirements; and
 - (xii) the intended purpose of the planting and the species' suitability for this, including uses such as:
 - (A) headlight screen planting;
 - (B) buffer screening;
 - (C) visual screening;
 - (D) visual guidance planting;
 - (E) user perceptions of speed;
 - (F) shade and sunlight control;
 - (G) windbreak;
 - (H) physical barrier;
 - (I) erosion control;
 - (J) safety; and
 - (K) noise attenuation.
- (h) Garden areas (mulched only) shall:
 - (i) be provided where shrubs and groundcovers are not desired or cannot be planted without impacting sight lines; and
 - (ii) where tree planting is incorporated in the mulched garden area.

(12) Street tree requirements

- (a) Street trees should be provided at the following rate:
 - (i) a minimum of one tree per standard building lot or spaced at approximately 20 m intervals; and
 - (ii) a maximum of four trees per standard building lot or spaced at approximately 7 m intervals.
- (b) The above rates may be altered where:
 - (i) there is insufficient available space based on safety and setback requirements; or
 - (ii) existing street trees will be retained; and
 - (iii) subject to council approval of the reduced rate.

Editor's note—in locations where lot sizes are below the standard lot width, street tree provision rates will need to be assessed on a case by case basis. In these instances, a balance between provision rates, reduced setback requirements and appropriate mitigation measures to reduce potential damage to adjacent infrastructure must be sought.

(c) Street trees shall be planted in accordance with:

- (i) all applicable council approved standard drawings for tree planting; and

Editor's note—currently, no standard drawings are formally adopted for landscape treatments.

- (ii) all setback requirements, being:

- (A) a minimum 5 m from an electricity pole or pillar box;
- (B) a minimum 7 m from a street light pole;
- (C) a minimum 2 m from side entry stormwater pits;
- (D) a minimum 2.5 m from either side of a driveway;
- (E) a minimum 1.05 m from back of kerb; and
- (F) a minimum 0.5 m from a footpath.

Editor's note—the above requirements are based on cross sections outlined on SD-015 Verge Service Corridors and other longitudinal setbacks intended to mitigate risk of conflict between street trees and other infrastructure. Setbacks from all utility services should be confirmed with the relevant asset owner/service provider. For setbacks on the approach and departure sides of bus stops, refer to SC6.4.4.8 Standard drawings (SD-515 Standard bus stop urban location layout details Type 1 and 2). For setbacks from intersections, refer to Austroads minimum gap acceptance and sight distance criteria. For setbacks on the approach and departure sides of pedestrian crossings and other designated crossing points, refer to crossing sight distance (CSD) requirements in *Traffic and Road Use Management Manual – Pedestrian Cross Facility Guidelines and Prioritisation System User Guide*.

(d) In addition to the above, the following apply:

- (i) When street trees are to be planted in medians or roundabouts, extended planting setbacks (from back of kerb or adjacent hard surface treatments) apply, being:
 - (A) for small trees or large shrubs (mature canopy between 5 – 10 m in height or large shrubs greater than 3.5 m in height), setback at a distance of 2 m or half the mature canopy diameter, whichever is greater;
 - (B) for medium trees (mature canopy between 10 – 15 m in height), setback at a distance of 4 m or half the mature canopy diameter, whichever is greater; and
 - (C) for large trees (mature canopy greater than 15 m in height), setback at a distance of 6 m or half the mature canopy diameter, whichever is greater.
- (ii) Where setbacks cannot be achieved, appropriate mitigation measures such as root barrier must be included.
- (iii) Where species proposed have a known invasive root system, increased setbacks are required and mitigation measures such as root barrier are to be provided as per arborist advice.
- (iv) Street trees will not be planted in clear zones, except where:
 - (A) Tree species are considered frangible and the mature trunk diameter will not exceed 100 mm; or
 - (B) where non-frangible tree species will be located behind road safety barriers.
- (v) When planted in the CBD, commercial zones, or where the planting area is completely surrounded by impervious surfaces, a minimum root development zone of 4 m³ must be provided for each street tree. This may be achieved through the use of structural soils, root cell products, pervious pavements or a combination of these treatments.

(e) Street tree species selection should:

- (i) be selected with consideration of suitability criteria, including:
 - (A) whether there is an existing dominant species in the street or suburb that contributes to the streetscape or suburb character;
 - (B) size of the available planting space as some tree species are better able to survive in restricted growing areas;
 - (C) location of the new tree, the species growing habit and branch structure;
 - (D) whether the new tree will be planted under power lines as only a limited number of species are suitable in this situation;
 - (E) tree species water requirements and drought resistance;
 - (F) suitability for prevailing soil type;
 - (A) pollution resistance;
 - (B) species with minimal fruit, leaf and limb drop;
 - (C) species with high shade potential;
 - (D) species with higher resilience to cyclone damage; and
 - (E) environmental and habitat value of particular species;
- (ii) be appropriate for the available planting space, accounting for all setback, offset and clearance requirements (overhead, longitudinally and horizontally across the road cross section);
- (iii) only consist of trees that will achieve canopy clearance heights applicable to the streetscape situations outlined in Table SC6.4.3.6.9 Canopy clearance heights and exhibit a 1.2 m clear trunk at the time of planting;

Table SC6.4.3.6.9 Canopy clearance heights

Streetscape situation	Minimum vertical clearance height (at maturity)
Standard pedestrian and car park environment	2.4m
Cyclist environment	2.7m
Main and arterial roads	5.4m
Other roads	4.6m
High clearance routes	5.9m
Very high clearance routes (with no alternative)	6.5m

Editor's note—above clearances are based on minimum vertical clearances detailed in Austroads *Guide to Road Design*, Part 3: Geometric Design.

- (iv) in established areas, the street trees species are to be nominated by council;
- (v) in new development areas, the street trees species are to be nominated by the developer and approved by council; and
- (vi) include palms in select locations only where:
 - (A) palm species are self-cleaning; or
 - (B) sufficient area beneath the palms are provided to mitigate risks from falling palms fronds; and
 - (C) the plantings will not impose an unsustainable maintenance requirement.
- (f) Selection of the street tree stock size for planting should consider:
 - (i) the planting location such as whether it is in a median, roundabout or on the footpath (e.g. more mature stock may be required in roundabout plantings where sight lines will be impeded by the foliage of a young tree);
 - (ii) the optimal size to achieve best establishment (e.g. smaller stock typically establish better, larger stock may be required to meet visibility requirements at time of planting); and
 - (iii) the size of the original tree where replacing a removed tree (e.g. in instances where a large,

significant tree is removed, a larger sized and/or increased quantity of replacement stock may be considered).

(13) Tree guards

- (a) Tree guards may be used in order to temporarily, semi-permanently or permanently protect trees during establishment and ongoing growth.
- (b) Trees guards should consist of proprietary available products and be installed as per manufacturer specifications.
- (c) Where new trees are to be planted within known areas of high vandalism, more durable, vandal resistant, temporary tree guards may need to be selected and installed to reduce potential loss of new plantings during establishment.
- (d) Where tree guards are to be provided semi-permanently or permanently and/or in conjunction with tree grates, tree guards are to be designed, constructed and installed as an integrated component of the tree grate system. In these instances, all requirements for tree grates detailed below should be considered, where applicable.

(14) Tree grates and surrounds

- (a) Tree grates and tree surrounds are to be provided in accordance with the following;
 - (i) tree grates are to be designed, constructed and installed in accordance with AS 3996 – Access covers and grates;
 - (ii) tree grates and alternative tree surrounds are to be provided in order to increase the usable walking space, protect tree and root systems and provide a cost effective solution to reduce maintenance requirements;
 - (iii) installation of tree grates and tree surrounds is to be limited to high trafficable areas of streetscapes (as detailed in SC6.4.3.3 Footpath treatment policy), regional level parks and civic spaces, unless approved otherwise;
 - (iv) the tree grates or surrounds should be of an appropriate material, size and colour suitable for the location, tree type and available space. Tree grate or surround design must allow for the penetration of air and water to the soil, whilst minimising potential trip and slip hazards and rubbish trapping. Consideration should be given to the growing habit of the selected trees, trunk shape, "off centre" trunks and expected changes to trunk and root diameter, allowing for variation or future modification with tree growth;
 - (v) tree grates or surrounds must be installed flush with adjacent surfaces, with grate metal support frames and appropriate fixings to be installed at the time of construction, as required to meet the specified loading capacity;
 - (vi) tree plantings with grates or other surrounds must be supported by all other necessary elements including but not limited to, structural root cell, root barrier, drainage gravel, and perforated pipe;
 - (vii) permeable paving is considered to be a suitable tree surround option, particularly for installation around existing, mature trees;
 - (viii) where the sub-section SC6.4.3.3 Footpath treatment policy applies, permeable paving is considered to be an alternative option for tree grates. In these instances, the specified colours must be used, in accordance with the pavement treatment hierarchy as per SC6.4.3.3 Footpath treatment policy. Table SC6.4.3.6.2, Table SC6.4.3.6.3, Table SC6.4.3.6.4, Table SC6.4.3.6.5, Table SC6.4.3.6.6 identify the corresponding permeable paving colours against the Footpath treatment policy pavement hierarchy; or
 - (ix) where SC6.4.3.3 Footpath treatment policy does not apply, alternative colours may be proposed.

Table SC6.4.3.6.2 P1 - Central business district (CBD) - Central and P2 Central business district (CBD) - Fringe

P1 – Central Business District (CBD) – Central	
P2 – Central Business District (CBD) – Fringe	
Permeable Paving Tree Surrounds: P1 AND P2	
Colour: "Dove"	

Table SC6.4.3.6.3 P3 - Commercial and activity areas: Biscuit, P4 - Commercial and activity areas: Paperbark, P5c - The Strand North, and P5e - Gregory Street North

P3 – Commercial And Activity Areas: Biscuit	
P4 – Commercial And Activity Areas: Paperbark	
P5c – The Strand North	
P5e – Gregory Street North	
Permeable Paving Tree Surrounds: P3, P4, P5c AND P5e	
Colour: "Sunset"	

Table SC6.4.3.6.4 P5a - Palmer Street

P5 a – Palmer Street	
Permeable Paving Tree Surrounds: P5a	
Colour: "K-Hill Blue"	

Table SC6.4.3.6.5 - P5b - The Strand South and P6 - Industrial Areas

P5 b – The Strand south	
P6 – industrial areas	
PERMEABLE PAVING TREE SURROUNDS: P5b and P6	
COLOUR: "K-Hill Grey"	

Table SC6.4.3.6.6 P5c - Sir Leslie Thesis Drive

P5 c – Sir Leslie Thesis Drive	
Permeable Paving Tree Surrounds: P5c	
Colour: "Desert Rose"	

(15) Operational requirements

- (a) Streetscape designs must seek to minimise the ongoing costs and operational maintenance requirements by:
 - (i) ensuring treatments are durable, weatherproof, UV resistant and of robust construction and finish to reduce repair or replacement frequency;
 - (ii) minimising the potential to create litter traps;
 - (iii) promoting resistance to damage, vandalism, unauthorised use and removal;
 - (iv) promoting easy cleaning and are fully accessible and responsive to maintenance activities including mechanical cleaning procedures;
 - (v) incorporating erosion and sediment control measures to reduce clearing out of drains;
 - (vi) minimising the need for herbicide applications and brush cutting around furniture such as guard rail posts or signs;

- (vii) ensuring effective access for maintenance and to critical road infrastructure is integrated into the streetscape design to support easy, time efficient operations;
 - (viii) ensuring all turf areas are of the minimum specified width to facilitate safe and efficient operation of mowing vehicles and reduce the requirement for "on foot" maintenance;
 - (ix) complying with all clearance and setback requirements to ensure maintenance can be safely undertaken without a reliance on traffic control;
 - (x) considering the plant maintenance regimes needed to maintain all safety requirements. Ongoing pruning requirements and frequency to maintain all clearances (particularly within clear zones and sight triangle) should be minimised through appropriate planting and species selection. All costs associated with these maintenance regimes should be built into the whole of life design cost;
 - (xi) using planting design to progressively reduce the number of maintenance interventions required over time for planted areas. This should include reducing weed and vegetation management activities through improved plant layout and layering, densities and species selection that establish quickly to choke out competing weeds and require no pruning or shaping;
 - (xii) identifying any traffic control requirements associated with ongoing maintenance operations in early design stages. This should include any lane or road closures, detours, and the ongoing cost to implement any such requirements. All options to reduce identified traffic control requirements should be explored in order to reduce ongoing operational costs; and
 - (xiii) mitigating any potential for streetscape elements to cause significant damage to other road infrastructure such as driveways, kerb and channel, road pavement and utility services.
- (b) In order to properly assess maintenance requirements associated with streetscape proposals, council may request the provision of a maintenance plan and approved traffic management plan as part of the development application, as per Section SC6.4.2 Development application guidelines.

SC6.4.3.6.32 Car parking plantings and shading

- (1) Landscaping is to be provided to on-street and off-street car parking areas so as to improve the aesthetic and climatic properties associated with these sites. The prevailing climatic conditions in Townsville demand that shade is provided to car parking areas to improve the comfort and reduce the urban heat island effect from large areas of hard surface.
- (2) Planting and shading options
Dependent on site and safety considerations, shading of car parks can be in the following manner:
- (a) in single sided, angle or parallel bays – 1 tree per 3 car parks;
 - (b) in double sided – 1 tree per 6 car parks; and
 - (c) shade structures may be used in conjunction with low shrubs and low groundcovers internal to the parking area; and trees, low shrubs and ground covers on the periphery of the car park.
- (3) Tree planting in car parks
- (a) Trees planted within off-street car parking areas are provided with:
 - (i) a minimum surface planting area of 1.2 m², or are incorporated into continuous garden beds; and
 - (ii) planting pits for trees in car parks surrounded by hardstand are to provide a minimum of 4 m³ for root zone development, at no greater depth than 1 m. The use of structural soils or root cell type products is highly recommended to achieve acceptable growth and form in shade trees.
 - (b) Trees planted within road reserve angle car parking areas are provided with garden bed areas between parking bays, which are to be kerbed and no less than 1.2 m wide internally.
 - (c) Trees must be planted in accordance with any approved standard drawings.
 - (d) Trees must be allowed to mature naturally and only pruned in accordance with AS4373.

Editor's note—currently, no standard drawings are formally adopted for tree planting. Refer also to SC.6.4.3.3 Footpath treatment policy.

(4) Landscape design and species selection

All car parking plantings must satisfy the following landscape design and species selection requirements:

- (a) ground cover and shrubs should have a maximum height of 600 mm to preserve sight lines;
- (b) tree canopies should achieve a minimum clearance above ground of 2.4 m above pedestrian and parking zones, or 4.6 m over vehicle movement zones;
- (c) in public parking areas, trees are to be a species as nominated by council;
- (d) in private parking areas, trees species are to be nominated by the developer and approved by council;
- (e) trees and garden beds within car parking areas are protected by raised kerbs, wheel stops or bollards;
- (f) all plantings in streetscapes and car parks are to comply with the specific design and construction requirements as detailed in sub-section SC6.4.6.26 Landscaping.

SC6.4.3.6.33 Green roofs, wall and vertical gardens

(1) Green roofs

Editor's note—due to the custom nature of green roofs, no design and construction standards are provided. Each site will be assessed on a case-by-case basis.

(2) Green walls, vertical gardens and façade greening

Editor's note—due to the custom nature of green walls, vertical gardens and façade greening, no design and construction standards are provided. Each site will be assessed on a case-by-case basis. Generally, planting features these types are to be within private property and should be under the maintenance regime of the owner. All engineering and hydraulic certification must be provided with any structure proposed.

SC6.4.3.6.34 Irrigation design and system requirements

(1) Introduction

Intent: Irrigation systems solely exist for the purpose of providing water to maintain the soil moisture content above the horticultural assets permanent wilting point and below the maximum field capacity. These conditions are required to maintain the health and growth of the horticultural assets.

- (a) These guidelines, supported by SC6.4.6.27 Irrigation, set out the scope of work, workmanship standards and the responsibilities for the supply and installation of irrigation systems within private open space and public open space and streetscapes that will become a council asset on handover.
- (b) In addition to this requirement council seeks to minimise water usage within all open space and reduce maintenance and operational costs associated with the council owned irrigation systems.
- (c) Product and brand names for components in this sub-section and SC6.4.6.27 Irrigation are used to define a standard and quality acceptable to council, with particular emphasis on long term maintenance requirements. Components other than those specified may only be used if the components are of equal or better standard and quality of those specified and an authorised change has been approved by council.
- (d) Where the developer/applicant has installed an unauthorized irrigation system not approved by Council, the developer/applicant will be required to remove such irrigation systems and rectify at their expense.
- (e) Developer/applicants must acquaint themselves with Townsville's water restrictions of the time, and where required obtain written permission from Council to implement landscape treatments that require establishment water treatment. Such water treatment permissions shall be in line with Townsville's water restriction policy requirements for the establishment period.

(2) Irrigation design objectives:

- (a) to ensure that irrigation systems are designed to the highest industry standards with the goal of maximising the efficient usage of water;

- (b) to ensure that irrigation systems and components are installed in accordance with the relevant industry standards and tradesman like workmanship; and
- (c) to ensure that the irrigation systems and components installed are of a quality and standard acceptable to council, with regard to the life of the system, the ongoing ease of maintenance and operational costs of the system and its components.

(3) General requirements

- (a) All irrigation must be of a high standard, being designed, constructed and installed in accordance with:
 - (i) the provisions within the planning scheme, planning scheme policies and this sub section of the Development manual planning scheme policy;
 - (ii) manufacturer specifications;
 - (iii) all applicable Australian Standards and legislation;
 - (iv) all applicable council local laws; and
 - (v) council's approved standard drawings.
- (b) All irrigation systems are to be:
 - (i) designed to achieve an even and efficient supply of water to the nominated Hydro-Zone areas;
 - (ii) designed with consideration of local conditions such as topography, prevailing winds, micro-climate, rainfall volumes and seasonal dry and wet periods;
 - (iii) constructed using quality materials and components;
 - (iv) automated to allow for efficient water usage;
 - (v) programmed to operate in accordance with any council water restrictions;
 - (vi) designed to operate efficiently and effectively based on the water supply pressure and flow volume available to the system;
 - (vii) The minimum industry accepted standard by TCC for turf sprinkler uniform cover is a Distribution Uniformity (DU) of 75% cover; and
 - (viii) The minimum industry accepted standard by TCC for sportsfield turf sprinkler uniform cover is a Distribution Uniformity (DU) of 100% cover for all of the sport playing surface with a 85% cover of the surrounding safety zone of the playing field surface.
- (c) All irrigation in private open space that is to be:
 - (i) installed and operated by a **private entity**, is **not** required to comply with the specific design and construction standards, however such systems that are connected to the reticulated water network is required to comply with Townsville's water restrictions of the time.
 - (ii) installed and/or operated by council, is to be designed and constructed as per requirements detailed in this sub section and SC6.4.6.27 Irrigation.
- (d) All irrigation systems in public open space and road landscaping are to:
 - (i) be designed by qualified professionals, being a certified irrigation agronomist or a certified irrigation designer;
 - (ii) constructed using quality materials and components to ensure a robust, reliable, and long asset life;
 - (iii) be designed to minimise life cycle costs through reduced operational and maintenance requirements;
 - (iv) be designed and apply volume that should not cause foreseeable damage to the road structure or surface; and
 - (v) be designed and constructed as per requirements detailed in this sub–section and SC6.4.6.27 Irrigation.
- (e) All irrigation systems in streetscapes and car parking areas are to:
 - (i) in a “main street” or “special character” situation where council owns and operates an irrigation system or has agreed to accept irrigation assets, the irrigation is to be provided in accordance

with SC6.4.6.27 Irrigation, and will be subject to the acceptance of works procedure as per Section SC6.4.7 Acceptance of completed works; and

- (ii) in all other locations where irrigated turf or plantings are required as a condition of development, the irrigation system is to be connected to the adjacent private development.

- (f) Irrigation systems in public open space and streetscapes should be designed in conjunction with all landscape elements to ensure that:

- (i) landscape design and plant selection ensures the required level of irrigation to maintain the function and longevity of landscape is analogous with the assigned irrigation profile, as detailed in SC6.4.3.6 Attachment C Irrigation Profile Level Hierarchy and SC6.4.3.6 Attachment D Irrigation Profile Level Matrix;
- (ii) landscape design and plant selection facilitates hydro-zoning;
- (iii) landscape features are designed to maximise water infiltration through use of appropriate landforms, soil types and mulches;
- (iv) landscape features are designed and constructed to ensure ease of irrigation coverage in the short and long term; and
- (v) landscape features are designed to contribute to an integrated water management system.

(4) Irrigation types requirements

- (a) All turf areas shall be irrigated with pop-up sprinklers or subsurface drip irrigation with the following specific requirements:
 - (i) all turf areas in roundabouts and median strips that border roadways shall be irrigated by drip irrigation;
 - (ii) all turf areas within 5 m of a roadway and within 50 m of the centre of an intersection shall be drip irrigated; and
 - (iii) where a site specific risk analysis recommending either method has been provided and accepted by council.
- (b) All garden areas shall to be irrigated with subsurface drip irrigation, except for areas containing plants or trees with vigorous root systems such as palms or lilies which shall be irrigated by pop-up sprinklers.

(5) Agronomic requirements

For all irrigation systems the approved hours of operation shall be between 10.00pm and 5.00am, the operation of such irrigation systems shall also comply with Townsville's water restrictions of the time.

- (a) For pop-up sprinklers the total time taken to deliver 7 mm of equivalent precipitation when each station is operated individually and consecutively shall not exceed a 7 hour period for all stations on a given system. Variations to this requirement may apply for stations operated simultaneously.
- (b) For drip irrigation the total time taken to deliver 7 mm of equivalent precipitation when each station is operated individually and consecutively shall not exceed a 7 hour period for all stations on a given system. Variations to this requirement may apply for stations operated simultaneously.
- (c) The irrigation application rate shall not exceed the infiltration rate of the soil.
- (d) The operation of irrigation systems must avoid operating in strong winds, excessive or poor irrigation mains pressure, poor irrigation design or lack of maintenance, which all contribute to system delivery inefficiency.
- (e) All irrigation systems that are to become Council assets to maintain must be fully commissioned and operating efficiently in accordance with the approved irrigation design plans for a minimum of 3 months prior to acceptance "Off Maintenance".

(6) Environmental requirements

The system shall not have excessive runoff which causes erosion or pollution of surrounding native areas and/or storm water drains.

(7) Automation requirements

- (a) The irrigation controller shall be chosen from the units outlined in Table SC6.4.3.6.10.

Table SC6.4.3.6.10 Controller Selection list

Controller Name	Power Type / Source	Valve Capacity
AC Irrinet M Slave 12 - 24	AC / 240V Mains	12 to 24
AC Irrinet M Slave 36 - 48	AC / 240V Mains	36 to 48
AC Irrinet M 12 - 24	AC / 240V Mains	12 to 24
AC Irrinet M 36 - 48	AC / 240V Mains	36 to 48
AC Irrinet ACE 24 - 48	AC / 240V Mains	24 to 48
XR 1 - 4	DC / 6V Solar	1 to 4

- (b) A maximum of three stations may be operated simultaneously (by programming only) given the following conditions:
- (i) irrigation type and precipitation rate of the stations to be operated simultaneously shall be the same;
 - (ii) the soil type, vegetation and topography of the stations to be operated simultaneously shall be the same; and
 - (iii) all stations to be operated simultaneously shall be able to supply the manufacturer's recommended pressure.
- (c) Only one valve per controller output is acceptable.

(8) Separation of irrigation zones

- (a) Irrigation zones shall be classified in the following vegetation types:
- (i) turf grass;
 - (ii) garden bed; and
 - (iii) native vegetation or revegetation plantings.
- (b) A single irrigation valve shall water no more than one irrigation zone.

(9) Safety requirements

The system shall not have runoff onto roadways, footpaths or other pedestrian areas to such an extent that it may result in a hazard to traffic and/or pedestrians.

(10) Temporary irrigation design

Temporary irrigation is exempt from the technical design and installation conditions outlined in this document provided it meets all other legislated requirements.

- (a) All temporary irrigation installed in the public realm must be removed and terminated in accordance with council specifications prior to the area being accepted "off maintenance". All terminations and disconnections of temporary irrigation must be inspected by a council officer prior to backfilling.

(11) Existing Council Irrigation Assets

- (a) Council's Irrigation Operations Unit must be notified of any disruptions to council owned irrigation assets prior to works commencing on these assets;
- (b) Works in areas containing existing council irrigation assets are required to have plans for the deconstruction and isolation of the existing irrigation to ensure the system is not unnecessarily damaged and account for the ongoing watering requirements of the soft landscaping serviced by that irrigation;
- (c) All existing council irrigation affected by development works must be reinstated to standards current at the time of the works;
- (d) Any extensions to existing mainline require the installation of an isolation valve;

- (e) Council shall charge costs for water usage based on agreement with the developer. Options include the installation of a sub-metering device or use of Irrinet flow data.
- (f) Upon activation of any additions to council owned irrigation, revised flow data must be provided to council's Irrigation Operations Unit.

Editor's note—For further information on the construction of all irrigation systems, refer to the detailed landscape specification standards as provided in SC6.4.6 Construction Standards – in particular SC6.4.6.26 Landscape Construction and SC6.4.6.27 Irrigation

SC6.4.3.6.35 Water features and water play areas

- (1) Water features and water play areas will only be permitted in limited circumstances, at specific locations, and where all relevant considerations are reasonably satisfied, and will be considered on a case-by-case basis.
- (2) Where the proposed water features and water play areas are associated with public open space, council owned land, or will involve potential future council assets, the infrastructure may only be permitted at approved locations and in accordance with council's Public Open Space Embellishment Framework, as detailed in Table SC6.4.3.6.1. Approval from the relevant council asset owner/s will also be required.
- (3) In order to properly assess any such proposals, council may request the provision of a maintenance plan and a life-cycle costing as part of the development application, as per SC6.4.2 Development application guidelines.
- (4) Where water features are proposed as a development entry statement, applications may only be approved where the water feature will be within private property and the developer will remain, for the life of the asset, solely responsible for all aspects relating to the water feature (including ongoing maintenance and water costs).
- (5) All water features and water play areas must be designed and installed to comply with all relevant Australian Standards.

Editor's note—due to the place-specific, custom nature of water features and water play areas, no further specifications are currently developed. Proposals will be considered on a case-by-case basis in accordance with necessary requirements defined by all applicable engineering, electrical, drainage, swimming pool and water safety standards, legislation, local laws and council's overarching design and management principles. Engagement and approval from other stakeholders/authorities may additionally be required as part of any development proposal.

SC6.4.3.6 Attachment A: Preferred plant species list

See here for Attachment A1 - Preferred plant species list												
CATEGORY	BOTANICAL NAME ¹	COMMON NAME	STREET TREES 3m wide desirable planting width (1m min) ²	STREET TREES- 3-6 m desirable planting with (2m min) ²	STREET TREES for ≥ 6m desirable planting width (5m min) ²	STREET TREES Suitable for planting under powerlines ²	STREET TREES Suitable for avenue plantings ²	TREES Suitable as features or specimen trees in parks & open space ³	Suitable for COASTAL FOREHSORE AREAS	Suitable in and near NATURAL AREAS ⁴	Suitable for Council PARKS AND OPEN SPACE (greater than 5m of space required for trees) ³	Suitable for COMMERCIAL AND DOMESTIC PREMISES where space permits ⁵
	Blank = does not fit criteria or	N.A.* = fits criteria.	TREES (BY LOCATION SUITABILITY)						ALL VEGETATION (BY 'SETTING' SUITABILITY)			
Large Trees over 10m (Native)												
	Acacia auriculiformis	Black Wattle		*	*			*		*	*	*
	Acacia crassicaarpa	Beach Wattle							*	*	*	*
	Acacia mangium	Hickory Wattle						*		*	*	
	Acacia melanoxylon	Blackwood			*			*		*	*	*
	Adenanthera pavonina	Red Bead Tree		*	*			*		*	*	*
	Agathis robusta	Kauri Pine			*			*		*	*	*
	Aidia racemosa	Archer Cherry								*	*	*
	Albizia procera	Forest Siris			*					*	*	*
	Allocasuarina torulosa	Forest Oak						*		*	*	
	Alstonia actinophylla	Cape Milkwood						*		*	*	
	Alstonia scholaris	Milky Pine			*			*		*	*	
	Araucaria bidwillii	Bunya Pine			*			*		*	*	
	Araucaria cunninghamii	Hoop Pine			*		*	*		*	*	*

Bombax ceiba	Native Kapok Tree			*		*	*			*	
Brachychiton acerifolius	Flame Tree	*	*			*	*		*	*	*
Calophyllum inophyllum	Beauty Leaf			*			*	*	*	*	
Cananga odorata	Ylang Ylang Tree						*		*	*	
Canarium australasicum	Mango Bark		*	*			*	*	*	*	
Canarium australianum	Melville Island White Beech		*	*			*	*	*	*	*
Castanospemum australe	Black Bean			*			*		*	*	*
Casuarina cunninghamiana	River she-oak						*		*	*	
Corymbia citriodora (syn. Eucalyptus citriodora)	Lemon-scented Gum			*			*		*	*	
Corymbia clarksoniana (syn. Eucalyptus clarksoniana)	Clarkson's Bloodwood						*		*	*	
Corymbia erythrophloia (syn. Eucalyptus erythrophloia)	Red-barked Bloodwood						*		*	*	
Corymbia ptychocarpa (syn. Eucalyptus ptychocarpa)	Swamp Bloodwood						*		*	*	
Corymbia setosa (syn. Eucalyptus setosa)	Rough Leaf Bloodwood						*		*	*	
Corymbia tessellaris (syn. Eucalyptus tessellaris)	Moreton Bay Ash			*			*	*	*	*	*
Eleocarpus angustifolius (syn. E. grandis)	Blue Quandong			*			*	*	*	*	
Eucalyptus camaldulensis	River Red Gum						*		*	*	
Eucalyptus crebra	Narrow leaved Ironbark						*		*	*	
Eucalyptus drepanophylla	QLD Grey Ironbark						*		*	*	
Eucalyptus miniata	Darwin Woollybutt		*	*			*		*	*	*
Eucalyptus pellita	Red Mahogany		*	*			*		*	*	
Eucalyptus platyphylla	Poplar Gum						*		*	*	
Eucalyptus raveretiana	Black Ironbox						*		*	*	
Eucalyptus similis	Inland Yellow Jacket		*	*			*		*	*	
Eucalyptus tereticornis	Blue Gum						*		*	*	
Euroschinus falcatus	Ribbon Wood		*	*					*	*	
Ficus benjamina	Weeping Fig			*			*		*	*	
Ficus microcarpa var hillii	Hills Weeping Fig			*			*		*	*	
Ficus racemosa	Cluster Fig						*		*	*	
Flindersia brayleyana	Queensland Maple		*	*			*		*	*	
Ganophyllum falcatum	Scaly Bark Ash		*	*			*	*	*	*	
Gossia bidwillii (syn. Austromyrtus bidwillii)	Python Tree		*	*					*	*	*
Grevillea hilliana	White Silky Oak		*	*			*		*	*	
Lophostemon confertus	Brush box			*			*		*	*	
Lophostemon grandiflorus	Northern Swamp Mahogany		*	*			*		*	*	*
Melaleuca dealbata	Cloudy or Silver-leaved Paperbark		*	*			*		*	*	*
Melaleuca fluviatilis	Weeping Paperbark		*	*		*	*		*	*	
Melaleuca leucadendra (fine leaf form included)	Paperbark		*	*			*		*	*	*
Melaleuca quinquenervia	Broad leaved paperbark		*	*			*		*	*	*

	<i>Nauclaea orientalis</i>	Leichhardt Tree			*			*		*	*	*
	<i>Peltophorum pterocarpum</i> (Nth Aust. Form)	Yellow Flame Tree			*			*		*	*	*
	<i>Pittosporum ferrugineum</i>	Rusty Pittosporum			*			*	*	*	*	*
	<i>Pleiogynium timorense</i>	Burdekin 87v Plum			*	*	*	*	*	*	*	*
	<i>Rapanea variabilis</i>	Muttonwood		*	*	*	*	*	*	*	*	*
	<i>Syzygium forte</i>	White Apple		*	*			*		*	*	*
	<i>Syzygium fortes</i> subsp.	Flaky Barked Satinash		*	*	*	*	*	*	*	*	*
	<i>Potamophilum</i>											
	<i>Syzygium francisii</i>	Francis's Water Gum		*	*			*		*	*	*
	<i>Syzygium hemilamprum</i> (Syn. <i>Acmena hemilampra</i>)	Broad-leaved Lillypilly	*	*				*		*	*	*
	<i>Syzygium luehmannii</i>	Small leaved Lillypilly		*	*			*		*	*	*
	<i>Syzygium tierneyanum</i>	River Cherry			*			*		*	*	*
	<i>Terminalia arenicola</i>	Damson Plum			*			*		*	*	*
	<i>Terminalia catappa</i>	Sea Almond			*			*	*	*	*	*
	<i>Terminalia complanata</i>	Cape York Terminalia			*			*		*	*	*
	<i>Terminalia melanocarpa</i>	Sea Almond			*			*		*	*	*
	<i>Terminalia porphyrocarpa</i>	Sea Almond		*	*			*		*	*	*
	<i>Terminalia sericocarpa</i> = <i>T. microcarpa</i>	Damson Plum			*			*		*	*	*
	<i>Timonius timon</i>	Tim Tam Tree		*	*			*		*	*	*
	<i>Toona ciliata</i> (syn. <i>T. australis</i>)	Red Cedar						*		*	*	*
	<i>Xanthostemon chrysanthus</i>	Golden Penda	*	*	*			*		*	*	*
Large Trees over 10m (Exotic)												
	<i>Caesalpinia ferrea</i>	Leopard Tree		*	*			*		*	*	*
	<i>Cassia javanica</i>	Pink Cassia		*	*	*	*	*		*	*	*
	<i>Ficus benghalensis</i>	Banyan Fig						*		*	*	*
	<i>Khaya senegalensis</i>	African Mahogany						*		*	*	*
	<i>Mangifera indica</i>	Mango		*	*			*		*	*	*
	<i>Mesua ferrea</i>	Ceylon Ironwood		*	*	*	*	*		*	*	*
	<i>Pterocarpus indicus</i>	Rosewood			*			*		*	*	*
	<i>Pterocarpus indicus</i> 'Pendula'	Weeping Rosewood		*	*			*		*	*	*
	<i>Handroanthus impetiginosus</i> (syn. <i>Tabebuia palmerii</i>)	Pink Trumpet Tree		*	*			*		*	*	*
	<i>Samanea saman</i> (syn. <i>Albizia saman</i>)	Rain Tree						*		*	*	*
	<i>Swietenia mahoganii</i>	Mahogany						*		*	*	*
	<i>Tamarindus indica</i>	Tamarind		*	*			*		*	*	*
	<i>Tectona grandis</i>	Teak						*		*	*	*
Trees 5-10 m (Native)												
	<i>Acacia flavescens</i>	Yellow Wattle, Toothed Wattle						*	*	*	*	*
	<i>Acmena smithii</i> = <i>Syzygium smithii</i>	Lillypilly		*	*					*	*	*
	<i>Alphitonia excelsa</i>	Red Ash		*	*			*	*	*	*	*
	<i>Antidesma bunius</i>	Herbert River Cherry		*	*				*	*	*	*
	<i>Arytera divaricata</i>	Rose Tamarind	*	*	*	*	*		*	*	*	*
	<i>Atalaya hemiglauc</i>	Whitewood		*					*	*	*	*
	<i>Atractocarpus fitzalanii</i> (Syn. <i>Randia fitzalanii</i>)	Brown Gardenia		*					*	*	*	*
	<i>Backhousia citriodora</i>	Lemon Scented Myrtle			*				*	*	*	*
	<i>Barringtonia acutangula</i>	Freshwater Mangrove	*	*	*			*	*	*	*	*
	<i>Barringtonia asiatica</i>	Fish Killer Tree		*	*			*	*	*	*	*

Barringtonia calyptata	Cassowary Pine	*	*	*		*	*	*	*	*	*
Barringtonia racemosa	Fish Poison Tree	*	*	*			*	*		*	*
Brachychiton australis	Broad-leaved Bottle Tree		*	*			*		*	*	*
Brachychiton discolor	White Kurrajong	*	*	*			*			*	*
Brachychiton rupestris	Bottle Tree		*	*		*	*			*	*
Buchanania arborescens	Little Gooseberry Tree					*	*			*	*
Buckinghamia celsissima (NQ Form)	Ivory Curl Tree	*	*	*		*	*		*	*	*
Bursaria spinosa	Prickly Box, Native Blackthorn		*	*	*			*	*	*	*
Carallia brachiata	Corkwood	*	*	*			*	*	*	*	*
Cassia brewsteri	Brewster's Cassia	*	*	*			*		*	*	*
Cassia queenslandica	Queensland Cassia	*	*	*			*			*	*
Cassia sp. (Paluma Range)	Paluma Range Cassia	*	*	*			*		*	*	*
Casuarina equisetifolia	Horsetail She-oak, Beach Casuarina			*				*	*	*	
Chionanthus ramiflorus	Native Olive	*	*	*					*	*	*
Cochlospermum gillivraei	Native Kapok							*	*	*	*
Cordia dichotoma	Glue Berry			*				*			
Cordia subcordata	Sea Trumpet	*	*	*			*	*		*	*
Corymbia peltata (syn. Eucalyptus peltata)	Rusty Jacket		*	*				*	*	*	*
Cupaniopsis anacardioides	Tuckeroo	*	*	*	*	*	*	*	*	*	*
Davidsonia pruriens	Davidson's Plum			*				*	*	*	*
Deplanchea tetraphylla	Golden Bouquet Tree		*	*			*		*	*	
Dillenia alata	Red Beech		*	*			*	*	*	*	*
Elaeocarpus eumundi	Eumundi Quandong	*	*	*			*		*	*	*
Elaeocarpus reticulatus	Blueberry Ash		*	*			*			*	
Erythrina vespertilio	Bat Wing Coral Tree						*	*	*	*	
Eucalyptus phoenicea	Scarlet Gum		*	*						*	*
Eucalyptus pruinosus	Silver Box		*	*			*		*	*	*
Eucalyptus shirleyi	Shirley's Silver Leaved Ironbark			*					*	*	*
Ficus platypoda	Rock-cracker Fig			*					*	*	*
Geijera salicifolia	Scrub Wilga		*				*		*	*	*
Glochidion philippicum	Daintree Cheese Tree							*	*	*	*
Grevillea baileyana	Findlay's Silky Oak	*	*			*			*	*	*
Grevillea parallela	Beefwood								*	*	*
Grevillea pteridifolia	Golden Grevillea								*	*	*
Grevillea striata	Beefwood								*	*	*
Harpullia hillii	Tulipwood		*	*					*	*	*
Harpullia pendula (NQ Form)	Tulipwood/ Tulip Lancewood	*	*	*		*	*		*	*	*
Hibiscus tiliaceus	Cottonwood							*	*	*	*
Hymenosporum flavum	Native Frangipani	*	*	*					*	*	*
Lysiphyllum hookeri = Bauhinia hookeri	Native Bauhinia	*	*		*	*	*		*	*	*
Macaranga tanarius	Heart Leaf								*	*	*
Mallotus philippensis	Red Kamala		*	*					*	*	*
Maniltoa browneoides	Handkerchief Tree		*	*			*			*	*
Maniltoa lenticellata	Silk Handkerchief Tree		*	*			*			*	*

Melaleuca bracteata	Black Tea-tree	*	*		*	*			*	*	*
Melaleuca linariifolia	Narrow-leaved Paperwork	*	*		*	*				*	*
Melaleuca nervosa	Paperbark								*	*	*
Melaleuca 'Revolution Green' & M. 'Revolution Gold'	Revolution Green & Revolution Gold	*			*						
Melaleuca viminalis & cultivars (syn. Callistemon viminalis)	Bottlebrush	*	*		*				*	*	
Melaleuca viridiflora	Broad-leaved Paperbark				*				*	*	*
Melicope elleryana	Corkwood		*	*						*	*
Melicope rubra (syn. Evodiella muelleri)	Little Evodia	*	*						*	*	*
Micromelum minutum	Lime Berry								*	*	*
Millettia pinnata (syn. Pongamia pinnata)	Pongamia or Indian Beech		*	*			*		*	*	*
Mimusops elengi	Red Coondoo	*	*	*	*	*	*	*	*	*	*
Mimusops elengi 'Street Elegance'	Variegated Mimusops	*	*	*	*	*				*	*
Morinda citrifolia	Cheese Fruit							*	*	*	*
Pararchidendron pruinosum	Snow Wood	*	*	*					*	*	*
Petalostigma pubescens	Quinine Bush								*	*	*
Pipturus argenteus	Native White Mulberry								*	*	*
Planchonia careya	Cocky Apple							*	*	*	*
Premna serratifolia	Creek Premna							*	*	*	*
Scolopia braunii	Brown Birch	*	*	*	*	*	*		*	*	*
Sterculia quadrifida	Peanut Tree	*	*	*		*			*	*	*
Syzygium angophoroides	Yarrabah Satinash		*	*					*	*	*
Syzygium australe & cultivars	Lillypilly	*	*						*	*	*
Syzygium cormiflorum	Bumpy Satinash			*		*			*	*	*
Syzygium johnsonii	Rose Satinash		*	*					*	*	*
Syzygium oleosum	Blue Lillypilly		*	*					*	*	*
Terminalia muelleri	Mueller's Damson			*			*		*	*	*
Waterhousea floribunda = Syzygium floribundum	Weeping Lillypilly	*	*	*		*			*	*	*
Waterhousea unipunctata = Syzygium unipunctatum	Roly Poly Satinash	*	*	*					*	*	*
Vachellia bidwillii (syn. Acacia bidwillii)	Corkwood								*	*	*
Trees 5-10m (Exotic)											
Cassia 'Rainbow Shower'	Rainbow Shower Cassia		*	*			*			*	*
Delonix regia	Poinciana, Flamboyant Tree		*	*			*			*	*
Fraxinus griffithii	Flowering Ash	*	*	*	*	*				*	*
Kigelia pinnata	Sausage Tree						*			*	*
Lagerstroemia speciosa	Queens Crepe Myrtle, Pride of India		*	*		*	*				
Magnolia champaca (syn. Michelia champaca)	Michelia	*	*	*	*	*	*			*	*
Plumeria obtusa and cultivars	Evergreen Frangipani	*	*	*	*	*	*			*	*
Plumeria rubra and cultivars	Frangipani	*	*	*	*	*	*			*	*
Polyalthia longifolia 'Pendula'	Indian Mast Tree	*	*	*		*	*			*	*
Schotia brachypetala	Drunken Parrot Tree	*	*	*		*	*			*	*

Tabebuia aurea syn. T. argentea	Silver Trumpet Tree	*	*	*	*	*	*			*	
Tabebuia heterophylla (syn. T. pallida (in part))	Pale Pink Trumpet Tree	*	*	*		*	*			*	*
Tabebuia pallida	White Trumpet Tree	*	*	*		*	*			*	*
Various tropical fruit, nut and spice trees	tropical fruit, nut and spice trees										*
Small Trees & Shrubs to 5m (Native)											
Acacia leptostachya	Townsville Wattle									*	*
Acacia jackesiana	Jackes Wattle									*	*
Acacia podalyriifolia	Mt Morgan Wattle									*	*
Acacia simsii	Sims Wattle									*	*
Acmena smithii var. minor = Syzygium smithii	Lillypilly	*			*	*				*	*
Acmena smithii 'Hot Flush'	Lillypilly - Hot Flush	*			*	*				*	*
Antidesma parvifolium	Currant Bush									*	*
Babingtonia spp. = Baeckea spp.	Baeckea									*	*
Babingtonia virgata (Complex) syn. Baeckea virgata & cultivars	Twiggy Baeckea									*	*
Banksia robur	Swamp Banksia									*	*
Brachychiton bidwillii	Little Kurrajong	*	*		*	*				*	*
Breynia oblongifolia (& 'Iron Range')	Coffee Bush (& Bronze Coffee Bush)									*	(*)
Bursaria incana	Prickly Pine									*	*
Bursaria tenuifolia	Native Mock Orange	*	*	*	*					*	*
Clerodendrum floribundum	Lolly Bush	*			*		*	*	*	*	*
Clerodendrum inermis	Scrambling Clerodendrum							*	*		
Cleistanthus apodus	Weeping Cleistanthus	*	*	*						*	*
Cleistanthus inylandii	Bernie's Cleistanthus		*		*	*				*	*
Dodonaea lanceolata	Hop Bush									*	*
Dodonaea viscosa	Sticky Hop Bush									*	*
Gossia floribunda (syn. Austromyrtus floribunda)	Cape Ironwood	*			*					*	*
Graptophyllum excelsum	Scarlet Fuchsia									*	*
Graptophyllum ilicifolium	Holly Leaved Fuchsia									*	*
Hibiscus divaricatus	Pink Native Hibiscus									*	*
Hibiscus tiliaceus 'Rubra'	Bronze Cottonwood									*	*
Jasminum simplicifolium subsp. australiense	Stiff Jasmine							*	*		*
Larsenaikia ochreatea	Native Gardenia									*	*
Leptospermum madidum ssp. madidum syn. L. longifolium (in part)	Northern Weeping Tea Tree			*						*	*
Leptospermum parvifolium syn. L. longifolium (in part)	Weeping Tea Tree		*	*						*	*
Leptospermum petersonii	Lemon-scented Tea Tree									*	*
Leptospermum polygalifolium syn. L. flavesens and cultivars	Yellow Tea Tree									*	*
Leptospermum Cultivars	Tea Tree									*	*
Lea indica	Bandicoot Berry									*	*

Melaleuca linariifolia cultivars 'Purpurea', 'Claret Tops' and similar	Claret Tops										*	*
Melaleuca sp. (Mount Stuart) (syn. Callistemon sp. (Mount Stuart))	Mount Stuart Bottlebrush									*	*	*
Melaleuca thymifolia & cultivars	Thyme Honey Myrtle										*	*
Melaleuca viminalis (Cultivars to 5m) (syn. Callistemon viminalis)	Bottlebrush	*	*	*	*	*				*	*	*
Melastoma affine	Blue Tongue									*		*
Melicope rubra	Little Evodia									*	*	*
Murraya ovatifoliolata	Native Murraya	*			*					*	*	*
Neofabrica myrtifolia	Yellow Tea Tree	*	*		*					*	*	*
Phyllanthus cuscutiflorus & cultivars	Pink Phyllanthus	*	*		*		*				*	*
Phyllanthus lamprophyllus	Phyllanthus									*	*	*
Scaevola taccada	Cardwell Cabbage						*	*	*			*
Sophora tomentosa	Silverbush						*	*	*			*
Syzygium australe 'Aussie Southern'	Lillypilly	*	*		*	*					*	*
Syzygium 'Elite'	Lillypilly	*	*		*	*					*	*
Syzygium australe (Cultivars to 5m)	Lillypilly	*	*		*	*					*	*
Thespesia populneoides	Beach Hibiscus						*	*				
Xanthostemon 'Daintree Gem'	Varigated Penda	*	*	*	*	*	*				*	*
Xanthostemon verticillatus	Cream Dancer										*	*
Vitex trifolia	Native Lavender						*	*	*	*	*	*
Shrubs to 5m (Exotic)												
Abelia spp.	Abelia										*	*
Acalypha spp. and cultivars	Acalypha										*	*
Barleria obtusa and cultivars	Purple Dazzler and Purple Gem										*	*
Brunfelsia australis (syn. B. latifolia & B. bonodorata)	Yesterday, Today and Tomorrow										*	*
Calliandra spp and cultivars	Pom pom Bush										*	*
Codiaeum variegatum	Croton										*	*
Duranta repens and cultivars	Duranta											*
Eugenia uniflora	Surinam Cherry										*	*
Euphorbia leucocephala	Snow Flake										*	*
Euphorbia pulcherrima	Poinsettia										*	*
Gardenia spp. and cultivars	Gardenia										*	*
Graptophyllum pictum and cultivars	Caricature Plant										*	*
Hibiscus spp and cultivars	Hibiscus										*	*
Ixora spp. and cultivars	Ixora										*	*
Mussaenda spp. & cultivars	Bangkok Rose										*	*
Polyscias spp and cultivars	Ming Aralias										*	*
Raphiolepis 'Apple Blossum' and similar	Indian Hawthorn										*	*
Russelia equisetiformis and cultivars	Coral Plant										*	*
Various tropical fruit, nut, spice, condiments and herbs	Tropical fruit, nut, spice, condiment & herbs											*

Palms, palm like and tropical foliage (Native)												
Archontophoenix alexandrae	Alexandra Palm									*	*	*
Archontophoenix cunninghamiana	Bangalow Palm										*	*
Asplenium australasicum	Birds Nest Fern									*	*	*
Asplenium nidus	Birds Nest Fern									*	*	*
Alpinia caerulea	Native Ginger									*	*	*
Alpinia modesta	Narrow-leaf Ginger									*	*	*
Bowenia serrulata	Byfield Fern										*	*
Bowenia spectabilis	Zamia Fern									*	*	*
Carpentaria acuminata	Carpentaria Palm							*			*	*
Cordyline cannifolia	Palm Lillies										*	*
Curcuma australasica	Native Turmeric, Cape York Lily										*	*
Cyathea cooperi	Tree Fern									*	*	*
Cyathea rebecca	Rebecca's Tree Fern									*	*	*
Cycas media subsp. media	Australian Nut Palm									*	*	*
Cycas spp	Cycad										*	*
Lepidozamia hopei	Hopes Lepidozamia										*	*
Lepidozamia peroffskyana	Peroffskys' Lepidozamia										*	*
Licuala ramsayi	Australian Fan Palm									*	*	*
Livistona australis	Cabbage Palm									*	*	*
Livistona decora (syn. L. decipiens)	Weeping Cabbage Palm						*	*	*	*	*	*
Livistona drudei	Fan Palm						*	*	*	*	*	*
Livistona lanuginosa	Cape River Fan Palm						*	*	*	*	*	*
Livistonia muelleri	Dwarf Fan Palm										*	*
Macrozamia spp	Cycad										*	*
Pandanus cookii (syn. P. whitei)	Screw Pine						*	*	*	*	*	*
Pandanus spp	Pandanus							*			*	*
Ptychosperma elegans	Solitary Palm									*	*	*
Ptychosperma macarthuri	Macarthur Palm										*	*
Wodyetia bifurcata	Foxtail Palm						*				*	*
Xanthorrhoea johnsonii	Grass Tree									*	*	*
Xanthorrhoea glauca	Grey Grass Tree										*	*
Palms, palm like and tropical foliage (Exotic)												
Alpinia spp. and cultivars	Shell Ginger										*	*
Alpinia galangal	Galangal										*	*
Ananas comosus 'Variegatus'	Variegated Pineapple										*	*
Beaucarnea recurvata	Ponytail Palm										*	*
Bismarckia nobilis	Bismarckia Palm										*	*
Calathea spp and cultivars	Calathea										*	*
Chamaedorea spp	Bamboo Palms										*	*
Codiaeum variegatum cultivars and forms	Garden Croton										*	*
Cordyline fruticosa and cultivars	Ti-Plant										*	*
Crinum spp. & cultivars	Crinum Lily										*	*
Ctenanthe spp and cultivars											*	*
Curcuma spp and cultivars	Ornamental Turmeric										*	*
Cyathea spp and cultivars	Tree Ferns										*	*
Cyrtostachys lakka	Lipstick Palm, Sealing Wax Palm						*				*	*
Cycas revoluta	Cycad										*	*
Dictyosperma album	Princess Palm						*	*			*	*
Dypsis lutescens	Golden Cane Palm										*	*

	Dypsis spp	Palms									*	*
	Dracaena spp and cultivars	Dragon Tree						*			*	*
	Furcraea foetida and cultivars	Mauritius Hemp									*	*
	Heliconia spp and cultivars	Crab Flowers									*	*
	Hippeastrum spp and cultivars	Amaryllis									*	*
	Hyophorbe lagenicaulis	Bottle Palm									*	*
	Hyophorbe verschaffelti	Spindle Palm									*	*
	Licuala grandis	Ruffled Fan Palm									*	*
	Maranta spp and cultivars	Prayer Plants									*	*
	Neodypsis decaryii	Triangle Palm									*	*
	Pandanus spp	Screw Pines					*	*			*	*
	Philodendron spp and cultivars	Philodendron									*	*
	Phoenix roebelenii	Dwarf Date Palm									*	*
	Pitcairnia spp and cultivars	Stappy-leaved Bromeliads									*	*
	Pleomeles spp and cultivars	Lance Dracaena					*				*	*
	Pritchardia pacifica	Fijian Fan Palm						*			*	*
	Roystonea regia	Royal Palm									*	*
	Rhapsis excelsa and cultivars	Lady Palm									*	*
	Spathiphyllum spp and cultivars	Peace Lilly									*	*
	Strelitzia spp and cultivars	Bird of Paradise									*	*
	Veitchia merrellii	Christmas Palm									*	*
	Yucca spp. and cultivars	Yucca					*				*	*
	Versaffeltia splendida	Stilt Palm									*	*
	Zamia furfuracea	Cardboard Plant						*			*	*
	Zamiaoculcas zamifolia	Zanzibar Gem or ZeeZee Plant									*	*
	Zingiber spp.	Ginger									*	*
Groundcover, border and tufted plants (Native)												
	Abelmoschus moschatus ssp.tuberosus	Native Rosella									*	*
	Acmena smithii 'Hedgemaster', 'Allyn Magic', 'Mini Magic' and similar	Dwarf Acmena									*	*
	Bothriochloa bladhii subsp. bladhii	Local Native Grass									*	*
	Bothriochloa decipiens	Local Native Grass									*	*
	Bothriochloa ewartiana	Local Native Grass									*	*
	Bothriochloa spp. (other)	Native Grass									*	*
	Canavalia maritima	Beach Bean						*	*		*	*
	Casuarina glauca 'Cousin It'	Cousin It'						*	*		*	*
	Crinum pedunculatum	Swamp Lily						*			*	*
	Crinum uniflorum	Small Swamp Lily						*			*	*
	Cajanus reticulatus	Rusty Rattlepod							*		*	*
	Canavalia rosea	Beach Bean						*	*		*	*
	Cymbopogon ambiguus	Australian Lemon-scented Grass							*	*	*	*
	Cymbopogon bombycinus	Silky Oil Grass							*	*	*	*
	Cymbopogon queenslandicus	Queenland Lemon-scented Grass						*	*		*	*
	Cymbopogon refractus	Barbed Wire Grass						*	*		*	*
	Dianella atraxis	Flax Lily							*	*	*	*
	Dianella caerulea	Blue Flax Lily							*	*	*	*

Dianella caerulea 'Little Jess'	Dwarf Flax Lily									*	*
Eleocharis atropurpurea	Purple Spikerush									*	*
Eleocharis dulcis	Water Chestnut									*	*
Eleocharis geniculata	Spike Sedge									*	*
Enchylaena tomentosa	Ruby Salt Bush								*	*	*
Enneapogon polyphyllus	Leafy Nineawn								*	*	*
Enteropogon unispiceus	Northern Kennedy Windmill Grass								*	*	*
Enneapogon spp.	Bottle Washers or Pappus Grass								*	*	*
Eustrephus latifolius	Wombat Berry								*	*	*
Ficinia nodosa syn. Isolepis nodosa	Knobby Club-rush								*	*	*
Haemodorum coccineum	Blood Lily								*	*	*
Heteropogon contortus	Black Spear Grass								*	*	*
Juncus usitatus	Common Rush								*	*	*
Indigofera pratensis	Forest Indigo								*	*	*
Ipomea pes-caprae	Beach Morning Glory or Goat's Foot								*	*	*
Lomandra confertifolia	Little Lomandra								*	*	*
Lomandra hystrix	Slender Mat Rush								*	*	*
Lomandra longifolia	Mat Rush								*	*	*
Melaleuca 'Little John' syn. Callistemon 'Little John' & similar cultivars	Little John Bottlebrush								*	*	*
Phylla nodiflora	Phylla or Frog Fruit								*	*	*
Proiphys amboinensis	Cardwell Lily								*	*	*
Schoenoplectus validus	Lake Club-rush								*	*	*
Spathoglottis plicata	Ground Orchid								*	*	*
Spinifex sericeus	Silky Spinifex								*	*	*
Syzygium australe 'Tiny Trev' and similar cultivars	Dwarf Lillypilly								*	*	*
Themeda triandra	Kangaroo Grass								*	*	*
Thuarea involuta	Beach Grass								*	*	*
Vigna marina	Beach Pea								*	*	*
Vitex rotundifolia (syn. V. ovata)	Beach Vitex								*	*	*
Viola hederaceae	Native Violet								*	*	*
Xanthostemon 'Little Goldie' and similar cultivars	Little Goldie Penda								*	*	*
Groundcover, border and tufted plants (Exotic)											
Aglaonema spp and cultivars	Aglaonema									*	*
Arachis pintoi	Peanut Pinto									*	*
Austromyrtus 'Copper Tops' and similar cultivars	Dwarf Midyim									*	*
Cuphea hyssopifolia	Mad Hatter									*	*
Dianella 'Silver Streak' & 'Silver'	Stripped Dianella									*	*
Dietes bicolor	Butterfly Iris									*	*
Dietes grandiflora	Wild Iris									*	*
Evolvulus pilosus 'Blue Sapphire'	Blue Sapphire									*	*
Gardenia florida 'Radicans'	Gardenia									*	*
Gazania spp and cultivars	Treasure Flowers									*	*
Hemigraphis spp	Red Ivy									*	*
Hippeastrum spp and cultivars	Hippeastrum									*	*

Hymenocallis littoralis	Spider/Seaside Lily									*	*
Hymenocallis 'Thai Spider'	Variegated Spider Lily									*	*
Hymenocallis speciosa	Green-tinged Spider Lily									*	*
Impatiens 'New Guinea' spp and cultivars	Impatiens										*
Liriope spp. and cultivars	Liriope									*	*
Ipomoea batatas 'Rust Red' & 'Bright Ideas Lime'	Ipomoea									*	*
Murraya paniculata 'Min-A-Min' and similar cultivars	Dwarf Mock Orange									*	*
Ophiopogon spp and cultivars	Mondo Grass									*	*
Pandanus pygmaeus 'Aurea Nana'	Pygmy Pandanus									*	*
Phyllanthus multiflorus	Fountain Plant									*	*
Rhoeo 'Hawaiian Dwarf'	Dwarf Rhoeo/Moses in the cradle									*	*
Trachelospermum jasminoides 'Tricolor'	Creeping Star-Jasmine									*	*
Tulbaghia violacea	Society Chives									*	*
Zephyranthes candida	Autumn Crocus or Rain Lily									*	*
Zephyranthes grandiflora	Rose Pink Rain Lily									*	*
Zoysia tenuifolia	No Mow Grass									*	*
Vegetables (various)											*
Vines and scrambling plants (Native)											
Aristolochia acuminata (syn. A. tagala)	Native Dutchman's Pipe									*	*
Cissus antarctica	Kangaroo Vine									*	*
Jasminium didymum	Coastal Jasmine						*			*	*
Jasminium simplicifolium	Simple-leaved Jasmin								*	*	*
Pandorea jasminoides	Bower of Beauty									*	*
Pandorea pandorana	Wonga Vine								*	*	*
Tecomanthe hillii	Fraser Island Creeper									*	*
Tecomanthe spp and Cultivars										*	*
Vines and scrambling plants (Exotic)											
Dipladenia spp and cultivars	Dipladenia									*	*
Mandevilla spp and cultivars	Mandevilla									*	*
Mucuna bennettii	Scarlet Jade Vine									*	*
Petrea volubilis	Purple Weath									*	*
Pyrostegia venusta	Orange Trumpet Vine									*	*
Strongylodon macrobotrys	Jade Vine									*	*
Trachelospermum jasminoides	Star Jasmin									*	*
Thunbergia mysorensis	Lady Slipper Vine									*	*
Various climbing & scrambling fruit, vegetables and condiments											*
Lawn grasses											
Axonopus affinis	South Johnson Buffalo									*	*
Axonopus compressus	Broad-leaf Carpet Grass or Nthn Buffalo Grass						*			*	*
Cynodon dactylon	Couch						*			*	*
Digitaria didactyla	Blue Couch									*	*
Stenotaphrum secundatum 'Sir Walter'	Sir Walter Soft Buffalo						*			*	*

Zoysia 'Empire' and similar	Zoysia Turf										.	.
Zoysia mutrella	Manila Grass										.	.

Click [here](#) to view PDF of SC6.4.3.6 Attachment A: Preferred plant species list

Note—

1. Nomenclature generally based on Census of the Queensland Flora 2013, edited by Peter D. Bostock and Ailsa E. Holland found on the Queensland Government data website = indicates where plant name differs from Australian Plant Name Index at <http://www.anbg.gov.au/cgi-bin/apclist>
Synonyms included where superseded name is still in common use in trade.
2. Refer streetscape design and treatments section for location and setback requirements. Case by case assessment of species suitability will be required dependent on location (verge, central median etc.)
3. Refer public open space section for requirements in these locations.
4. Species with a natural distribution within North Kennedy Pastoral District. Distribution checked against Census of the Queensland Flora 2010.
5. Refer to development codes for offset distances from property boundaries.

SC6.4.3.6 Attachment B: Adopted Master plans

Thuringowa Riverway Master Plan
Stage 1: Pioneer Park and Loam Island
February 2003

Riverway Sustainable Development Policy
City of Thuringowa Planning Scheme Policy 2003

SC6.4.3.6 Attachment C: Irrigation Profile Level (IPL) Hierarchy definition

The TCC Irrigation Profile Level (IPL) Hierarchy includes the following types: High, Medium, Low, Non.

IPL	Function Description	Performance Requirements	Typical Image of Turf Area
High	- Provides irrigation to Townsville City Councils landscaped areas including: - Public open spaces, - Facilities and utility assets, - Local road reserves and street scaping - Provides irrigation to State Government main road - road reserves. - Formal gardens irrigated to (IPL) levels High and Medium only.	Provide irrigation in a uniform application to supply landscaping plants with soil moisture to Promote: Vigorous plant growth, Best plant health, Best presentation. Visual Indicators - turf: Lush thick turf, Rich even green appearance. Yearly application range (assumed clay to clay loam soil types and subject to site conditions) Turf 28 - 38mm/week. Garden 18 – 28mm/week.	

IPL	Function Description	Performance Requirements	Typical Image of Turf Area
Medium	- Provides irrigation to Townsville City Councils landscaped areas including: - Public open spaces, - Facilities and utility assets, - Local road reserves and street scaping	Provide irrigation in a uniform application to supply landscaping plants with soil moisture to Promote: Good plant growth, Good plant health, Good presentation.	
	- Provides irrigation to State Government main road - road reserves. - Formal gardens irrigated to (IPL) levels High and Medium only.	Visual Indicators - turf: Mostly medium thickness turf, Mostly green appearance, with some patches of green/brown. Yearly application range (assumed clay to clay loam soil types and subject to site conditions) Turf 18 - 28mm/week, Garden 15 – 25mm/week.	

IPL	Function Description	Performance Requirements	Typical Image of Turf Area
Low	- Provides irrigation to Townsville City Council's landscaped areas including: - Public open spaces, - Facilities and utility assets - Local road reserves and street scaping - Provides irrigation to State Government main road - road reserves. Formal gardens irrigated to (IPL) levels High and Medium only.	Provide irrigation in a uniform application to supply landscaping plants with soil moisture to Sustain: Minimal plant growth, Minimal plant health, Minimal plant presentation. Significant seasonal influences on landscaping. Visual Indicators –turf: Thin coverage of turf, Mostly brown with green tinge appearance, some patches of brown. Yearly application range (assumed clay to clay loam soil types and subject to site conditions) Turf 12 - 20mm/week.	

IPL	Function Description	Performance Requirements	Typical Image of Turf Area
None	Areas where no irrigation is required: - Natural areas - Naturally landscaped areas such as native plantings, - Open grass areas such as drainage swales, - Other areas deemed not requiring irrigation.	Areas depend solely on rain and naturally occurring moisture. Seasonal plant growth, health and presentation.	

[Click here to view PDF of SC6.4.3.6 Attachment D: Irrigation Profile Level Matrix](#)

IRRIGATION PROFILE LEVEL (IPL) - CRITERIA

SC6.4.3.7 Steep land development design guidelines

SC6.4.3.7.1 Introduction

(1) Background

- (a) Development on steep land requires additional considerations for design, in particular, geotechnical considerations, as well as safety, servicing, environmental and economic considerations for the provision of development and associated infrastructure services.
- (b) The stability of land which is steep, erosion prone, prone to slip and other geotechnical problems can be adversely affected by the following actions or development:
 - (i) earthworks (filling and excavation);
 - (ii) vegetation clearing;
 - (iii) construction of buildings and other structures (retaining walls);
 - (iv) construction of roads and driveways;
 - (v) on-site disposal of waste water; and
 - (vi) changes to the existing flow of surface or groundwater.

Inappropriate development on land subject to landslide hazard can result in significant risk to people and property on the subject site, on surrounding land and land down slope of the site. To ensure that these matters are appropriately considered when making decisions, geotechnical investigations are required and appropriate design solutions implemented. In some circumstances development may be avoided.

- (c) This sub-section provides guidelines and advice for undertaking development on steep lands and the application of suitable design practices and design considerations.

Editor's note—this policy sub-section should also be read in conjunction with the AGS (2007e), *The Australian GeoGuides for slope management and maintenance*, Australian Geomechanics Society, *Australian Geomechanics*, Vol 42, No 1 and the planning scheme policy sub-section SC6.4.3.18 Geotechnical investigations.

- (d) Wherever practical to do so, best practice techniques for construction and development techniques are expected to be demonstrated.
- (e) In a broad sense, development should seek to achieve the following objectives:
 - (i) avoid unstable or hazardous sites and protect lives and property from hazardous conditions such as rock falls, excess stormwater run-off, erosion etc.;
 - (ii) minimise infrastructure maintenance requirements and costs to the community and residents;
 - (iii) provide practical and safe access for residents, visitors and service providers;
 - (iv) complement the scenic hillside character of the surrounding area by integrating unique or special natural features such as landforms, rock outcroppings, existing trees and vegetation, water features, hilltops and ridgelines and avoid further expansion onto scenic features, particularly ridgelines;
 - (v) minimise the footprint of development during and after construction;
 - (vi) protect wildlife habitat, corridors and environmentally sensitive areas; and
 - (vii) be compatible with existing adjacent development.

The creation of good amenity, when viewing the development from streetscapes and surrounding areas, should be a key consideration in all designs to avoid development on steep slopes that is visually dominant.

SC6.4.3.7.2 Development on steep land

As a general and overall consideration, the design of development on steep land should consider the following.

(1) Safety

- (a) Major considerations in relation to safety are:
 - (i) landslide risk; and
 - (ii) debris flow.
- (b) The location and/or form of development and infrastructure should not increase the extent or severity of any landslide hazard or present any unacceptable risk to life, property, the community, or the environment. Risks may arise internally or externally to the site, or affect the subject site or adjacent sites.
- (c) Safety of the development should be addressed through appropriate investigations and design.

Editor's note—the preparation of a site specific geotechnical investigation is to be undertaken in accordance with SC6.4.3.18 Geotechnical investigations.

- (d) The findings, recommendations and specific works of the geotechnical investigation report must be implemented and complied with to ensure that the risk level for the development will be no more than “low” in accordance with SC6.4.3.18 Geotechnical investigations. If the engineer's assessment report finds that the site will be “low risk” after development without the need for specific works to achieve this, certification need not be required.

Editor's note—risk level “low” in accordance with “Landslide Risk Management”, Australian Geomechanics Volume 42 No 1 March 2007.

- (e) Any recommendations contained in the geotechnical investigation report must be adopted in the final approved design.

(2) Servicing

- (a) Development should provide for the safe and efficient servicing of the site by appropriate infrastructure and minimise ongoing costs to the final user and community. Specific designs for earthworks, roads, drainage, water and sewerage, water quality treatment, and site access may need to be demonstrated at an earlier stage than comparable developments on flatter land.
- (b) Stormwater, in particular, should be controlled and conveyed in a manner that mitigates potential problems and emulates the area's natural water cycle, rather than shifting increased flows and issues downstream. Post development flows must not exceed pre-development flows. Particular attention should be paid to designing practical and robust inter-allotment drainage systems. Groundwater flows should also be a key consideration in relation to drainage systems and the potential for landslide risk.
- (c) Any public infrastructure developed should not result in unsustainable increases in infrastructure operation and maintenance costs relative to the number of rateable units created (e.g. high level water systems, high maintenance drainage systems). Retaining walls in road or drainage reserves are discouraged and will only be accepted in exceptional circumstances where there is demonstrated benefit for the protection of public infrastructure. All retaining structures must be certified by an RPEQ and constructed of material that ensures public safety and minimised maintenance costs for the design life and should be designed to achieve good streetscape amenity.
- (d) Road geometry should be designed in accordance with SC6.4.4.1 Geometric road design and Austroads with particular attention to grades, property accesses, design speeds and sight distances to ensure the safety of all road users. Where variations are sought to council's standards strong justification must be given to support the application. Long distances of steep roads or sharp curves without adequate sight distances or turning paths will not be approved. Road aesthetics are valued as a significant contributor to the character and quality of development and should be a key consideration.
- (e) Access to all properties must be safe and functional. The design of the accesses must be shown in the overall development design to ensure the safety, practicality and impact on the public and private

domains. Lot levels should reflect the requirement of accesses to meet minimum grade requirements and allow for additional near level on-site parking for visitors, service vehicles and other parking needs. Access designs should be in accordance with the SC6.4.3.17 Driveways. Where lot accesses may be problematic to construct later, they should be constructed with the roads.

- (f) Pedestrian, cyclist and public transport infrastructure design should also be considered at the overall development design as these means of movement are often restricted on steep lands. Alternate facilities to standard road routes and footpaths (e.g. pedestrian connections stairs) may require special design considerations due to grade and safety needs. Residential streets are designed to create low speed environments and to facilitate and encourage pedestrian and cyclist use.

(3) Sustainability

- (a) Hillside development can add its own positive character to the particular region however it can also have negative effects on the natural and built environment. Development should seek to enhance positive site characteristics and should enhance the natural qualities of hillsides (e.g. skylines, vistas, landscape form, vegetation, rock outcrops and other topographic features) whilst negative effects (e.g. scarring and a lack of respect for natural terrain and aesthetics) should be contained and avoided. Scenic natural features should be incorporated into the subdivision design as natural open space or through the use of larger allotments that can contain the features.
- (b) The layout of a development should be sympathetic to the area's natural terrain and hazardous conditions. It should endeavour to maintain sensitive natural areas and protect and preserve the scenic characteristics of hillsides. Where possible the clustering of development should be used to restrict the impact on the natural state, improve the financial efficiency of the development and assist in creating a variety of the housing forms.
- (c) The effect of slope on built form should be identified in the initial stages of the development's design and appropriate types of construction should be encouraged through suitable lot sizes, site and access works, building envelopes, and covenants. This will help ensure the development can be built as proposed and reduce the likelihood of conflict or compromise at a later date.
- (d) The extent of earthworks (cut and fill) is a major consideration in the design of developments on steep slopes, not just for reasons of site stability but in terms of cost and efficient use of land as well as visual impact. Constructed slopes should be stable and capable of re-vegetation and effective maintenance. They should also not be so high as to be obtrusive to the streetscape or scenic quality of the development. Heights between the streets and site levels should not be so great as to provide a disconnect between housing and the street or prove impractical for regular movement. Long stretches of high cuts or fill adjacent to road edges will not be approved. Site grading and retaining walls respect existing terrain; that is, large cuts/fills are not used to create "build-able lots" or flat yards. Final lot grades should wherever practical mimic the natural slope.
- (e) Where disturbance from future site development is likely to be problematic then earthworks to individual sites should occur at the subdivision stage. For subdivision, this may include providing level building pads to accommodate a future dwellings, associated filling and the construction of private retaining walls. This may occur where there are large cuts and fills, repeated or close accesses, or where future blasting may be required.
- (f) Retaining walls should be minimised and should not be of heights that detract from the amenity and human scale of the development. Generally, walls should not exceed one metre in height adjacent to roadways on property boundaries. High walls should be articulated, be constructed with appealing materials or finishes (complementing natural materials where possible), and have sufficient landscaping to screen the wall and should be set back from the road boundary to permit landscape treatment. Where possible a series of smaller stepped walls should be utilised and designed to permit landscaping of the terraces. Retaining walls can be used to reduce slope disturbance, rather than modify natural terrain – lot sizes should increase as the natural slope increases. Constructed slopes can be placed behind buildings if needed, however, consideration should be given to the principle of reduced earthworks in the first instance.

(4) Economic

- (a) The volume of cut and fill over the development should be minimised and a cut and fill balance over the

site as a whole should be achieved where possible.

- (b) It is expected that with any new public infrastructure the cost of ongoing maintenance should generally be no more for steep sites than for flat sites on a per lot basis. Where there may be a special requirement for non-standard or higher maintenance infrastructure it is expected that a full life cycle cost comparison would be provided (e.g. high level pumps or reservoirs, drainage structures, access to landscaped areas, etc.).

SC6.4.3.7.3 Development applications advice

Particular steep land issues that must be addressed at various application stages are indicated below.

- (1) Council encourages applicants to discuss development proposals with council during initial design phases.
- (2) It is important that the design reflect all the recommendations of the geotechnical report and that sufficient design detail is provided to demonstrate that the proposed road and lot layouts will work in practice and result in infrastructure and built form outcomes that comply with these guidelines. In particular, there should be enough certainty provided to be sure that the layout will not require significant change due to technical design constraints, i.e. it should not be left to the operational works stage to prove the development will work. Sufficient drawings and design data (including multiple sites and building sections) should be provided to determine this.
- (3) The technical design of all earthworks and infrastructure should reflect the recommendations of the geotechnical report and all relevant design guidelines and standards. Where the initial MCU/ROL geotechnical report outlined further detailed investigation prior to design as necessary then this must be carried out. The operational works design should be certified by a geotechnical engineer as complying with the recommendations of the geotechnical report.

SC6.4.3.8 Stormwater management plans for development

SC6.4.3.8.1 Introduction

The development of effective site based stormwater management plans is imperative to the understanding of stormwater quality and quantity during the land development phase to minimise the risk of causing environmental harm to receiving waters, damage to council infrastructure, and unnecessary financial burdens to council and the community.

Where a development is required to demonstrate how proposed stormwater management is protecting water quality and quantity, an applicant will be requested to undertake and prepare a conceptual site based stormwater management plan (CSBMP) or a site based stormwater management plan (SBMP) which addresses the likely impacts of the proposed development and suggests measures to avoid or mitigate against unacceptable risk and other impacts.

(1) Objectives

- (a) Ensure that land-use activities potentially discharging contaminated run-off or wastes to waterways during land development, construction and operation phases are sited and managed to minimise such discharges and to protect the quality and quantity of water entering natural and constructed waterways, natural and constructed wetlands, as well as groundwater resources.
- (b) To assist planning and decision making on development that may result in stormwater erosion of disturbed soil and sediment transport to land and waters, potentially having an impact on receiving waters environmental values under the *Environmental Protection (Water) Policy 2009* (the EPP Water).

The environmental values established under the EPP Water need to be protected, in part, by:

- (i) providing natural water infiltration and flows;
- (ii) using water sensitive urban design (WSUD) principles and effective erosion and sediment control; and
- (iii) using best practice urban stormwater quality and quantity management.

(2) Terminology

In addition to the definitions presented in Part 1.3.1 of the Townsville City Plan, the following terminology is referenced in support of this policy sub-section.

Site based stormwater management	land development controls identified by a site assessment report. Examples of land development controls include: • erosion source control; • sediment traps; • wetlands for nutrient control; • stabilised temporary drainage lines; • riparian management; and • site rehabilitation.

Wetland	area of permanent or periodic/intermittent inundation, whether natural or artificial, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which a low tide does not exceed 6 m.

AS/NZS 1547:2000 Onsite domestic waste water management.

(3) References and source documents

- (a) Development manual planning scheme policy sub-sections to be read and applied in conjunction with this sub-section are as follows:
 - SC6.4.3.9 Water sensitive urban design guidelines
 - SC6.4.4.4 Stormwater drainage design
 - SC6.4.6.1 Water sensitive urban design construction and establishment guidelines

- (b) Queensland guidelines
Queensland Government (1999) *Strategy for the conservation and Management of Queensland Wetlands*
Queensland Government (2010) *Urban Stormwater Quality Planning Guidelines*
SEQ Healthy Waterways Partnership, *Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands*
- (c) Other guidelines
Water by Design, *Construction and establishment guidelines*; Swales, Bioretention Systems and Wetlands
International Erosion Control Association (2008), *Best practice erosion and sediment control*.
Water by Design, *MUSIC modelling guidelines*, June 2012 (as amended)

Note—where local guidelines exist and these include modifications to the Queensland or other guidelines based on local knowledge or investigation, these shall take precedence over Queensland or other guidelines.

SC6.4.3.8.2 Planning and concept design guidelines

- (1) Pre-lodgement development guidelines
 - (a) Prior to the lodgement of a development application it is recommended that the applicant meet with council to confirm acceptable stormwater management practices (for example, wetland, sediment basin and bioretention system designs) and discuss how stormwater treatment may influence overall development design.
 - (b) In order to make pre-lodgement more beneficial, it is recommended that applicants undertake a preliminary site assessment and provide a range of baseline information to council to assist and inform the pre-lodgement discussions.
 - (c) This baseline information ideally will include accurate survey plans which demonstrate information on pre-development site conditions including:
 - (d)

topography	a suitable ground survey of the site is required to allow an assessment of existing grades and flow pathways;
drainage characteristics	drainage infrastructure and flowpaths upstream, within, and downstream of the development must be surveyed for size, location and level;
proposed discharge points and invert levels	define likely flow paths and the level of the receiving drainage system or waterway. Critically, levels must be collected for inverts of drainage systems that will accept treated water from the stormwater treatment systems. If water is ponding in these drainage systems, the water level must also be surveyed;
wetlands	if the site contains wetlands identified through council wetland mapping (refer to Part 8 Overlays and SC2.5 Overlay maps), they should be identified on preliminary plans;
soils	a soil evaluation undertaken in accordance with AS/NZS 1547:2000. Clause 4.1.3 will assist in selecting and locating treatment devices. The soil evaluation should identify soil types, hydraulic conductivity, presence of potential acid sulphate, sodic or saline soils, presence of rock, and general groundwater details; and
site disturbance	an indication of the current extent of disturbance across the site during the previous 12 months.
 - (e) This baseline information is critical to facilitate designs which suitably respond to site constraints and opportunities. Consideration of constraints and opportunities early in the design process minimises redesigns and expedites the assessment process. The recommended approach allows the information request stage to then be used to clarify minor issues in the report (should this practically be required).
- (2) General guidelines
 - (a) It is recommended that the above information is included with the lodgement of an application to manage stormwater quality and quantity. This will ensure that stormwater treatment matters are suitably addressed prior to a decision notice being issued and do not contribute to extended assessment timeframes.
 - (b) The design and location of stormwater treatment measures has the potential to greatly influence a

number of things, including lot configuration and as a result, needs to be resolved prior to the presentation to council for approval of any site development plans. Designers should be aware that the design of stormwater treatment measures will not only influence site design due to the footprint but also potentially due to their specific drainage requirements. Ensuring that treatment systems can freely drain becomes an increasingly important issue on sites with flat topography and must be resolved on every site prior to plan approval.

- (c) A conceptual site based stormwater quality management plan (CSBMP) should be submitted for material change of use (MCU) and reconfiguring a lot (ROL) applications to demonstrate that there are feasible measures available to adequately manage the impacts of development as they are understood and relevant to those stages and to the degree required to protect the environmental values. See Table SC6.4.3.8.1 for a checklist of items to be included in a CSBMP.
- (d) Table SC6.4.3.8.1 has been provided as a check list to outline the minimum standards for creation and preparation of a SBMP. Further, SC6.4.3.8.5 and SC6.4.3.8.6 provide additional information to that provided in Table SC6.4.3.8.1 and should be read in conjunction when preparing a SBMP.
- (e) This also informs the developer of the economic consequences of impact management at the outset of the development process. As site constraints increase, the cost-effectiveness of best practice control measures decrease. Where the conceptual plan cannot substantiate that best practice control measures are feasible and still achieve the environmental performance objectives, the proposed nature, layout and intensity of development should be reconsidered, for example—by fitting the development more to the terrain, rather than fitting the terrain to the development, to reduce the need for clearing and earthworks.
- (f) The designer is to consider the site characteristics, constraints and opportunities relating to stormwater management at the initial planning phases of the development. This is to ensure that sufficient area is allocated within the development site for appropriate stormwater management infrastructure during land development, construction and operational stages.

SC6.4.3.8.3 Development Applications

- (1) Development applications may require a CSBMP or site based stormwater management plan (SBMP) to be submitted with the development application to council for all developments requiring assessment against the Part 9.4.2 Healthy waters code. This will assist in assessing the impact of the development on the site.
- (2) SC6.4.3.8.5 SBMP document information outlines the overall framework required for SBMPs. The following information should also be considered:
 - (a) the overall potential impacts of both the construction and permanent phases, and the feasibility and cost-effectiveness of control measures on each site (given, for example, site constraints, and nature and scale of the development) need to be considered first when a change in land use is proposed, and subsequently as the development unfolds; and
 - (b) potentially serious land capability constraints affecting the cost-effectiveness and hence the feasibility of a development include:

flood prone areas	sediment basins are often located at the low point of a development and they may not be stable or able to be properly installed or operated if subject to flooding;
acid sulphate soils	larger treatment devices such as sediment basins, wetlands and bioretention systems are often located in low lying areas that are susceptible to the disturbance of acid sulphate soils;
steep terrain	high erosion risk, difficulty in preventing erosion, and in installing a stable and adequately sized sediment basin; and
flat terrain with high groundwater levels	difficulty in collecting and directing surface flows, coupled with difficulty of installing a sediment basin in the presence of high groundwater, which is sometimes geochemically contaminated.

Editor's note—this will include a brief description of erosion and sediment control (ESC) for these two stages of the development approval process.

(4) Operational works guidelines

- (a) Operational works applications may require the submission of a preliminary erosion and sediment control plan (ESCP) as supportive information which complies with council requirements as a minimum technical standard.
- (b) The preliminary ESCP will be confirmed on site during the pre-start meeting. At this stage, council can check the appropriateness of the preliminary design on site to ensure that the contractor(s) will implement what is on the design plan and will not be responsible in making any changes to suit the site condition during the construction phase.
- (c) The preliminary ESCP should take into consideration change to surface levels that are reflected in the bulk earthworks plan(s) of the siteworks plan(s) accepted as part of the operational works approval. The primary ESCP submitted as part of the CSBMP may later be followed by a series of secondary ESCPs for the various stages of the project.
- (d) Subsequent installation, operation, maintenance and monitoring of structural controls and their works programming and coordination requires ongoing adaptive management, and this must be carried out in compliance with the general environmental duty under the Environmental Protection Act, that is, taking all reasonable and practicable measures to protect the environmental values of receiving waters from environmental harm. Refer to information in Table SC6.4.3.8.1. Operational works applications should be accompanied by a series of detailed stormwater management drawings. The plans (ESCP) should include notes on the drawings which require contractors to follow the preferred construction and establishment methodology outlined in an approved SBMP and in accordance with the *SEQ Healthy Waterways Partnership Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands*.
- (e) Drawings should be in accordance with SC6.4.2 Development application guidelines.
- (f) The extent of unnecessary soil disturbance, including disturbances outside the designated work area, must be minimised at all times.
- (g) Land clearing must be limited to the current stage of works unless otherwise approved in writing possible standard condition by the assessment manager.
- (h) It is recommended that land clearing is undertaken, as a minimum, necessary to provide either of the following:
 - (i) up to 8 weeks of site activity during those months when the expected rainfall erosivity is less than 100, 6 weeks if between 100 and 285, 4 weeks if between 285 and 1500, and 2 weeks if greater than 1500; or
 - (ii) up to 8 weeks of site activity during those months when the actual or average rainfall is less than 45 mm, 6 weeks if between 45 and 100 mm, 4 weeks if between 100 and 225 mm, and 2 weeks if greater than 22 mm; or
 - (iii) utilising local sediment export data to assess the risks of land exposure during different months of the year.

Editor's note—minimise works during the “wet season” months of 1 December to 31 March. The month of December is also critical to allow establishment of 70% groundcover prior to the expected high rainfall in the months of January and February.

These impacts need to be considered separately from the post-development or permanent settlement phase as the issues and impact assessment methodology are different.

- (i) The critical impact factors are site erosion hazard (including the timing of development with respect to wet seasons) and the duration and areal extent of exposed soil until final site stabilisation after the end of major house-building activities.

Editor's note—definitions of site erosion hazard and major house-building activities to come.

- (j) Avoiding exposure of disturbed areas during peak rainfall periods will significantly reduce the potential for erosion and stream hydro-modification to occur. While it is generally recommended that larger sites are

cleared and developed in manageable smaller stages, this may sometimes conflict with the need to quickly complete and stabilise a large development prior to the wet season.

Editor's note—minimise works during the “wet season” months of 01 December to 31 March. The month of December is also critical to allow establishment of 70% groundcover prior to the expected high rainfall in the months of January and February.

- (k) Where larger sites are not staged, however, there should be a progressive revegetation (or other effective stabilisation measure) program implemented following commencement of clearing (not at the end) so that no part of the site is left exposed and unstable for extended periods in the high rainfall coastal regions. Refer to SC6.4.3.8 Attachment A: Background information - Sediment load from unprotected soils during construction.

Editor's note—even temporary grass vegetation or synthetic covers can reduce erosion levels to less than 1 per cent of the level expected if the site is left with soils exposed.

(5) Water quality objectives

- (a) Environmental values (EVs) and water quality objectives (WQOs) need to be identified to ensure that the quality of affected receiving waters are maintained or enhanced. WQOs includes all measurable water quality goals that have been derived to protect corresponding environmental values.
- (b) The EPP (Water) establishes the EVs in receiving waters.
- (c) The associated WQOs form the basis for defining the required water quality of urban stormwater entering and mixing in local waterways.
- (d) There are three ways to estimate the level of stormwater quality improvement necessary for a site to ensure WQOs are taken into account to help protect council infrastructure and the EVs for waterways.

For the site scale these are:

- (i) monitoring – actual stormwater quality can be compared with receiving water quality to establish the level of treatment necessary to protect EVs, where sufficient monitoring data are available from the same development type in similar landscape conditions;
 - (ii) modelling – stormwater quality and its potential impact on receiving waters can be mathematically modelled to determine treatment requirements (design objectives). Some monitoring data are usually required to validate such models. e.g. SC6.4.3.8.6 MUSIC modelling; and
 - (iii) best management practices – best available data on the performance efficacy of current best practice treatment technologies can be used to establish minimum standards of performance (typically expressed as minimum average annual pollutant load reductions, or minimum average percentage reductions in pollutant loads, e.g. measures in SC6.4.3.9 Water sensitive urban design guidelines).
- (e) In rapidly urbanising catchments, the wet-weather impacts of the construction phase of the land development phase need to be considered as well as the post-development (or permanent settlement phase), as the issues and impact assessment methodology are different. Critical impact factors include soil erosion hazard of the landscapes being developed, and increased rainfall run-off coefficients which occur when land is cleared and topsoil removed.
 - (f) The preferred method for determining the required level of treatment is described in SC6.4.3.9 Water sensitive urban design guidelines.
 - (g) Modelling provides an ability to predict likely changes in water quality associated with proposed urban developments. Such water quality models can be used to establish performance outcomes for stormwater systems. These are limited by the availability of local water quality data and the understanding of the biological and physical processes that influence water quality and the receiving water environment. There are often significant limits on the confidence with which predictions can be made using water quality models at the site scale. Despite the uncertainty of modelling, adopting predictive modelling techniques to quantify estimates of stormwater pollutant concentrations and loads from urban land surfaces and the pollutant removal efficacy of current best practice stormwater treatment infrastructure is an accepted method for establishing best practice stormwater management "treatment

train" design for regions where limited or no monitoring data exists.

(6) Stormwater quality risk classification

Developments are classified as either having a "low risk" or a "high risk".

Note—a development (or development proposal) may be classified as "high risk" if it falls within one of the following categories:

- (a) any development (or development proposal) within or adjoining areas of identified ecological status as indicated on council planning scheme maps; or
- (b) material change of use for urban purposes that involves:
 - (i) greater than 2,500m² of land; or
 - (ii) 6 or more additional dwellings; or
- (c) reconfiguring a lot for urban purposes that:
 - (i) would result in 6 or more residential allotments or that provides for 6 or more dwellings; or
 - (ii) involves greater than 2,500m² of land and results in an increased number of lots; or
 - (iii) is associated with operational work disturbing greater than 2,500m² of land; or
- (d) operational work for urban purposes that involves:
 - (i) disturbing greater than 2,500m² of land.

"Low risk" is a development (or development proposal) that is not "high risk".

Small, "low risk" developments in Townsville do not have to identify EVs and WQOs for receiving waters. Proposals for these developments need to demonstrate achievement of best management practices for the type of pollutants that are likely to be generated.

- (a) Developments in Townsville considered as "high risk" in relation to impacts on stormwater quality require the identification of EVs and WQOs for receiving waters within and/or downstream of the development. Proposals for these developments need to demonstrate that stormwater draining from the site will not threaten the relevant environmental values and their corresponding water quality objectives, in affected receiving waters through the use of appropriate SBMPs.

(7) Water sensitive urban design considerations.

Note—refer to information in Table SC6.4.3.8.1.

- (a) WSUD approaches to water management during development and its construction aim to minimise impacts on the natural water cycle, avoid or minimise off-site pollutant discharge, limit changes to the volume, rate, duration and frequency of stormwater discharge, and protect council infrastructure and the EVs of receiving waters.
- (b) WSUD applied to the construction phase of land development is primarily concerned with surface drainage and erosion and sediment control.
- (c) WSUD at the construction stage needs to take account of the final layout of permanent stormwater controls that will be constructed.
- (d) Temporary erosion and sediment controls need to be incorporated into SBMPs to protect permanent stormwater controls such as wetlands, swales, and bio-retention systems proposed to be constructed.
- (e) Poor erosion and sediment control planning and implementation can severely compromise the success of biological assets utilised as part of operational stormwater quality controls and increase weed infestations, decrease drainage and filtering capacities, smother landscaping and greatly reduce system reset times.
- (f) WSUD principles must be incorporated into construction phase, planning and design.

(8) Detailed design

- (a) A SBMP shall be submitted to council as part of the detailed engineering design documentation following

approval of the concepts from council.

- (b) The documents are to be site specific and not a generalisation of erosion and sediment control or stormwater quality. The documents may also form part of the contract specifications for a contractor to comply with during construction.
- (c) Where available, examples of proposed developments detailing locations of water quality structures, sediment and erosion control methodology may be obtained from council and used as a guide when preparing SBMPs.

(9) Construction

- (a) No site works shall commence prior to council's approval of the detailed design documents.
- (b) All works are to be undertaken in accordance with the development conditions, accepted drawings, the approved SBMP, local laws and environmental regulations.
- (c) Implementation of the approved works during construction must be supervised by the nominated professional.
- (d) The developer (or representative) shall constantly monitor, review and modify soil and water management practices to correct any deficiencies.
- (e) Random audits may be performed by council throughout the construction phase of the project to review compliance with approved documentation.

Editor's note—where inconsistencies are noted, written advice will be sent to the developer (or representative) requiring appropriate action within 24 hours.

- (f) A key reference document, *Best Practice Erosion and Sediment Control*, should be consulted for information on the main concepts for reducing pollution from construction sites.
- (g) Construction activity can be divided into two phases—the land development stage and the building construction stage.

Editor's note—both of these phases are known to result in serious stormwater pollution unless appropriately managed.

- (i) Land development stage
Land development involves making undeveloped vacant land suitable for urban uses through vegetation clearing, land forming and provision of services such as roads, drainage, water supply, sewers, electricity, gas and other services.

Land development usually involves major earthworks resulting in significant potential for contamination of stormwater by eroding soils.

- (ii) Building stage
Building construction can result in significant soil disturbance as well as the contamination of stormwater with building wastes. Pollutants can include litter, rubble, concrete-mixer waste, paints, plaster, brick sand, cleaning products and imported soils, etc. It should be noted that conventional allotment sediment control practices for a building site are largely ineffective at turbidity control. Therefore, for greenfield developments, subdivision-scale controls may be needed.
- (iii) Effective source control measures employed during construction can greatly minimise the impact of both phases of construction activity on stormwater quality. SBMPs (these may sometimes be referred to as erosion and sediment control plans or include such provisions) are an effective means of planning and implementing measures to minimise the generation of pollutants from construction activities.

(10) Maintenance plan requirements

- (a) Maintenance plans are to be provided for stormwater quality improvement devices (SQIDs) that are to be handed over to council.
- (b) SC6.4.3.9 Water sensitive urban design guidelines should be consulted when preparing a maintenance plan.

- (c) The responsibilities for maintenance of SQIDs are to be detailed in the SBMP.
- (d) The maintenance plans are to be written for use by council's maintenance and asset personnel.

Editor's note—examples of SQIDs that require maintenance plans include trash racks, constructed wetlands and ponds.

Note—trash racks, Gross Pollutants Traps and similar are not preferred.

- (e) The maintenance plans are to include as a minimum:
 - (i) design details;
 - (ii) manufacturer and supplier contact details (where relevant);
 - (iii) inspection frequency;
 - (iv) maintenance frequency;
 - (v) data collection requirements;
 - (vi) clean-out procedures that address, at a minimum, public safety, maintenance techniques, wet waste disposal, equipment requirements, environmental management considerations and occupational health and safety and disposal requirements; and
 - (vii) permeability testing requirements and guidelines for the filter media.
- (f) An on-site hand-over meeting and completion of handover documentation must occur between the developer (or representative), responsible maintenance personnel and appropriate representatives from council.
- (g) In the event that the SQID is not complying with approved conditions, council is under no obligation to accept responsibility of the asset.

SC6.4.3.8.4 Lodgement of site based stormwater management plans

- (1) A site based stormwater management plan (SBMP) identifies stormwater management strategies and actions to broadly address:
 - (a) water quality;
 - (b) water quantity;
 - (c) waterway corridor issues; and
 - (d) The contents of the SBMP are dependent on the stage of development (concept or detailed design) and the level of risk for the proposed development ("low" or "high").
- (2) The SBMP should contain sufficient detail to determine whether the stormwater controls are acceptable to address water quality, water quantity and waterway corridor issues. All SBMP should consider if a development is staged, including the anticipated timeframes for the staged works.
- (3) Where an SBMPs is required, it should be prepared in accordance with this sub-section and Table SC6.4.3.8.1 as a minimum standard.
- (4) Tables SC6.4.3.8.1, SC6.4.3.8.2 and SC6.4.3.8.3 Checklist for preparation of a site based stormwater management plan has been provided as a detailed check list to outline the minimum standards for creation and preparation of an SBMP that has been requested by council, to be submitted as part of an application or as part of a development condition.

SC6.4.3.8.1 Rapid risk assessment for conceptual site based management plans

Rapid risk assessment for cSBMP	Value
Land size:	
≤5,000m ²	0
>5,000m ² ≤10,000m ²	1
>10,000m ²	2
Estimated impervious area of site (road, roofs, parking, etc)	
≤25% of developable area	0
>25% ≤75% of developable area	1
>75% of developable area	2
Lot distance from areas identified within Natural assets environmental importance overlay map OM-08 as of 'very high environmental importance'	
>100m from the proposed development	0
Within 100m of the proposed development	1
Within 50m of the proposed development	2
Within the proposed development	3
Total value – 3 scores combined	
Conceptual site based management plan required at MCU and ROL stages for scores >6	

Table SC6.4.3.8.2 Checklist for preparation of a site based stormwater management plan

Site Based Management Plan Requirements
Introduction and Site Characteristics - Both Operational and Construction Phases
Description and location of the proposed development including existing and proposed land uses
Identification and description of any waterways or wetlands on or adjacent to the site including relevant background water quality data
Related studies and or plans such as catchment management plans, waterway management plans, stormwater management plans
Description of site flora and fauna including any areas of ecological significance
Summary of hydrologic and hydraulic information
Map indicating the proposed size and location for all major stormwater treatment devices such as sediment basins, constructed wetlands and bioretention systems
Parkland contributions (if required)
Completed site risk assessment
Summary of the SBMP study team
Construction Phase Elements (ESCP)
General Plan Requirements
Plan sign off including contact details for the nominated 'Suitably Qualified Person' and 'Responsible Person'
A summary statement describing the scope and intent of the work to be performed
Proposed limits of disturbance during construction activities including fencing, non-disturbance areas, retained groundcover and vegetation
Description of the proposed works including commencement and duration
Description of site preparation and initial land clearing strategies, including ESC controls to be installed prior to disturbance
Map indicating any areas of high erosion risk and/or critical environmental values
Map indicating the existing and proposed topography and drainage (including clearly depicted overland flows)
Descriptions of stabilised construction access points
Plan indicating the locations of the site office, car park(s), sediment stockpiles and associated drainage and sediment controls
Soils
General soil description as identified from published soil maps used in the soil investigation for the site
If required by State Planning Policy 2/02 - an acid sulphate soil investigation
Testing and description of local soil types, identifying the limitations of both topsoils and subsoils determined through soil testing and in particular the 'Cation Exchange Capacity' values
Description of the proposed remedial actions required to treat problem soils: steep slopes, saline soils, dispersive soils, extremely acidic or alkaline soils and acid sulphate soils

<i>Drainage, Erosion and Sediment Control Measures</i>
Map indicating how off site water is diverted around or through the site and how stormwater is diverted away from site entry and exit points
Plan/s submitted for each stage of works that utilise standard ESC symbols and clearly indicate the proposed controls and control locations
Design and construction details for any specified ESC measures, including calculation sheets for the sizing and layout of sediment basins
Specification of the flocculent type, methodology and application rate for any and each sediment basin proposed
Description of how any soil stockpiles are to be protected
Hydraulic analysis demonstrating flow velocities and capacities on site
Implementation schedule providing specific timeframes and sequences for works to be carried out
Specifications of stabilising measures for surfaces exposed for more than 14 days
Technical notes demonstrating best practice site management including dust, chemical, oil, fuel, litter and debris control
<i>Site Revegetation, Rehabilitation, Maintenance and Monitoring</i>
Capital cost of proposed strategy
Description of revegetation, hydroseeding, hydromulching or mulching methods
Site maintenance plan indicating performance standards for ESC structures, establishment of ground cover and monitoring frequencies
An Inspection Test Plan (ITP) for monitoring site performance is provided clearly indicating witness points, hold points and end points
Nominated Total Suspended Solid (TSS) concentration targets for water leaving site
Weekly site inspection checklist for ESC controls in place
Completion of the Townsville City Council Erosion and Sediment Control Plan Checklist
Nomination of 'Responsible Person' accountable for maintenance of structural controls
Total Suspended Solids monitoring program identifying methodology and locations for water quality monitoring
Operational Phase Elements (WSUD)
<i>General Plan Requirements</i>
Plan sign off and contact details for the nominated 'Suitably Qualified Person' and 'Responsible Person'
Clear indication of proposed works including expected commencement and duration
Map indicating the existing and proposed topography and drainage (including clearly depicted flowpaths for various AEP's)
General soil description as identified from published soil maps used in the soil investigation for the site
Testing and description of local soil types, identifying the limitations of both topsoils and subsoils determined through soil testing and in particular the Cation Exchange Capacities values
Proposed remedial actions required to treat problem soils: steep slopes, saline soils, dispersive soils, extremely acidic or alkaline soils and acid sulphate soils
Electronic copy of MUSIC (or similar pollution reduction modelling program) outputs for the proposed works
Description of any existing stormwater infrastructure
<i>Stormwater Quantity (Hydrology and Hydraulics)</i>
Description of proposed methodology
Details of model analysis
Comparison of existing and proposed hydrology and hydraulics eg. catchments, flows and flood levels for various AEP's
Selection and assessment of controls
Description of proposed mitigation measures
Designs drawings for proposed controls
<i>Stormwater Quality (Pollution Reduction)</i>
Identification of environmental values, pollutions of concern and water quality objectives
Description of proposed methodology
Details of model analysis
Selection and assessment of controls
Description of proposed mitigation measures
Design drawings for proposed controls

Water quality monitoring program identifying methodology and locations for water quality monitoring
<i>Maintenance and Asset Handover</i>
Capital cost of proposed strategy
Map and details of maintenance access points and dewatering areas
Annual maintenance strategy including asset access, maintenance and resetting methodologies
Details of asset reset times and life cycle costings including ongoing maintenance costs
Nomination of 'Responsible Person' accountable for maintenance of structural controls
Description and timing for asset handover to council

SC6.4.3.8.3 Checklist preparation of a conceptual site based stormwater management plan

Site Based Management Plan Requirements

Introduction and Site Characteristics Both Operational and Construction Phases

Description and location of the proposed development including existing and proposed land uses

Identification and description of any waterways or wetlands on or adjacent to the site including relevant background water quality data

Description of site flora and fauna including any areas of ecological significance

Map indicating the proposed size and location for all major stormwater treatment devices such as sediment basins, constructed wetlands and bioretention systems

Parkland contributions (if required)

Completed site risk assessment

Construction Phase Elements (ESCP)

General Plan Requirements

Description of the proposed works including commencement and duration

Map indicating the existing and proposed topography and drainage (including clearly depicted overland flows)

Soils

General soil description as identified from published soil maps used in the soil investigation for the site

Testing and description of local soil types, identifying the limitations of both topsoils and subsoils determined through soil testing and in particular the 'Cation Exchange Capacity' values

Drainage, Erosion and Sediment Control Measures

Site Revegetation, Rehabilitation, Maintenance and Monitoring

Nominated Total Suspended Solid (TSS) concentration targets for water leaving site

Operational Phase Elements (WSUD)

General Plan Requirements

Clear indication of proposed works including expected commencement and duration

Map indicating the existing and proposed topography and drainage (including clearly depicted flowpaths for various AEP's)

Description of any existing stormwater infrastructure

Stormwater Quality (Pollution Reduction)

Description of proposed mitigation measures

SC6.4.3.8.5 SBMP document information

The SBMP should outline information relevant to the authorship of the SBMP (ideally provided in tabular form), including document title, reference number, document ownership (including names of personnel that have issued and checked the SBMP) and name of client (and client representative, if appropriate).

The lodgement of development information should be accompanied by information including topographic, drainage, vegetation and soils details as well as the proposed development plan in addition to the following items (1) to (12) and clause SC6.4.3.8.6.

(1) Executive summary

A concise summary of the study methodology and findings should be presented along with a table outlining how the proposed methodology and findings and response to any previous information requests from council.

(2) Table of contents

The table of contents should include a table of the body of the report, a table of appendixes and a table of figures and diagrams.

(3) Introduction

The introduction should include a general description of the proposed development/ works, existing site, scope of the SBMP and the following information:

- (a) submission date;
- (b) developer's name;
- (c) consultant's name;
- (d) current and proposed land use of development site;
- (e) description of site location (including street directory reference); and
- (f) reference to associated documents.

(4) Locality plan

The report should include a locality plan which shows the site location in relation to major topographic features and landmarks such as waterways and major infrastructure such as roads as well as applying the principles of good mapping and drafting.

(5) Site characteristics

- (a) An accurate site plan, including survey, should be presented at a smaller scale than the locality plan to show appropriate development site details; and
- (b) The plan should include the baseline information used to determine the layout including existing topography catchment/drainage information and vegetation.
- (c) If the development is to be constructed in stages these should also be shown on the site plan.
- (d) Depending on the extent of information available and scale, it may be more appropriate to present a range of plans which show the different site characteristics. These plans can be presented in the appendixes but for ease of assessment the report should not simply refer to separate reports.
- (e) Supporting text should include detailed description of the site characteristics and discussion of how proposed clearing/earthworks will influence existing drainage.
- (f) A description of the opportunities and constraints (for example, steep topography preventing the application of devices like swales) should also be discussed.

(6) Proposed land uses

As well as presenting information in plan format, land uses should also be presented in tabular form as follows:

Table SC6.4.3.8.4 Proposed land-uses in tabular format

Land type	Area (ha)	Assumed impervious area
Open space/parkland		
Low density residential		
Medium density residential		
High density residential		
Industrial		
Commercial		
Other		
Total/Overall		

(7) Location conditions

The rainfall and soil category will influence treatment location, design and construction and should also be presented.

(8) Design objectives

The report is to identify the stormwater quality management objectives for both the construction phase and post-construction phase (operational-construction phase) of the proposed development.

- (9) Strategy description and plan
- (a) The proposed treatment strategy should be presented in plan format (with scale bar) showing sub-catchment boundaries (including any untreated areas) and flow paths.
 - (b) Other aspects critical in explaining the proposed strategy include:
 - (i) treatment area locations and indicative footprints including allowance for all relevant design;
 - (ii) requirements, for example, batters, maintenance access and fore bays;
 - (iii) description of how run-off will be conveyed to treatment systems; and
 - (iv) confirmation that treatment system can drain (that is, outlet can freely drain).
 - (c) Sub-catchments should also be presented in tabular form as follows:

Table SC6.4.3.8.5 Sub-catchment in tabular format

Sub-catchment code	Sub-catchment land use category	Treatment ID	Sub-catchment area (ha (% imp))
A			
B			
Total			

The designer should ensure that sub-catchment names (for example, sub-catchment A) and sub-catchment areas noted on the plan also match those presented in the table. Similarly the designer should ensure that the areas match the sub-catchment names and areas modelled. Confirmation that these cross checks have occurred should be noted in the report.

- (10) Modelling approach
- Reporting the modelling approach should be undertaken in accordance with council's music modelling requirements.
- (11) Treatment plans and sections
- (a) The tables should be supported by a full layout plan and sections (longitudinal and cross sections) 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 and other conceptual features such as, but not limited to, maintenance access, monitoring access (if proposed) and safety precautions (for example, fencing and/ or dense vegetation restricting public access).
 - (b) For sites with multiple small treatment devices, a full layout plan and a section drawing of a selected representative sample of devices must be provided.
 - (c) Layout plans should consider the integration of the stormwater treatment measures into the surrounding topography.
 - (d) These designs must be prepared as preliminary design drawings suitable for the subsequent preparation of detailed civil design drawings for construction.
 - (e) The design of treatment devices should be in accordance with SC6.4.3.9 Water sensitive urban design guidelines.
- (12) Professional preparation of site based stormwater management plans
- (a) It is a requirement that all site based stormwater management plans are prepared by suitably qualified and experienced professionals.
 - (b) A suitably qualified and experienced professional is defined as a person with the following attributes:
 - (i) Site Based Stormwater Management Plans (SBMP): relevant tertiary qualifications or equivalent, including being a registered professional Engineer of Queensland (RPEQ).

SC6.4.3.8.6 MUSIC modelling requirements

- (1) MUSIC modelling is the standard accepted for modelling for stormwater management for development in Townsville.

- (2) The modelling, reporting and assessment methodology presented in the MUSIC Modelling Guidelines is to be applied using local data.
- (3) Rainfall, evaporation and pollutant data are to be used from the following sources to ensure that parameter values within the Townsville Local Government Area are regionally relevant to the Townsville environment.
 - (a) Data for rainfall is to be based on Townsville records for a significant period of time (10 – 20 years) with a range of significant wet and dry periods.
 - (b) Parameter values for pollutant loads are to be sourced from SC6.4.3.9 Water sensitive urban design guidelines.
- (4) Reporting is to specifically outline all parameters used (for example, meteorological data, time step, percentage effective impervious areas, base and stormflow concentration parameters, pollutant reduction efficiencies, treatment node dimensions), either in the body of the report or as an appendix.
- (5) The report should record the version of urban stormwater model used.
- (6) A digital file containing all relevant modelling files must be provided with the report to enable checking of all modelling calculations by Townsville City Council. The files should include a 'readme' text file, containing a description of the contents and details of any naming conventions used for model files. The checking will also ensure integrity of data to ensure that no parameters have been altered.
- (7) Models provided should include:
 - (a) pre-development condition;
 - (b) developed site without any stormwater treatment measures; and
 - (c) developed site with proposed stormwater treatment strategy.
- (8) The design of treatment devices should be in accordance with the SC6.4.3.9 Water sensitive urban design guidelines.
- (9) Parameters used in the modelling will therefore need to be checked for consistency during design as well as assessment.
- (10) A description of the selected stormwater management options should be presented.
- (11) This section should include modelling results and dimensions of stormwater treatment measures.

SC6.4.3.8.7 Erosion and sediment control plans

- (1) Erosion and sediment control plans (ESCPs) shall contain the following.
 - (a) Adequate local site data, including soil data, must be obtained to allow the preparation of an appropriate ESCP, and allow the selection, design and specification of required Erosion and sediment control (ESC) measures.
 - (b) Prior to development of the ESCP, the site must be assessed from a hydrological, hydro-geological, hydraulic, vegetation, soils and geological perspective to determine relevant site constraints that may affect the focus or detail of the plan.
 - (c) The plan(s) must include all aspects of proposed site disturbance, temporary drainage works, erosion and sediment control measures, installation sequence, and site rehabilitation for the duration of the project, including (where appropriate) the nominated maintenance period.
 - (d) Generally, an ESCP must address the following issues:
 - (i) identify the likely need for the construction of sediment basins on the site;

- (ii) identify that adequate space has been made available for the construction and operation of major sediment traps and essential flow diversion systems;
- (iii) demonstrate that there is a feasible means of constructing the project while still protecting key environmental values;
- (iv) identify problem soil areas including, dispersive soils, acid sulfate soils, areas of potential mass movement; and
- (v) identify key environmental features on the site such as protected vegetation.
- (e) The level of detail supplied in the ESCP must be commensurate with the complexity of the proposal and the assessed environmental risk.
- (f) Where appropriate, ESCPs (including supporting documentation) should include, but not be limited to:
 - (i) north point and plan scale;
 - (ii) site and easement boundaries and adjoining roadways;
 - (iii) construction access points;
 - (iv) site office, car park and location of material stockpiles;
 - (v) limits of disturbance;
 - (vi) retained vegetation including protected trees;
 - (vii) general soil information and location of problematic soils;
 - (viii) groundwater, and flood-affected areas (50% AEP);
 - (ix) location of critical environmental values (where appropriate);
 - (x) existing site contours (unless the provision of these contours adversely impacts the clarity of the ESCP);
 - (xi) final site contours including locations of cut and fill;
 - (xii) construction drainage plans for each stage of earthworks, including land contours for that stage of construction, sub-catchment boundaries and location of watercourses;
 - (xiii) existing and final overland flow drainage paths;
 - (xiv) location of vegetated buffer strips;
 - (xv) stabilised entry/exit point (rumble pad);
 - (xvi) location of soil and sand stockpiles;
 - (xvii) location of all proposed temporary drainage control measures;
 - (xviii) location of all proposed erosion control measures (alternatively, use notes to describe locations);
 - (xix) installation sequence and maintenance requirements;
 - (xx) permanent site stabilisation measures;
 - (xxi) a statement of who is responsible for establishing and maintaining all erosion and sediment control measures;
 - (xxii) general layout and staging of proposed works;
 - (xxiii) location of all drainage, erosion and sediment control measures;
 - (xxiv) full design and construction details (such as, cross-sections, minimum channel grades, channel linings) for all drainage and sediment control devices, including diversion channels and sediment basins;
 - (xxv) site revegetation requirements (if not contained on a separate plan submitted to the assessing authority);
 - (xxvi) site monitoring and maintenance program, including the location of proposed water quality monitoring stations (if required);
 - (xxvii) technical notes relating to:
 - (A) site preparation and land clearing;
 - (B) extent, timing and application of erosion control measures;
 - (C) temporary ESC measures installed at end of working day;

- (D) temporary ESC measure in case of impending storms, or emergency situations;
 - (E) installation sequence for ESC measures;
 - (F) site revegetation and rehabilitation requirements;
 - (G) application rates (or at least the minimum application rates) for mulching and revegetation measures;
 - (H) legend of standard symbols used within the plans; and
 - (I) sediment basin operation and flocculent dosing.
- (xxviii) calculation sheets for the sizing of ESC measures;
- (xxix) completed ESCP checklist; and
- (xxx) any other relevant information council may require to properly assess the ESCP.
- (g) If the timing of the proposed construction activities are not known during development of the ESCP, and if rainfall erosivity varies significantly throughout the year, then the erosion control specifications placed on the ESCP must specify appropriate erosion control measures for each level of rainfall erosivity. Refer to SC6.4.3.8 Attachment A: Background information - Sediment load from unprotected soils during construction.
- (h) The timing of works and the installation of control measures has a major influence on the management of stormwater. As such, the installation sequence must be considered generally as outlined below.
- (i) establish a single stabilised entry/exit point (rumble pad);
 - (ii) install sediment fence(s) along the low side of the site;
 - (iii) divert up-slope water around or through the work site and appropriately stabilise any drainage channels;
 - (iv) clear only those areas necessary for building or construction work to occur;
 - (v) stockpile topsoil within the sediment-control zone;
 - (vi) stabilise exposed earth banks e.g. vegetation, erosion control blankets;
 - (vii) install on-site waste receptacles e.g. mini-skips, bins, reo cages. These should be covered to prevent waste being moved by wind;
 - (viii) commence building activities;
 - (ix) install roof downpipes as soon as practicable after the roof is laid;
 - (x) maintain all control measures in good working order; and
 - (xi) revegetate or otherwise stabilise the site.
- (i) An ESCP is required to be approved by council prior to the commencement of any work or activity, including land clearing (except as allowed under for the purposes of ground survey, geotechnical investigation, or other recognised essential purposes), provided the work is:
- (i) consistent with state and council vegetation protection and/or preservation requirements and/or policies; and
 - (ii) undertaken so that the ground surface is not disturbed and at least 150mm stubble remains on the surface (where such a stubble exists prior to clearing); or
 - (iii) to provide site access via the minimum practicable number of site access corridors.
- (j) Erosion and sediment control management plans (ESCMP) shall be scaled drawings (no larger than 1:1000) with detailed specifications/diagrams which can be readily understood and applied on site by supervisory staff.
- (k) All drawings/plans shall be prepared in accordance with SC6.4.2 Development application guidelines and good drafting principles.

(2) Professional ESCP sign-off

- (a) The ESCP must clearly state that no land-disturbing activities on the site shall occur until all perimeter ESC measures, sediment basins, and associated temporary drainage controls, have been constructed in accordance with best practice erosion and sediment control.

- (b) It is a requirement that all ESCPs are signed by suitably qualified and experienced professional. A suitably qualified and experienced professional is defined as a person with the following attributes:
 - (i) design phase (ESCP) - relevant tertiary qualification or satisfies at least one of the following 3 criteria:
 - (A) Statement of Attainment from a Townsville City Council 5 or 6 Day Course (Erosion and Sediment Control Planning for North Queensland); or
 - (B) Certified Professional in Erosion and Sediment Control (CPESC); or
 - (C) holds a qualification which is equivalent to either of the above and is accepted by council.
 - (ii) construction phase (ESCP): relevant tertiary qualifications or satisfies at least one of the following criteria:
 - (A) holds a Statement of Attainment from a Townsville City Council 2 Day Course (Erosion and Sediment Control for Site Supervisors); or
 - (B) holds a qualification which is equivalent to the above and is accepted by council; or
 - (iii) operational phase (WSUD):
 - (A) relevant tertiary qualifications or a Statement of Attainment from a Townsville City Council 2 day course (Water sensitive urban design for Site Supervisors).
 - (B) holds a qualification which is accepted by council.

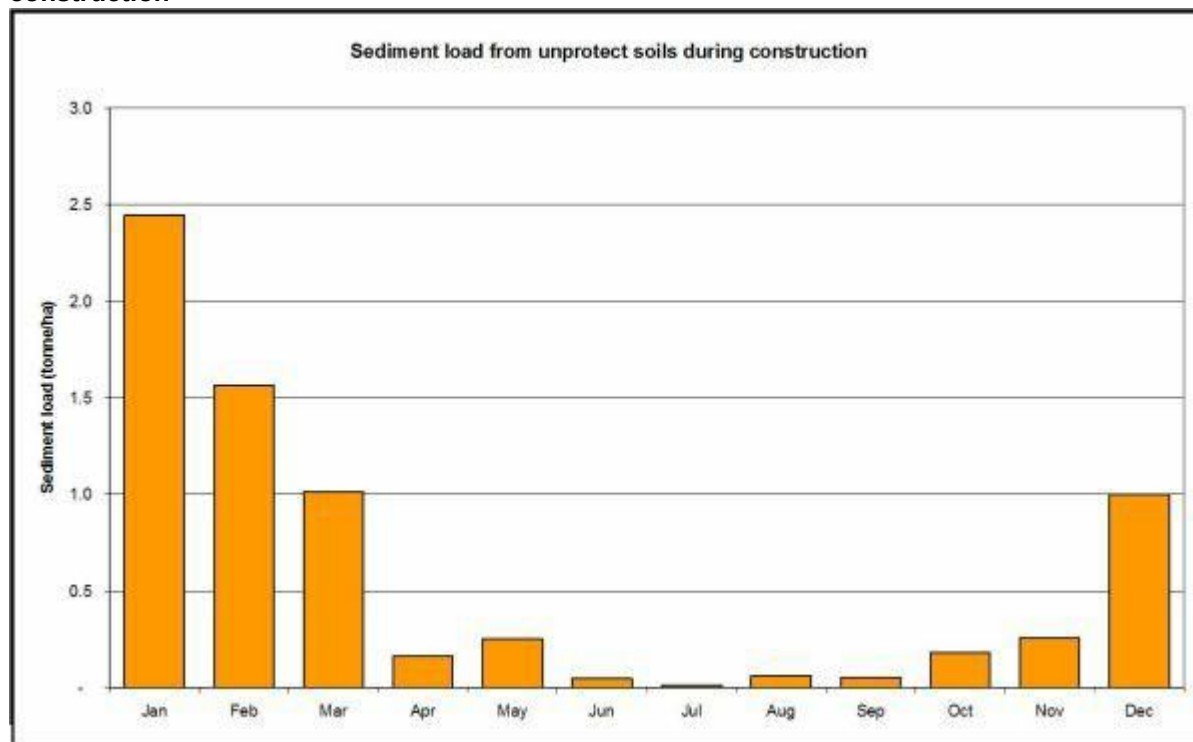
Editor's note—Statement of Attainment from a Townsville City Council 2 Day Course (Water sensitive urban design for Site Supervisors) is a course currently being developed by TCC.

- (c) When signing-off on an ESCP, the signatory is deemed to be making the following statements:
 - (i) the ESCP satisfies the intent and design/performance standards established by all relevant local, state and federal policies relating to erosion and sediment control;
 - (ii) the ESCP has been reviewed and approved by personnel suitably trained and experienced (to a degree appropriate for the given type and size of the land disturbance) in each of the following categories: construction, soil science, hydrology/hydraulics, and site revegetation/rehabilitation;
 - (iii) the ESCP is both reasonable and practicable; and
 - (iv) the ESCP contains sufficient information to allow the appropriate implementation of the plans.
 - (d) ESCPs that incorporate a sediment basin with a constructed earth embankment with a height greater than 1m, must be signed-off by a geotechnical specialist.
 - (e) The approved ESCP must be available on-site for inspection by council officers while work activities are occurring.
- (3) Should the development be commenced and not completed within 12 months of approval of the ESCP, a revised ESCP must be prepared, with further revisions thereafter at half-yearly intervals. For master planned developments this requirement applies for the ESCPs for each stage.
 - (4) Additional erosion and sediment control measures are implemented, and a revised ESCP is submitted for approval (within five business days of any such amendments) in the event that:
 - (a) there is a high probability that serious or material environmental harm may occur as a result of sediment leaving the site; or
 - (b) the implemented works fail to achieve the local government ESC standard/code, or state environmental protection requirements; or
 - (c) site conditions significantly change; or
 - (d) site inspections indicate that the implemented works are failing to achieve the "objective" of the ESCP.
 - (5) In circumstances where it is considered necessary to prepare an amended ESCP, and the preparation of the amended ESCP is not imminent, then all necessary new or modified erosion and sediment control measures

must be implemented in accordance with current best practice:

- (a) in circumstances where there is significant risk of environmental harm, then upon receipt of the amended ESCP, all works must be implemented in accordance with the revised plan;
 - (b) otherwise, only upon approval of the amended ESCP by the assessing authority shall works be implemented in accordance with the amended plan; and
 - (c) a copy of the amended ESCP must be forwarded to council within 5 business days of any such amendments.
- (6) The design standard of erosion and sediment control must be commensurate with the degree of environmental risk associated to the proposed works.
- (7) All erosion and sediment control measures, including temporary drainage control measures, must be designed in accordance with the design standards in SC6.4.4.4 Stormwater drainage design.
- (8) The ESCP must incorporate “hold points” (where appropriate) detailing critical performance indicators of the various elements of the ESCP. The development must not be allowed to proceed without adherence to designated hold points at specified times.

SC6.4.3.8 Attachment A: Background information - Sediment load from unprotected soils during construction



Month	Sediment (Tonnes/hectare)	% yearly load		
Jan	2.40	32.9		Very high risk
Feb	1.60	21.9		
Mar	1.00	13.7		
Apr	0.20	2.7		Low to moderate risk
May	0.30	4.1		
Jun	0.10	1.4		
Jul	0.00	0		
Aug	0.10	1.4		
Sep	0.10	1.4		
Oct	0.20	2.7		
Nov	0.30	4.1		
Dec	1.00	13.7		
	7.30	100		

Source: Extrapolated from *Black Ross Water Quality Improvement Plan*.

SC6.4.3.9 Water sensitive urban design guidelines

SC6.4.3.9.1 Introduction

- (1) Water By Design's *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland*, Version 1, 2006 (or as amended), are adopted, with the following exclusions:
 - (a) Chapter 1 Introduction
 - (b) Chapter 6 Constructed Stormwater Wetlands.

Note—Chapter 3 Bioretention Swales, Chapter 5 Bioretention Basins, and Appendix A Plant Selection for WSUD Systems, which formed part of the original version of the Technical Design Guidelines, have been superseded by Healthy Waters' *Bioretention Technical Design Guidelines (Version 1, October 2012)*. The *Bioretention Technical Design Guidelines* are **not** being adopted.

- (2) The following sections – Introducing water sensitive urban design, Bioretention swales, Bioretention basins, Constructed stormwater wetlands, and Appendix A Plant selection for water sensitive urban design systems - have been developed specifically for the coastal dry tropic conditions found in the Townsville area, and replace those equivalent sections in the *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland* (and the superseded parts that form the *Bioretention Technical Design Guidelines*).
- (3) References to chapters and sections in this sub-section refer to the chapters and sections in the *Water Sensitive Urban Design Guidelines for South East Queensland*.

SC6.4.3.9.2 Introducing water sensitive urban design

- (1) Water sensitive urban design (WSUD) is an internationally recognised concept that offers an alternative to traditional development practices. WSUD is a holistic approach to the planning and design of urban development that aims to minimise negative impacts on the natural water cycle and protect the health of aquatic ecosystems. It promotes the integration of stormwater, water supply and sewage management at the development scale.

The key principles of WSUD are to:

- (a) protect existing natural features and ecological processes;
- (b) maintain the natural hydrologic behaviour of catchments;
- (c) protect water quality of surface and ground waters;
- (d) minimise demand on the reticulated water supply system;
- (e) minimise sewage discharges to the natural environment; and
- (f) integrate water into the landscape to enhance visual, social, cultural and ecological values.

These guidelines are not intended to limit innovation in design or construction of WSUD elements by restricting alternative approaches to those presented here. Alternative designs should be considered where potential improvements in performance, constructability or maintenance requirements can be demonstrated. However, the design procedures and recommendations given in these guidelines are based on contemporary best practice, incorporating lessons from local experience, and are regarded as appropriate for the coastal dry tropics region.

- (2) Design objectives for stormwater management
The adopted design objectives for the coastal dry tropics in mean annual pollutant load leaving a development site, compared to traditional urban design where stormwater is not treated:
 - (a) $\geq 80\%$ reduction in total suspended solids load
 - (b) $\geq 65\%$ reduction in total phosphorus load
 - (c) $\geq 40\%$ reduction on total nitrogen load
 - (d) $\geq 90\%$ reduction in gross pollutant load.

Editor's note—this sub-section contains illustrations and photographs of stormwater treatment devices. These are intended as examples only and should not be regarded as acceptable solutions. Unless specifically indicated, all drawings are not to scale.

(3) Selection of appropriate stormwater management measures

- (a) Not all of the stormwater management measures presented in this sub-section are suitable for any given site. Appropriate measures should be selected by matching device characteristics to target pollutants and the physical constraints of the site.
- (b) These guidelines are not intended to provide detailed advice on selection of stormwater treatment devices. However, the following tables provide an indication of:
 - (i) the scale at which various treatment measures are typically applied (Table SC6.4.3.9.1);

Table SC6.4.3.9.1 Scale of WSUD application in urban catchments

WSUD Measure	Allotment Scale	Street Scale	Precinct or Regional Scale
Swales and buffer strips		✓	
Bioretention Swales		✓	✓
Sedimentation basins			✓
Bioretention basins	✓	✓	✓
Constructed wetlands		✓	✓
Infiltration measures	✓	✓	
Sand filters	✓	✓	
Aquifer storage and recovery			✓

- (ii) the effectiveness of these treatment measures in removing pollutants, attenuating peak flow rates and reducing runoff volume (Table SC6.4.3.9.2); and

Table SC6.4.3.9.2 Effectiveness of WSUD measures for runoff quality and quantity management

WSUD Measure Water	Quality Treatment			Peak Flow Attenuation*	Reduction in Runoff Volume*
	TSS	TP	TN		
Swales and buffer strips	H	M	L	L	L
Bioretention Swales	H	H	H	M	L
Sedimentation basins	H	M	L	M	L
Bioretention basins	H	H	H	M	L
Constructed wetlands	H	H	H	H	L
Infiltration measures**	-	-	-	H	H
Sand filters	H	M	L	L	L
Aquifer storage and recovery**	-	-	-	H	H

H – High; M – Medium; L – Low * Frequent events only ** Water quality treatment is not a primary function of these devices

- (iii) site conditions that may affect the suitability of different treatment measures (Table SC6.4.3.9.3).

Table SC6.4.3.9.3 Site constraints for WSUD measures

WSUD Measure	Steep site (>5%)	Shallow bedrock	Acid Sulfate Soils	Low permeability soil (eg. Clay)	High permeability soil (eg. sand)	High water table	High sediment input	Land availability
Swales and buffer strips	C	D	D	✓	✓	D	D	D
Bioretention Swales	C	C	C	✓	✓	C	D	D
Sedimentation basins	C	✓	✓	✓	✓	D	✓	D
Bioretention basins	D	D	D	✓	✓	C	C	D
Constructed wetlands	C	D	C	✓	D	D	D	D
Infiltration measures	C	C	C	C	✓	C	C	D
Sand filters	D	✓	✓	✓	✓	D	C	✓
Aquifer storage and recovery	C	C	C	C	✓	C	C	D

C – Constraint may preclude use; D – Constraint may be overcome through appropriate design; ✓ – Generally not a constraint

(4) Safety and risk management

- (a) WSUD aims to protect the environmental assets of a site and enhance liveability through greater integration of built and natural features. This approach may introduce some risks to the urban environment that are greater than or different to those encountered in traditional land development practice. The more obvious of these risks relate to the presence of open water bodies and the introduction of street-scape elements that may alter lines of sight or other aspects of traffic safety.
- (b) Whilst this sub-section makes occasional comment on various aspects of safety, they are not intended to provide comprehensive advice on appropriate risk management strategies. Designers are responsible for providing an appropriate level of public safety in their designs and for ensuring that risk management procedures, in accordance with relevant standards and guidelines, are followed. Further information on risk management for water-related urban infrastructure is provided in the *Queensland Urban Drainage Manual*.

SC6.4.3.9.3 Bioretention swales

- (1) Bioretention swales act to disconnect impervious areas from downstream waterways and provide protection to natural receiving waterways from frequent storm events by reducing flow velocities compared with piped systems. The bioretention component is typically located at the downstream end of the overlying swale “cell” (i.e. immediately upstream of the swale overflow pit(s) as shown in Figure SC6.4.3.9.1.

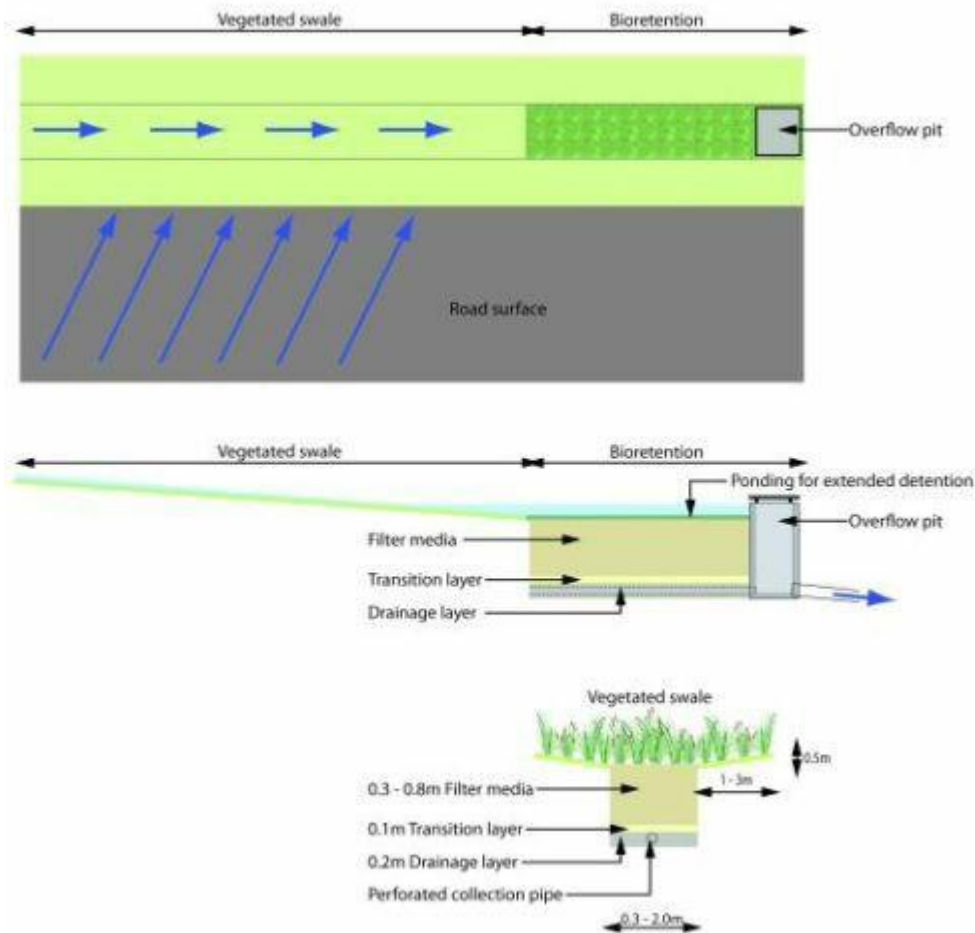


Figure SC6.4.3.9.1 Bioretention swale conceptual layout

The choice of bioretention location within the overlying swale will depend on a number of factors, including area available for the bioretention filter media and the maximum batter slopes for the overlying swale. Typically, when used as a continuous trench along the full length of a swale, the desirable maximum longitudinal grade of the swale is 4%. For other applications, the desirable grade of the bioretention zone is either horizontal or as close as possible to encourage uniform distribution of stormwater flows over the full surface area of bioretention filter media and allowing temporary storage of flows for treatment before bypass occurs.

(2) Design considerations for bioretention swales

- (a) This section outlines some of the key design considerations for bioretention swales that the detailed designer should be familiar with before applying the design procedure presented later in this chapter. Standard design considerations for the swale component of bioretention swales are discussed in detail in Chapter 2 (Swales) and are not reproduced here. However, other swale design considerations that relate specifically to the interactions between the swale and bioretention components are presented in the following sections together with design considerations relating specifically to the bioretention component.

(i) Landscape design

Bioretention swales may be located within parkland areas, easements, car parks or along roadway corridors within footpaths (i.e. road verges) or centre medians. Landscape design of bioretention swales along the road edge can assist in defining the boundary of road or street corridors as well as providing landscape character and amenity. It is therefore important that the landscape design of bioretention swales addresses stormwater quality objectives whilst also being sensitive to these other important landscape functions. It is also necessary to adequately address potential aesthetics issues such as weeds and sustaining perennial plants during the dry season.

(i) Hydraulic design

A key hydraulic design consideration for bioretention swales is the delivery of stormwater runoff from the swale onto the surface of a bioretention filter media. Flow must not scour the bioretention surface and needs to be uniformly distributed over the full surface area of the filter media. In steeper areas, check dams may be required along the swale to reduce flow velocities discharged onto the bioretention filter media.

It is important to ensure that velocities in the bioretention swale from both minor (2-10 year ARI) and major (50-100 year ARI) runoff events are kept sufficiently low (preferably below 0.5 m/s and not more than 2.0 m/s for major flood) to avoid scouring. This can be achieved by ensuring the slope and hydraulic roughness of the overlying swale reduce flow velocities by creating shallow temporary ponding (i.e. extended detention) over the surface of the bioretention filter media via the use of a check dam and raised field inlet pits. This may also increase the overall volume of stormwater runoff that can be treated by the bioretention filter media.

(iii) Ex-filtration to in-situ soils

Bioretention swales can be designed to either preclude or promote ex-filtration of treated stormwater to the surrounding in-situ soils depending on the overall stormwater management objectives established for the given project.

Where the concept design specifically aims to preclude ex-filtration of treated stormwater runoff it is necessary to consider if the bioretention swale needs to be provided with an impermeable liner. The amount of water lost from bioretention trenches to surrounding in-situ soils is largely dependent on the characteristics of the local soils and the saturated hydraulic conductivity of the bioretention filter media (see SC6.4.3.9.3(2)(a)(iii)).

If the selected saturated hydraulic conductivity of the bioretention filter media is less than 10 times that of the native surrounding soils, it may be necessary to provide an impermeable liner. Flexible membranes or a concrete casting are commonly used to prevent excessive ex-filtration. This is particularly applicable for surrounding soils that are very sensitive to any ex-filtration (e.g. sodic soils and reactive clays in close proximity to significant structures such as roads).

The greatest pathway of ex-filtration is through the base of a bioretention trench, as gravity and the difference in hydraulic conductivity between the filter media and the surrounding native soil would typically act to minimise ex-filtration through the walls of the trench. If lining is required, it is likely that only the base and the sides of the drainage layer (refer to SC6.4.3.9.3(2)(a)(iii)) will need to be lined.

Where ex-filtration of treated stormwater to the surrounding in-situ soils is promoted by the bioretention swale concept design, it is necessary to ensure the saturated hydraulic conductivity of the in-situ soils is at least equivalent to that of the bioretention filter media, thus ensuring no impedance of the desired rate of flow through the bioretention filter media. Depending on the saturated hydraulic conductivity of the in-situ soils it may be necessary to provide an impermeable liner to the sides of the bioretention filter media to prevent horizontal ex-filtration and subsequent short-circuiting of the treatment provided by the filter media. Bioretention trenches promoting ex-filtration do not require perforated under-drains at the base of the filter media or a drainage layer.

A subsurface pipe is often used to prevent water intrusion into a road sub-base. This practice is to continue as a precautionary measure to collect any water seepage from bioretention swales located along roadways.

(iv) Vegetation types

Bioretention swales can use a variety of vegetation types including turf (swale component only), sedges and tufted grasses. Vegetation is required to cover the whole width of the swale and bioretention filter media surface, be capable of withstanding design flows and be of sufficient density to prevent preferred flow paths and scour of deposited sediments.

Grassed (turf) bioretention swales can be used in residential areas where a continuous bioretention

trench approach is used. The preferred vegetation for the bioretention component of bioretention swales is therefore sedges and tufted grasses (with potential occasional tree plantings) that do not require mowing.

The denser and taller the vegetation planted in the bioretention filter media, the better the treatment provided, especially during extended detention. Taller vegetation has better interaction with temporarily stored stormwater during ponding, which results in enhanced sedimentation of suspended sediments and associated pollutants. The vegetation that grows in the bioretention filter media also acts to continuously break up the surface of the media through plant root growth and wind induced agitation, which prevents surface clogging. Vegetation also provides a substrate for biofilm growth in the upper layer of the filter media which facilitates biological transformation of pollutants (particularly nitrogen).

To maintain aesthetics in highly visible areas supplemental irrigation may be required to sustain vegetation. The incorporation of saturated zones beneath the bioretention filter media can help to sustain soil moisture and is beneficial for nitrogen removal from stormwater. The ability to sustain dense perennial vegetation is important for long term weed management.

SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics provides more specific guidance on the selection of appropriate vegetation for bioretention swales.

(v) Bioretention filter media

Selection of an appropriate bioretention filter media is a key design step involving consideration of three inter-related factors:

- (A) saturated hydraulic conductivity required to optimise the treatment performance of the bioretention component given site constraints on available filter media area;
- (B) depth of extended detention provided above the filter media; and
- (C) suitability as a growing media to support vegetation growth (i.e. retaining sufficient soil moisture and organic content).

The area available for bioretention swales in an urban layout is often constrained by factors such as the available area within the footpaths of standard road reserves. Selecting bioretention filter media for bioretention swale applications in the coastal dry tropics will often require careful consideration of saturated hydraulic conductivity and extended detention depth to ensure the desired minimum volume of stormwater runoff receives treatment. This must also be balanced with the requirement to also ensure the saturated hydraulic conductivity does not become too high such that it can no longer sustain healthy vegetation growth. The maximum saturated hydraulic conductivity should not exceed 500 mm/hr (and preferably be between 50 - 200 mm/hr) in order to sustain vegetation growth.

The concept design stage will have established the optimal combination of filter media saturated hydraulic conductivity and extended detention depth using a continuous simulation modelling approach (such as MUSIC). Any adjustment of either of these two design parameters during the detailed design stage will require the continuous simulation modelling to be re-run to assess the impact on the overall treatment performance of the bioretention system.

As shown in Figure SC6.4.3.9.2 below, bioretention media can consist of three or four layers. In addition to the filter media required for stormwater treatment, a saturated zone can also be added to enhance nitrogen removal and to provide a source of water for vegetation over the dry season. A drainage layer is also required to convey treated water from the base of the filter media or saturated zone into the perforated under-drains. The drainage layer surrounds the perforated under-drains and can be either coarse sand (1 mm) or fine gravel (2-5 mm). If fine gravel is used, a transition layer of sand must also be installed to prevent migration of the filter or saturated zone media into the drainage layer and subsequently into the perforated under-drains.

(vi) Saturated zone

The saturated zone design involves a relatively simple modification to a conventional bioretention system. An additional layer located below the filter media is designed to retain stormwater providing a saturated zone at the base of the bioretention system. A saturated zone can be formed by using a riser pipe with the outlet level higher than the drainage layer or by incorporating a weir within the outlet pit. The saturated zone holds water and therefore provides a source of water to maintain soil moisture for plant uptake during dry periods.

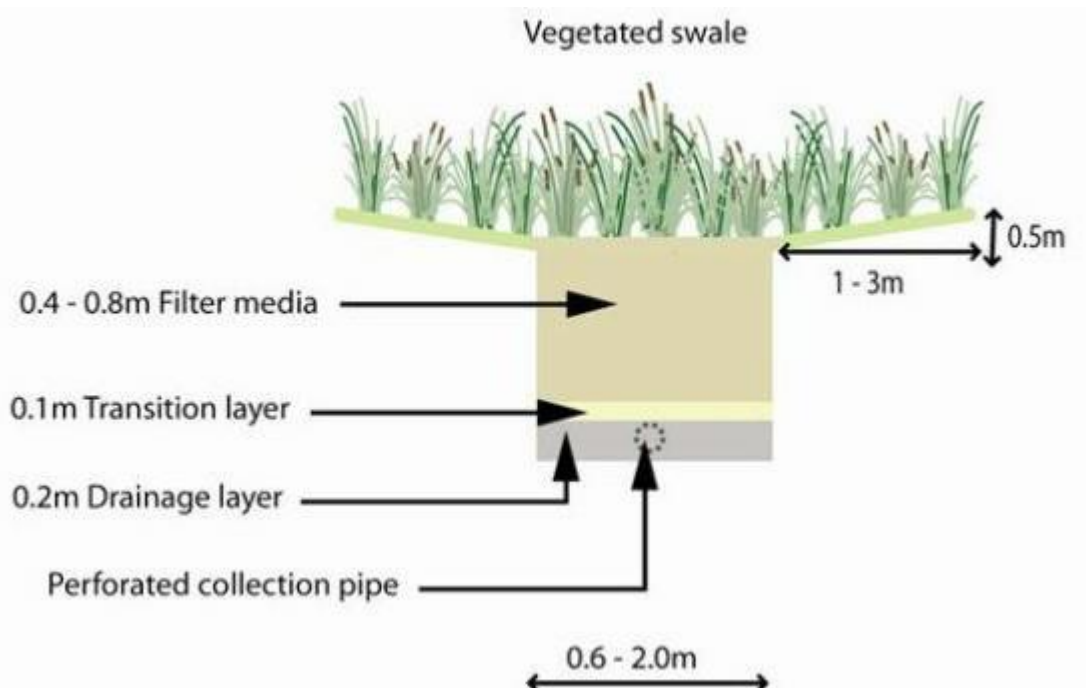


Figure SC6.4.3.9.2 Typical section of a bioretention swale

(vii) Traffic controls

Another design consideration is keeping traffic and building material deliveries off swales, particularly during the building phase of a development.

A staged construction and establishment method (SC6.4.3.9.3(5) Construction and establishment - bioretention swales) affords protection to the sub-surface elements of a bioretention swale from heavily sediment laden runoff during the subdivision construction and allotment building phases. However, to prevent vehicles driving on bioretention swales and inadvertent placement of building materials, it is necessary to consider appropriate traffic control solutions as part of the system design. These can include temporary fencing of the swale during the subdivision construction and allotment building phases with signage erected to alert builders and contractors of the purpose and function of the swales. Kerb and channel should be used at all corners, intersections, cul-de-sac heads and at traffic calming devices to ensure correct driving path is taken. For all of these applications, the kerb and channel is to extend 5 m beyond tangent points.

(viii) Roof water discharge

Roof runoff can contain a range of stormwater pollutants including nitrogen washed from the atmosphere during rainfall events. Roof water should be discharged onto the surface of the swale for subsequent conveyance and treatment by the swale (and downstream treatment measures) before being discharged to receiving aquatic environments. Depending on the depth of the roof water drainage system and the finished levels of the bioretention swale, this may require the use of a small surcharge pit located within the invert of the swale to allow the roof water to surcharge to the swale. Any residual water left in the surcharge pit can be discharged to the underlying subsoil drainage by providing perforations in the base and sides of the surcharge pit. If a surcharge pit is used then an inspection chamber along the roof water drainage line is to be provided within the property boundary. Surcharge pits are discussed further in SC6.4.3.9.3(3)(d)(ii) Concentrated inflow.

(ix) Services

Bioretention swales located within footpaths (i.e. road verges) must consider the standard location for services within the verge and ensure access for maintenance of services. Typically it is acceptable to have water and sewer services located beneath the batters of the swale with any sewers located beneath bioretention swales to be fully welded polyethylene pipes with rodding points.

(3) Bioretention swale design process

(a) Step 1: Confirm treatment performance of concept design

This design process assumes a conceptual design has been undertaken. Before commencing detailed design, the designer should first undertake a preliminary check to confirm the bioretention swale treatment area from the concept design is adequate to deliver the required level of stormwater quality improvement. This assessment should be undertaken by a WSUD specialist and can be achieved by modelling expected treatment performance in an appropriate quantitative modelling program. This modelling must be based on local rainfall data, the proposed configuration of the system, and based on local stormwater treatment performance data.

(b) Step 2: Determine design flows for the swale component

(i) Design flows

Two design flows are required for the design of a swale:

- (A) minor flood flow (2 year ARI) to allow minor floods to be safely conveyed. For commercial and industrial areas the design flow requirement for minor flows is a 5 year ARI event.
- (B) major flood flow (100 year ARI) to check flow velocities, velocity depth criteria, conveyance within road reserve, and freeboard to adjoining property.

(ii) Design flow estimation

A range of hydrologic methods can be applied to estimate design flows. As the typical catchment area should be relatively small (<50 ha) the Rational Method design procedure is considered to be a suitable method for estimating design peak flows.

(c) Step 3: Dimension the swale component with consideration to site constraints

Factors to consider are:

- (i) allowable width given the proposed road reserve and/ or urban layout;
- (ii) how flows are delivered into a swale (e.g. cover requirements for pipes or kerb details);
- (iii) vegetation height;
- (iv) longitudinal slope;
- (v) maximum side slopes and base width;
- (vi) provision of crossings (elevated or at grade); and
- (vii) requirements of QUDM and Townsville City Plan.

Depending on which of the above factors are fixed, the other variables can be adjusted to derive the optimal swale dimensions for the given site conditions. The following sections outline some considerations in relation to dimensioning a swale.

(i) Swale width and side slopes

Where the swale width is not constrained by an urban layout (e.g. when located within a large parkland area) then the width of the swale can be selected based on consideration of landscape objectives, maximum side slopes for ease of maintenance and public safety, hydraulic capacity required to convey the desired design flow, and treatment performance requirements. The maximum swale width needs to be identified early in the design process as it dictates the remaining steps in the swale design process. Selection of appropriate sideslopes for swales in parks, easements or median strips is heavily dependent on site constraints, and swale side slopes are typically between 1 in 10 and 1 in 4.

For swales located adjacent to roads, the types of driveway crossing used will typically dictate batter slopes. Where there are no driveway crossings, the maximum swale side slopes will be established for ease of maintenance and public safety considerations. Generally “at-grade”

crossings, are preferred which require the swale to have 1:9 side slopes with a nominal 0.5 m flat base to provide sufficient transitions to allow for traffic movement across the crossing. Flatter swale side slopes can be adopted but this will reduce the depth of the swale and its conveyance capacity. Where “elevated” crossings are used, swale side slopes would typically be between 1 in 6 and 1 in 4. “Elevated” crossings will require provision for drainage under the crossings with a culvert or similar.

(ii) Maximum length of a swale

The maximum length of a swale located within parkland areas and easements is calculated as the distance along the swale to the point where the flow in the swale from the contributing catchment (for the specific design flood frequency) exceeds the bank full capacity of the swale. For example, if the swale is to convey the minor flood flow (1-5 year ARI) without overflowing, then the maximum swale length would be determined as the distance along the swale to the point where the 1-5 year ARI flow from the contributing catchment is equivalent to the bank full flow capacity of the swale (bank full flow capacity is determined using Manning’s equation as discussed in SC6.4.3.9.3(c) (iii) Swale capacity).

(iii) Swale capacity – Manning’s Equation and selection of Manning’s n

To calculate the flow capacity of a swale, use Manning’s equation. This allows the flow rate and flood levels to be determined for variations in swale dimensions, vegetation type and longitudinal grade.

$$Q = \frac{A \cdot R^{2/3} \cdot S^{1/2}}{n}$$

Where A = cross section area of swale (m^2)
 R = hydraulic radius (m)
 S = channel slope (m/m)
 N = roughness factor (Manning’s n)

Figure SC6.4.3.9.3 shows a plot of Manning’s n versus flow depth for a grass swale with longitudinal grade of 5 %. It is reasonable to expect the shape of the Manning’s n relation with flow depth to be consistent with other swale configurations, with the vegetation height at the boundary between low flows and intermediate flows (Figure SC6.4.3.9.3) on the top axis of the diagram. The bottom axis of the plot has been modified from Barling and Moore (1993) to express flow depth as a percentage of vegetation height.

Further discussion on selecting an appropriate Manning’s n for a swale is provided in Appendix E of the MUSIC User Guide (CRCCH 2005).

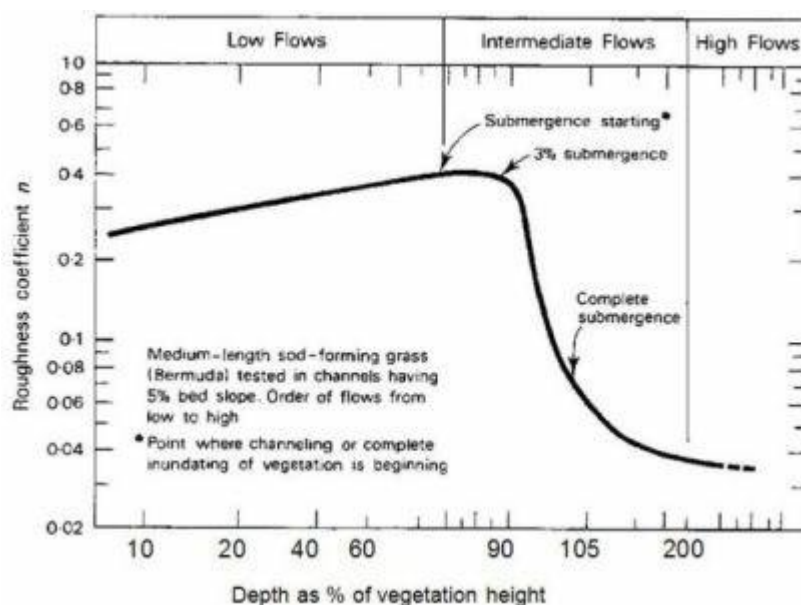


Figure SC6.4.3.9.3 Impact of flow depth on hydraulic roughness (adapted from Barling and Moore (1993))

(d) Step 4: Design inflow systems to swale and bioretention components

Inflows to bioretention swales can be via distributed runoff (e.g. from flush kerbs on a road) or point outlets such as pipe outfalls. Combinations of these inflow pathways can also be used.

(i) Distributed inflow

An advantage of flows entering a bioretention swale system in a distributed manner (i.e. entering perpendicular to the direction of the swale) is that flow depths are kept as shallow sheet flow, which maximises contact with the swale and bioretention vegetation, particularly on the batter receiving the distributed inflows. This swale and bioretention batter is often referred to as a buffer (see Figure SC6.4.3.9.4). The requirement of the buffer is to ensure there is dense vegetation growth, flow depths are shallow (below the vegetation height) and erosion is avoided. The buffer provides good pre-treatment (i.e. significant coarse sediment removal) prior to flows being conveyed along the swale.

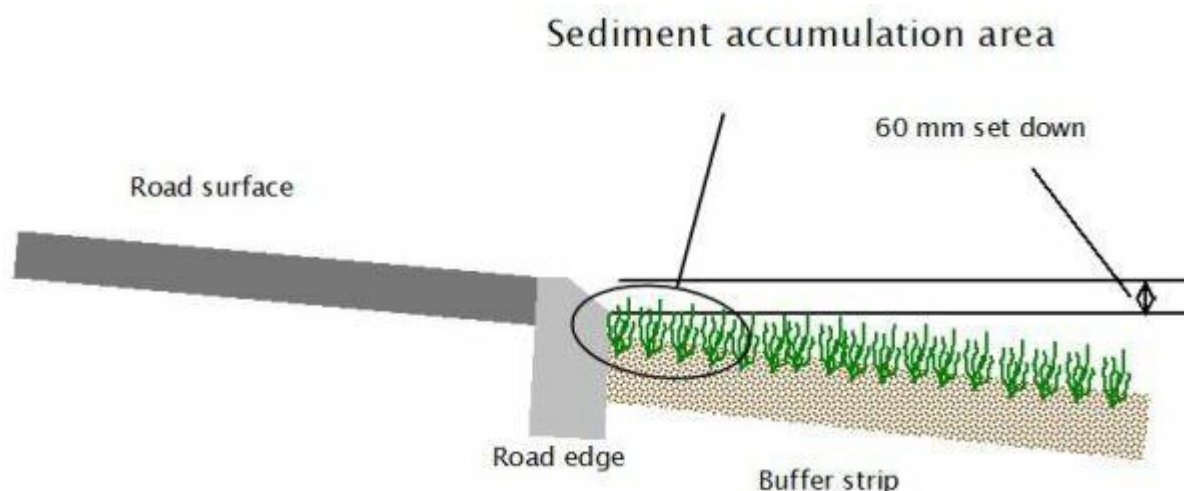


Figure SC6.4.3.9.4 Flush kerb with 60 mm setdown to allow sediment to flow into vegetated area

Distributed inflows can be achieved either by having a flush kerb or by using kerbs with regular breaks in them to allow for even flows across the buffer surface (Figure SC6.4.3.9.5).



Figure SC6.4.3.9.5 Kerb arrangements with breaks and flush kerbs to distribute inflows on to bioretention swales and prevent vehicle access

Key design parameters of buffer systems are:

- (A) providing distributed flows into a buffer (potentially spreading stormwater flows to achieve this);
- (B) avoiding rilling or channelised flows;
- (C) maintaining flow heights lower than vegetation heights (this may require flow spreaders, or check dams); and
- (D) minimising the slope of buffer, best if slopes can be kept below 5%.

Maintenance of buffers is required to remove accumulated sediment and debris therefore access is important. It is important to ensure coarse sediments accumulate off the road surface at the start

of the buffer. Figure SC6.4.3.9.6 shows sediment accumulating on a street surface where the vegetation is the same level as the road. To avoid this accumulation, a tapered flush kerb must be used that sets the top of the vegetation 60 mm which requires the top of the ground surface (before turf is placed) to be approximately 100 mm below the road surface. This allows sediments to accumulate off any trafficable surface.



Figure SC6.4.3.9.6 Flush kerb without setdown, showing sediment accumulation on road

(ii) Concentrated inflow

Concentrated inflows to a bioretention swale can be in the form of a concentrated overland flow or a discharge from a piped drainage system (e.g. allotment drainage line). For all concentrated inflows, energy dissipation at the inflow location is required to minimise any erosion potential. This can usually be achieved with rock benching and/ or dense vegetation.

The most common constraint on pipe systems discharging to bioretention swales is bringing the pipe flows to the surface of a swale. In situations where the swale geometry does not allow the pipe to achieve “free” discharge to the surface of the swale, a “surcharge” pit may be used but should be avoided where possible.

Surcharge pit systems are most frequently used when allotment runoff is required to cross a road into a swale on the opposite side of the road or for allotment runoff discharging into shallow profile swales. Where allotment runoff needs to cross under a road to discharge to a swale, it is preferable to combine the runoff from more than one allotment to reduce the number of crossings required under the road pavement. Figure SC6.4.3.9.7 illustrates a typical surcharge pit discharging into a swale.

Another important form of concentrated inflow in a bioretention swale is the discharge from the swale component into the bioretention component, particularly where the bioretention component is located at the downstream end of the overlying swale and receives flows concentrated within the swale. Depending on the grade, its top width and batter slopes, the resultant flow velocities at the transition from the swale to the bioretention filter media may require the use of energy dissipation to prevent scour of the filter media (if flow velocities > 0.5 m/sec). For most cases, this can be achieved by placing several large rocks in the flow path to reduce velocities and spread flows. Energy dissipaters located within footpaths must be designed to ensure pedestrian safety.

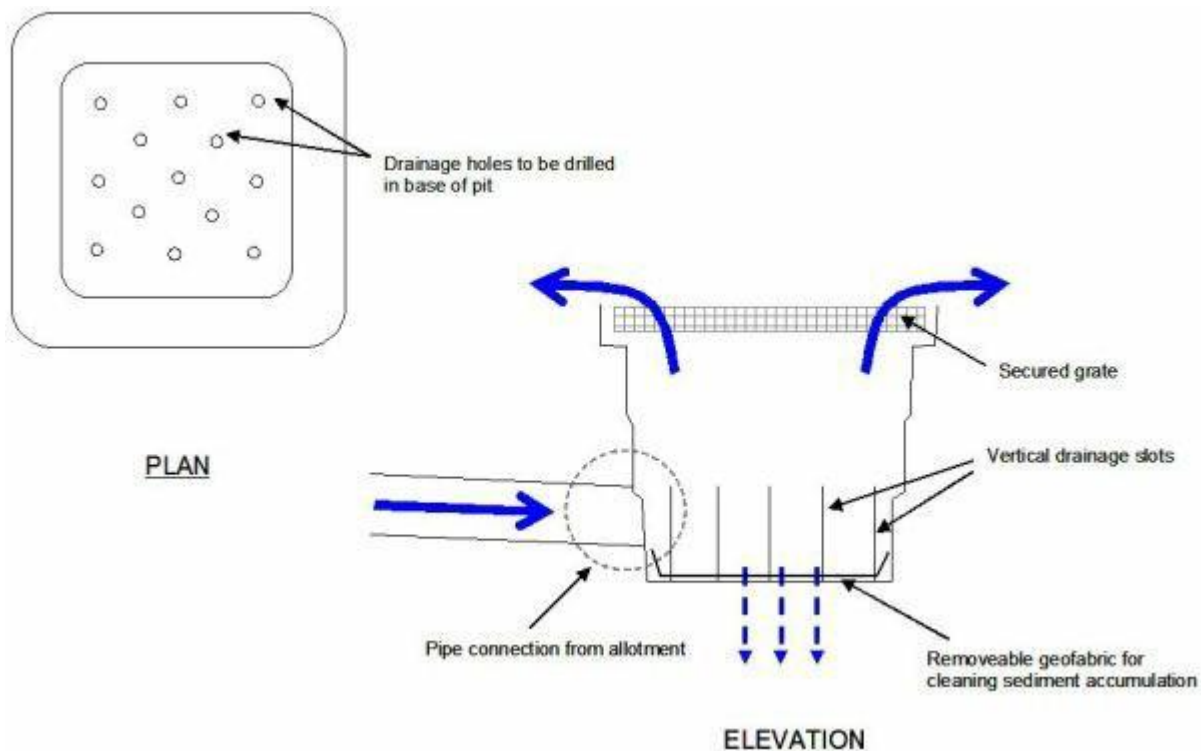


Figure SC6.4.3.9.7 Example of surcharge pit for discharging allotment runoff into a swale

(e) Step 5: Design bioretention component

(i) Select filter media saturated hydraulic conductivity and extended detention

Where design Steps 2 and 3 (SC6.4.3.9.3(3)(b) and SC6.4.3.9.3(3)(c)) reveal that the swale geometry derived during the concept design stage does not comply with the relevant local road drainage design standards and/or the standards established in QUDM for minor flood and major flood flows on adjoining road pavements and minimum freeboard requirements to adjoining properties, it is necessary to revise the swale geometry. As such, an alternative dimension for the surface area of the bioretention component may result and this may require further quantitative modelling to determine the “new” optimal combination of filter media saturated hydraulic conductivity and extended detention depth to maximise the water quality treatment function of the bioretention component.

(ii) Specify the bioretention filter media characteristics

Three to four types of media can be required in the bioretention component of bioretention swales (refer Figure SC6.4.3.9.2).

Filter media

The filter media layer provides the majority of the pollutant treatment function, through fine filtration and also by supporting vegetation. The vegetation enhances filtration, keeps the filter media porous, provides substrate for biofilm formation and provides some uptake of nutrients and other stormwater pollutants. As a minimum, the filter media is required to have sufficient depth to support vegetation. Typical depths are between 600-1000 mm with a minimum depth of 300 mm accepted in depth constrained situations. It is important to note that if deep rooted plants such as trees are to be planted in bioretention swales, the filter media must have a minimum depth of 800 mm to avoid roots interfering with the perforated under-drain system.

The saturated hydraulic conductivity of the filter media is established by optimising the treatment performance of the bioretention system given site constraints of the particular site (using a continuous simulation model). Saturated hydraulic conductivity should remain between 50-200 mm/hr (saturated hydraulic conductivity of greater than 500 mm/hr would not be accepted by most councils). Once the saturated hydraulic conductivity of the filter media has been determined for a particular bioretention swale, the following process can then be applied to derive a suitable filter media soil to match the design saturated hydraulic conductivity:

- (A) identify available sources of a suitable base soil (i.e. topsoil) capable of supporting vegetation growth such as a sandy loam or sandy clay loam. In-situ topsoil should be considered first before importing a suitable base soil. Any base soil found to contain high levels of salt (see last bullet point), extremely low levels of organic carbon (< 5%), or other extremes considered retardant to plant growth and denitrification should be rejected. The base soil must also be structurally sound and not prone to structural collapse as this can result in a significant reduction in saturated hydraulic conductivity. The risk of structural collapse can be reduced by ensuring the soil has a well graded particle size distribution with a combined clay and silt fraction of < 12%;
- (B) using laboratory analysis, determine the saturated hydraulic conductivity of the base soil using standard testing procedures (AS 4419-2003 Appendix H Soil Permeability). A minimum of five samples of the base soil should be tested. Any occurrence of structural collapse during laboratory testing must be noted and an alternative base soil sourced;
- (C) the required content of sand or clay (by weight) to be mixed to the base soil will need to be established in the laboratory by incrementally increasing the content of sand or clay until the desired saturated hydraulic conductivity is achieved. The sand or clay content (by weight) that achieves the desired saturated hydraulic conductivity should then be adopted on-site. A minimum of five samples of the selected base soil and sand (or clay) content mix must be tested in the laboratory to ensure saturated hydraulic conductivity is consistent across all samples. If the average saturated hydraulic conductivity of the final filter media mix is within $\pm 20\%$ of the design saturated hydraulic conductivity then the filter media can be adopted and installed in the bioretention system. Otherwise, further amendment of the filter media must occur through the addition of sand (or clay) and retested until the design saturated hydraulic conductivity is achieved;
- (D) the base soil must have sufficient organic content to establish vegetation on the surface of the bioretention system. If the proportion of base soil in the final mix is less than 50%, it may be necessary to add organic material. This should not result in more than 10% organic content (measured in accordance with AS 1289.4.1.1-1997) and should not alter the saturated hydraulic conductivity of the final filter media mix;
- (E) the pH of the final filter media is to be amended (if required) to between 6 and 7. If the filter media mix is being prepared off-site, this amendment should be undertaken before delivery to the site; and
- (F) the salt content of the final filter media (as measured by EC1:5) must be less than 0.63dS/m for low clay content soils like sandy loam. (EC1:5 is the electrical conductivity of a 1:5 soil/ water suspension).

Transition layer (if required)

The purpose of the transition layer is to prevent the filter media from migrating down into the drainage layer (or saturated layer). It also acts as a buffer between the permanently saturated zone and the filter media. This buffer is necessary to ensure the filter media is not saturated for prolonged periods during rainfall events due to increases in water levels in the saturated zone. To achieve this, the transition layer depth must be greater than the head created by flows over the saturated zone outlet weir.

It is required if the particle size difference between the filter media and the drainage layer (or saturated layer) is more than one order of magnitude. If a transition layer is required then the material must be a clean, well-graded sand/coarse sand material containing little or no fines.

The transition layer is recommended to be 100 mm thick and have a minimum saturated hydraulic conductivity of 1000 mm/hr.

A recent particle size distribution for the transition layer sand will need to be obtained to ensure that it meets the required grading/"bridging" criteria outlined below. The "bridging" criteria is based on the engineering principles that rely on the largest 15% of the filter media particles "bridging" with the smallest 15% of the sand particles. This results in smaller voids, which prevent the migration of the filter media particles into the sand particles. The following equation is taken from the United

States Golf Association's recommendations for golf course construction:

Bridging Factor: **D15 (transitional layer sand) $\leq$ 8 x D85 (filter media)**

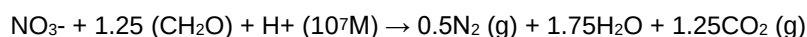
The addition of a transition layer increases the overall depth of the bioretention system and may be an important consideration for some sites where total depth of the bioretention system may be constrained. In such cases, the use of a sand drainage layer and/ or perforated pipes with smaller slot sizes may need to be considered (SC6.4.3.9.4(2)(e) Step 5: Design under-drain and undertake capacity checks (if required)).

Saturated layer (if required)

The saturated layer should be about 400 mm deep (but may deeper depending on the specific application) and composed of clean (i.e. free from fines) medium-coarse washed sand, gravel or small rock (50 mm diameter maximum) together with a long term carbon source. Hardwood wood chips, 5 mm to 40 mm in size, are recommended as the carbon source because they breakdown slowly to provide a long term carbon source yet have a decomposition rate that should not limit the denitrification process.

The total mass of carbon/electron donor that is required for denitrification must be calculated based on the expected stormwater influent TN mass over the desired life span of the system (e.g. 25 years). The calculation is based on the stoichiometry of the denitrification reaction (shown below).

Denitrification reaction:



Based on a 400 mm deep saturated zone and the modelled annual TN runoff mass (for Townsville) for a bioretention system that is 2% of the contributing 1ha catchment, the saturated zone media would have the following composition:

- 76.7 m³ washed coarse sand, gravel or small rock; and
- 3.3 m³ hardwood wood chips, well graded 5 mm-40 mm.

This is equivalent to an organic carbon content of approximately 4-5% by volume. If the saturated zone depth changed, or the bioretention system to catchment area ratio changed, the hardwood proportion would need to be recalculated using the denitrification stoichiometry.

Calculating Carbon Source for Saturated Zone with safety factor (x2)	
Catchment Area	1 ha
Treatment Area Required	2%
Bioretention Surface Area	200 m ²
Saturated Zone Depth	400 mm
Total volume of Saturated Zone	80 m ³
TN load 1 year	12.5 kg/yr
TN load 25 years	312.5 kg/25yrs
Stoichiometry:	
N:C ratio = 1:1.25 (mol), which equates to 14:15(g) [Mw: N = 14g/mol, C = 12g/mol]	
Average total carbon content of hardwood woodchips is 50%, therefore	
N:C (woodchip) = 14:30 (g)	
N:C (woodchip) = 1:2.1	
Woodchips (312.5 x 2.1)	656 kg/carbon
Safety Factor (x 2)	1313kg/carbon
Density of woodchips	400 kg/m ³ (approx.)
Hardwood Wood Chips	3.3 m³
Clean Coarse Sand	76.7 m³

The saturated media must have a hydraulic conductivity of >1000 mm/hr (the ASTM F1815-06 test method is to be used to measure hydraulic conductivity).

The saturated zone should be lightly compacted (e.g. with one pass of a smooth drum lawn roller) during installation to stabilise the structure. Under no circumstances should heavy compaction or multiple-passes be made.

Drainage layer (if required)

The drainage layer is used to convey treated flows from the base of the filter media layer (or saturated zone) into the perforated under-drainage system. The composition of the drainage layer is to be considered in conjunction with the selection and design of the perforated under-drainage system (refer to SC6.4.3.9.3(e)(iii)) as the slot sizes in the perforated pipes may determine the minimum drainage layer particle size to avoid washout of the drainage layer into the perforated pipe system. Coarser material (e.g. fine gravel) is to be used for the drainage layer if the slot sizes in the perforated pipes are too large for use of a sand based drainage layer. Otherwise, sand is the preferred drainage layer media as it is likely to avoid having to provide a transition layer between the filter media and the drainage layer (if there is no saturated zone). The drainage layer is to be a minimum of 200 mm thick.

Bridging Factor:

D15 (drainage gravel/sand) ≤ 8 x D85 (filter media/saturated zone/transition layer)

Ensure drainage media is washed prior to placement in bioretention system to remove any fines.

(iii) Under-drain design and capacity checks

The maximum spacing of the perforated pipes in wide bioretention trenches is 1.5 m (centre to centre) so that the distance water needs to travel (horizontally) through the drainage layer does not hinder drainage of the filtration media.

By installing parallel pipes, the capacity of the perforated pipe under-drain system can be increased. The recommended maximum size for the perforated pipes 100 mm to minimise the required thickness of the drainage layer. Either flexible perforated pipe (e.g. ag pipe) or slotted

PVC pipes can be used, however care needs to be taken to ensure that the slots in the pipes are not so large that sediment would freely flow into the pipes from the drainage layer. This is also a consideration when specifying the drainage layer media.

To ensure the slotted pipes are of adequate size, several checks are required:

- ensure perforations are adequate to pass the maximum infiltration rate;
- ensure the pipe itself has capacity to convey the design flow/ infiltration rate; and
- ensure that the material in the drainage layer will not be washed into the perforated pipes (consider a transition layer).

The maximum infiltration rate represents the maximum rate of flow through the bioretention filter media and is calculated by applying Darcy's equation (Equation 3.2) as follows:

$$Q_{\max} = K_{\text{sat}} \cdot L \cdot W_{\text{base}} \cdot \frac{h_{\max} + d}{d}$$

Where $Q_{\max}$	=	maximum infiltration rate (m ³ /s)
K_{sat}	=	hydraulic conductivity of the soil filter (m/s)
W_{base}	=	base width of the ponded cross section above the soil filter (m)
L	=	length of the bioretention zone (m)
$h_{\max}$	=	depth of pondage above the soil filter (m)
d	=	depth of filter media (m)

The capacity of the perforated under-drains need to be greater than the maximum infiltration rate to ensure the filter media drains freely and the pipe(s) do not become the hydraulic “control” in the bioretention system (i.e. to ensure the filter media sets the travel time for flows percolating through the bioretention system rather than the perforated under-drainage system).

To ensure the perforated under-drainage system has sufficient capacity to collect and convey the maximum infiltration rate, it is necessary to determine the capacity for flows to enter the under-drainage system via perforations in the pipes. To do this, orifice flow can be assumed and the sharp edged orifice equation can be used. Firstly, the number and size of perforations needs to be determined (typically from manufacturer's specifications) and used to estimate the flow rate into the pipes using the maximum driving head (being the depth of the filtration media if no extended detention is provided or if extended detention is provided in the design then to the top of extended detention). It is conservative but reasonable to use a blockage factor to account for partial blockage of the perforations by the drainage layer media. A 50% blockage of the perforation is recommended.

$$Q_{\text{perf}} = B \cdot C_d \cdot A \sqrt{2 \cdot g \cdot h}$$

Where Q_{perf}	=	flow through perforations (m ³ /s)
B	=	blockage factor (0.5)
C_d	=	orifice discharge coefficient (assume 0.61 for sharp edge orifice)
A	=	total area of the orifice (m ²)
g	=	gravity (9.79 m/s ²)
h	=	head above the perforated pipe (m)

If the capacity of the drainage system is unable to collect the maximum infiltration rate then additional under- drains will be required.

After confirming the capacity of the under-drainage system to collect the maximum infiltration rate it is then necessary to confirm the conveyance capacity of the underdrainage system is sufficient to convey the collected runoff. To do this, Manning's equation (Equation 3.1) can be used (which assumes pipe full flow (in place of channel flow) but not under pressure). The Manning's roughness used will be dependent on the type of pipe used. When a saturated zone is incorporated into the design, the underdrainage pipes are laid flat however the conveyance capacity can be calculated using the Manning's equation with an assumed friction slope of 0.5%.

The under-drains should be extended vertically to the surface of the bioretention system to allow inspection and maintenance when required. The vertical section of the under-drain should be unperforated and capped to avoid short circuiting of flows directly to the drain.

In bioretention systems with a saturated zone, the capacity of the weir or up-turned pipe (maintaining the water level within the saturated zone) must also be checked to ensure it does not become the hydraulic “control” in the bioretention system (i.e. to ensure the filter media sets the travel time for flows percolating through the bioretention system). A broad crested weir equation can be used to determine the length of weir required (assuming free flowing conditions) to convey the maximum flow/filtration rate. The maximum depth of flow over the weir is to be 100 mm. This is important to limit increase in the saturated zone depth and avoid prolonged saturation of the filter media.

(iv) Check requirement for impermeable lining

The saturated hydraulic conductivity of the natural soil profile surrounding the bioretention system should be tested together with depth to groundwater, chemical composition and proximity to structures and other infrastructure. This is to establish if an impermeable liner is required at the base (only for systems designed to preclude ex-filtration to in-situ soils) and/or sides of the bioretention system (refer also to discussion in SC6.4.3.9.3(2)(a)(iii) Ex-filtration to in-situ soils). If the saturated hydraulic conductivity of the filter media in the bioretention system is more than one order of magnitude (10 times) greater than that of the surrounding in-situ soil profile, no impermeable lining is required.

(f) Step 6: Verify design

(i) Vegetation scour velocity check

Potential scour velocities are checked by applying Manning’s equation (Equation 3.1) to the bioretention swale design to ensure the following criteria are met:

- (A) less than 0.5 m/s for minor flood (2-10 year ARI) discharge; and
- (B) less than 2.0 m/s for major flood (50-100 year ARI) discharge.

(ii) Velocity and depth check – safety

As bioretention swales are generally accessible by the public, it is important to check that depth x velocity within the bioretention swale, at any crossings and adjacent pedestrian and bicycle pathways, satisfies the following public safety criteria:

- (A) depth x velocity < 0.6 m²/s for low risk locations and 0.4 m²/s for high risk locations as defined in QUDM; and
- (B) maximum depth of flow over crossing = 0.3 m.

(iii) Confirm treatment performance

If the previous two checks are satisfactory then the bioretention swale design is satisfactory from a conveyance function perspective and it is now necessary to confirm the treatment performance of the bioretention swale by reference to the performance information presented in SC6.4.3.9.3(3)(a)).

(g) Step 7: Size overflow pit (field inlet pits)

In a bioretention swale system, an overflow pit can be provided flush with the invert of the swale and/ or bioretention system filter media (i.e. when no extended detention is provided in the design) or it can be provided with the pit crest raised above the level of the bioretention filter media to establish the design extended detention depth (if extended detention is provided for in the design).

Grated pits are typically used and the allowable head for discharges into the pits is the difference in level between the pit crest and the maximum permissible water level to satisfy the local council’s minimum freeboard requirements. Depending on the location of the bioretention swale, the design flow to be used to size the overflow pit could be the maximum capacity of the swale, the minor flood flow (2-5 year ARI) or the major flood flow (50 year ARI). There should be a minimum of 100 mm head over the overflow pit crest to facilitate discharge of the design flow into the overflow pit.

To size an overflow pit, two checks should be made to test for either drowned or free flowing conditions. A broad crested weir equation can be used to determine the length of weir required (assuming free overflowing conditions) and an orifice equation used to estimate the area between openings required in the grate cover (assuming drowned outlet conditions). The larger of the two pit configurations should be adopted (as per Section 7.05 QUDM). In addition, a blockage factor is to be used, that assumes the grate is 50% blocked.

For free overfall conditions (weir equation):

$$Q_{\text{weir}} = B \cdot C_w \cdot L \cdot h^{3/2}$$

Where

Q_{weir}	=	Flow into pit (weir) under free overfall conditions (m ³ /s)
B	=	Blockage factor (= 0.5)
C_w	=	Weir coefficient (= 1.66)
L	=	Length of weir (perimeter of pit) (m)
h	=	Flow depth above the weir (pit) (m)

Once the length of weir is calculated, a standard sized pit can be selected with a perimeter at least the same length of the required weir length.

For drowned outlet conditions (orifice equation):

$$Q_{\text{orifice}} = B \cdot C_d \cdot A \cdot \sqrt{2 \cdot g \cdot h}$$

Where B , g and h have the same meaning as in Equation 3.4

Q_{orifice}	=	flow rate into pit under drowned conditions (m ³ /s)
C_d	=	discharge coefficient (drowned conditions = 0.6)
A	=	area of orifice (perforations in inlet grate) (m ²)

When designing grated field inlet pits, reference is also to be made to the procedure described in QUDM Section 7.05.4 (DNRW, IPWEA and BCC, 1998).

When a saturated zone is included in the design of a bioretention system, additional components must be incorporated into the outlet design. A saturated zone can be formed at the base of a bioretention system by using a riser pipe with the outlet level set at the top of the desired saturation depth (i.e. top of the saturated zone) or by incorporating a weir/overflow structure within the outlet pit (see Figure SC6.4.3.9.22). The saturated zone would hold water rather than draining freely, and would therefore provide a source of water to the plants during dry periods.

- (h) Step 8: Make allowances to preclude traffic on swales
Refer to SC6.4.3.9.3(a)(vii) for discussion on traffic control options.
- (i) Step 9: Specify plant species and planting densities
Refer to SC6.4.3.9.3(4) Landscape design notes - bioretention swales and SC6.4.3.6 Landscape policy for advice on selecting suitable plant species for bioretention swales in the coastal dry tropics. Consultation with landscape architects is recommended when selecting vegetation to ensure the treatment system compliments the landscape design of the area.
- (j) Step 10: Consider maintenance requirements
Consider how maintenance is to be performed on the bioretention swale (e.g. how and where is access available, where is litter likely to collect etc.). A specific maintenance plan and schedule should be developed for the bioretention swale in accordance with SC6.4.3.9.3(6) Maintenance requirements - bioretention swales.
- (k) Design calculation summary
The following design calculation table (Table SC6.4.3.9.4) can be used to summarise the design data and calculation results from the design process.

Click here to view **Table SC6.4.3.9.4 Bioretention swales design calculation summary**

- (l) Typical design parameters

Table SC6.4.3.9.5 Typical design parameters for bioretention swales

Design Parameter	Typical Values
Swale longitudinal slope	1% to 4%
Swale side slope for trafficability (with “at grade” crossover)	Maximum 1 in 9
Swale side slope (with elevated driveway crossover)	1 in 4 to 1 in 10
Manning's <i>n</i> (with flow depth lower than vegetation height)	0.15 to 0.3
Manning's <i>n</i> (with flow depth greater than vegetation height)	0.03 to 0.05
Maximum velocity for scour in minor event (e.g. 2-10yr ARI)	0.5 m/s
Maximum velocity for 50-100yr ARI	2.0 m/s
Perforated pipe size	100 mm (maximum)
Drainage layer average material diameter (typically fine gravel or coarse sand)	1-5 mm diameter
Transition layer average material diameter typically sand to coarse sand	0.7 – 1.0 mm diameter

(4) Landscape design notes - bioretention swales

Bioretention swales are a combined solution that involves integrating a swale with the filtration function of a bioretention basin/trench. These can involve an extended detention treatment and some biological uptake through the planted bioretention component. The landscaping for both the swale and bioretention parts are essentially similar to the treatments for the stand alone components however consideration of the interface landscape between the vegetated swale and bioretention is important.

(a) Objectives

Landscape design for bioretention swales has four key objectives:

- (i) ensure surface treatments and planting designs address stormwater quality objectives by incorporating appropriate plant species for stormwater treatment (biologically active root zone) whilst enhancing the overall natural landscape. This includes requirements for maintaining dense perennial vegetation throughout the dry season to maintain aesthetics and to minimise weed growth;
- (ii) integrated planning and design of bioretention swales within the built and landscape environments;
- (iii) incorporating crime prevention through environmental design (CPTED) principles and road, driveway and footpath visibility safety standards; and
- (iv) create landscape amenity opportunities that enhance community and environmental needs, such as visual aesthetics, shade, screening, view framing, and way finding.

(b) Streetscape bioretention systems

When using bioretention swales in road reserves it is important to understand how the swale landscape can be used to define the visual road space. Creative landscape treatments may be possible given that the bioretention swale element will typically be a minimum of 4 m in width. Design responses may range from informal “natural” planting layouts to regimented avenues of trees along each external and internal edge of the bioretention swale element. Bioretention swales can be incorporated into a typical streetscape landscape using either a central splitter median or using one side of the road reserve.

Bioretention swale surface treatments are generally a vegetated swale that integrates into a densely planted bioretention component. The use of turf for the bioretention parts of the system is discouraged as mowing and public use of these areas will compact the upper filter media and limit the amount of filtration.

Vegetated bioretention swales can provide a relatively maintenance free finish if the planting and invert treatment are designed well. Key considerations when detailing are density and types of plantings, locations of trees and shrubs, type of garden (mowing) edges to turf areas that allows unimpeded movement of stormwater flow and overall alignment of swale invert within the streetscape.

(i) Centre median

Generally, the central median swale will provide a greater landscaped amenity, allowing planting and shade trees to enhance the streetscape more effectively, whilst verges remain constraint free. This swale configuration is however confined to roads requiring larger corridors for increased traffic.

This can be seen in Figure SC6.4.3.9.8 and Figure SC6.4.3.9.9.

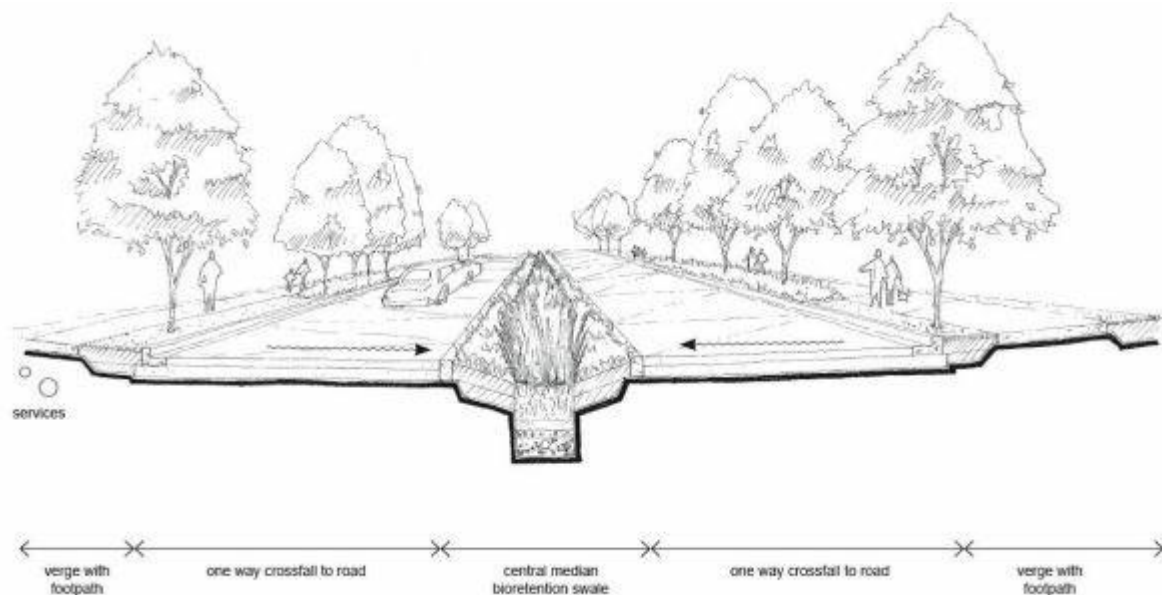


Figure SC6.4.3.9.8 Bioretention swale in centre median



Figure SC6.4.3.9.9 Median strip bioretention applications

(ii) Side of road

In smaller minor roads, one side of the road can have a swale landscape to capture stormwater runoff from road pavements and house lots. To enhance the visual road space, creative landscape treatments to driveway cross-overs, general planting and invert treatments should be used. It is important in this swale arrangement that services and footpaths that are standard for road verges have been planned and located to avoid clashes of function. This can be seen in Figure SC6.4.3.9.10.

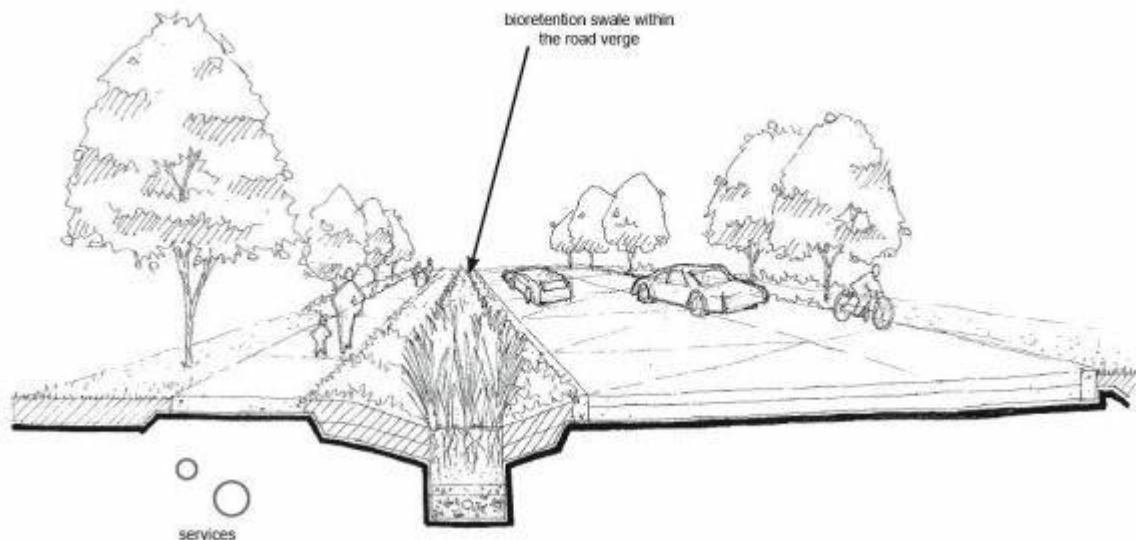


Figure SC6.4.3.9.10 Bioretention swale within road verge

(c) Civic and urban spaces

With increasing population growth in the coastal dry tropics, gentrification of urban areas is required to create more robust spaces that meet current environmental and social needs. Often constrained by existing infrastructure, landscape treatments of swales can have a dual role of providing functional stormwater quality objectives whilst creating landscapes that enhance the communities' perception of water sensitive design.

By creating hard useable edges to swales and using complimentary planting strategies, civic spaces can provide an aesthetic landscape that meets recreational uses and promotes water sensitive design to the community. Refer to Figure SC6.4.3.9.11 for an illustrative example.



Figure SC6.4.3.9.11 Swale treatment in civic space

(d) Appropriate plant species

Planting for bioretention swale elements may consist of up to four vegetation types:

- (i) groundcovers for stormwater treatment and erosion protection (required element);
- (ii) shrubbery for screening, glare reduction, character, and other values;
- (iii) street trees for shading, character and other landscape values; and
- (iv) existing vegetation.

It is important to note that deep rooted plants such as trees are to be planted towards the top of the swale bank rather than near the bioretention trench, to avoid roots interfering with the underdrain system.

Where the landscape design includes canopy layers, more shade tolerant species should be selected for the groundcover layer. Trees and shrubbery should be managed so that the groundcover layer is not out-competed. If this does occur, replacement planting and possible thinning of the upper vegetation layers may be required.

(v) Groundcovers, shrubs and street trees

Refer to SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics for guidance on selecting suitable plant (including turf) species and cultivars that meet the functional requirements of bioretention swales to deliver the desired stormwater quality objectives.

(vi) Existing vegetation

Existing vegetation, such as remnant native trees, within the bioretention swale alignment may be nominated for retention. In this case, the swale will need to be diverted or piped to avoid the vegetation's critical root zone (equivalent to 0.5 m beyond the vegetation's drip line).

(e) Safety issues

Bioretention swales within streetscapes and parks need to be generally consistent with public safety requirements for new developments. These include reasonable batter profiles for edges, providing adequate barriers to median swales for vehicle/pedestrian safety and safe vertical heights from driveways to intersecting swale inverts.

(i) Crime prevention through environmental design (CPTED)

Landscape design of bioretention swales need to accommodate the standard principles of informal surveillance, exclusion of places of concealment and open visible areas. Regular clear sightlines should be provided between the roadway and footpaths/ property. Where planting may create places of concealment or hinder informal surveillance, groundcovers and shrubs should not generally exceed 1 m in height.

(ii) Traffic sightlines

The standard rules of sightline geometry apply – planting designs should allow for visibility at pedestrian crossings, intersections, rest areas, medians, driveways and roundabouts. Refer to the *Road Landscape Manual* (DMR 1997) for further guidance.

(5) Construction and establishment - bioretention swales

This section provides general advice for the construction and establishment of bioretention swales and key issues to be considered to ensure their successful establishment and operation.

(a) Staged construction and establishment method

(i) Construction and establishment challenges

There exist a number of challenges that must be appropriately considered to ensure successful construction and establishment of bioretention swales. These challenges are best described in the context of the typical phases in the development of a greenfield or infill development, namely the subdivision construction phase and the building phase (see Figure SC6.4.3.9.13).

(A) Subdivision construction - the risks to successful construction and establishment of the WSUD systems during this phase of work have generally related to the following:

- construction activities which can generate large sediment loads in runoff which can smother vegetation and clog bioretention filter media; and

- construction traffic and other works can result in damage to the bioretention swales. Importantly, all works undertaken during Subdivision Construction are normally “controlled” through the principle contractor and site manager. This means the risks described above can be readily managed through appropriate guidance and supervision.
- (B) Building phase - the allotment building phase (see Figure SC6.4.3.9.12) represents the greatest risk to the successful establishment of bioretention swales.



Figure SC6.4.3.9.12 Example of building phase

- (ii) Staged construction and establishment method
- To overcome the challenges associated within delivering bioretention swales a staged construction and establishment method should be adopted (see Figure SC6.4.3.9.13).
- (A) Stage 1: Functional installation - construction of the functional elements of the bioretention system at the end of subdivision construction (i.e. during landscape works) and the installation of temporary protective measures.
- (B) Stage 2: Sediment and erosion control – during the building phase the temporary protective measures preserve the functional infrastructure of the bioretention swales against damage whilst also providing a temporary erosion and sediment control facility throughout the building phase to protect downstream aquatic ecosystems.
- (C) Stage 3: Operational establishment - at the completion of the building phase, the temporary measures protecting the functional elements of the bioretention swales can be removed along with all accumulated sediment and the system planted in accordance with the design planting schedule.

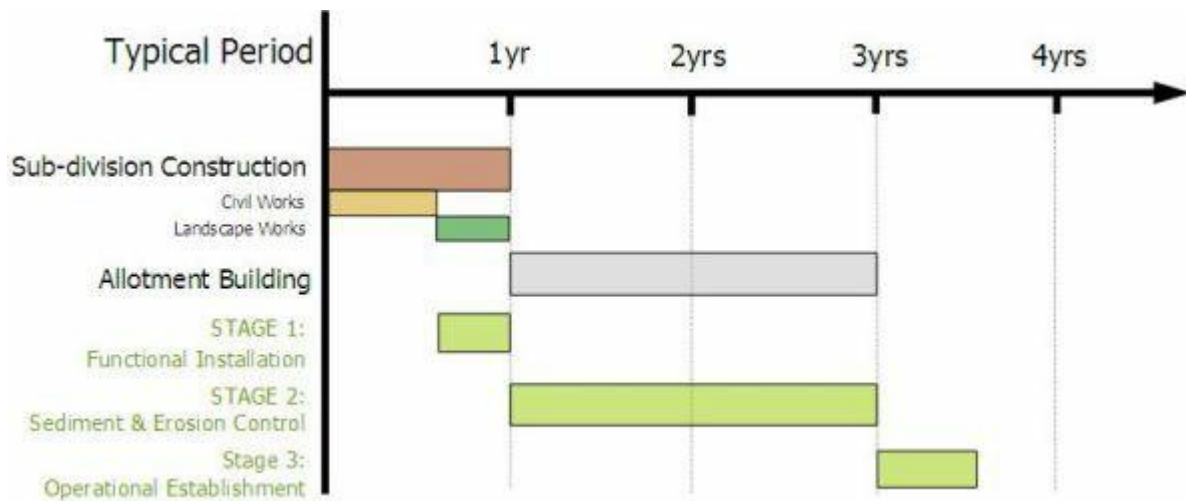


Figure SC6.4.3.9.13 Staged construction and establishment method

(iii) Functional installation

Functional installation of bioretention swales (see Figure SC6.4.3.9.14) occurs at the end of subdivision construction as part of landscape works and involves:

- (A) bulking out and trimming;
- (B) installation of the outlet structures;
- (C) placement of liner and installation of drainage layer (i.e. under-drains and drainage layer);
- (D) placement of filter media;
- (E) placement of a temporary protective layer - covering the surface of filtration media with geofabric and placement of 25 mm topsoil and turf over geofabric. This temporary geofabric and turf layer will protect the bioretention system during construction (subdivision and building phases) ensuring sediment/litter laden waters do not enter the filter media causing clogging; and
- (F) place silt fences around the boundary of the bioretention swale to exclude silt and restrict access.



Figure SC6.4.3.9.14 Bioretention swale functional installation

(iv) Sediment and erosion control

The temporary protective layers are left in place through the allotment building phase to ensure sediment laden waters do not clog the filtration media and allotment building traffic does not enter the bioretention swale (see Figure SC6.4.3.9.15). Importantly the configuration of the bioretention swale and the turf vegetation allow the system to function effectively as a shallow sedimentation

basin reducing the load of coarse sediment discharging to the receiving environment. Using this approach, WSUD systems can operate effectively to protect downstream ecosystems immediately after construction.



Figure SC6.4.3.9.15 Bioretention swale sediment and erosion control

(v) Operational establishment

At the completion of the allotment building phase the temporary measures are removed with all accumulated sediment and the bioretention swale re-profiled and planted in accordance with the proposed landscape design. Establishment of the vegetation to design condition can require more than two growing seasons, depending on the vegetation types, during which regular watering and removal of weeds will be required.

(b) Sourcing bioretention vegetation

The minimum recommended lead time for ordering is 3-6 months. This usually allows enough time for plants to be grown to the required size. The following pot sizes are recommended as the minimum:

- (i) viro tubes 50 mm wide x 85 mm deep;
- (ii) 50 mm tubes 50 mm wide x 75 mm deep; and
- (iii) native tubes 50 mm wide x 125 mm deep.

(c) Vegetation establishment

The following weed control measures and watering schedule are recommended to ensure successful plant establishment. Regular general maintenance as outlined in SC6.4.3.9.3(6) Maintenance requirements - bioretention swales will also be required.

(i) Weed control

Conventional surface mulching of bioretention swales with organic material like tanbark, should not be undertaken. Most organic mulch floats and runoff typically causes this material to be washed away with the risk of blockage of drains occurring. Weed management will need to be done manually until such time that the design vegetation is established with sufficient density to effectively prevent weed propagation.

(ii) Watering

Regular watering of bioretention swale vegetation is essential for successful establishment and healthy growth and weed reduction. The frequency of watering to achieve successful plant establishment is dependent upon rainfall, maturity of planting stock and the water holding capacity of the soil. The following watering program is generally adequate but should be adjusted (increased) to suit the site conditions:

- (A) Week 1-2 3 visits/ week;

(B) Week 3-6 2 visits/ week; and

(C) Week 7-12 1 visit/ week.

After this initial three month period, temporary, supplementary irrigation will be required in bioretention swales without submerged zones and may be required in bioretention swales with submerged zones (particularly during the 2 year plant establishment period). Watering requirements to sustain healthy vegetation should be determined during ongoing maintenance site visits.

(6) Maintenance requirements - bioretention swales

Bioretention swales have a flood conveyance role that needs to be maintained to ensure adequate flood protection for local properties. Vegetation plays a key role in maintaining the porosity of the soil media of the bioretention system and a strong healthy growth of vegetation is critical to its performance.

(a) Typical maintenance of bioretention swale elements will involve:

- (i) routine inspection of the swale profile to identify any areas of obvious increased sediment deposition, scouring of the swale invert from storm flows, rill erosion of the swale batters from lateral inflows, damage to the swale profile from vehicles and clogging of the bioretention trench (evident by a “boggy” swale invert);
- (ii) routine inspection of inlet points (if the swale does not have distributed inflows), surcharge pits and field inlet pits to identify any areas of scour, litter build up and blockages;
- (iii) removal of sediment where it is impeding the conveyance of the swale and/ or smothering the swale vegetation, and if necessary, reprofiling of the swale and revegetating to original design specification;
- (iv) repairing any damage to the swale profile resulting from scour, rill erosion or vehicle damage;
- (v) tilling of the bioretention trench surface if there is evidence of clogging;
- (vi) clearing of blockages to inlet or outlets;
- (vii) regular watering/ irrigation of vegetation until plants are established and actively growing (see SC6.4.3.9.3(5)(c) Vegetation establishment);
- (viii) mowing of turf or slashing of vegetation (if required) to preserve the optimal design height for the vegetation;
- (ix) removal and management of invasive weeds;
- (x) removal of plants that have died and replacement with plants of equivalent size and species as detailed in the plant schedule;
- (xi) pruning to remove dead or diseased vegetation material and to stimulate new growth;
- (xii) litter and debris removal; and
- (xiii) vegetation pest monitoring and control.

(b) Additional maintenance required if a saturated zone is included in the design:

- (i) check weir/up-turned pipe is clear of debris; and
- (ii) check water level in the saturated zone is at the design level.

(c) Resetting (i.e. complete reconstruction) of bioretention elements will be required if the available flow area of the overlying swale is reduced by 25% (due to accumulation of sediment) or if the bioretention trench fails to drain adequately after tilling of the surface. Inspections are also recommended following large storm events to check for scour.

(d) All maintenance activities must be specified in a maintenance plan (and associated maintenance inspection forms) to be developed as part of the design procedure. Maintenance personnel and asset managers will use this plan to ensure the bioretention swales continue to function as designed. The maintenance plans and forms must address the following:

- (i) inspection frequency;
- (ii) maintenance frequency;
- (iii) data collection/ storage requirements (i.e. during inspections);

- (iv) detailed cleanout procedures (main element of the plans) including:
 - (A) equipment needs;
 - (B) maintenance techniques;
 - (C) occupational health and safety;
 - (A) public safety;
 - (B) environmental management considerations;
 - (C) disposal requirements (of material removed);
 - (D) access issues;
 - (E) stakeholder notification requirements; and
 - (F) data collection requirements (if any); and
- (v) design details.

An example operation and maintenance inspection form is included in the checking tools provided in SC6.4.3.9.3(7).

(7) Checking tools - bioretention swales

A number of checking aids have been developed for designers and council development assessment officers. In addition, advice on construction techniques and lessons learnt from building bioretention swale systems are provided.

(a) Design assessment

The checklist at Table SC6.4.3.9.6 presents the key design features to be reviewed when assessing design of a bioretention swale. These considerations include configuration, safety, maintenance and operational issues that need to be addressed during the design phase. Where an item results in an “N” when reviewing the design, referral is to be made back to the design procedure to determine the impact of the omission or error.

In addition to the checklist, a proposed design is to have all necessary permits for its installations. Council development assessment officers need to ensure that all relevant permits are in place. These can include permits to clear vegetation, to dredge, create a waterbody, divert flows or disturb fish or platypus habitat.

[Click here to view Table SC6.4.3.9.6 Bioretention swale design assessment checklist](#)

(b) Construction (during and post)

The checklist at Table SC6.4.3.9.7 presents the key items to be reviewed when inspecting the bioretention swale during and at the completion of construction. The checklist is to be used by construction site supervisors and compliance inspectors to ensure all the elements of the bioretention system have been constructed in accordance with the design. If an item receives an “N” in Satisfactory criteria then appropriate actions must be specified and delivered to rectify the construction issue before final inspection sign-off is given.

[Click here to view Table SC6.4.3.9.7 Bioretention swale construction inspection checklist](#)

(c) Operation and maintenance inspection

The form at Table SC6.4.3.9.8 is to be used whenever an inspection is conducted and kept as a record on the asset condition and quantity of removed pollutants over time.

[Click here to view Table SC6.4.3.9.8 Bioretention swale maintenance checklist](#)

(d) Asset transfer (following defects period)

Land ownership and asset ownership are key considerations prior to construction of a stormwater

treatment device. A proposed design is to clearly identify the ultimate asset owner and who is responsible for its maintenance. Local authorities will use the asset transfer checklist at Table SC6.4.3.9.9 when the asset is to be transferred to the local authority.

[Click here to view Table SC6.4.3.9.9 Bioretention swale asset transfer checklist](#)

(8) Engineering drawings - bioretention swales

The relevant local authority should be consulted to source standard drawings applicable to bioretention swales. These drawings may provide example dimensions for a number of different road reserve configurations. Standard drawings are not intended to be prescriptive drawings which must be adhered to, rather they are intended to provide detailed examples of swales which can be incorporated into commonly used urban subdivision layouts. Designers are encouraged to develop alternative bioretention swale designs to suit site specific conditions.

In the absence of locally specific guidelines, Brisbane City Council (BCC) standard drawings applicable to swales and bioretention systems are UMS 151-158. These may also be used as reference standards for swale design. BCC Standard drawings are available online.

(9) References - bioretention swales

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SC6.4.3.9.4 Bioretention basins

- (1) Bioretention basins are vegetated areas where runoff is filtered through a filter media layer (e.g. sandy loam) as it percolates downwards. It is then collected via perforated under-drains and flows to downstream waterways or to storages for reuse. Bioretention basins often use temporary ponding above the filter media surface to increase the volume of runoff treated through the filter media. They treat stormwater in the same way as bioretention swales; however, “above design” flows are conveyed through overflow pits or bypass paths rather than over the filter media. This has the advantage of protecting the filter media surface from high velocities that can dislodge collected pollutants or scour vegetation.

Bioretention basins are generally not intended to be “infiltration” systems that discharge from the filter media to surrounding in-situ soils. Rather, the typical design intent is to recover stormwater at the base of the filter media in perforated under-drains and discharge to receiving waterways or to storages for potential reuse.

Figure SC6.4.3.9.16 shows examples of a basin integrated into a local streetscape and into a car park. Figure SC6.4.3.9.16 also illustrates the key elements of bioretention basins, namely surface vegetation, extended detention, filter media, drainage layer and overflow pit.

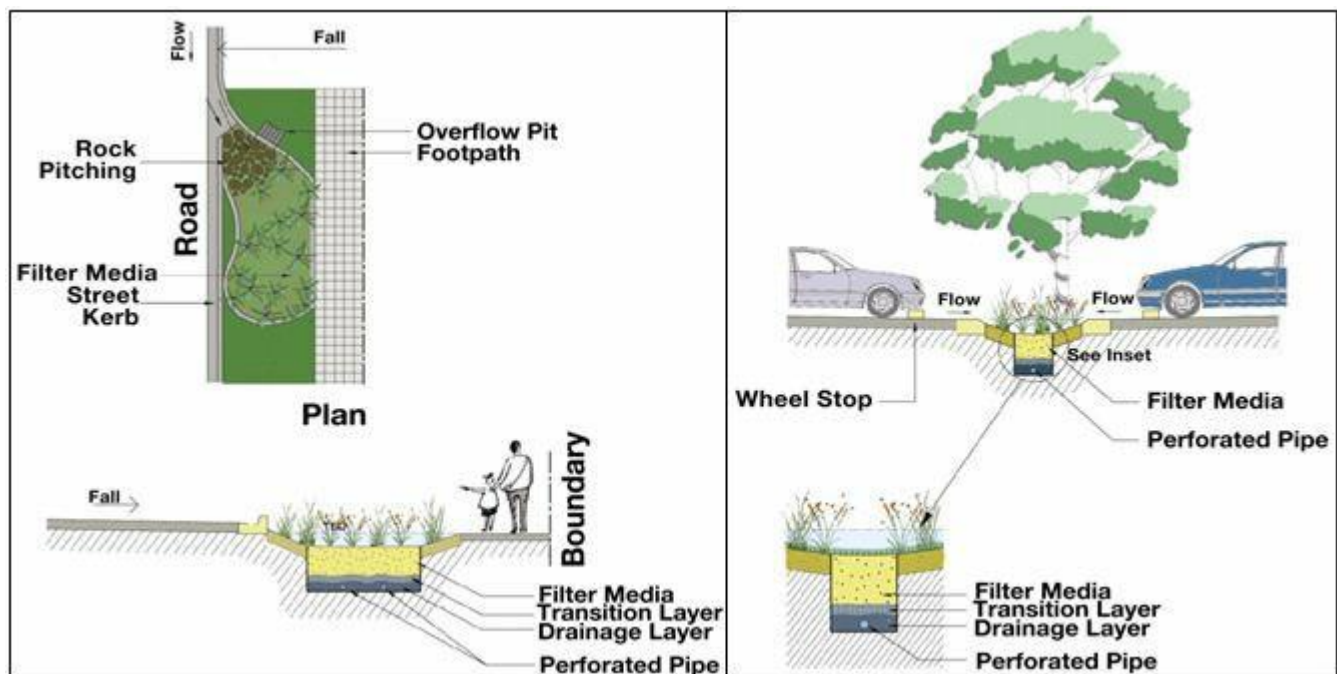


Figure SC6.4.3.9.16 Bioretention basin integrated into a local streetscape (left) and a car park (right).

- (2) Design considerations – bioretention basins

This section outlines some of the key design considerations for bioretention basins that the detailed designer should be familiar with before applying the design procedure presented later in this chapter.

Rain patterns in the dry tropics mean that bioretention systems will receive large volumes of consistent rainfall during the wet season and are likely to remain dry for extended periods during the dry season. Therefore, bioretention basin design will need to be adapted to incorporate the following elements:

- controls to ensure the bioretention basin is not compromised by sediment smothering;
- a saturated zone beneath the filter media to increase soil moisture and help sustain vegetation during dry periods; or
- supplemental temporary irrigation to sustain vegetation and maintain aesthetics in highly visible areas (e.g. bioretention pods within road verges).

(a) Landscape design

Bioretention basins are predominantly located within public areas, such as open space or within streets, which provide a primary setting for people to experience their local community and environment. It is therefore necessary for bioretention basins to be given an appropriate level of landscape design consideration to compliment the surrounding landscape character and to adequately address potential aesthetics issues such as weeds and sustaining perennial plants during the dry season. The landscape design of bioretention basins must address stormwater quality objectives whilst also being sensitive to other important landscape objectives such as road visibility, public safety and community character and habitat. To achieve this, the design process requires close collaboration between landscape architects, urban designers, ecologists and WSUD engineers (see example at Figure SC6.4.3.9.17).



Figure SC6.4.3.9.17 Bioretention basin within roundabout at Kalynda Chase Development, Bohle Plains

(b) Hydraulic design

The correct hydraulic design of bioretention basins is essential to ensure effective stormwater treatment performance, minimise damage by storm flows, and to protect the hydraulic integrity and function of associated minor and major drainage systems. The following aspects are of key importance:

- (i) the finished surface of the bioretention filter media must be horizontal (i.e. flat) to ensure even flow dispersion across the filter media surface (i.e. full engagement of the filter media by stormwater flows) and to prevent concentration of stormwater flows within depressions and ruts resulting in potential scour and damage to the filter media;
- (ii) temporary ponding (i.e. extended detention) of up to 0.3 m depth over the surface of the bioretention filter media created through the use of raised field inlet pits (overflow pits) can assist in managing flow velocities over the surface of the filter media as well as increase the overall volume of stormwater runoff that can be treated by the bioretention filter media;
- (iii) where possible, the overflow pit or bypass channel should be located near the inflow zone (refer to Figure SC6.4.3.9.16 (left)) to prevent high flows passing over the surface of the filter media. If this is not possible, then velocities during the minor (2-10 year ARI) and major (50-100 year ARI) floods should be maintained sufficiently low (preferably below values of 0.5 m/s and not more than 1.5 m/s for major flood) to avoid scouring of the filter media and vegetation;
- (iv) where the field inlets in a bioretention system is required to convey the minor storm flow (i.e. is part of the minor drainage system), the inlet must be designed to avoid blockage, flow conveyance and public safety issues; and
- (v) for streetscape applications, the design of the inflow to the bioretention basin must ensure the kerb and channel flow requirements are preserved as specified in the Queensland Urban Drainage Manual (QUDM) (DNRW, IPWEA and BCC 1998).

(c) Ex-filtration to in-situ soils

Bioretention basins can be designed to either preclude or promote ex-filtration of treated stormwater to the surrounding in-situ soils depending on the overall stormwater management objectives established for the given project. When considering ex-filtration to surrounding soils, the designer must consider site

terrain, hydraulic conductivity of the in-situ soil, groundwater and building setback. Where the concept design specifically aims to preclude ex-filtration of treated stormwater runoff it is necessary to consider if the bioretention basin needs to be provided with an impermeable liner. If the selected saturated hydraulic conductivity of the bioretention filter media is less than 10 times that of the native surrounding soils, it may be necessary to provide an impermeable liner. Flexible membranes or a concrete casting are commonly used to prevent excessive ex-filtration. This is particularly applicable for surrounding soils that are very sensitive to any ex-filtration (e.g. shallow groundwater or close proximity to significant structures).

Bioretention systems constructed in sodic soils without an impermeable lining are not at risk of exporting salt from in-situ soil into local streams or groundwater. Even after six months of intensive flushing under controlled, laboratory conditions, bioretention systems (constructed in sodic soils) did not leach salt from the surrounding soils (Deletic and Mudd, 2006).

The greatest pathway of ex-filtration is through the base of a bioretention basin, as gravity and the difference in hydraulic conductivity between the filter media and the surrounding native soil would typically act to minimise ex-filtration through the walls of the trench. If lining is required, it is likely that only the base and the sides of the drainage layer will need to be lined.

(d) Vegetation types

Vegetation is required to cover the whole bioretention filter media surface, be capable of withstanding minor and major design flows, and be of sufficient density to prevent preferred flow paths, scour and re-suspension of deposited sediments. Additionally, vegetation that grows in the bioretention filter media functions to continuously break up the surface of the filter media through root growth and wind induced agitation, which prevents surface clogging. The vegetation also provides a substrate for biofilm growth within the upper layer of the filter media, which facilitates biological transformation of pollutants (particularly nitrogen).

Ground cover vegetation (e.g. sedges and tufted grasses) is an essential component of bioretention basin function. Generally, the greater the density and height of vegetation planted in bioretention filter media, the better the treatment provided especially when extended detention is provided for in the design. Contact between stormwater and vegetation results in enhanced sedimentation of suspended sediments and adsorption of associated pollutants.

Plant species selected for bioretention systems must be able to tolerate free draining sandy soils and be capable of withstanding long dry periods as well as periods of inundation. To maintain aesthetics in highly visible areas (e.g. bioretention pods within road verges) temporary supplemental irrigation may be required to sustain vegetation. The incorporation of saturated zones beneath the filter media can help to sustain soil moisture and is beneficial for nitrogen removal from stormwater. The ability to sustain dense perennial vegetation is important for long term weed management.

SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics provides more specific guidance on the selection of appropriate vegetation for bioretention basins. It should be noted that turf is not considered to be suitable vegetation for bioretention basins. The stem and root structure of turf is not suitably robust and rapid growing to ensure the surface of the bioretention filter media is continuously broken up to prevent clogging.

(e) Bioretention filter media

Selection of an appropriate bioretention filter media is a key design step that involves consideration of the following four inter-related factors:

- (i) saturated hydraulic conductivity required to optimise the treatment performance of the bioretention basin given site constraints and available filter media area;
- (ii) depth of extended detention provided above the filter media;
- (iii) surface area of the filter media; and
- (iv) suitability as a growing media to support vegetation (i.e. retains sufficient soil moisture and organic content).

The concept design stage will have established the optimal combination of filter media saturated

hydraulic conductivity and extended detention depth using a continuous simulation modelling approach (i.e. MUSIC). Any adjustment of either of these two design parameters during the detailed design stage will require the continuous simulation modelling to be re-run to assess the impact on the overall treatment performance of the bioretention basin.

As shown in Figure SC6.4.3.9.18 below, bioretention media can consist of three or four layers. In addition to the filter media required for stormwater treatment, a saturated zone can also be added to enhance nitrogen removal and to provide a source of water for vegetation over the dry season. A drainage layer is also required to convey treated water from the base of the filter media or saturated zone into the perforated under-drains. The drainage layer surrounds the perforated under-drains and can be either coarse sand (1 mm) or fine gravel (2-5 mm). If fine gravel is used, a transition layer of sand must also be installed to prevent migration of the filter or saturated zone media into the drainage layer and subsequently into the perforated under-drains.

(f) Saturated zone

The incorporation of a saturated zone into bioretention design has evolved from research demonstrating improved nitrate removal through denitrification processes (Kim et al. 2003 and Zinger et al. 2007b).

The saturated zone design involves a relatively simple modification to a conventional bioretention system. An additional layer located below the filter media is designed to retain stormwater providing a saturated zone at the base of the bioretention system. A saturated zone can be formed by using a riser pipe with the outlet level higher than the drainage layer or by incorporating a weir within the outlet pit (see Figure SC6.4.3.9.18 below). The saturated zone holds water and therefore provides a source of water to maintain soil moisture for plant uptake during dry periods.

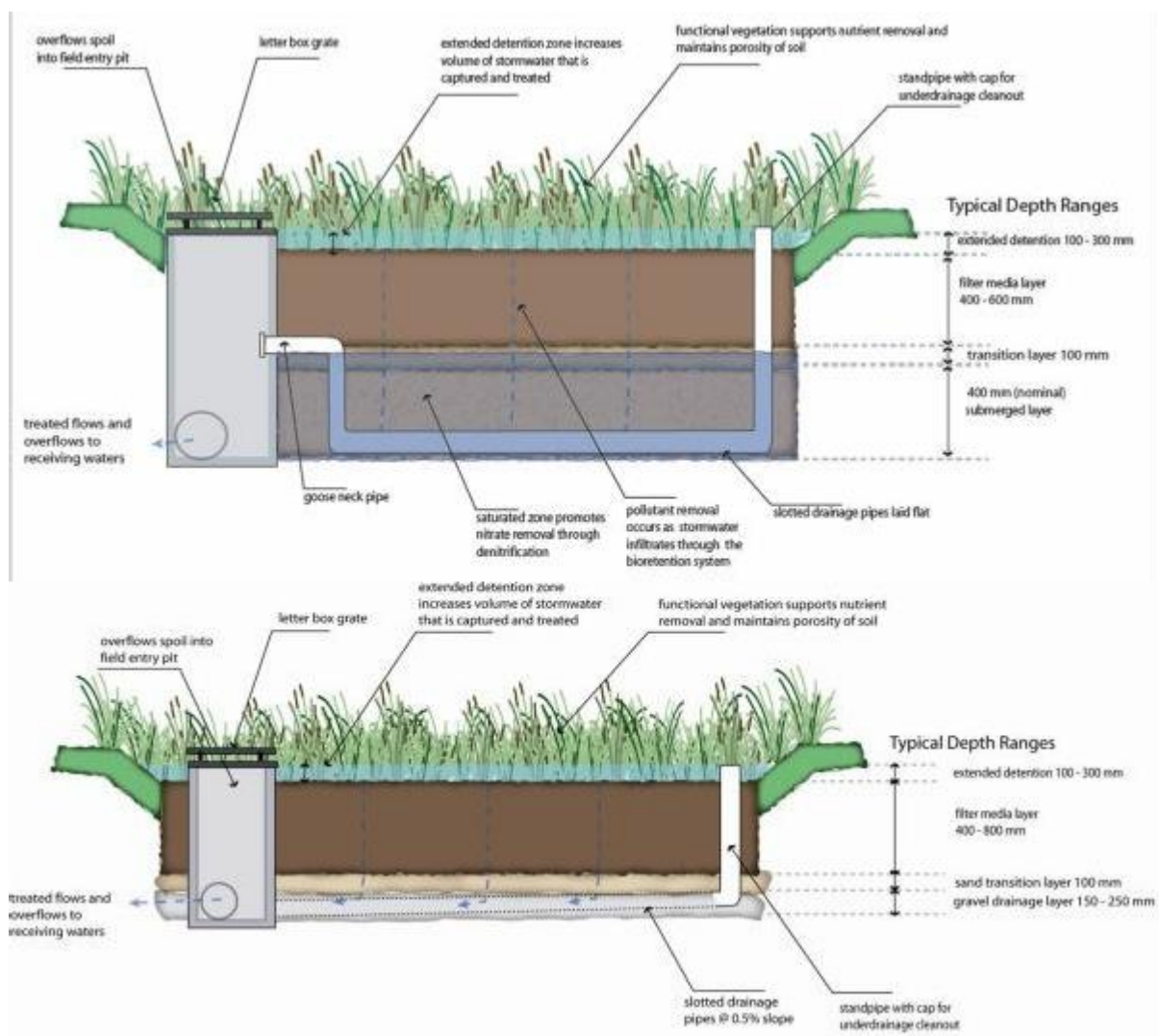


Figure SC6.4.3.9.18 Cross section of bioretention basins (top- with a saturated zone; below- without a saturated zone)

(g) Traffic controls

Another design consideration is keeping traffic and building material deliveries off bioretention basins (particularly during the construction phase of a development). If bioretention basins are driven over or used for parking, the filter media will become compacted and the vegetation damaged.

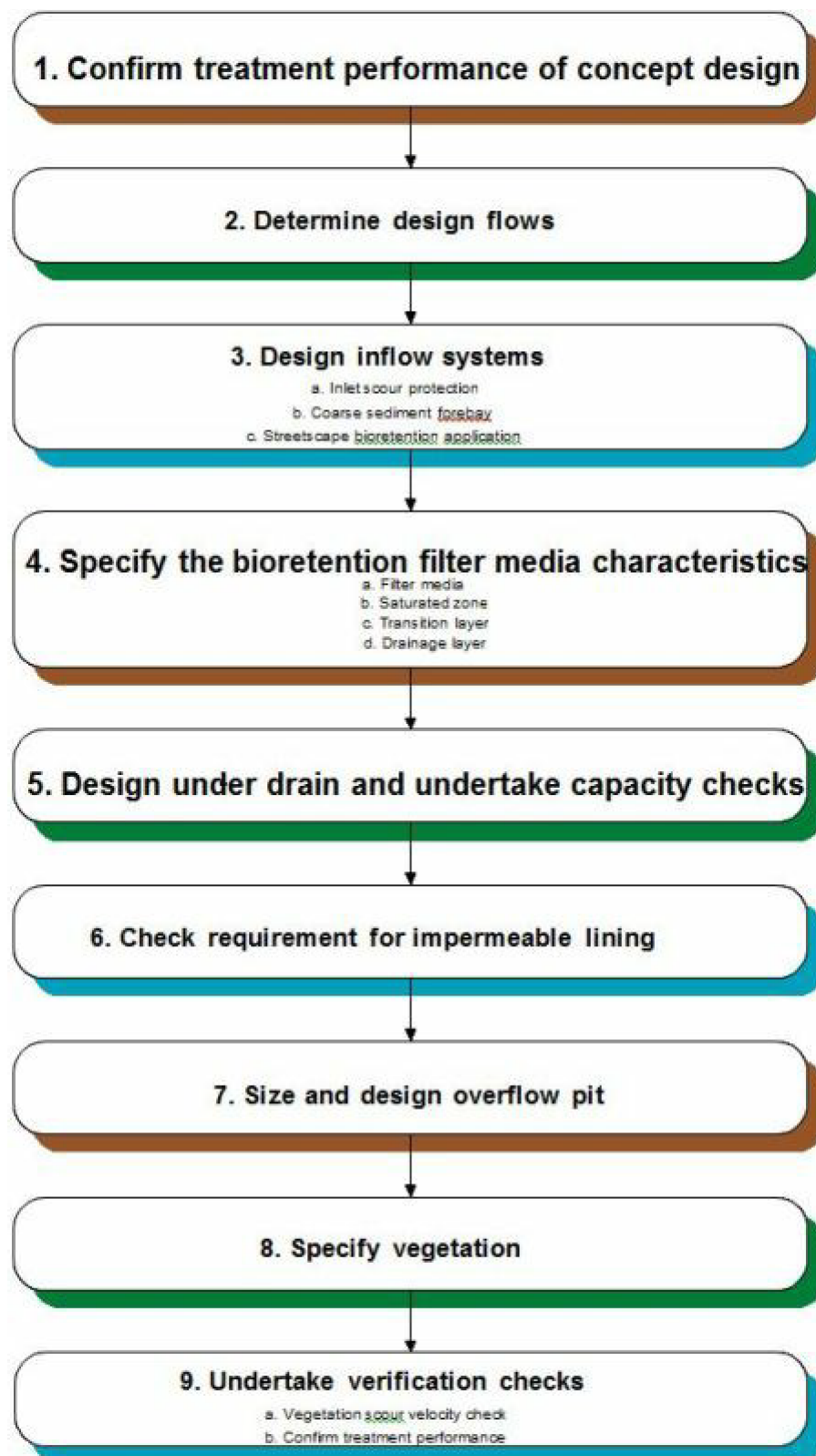
Streetscape bioretention systems must be designed to satisfy local authority requirements with respect to traffic calming devices within particular street or road reserve widths. Where bioretention is incorporated into traffic calming or control devices, or directly adjacent to mountable kerbs, consideration should be given to protection of the area immediately behind the kerb where vehicles are likely to mount the kerb.

(h) Services

Bioretention basins or cells located within road verges or within footpaths must consider the standard location for services within the verge and ensure access for maintenance of services without regular disruption or damage to the bioretention system.

(3) Design process – bioretention basins

The following sections detail the design steps required for bioretention basins. Key design steps are:



(a) Step 1: Check treatment performance of concept design

Before commencing detailed design, the designer should first undertake a preliminary check to confirm the bioretention basin treatment area (i.e. the surface area of the filter media) from the concept design is adequate to deliver the required level of stormwater quality improvement. This design process assumes a conceptual design has been undertaken.

This assessment should be undertaken by a WSUD specialist and can be achieved by modelling expected treatment performance in an appropriate quantitative modelling program. Where possible, this modelling should be based on local rainfall data, the proposed configuration of the system, and based on local stormwater treatment performance data.

(b) Step 2: Determine design flows

(i) Design flows

The hydraulic design of the bioretention basin should be based on the following design flows:

- (A) minor flood flow (2 year ARI) to allow minor floods to be safely conveyed. For commercial and industrial areas the design flow requirement for minor flows is a 5 year ARI event; and
- (B) major flood flow (100 year ARI) to check flow velocities, velocity depth criteria, conveyance within road reserve, and freeboard to adjoining property.

(ii) Design flow estimation

A range of hydrologic methods can be applied to estimate design flows. If the typical catchment areas are relatively small, the Rational Method design procedure is considered to be a suitable method for estimating design flows. However, if the bioretention system is to form part of a retention basin or if the catchment area to the bioretention system is large, then a full flood routing computation method needs to be used to estimate design flows.

(c) Step 3: Design inflow systems

(i) The design of the inflow systems to bioretention basins needs to consider a number of functions:

- (A) scour protection – In most bioretention applications stormwater flows will enter the bioretention basin as concentrated flow (piped, channel or open channel) and as such is it important to slow and spread flows using appropriate scour (rock) protection;
- (B) coarse sediment forebay – Where stormwater runoff from the catchment is delivered directly to the bioretention basin without any coarse sediment management (through vegetated swale or buffer treatment) a coarse sediment forebay is to be included in the design. The forebay is to remove coarse sediment (1 mm +) from stormwater to minimise the risk of vegetation in the bioretention basin being smothered;
- (C) constant low base flows have to be taken into account and dealt with as they can blind the filter material and promote weed growth within permanently saturated areas; and
- (D) street hydraulics (streetscape applications only) – In streetscape applications, where stormwater is delivered directly from the kerb and channel to the bioretention basin, it is important to ensure the location and width of the kerb opening is designed such that flows enter the bioretention basin without adversely affecting trafficability of the road (QUDM, Table 7.04.1).

(ii) Each of these functions and the appropriate design responses are described in the following sections.

(iii) Inlet scour protection

Erosion protection should be provided for concentrated inflows to a bioretention basin. Typically, flows will enter the bioretention basin from either a surface flow system (i.e. roadside kerb, open channel) or a piped drainage system. Rock beaching is a simple method for dissipating the energy of concentrated inflow, as depicted in Figure SC6.4.3.9.19 (with the “D” representing the pipe diameter dimension). The rocks can form part of the landscape design of the bioretention component.

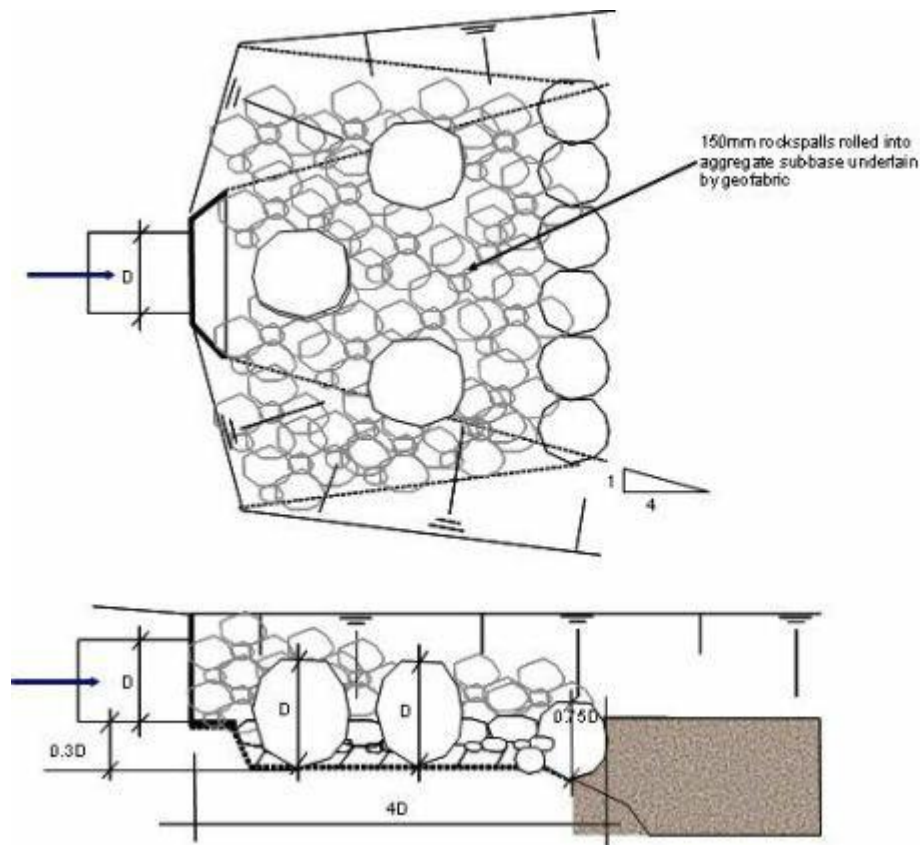


Figure SC6.4.3.9.19 Typical inlet scour protection detail for bioretention basins receiving piped flows

(iv) Coarse sediment control

Where stormwater runoff from the catchment is delivered directly to the bioretention basin without pre-treatment (through vegetated swale or buffer treatment), coarse sediment may accumulate near the basin inflow. This sediment may smother vegetation and reduce infiltration to the filter media. To mitigate these effects, either a sedimentation basin (see Chapter 4) is to be located upstream or the bioretention basin inflow system is to incorporate a coarse sediment forebay. The forebay should be designed to:

- (A) remove particles that are 1 mm or greater in diameter from the 3 month ARI storm event; and
- (B) provide appropriate storage for coarse sediment to ensure desilting is required no more than once per year.

The size of the sediment forebay is established using the following equation:

$$V_s = A_c \cdot R \cdot L_o \cdot F_c$$

Where	V_s	= volume of <u>forebay</u> sediment storage required (m ³)
	A_c	= contributing catchment area (ha)
	R	= capture efficiency (assume 80%)
	L_o	= sediment loading rate (m ³ /ha/year)
	F_c	= desired cleanout frequency (years)

A catchment loading rate (L_o) of 1.6 m³/ha/year for developed catchments can be used to estimate the sediment loads entering the basin. The area of the forebay is established by dividing the volume by the depth. The depth of the forebay should not be greater than 0.3 m below the surface of the filter media.

$$A_s = \frac{V_s}{D_s}$$

Where D = depth of sediment forebay (max 0.3 m below filter media surface).

The sediment forebay area should be checked to ensure it captures the 1 mm and greater particles using the following expression (modified version of Fair and Geyer (1954)).

$$R = 1 - \left[1 + \frac{1}{n} \cdot \frac{v_s}{Q/A} \right]^{-n}$$

Where:	R	=	fraction of target sediment removed (80%)
	v_s	=	settling velocity of target sediment (100 mm/s or 0.1 m/s for 1 mm particle)
	Q/A	=	applied flow rate divided by forebay surface area (m ³ /s/m ²)
	n	=	turbulence or short-circuiting parameter (adopt 0.5)

The coarse sediment forebays will contain large rocks for energy dissipation and be underlain by filter material to promote drainage following storm events.

(v) Kerb opening configuration (streetscape applications)

In streetscape applications where stormwater is delivered directly from a kerb and channel to a bioretention basin, the following design issues must be considered:

- (A) the location of the kerb opening must be designed to ensure flows in the channel do not exceed the maximum allowance widths as defined by QUDM Table 7.04.1 (DNRW, IPWEA & BCC 1998); and
- (B) the width of the kerb opening is designed to allow the design flow to enter the bioretention basin.

Channel flow width at kerb opening

The width of channel flow at the kerb opening during a minor storm event (2-10 year ARI) needs to be checked to ensure it does not exceed the maximum allowable channel flow widths defined by QUDM Table 7.04.1 (DNRW, IPWEA & BCC 1998) and the local authority requirements. This check can be undertaken by applying Manning's equation or Izzard's equation and ensuring the flow depth does not exceed either the crest of the road or the top of kerb (whichever is lowest).

Design kerb opening width (where kerb and channel is used)

To determine the width of the opening in the kerb to allow flows to enter the bioretention basin, Manning's equation or Izzard's equation (QUDM Section 7.04.2) can be used with the kerb, channel and road profile to estimate the flow depth in the kerb and channel at the entry point. Once the flow depth for the minor storm (e.g. 2-10 year ARI) is known, this can then be used to calculate the required width of the opening in the kerb by applying a broad crested weir equation. The opening width is estimated by applying the flow depth in the channel (as h) and solving for L (opening width).

$$Q = C_w \cdot L \cdot h^{3/2}$$

Where	Q	=	flow (m ³ /s)
	C _w	=	weir coefficient (= 1.66)
	L	=	length of opening (m)
	h	=	depth of flow (m)

This method ensures the kerb opening does not result in an increase in the upstream channel flow depth, which in turn ensures the bioretention basin does not impact on the trafficability of the adjoining road pavement as required by the QUDM. To ensure the kerb opening width is adequate, additional width factors may be required to account for slope of the kerb and channel, and the angle at which flow meets the kerb opening. This will depend on the location and position of the bioretention system in relation to the kerb and channel. Design of the inflow system within the kerb and channel will need to consider maximising flow into the bioretention system. The kerb opening

can be made more effective by lowering the kerb opening below the channel, increasing the cross fall at the kerb opening or by providing deflectors at the kerb opening.

(d) Step 4: Specify the bioretention filter media characteristics

Up to four types of media are required in bioretention basins (refer Figure SC6.4.3.9.18 Cross section of bioretention basins (top—with a saturated zone; below—without a saturated zone)).

(i) Filter media

As a minimum, the filter media is required to have sufficient depth to support vegetation, typically between 400-600 mm (or as specified in the engineering design). It is important to note that if deep rooted plants such as trees are to be planted in bioretention basins, the filter media must have a minimum depth of 800 mm to avoid roots interfering with the perforated under-drain system.

In general, the media should be a loamy sand with an appropriately high permeability under compaction and should be free of rubbish, deleterious material, weed seeds, toxicants, and should not be hydrophobic. The filter media should contain some organic matter for increased water holding capacity but be low in nutrient content. To ensure a proposed soil is suitable as filter media, a testing regime is required. The *Guidelines for Soil Filter Media in Bioretention Systems*: Version 2.01 (FAWB, March 2008) (refer to <http://www.monash.edu.au/fawb/products/index.html>) provides best practice guidance on filter media selection and testing. It is recommended that soils used for bioretention filter media fulfil the requirements outlined in the FAWB Guideline. In summary, these requirements include:

- (A) organic carbon levels < 5%;
- (B) pH between 5.5 and 7.5;
- (C) electrical conductivity < 1.2 dS/m;
- (D) saturated hydraulic conductivity between 100-500 mm/hr. The saturated hydraulic conductivity of the filter media is established by optimising the treatment performance of the bioretention system given site constraints of the particular site (using a continuous simulation model such as MUSIC); and
- (E) the filter media must also be structurally sound and not prone to structural collapse as this can result in a significant reduction in saturated hydraulic conductivity. The risk of structural collapse can be reduced by ensuring the soil has a well graded particle size distribution with a combined clay and silt fraction of < 3%.

(ii) Transition layer (if required)

The purpose of the transition layer is to prevent the filter media from migrating down into the drainage layer (or the saturated zone). It also acts as a buffer between the permanently saturated zone (if required) and the filter media. This buffer is necessary to ensure the filter media is not saturated for prolonged periods during rainfall events due to increases in water levels in the saturated zone. To achieve this, the transition layer depth must be greater than the head created by flows over the saturated zone outlet weir.

It is required if the particle size difference between the filter media and the drainage layer (or the saturated zone) is more than one order of magnitude. If a transition layer is required then the material must be a clean, well-graded sand/coarse sand material containing little or no fines.

The transition layer is recommended to be 100 mm thick and have a minimum saturated hydraulic conductivity of 1000 mm/hr.

A recent particle size distribution for the transition layer sand will need to be obtained to ensure that it meets the required grading/"bridging" criteria outlined below. The "bridging" criteria is based on the engineering principles that rely on the largest 15% of the filter media particles (or saturated zone particles) "bridging" with the smallest 15% of the sand particles. This results in smaller voids, which prevent the migration of the filter media particles into the sand particles. The following equation is taken from the United States Golf Association's recommendations for golf course construction:

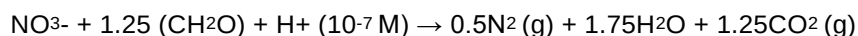
The addition of a transition layer increases the overall depth of the bioretention system and may be an important consideration for some sites where total depth of the bioretention system may be constrained. In such cases, the use of a sand drainage layer and/ or perforated pipes with smaller slot sizes may need to be considered.

(iii) Saturated layer (if required)

The saturated layer should be about 400 mm deep (but may deeper depending on the specific application) and composed of clean (i.e. free from fines) medium-coarse washed sand, gravel or small rock (50 mm diameter maximum) together with a long term carbon source. Hardwood wood chips, 5 mm to 40 mm in size, are recommended as the carbon source because they breakdown slowly to provide a long term carbon source yet have a decomposition rate that should not limit the denitrification process.

The total mass of carbon/electron donor that is required for denitrification must be calculated based on the expected stormwater influent TN mass over the desired life span of the system (e.g. 25 years). The calculation is based on the stoichiometry of the denitrification reaction (shown below).

Denitrification reaction:



Based on a 400 mm deep saturated zone and the modelled annual TN runoff mass (for Townsville) for a bioretention system that is 2% of the contributing 1 ha catchment, the saturated zone media would have the following composition:

(A) 76.7 m³ washed coarse sand, gravel or small rock; and

(B) 3.3 m³ hardwood wood chips, well graded 5 mm-40 mm.

This is equivalent to an organic carbon content of approximately 4-5% by volume. If the saturated zone depth changed, or the bioretention system to catchment area ratio changed, the hardwood proportion would need to be recalculated using the denitrification stoichiometry.

Calculating carbon source for saturated zone with safety factor (x2)

Catchment Area	1 ha
Treatment Area Required	2%
Bioretention Surface Area	200 m ²
Saturated Zone Depth	400 mm
Total volume of Saturated Zone	80 m ³
TN load 1 year	12.5 kg/yr
TN load 25 years	312.5 kg/25 yrs

Stoichiometry:

N:C ratio = 1:1.25 (mol), which equates to 14:15 (g) [Mw: N = 14g/mol, C = 12g/mol]

Average total carbon content of hardwood woodchips is 50%, therefore

N:C (woodchip) = 14:30 (g)

N:C (woodchip) = 1:2.1

Woodchips (312.5 x 2.1)	656kg/carbon
Safety Factor (x 2)	1313kg/carbon
Density of wood chips	400kg/m ³ (approx.)

Hardwood Wood Chips	3.3 m³
Clean Coarse Sand	76.7 m³

The saturated media must have a hydraulic conductivity of >1000mm/hr (the ASTM F1815-06 test method is to be used to measure hydraulic conductivity).

The saturated zone should be lightly compacted (e.g. with one pass of a smooth drum lawn roller) during installation to stabilise the structure. Under no circumstances should heavy compaction or multiple-passes be made.

(iv) Drainage layer (if required)

The drainage layer is used to convey treated flows from the base of the filter media layer (or the saturated zone) into the perforated under-drainage system. The composition of the drainage layer is to be considered in conjunction with the selection and design of the perforated under-drainage pipes as the slot sizes in the perforated pipes may determine the minimum drainage layer particle size to avoid washout of the drainage layer into the perforated pipe system. Coarser material (e.g. fine gravel aggregate) is to be used for the drainage layer if the slot sizes in the perforated pipes are too large for use of a sand based drainage layer. The drainage layer is to provide a minimum of 50 mm cover above the perforated under-drainage pipes and have a minimum saturated hydraulic conductivity of 1000 mm/hr.

A particle size distribution for the gravel will need to be obtained to ensure that it meets the “bridging” criteria outlined below:

Bridging Factor:

$$D_{15} (\text{drainage gravel/sand}) \leq 8 \times D_{85} (\text{filter media/saturated zone/transition layer})$$

Ensure drainage media is washed prior to placement in bioretention system to remove any fines.

(e) Step 5: Design under-drain and undertake capacity checks (if required)

The maximum spacing of the perforated under-drains in bioretention basins located in streetscape zones and small public zones (i.e. bioretention < 100 m²) is 1.5 m (centre to centre). This ensures that the distance water needs to travel horizontally toward the perforated pipes through the drainage layer does not hinder drainage of the filter media. The maximum spacing of the perforated pipes in bioretention basins located in local parks and large open space areas (i.e. bioretention > 100 m²) can be increased to 2.5 – 3 m.

In bioretention systems without saturated zones, perforated pipes are to grade at a minimum of 0.5% towards the overflow pit to ensure effective drainage. In bioretention systems with saturated zones, perforated pipes should be laid flat (i.e. at 0% grade) to avoid preferential flow paths forming vertically through the filter media closer to the outlet.

Perforated pipes should not use a geofabric wrapping, as this is a potential location for blockage and would require a complete resetting of the bioretention system. Where perforated pipes are supplied with geofabric wrapping, it is to be removed before installation.

Installing parallel pipes is a means to increase the capacity of the perforated pipe system. 100 mm diameter is recommended as the maximum size for the perforated pipes to minimise the thickness of the drainage layer. Either slotted PVC pipes or flexible perforated pipes (e.g. Ag pipe) can be used; however, care needs to be taken when selecting the type of pipe to consider the following:

- (i) ensure the slots in the pipes are not so large that sediment will freely flow into the pipes from the drainage layer. This is also a consideration when specifying drainage layer media; and
- (ii) minimise the potential for tree roots to enter the pipes in search of water. Generally, this is only a concern when the filter media has a low water holding capacity, or trees are planted in filter media whose depth is too shallow. In general, trees are not recommended if the filter media depth is less than 800 mm. Flexible “ribbed” pipes are more likely, than PVC pipes, to retain “beads” of moisture due to the small corrugations on the inside of the pipe. Therefore, a smooth surface perforated/slotted pipe system is recommended for use in bioretention basins exhibiting any of these characteristics.
- (iii) To ensure slotted pipes are of adequate size, several checks are required:
 - (A) ensure the perforations are adequate to pass the maximum filtration rate;

- (B) ensure the pipe itself has sufficient capacity; and
- (C) ensure that the material in the drainage layer will not be washed into the perforated pipes (consider a transition layer).

The maximum filtration rate represents the maximum rate of flow through the bioretention filter media and is calculated by applying Darcy's equation as follows:

$$V_s = A_c \cdot R \cdot L_o \cdot F_c$$

Where	V_s	= volume of <u>forebay</u> sediment storage required (m ³)
	A_c	= contributing catchment area (ha)
	R	= capture efficiency (assume 80%)
	L_o	= sediment loading rate (m ³ /ha/year)
	F_c	= desired cleanout frequency (years)

To ensure the perforated under-drainage system has sufficient capacity to collect and convey the maximum filtration rate, it is necessary to determine the capacity for flows to enter the under-drainage system via the perforations in the pipes. To do this, orifice flow can be assumed and the sharp edged orifice equation used. It is conservative, but reasonable to use a blockage factor to account for partial blockage of the perforations by the drainage layer media. A 50% blockage of the perforations should be used.

The flow capacity of the perforations is thus:

$$A_s = \frac{V_s}{D_s}$$

If the capacity of the drainage system is unable to collect the maximum filtration rate additional under-drains will be required.

The Manning's roughness used will be dependent on the type of pipe used (refer to QUDM Table 7.16.3 (DNRW, IPWEA & BCC 1998)). When a saturated zone is incorporated into the design, the underdrainage pipes are laid flat however the conveyance capacity can be calculated using the Manning's equation with an assumed friction slope of 0.5%.

Under-drains should be extended vertically to the surface of the bioretention system to allow inspection and maintenance when required. The vertical section of the under-drain should be unperforated and capped to avoid short-circuiting of flows directly to the drain. Reference is made to the drawings following the worked example (Section SC6.4.3.9.4(3)(i) Step 9: Undertake verification checks) for further guidance.

In bioretention basins with a saturated zone, the capacity of the weir or up-turned pipe (maintaining the water level within the saturated zone) must also be checked to ensure it does not become the hydraulic "control" in the bioretention system (i.e. to ensure the filter media sets the travel time for flows percolating through the bioretention system). A broad crested weir equation can be used to determine the length of weir required (assuming free flowing conditions) to convey the maximum flow/filtration rate. The maximum depth of flow over the weir is to be 100 mm. This is important to limit increase in the saturated zone depth and avoid prolonged saturation of the filter media.

(f) Step 6: Check requirement for impermeable lining

The saturated hydraulic conductivity of the natural soil profile surrounding the bioretention system should be tested together with depth to groundwater, chemical composition and proximity to structures and other infrastructure. This is to establish if an impermeable liner is required at the base (only for systems designed to preclude ex-filtration to in-situ soils) and/or sides of the bioretention basin (refer also to discussion in SC6.4.3.9.4(2)(c) Ex-filtration to in-situ soils). If the saturated hydraulic conductivity of the filter media in the bioretention system is more than one order of magnitude (10 times) greater than that of the surrounding in-situ soil profile, no impermeable lining is required.

(g) Step 7: Size overflow pit

There should be a minimum of 50 mm head over the overflow pit crest to facilitate discharge of the design flow into the overflow pit.

In streetscape bioretention applications, a level of conservatism is built into the design of grated overflow pits by placing their inverts at least 50 mm below the invert of the street channel (and therefore setting the maximum ponding depth). The head over the overflow pit crest is the sum of the 50 mm and the maximum ponding in the street channel under the minor storm (see SC6.4.3.9.4(3)(c)(v) Kerb opening configuration). To size an overflow pit, two checks must be made to test for either drowned or free flowing conditions. A broad crested weir equation can be used to determine the length of weir required (assuming free flowing conditions) and an orifice equation used to estimate the area between openings required in the grate cover (assuming drowned outlet conditions). The larger of the two pit configurations should be adopted (as per Section 7.05 QUDM (DNRW, IPWEA & BCC 1998)). In addition, a blockage factor that assumes the grate is 50% blocked is to be used.

For free overfall conditions (weir equation):

$$R = 1 - \left[1 + \frac{1}{n} \cdot \frac{v_s}{Q/A} \right]^{-n}$$

Where:

R	=	fraction of target sediment removed (80%)
v_s	=	settling velocity of target sediment (100 mm/s or 0.1 m/s for 1 mm particle)
Q/A	=	applied flow rate divided by forebay surface area (m ³ /s/m ²)
n	=	turbulence or short-circuiting parameter (adopt 0.5)

Once the length of weir is calculated, a standard sized pit can be selected with a perimeter at least the same length of the required weir length.

For drowned outlet conditions (orifice equation):

$$Q = C_w \cdot L \cdot h^{3/2}$$

Where

Q	=	flow (m ³ /s)
C _w	=	weir coefficient (= 1.66)
L	=	length of opening (m)
h	=	depth of flow (m)

When designing grated field inlet pits, reference is also to be made to the procedure described in QUDM Section 7.05.4.

In terms of the actual grate, letter box or dome type grates must be used in bioretention basins.

When a saturated zone is included in the design of a bioretention system, additional components must be incorporated into the outlet design. A saturated zone can be formed at the base of a bioretention system by using a riser pipe with the outlet level set at the top of the desired saturation depth (i.e. top of the saturated zone) or by incorporating a weir/overflow structure within the outlet pit (see Figure SC6.4.3.9.18). The saturated zone would hold water rather than draining freely, and would therefore provide a source of water to the plants during dry periods.

(h) Step 8: Specify vegetation

Refer to SC6.4.3.9.4(4) Landscape design notes and SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics for advice on selecting vegetation for bioretention basins in the coastal dry tropics.

Editor's note—applicants will also need to address [9.4.39.3.3](#) Landscape Code and sub-section SC6.4.3.6 Landscape policy.

(i) Step 9: Undertake verification checks

Once the detailed design is complete, a final check should be undertaken to confirm that vegetation will be protected from scour during flood events and that the final design will achieve the required treatment performance.

(i) Vegetation scour velocity check

Velocities should be kept below:

- (A) 0.5 m/s for minor flood (2-5 year ARI) discharges; and
- (B) 2.0 m/s for major flood (50 year ARI) discharges.

If the inlet to the bioretention basin “controls” the maximum inflow to the basin then it is appropriate to use this maximum inflow to check velocities. In this case, velocities should be maintained below 0.5 m/s.

(ii) Confirm treatment performance

If, during the course of undertaking detailed design of the bioretention basin, the basic design parameters established by the conceptual design phase have changed (e.g. area, filter media depth, etc.) then the designer should verify that the current design meets the required water quality improvement performance. This can be done by re-modelling expected treatment performance determined in the conceptual design based on the revised configuration of the system.

(j) Design calculation summary

A calculation summary sheet for the key design elements of a bioretention basin is provided in Table SC6.4.3.9.10.

Click here to obtain a copy of **Table SC6.4.3.9.10**

(4) Landscape design notes – bioretention basins

(a) Objectives

Landscape design for bioretention basins has four key objectives:

- (i) addressing stormwater quality objectives by incorporating appropriate groundcover plant species for sediment removal, erosion protection, stormwater treatment (biologically active root zone) and preventing filter media blockages;
- (ii) ensuring that the overall landscape design for the bioretention basin integrates with its surrounding environment. This includes requirements for maintaining dense perennial vegetation throughout the dry season to maintain aesthetics and to minimise weed growth;
- (iii) incorporating crime prevention through environmental design (CPTED) principles and traffic visibility safety standards for roadside systems. This objective also needs to incorporate public safety; and
- (iv) providing other landscape values such as shade, amenity, character, buffers, glare reduction, place making and habitat.

For further guidance refer to the *South East Queensland WSUD Conceptual Design Guidelines* (Healthy Waterways Partnership, 2008)

(b) Bioretention basin vegetation

Planting for bioretention basin elements may consist of up to three vegetation types:

- (i) groundcovers for stormwater treatment and erosion protection;
- (ii) shrubbery for screening, glare reduction and character; and
- (iii) trees for shading, character, breaking up filter material and other landscape values.

The plant species listed in SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics tolerate free draining sandy soils and are capable of withstanding long dry periods as well as periods of inundation. However, because the dry periods in the coastal dry tropics can be severe, bioretention systems must have supplemental temporary irrigation or include a saturated zone. These measures ensure dense perennial vegetation can be sustained to maintain aesthetics, stormwater treatment capacity and to minimise weed growth.

(c) Parkland bioretention basins

Once the general location has been determined, it will be necessary to investigate how the elements of the bioretention system will be arranged within the open space including:

- (i) opportunities and constraints presented by various siting options;
 - (ii) if the device is to be visually prominent (perhaps for educational value) or merged with the surrounding parkland space using a consistent planting layout in the basin, embankment and parkland; and
 - (iii) a formal or informal style dependent on the setting and surrounding open space and urban design.
- (d) Safety issues

The standard principles of informal surveillance, exclusion of places of concealment and open visible areas apply to the landscape design of bioretention basins. Regular clear sightlines should be provided between the roadway and footpaths/ property. Safety measures in accordance with the requirements of the relevant local authority should also be installed around structural components of bioretention basins where safety hazards exist.

- (i) Crime prevention through environmental design (CPTED)

Where planting may create places of concealment or hinder informal surveillance, groundcovers and shrubs should not generally exceed 1 m in height.

- (ii) Traffic sightlines

The standard rules of sightline geometry apply. Planting designs should allow for visibility at pedestrian crossings, intersections, rest areas, medians and roundabouts.

(5) Construction and establishment – bioretention basins

This section provides general advice for the construction and establishment of bioretention basins and key issues to be considered to ensure their successful establishment and operation (see Figure SC6.4.3.9.20).



Figure SC6.4.3.9.20 Bioretention basin functional installation

(a) Staged construction and establishment method

- (i) Sediment and erosion control

Many soils within the coastal dry tropics region are dispersive, highlighting the critical importance of appropriate sediment and erosion control. All development and land disturbance activities must employ best practice sediment and erosion control practices to minimise the impact on receiving environments (refer to the Development manual planning scheme policy SC6.4.3.8 Stormwater management plans for development).

In relation to bioretention systems, temporary protective layers must be installed and left in place throughout the allotment building phase to ensure sediment laden waters do not clog the filtration media and allotment building traffic does not enter the bioretention system (see Figure SC6.4.3.9.21). Importantly the configuration of the bioretention basin and the turf vegetation allow the system to function effectively as a shallow sedimentation basin reducing the load of sediment discharging to the receiving environment. Using this approach, WSUD systems can operate effectively to protect downstream ecosystems immediately after construction.



Figure SC6.4.3.9.21 Bioretention basin sediment and erosion control

(ii) Operational establishment

At the completion of the allotment building phase the temporary measures (i.e. geofabric and turf) are removed with all accumulated sediment and the bioretention system re-profiled and planted in accordance with the proposed landscape design. Establishment of the vegetation to design condition can require more than two growing seasons, depending on the vegetation types, during which regular watering and removal of weeds will be required.

(iii) Quality control during construction

The primary responsibility for supervision of the construction of WSUD elements lies with the site superintendent. Key milestones requiring inspection and sign off by either the superintendent or

the design team are detailed in the suggested construction sequence below.

Meetings between the design team and contractors should also take place at the commencement of each phase of works, i.e.:

- prior to commencement of civil works;
- prior to commencement of landscape works; and
- at the completion of works.

Regular site inspections by a member of the design team are also recommended to ensure the bioretention basins are constructed as per the design intent and to provide ongoing construction and establishment advice to the contractors.

The suggested construction sequence for the bioretention basins are as follows:

- (A) survey bioretention basin location;
- (B) undertake bulking out, including construction of bunds surrounding basin. Construct outflow headwall(s) and install section(s) of stormwater reinforced concrete pipes (RCP) that runs underneath bund. Terminate pipe at interface of bund and bioretention basin;
- (C) excavate surrounding landform to design subsoil level (achieving surrounding level at this stage reduces the need for earthworks adjacent to the basins after they have been constructed);
- (D) install overflow pit(s) and ensure pit crest(s) is at design level. The pit crest(s) will then be used as a datum from which other levels within the basin will be measured. The pit requires holes for pipe connections and these should be drilled at this stage;
- (E) detailed excavation, trimming and profiling of sides and base of basin, ensuring base has minimum 0.5% grade (0% slope when saturated zones are included in the designs) towards pit. Ensure base of basins are free from debris. As constructed survey is required at this time and should include the base and bunds of the system and all hard structures (i.e. overflow pit, overflow weir and pipe connection punch-out holes);
- (F) install silt fences around basin to prevent sediment entering system and to keep construction vehicles off the basin;

SUPERINTENDENT INSPECTION AND SIGN OFF REQUIRED BEFORE PROCEEDING

- (G) line basin with geofabric, ensuring geofabric extends beyond top of bioretention basin side walls, up to the sediment control fence. This ensures that exposed earth on the bunds won't wash into basins during construction;
- (H) install remaining RCP stormwater pipe connecting overflow pit(s) to existing RCP stormwater pipe installed as part of Step 2;
- (I) install slotted PVC under-drainage pipes and PVC collector pipes in specified layout. Ensure all pipes are laid at min 0.5% slope (0% slope when saturated zones are included in the designs) with no localized depressions verified using level or string line. Arrange slots so that they are not directly on top of the pipe (to minimise fine particles blocking the slots). Seal junctions and connections (i.e. slotted PVC pipes to PVC collector pipes; slotted PVC pipes/PVC collector pipes to overflow pits) using sealant to prevent sand/gravel/soil passing into drainage network. Connect clean out points ensuring top of clean out points will ultimately sit 200 mm below overflow pit crest;

SUPERINTENDENT INSPECTION AND SIGN OFF REQUIRED BEFORE PROCEEDING

- (J) install drainage, transition and saturated zones as required and as detailed in the design drawings;
- (K) place prescribed bioretention filter media to design surface level of bioretention basin. Spread material using excavator bucket, hand tools, or a small "pozitrack" bobcat. Do not drive over filter media with any vehicle other than a "pozitrack" bobcat and only if agreed to by civil superintendent. In order to remove air pockets within the filter media, apply light and even compaction by making a single pass with a "pozitrack" bobcat (or similar). If required, apply additional filter media to ensure final surface level is correct. Use a spreader bar to flatten the surface of the filter media. Ultimately, the surface of the filter media must be level

(horizontal) and free from local depressions and set at 300 mm below pit crest;

- (L) construct coarse sediment forebay utilising large, flat rocks to form base of forebay and interface between forebay and bioretention area;
- (M) install temporary protective covering over bioretention surface. This involves covering the surface of filtration media with geofabric and placement of 50 mm topsoil and turf over the geofabric. This geofabric/turf layer is a temporary measure to protect the filter media from being clogged with construction sediment while allotment building is being undertaken. Once a majority of the allotment building is complete and the construction sediment load is minimal, this protective layer will be removed, and the system will be planted out with the vegetation as per designs;
- (N) place landscaping topsoil on top of geofabric covering the bunds and around basin as per designs;
- (O) flush under-drainage pipes to remove any initial ingress of material; and
- (P) undertake as constructed survey of the basin surface and surrounding bunds, picking up at least one spot level per 100m² on the basin surface and at least one spot level every 10m along the top of the bunds.

FINAL SUPERINTENDENT INSPECTION AND SIGN OFF

(b) Construction tolerances

It is important to emphasise the significance of tolerances in the construction of bioretention basins (e.g. profiling of trench base and surface grades). Ensuring the surface of the bioretention filter media is free from localised depressions is particularly important to achieve even distribution of stormwater flows across the surface. In bioretention systems without saturated zones, the base of the trench should be sloped towards the outlet pit (min 0.5% longitudinal grade) to enable the perforated sub-surface drainage pipes to drain freely. Generally an earthworks tolerance of plus or minus 50 mm is considered acceptable.

(c) Sourcing bioretention vegetation

Notifying nurseries early for contract growing is essential to ensure the specified species are available in the required numbers and of adequate maturity in time for bioretention basin planting. When this is not done and the planting specification is compromised, poor vegetation establishment and increased initial maintenance costs may occur. The species listed in SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics are generally available commercially from local native plant nurseries. Availability is, however, dependent upon many factors including demand, season and seed availability. To ensure planting specification can be accommodated, the minimum recommended lead time for ordering is 3-6 months. This usually allows enough time for plants to be grown to the required size. The following pot sizes are recommended as the minimum:

- (i) viro tubes - 50 mm wide x 85 mm deep;
- (ii) 50 mm tubes - 50 mm wide x 75 mm deep; and
- (iii) native tubes - 50 mm wide x 125 mm deep.

(d) Vegetation establishment

The following weed control measures and watering schedule are recommended to ensure successful plant establishment. Regular general maintenance as outlined in SC6.4.3.9.4(5) will also be required.

(i) Weed control

Conventional surface mulching of bioretention basins with organic material like tanbark, should not be undertaken. Most organic mulch floats and runoff typically causes this material to be washed away with a risk of blocking drains. Adopting high planting densities (e.g. 8-10 plants per square metre) and if necessary, applying a suitable biodegradable erosion control matting to the basin batters will help to combat weed invasion and reduce labour intensive maintenance requirements for weed removal. A heavy application of seedless hydro-mulch or hydro-mulch seeded with a sterile annual grass (e.g. Sterile Rye Grass) to create an anchored mulch can also provide short term erosion and weed control prior to planting with nursery stock. No matting or hydro-mulch is to be applied to the surface of the bioretention basin following the construction phase (i.e. in its final design form, vegetated as per planting schedule), as this will hinder filtration of stormwater through

the filter media.

(ii) Watering

Regular watering of bioretention basin vegetation is essential for successful establishment and healthy growth. The frequency of watering to achieve successful plant establishment is dependent upon rainfall, maturity of planting stock and the water holding capacity of the soil. The following watering program is generally adequate but should be adjusted (increased) to suit the site conditions:

- (A) week 1-2 3 visits/ week;
- (B) week 3-6 2 visits/ week; and
- (C) week 7-12 1 visit/ week.

After this initial 3 month period, supplementary irrigation will be required in bioretention basins without submerged zones and may be required in bioretention basins with saturated zones (particularly during the 2 year plant establishment period (see Figure SC6.4.3.9.22)). Watering requirements to sustain healthy vegetation should be determined during ongoing maintenance site visits.



Figure SC6.4.3.9.22 Plant establishment period in bioretention basin

(6) Maintenance requirements – bioretention basins

Vegetation plays a key role in maintaining the porosity of the filter media of a bioretention basin and a strong healthy growth of vegetation is critical to its performance. Therefore the most intensive period of maintenance is during the plant establishment period (first 2 years) when weed removal and replanting may be required.

Inflow systems and overflow pits require careful monitoring, as these can be prone to scour and litter build up. Debris can block inlets or outlets and can be unsightly, particularly in high visibility areas. Inspection and removal of debris should be done regularly, and debris should be removed whenever it is observed on a site. Where sediment forebays are adopted, regular inspection of the forebay is required (3 monthly) with removal of accumulated sediment undertaken as required.

For larger bioretention basins, a maintenance access track for maintenance vehicles (e.g. 4WD ute) should be provided to the full perimeter of the system for maintenance efficiency and ease.

(7) Checking tools – bioretention basins

A number of checking aids have been developed for designers and council development assessment officers. In addition, SC6.4.3.9.4(5) Construction and establishment - bioretention basins provides general advice for the construction and establishment of bioretention basins and key issues to be considered to ensure their successful establishment and operation based on observations from construction projects around Australia.

(a) Design assessment

The checklist at Table SC6.4.3.9.11 presents the key design features that are to be reviewed when assessing the design of a bioretention basin. These considerations include configuration, safety, maintenance and operational issues that need to be addressed during the design phase. If an item receives an “N” when reviewing the design, referral is made back to the design procedure to determine the impact of the omission or error. A copy of the completed design calculation summary from Table SC6.4.3.9.10 should be provided as part of the application to assist in the design assessment. In addition to the checklist, a proposed design is to have all necessary permits for its installation. Council development assessment officers will require all relevant permits to be in place prior to accepting a design.

Click here to view **Table SC6.4.3.9.11 Bioretention basin design assessment checklist**

(b) Construction (during and post)

The checklist at Table SC6.4.3.9.12 presents the key items to be reviewed when inspecting the bioretention basin during and at the completion of construction. The checklist is to be used by Construction Site Supervisors and local authority Compliance Inspectors to ensure all the elements of the bioretention basin have been constructed in accordance with the design. If an item receives an “N” in Satisfactory criteria then appropriate actions must be specified and delivered to rectify the construction issue before final inspection sign-off is given.

Click here to view **Table SC6.4.3.9.12 Bioretention basin construction inspection checklist**

(c) Operation and maintenance inspection

The example form at Table SC6.4.3.9.13 should be developed and used whenever an inspection is conducted and kept as a record on the asset condition and quantity of removed pollutants over time. Inspections should occur every 1 - 6 months depending on the size and complexity of the system. More detailed site specific maintenance schedules should be developed for major bioretention basins and include a brief overview of the operation of the system and key aspects to be checked during each inspection.

Click here to view **Table SC6.4.3.9.13 Bioretention basin maintenance checklist**

(d) Asset transfer (following on maintenance period)

Land ownership and asset ownership are key considerations prior to construction of a stormwater treatment device. A proposed design should clearly identify the asset owner and who is responsible for its maintenance. The proposed owner should be responsible for performing the asset transfer checklist. For details on asset transfer to specific to each council, contact the relevant local authority. Table SC6.4.3.9.14 provides an indicative asset transfer checklist.

Click here to view **Table SC6.4.3.9.14 Bioretention basin asset transfer checklist**

(8) Example engineering drawings – bioretention basins

Where council has standard drawings appropriate to a bioretention basin application, these should be used to guide the design and construction of a bioretention basin. In the absence of local standards, Brisbane City Council have developed a set of Standard Drawings (UMS 155, 156 and 337) that can be readily applied to bioretention basin applications in the coastal dry tropics. These drawings relate specifically to inlet pits and sub-surface drains for bioretention swales but may be used to guide design for bioretention basins.

Editor’s note—these are not intended to be prescriptive drawings which must be adhered too; rather they are intended to provide detailed examples of bioretention system configurations.

(9) References and additional information – bioretention basins

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SC6.4.3.9.5 Constructed stormwater wetlands

Editor's note—due to the different climatic conditions, the design of constructed wetlands in the coastal dry topics differs from the design of wetlands in south east Queensland and southern states. The following design considerations and criteria outlined below are specific to the coastal dry topics and are intended to address key requirements such as maintaining perennial wetland vegetation during the dry season; managing the potential for weed ingress and providing natural means of managing mosquito populations.

- (1) Constructed wetland systems are densely vegetated water bodies that use enhanced sedimentation, fine filtration and biological uptake processes to remove pollutants from stormwater. Water levels rise during rainfall

events and outlets are configured to slowly release flows, typically over two to three days, back to dry weather water levels. In addition to treating stormwater, constructed wetlands can also provide habitat, passive recreation and improved landscape amenity.

Constructed wetlands in the coastal dry tropics will generally consist of an inlet zone (sedimentation basin to remove coarse sediments, deep pools, a deep marsh macrophyte zone (i.e. a heavily vegetated area to remove fine particulates and uptake soluble pollutants) and a high flow bypass channel (to protect the macrophyte zone from scour and vegetation damage). Figure SC6.4.3.9.23 Schematic layout of a constructed wetland system and Figure SC6.4.3.9.24 Wet and dry season conditions in a constructed freshwater wetland show the key elements of constructed stormwater wetland systems.

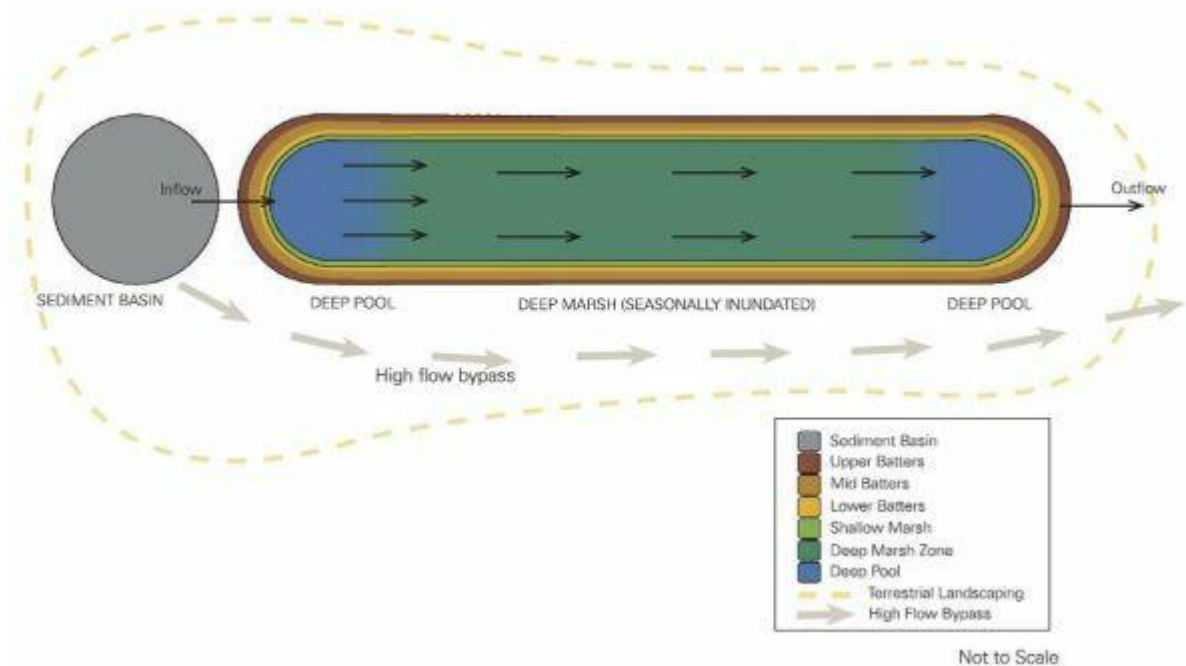


Figure SC6.4.3.9.23 Schematic layout of a constructed wetland system

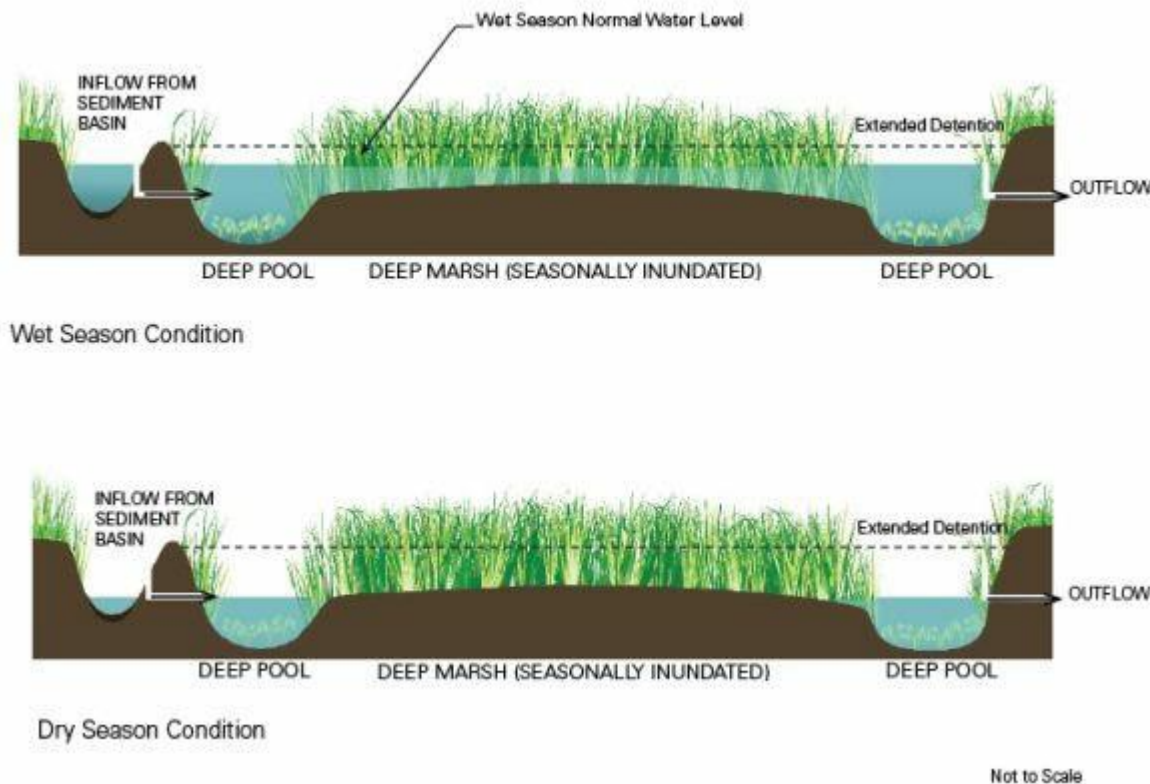
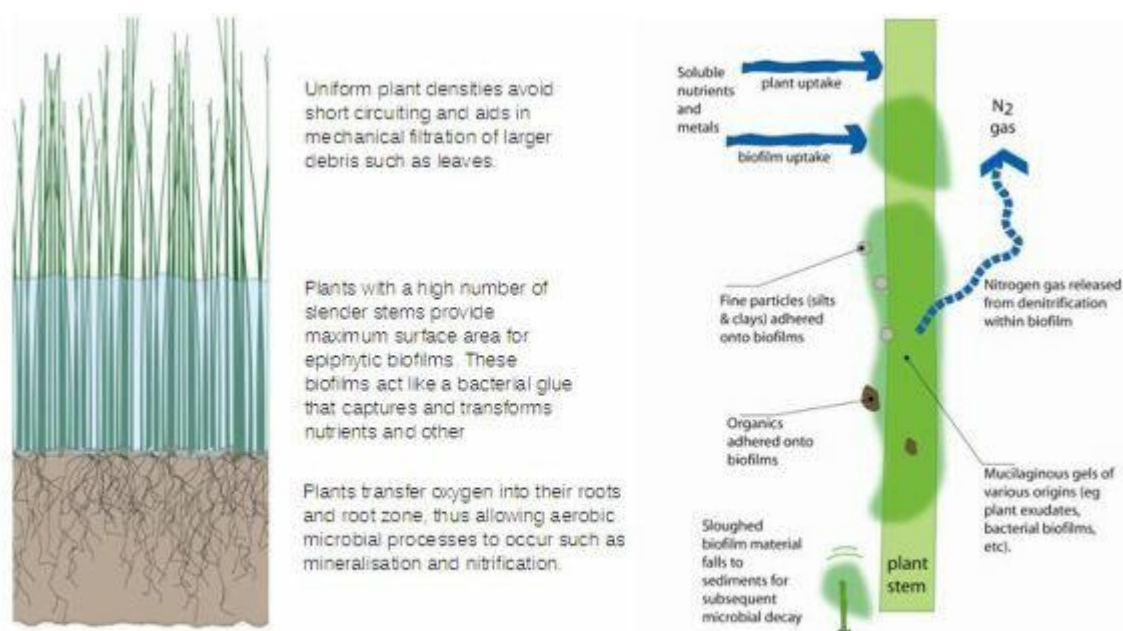


Figure SC6.4.3.9.24 Wet and dry season conditions in a constructed freshwater wetland

Constructed wetlands treat stormwater by capturing runoff and slowly passing it horizontally through a densely vegetated macrophyte zone. Soluble and colloidal (fine particles held in suspension) pollutants are mostly removed by sorption (absorption – “into” and adsorption – “onto”) to biofilms on stems of wetland plants (Figure SC6.4.3.9.25). For this reason, dense vegetation is important for effective treatment and vegetation with a large stem surface area provides greatest treatment (i.e. plants with many small diameter stems are able to support more biofilms than plants with fewer, thicker stems). Emergent macrophytes are also important for:

- (a) transferring oxygen to the sediments (oxygen pumps) thereby facilitating the processing and/or immobilising of pollutants captured and held within wetland sediments;
- (b) aiding in the treatment of nutrient and heavy metal concentrations, either through direct uptake, or through providing a surface for biofilms and epiphytes that assist with the removal of pollutants;
- (c) influencing sediment deposition and physically filtering sediment particles from the water column;
- (d) influencing hydrology and hydraulics by promoting even flow distribution through the wetland;
- (e) providing shade, decreasing light availability for algal synthesis;
- (f) decreasing erosion by reducing wave action and flow velocities while binding soil particles with their root systems; and
- (g) providing a basis for wetland food chains and supplying shelter for mosquito predators such as macroinvertebrates and fish.



(Figure and associated text from the *Healthy Waterways WSUD Technical Design Training Notes for South East Queensland* - Version 1 June 2007)

Figure SC6.4.3.9.25 Dense emergent macrophytes and biofilms on the plant stems play an important role in nutrient removal in constructed stormwater wetlands

Source—Figure and associated text from the *Healthy Waterways WSUD Technical Design Training Notes for South East Queensland* - Version 1 June 2007.

(2) Design considerations - constructed wetlands

Due to the different climatic conditions, the design of constructed wetlands in the coastal dry topics differs from the design of wetlands in south-east Queensland and southern states. The following design considerations and criteria outlined below are specific to the coastal dry topics and are intended to address key requirements such as maintaining perennial wetland vegetation during the dry season; managing the potential for weed ingress and providing natural means of managing mosquito populations. Constructed wetlands in the form detailed below have not yet been constructed in the Townsville region. Therefore it is recommended that demonstration projects adopting the design guidelines detailed below are constructed and revisions/updates of this clause

made, where deemed appropriate, to reflect practical learnings and understanding of the performance and sustainability of constructed stormwater treatment wetlands in the coastal dry tropics.

Community acceptance of constructed wetlands will be driven by their aesthetics and landscape amenity value. Poorly designed and/or maintained wetlands are unlikely to gain community support; therefore, it is essential to address potential issues such as pests and weeds starting at conceptual design and continuing through implementation and long-term maintenance.

The operation of constructed wetlands involves the interaction between stormwater runoff, vegetation and hydraulic structures and the successful implementation of constructed wetlands requires appropriate integration into the landscape design. In this regard, the following sections provide an overview of the key design issues that must be considered when conceptualising and designing constructed wetlands.

(a) Landscape design

Constructed wetlands are often located within accessible open space areas and can become interesting community features. Landscape design aims to ensure that macrophyte planting fulfils the intended stormwater treatment function as well as integrating with their surrounds. Opportunities to enhance public amenity and safety with viewing areas, pathway links, picnic nodes and other elements should be exploited. Community education through signage and public art can also be explored. It is important that the landscape of constructed wetlands addresses stormwater quality objectives whilst being sensitive to these other important landscape aims.

Terrestrial landscaping provides a visual buffer and framework for the wetland system within the community and native habitat. Native trees can encourage recreational elements such as walking and bird watching. These recreational elements, as well as education in the form of descriptive panels and signs, can increase acceptance of these systems within the community.



Figure SC6.4.3.9.26 Boardwalk and public viewing area on the edge of a landscaped wetland

(b) Invasive weed control

To protect landscape amenity and the stormwater treatment efficiency of the wetland it is important to maintain, throughout the year, the design vegetation communities to avoid excessive colonisation of the wetland by weeds. Weed infestation is a major problem in the dry tropics, particularly within ephemeral waterways and stormwater treatment facilities. The wetland design presented in this chapter is based on an ephemeral wetland (i.e. it will dry periodically) and therefore, the design and management of the wetland to manage weed infestation takes on high importance. Management of weeds is achieved as follows:

- (i) designing the macrophyte zone as predominately a deep marsh system (i.e. water depth 0.5 m - 0.7 m) to maintain the macrophyte vegetation by minimising the frequency and duration of wetland drying, thus permanently occupying the habitat and restricting weed colonisation opportunities;
- (ii) planting dense littoral vegetation around the perimeter of the wetland to avoid the ingress of weed species. To maintain dense perennial littoral vegetation, irrigation is likely to be required, particularly during the dry season; and

- (iii) during the establishment and ongoing maintenance of the wetland, prompt removal of weeds before they spread and/or set seed is of critical importance.

(c) Detention time and hydrologic effectiveness

Detention time is the time taken for each “parcel” of water entering the wetland to travel through the macrophyte zone assuming “plug” flow conditions. In highly constrained sites, simulations using quantitative computer models, such as the Model for Urban Stormwater Improvement Conceptualisation (MUSIC, CRCCH 2005), are often required to optimise the relationship between wetland detention time¹ and wetland hydrologic effectiveness to maximise treatment performance. Hydrologic effectiveness is a measure of the mean annual volume of stormwater runoff captured and treated within the wetland and is expressed as a percentage of the mean. It is recommended that a notional detention time should preferably be around 48 hours to remove nutrients effectively from urban stormwater. Optimal hydrologic effectiveness in the coastal dry tropics Region is a balance between minimising overflows in the wet season and sustaining vegetation in the dry season (i.e. sizing the wetland to treat the majority of stormwater runoff while not being too large as to result in water level drawdown and drying in excess of 60–70 days in the dry season). Further discussion on hydrologic effectiveness and sizing of wetlands in the coastal dry tropics is provided in the following sections of this clause.

Editor’s note—it should be noted that detention time is rarely a constant and the term notional detention time is used throughout this chapter to provide a point of reference in modelling and determining the design criteria for riser outlet structures.

(d) Hydrodynamic design

Poor wetland hydrodynamics is often identified as a major contributor to wetland operational and management problems. A summary of desired hydrodynamic characteristics and design considerations is presented in Table SC6.4.3.9.15.

Table SC6.4.3.9.15 Desired wetland hydrodynamic characteristics and associated design considerations

Hydrodynamic Characteristics	Design Considerations	Remarks
Uniform Distribution of flow velocity	Wetland shape, inlet and outlet placement and bathymetrical design of wetland to eliminate short-circuit flow paths and poorly mixed zones.	Poor flow pattern within a wetland will lead to zones of stagnant pools which promote litter, oil and scum accumulation as well as potentially supporting mosquito breeding. Short circuit flow paths of high velocities will lead to the wetland being ineffective in water quality improvement.

Inundation depth, wetness gradient, base flow and hydrologic regime	Selection of wetland size and design of outlet control to ensure compatibility with the hydrology and size of the catchment draining into the wetland. Bathymetry layout and outlet control design to compliment the botanical design and the hydrology of the wetland.	Wetland area and outlet design is critical to achieve the WSUD Objectives (e.g. target pollutant load reduction) as well as ensuring the size is adequate to sustain wetland vegetation (i.e. not too large as to result in excessive water level drawdown and drying in excess of 60 days in the dry season). Inadequate attention to the inundation depth, wetness gradient of the wetland and the frequency of inundation at various depth ranges would lead to sparse vegetation cover and/or dominance of certain plant species (especially weed species over time). This results in a deviation from the intended botanical layout of the wetland and reduced stormwater treatment performance.
Uniform vertical velocity profile	Selection of plant species and location of inlet and outlet structures to promote uniform vertical velocity profile.	Preliminary research findings have indicated that certain plant species have a tendency to promote stratification of flow conditions within a wetland leading to ineffective water pollution control and increasing the potential for algal blooms.
Scour protection	Design of inlet structures and erosion protection of banks.	Owing to the highly dynamic nature of stormwater inflows, measures are to be taken to “protect” the wetland from erosion during periods of high inflow rates.

(e) Inlet zone design considerations

The inlet zone of a constructed stormwater wetland is designed as a sedimentation basin and has two key functional roles. The primary role is to remove coarse to medium sized sediment (i.e. 125 µm or larger) prior to flows entering the macrophyte zone. This ensures the vegetation in the macrophyte zone is not smothered by coarse sediment and allows the macrophyte zone to target finer particulates, nutrients and other pollutants.

The second role of the inlet zone is the control and regulation of flows entering the macrophyte zone and bypass of flows during “above design flow” conditions. The outlet structures from the inlet zone (i.e. sedimentation basin) are designed such that flows up to the “design flow” (typically the 1 year ARI) enter the macrophyte zone whereas “above design flows” are bypassed around the macrophyte zone. In providing this function, the sedimentation basin protects the vegetation in the macrophyte zone against scour during high flows (see Figure SC6.4.3.9.27).

When the available space for a constructed wetland is constrained, it is important to ensure that the size of the inlet zone (i.e. sedimentation basin) is not reduced. This ensures the larger sediments are effectively trapped and prevented from smothering the macrophyte zone. When the site constrains the size of the constructed wetland it is the macrophyte zone of the wetland that should be reduced accordingly.

Large wetland systems usually require a gross pollutant trap (GPT) as part of the inlet zone to protect the wetland from litter and debris. The decision of whether a GPT is required or not, depends on the presence of upstream GPT measures and catchment size. The relevant local authority should be

consulted to determine if a GPT is required.



Figure SC6.4.3.9.27 Inlet zone bypassing major design flows around wetland.

(f) Macrophyte zone design considerations

The layout of the macrophyte zone needs to be configured such that system hydraulic efficiency is optimised and healthy vegetation sustained. Design considerations include:

- (i) the preferred extended detention depth is 0.5 m. Deeper extended detention depths, up to a maximum of 0.75 m, may be acceptable where the wetland has a high hydrologic effectiveness and where the botanic design uses plant species tolerant to greater depths of inundation;
- (ii) the longitudinal bathymetry of the macrophyte zone should grade (min 0.5% grade) smoothly from 0.7 m in depth (based on design normal water level) up to a central crest 0.5 m in depth and then back down to a maximum of 0.7 m in depth. This ensures that isolated pools of water are not created within the macrophyte zone during the dry season when the normal water level slowly draws down due to evapotranspiration;
- (iii) the macrophyte zone is to have a flat cross sectional bathymetry only grading up at the edge batters. This facilitates the even distribution of flows to avoid short circuiting, creates a uniform hydraulic conveyance and maximises stormwater contact with macrophyte stems and biofilms;
- (iv) the bathymetry of the macrophyte zone should be designed so that the macrophyte zone is connected to deeper open water pools (located at the inlet and outlet of the macrophyte zone) to allow mosquito predators to seek refuge in the deeper open water zones during periods of extended dry weather;
- (v) the deep open water pools should be 2 m in depth to ensure that a permanent pool of water is sustained throughout the dry season. This ensures habitat is retained for fish, macroinvertebrates (mosquito predators) and submerged macrophytes;
- (vi) the surface area of deep refuge pools (excluding the sediment basin) within the wetland should be between 20% and 30% of the total macrophyte area;
- (vii) the constructed wetland is required to retain water permanently and therefore the base must be of suitable material to retain water (e.g. clay). If in-situ soils are unsuitable for water retention, a clay liner (e.g. compacted 300 mm thick) must be used to ensure there will be permanent water for vegetation and habitat;
- (viii) particular attention should be given to the placement of the inlet and outlet structures, the length to width ratio of the macrophyte zone and flow control features to promote a high hydraulic efficiency within the macrophyte zone;
- (ix) dense littoral vegetation around the perimeter of the wetland is required to avoid the ingress of weed species. To maintain dense perennial littoral vegetation, irrigation is likely to be required, particularly during the dry season. During extended dry periods (e.g. in excess of 60 days) wetland macrophytes may also require irrigation to sustain dense foliage and prevent habitat opportunities for weed species;
- (x) provision to drain the macrophyte zone for water level management during the plant establishment phase should also be considered; and

- (xi) the macrophyte zone outlet structure needs to be designed to provide a notional detention time (usually 48 hours) for a wide range of flow depths. The outlet structure should also include measures to exclude debris to prevent clogging.

(g) Wetlands constructed within retention (or detention) basins

In many urban applications, wetlands can be constructed in the base of retention basins, thus reducing the land required for stormwater treatment. In these situations, wetland systems will occasionally become inundated to greater depths than the extended detention depth; however, the inundation duration is usually relatively short (hours) and is unlikely to affect the wetland vegetation provided there is a safe pathway to drain the wetland following flood events which avoids scour of the wetland vegetation and banks.

When designing a wetland within a retention basin, the outlet control structure of the retention basin (typically culverts) should be placed at the end of the wetland bypass channel. This ensures flood flows “backwater” across the wetland thus protecting the macrophyte vegetation from scour by high velocity flows.

(h) Vegetation types

Vegetation planted in the macrophyte zone has an important functional role in treating stormwater flows, as well as adding aesthetic value. A dense cover of perennial emergent macrophytes is essential for both stormwater treatment function and for the control of weeds. It is necessary for the macrophytes to permanently occupy the wetland habitat to limit weed colonisation opportunities. Dense perennial littoral vegetation is also important to avoid the ingress of weed species into the wetland macrophyte zone. Dense planting of the littoral zone will inhibit public access to the macrophyte zone, minimising potential damage to wetland plants and reducing the safety risks posed by water bodies.

The reader is referred to SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics for a list of suggested plant species suitable for constructed wetland systems in the coastal dry tropics. The planting densities recommended in the list should ensure that 70 - 80% cover is achieved within two growing seasons (2 years). The distribution of the species within the wetland will relate to their structure, function, relationship and compatibility with other species. The plant species in SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics are listed in accordance with the wetland zone/water depth in which they should be planted. The wetland zones are: deep marsh, shallow marsh (wetland edge), lower littoral and upper littoral.

(i) Designing to avoid mosquitoes

To reduce the risk of high numbers of mosquitoes, there are a number of design features that can be considered. Not all of these will be feasible in any one situation, but they include:

- (i) providing access for mosquito predators, such as fish and predatory insects, to all parts of the water body (avoid stagnant isolated areas of water);
- (ii) providing a deep permanent pool (for long dry periods or for when water levels are artificially lowered) so that mosquito predators can seek refuge and maintain a presence in the wetland;
- (iii) where possible, incorporating a steep slope into the water, preferably greater than 300 or 3:1 horizontal to vertical. Note that steep edges may be unacceptable for public safety reasons, and a slope of up to 8:1 horizontal to vertical is generally used;
- (iv) wave action from wind over open water will discourage mosquito egg laying and disrupt the ability of larvae to breathe;
- (v) providing a bathymetry such that water draws down evenly so isolated pools are avoided;
- (vi) providing sufficient gross pollutant control at the inlet such that human derived litter does not accumulate and provide breeding habitat;
- (vii) providing ready access for field operators to monitor and treat mosquito larvae if required;
- (viii) ensuring maintenance procedures do not result in wheel rut and other localised depressions that create isolated pools when water levels fall; and
- (ix) ensuring overflow channels don't have depressions that will hold water after a storm event.

(j) Designing for maintenance access

Access to all areas of a constructed wetland is required for maintenance. In particular inlet zones and

gross pollutant traps require a track suitable for heavy machinery for removal of debris and desilting as well as an area for dewatering removed sediments. If sediment removal requires earthmoving equipment to enter the basin, then a stable ramp suitable for heavy plant will be required into the base of the inlet zone (maximum slope 1:10).

To aid maintenance, it is recommended that the inlet zone is constructed with a hard (i.e. rock) bottom. This is important if maintenance is performed by driving into the basin. It also serves an important role by allowing excavator operators to detect when they have reached the base of the inlet zone during desilting operations.

Macrophyte zones require access to the areas for weeding and replanting as well as regular inspections. Commonly, these access tracks can be incorporated with walking paths around a wetland system. Maintenance access to constructed wetland needs to be considered when determining the layout of a wetland system.

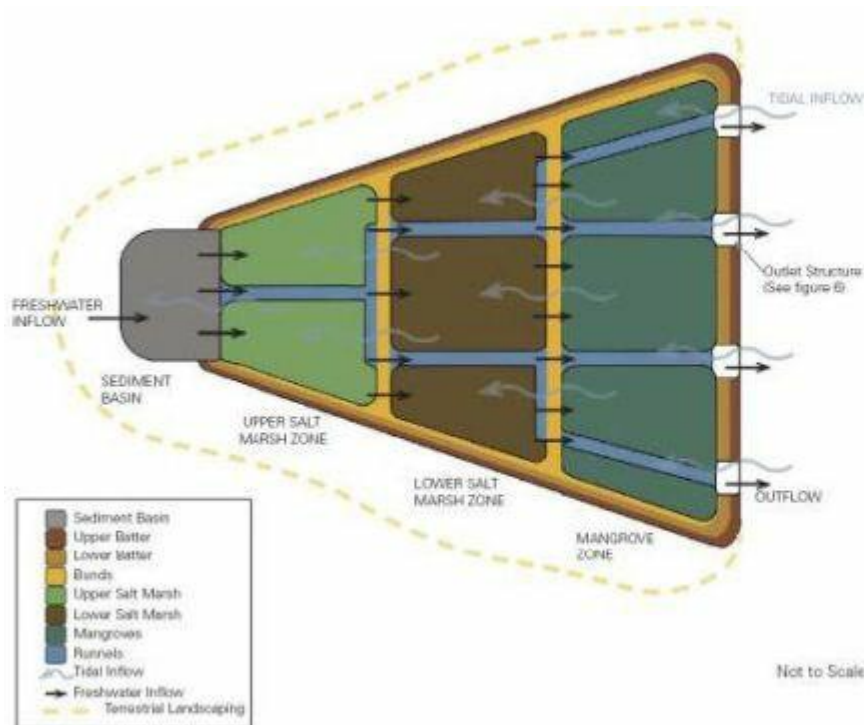
(3) Technical note: saline/brackish constructed wetlands

Urban communities in the dry tropics are often located near large estuarine river systems. In some locations it may be useful to have an optional estuarine stormwater treatment system. While estuarine systems are typically lower nutrient environments than freshwater stormwater treatment systems, a modified salt marsh community would still have considerable nutrient processing capability and could potentially provide a stormwater treatment capacity in some locations. This is a new concept that has not yet been tested and therefore should only be considered if other design solutions are not possible or practical.

If an estuarine stormwater treatment system was to be trialled/ constructed as a demonstration project, it is recommended that the model would need to consider the following list of features/design elements:

- (a) drain a large stormwater runoff event over several tidal cycles;
- (b) during a runoff event, extended detention depth should not exceed 0.5 m, but preferably be lower;
- (c) the wetland should consist of a series of cells that would progressively fill and spill during a runoff event;
- (d) the initial cell would be a sedimentation pond;
- (e) surrounding the sedimentation pond and throughout the subsequent cells would support salt marsh communities (ranging from herbaceous to woody);
- (f) a dry weather drainage system would allow complete drainage over a single tide cycle;
- (g) the wetland would be drained by a series of runnels that would be capable of completely draining the system on a low tide sequence, thus managing potential mosquito breeding habitat;
- (h) high tides (exceeding mean high tide) would be allowed to penetrate the entire system;
- (i) a salinity gradient would be maintained through the system for most seasons;
- (j) a series of berms and chokes would be included to ensure cells progressively fill and spill and that a salinity gradient is created and maintained;
- (k) in high tidal range environments particular care will be needed in the design of the hydraulic connection between the perched salt marsh treatment system and the larger and deeper estuarine drainage channels (these environments are highly susceptible to erosion particularly after catchment development); and
- (l) an important element in a estuarine system will be the wetting and drying sequence in that this will heighten the capacity to process nitrogen pollutants which are critical pollutants to near shore marine ecosystems.

The illustrations on the following page (Figure SC6.4.3.9.28 Possible design features of saline/brackish constructed wetlands), demonstrate how a saline/brackish wetland may be configured to achieve the above design criteria.



Runnels are small channels or rivulets located throughout the system providing a key hydrologic linkage between treatment zones. The saline/brackish wetland needs to be large enough to drain the runoff volume at all tide cycles, i.e. completely drain during low tide to prevent the creation of mosquito larval habitat. Complete draining will depend on the frequency of inundation. If the system is at the top of the tide height some residual water may be necessary. This may increase the risk of mosquito habitat being created. In addition, the wetlands need to be small enough to retain stormwater inflows and backwater the entire wetland during runoff events. Inundation depth during wet weather flows probably should not exceed 0.5 metres.

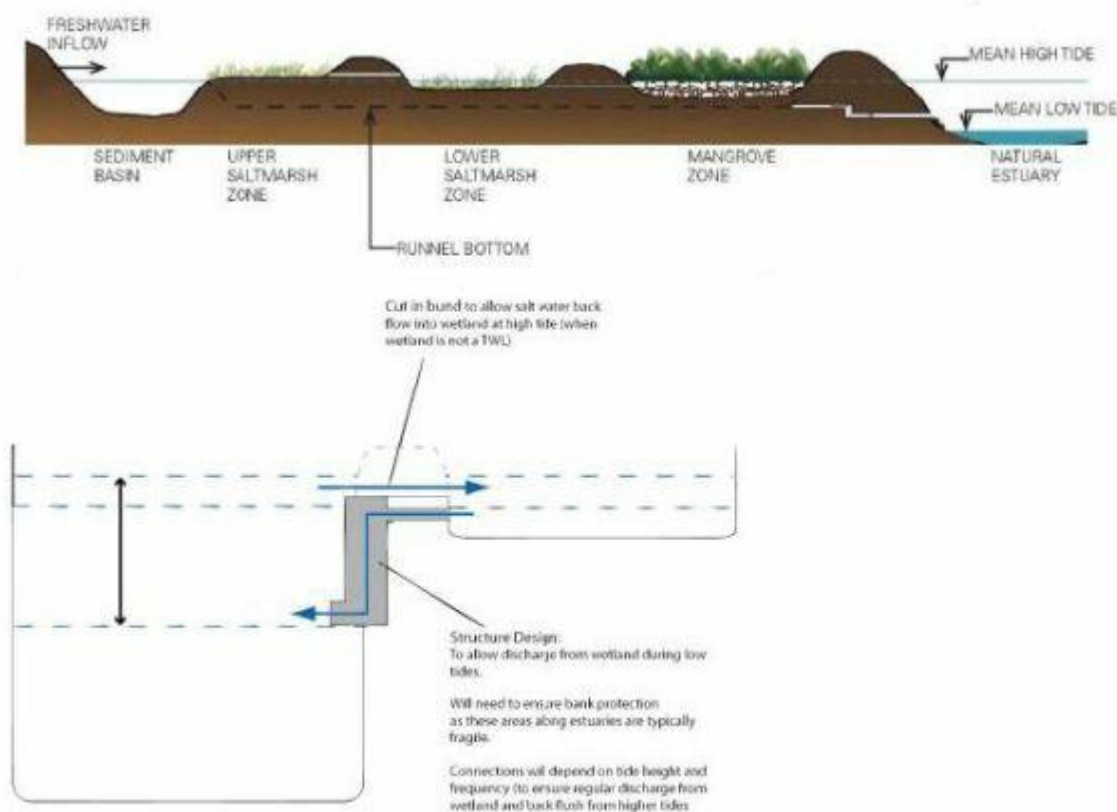
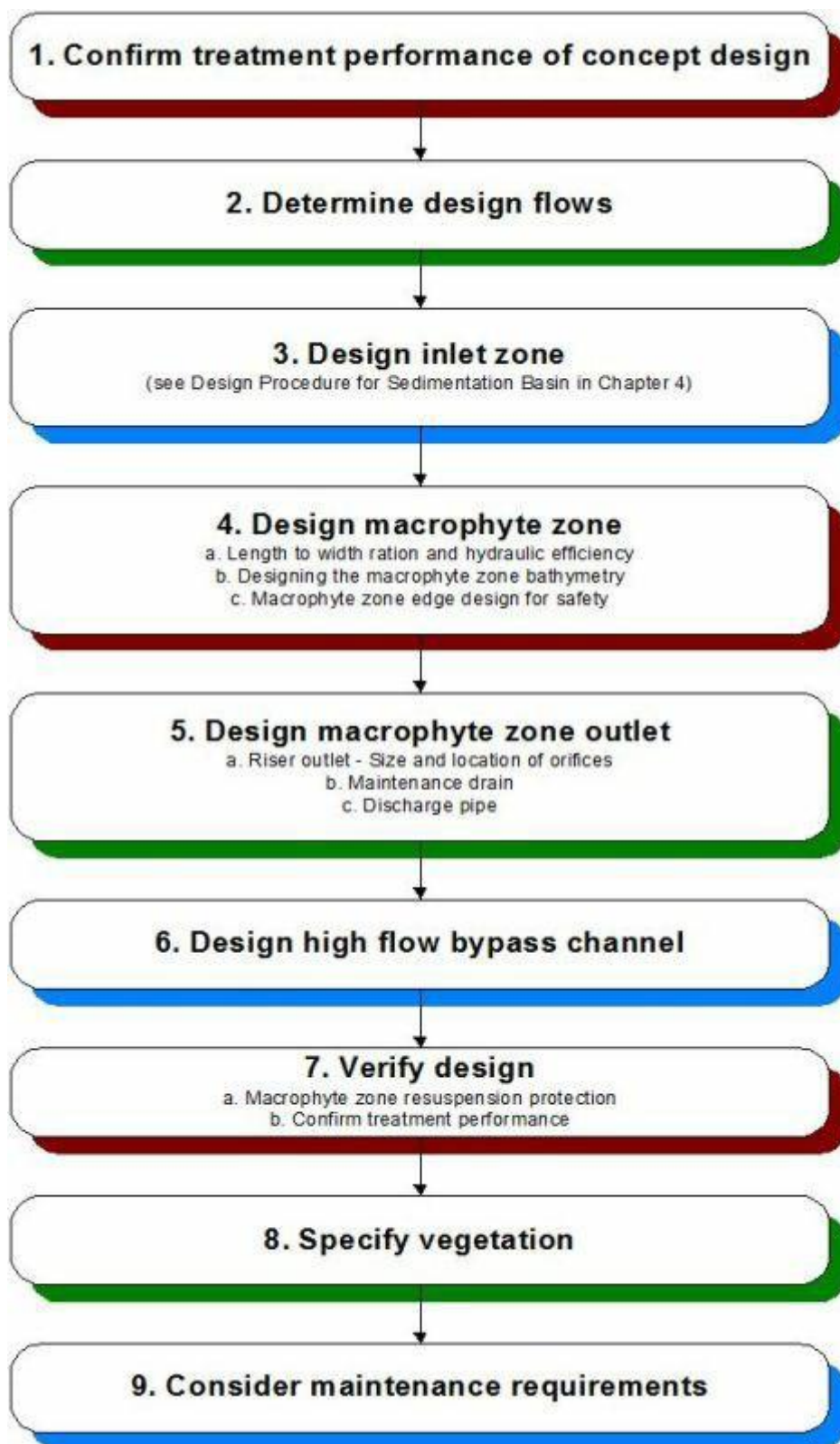


Figure SC6.4.3.9.28 Possible design features of saline/brackish constructed wetlands

(4) Wetland design process

The key design steps following the site planning and concept development stages are:



(a) Step 1: Confirm treatment performance of concept design

Before commencing detailed design, the designer should first undertake a preliminary check to confirm the constructed wetland area (i.e. the macrophyte zone surface area) from the concept design is adequate to deliver the required level of stormwater quality improvement. This assessment should be undertaken by a WSUD specialist and can be achieved by modelling expected treatment performance in

an appropriate quantitative modelling program. Where possible, this modelling should be based on local rainfall data, the proposed configuration of the system, and based on local stormwater treatment performance data.

(b) Step 2: Determine design flows

(i) Design discharges

To configure the inlet zone and high flow bypass elements of a constructed wetland the following design flows apply:

- (A) design operation flow (1 year ARI) for sizing the inlet zone (i.e. sedimentation basin) and the “control” outlet structure (i.e. overflow pit and pipe connection) discharging to macrophyte zone; and
- (B) above design flow for design of the high flow bypass around the macrophyte zone. The discharge capacity for the bypass system may vary depending on the particular situation but will typically correspond to one of the following:
 - minor design flow (2 year ARI) – for situations where only the minor drainage system is directed to the inlet zone; and
 - major flood flow (100 year ARI) – for situations where both the minor and major drainage system discharge into the inlet zone.

(ii) Design flow estimation

A range of hydrologic methods can be applied to estimate design flows. If the typical catchment areas are relatively small, the Rational Method design procedure is considered to be a suitable method for estimating design flows. However, if the constructed wetland is to form part of a retention basin (refer to SC6.4.3.9.5(2)(g) Wetlands constructed within retention (or detention) basins) or if the catchment area to the wetland is large (> 50 ha), then a full flood routing computation method needs to be used to estimate design flows.

(c) Step 3: Design inlet zone

As outlined in SC6.4.3.9.5(2)(e) Inlet zone design considerations, the inlet zone (see example in Figure SC6.4.3.9.29 Inlet zone of a constructed wetland in Brisbane) of a constructed stormwater wetland is designed as a sedimentation basin and serves two functions: (1) pretreatment of inflow to remove coarse to medium sized sediment; and (2) the hydrologic control of inflows into the macrophyte zone and bypass of floods during “above design” operating conditions. As depicted in Figure SC6.4.3.9.30 Example of inlet zone connection to macrophyte, the inlet zone consists of the following elements:

- (i) sedimentation basin “pool” to capture coarse to medium sediment (125µm or larger).
- (ii) inlet zone connection to the macrophyte zone (or “control” structure as defined in normally consisting of an overflow pit within the inlet zone connected to one or more pipes through the embankment separating the inlet zone and the macrophyte zone.
- (iii) high flow bypass weir (or “spillway” outlet structure to deliver “above design” flood flows to the high flow bypass channel.



Figure SC6.4.3.9.29 Inlet zone of a constructed wetland in Brisbane

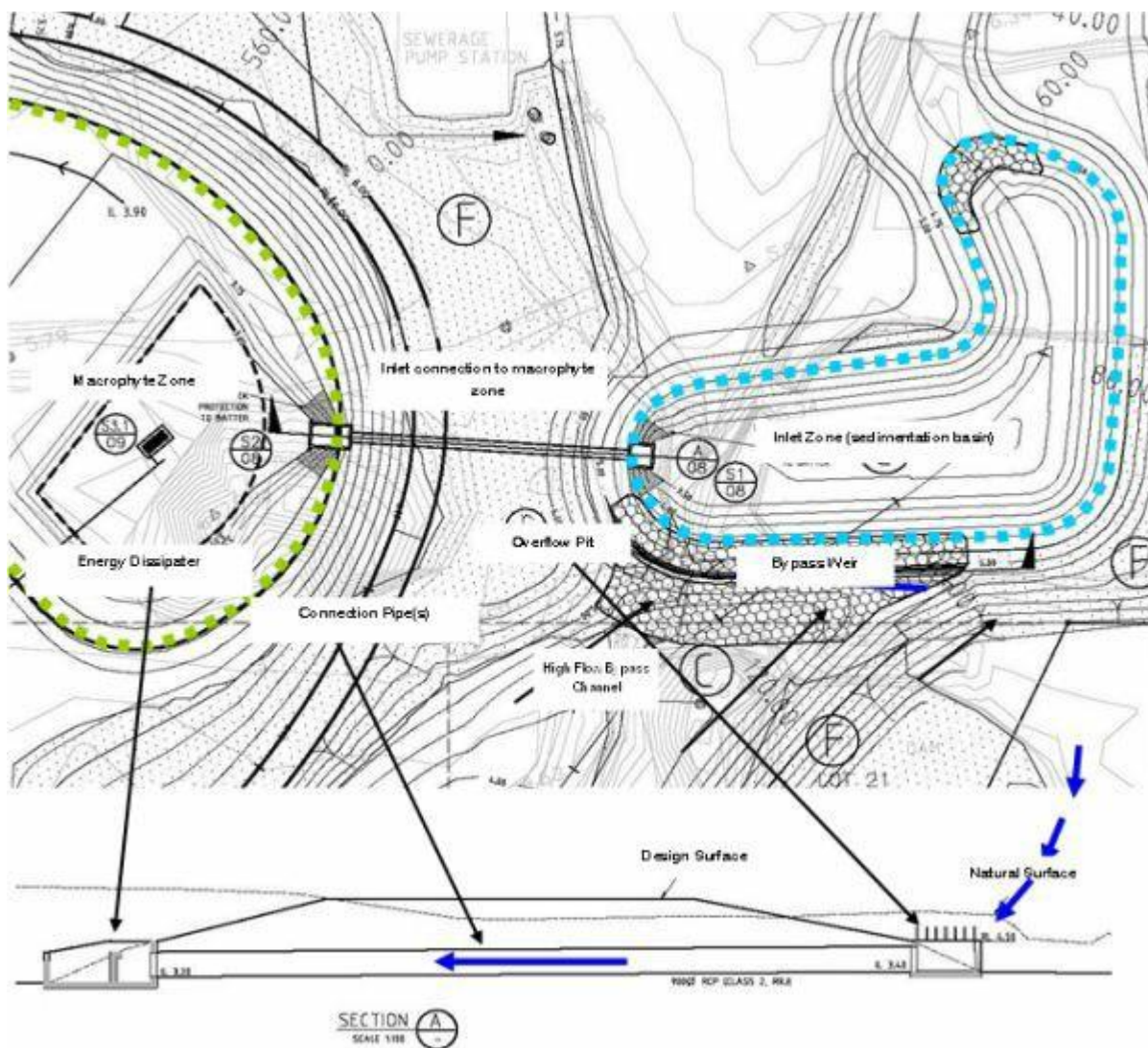


Figure SC6.4.3.9.30 Example of inlet zone connection to macrophyte zone

- (iv) For more information and design guidance for each of the inlet zone elements listed above, the reader is referred to Chapter 4 Sedimentation Basins. When applying the design procedure outlined in Chapter 4, the following should be used as a guide:
- (A) the inlet zone typically must comprise a deep open water body that operates essentially as a sedimentation basin designed to capture coarse to medium sized sediment (i.e. 125 μm or larger);
 - (B) it may be necessary for a GPT to be installed such that litter and large debris can be captured at the interface between the incoming waterway (or pipe) and the open water of the inlet zone;
 - (C) the crest of the overflow pit must be set at the normal water level of the inlet zone (which is typically set 0.3 m above the normal water level of the macrophyte zone);
 - (D) the pipe that connects the sedimentation basin to the macrophyte zone needs to have sufficient capacity to convey a 1 year ARI flow, assuming the macrophyte zone is at the normal water level and without resulting in any flow over the high flow bypass weir;
 - (E) the obvert of the connection pipe can be set below the normal water level of the wetland to conceal the pipe (below the normal water level) during the dry season;
 - (F) an energy dissipater is usually required at the end of the pipes to reduce velocities and distribute flows into the macrophyte zone;
 - (G) the inlet zone is to have a structural base (e.g. rock) to define the base when desilting and provide support for maintenance plant/ machinery when entering the basin for maintenance; and

- (H) the high flow bypass weir (“spillway” outlet) is to be set at the same level as the top of extended detention in the macrophyte zone.

(d) Step 4: Designing the macrophyte zone

(i) Length to width ratio and hydraulic efficiency

To optimise wetland performance, it is important to avoid short circuit flow paths and poorly mixed regions within the macrophyte zone. One way to minimise this is to adopt a high length to width ratio not less than 5 to 1 for the macrophyte zone. Length to width ratios less than this can lead to poor hydrodynamic conditions and reduced water quality treatment performance.

Persson et al. (1999) used the term hydraulic efficiency (λ) to define the expected hydrodynamic characteristics for a range of configurations of stormwater detention systems (Figure SC6.4.3.9.31). Engineers Australia (2006) recommend that constructed wetland systems should not have a hydraulic efficiency (λ) less than 0.5 and preferably should be greater than 0.7.

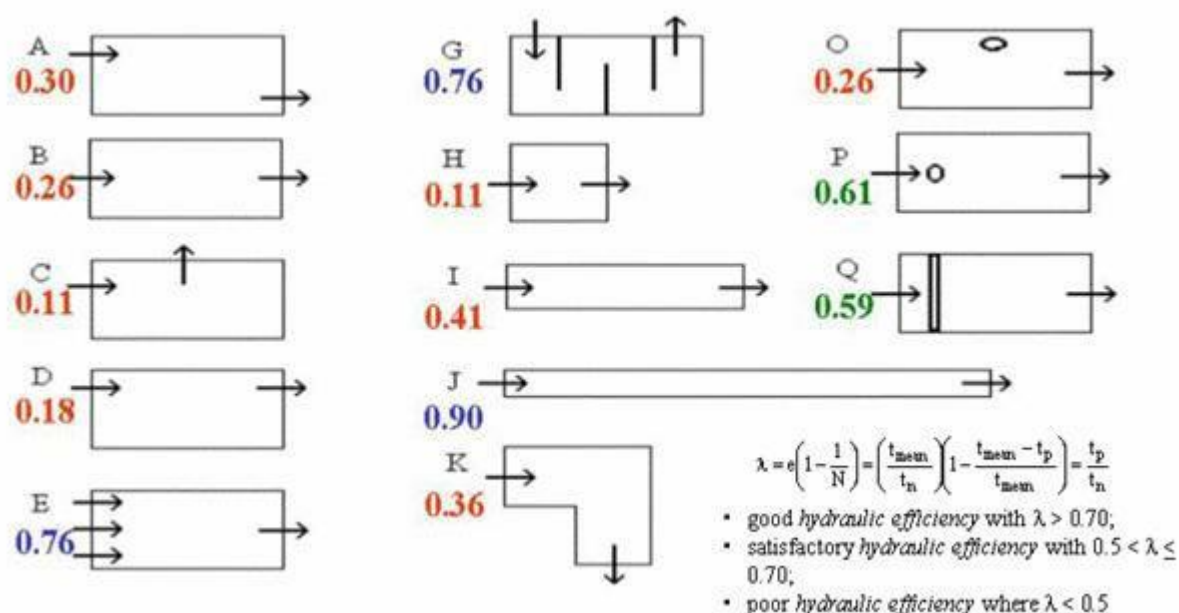


Figure SC6.4.3.9.31 Hydraulic efficiency (λ) ranges

Hydraulic efficiency ranges from 0 to 1, with 1 representing the best hydrodynamic conditions for stormwater treatment. The o in diagrams O and P represent islands in the waterbody and the double line in diagram Q represents a weir structure to distribute flows evenly (Persson et al. 1999).

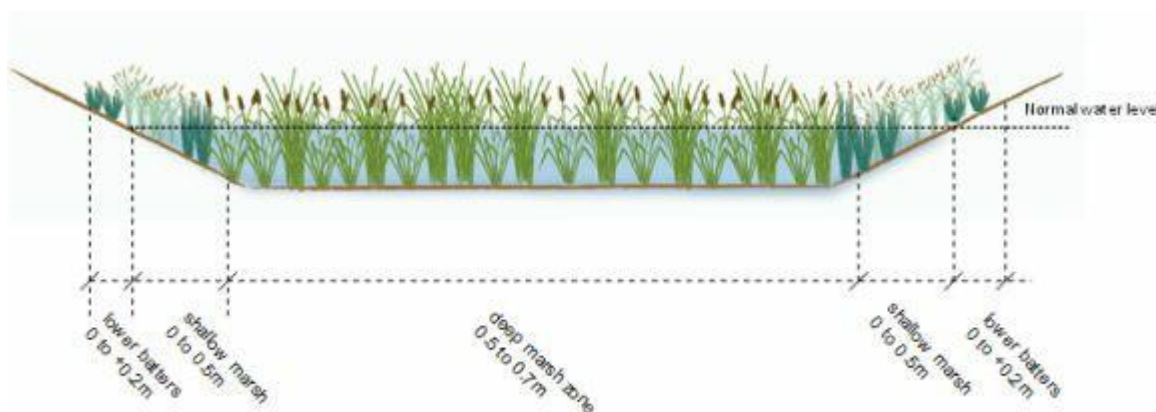
(ii) Designing the macrophyte zone bathymetry

The bathymetry of constructed wetlands in the coastal dry tropics are to be designed to ensure that macrophytes can provide adequate pollutant removal during the wet season and also be sustained during the dry season. To achieve this, the longitudinal bathymetry of the macrophyte zone should gently grade (min 0.5% grade) from 0.7 m in depth (based on design normal water level) up to a central crest 0.5 m in depth and then back down to a maximum of 0.7 m in depth. This ensures that isolated pools of water are not created during the dry season when the normal water level slowly draws down due to evapotranspiration. Smaller deep open water permanent pools at the inlet and outlet of the wetland are required to provide habitat for mosquito predators during the dry season (Refer to Figure SC6.4.3.9.23 Schematic layout of a constructed wetland system and Figure SC6.4.3.9.24 Wet and dry season conditions in a constructed freshwater wetland). For large wetlands, this bathymetry could be repeated in series (i.e. a deep pool located between two macrophyte zones).

The macrophyte zone is to have a flat cross sectional bathymetry only grading up at the edge

batters (Figure SC6.4.3.9.32). This facilitates the even distribution of flows to avoid short circuiting, creates a uniform hydraulic conveyance and maximises stormwater contact with macrophyte stems and biofilms. This is also assisted by providing banded macrophyte planting perpendicular to the direction of flow (Figure SC6.4.3.9.33).

The deep open water pools should be 2 m in depth to ensure that a permanent pool of water is sustained throughout the dry season. This ensures habitat is retained for fish, macroinvertebrates (mosquito predators) and submerged macrophytes. Submerged macrophytes are important to provide habitat and for maintaining dissolved oxygen levels and therefore deeper pools (i.e. >2 m) should be avoided. A balance pipe connection between the deep pools is necessary to allow inflows in dry conditions to benefit and sustain the deep permanent pools. The surface area of deep refuge pool (excluding the sediment basin) within the wetland should be between 20% and 30% of the total macrophyte area. This ensures the volume of water within the pools is sufficient to maintain permanent water during the dry season but not so large that the macrophyte zone is likely to experience dry periods of greater than 60 days (due to larger inflows required to fill the pools before wetting the macrophyte zone).



Note—refer to SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics for more detail on planting zones and suitable macrophyte species.

Figure SC6.4.3.9.32 Typical cross section of a constructed wetland system showing preferred bathymetry and planting zones.



Figure SC6.4.3.9.33 Macrophyte zone banded planting (direction of flow is from left to right)

(iii) Macrophyte zone edge design for safety

Consideration of public safety is required when wetlands are located in parklands/public open space or any areas readily accessible. Reducing public safety risk can be achieved in a number of ways and the measures adopted should respond to the level of perceived risk given the particular

site characteristics.

One method of reducing the risk posed by water bodies is to design batter slopes on approaches and immediately under the normal water level (refer Figure SC6.4.3.9.34). It is recommended that a gentle slope to the water edge and extending below the water line be adopted before the batter slope steepens into deeper areas.

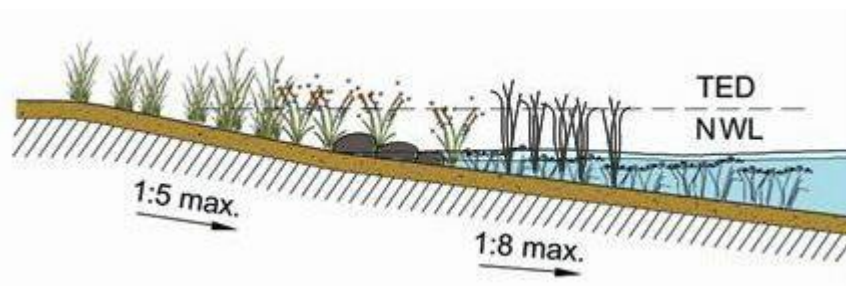


Figure SC6.4.3.9.34 Example of a wetland edge design for public safety

The safety requirements for individual wetlands will vary from site to site and requires careful consideration. The following requirements from the *Sediment Basin Design, Construction and Maintenance Guidelines* (BCC 2001) can be applied to constructed wetland systems:

- for water depths greater than 150 mm and maximum batter slope of 5:1 (H:V) or less, no fencing is required; and
- for water depths greater than 150 mm and maximum batter slope greater than 5:1 (H:V) fencing may be required.

In some cases, vertical edges are used for wetlands (refer to SC6.4.3.9.5(5) Landscape design notes). When vertical edges are used, a safety fencing/ barrier should be considered on top of concrete or stone walls where:

- (A) there is a risk of serious injury in the event of a fall (over 0.5 m high and too steep to comfortably walk up/down or the lower surface has sharp or jagged edges);
- (B) there is a high pedestrian or vehicular exposure (on footpaths, near bikeways, near playing/sporting fields, near swings and playgrounds);
- (C) where water ponds to a depth of greater than 300 mm on a constructed surface of concrete or stone;
- (D) where the water is expected to contain concentrated pollutants; and
- (E) where mowed grassed areas abut the asset.

The type of fence/ barrier to be considered should be a:

- dense vegetation at least 2 m wide and 1.2 m high (minimum) may be suitable; or
- pool fence (or similar) when there is a chance of drowning and the surrounding area is specifically intended for use by small children (swings, playgrounds, sporting fields etc.).

(iv) Macrophyte zone soil testing

Constructed wetlands are permanent water bodies and therefore the soils in the base must be capable of retaining water. Geotechnical investigations of the suitability of the in-situ soils are required to establish the water holding capacity of the soils. Where the infiltration rates are too high for permanent water retention, tilling and compaction of in-situ soils may be sufficient to create a suitable base for the wetland. Where in-situ soils are unsuitable for water retention, a compacted clay liner may be required (e.g. 300 mm thick). Specialist geotechnical testing and advice must be sought.

Wetland plants must be planted into suitable topsoil with a minimum depth of 200 mm (see SC6.4.3.9.5(6)(d) Topsoil specification and preparation). Most terrestrial topsoils provide a good substratum for wetlands, nonetheless laboratory soil testing (using Australian Standard testing procedures, e.g. AS 4419-2003: Soils for landscaping and garden use) of topsoil is necessary to ensure the topsoil will support plant and microbial growth and have a high potential for nutrient retention. Careful consideration should be given to the topsoil source and its propensity to contain weed seeds which may be viable in an ephemeral wetland habitat.

(e) Step 5: Design macrophyte zone outlet

A macrophyte zone outlet has two purposes: (1) hydrologic control of the water level and flows in the macrophyte zone to achieve the design detention time; and (2) to allow the wetland permanent pool to be drained for maintenance.

(i) Riser outlet – size and location of orifices

The riser outlet is designed to provide a uniform notional detention time in the macrophyte zone over the full range of the extended detention depths. The target maximum discharge ($Q_{\max \text{ riser}}$) may be computed as the ratio of the volume of the extended detention to the notional detention time as follows

$$Q_{\max \text{ riser}} = \frac{\text{extended detention storage volume (m}^3\text{)}}{\text{notional detention time (s)}}$$

The placement of orifices along the riser and determining their appropriate diameters is an iterative process. The orifice equation (Equation 6.2) is applied over discrete depths along the length of the riser starting at the normal water level and extending up to the riser maximum extended detention depth.

$$A_o = \frac{Q}{C_d \sqrt{2 \cdot g \cdot h}} \quad (\text{Small orifice equation})$$

Where	C_d	=	orifice discharge coefficient (0.67)
	h	=	depth of water above the centroid of the orifice (m)
	A_o	=	orifice area (m ²)
	Q	=	required flow rate to achieve notional detention time (m ³ /s) at the given h
	g	=	9.79 m/s ²

As the outlet orifices can be expected to be small, it is important that they are prevented from clogging by debris. Some form of debris guard is recommended as illustrated in Figure SC6.4.3.9.35 below. An alternative to using a debris guard is to install a riser in a pit located in the embankment surrounding the wetland macrophyte zone (thus reducing any visual impact). A riser within the pit can also be configured with a weir plate (by drilling holes through the plate). An advantage of using a weir plate is that it provides an ability to drain the wetland simply by removing the weir plate entirely. Additionally, shorter weir plates may also be used during the vegetation establishment phase, thus providing more flexibility for water level manipulation.



Figure SC6.4.3.9.35 Example outlet riser assemblies with debris guards

The pit is connected to the deep pool of the macrophyte zone via a submerged pipe culvert. The connection should be adequately sized such that there is minimal water level difference between the water within the pit and the water level in the macrophyte zone. With the water entering into the outlet pit being drawn from below the normal water level (i.e. pipe invert a minimum 0.3 m below normal water level), floating debris is generally prevented from entering the outlet pit, while heavier debris would normally settle onto the bottom of the wetland. The riser pipe should be

mounted upright on a socketed and flanged tee with the top of the pipe left open to allow overtopping of waters if any of the riser orifices become blocked. Figure SC6.4.3.9.36 and Figure SC6.4.3.9.37 show one possible configuration for a riser outlet pit.



Figure SC6.4.3.9.36 Macrophyte zone outlet arrangement

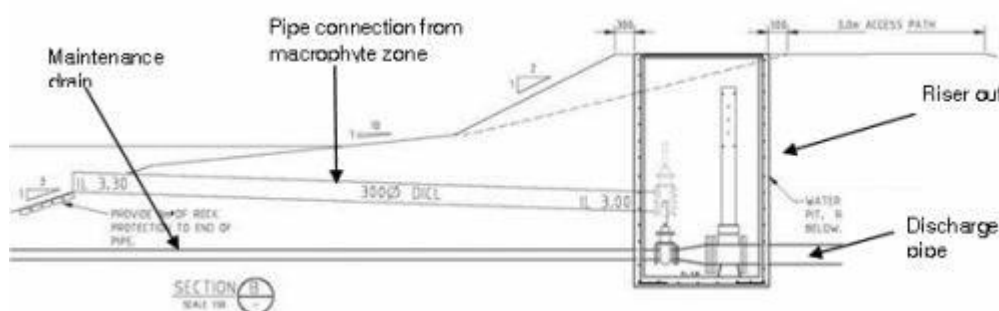


Figure SC6.4.3.9.37 Typical macrophyte zone outlet arrangement

(ii) Maintenance drains

To allow access for maintenance, the wetland should have appropriate allowance for draining. A maintenance drainage pipe should be provided that connects the low points in the macrophyte zone bathymetry to the macrophyte zone outlet. A valve is provided on the maintenance drainage pipe (typically located in the outlet pit as shown in Figure SC6.4.3.9.37), which can be operated manually. The maintenance drainage pipe should be sized to draw down the permanent pool within 12 hours (i.e. overnight). If a weir plate is used as a riser outlet, provision should be made to remove the weir plate and allow drainage for maintenance.

(iii) Discharge pipe

The discharge pipe of the wetland conveys the outflow of the macrophyte zone to the receiving waters (or existing drainage infrastructure). The conveyance capacity of the discharge pipe is to be sized to match the higher of the two discharges (i.e. maximum discharge from the riser or the maximum discharge from the maintenance drain).

(iv) Balance pipe

A balance pipe connection between the deep permanent pools in the wetland is necessary to allow inflows in dry conditions to benefit and sustain all deep pools rather than just the pool located at the inlet. The deep pools are generally 2 m in depth and may experience up to 1m of draw down during the dry season. The invert of the balance pipe should therefore be located approximately 1 m below the normal water level. A 300 mm diameter pipe is typically sufficient for a balance pipe.

(f) Step 6: Design high flow bypass channel

The bypass channel accepts “above design flow” from the inlet zone (sediment pond) of the wetland via the bypass weir (SC6.4.3.9.5(4)(c)) and conveys these flows downstream around the macrophyte zone of the wetland. The bypass channel should be designed using standard methods (i.e. Manning’s Equation) to convey the “above design flow” (SC6.4.3.9.5(4)(b)) and to avoid bed and bank erosion (see Chapter 2). Typically, a turf finish will provide appropriate protection for most bypass channel applications (but velocities need to be checked). Dense planting can be applied when appropriately designed for in terms of design roughness and management of velocities. Figure SC6.4.3.9.38 shows typical high flow bypass channel configurations.



Figure SC6.4.3.9.38 Turfed constructed wetland high flow bypass weir configuration.

(g) Step 7: Verify design

(i) Macrophyte zone resuspension protection

The principle pathway for biological uptake of soluble nutrients in wetlands is through biofilms (epiphytes) attached to the surface of the macrophyte vegetation. The biofilms, being mostly algae and bacteria, are susceptible to wash out under high flow conditions. Further, wetland surveys indicate that up to 90% of the total nutrients are stored in the sediments, therefore, the key to effective retention of pollutants is managing high velocity flows that could potentially resuspend and remobilise these stored pollutants.

A velocity check is to be conducted for design conditions, when the wetland water level is at the top of the extended detention level and the riser is operating at design capacity, to ensure velocities are less than 0.05 m/s through all zones of the wetland. The following condition must be met:

$$\frac{Q_{\text{max riser}}}{A_{\text{section}}} < 0.05 \text{ m/s}$$

Where $Q_{\text{max riser}}$ = target maximum discharge (defined in Equation 6.1) (m^3/s)

A_{section} = minimum wetland cross-section area* (m^2) x 0.5 vegetation blockage factor**

*measured from top of extended detention

**blockage due to tall dense vegetation

(ii) Confirm treatment performance

If the basic wetland parameters established by the conceptual design phase have changed during the course of undertaking detailed design (e.g. macrophyte zone area, extended detention depth, etc.) then the designer should verify that the current design meets the required water quality improvement performance. This can be done by simulating the current design using a suitable quantitative modelling program.

(h) Step 8: Specify vegetation

Refer to SC6.4.3.9.5(5) Landscape design notes and SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics for advice on selecting suitable plant species for constructed wetlands.

(i) Step 9: Consider maintenance requirements

Consider how maintenance is to be performed on the wetland (e.g. how and where is access available, where is litter likely to collect etc.). A specific maintenance plan and schedule should be developed for the wetland, either as part of a maintenance plan for the whole treatment train, or for each individual asset. Guidance on maintenance plans is provided in SC6.4.3.9.5(7) Maintenance requirements - constructed wetlands.

(j) Design calculation summary

Following is Table SC6.4.3.9.16 Constructed wetlands design calculation summary, for the key design elements.

[Click here to view **Table SC6.4.3.9.16 Constructed wetlands design calculation summary**](#)

(5) Landscape design notes - constructed wetlands

Whilst constructed wetlands play a significant role in delivering stormwater quality objectives, they can also play an important role in creating a community landscapes and urban ecology. The following sections outline some of the landscape design issues that should be considered when designing constructed wetland systems.

(a) Objectives

Landscape design of wetlands generally requires consideration of the following objectives:

- (i) integrated planning and design of constructed wetlands within the built and landscape environments ensuring that the overall landscape design for the wetland integrates with its host natural and/ or built environment;
- (ii) achieving dense perennial littoral vegetation around the perimeter of the wetland to avoid the ingress of weed species. To maintain dense perennial littoral vegetation, irrigation is likely to be required, particularly during the dry season;
- (iii) ensuring that the wetland planting strategy is based on the wetland design depths/zones, achieves dense perennial emergent macrophyte cover and has the structural characteristics to perform particular treatment processes (e.g. well distributed flows, enhance sedimentation, maximise surface area for the adhesion of particles and provide a substratum for algal epiphytes and biofilms);
- (iv) providing maintenance access to allow for the prompt removal of weeds before they spread and/or set seed;
- (v) incorporating crime prevention through environmental design (CPTED) principles; and
- (vi) providing other landscape values, such as shade, amenity, character and place making.

Comprehensive site analysis should inform the landscape design as well as road layouts, maintenance access points and civil works. Existing site factors such as roads, buildings, landforms, soils, plants, microclimates, services and views should be considered. For further guidance refer to the *South East Queensland WSUD Conceptual Design Guidelines* (Healthy Waterways Partnership, 2008).

(b) Wetland siting and shapes

Constructed wetlands need to be arranged to meet hydrological and stormwater quality requirements, but also to integrate effectively into the surrounding existing landscape. The arrangement of wetland, basin and high flow bypass should be designed early in the concept design phase, to ensure that amenity of open space is enhanced.

The final shape of a wetland should provide landscape opportunities to create alternate useable spaces/recreation areas (see Figure SC6.4.3.9.39). Often different shapes to wetland edges can make pathway connections through and around these recreation areas more convenient and enhances the community perception of constructed wetlands. Pathways and bridges across planted earth bunds can be the best way of getting across or around wetlands (see Figure SC6.4.3.9.40). The materials on the bridge and pathways are important to be low maintenance and do not impede hydrological flows. Ease of access to the inlet basin for sediment and trash removal is also important to consider.

The area required for the high flow bypass can be manipulated to provide open spaces that only periodically convey stormwater flows. Further discussion of high flow bypass configuration is provided in SC6.4.3.9.5(c)(iii) High flow bypass channel.

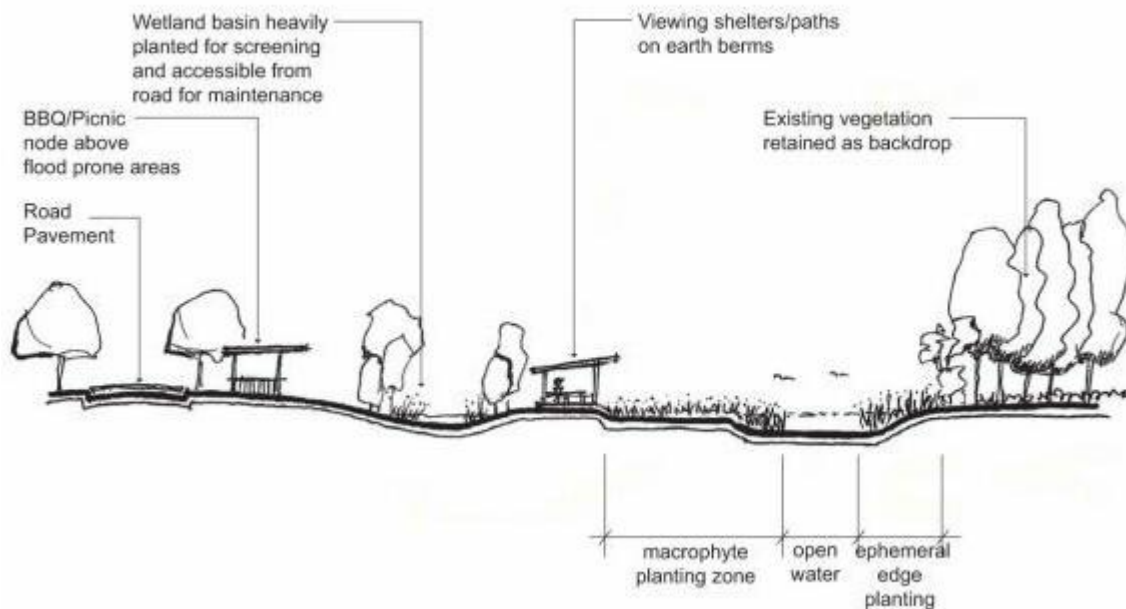


Figure SC6.4.3.9.39 Typical landscape treatments to constructed wetlands in open space areas



Figure SC6.4.3.9.40 Boardwalk treatment over wetland (left) and integration of urban art with wetland setting (right)

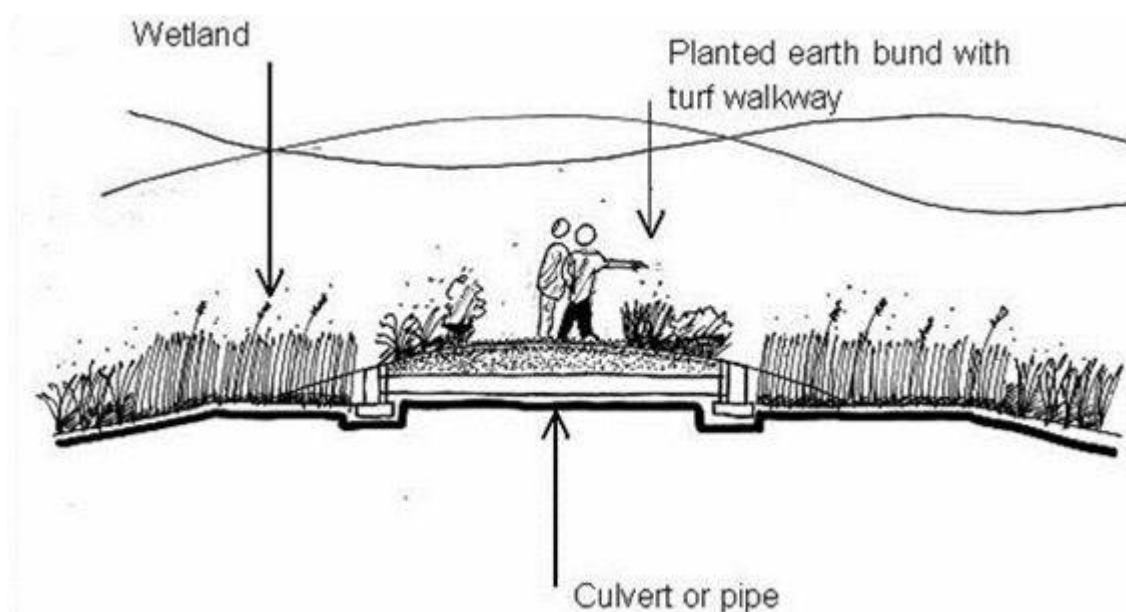


Figure SC6.4.3.9.41 Earth bund structure as wetland crossing

(c) Specific landscape considerations

Numerous opportunities are available for creative design solutions for specific elements. Close collaboration between landscape designer, hydraulic designer, civil/structural engineer and maintenance personnel is essential. In parklands and residential areas, the aim is to ensure elements are sympathetic to their surroundings and are not overly engineered or industrial in style and appearance. Additionally, landscape design to specific elements should aim to create places that local residents and visitors will come to enjoy and regard as an asset.

(i) Crossings

Given the size and location of wetland systems, it is important to consider if access is required across the wetland as part of an overall pathway network and maintenance requirement. Factors that should be considered include:

- (A) the appropriateness of hardwood timber board walks given their life-cycle costs. Where walkway footings are in contact with water, council will not accept timber piers;
- (B) if boardwalks are used, they should not be located near open water where they could encourage the public to feed wildlife; and
- (C) earth bunds located between the sedimentation basin and macrophyte zone can be used as crossings and can be planted as a shaded walkways.

Figure SC6.4.3.9.41 illustrates a conceptual earth bund walkway.

(ii) Wetland embankments

The landscape design approach for the wetland embankments is similar to the approach taken for embankments in sedimentation basins.

(iii) High flow bypass channel

The high flow bypass channel will convey stormwater during above design flow and in some situations can form a large element in the landscape. Therefore the design of the high flow bypass needs to be carefully considered to provide recreational and landscape opportunities during times outside of above design flow events.

The key considerations for design of the high flow bypass area are as follows:

- (A) no major park infrastructure including playgrounds, barbeques and amenity buildings to be located within the high flow bypass areas. Passive recreation infrastructure including seating and picnic tables are suitable provided they are of robust design;
- (B) in many cases, the high flow bypass will be formed through the use of turf and in these cases the opportunity for creating more active spaces should be investigated;
- (C) designers should investigate the opportunities for locating trees and other vegetation types within the bypass channel. Provided hydraulic efficiencies can be accommodated, grassed mounds and landform;
- (D) grading of the embankment edge could also be explored to add variation and interest;
- (E) where groundcover species other than turf are adopted, plant species should be selected to ensure appropriate response after periodic flooding;
- (F) areas of large revegetation or garden beds that cut through the high flow bypass zone should use thick matting mulch types that bind well to the surface to minimise loss; and
- (G) the relationship between the high flow bypass channel and the permanent water bodies should be considered in order to create interesting spaces and forms within the open space. For example, after consideration of site constraints and hydraulic parameters, designers could investigate options to separate the elements from each other or to channel both elements alongside each other. Opportunities should also be sought to achieve balanced cut and fill earthworks. Figure SC6.4.3.9.42 provides an illustration of creation of open spaces through configuration of key wetland components.

(iv) Macrophyte zone outlet structure

Landscape design approach for the macrophyte outlet zone is similar to the approach taken for overflow pits in sedimentation basins. Refer to Chapter 4, Section 4.4.3.6 for further guidance.

- (v) Viewing areas
Refer to Chapter 4, Section 4.4.3.8 for guidance.
- (vi) Fencing
Refer to Chapter 4, Section 4.4.3.9 for guidance.

Editor's note—these Chapter and Section references are to *Water Sensitive Urban Design Guidelines for South East Queensland*.

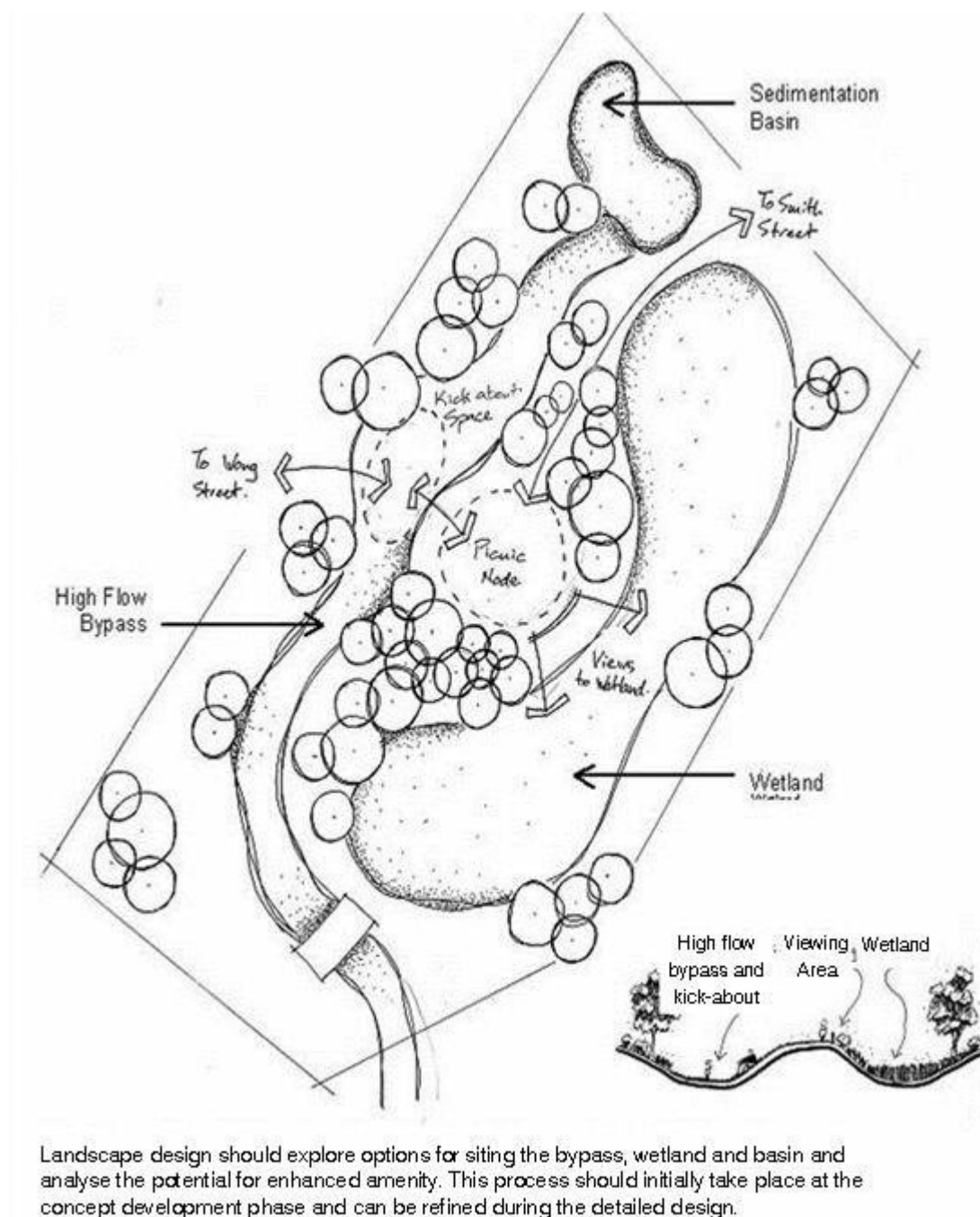


Figure SC6.4.3.9.42 Example relationship between high flow bypass wetland and basin and the creation of open space

- (d) Constructed wetland vegetation
Planting for constructed wetlands systems may consist of up to three vegetation types:
 - (i) Macrophyte zone planting consisting of deep marsh (0.5 m – 0.7 m in depth at design normal water level) and shallow marsh (edges) (0.5 m – 0 m in depth at design normal water level);

Macrophyte zone planting (from 1.0 m below to 0.2 m above design water level)

SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics provides guidance on selecting suitable plant species and cultivars that deliver the desired stormwater quality objectives for constructed wetlands. Often the most effective way to meet those objectives with the macrophyte planting is to create large bands of planting perpendicular to flow that respond to designed depth zones and local biodiversity.

In general, macrophyte vegetation should provide:

- (A) well distributed flows;
- (B) enhanced sedimentation;
- (C) maximum surface area for the adhesion of particles;
- (D) a substratum for algal epiphytes and biofilms; and
- (E) habitat and refuge for fauna, both terrestrial and aquatic.

This is achieved by selecting species with many small diameter vertical leaves or stems and planting the vegetation in bands. When selecting suitable species it is important to also note the ability of some species to be highly self-sustaining. Littoral planting should provide a dense buffer between the wetland and publicly accessible open space to discourage contact with the water.

- (ii) Littoral vegetation (embankment) (above design normal water level) and parkland vegetation
Between the macrophyte zone and the top of the embankment, establishment of trees, shrubs and groundcovers can occur in consideration of the following:
 - (A) selecting groundcovers, particularly for slopes greater than 1 in 3, with matting or rhizomatous root systems to assist in binding the soil surface during the establishment phase;
 - (B) achieving dense perennial littoral vegetation around the perimeter of the wetland to avoid the ingress of weed species. To maintain dense perennial littoral vegetation, irrigation is likely to be required, particularly during the dry season;
 - (C) preventing macrophyte zone plants and ground covers from being shaded out by minimising tree densities at the water's edge and choosing species such as *Melaleuca* that allow sunlight to penetrate the tree canopy;
 - (D) locating vegetation to allow views of the wetland and its surrounds whilst discouraging the public from accessing the water body; and
 - (E) parkland vegetation may be of a similar species to the embankments littoral vegetation and layout to visually integrate the wetland with its surrounds. Alternatively, vegetation of contrasting species and/ or layout may be selected to highlight the water body as a feature within the landscape. Turf may be considered to achieve this goal.
- (iii) Terrestrial plants, including existing vegetation, adjacent to the upper littoral edge.

(e) Safety issues

(i) General

Constructed wetlands need to be generally consistent with public safety requirements for new developments. These include reasonable batter profiles for edges to facilitate public egress from areas with standing water and fencing where water depths and edge profile requires physical barriers to public access. Fences can be substituted where possible by using dense edge plantings to deter public access to areas of open water. Dense littoral vegetation that can grow to around 2 m high and 1.5 m wide are effective in deterring public access.

(ii) Restricting access to open water

Fences or vegetation barriers to restrict access should be incorporated into wetland areas, particularly on top of concrete or stone walls where:

- (A) there is a risk of serious injury in the event of a fall (over 0.5 m high and too steep to comfortably walk up/ down or the lower surface or has sharp or jagged edges);
- (B) there is a high pedestrian or vehicular exposure (on footpaths, near bikeways, near playing/ sporting fields, near swings and playgrounds etc.);
- (C) where water ponds to a depth of greater than 300 mm on a constructed surface of concrete

- or stone. Natural water features are exempt; and
- (D) where grassed areas requiring mowing about the asset.

Barriers that may be appropriate are:

- dense vegetation at least 2 m wide and 1.2 m high (minimum) may be suitable; and
- pool fence (or similar) when there is a chance of drowning and the surrounding area is specifically intended for use by small children (swings, playgrounds, sporting fields etc.).

Dense littoral planting around the wetland and particularly around the deeper open water pools of the sediment pond (with the exception of any maintenance access points), will deter public access to the open water and create a barrier to improve public safety. Careful selection of plant species (e.g. tall, dense or “spiky” species) and planting layouts can improve safety as well as preventing damage to the vegetation by trampling.

Dense vegetation (hedge) at least 2 m wide and 1.2 m high (minimum) may be suitable. A temporary fence may be required until the vegetation has established and becomes a deterrent to pedestrians.

An alternative to the adoption of a barrier/ fence is to provide a 2.4 m safety bench that is less than 0.2 m deep below the normal water level around the waterbody. This is discussed in Chapter 4 Section 4.3.3.3 with respect to appropriate batter slopes.

(6) Construction and establishment - constructed wetlands

This section provides general advice for the construction and establishment of constructed wetlands and key issues to be considered to ensure their successful establishment and operation. Some of the issues raised have been discussed in other sections of this chapter and are reiterated here to emphasise their importance based on observations from construction projects around Australia.

(a) Staged construction and establishment method

It is important to note that constructed wetlands, like most WSUD elements that employ soil and vegetation based treatment processes, require approximately two growing seasons (i.e. two years) before the vegetation in the systems has reached its design condition (i.e. height and density). In the context of a large development site and associated construction and building works, delivering constructed wetlands and establishing vegetation can be a challenging task. Therefore, constructed wetlands require a careful construction and establishment approach to ensure the wetland establishes in accordance with its design intent. The following sections outline a recommended staged construction and establishment methodology for constructed wetlands (Leinster, 2006).

(i) Construction and establishment challenges

There exist a number of challenges that must be appropriately considered to ensure successful construction and establishment of wetlands. These challenges are best described in the context of the typical phases in the development of a greenfield or infill development, namely the subdivision construction phase and the building phase.

(A) subdivision construction - involves the civil works required to create the landforms associated with a development and install the related services (roads, water, sewerage, power etc.) followed by the landscape works to create the softscape, streetscape and parkscape features. The risks to successful construction and establishment of the WSUD systems during this phase of work have generally related to the following:

- construction activities which can generate large sediment loads in runoff which can smother wetland vegetation; and
- construction traffic and other works can result in damage to the constructed wetlands.

Importantly, all works undertaken during subdivision construction are normally “controlled” through the principle contractor and site manager. This means the risks described above can be readily managed through appropriate guidance and supervision.

- (B) building phase - once the subdivision construction works are complete and the development plans are sealed then the building phase can commence (i.e. construction of the houses or built form). This phase of development is effectively “uncontrolled” due to the number of building contractors and sub- contractors present on any given allotment. For this reason the allotment building phase represents the greatest risk to the successful establishment of constructed wetlands.
- (ii) Staged construction and establishment method
- To overcome the challenges associated within delivering constructed wetlands a staged construction and establishment method should be adopted (see Figure SC6.4.3.9.43):
- (A) Stage 1: Functional installation - construction of the functional elements of the constructed wetland at the end of subdivision construction (i.e. during landscape works) and the installation of temporary protective measures.
- (B) Stage 2: Sediment and erosion control – during the building phase the temporary protective measures preserve the functional infrastructure of the constructed wetland against damage whilst also providing a temporary erosion and sediment control facility throughout the building phase to protect downstream aquatic ecosystems.
- (C) Stage 3: Operational establishment - at the completion of the building phase, the temporary measures protecting the functional elements of the constructed wetland can be removed along with all accumulated sediment.



Figure SC6.4.3.9.43 Staged construction and establishment method

- (iii) Functional installation
- Functional installation of constructed wetlands occurs at the end of subdivision construction as part of landscape works and involves:
- (A) earthworks to configure the bathymetry of the wetland;
- (B) installation of the hydraulic control structures including inlet/outlet control and the high flow bypass weir;
- (C) placement of topsoil, trimming and profiling;
- (D) placement of turf in the High Flow Bypass channel to protect against erosion;
- (E) disconnecting the Inlet Zone from Macrophyte Zone and allowing all stormwater to flow along High Flow Bypass. This effectively isolates the Macrophyte Zone from catchment flows and allows the establishment of wetland plants without the risk of being smothered with coarse sediment during the Subdivision Construction and Allotment Building Phases;
- (F) planting of the Macrophyte Zone once the disconnection is in place;
- (G) water level in the Macrophyte Zone can be varied as required by the rate of wetland plant maturity by opening the connection for short periods or opening the outlet control. Irrigation of edges may be required; and
- (H) planting the littoral zone and providing irrigation to ensure fast establishment of dense vegetation to minimise weed growth.



Figure SC6.4.3.9.44 depicts the functional installation of a constructed wetland

(iv) Sediment and erosion control

During allotment building phases the sedimentation pond can be used to reduce the load of coarse sediment discharging to the receiving environment. The disconnection between the sediment pond and the macrophyte zone will remain in place to ensure the majority of flows from the catchment continue to bypass the macrophyte zone thus allowing the wetland plants to reach full maturity without the risk of being smothered with coarse sediment (see Figure SC6.4.3.9.45).

This means the macrophyte zone can be fully commissioned and made ready for operation once the allotment building phase is complete.



Figure SC6.4.3.9.45 Constructed wetland sediment and erosion control operation

(v) Operational establishment

At the completion of the allotment building phase the sediment pond is de-silted, the disconnection between the sediment pond and macrophyte zone is removed and the constructed wetland is allowed to operate in accordance with the design.



Figure SC6.4.3.9.46 Constructed wetland operational establishment

(b) Construction tolerances

It is important to emphasise the significance of tolerances in the construction of constructed wetland systems. Ensuring the relative levels of the control structures (inlet connection to macrophyte zone, bypass weir and macrophyte zone outlet) are correct is particularly important to achieve appropriate hydraulic functions. Generally control structure tolerance of plus or minus 5 mm is considered acceptable.

Additionally the bathymetry of the macrophyte zone must be free from localised depressions and low points resulting from earthworks. This is particularly important to achieve a well distributed flow path and to prevent isolated pools from forming (potentially creating mosquito habitat) when the wetland drains. Generally an earthworks tolerance of plus or minus 25 mm is considered acceptable.

(c) Sourcing wetland vegetation

To ensure the specified plant species are available in the required numbers and of adequate maturity in time for wetland planting, it is essential to notify nurseries early for contract growing. When early ordering is not undertaken, the planting specification may be compromised due to sourcing difficulties, resulting in poor vegetation establishment and increased initial maintenance costs. The species listed in SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics are generally available commercially from local native plant nurseries but availability is dependent upon many factors including demand, season and seed availability. To ensure the planting specification can be accommodated the minimum recommended lead time for ordering is 3-6 months. This generally allows adequate time for plants to be grown to the required size. The following sizes are recommended as the minimum:

- (i) viro tubes 50 mm wide x 85 mm deep;
- (ii) 50 mm tubes 50 mm wide x 75 mm deep; and
- (iii) native tubes 50 mm wide x 125 mm deep.

“Floral Edges”, a system of interlocking plants within one long container is recommended for wetland planting, particularly for the deep marsh zone. The series of plants (usually five) are grown together in a single “strip” container. Generally, these “floral edges” are supplied as more mature plants with developing rhizomes (for rhizomatous species) and interlocking roots. This has been used very successfully in wetland planting previously because the larger more mature plants, often with a thick rhizome system, can survive in deeper water and are more tolerant to fluctuations in water level. The

structure of this system slows the movement of water and binds the substrate, helping to reduce erosion. The weight of the interlocking plants also prevents birds from removing them, a common problem encountered during wetland plant establishment. Nurseries require a minimum lead time of 6 months for supply of these systems.

(d) Topsoil specification and preparation

The provision of suitable topsoil in wetlands is crucial to successful macrophyte establishment and to the long term functional performance of the wetland. Wetland macrophytes typically prefer medium textured silty to sandy loams that allow for easy rhizome and root penetration. Although there are a few plants that can grow in in-situ heavy clays (e.g. phragmites), growth is slow and the resulting wetland system will have low species richness, which is undesirable. The wetland must therefore have a layer of topsoil no less than 200 mm deep and preferably 300 mm in depth for improved dry season moisture retention.

During the wetland construction process, topsoil is to be stripped and stockpiled for possible wetland reuse as a plant growth medium. Most terrestrial topsoils provide a good substratum for wetlands, nonetheless laboratory soil testing (using Australian Standard testing procedures, e.g. AS 4419-2003: *Soils for landscaping and garden use*) of the in-situ topsoil is necessary to ensure the topsoil will support plant and microbial growth and have a high potential for nutrient retention. Typically, standard horticultural soil analysis, which includes major nutrients and trace elements, is suitable for topsoils intended for wetland use. The laboratory report will indicate the soils suitability as a plant growth medium and if any amendments are required.

Careful consideration should be given to the topsoil source and its propensity to contain weed seeds which may be viable in an ephemeral wetland habitat. If a problematic weed bank is likely to be present within the topsoil then importing alternative topsoil should be considered. If the in-situ topsoil is found to contain high levels of salt, extremely low levels of organic carbon (< 5%), or any other extremes that may be considered a retardant to plant growth, it should be rejected.

If the in-situ topsoil is not suitable and soil amendment is considered impractical or not cost effective, sandy loam topsoil should be purchased from a soil supplier. If the local topsoil is suitable but very shallow, mixing with an imported soil will be necessary to reach the required volume to ensure a minimum 200 mm deep topsoil for wetland planting.

Imported topsoils are generally suitable as wetland plant growth medium, however as for in-situ soils (above), testing is required to determine the appropriate gypsum or lime dosing rate. If the local topsoil was tested and found to be suitable but then mixed with an imported soil to meet the required volume, laboratory soil testing should be repeated.

(i) Topsoil treatments

The wetland topsoil should be tested in accordance with AS 4419-2003: *Soils for landscaping and garden use* to ensure it is appropriate for growth of vegetation. If testing finds the topsoil is not appropriate then an alternative source should be found.

Topsoils for wetlands generally do not require fertiliser treatment. Imported foreign loam will contain sufficient nutrients for vegetation growth and local terrestrial topsoil will release nutrients after the wetting process. Submersion of terrestrial soils in water causes a shift from aerobic to anaerobic processes, prompting mineralisation and decomposition of organic matter contained in the soil, thus increasing available nitrogen. When soils become anaerobic, reduction processes cause iron oxides to be released from the surface of soil particles leading to increased availability of phosphorus. The addition of nutrients (fertiliser application) can facilitate the growth of algae (including cyanobacteria (blue-green) algae), particularly when the competing macrophytes and submerged plants are in the early stages of development, increasing the likelihood of algal blooms.

The topsoil within the wetland (macrophyte zones and open water zones) may need to be treated with gypsum or lime. The application of gypsum is standard on most construction sites for the purpose of securing or flocculating dispersive soils if entrained in runoff. The use of gypsum in wetland should only occur within catchments with dispersive soils and applied at a maximum rate of 0.4 kg/m². The application of lime may be required where the AS4419 (2003) soil testing

identifies a potential soil pH problem ($\text{pH} < 5$) or where acid sulfate soils (ASS) exist in the vicinity of the wetland. The rate of lime application should be guided by soil test results, an ASS Management Plan and water quality (pH) monitoring of the wetland and inflow.

Gypsum/ lime should be applied about one week prior to vegetation planting. Subsequent application may be required at intervals depending on water quality monitoring. Application of gypsum/ lime too far in advance of planting may lead to aquatic conditions that promote algal growth (i.e. clear water with no aquatic plants competing for resources).

(e) Vegetation establishment

(i) Timing for planting

Timing of vegetation planting is dependent on a suitable time of year (and potential irrigation requirements) as well as timing in relation to the phases of development. October and November are considered ideal times to plant vegetation in treatment elements. This allows for adequate establishment/ root growth before the heavy summer rainfall period but also allows the plants to go through a growth period soon after planting, resulting in quicker establishment. Planting late in the year also avoids the dry winter months, reducing maintenance costs associated with watering. Construction planning and phasing should endeavour to correspond with suitable planting months wherever possible. However, as lead times from earthworks to planting can often be long, temporary erosion controls (e.g. use of matting or sterile grasses to stabilise exposed batters) should always be used prior to planting.

(ii) Water level manipulation

To maximise the chances of successful emergent macrophyte establishment, the water level of the wetland system is to be manipulated in the early stages of vegetation growth. When first planted, vegetation in the deep marsh zone may be too small to be able to exist in their prescribed water depths (depending on the maturity of the plant stock provided). Macrophytes intended for the deep marsh sections will need to have half of their form above the water level, which may not be possible if initially planted at their intended depth. Similarly, if planted too deep, the young submerged plants will not be able to access sufficient light in the open water zones. Without adequate competition from submerged plants, phytoplankton (algae) may proliferate.

The water depth must be controlled in the early establishment phase. This can be achieved by closing off the connection between the sediment pond and the macrophyte zone (i.e. covering the overflow pit) and opening the maintenance drain. The deep marsh zones should have a water depth of approximately 0.2 m for at least the first 6 - 8 weeks. This will ensure the deep marsh zones of the wetland are inundated to shallow depth and the shallow marsh edges remain moist (muddy) providing suitable conditions for plant establishment. Seedlings planted in the littoral zones of the wetland will require ongoing watering at a similar rate as the terrestrial landscape surrounding the wetland (SC6.4.3.9.5(5)(e)(ii) Restricting access to open water). When it is evident that the plants are establishing well and growing actively, a minimum of 6 - 8 weeks following planting, the plants should be of sufficient stature to endure deeper water. At this time, the connection between the inlet pond and the macrophyte zone can be temporarily opened to allow slow filling of the wetland to the design operating water level.

(iii) Weed control

To protect landscape amenity and the stormwater treatment efficiency of the wetland it is important to maintain, throughout the year, the design vegetation communities to avoid excessive colonisation of the wetland by weeds. Weed infestation is a major problem in the dry tropics, particularly within ephemeral waterways and stormwater treatment facilities, therefore, the design and management of the wetland to manage weed infestation takes on high importance.

Management of weeds is achieved as follows:

- (A) designing the macrophyte zone as predominately a deep marsh system (i.e. water depth 0.5 m - 0.7 m) to maintain the macrophyte vegetation by minimising the frequency and duration of wetland drying, thus permanently occupying the habitat and restricting weed colonisation opportunities;
- (B) planting dense littoral vegetation around the perimeter of the wetland to avoid the ingress of weed species. To maintain dense perennial littoral vegetation, irrigation is likely to be

required, particularly during the dry season; and maintaining dense macrophyte vegetation in the wetland during prolonged dry conditions is necessary to avoid opening up habitat opportunities for weeds. When the macrophyte zone dries (i.e. the macrophyte zone sediments are exposed) for a period in excess of 60 days, irrigation of the macrophyte zone may be required to achieve this.

During the establishment and ongoing maintenance of the wetland, prompt removal of weeds before they spread and/or set seed is of critical importance.

Conventional surface mulching of the wetland littoral berms with organic material like tanbark is not recommended. Most organic mulch floats and water level fluctuations and runoff typically causes this material to be washed into the wetland with a risk of causing blockages to outlet structures. Mulch can also increase the wetland organic load, potentially increasing nutrient concentrations and the risk of algal blooms. Adopting high planting density rates and if necessary applying a suitable biodegradable erosion control matting to the wetland batters (where appropriate), will help to combat weed invasion and will reduce maintenance requirements for weed removal. If the use of mulch on the littoral zones is preferred, it must be secured in place with appropriate mesh or netting (e.g. jute mesh).

(iv) Watering

Regular watering of the littoral vegetation during the plant establishment phase is essential for successful establishment and vigorous growth. The frequency of watering to achieve successful plant establishment is dependent upon rainfall, maturity of planting stock and the water level within the wetland. However, the following watering program is generally adequate but should be adjusted (i.e. increased) as required to suit site conditions:

- (A) week 1-2 3 visits/ week;
- (B) week 3-6 2 visits/ week; and
- (C) week 7-12 1 visit/ week.

After this initial 3 month period, irrigation will still be required, particularly during the dry season. Watering requirements to sustain healthy dense vegetation should be determined during ongoing monitoring and maintenance site visits.

(v) Bird protection

During the early stages of wetland establishment, water birds can be a major nuisance due to their habit of pulling out recently planted species. Interlocking planting systems (i.e. where several plants are grown together in a single container such as “floral edges”) can be used, as water birds find it difficult to lift the interlocking plants out of the substrate unlike single plants grown in tubes.

(7) Maintenance requirements - constructed wetlands

Wetlands treat runoff by filtering it through vegetation and providing extended detention to allow sedimentation to occur. In addition, they have a flow management role that needs to be maintained to ensure adequate flood protection for local properties and protection of the wetland ecosystem.

Maintaining healthy vegetation and adequate flow conditions in a wetland are the key maintenance considerations. Weeding, planting, mowing and debris removal are the dominant tasks (but should not include use of herbicides as this affects water quality). In addition, the wetland needs to be protected from high loads of sediment and debris and the inlet zone needs to be maintained in the same way as sedimentation basins (see Chapter 4). Routine maintenance of wetlands should be carried out once a month.

- (a) The most intensive period of maintenance is during plant establishment period (first two years) when weed removal and replanting may be required. It is also the time when large loads of sediments could impact on plant growth, particularly in developing catchments with poor building controls. Debris removal is an ongoing maintenance function. If not removed, debris can block inlets or outlets, and can be unsightly if in a visible location. Inspection and removal of debris should be done regularly. Typical maintenance of constructed wetlands will involve:

- (i) irrigation of the littoral zone plants (especially during dry periods) to prevent the ingress of invasive weeds;

- (ii) prompt removal of weeds before they spread and/or set seed is of critical importance;
- (iii) desilting the inlet zone following the construction/ building period;
- (iv) routine inspection of the wetland to identify any damage to vegetation, weed growth, scouring, formation of isolated pools, litter and debris build up or excessive mosquitoes;
- (v) routine inspection of inlet and outlet points to identify any areas of scour, litter build up and blockages;
- (vi) removal of litter and debris;
- (vii) removal and management of invasive weeds;
- (viii) repair to wetland profile to prevent the formation of isolated pools;
- (ix) periodic (usually every 5 years) draining and desilting of the inlet pond;
- (x) watering of wetland macrophytes during prolonged dry periods (in excess of 60 days);
- (xi) water level control during plant establishment;
- (xii) replacement of plants that have died (from any cause) with plants of equivalent size and species as detailed in the planting schedule; and
- (xiii) vegetation pest monitoring and control.

Inspections are recommended following large storm events to check for scour and damage.

- (b) All maintenance activities must be specified in a maintenance plan (and associated maintenance inspection forms) to be developed as part of the design procedure (SC6.4.3.9.5(4)(i) Step 9: Consider maintenance requirements). Maintenance personnel and asset managers will use this plan to ensure the wetlands continue to function as designed. To ensure maintenance activities are appropriate for the wetland as it develops, maintenance plans should be updated a minimum of every three years. The maintenance plans and forms must address the following:
 - (i) inspection frequency;
 - (ii) maintenance frequency;
 - (iii) data collection/ storage requirements (i.e. during inspections);
 - (iv) detailed clean-out procedures (main element of the plans) including:
 - (A) equipment needs;
 - (B) maintenance techniques;
 - (C) occupational health and safety;
 - (D) public safety;
 - (A) environmental management considerations;
 - (B) disposal requirements (of material removed);
 - (C) access issues;
 - (D) stakeholder notification requirements; and
 - (E) data collection requirements (if any); and
 - (v) design details.

An approved maintenance plan is required prior to asset transfer to the local authority. Refer to the guidelines or direction from the relevant local authority for more specific guidance on requirements for asset transfer.

An example operation and maintenance inspection form is included in the checking tools provided in SC6.4.3.9.5(8)(c) Operation and maintenance inspection form. These forms must be developed on a site specific basis as the configuration and nature of constructed wetlands varies significantly.

(8) Checking tools - constructed wetlands

A number of checking aids has been developed for designers and council development assessment officers. In

addition, SC6.4.3.9.5(6) Construction and establishment provides general advice for the construction and establishment of wetlands and key issues to be considered to ensure their successful establishment and operation, based on observations from construction projects around Australia.

(a) Design assessment

The checklist in Table SC6.4.3.9.17 presents the key design features to be reviewed when assessing a design of a wetland. These considerations include configuration, safety, maintenance and operational issues that should be addressed during the design phase. Where an item results in an “N” when reviewing the design, referral should be made back to the design procedure to determine the impact of the omission or error. In addition to the checklist, a proposed design must have all necessary permits for its installations. Council development assessment officers will require supporting evidence/ proof from the developer that all relevant permits are in place.

Click here to view **Table SC6.4.3.9.17 Wetland design assessment checklist**

(b) Construction (during and post)

The checklist in Table SC6.4.3.9.18 presents the key items to be reviewed when inspecting the bioretention basin during and at the completion of construction. The checklist is to be used by Construction Site Supervisors and local authority Compliance Inspectors to ensure all the elements of the bioretention basin have been constructed in accordance with the design. If an item receives an “N” in Satisfactory criteria then appropriate actions must be specified and delivered to rectify the construction issue before final inspection sign-off is given.

Click here to view **Table SC6.4.3.9.18 Wetland construction inspection checklist**

(c) Operation and maintenance inspection

The example form in Table SC6.4.3.9.19 should be developed and used whenever an inspection is conducted and kept as a record on the asset condition and quantity of removed pollutants over time. Inspections should occur every 1 - 6 months depending on the size and complexity of the system. More detailed site specific maintenance schedules should be developed for major constructed wetland systems and include a brief overview of the operation of the system and key aspects to be checked during each inspection.

Click here to view **Table SC6.4.3.9.19 Wetland maintenance checklist**

(d) Asset transfer (following on maintenance period)

Land ownership and asset ownership are key considerations prior to construction of a stormwater treatment device. A proposed design should clearly identify the asset owner and who is responsible for its maintenance. The proposed owner should be responsible for performing the asset transfer checklist. Table SC6.4.3.9.20 provides an indicative asset transfer checklist.

Click here to view **Table SC6.4.3.9.20 Asset transfer checklist**

(9) References - constructed wetlands

BCC 2000 (with revisions 2004), *Subdivision and Development Guidelines*, BCC, Brisbane

BCC 2001, *Sediment Basin Design, Construction and Maintenance: Guidelines*, BCC, Brisbane

Engineers Australia 2006, *Australian Runoff Quality*, Engineers Australia, ACT

GBLA (Graeme Bentley Landscape Architects) 2004, *Preliminary drawings for Mernda Wetland*, report for Stockland, GBLA, Victoria

Leinster, S 2006, *Delivering the Final Product – Establishing Water Sensitive Urban Design Systems*, 7th International Conference on Urban Drainage Modelling and 4th International Conference on Water Sensitive

LHCCREMS (Lower Hunter and Central Coast Regional Environmental Management Strategy) 2002, *Water Sensitive Urban Design in the Sydney Region: 'Practice Note 2 – Site Planning'*, LHCCREMS, NSW

McFarlane A 1997, *Successful Gardening in Warm Climates*, Kangaroo Press, Sydney

DNRW, IPWEA & BCC (Department of Natural Resources and Water, Institute of Public Works Engineering Australia – Qld Division & Brisbane City Council) 1998, *Queensland Urban Drainage Manual (QUDM)* Second Edition, prepared by Neville Jones & Associates and Australian Water Engineering for DNRW, IPWEA & BCC, Brisbane.

Persson J, Somes NLG and Wong THF 1999, *Hydraulic efficiency and constructed wetland and ponds*, Water Science and Technology, vol. 40 no. 3, pp. 291–289

Standards Australia 2003, AS 4419-2003: *Soils for landscaping and garden use*, Standards Australia

Townsville City Council, *Water sensitive urban design for the coastal dry tropics (Townsville): Technical design guidelines for stormwater management*, 2011

SC6.4.3.9.6 Plant selection for WSUD systems in the coastal dry tropics

- (1) This clause provides guidance on selecting appropriate plant species for water sensitive urban design (WSUD) systems where the plants have a functional role in stormwater treatment and/ or erosion protection. Selecting suitable plant species is critical to the long term landscape amenity, functional performance and structural integrity of WSUD systems.

Due to the strong seasonal rainfall patterns in the dry tropics, weed infestation is a major problem, particularly within ephemeral waterways and stormwater treatment facilities. The vegetation design to manage weed infestation takes on high importance and requires special consideration to achieve the following objectives:

- (a) maintain, throughout the year, a dense cover of the design vegetation to occupy habitat and avoid excessive colonisation by weeds;
- (b) manage potential weed ingress from edges by sustaining perennial littoral vegetation;
- (c) in bioretention systems the vegetation must be able to tolerate long dry periods, periodic inundation and free draining sandy soils;
- (d) provision of irrigation to wetland littoral zones; and
- (e) provision of irrigation to bioretention systems designed without saturated zones.

Careful selection of plant species and by adopting suitably high planting densities can significantly reduce costs associated with weed management.

- (2) A list of recommended plant species for various WSUD systems, including appropriate planting densities, is provided in the following tables:
 - (a) Table SC6.4.3.9.21 A1 Groundcover plant species list for swales (incorporating buffer strips), bioretention swales and bioretention basins and Table SC6.4.3.9.22 A2 Shrub and tree plant species list for bioretention basins:
 - (i) swales (incorporating buffer strips);
 - (ii) bioretention swales; and
 - (iii) bioretention basins; and
 - (b) Table SC6.4.3.9.23 A3 Macrophyte and groundcover plant species list for wetlands and sedimentation basins and Table SC6.4.3.9.24 A4 Shrub and tree plant species list for wetlands and sedimentation basins;

- (i) sedimentation basins; and
- (ii) wetlands.

The plant species lists in Table SC6.4.3.9.21 A1 and Table SC6.4.3.9.22 A2 are not exhaustive and other plants may be used provided their physiological and structural characteristics match the characteristics of the plant species listed in the tables.

Non-indigenous natives and exotics should only be considered when there is a specific landscape need and the species has the appropriate growth form and habit. If non-indigenous natives and exotics are chosen, careful consideration should be given to the potential impacts on downstream receiving ecosystems. Species (including natives) that have the potential to become invasive weeds should be avoided.

(3) Swales (and buffer strips), bioretention swales and bioretention basins - plant selection

(a) Required plant characteristics

Planting for bioretention basin elements may consist of up to three vegetation types:

- groundcovers for stormwater treatment and erosion protection;
- shrubbery for screening, glare reduction and character; and
- trees for shading, character and other landscape values.

For specific guidance on plant species the designer is directed to Table SC6.4.3.9.21 A1 and Table SC6.4.3.9.22 A2 which outline plant species suitable for the coastal dry tropics. The designer should also refer to any relevant local guidelines.

(i) Groundcovers

The plant (groundcover) species listed in Table SC6.4.3.9.21 A1 have been specifically selected, based on their life histories, physiological and structural characteristics, to meet the functional requirements of swales, buffer strips and bioretention systems (i.e. bioretention swales and bioretention basins). Bioretention systems must have filter media with a minimum depth of 400 mm for groundcover plants to provide an adequate depth of aerobic soil for healthy root development.

Plant species selected for bioretention systems must be able to tolerate free draining sandy soils and be capable of withstanding long dry periods punctuated by short periods of temporary inundation. The addition of saturated zones in bioretention systems will help retain moisture during the dry season where supplemental irrigation is not provided. Suitable plants species are listed in Table SC6.4.3.9.21 A1. Where irrigation of bioretention systems is provided, a more diverse range of species may be selected to achieve the desired landscape aesthetic provided they are tolerant of the filter media conditions and have the required features to fulfil the functional roles of the WSUD element. In general, the plant species in Table SC6.4.3.9.21 A1 have the following features:

- (A) they are able to tolerate short periods of inundation punctuated by longer dry periods. For bioretention systems these dry periods may be reasonably severe due to the free draining nature (relatively low water holding capacity) of bioretention filter media. In the dry tropics climate irrigation of bioretention vegetation will be required unless saturated zones are provided to maintain soil moisture;
- (B) they generally have spreading rather than clumped growth forms;
- (C) they are perennial rather than annual;
- (D) they have deep, fibrous root systems;
- (E) groundcover plants can be turf, prostrate or tufted;
- (F) prostrate species would typically be low mat forming stoloniferous or rhizomatous plants; and
- (G) tufted species would typically be rhizomatous plants with simple vertical leaves.

Most of the groundcovers listed in Table SC6.4.3.9.21 A1 are widespread, occurring throughout the coastal dry tropics. However, alternative locally occurring species that display the required features may be selected to tailor the species list to match the native vegetation associations of the area

and to compliment surrounding vegetation communities.

(ii) Shrubs and trees

Shrubs and trees are not a functional requirement within swales, bioretention swales or bioretention basins, but can be integrated to provide amenity, character and landscape value. Planting trees and shrubs in bioretention systems requires the filter media to have a minimum depth of 800 mm to avoid root interference with the perforated subsurface drainage pipes. They must also be accompanied by densely planted shade tolerant groundcover species with the characteristics outlined above. Trees and shrubs are to be managed so that the ground cover layer is not out-competed. To avoid over-shading, trees and shrubs should be planted at low densities. Periodic thinning of the upper vegetation layers may also be required. In general, tree and shrub species that can be incorporated into bioretention systems have the following general features:

- (A) trees need to be able to tolerate short periods of inundation punctuated by longer dry periods. These dry periods may be reasonably severe due to the free draining nature (relatively low water holding capacity) of bioretention filter media. In the dry tropics climate irrigation of bioretention vegetation will be required unless saturated zones are provided to maintain soil moisture;
- (B) they need to have relatively sparse canopies to allow light penetration to support dense groundcover vegetation;
- (C) have shallow root systems and root systems that are not known to be adventurous “water seekers” to reduce the risk of root intrusion into subsurface drainage pipes;
- (D) trees must not be deciduous; and
- (E) preferably native and occur naturally in the local area.

The shrubs and trees listed in Table SC6.4.3.9.22 A2 are recommended as they display the above features.

Most of the shrub and tree species listed in Table SC6.4.3.9.22 A2 are widespread, occurring throughout the coastal dry tropics. However, alternative locally occurring species that display the required features may be selected to tailor the species list to match the native vegetation associations of the area and to compliment surrounding vegetation communities.

(b) Plant species selection

Well established uniform groundcover vegetation is crucial to the successful operation of swale and bioretention system treatment elements. As a result, plant species selection needs to consider both the aesthetic and functional requirements. The functional plant traits required for effective water treatment are different for different devices. For example:

- (i) swales – require plants with vigorous growth and a spreading habit to hold soil in place against flow. They should also be suited to growth in wet clay soils. Examples include turf grasses, tufted grasses and sedges;
- (ii) bioretention swales - require plants with vigorous growth and a spreading habit to hold soil in place against flow. They should be drought tolerant and suited to growth in sandy soils. Examples include turf grasses, tufted grasses and sedges;
- (iii) bioretention basins – plants should be drought tolerant and suited to growth in sandy soils. Examples include grasses, shrubs and trees. A diverse mix is recommended; and
- (iv) when selecting plant species from Table SC6.4.3.9.21 A1, consideration must be given to the following factors:
 - (A) other WSUD objectives such as landscape, aesthetics, biodiversity, conservation and ecological value;
 - (B) region, climate, soil type and other abiotic factors;
 - (C) roughness of the channel (Manning’s n roughness factor) (for swales); and
 - (D) extended detention depth (for bioretention systems).

Typical heights of each plant species and comments relating to shade and salt tolerances and soil moisture requirements are provided in Table SC6.4.3.9.21 A1 and will help with the selection process.

The low growing and lawn species are suitable for swale elements that require a low hydraulic roughness. The treatment performance of bioretention systems, in particular, requires dense vegetation to a height equal to that of the extended detention depth. Therefore, a system with a 300 mm extended detention depth should have vegetation that will grow to at least 300 mm high. Turf is not considered to be suitable vegetation for bioretention basins. The stems do not grow high enough and the root structure of turf is not suitably robust to ensure the surface of the bioretention filter media is continuously broken up to prevent clogging.

Included in Table SC6.4.3.9.21 A1 is a recommended planting density for each plant species. The groundcover planting densities should ensure that 70-80 % cover is achieved after two growing seasons (2 years) given adequate irrigation and weed control. High density planting to avoid weed ingress is particularly important in the dry tropics due to the climatic conditions which favour opportunistic (colonising) seasonal weed species. High density planting also ensures runoff does not establish preferential flow paths around the plants and erode the swale/ bioretention surface. Dense vegetation is also required to ensure a uniform root zone, which is particularly important in bioretention systems.

If prostrate shrubs that form scrambling thickets are used (in place of or in conjunction with the plant species in Table SC6.4.3.9.21 A1) they should be planted at high densities (8-10 plants/m²) and may require pruning to ensure even plant cover and to maintain an even root distribution below ground.

(c) Vegetation establishment and maintenance

Swales, buffer strips and bioretention basins are living systems and require two years of establishment before the vegetation matures and reaches fully functional form. During this establishment period, regular site monitoring and maintenance is critical to the success of these systems. In addition, specific requirements for plant stock sourcing, topsoil selection and testing and vegetation establishment, as detailed in the relevant WSUD element chapters, are necessary to maximise successful vegetation establishment and system treatment performance. Particular reference is made to the sections titled "Landscape Design Notes", "Maintenance Requirements" and "Construction and Establishment" for guidance on vegetation establishment and maintenance procedures. The "Construction and Establishment" section also details a staged implementation approach by which the functional elements of the WSUD system are protected from building site runoff and associated sedimentation, weeds and litter during the building phase.

Table SC6.4.3.9.21 A1 Groundcover plant species list for swales (incorporating buffer strips), bioretention swales and bioretention basins

S Swale,

BS Bioretention Swale,

BB Bioretention Basin

Strongly recommended – perennial, vigorously growing species with appropriate traits for good pollutant removal

Scientific Name	Common Name	Application	Form	Height (mm)	Planting Density ¹ (Qty/m ²)	Comments
<i>Atriplex muelleri</i>	Salt Bush	BB	Prostrate	100	2-3	Very common low prostrate mat in saline areas, silver foliage highly ornamental
<i>Bacopa monnieri</i>	Bacopa	BB	Prostrate	100	6-8	Not suitable for sandy soils with low water holding capacity, Native to region prostrate herb
<i>Bothriochloa pertusa</i>	Indian Couch	S, BS, BB	Turf		Seeded or rolled	Tolerates prolonged dry periods
<i>Carex fascicularis</i>	Tassel Sedge	S	Tufted	1000	6-8	Not suitable for sandy soils with low water holding capacity,
<i>Carex polyantha</i>	Creek Sedge	S	Tufted	To 900	6-8	Not suitable for sandy soils with low water holding capacity,

Scientific Name	Common Name	Application	Form	Height (mm)	Planting Density ¹ (Qty/m ²)	Comments
<i>Cymbopogon refractus</i>	Barbed Wire Grass	S	Tufted	300	8-10	Does not tolerate prolonged dry periods
<i>Cyperus haspan</i>	Haspan Flatsedge	S	Tufted	400	8	Suitable for, sandy soils, perennial, native to region
<i>Cyperus javanicus</i>		S	Tufted	1400	8	Suitable for, sandy soils, perennial, native to region
<i>Cyperus polystachyos</i>	Bunchy Sedge	S	Tufted	600	8	Suitable for both sand and clay soils, perennial, native to region, tolerates salinity
<i>Cyperus scariosus</i> #		S		900	8	Suitable for, sandy soils, perennial, native to region, tolerates salinity levels may suppress <i>Urochloa mutica</i> (para grass)
<i>Dianella longifolia</i> var. <i>longifolia</i>	Pale Flax-lily	S, BS, BB,	Tufted	300-800	8	Shade tolerant, native to region
<i>Eragrostis elongata</i>	Lavender Grass	S, BS, BB			8	Annual or weak perennial, best in rockeries and roadsides
<i>Fimbristylis dichotoma</i>		BS, BB	Tufted	750	8	Suitable for, sandy soils, perennial, native to region
<i>Fimbristylis ferruginea</i>	Rusty Finger Rush	BS, BB	Tufted	650 -800	8	Suitable for, sandy soils, perennial, native to region, salt tolerant
<i>Fimbristylis tristachya</i>		BS, BB	Tufted	600	8	Suitable for, sandy soils, perennial, native to region
<i>Gahnia aspera</i>	Saw Sedge	S	Tufted	1000	6	Not suitable for sandy soils, native to region, difficult to propagate
<i>Gahnia sieberiana</i>	Red-fruited Sword Sedge	S	Tufted	1500-3000	6	Aesthetic, difficult to propagate
<i>Imperata cylindrical</i> #	Blady grass	S, BS, BB	Tufted	500	8	Only use when it occurs in natural surroundings, native to region,
<i>Juncus usitatus</i> #	Common Rush	S, BS, BB	Tufted	500	8-10	Not suitable for sandy soils
<i>Lomandra hystrix</i>	Creek Matt Rush	S, BS, BB	Tufted	1000	6	Shade tolerant, native to region
<i>Lomandra longifolia</i>	Matt Rush	S, BS, BB	Tufted	500-1000	6	Shade tolerant, native to region
<i>Paspalum distichum</i>	Water Couch	S, BS, BB	Turf	To 500	Seeded or rolled	Not suitable for sandy soils, native to region
<i>Paspalum vaginatum</i> cv 'Saltene'	Salt Water Couch	S, BS, BB	Turf	To 500	Seeded or rolled	Salt tolerant, native to region
<i>Platyzoma microphyllum</i>	Fern	BB	Fern	150-500	8	Not suitable in areas expecting prolonged dry periods , Native to region
<i>Eragrostis spartinoides</i>	Love Grass	S, BS, BB	Grass	600	8	Native to region
<i>Sporobolus virginicus</i>	Marine Couch	S, BS, BB	Turf	To 400	Seeded or rolled	Salt tolerant, Native to region
<i>Themeda triandra</i>	Kangaroo Grass	S, BS, BB	Tufted	300-500	6-8	

Note—planting density indicates the mean number of plants per square metre for the species spatial distribution within the zone. The planting

densities recommended are suggested minimums. Any reduction in planting density has the potential to reduce the rate of vegetation establishment, increase the risk of weed invasion, and increase maintenance costs. S = Swale, BS = Bioretention Swale, BB= Bioretention Basin

Table SC6.4.3.9.22 A2: Shrub and tree plant species list for bioretention basins

Note—trees not suitable for systems requiring flow conveyance (i.e. swales and bioretention swales) due to shading reducing growth of ground cover.

Scientific Name	Common Name	Form	Height (m)	Planting Density ² (Qty/m ²)	Comments
<i>Breynia oblongifolia</i>	False Coffee Bush	Shrub	1-2	2-4	Native to region
<i>Corymbia tessellaris</i>	Moreton Bay Ash	Tree	10-20		Suitable for sandy soils, native to region
<i>Aidia racemosa</i>		Shrub	10-15		Native to region, tolerates high winds
<i>Atractocarpus fitzalanii</i>	Ivory Curl Tree	Shrub	3-10		Native to region
<i>Eugenia reinwardtiana</i>	Cedar Bay Cherry	Tree	1-3		Native to region
<i>Leptospermum polygalifolium</i>	Wild May	Shrub	1-4	2-4	Sunny position, native to region
<i>Myoporum acuminatum</i>	Coastal Boobialla	Shrub	0.5-6	2-4	Sun or semi-shade, salt tolerant, native to region
<i>Albizia canescens</i>	Townsville Siris	Tree			Native to region, rare
<i>Buckinghamia celsissima</i>		Tree	20-30		Native to region
<i>Chionanthus ramiflorus</i>	Native Olive	Tree	6-8		Native to region
<i>Colubrina asiatica</i>		Tree			Salt tolerant
<i>Cupaniopsis anacardioides</i>	Beach Tuckeroo	Tree	8-15		Suitable for sandy soils, native to region
<i>Callistemon(Melaleuca) viminalis</i>	Weeping Bottle Brush	Tree	5-10	<1	Requires moist soils during establishment but tolerates dry periods once established
<i>Eucalyptus raveretiana</i>	Black Ironbox	Tree			Tolerates high winds
<i>Eucalyptus tereticornis</i>	River Blue Gum	Tree	20-50m		Native to region
<i>Ganophyllum falcatum</i>		Tree	10-25		Native to region
<i>Lophostemon grandiflorus</i>		Tree	8-12		Native to region, tolerates high winds, periods of flooding and fire
<i>Melaleuca dealbata</i>	Cloudy Tea Tree	Tree	5-15		Native to region, tolerates high winds, periods of flooding and fire
<i>Melaleuca fluviatilis</i>		Tree			Native to region, tolerates high winds and periods of flooding, forms a root mat good for erosion control
<i>Mimusops elengi</i>		Tree	10-15		Suitable for all soil types, native to region, tolerates high winds

Note—planting density indicates the mean number of plants per square metre for the species spatial distribution within the zone. The planting densities recommended are suggested minimums. Any reduction in planting density has the potential to reduce the rate of vegetation establishment, increase the risk of weed invasion, and increase maintenance costs.

(4) Wetlands and sedimentation basins - plant selection

Due to the strong seasonal rainfall patterns in the dry tropics, weed infestation is a major problem, particularly within ephemeral waterways and stormwater treatment facilities such as wetlands and sediment basins. Therefore, the design and management of these systems to manage weed infestation takes on high importance. Management of weeds is achieved through the plant selection and landscape design as follows:

- planting dense littoral vegetation around the perimeter of the wetland to avoid the ingress of weed species. To maintain dense perennial littoral vegetation, irrigation is likely to be required, particularly during the dry season; and
- designing the macrophyte zone as predominately a deep marsh system (i.e. water depth 0.5 m - 0.7 m) to maintain the macrophyte vegetation by minimising the frequency and duration of wetland drying, thus permanently occupying the habitat and restricting weed colonisation opportunities.

During the establishment and ongoing maintenance of the wetland, prompt removal of weeds before they spread and/or set seed is of critical importance.

(a) Required plant characteristics

Planting for wetlands and sedimentation basins may consist of two vegetation types:

- macrophytes and groundcovers for stormwater treatment, erosion protection and weed management. The macrophytes are divided further into several different zones as outlined in Table SC6.4.3.9.23 A3; and
- shrubbery and trees for screening, shading, character and other landscape values.

For specific guidance on plant species the designer is directed to Table SC6.4.3.9.23 A3 and Table SC6.4.3.9.24 A4 which outline plant species suitable for the coastal dry tropics.

(i) Macrophytes and groundcovers

The plant species listed in Table SC6.4.3.9.23 A3 have been specifically selected based on their life histories and physiological and structural characteristics, to meet the functional requirements of wetland systems. Plant species suitable for wetlands will also be suitable for edge planting around sedimentation basins. The following sections address wetlands specifically as they have very defined vegetation requirements for stormwater treatment. This includes consideration of the wetland zone/ depth range, typical extended detention time (typically 48 hrs) and extended detention depth (typically 0.5 m).

Other species can be used to supplement the core species listed in Table SC6.4.3.9.23 A3 provided they have the required features to fulfill the functional roles of the wetland zone. Careful consideration of the water depth range and wetland hydrological regime (water depth and inundation period) is also required to assess the suitability of alternate species for constructed wetlands. Wetland plants in the dry tropics must be able to tolerate large water level variations and dry periods of up to 60 days. Short growing emergent macrophytes will not be suitable for the deep marsh zone as they will become over inundated. As a guide, emergent macrophytes require 1/3 of their foliage to extend above the water level 80% of the time. However, during the plant establishment phase emergent macrophytes require 50% of their foliage above the water level.

In general, the species in Table SC6.4.3.9.23 A3 have the following features:

- (A) they grow in water as either submerged or emergent macrophytes, or they grow adjacent to water and tolerate periods of inundation (typically sedge, rush or reed species);
- (B) they generally have spreading rather than clumped growth forms;
- (C) they are perennial rather than annual;
- (D) they generally have rhizomatous growth forms;
- (E) they have fibrous root systems; and
- (F) they are generally erect species with simple vertical leaves (e.g. *Juncus* spp, *Baumea* spp).

(ii) Shrubs and trees

Shrubs and trees are not a required element of wetlands or sedimentation basins but can be integrated to provide amenity, character and landscape value. Shrubs and trees (generally only planted in the littoral zones) should be accompanied by dense shade tolerant groundcover species

as an understorey to occupy habitat and provide a weed ingress barrier. Table SC6.4.3.9.24 A4 provides a list of shrubs and trees that are natives to the coastal dry tropics and are suitable for planting in the littoral zone (i.e. on the batters) around wetlands and sedimentation basins.

Littoral zone vegetation is primarily for weed management (to avoid weed ingress into the macrophyte zone), batter stabilisation, aesthetics and to restrict public access, rather than for stormwater treatment. For this reason, species that do not have all of the above structural features, but fulfill the primary littoral zone requirements (e.g. weed management and erosion protection) and landscape objectives may still be acceptable for inclusion in this zone (refer to the “Landscape Design Notes” section in the relevant WSUD chapter).

(b) Plant species selection

Plant species listed in Table SC6.4.3.9.23 A3 are recommended as core species for wetland planting. These plant species have been grouped into a wetland macrophyte zone according to their preferred water depth and the hydrologic conditions of the zone. The perennial wetland plants must be able to tolerate large water level variations and periodic drying (potentially of up to 60 days duration). In general, the deep marsh emergent macrophytes must be capable of a standing water level of 0.5 m – 0.7 m punctuated with short episodes of extended detention (up to 1.2 m in total water depth) and seasonal drying.

While individual plant species can have very specific water depth requirements other species can be quite adaptive to growing across various zones over time. It is however, recommended that the suggested zones and plant groups are adhered to for planting purposes. Plant species listed against the shallow marsh and lower batters are only suited for edge planting in wetlands and sedimentation basins. Planting densities recommended should ensure that 70-80 % cover is achieved after two growing seasons (2 years). This is particularly important for weed management and therefore the recommended planting densities should not be reduced.

Suitable plant species for the littoral zone that surrounds wetlands and sedimentation basins have also been recommended in Table SC6.4.3.9.23 A3. The littoral zone relates to the berms, batters or embankments around the systems. Plants that have a drier habit should be planted towards the top of batters, whereas those that are adapted to more moist conditions should be planted closer to the water line. High density planting of the littoral zone is required to provide a barrier (by occupying habitat) to prevent weed ingress into the wetland or sediment basin.

(c) Vegetation establishment and maintenance

To maximise the success of plant establishment in wetland macrophyte zones specific procedures are required in site preparation, stock sourcing, vegetation establishment and maintenance. Reference is to be made to procedures detailed in SC6.4.3.9.5(5) Sourcing wetland vegetation as follows:

- (i) sourcing plant stock (SC6.4.3.9.5(6)(c) Sourcing wetland vegetation):
 - (A) lead times for ordering plants; and
 - (B) recommended planting systems/ products;
- (ii) topsoil specification and preparation SC6.4.3.9.5(6)(d) Topsoil specification and preparation):
 - (A) sourcing, testing and amendment; and
 - (B) top soil treatments (e.g. gypsum, lime, fertiliser); and
- (iii) vegetation establishment (SC6.4.3.9.5(6)(e) Vegetation establishment):
 - (A) weed control;
 - (B) watering; and
 - (C) water level manipulation.

Constructed wetlands are living systems and they require two years of establishment before the vegetation matures and reaches fully functional form. During this establishment period, regular site monitoring and maintenance is critical to the success of these systems. Reference must also be made to the SC6.4.3.9.5(7) Maintenance requirements – constructed wetlands and SC6.4.3.9.5(6) Construction and establishment – constructed wetlands for guidance on maintenance procedures and vegetation

establishment.

Similarly, the vegetation planted in sedimentation basins require an equivalent vegetation establishment period (i.e. 2 years) and level of attention to site preparation, stock sourcing, vegetation establishment and maintenance to ensure success. Reference must be made to the sections entitled “Landscape Design Notes”, “Maintenance Requirements” and “Construction and Establishment” in Chapter 4.

(d) Vegetation selection for mosquito management

Species selected should have a stiff, thin, upright growth habit. This allows mosquito predators to access all wet areas and control mosquito larvae. Species with a spreading habit such as turf grasses or wide strappy leaves such as Typha can isolate pockets of water where mosquitoes can breed and avoid predation.

Table SC6.4.3.9.23 A3: Macrophyte and groundcover plant species list for wetlands and sedimentation basins

Key to Table SC6.4.3.9.22 A3:

Zone		Depth*(m)	Form	
P	Permanent Pool	2.0– 0.7	S	Submerged macrophyte
DM	Deep Marsh	0.7 – 0.35	E	Emergent macrophyte
SM	Shallow Marsh	0.35 – 0	Am	Amphibious
LB	Lower Batters	0 – +0.5**	A	Annual Groundcover
UB	Upper Batters	+0.5- +1.0**	Sh	Shrub
			Tr	Trees

* ‘Depth’ refers to depth below permanent pool water level

** ‘+’ denotes levels above permanent pool water level

Strongly recommended – perennial, vigorously growing species with appropriate traits for good pollutant removal.

Scientific name	Common name	Zone	Type	Perennial or Annual	Height (mm)	Planting Density ² (Qty/m ²)	Comments
<i>Isolepis inundata</i>	Swamp Club-rush	SM	Emergent Macrophyte		To 300	6-8	High surface area; rapid growth
<i>Oryza australiensis</i>	Native Rice	SM	Emergent Grass	Perennial	2500		Attracts birds, native to region
<i>Actinoscirpus grossus</i>		DM	Emergent	Perennial	3000	6	Suitable for clay soils
<i>Baumea articulata</i> #	Jointed Twig-rush	DM	Emergent	Perennial	1000-2000	6-8	Slow growth, plant solo
<i>Eleocharis sphacelata</i> #	Tall Spike-rush	DM	Emergent	Perennial	500-2000	6-8	Plant solo, rhizomes can restrict growth of other plants; slow establishment, flow resistant,
<i>Leersia hexandra</i>	Swamp Ricegrass	DM	Emergent	Perennial	2000	6	Tolerates periods of flooding, fire resistant
<i>Lepironia articulata</i> #	Grey Rush	DM	Emergent	Perennial	600-2300	4-6	Tall grey sedge from Hidden Valley, very ornamental, popular in wetland plantings
<i>Phragmites australis</i> #	Common Reed	DM	Emergent	Perennial	5000	6	Native to region, forms dense swards
<i>Phragmites karka (vallatoria)</i> #	Spiny MudgrassTropical Reed	DM	Emergent	Perennial	1000-2000	6	Native to region

Scientific name	Common name	Zone	Type	Perennial or Annual	Height (mm)	Planting Density ² (Qty/m ²)	Comments
<i>Schoenoplectus litoralis</i>	Shore Club-rush	DM	Emergent	Perennial	600-1500	4-6	Tolerates salinity
<i>Schoenoplectus validus</i> #	River Club-rush	DM	Emergent	Perennial	600-1600	4-6	
<i>Scleria poiformis</i>		DM	Emergent	Perennial	2200	6	Requires irrigation
<i>Thoracostachyum sumatran</i>	Sedge	DM	Emergent	Perennial	2500	6	
<i>Eleocharis dulcis</i> #	Water Chestnut	DM & SM	Emergent	Perennial	1000-1500	4-6	Plant solo, flow resistant
<i>Oryza australiensis</i>	Native Rice	DM & SM	Emergent	Perennial	2500	6	Attracts birds, native to region
<i>Carex polyantha</i> #	Creek Sedge	LB	Emergent Macrophyte	Perennial	To 900	6-8	
<i>Cyperus digitatus</i>	Sedge	LB	Amphibious Sedge	Wet Season Annual	500-1500	8	
<i>Cyperus iria</i>	Rice Flat Sedge	LB	Amphibious Sedge	Wet Season Annual	600	8	Tufted growth
<i>Cyperus tenuispica</i>		LB	Amphibious Sedge	Wet Season Annual	400	8	Suitable for sand and clay solids
<i>Fimbristylis littoralis</i>	Fimbry	LB	Amphibious Sedge	Wet Season Annual		8	Native to region
<i>Juncus prismatocarpus</i>	Branching Rush	LB	Emergent Macrophyte	Perennial	300-600	6-8	
<i>Phyla nodiflora</i>		LB	Herb	Perennial	200		Native to region
<i>Schoenoplectus lateriflorus</i>		LB	Amphibious Sedge	Wet Season Annual	700	8	
<i>Schoenoplectus praelongatus</i>		LB	Amphibious Sedge	Wet Season Annual	350	8	
<i>Ceratophyllum demersum</i>	Hornwort	P	Submerged	Perennial	600		Native to region
<i>Myriophyllum dicoccum</i>	Water Milfoil	P	Submerged	Perennial or Annual	To 200	1	
<i>Myriophyllum filiforme</i>	Water Milfoil	P	Emergent Aquatic Herb	Dry Season Annual	150	1	
<i>Myriophyllum verrucosum</i>	Red Water-milfoil	P	Submerged	Perennial	100-1500	1	Native to region
<i>Najas tenuifolia</i>	Water Nymph	P	Submerged	Perennial	500	1	
<i>Potamogeton crispus</i>	Curly Pondweed	P	Submerged	Perennial	To 4500	1	Growth can be dense, native to region
<i>Potamogeton octandrus</i>	Pondweed	P	Submerged	Perennial	To 4500	1	
<i>Potamogeton tricarinatus</i>	Pondweed	P	Submerged	Perennial		1	

Scientific name	Common name	Zone	Type	Perennial or Annual	Height (mm)	Planting Density ² (Qty/m ²)	Comments
<i>Vallisneria gigantea</i>	Ribbonweed	P	Submerged	Perennial	To 3000	1	Rapid growth; salt tolerant (1500 ppm),
<i>Vallisneria nana</i>	Ribbonweed	P	Submerged	Perennial	700	1	Native to region
<i>Ischaemum australe</i>	Zipper Grass	SM	Amphibious Grass	Perennial	1500	6	Forms dense swards
<i>Ischaemum rugosum</i>		SM	Amphibious Grass	Perennial	1200	6	Native to region
<i>Schoenoplectus mucronatus</i> #	Club Rush	SM		Perennial	0.35-1.0m	8	Native to region
<i>Cyperus scariosus</i>	Sedge	SM & LB	Amphibious Sedge	Perennial	800	8	Native to region, salt tolerant
<i>Fimbristylis dichotoma</i> #		SM & LB	Amphibious Sedge	Perennial	1000	8	Native to region
<i>Juncus usitatus</i> #	Common Rush	SM & LB	Emergent Macrophyte		300-1200	8-10	Rapid growth
<i>Dianella longifolia</i> var. <i>longifolia</i>	Pale Flax-lily	UB	GrassLily	Perennial	300-800	6-8	Aesthetic; shade tolerant
<i>Lomandra filiformis</i> spp. <i>filiformis</i>	Wattle Mat-rush	UB	Tufted	Perennial	150-500	6-8	Shade tolerant when established, native to region
<i>Lomandra longifolia</i> #	Spiny-headed Mat Rush	UB	Tufted	Perennial	500-1000	4-6	Shade tolerant, native to region
<i>Sorghum plumosum</i>	Plume Sorghum	UB	Grass		To 4000	6	Growth can be dense
<i>Themeda triandra</i>	Kangaroo Grass	UB	Grass	Perennial	750	8	Requires local propagation, does not tolerate waterlogged soils
<i>Cyperus polystachyos</i> #	Bunchy Sedge	UB & LB	Sedge	Perennial	To 600	6-8	Suitable for sand and clay soils, Native to region, salt tolerant
<i>Gahnia siberiana</i>	Red-fruited Sword Sedge	UB & LB	Tufted	Perennial	1500-3000	4-6	Aesthetic. difficult to germinate

Note—planting density indicates the mean number of plants per square metre for the species spatial distribution within the zone. The planting densities recommended are suggested minimums. Any reduction in planting density has the potential to reduce the rate of vegetation establishment, increase the risk of weed invasion, and increase maintenance costs.

Table SC6.4.3.9.24 A4: Shrub and tree plant species list for wetlands and sedimentation basins

Scientific name	Common name	Zone	Form	Height (mm)	Planting Density ³ (Qty/m ²)	Comments
<i>Callistemon viminalis</i>	Weeping Bottle Brush	UB	Tree	5.0-10.0	<1	Moist, medium to heavy soils, tolerates dry periods once established
<i>Eucalyptus coolabah</i>		UB	Tree		<1	
<i>Livistona decora</i>		UB	Tree		<1	Native to region
<i>Lophostemon suaveolens</i>	Swamp Box	UB	Tree	5.0-25.0	<1	Moist sandy soils
<i>Melaleuca leucadendron</i>	Weeping Paperbark	UB	Tree		2-4	
<i>Melaleuca nodosa</i>	Prickly-leafed Paperbark	UB	Tree	2.0-7.0	2-4	Deep sands and moist sandy soils
<i>Melaleuca viridiflora</i>		UB	Tree		2-4	Native to region
<i>Nauclea orientalis</i>	Leichardt Tree	UB	Tree		<1	Native to region, tolerates high winds and periods of flooding
<i>Pandanus cookii</i>	Screw Pine	UB	Tree		<1	Native to region, tolerates high winds, periods of flooding, fire resistant, will drop leaves
<i>Myoporum acuminatum</i>	Coastal Boobialla	UB	Shrub	0.5-6.0	2-4	Sun or semi-shade, salt tolerant Native to region

Note—planting density indicates the mean number of plants per square metre for the species spatial distribution within the zone. The planting densities recommended are suggested minimums. Any reduction in planting density has the potential to reduce the rate of vegetation establishment, increase the risk of weed invasion, and increase maintenance costs.

(5) References - plant selection

BCC 2005, *Growing Native Plants in Brisbane*, BCC, Brisbane, accessed 25th July 2005

BCC, DMR & PRSC (Brisbane City Council, Queensland Department of Main Roads and Pine Rivers Shire Council) 2001, *Preferred Species Manual: Green Routes Program*, prepared for the Green Routes Program by BCC, DMR and PRSC, Brisbane

SC6.4.3.10 On-site sewerage facilities

SC6.4.3.10.1 Introduction

This sub-section provides standards, advice and guidelines for applicants in the design, installation and siting of wastewater treatment and disposal systems.

The principle underpinning the use of on-site wastewater treatment and disposal is that all design, installation and construction will meet the demands of a development, whilst having full consideration of the effects to public health and ensuring that adverse impacts on environmental values are avoided.

Council will apply these guidelines when processing applications involving on-site sewerage facilities or servicing of development outside of reticulated sewerage supply areas, or applications incorporating the use of an on-site sewerage facility.

Editor's note—development within SC2.5 Natural resources overlay map-Water resource catchments (OM-09) or Natural assets environmental importance overlay map (OM-08) will need to consider additional setback requirements, including requirements for exclusions of infrastructure in some instances when applying the standards of this policy.

Editor's note—before an on-site sewerage facility can be installed on a property, the applicant is required to apply for a permit to install the treatment facility on that property. Applications to install an onsite sewerage facility are to be lodged with the Hydraulic and Building Services Unit of council as part of the plumbing/drainage application. Applicants should also refer to the On-site sewerage facilities for non-sewered properties guidelines which provides details on the application and installation stages of an on-site sewerage facility. This document may be found on council's website.

(1) Terminology

Unless noted otherwise all terms have the same meaning as given in the *Plumbing and Drainage Act 2002* (the PD Act), the *Standard Plumbing and Drainage Regulation 2003* and the relevant Australian/New Zealand Standard or Australian Standard. If a definition given in the relevant Australian/New Zealand Standard or Australian Standard is inconsistent with the PD Act or Regulation, the PD Act or Regulation prevails to the extent of the inconsistency.

Intermittent water course	A natural or artificial channel, identifiable by recognisable bed and banks, along which rain water or storm water usually or occasionally flows. The term does not include a closed conduit for conveying storm water.

Top bank	The same meaning as outer bank as defined in the <i>Water Act 2000</i> .

(2) Reference and source documents that are to be read and applied in conjunction with this policy sub-section are as follows:

AS/NZS 1546.1 *On-site domestic wastewater treatment units-septic tanks*

AS/NZS 1547:2000 *On-site domestic wastewater management*

AS/NZS 3500.2:2003 *Sanitary Plumbing and Drainage*

Environmental Protection Act and all subordinate legislation, in particular the *Environmental Protection (Waste Management) Regulation 2000* (Design Rules)

National Construction Code Volume 3 – Plumbing Code of Australia

Plumbing and Drainage Act 2002 (and associated Regulations)

Queensland Plumbing and Wastewater Code

Editor's note—council has specifically referred to AS/NZS 1547:2000 *On-site domestic waste water management* and is, for the purpose of this policy, the adopted standard to be read and applied in conjunction with this policy sub-section.

SC6.4.3.10.2 Application guidelines

- (1) The following section details the design standards and reporting requirements for wastewater treatment systems generally, to assist applicants in demonstrating they have met the requirements of the Townsville City Plan.
- (2) Development which is not connected to council's sewerage system and is not within a reticulated service area will require an on-site sewerage disposal report to demonstrate the effective and safe disposal of sewerage on-site, having particular regard to the nature of the development proposed, demands the development will place on a system, the land and surrounding environment and known hydro-geologic, public health or otherwise constrained concerns.

The report should be prepared by a professional engineer or hydraulic consultant, to document a site and soil evaluation and design of disposal facility as per procedures, reporting requirements and standards outlined AS/NZS1547:2000.

- (3) As a minimum, the on-site sewerage disposal report submitted in support of an application should provide detailed information on the following; the report should:
 - (a) provide sufficient information for deciding whether or not a development area, subdivision, or lot is suitable for on-site system(s);
 - (b) provide detailed site-specific information identifying the site-and-soil characteristics to be taken into account when selecting and designing an on-site system;
 - (c) identify, analyse, and evaluate any risks posed by site-and-soil characteristics which might compromise the long-term effectiveness of the on-site system(s);
 - (d) identify, analyse, and evaluate any risks of contamination of groundwater or surface water and of associated health risks; and
 - (e) specify measures required to reduce and monitor such risks.

Editor's note—the flow rates should be determined using Appendix 4.2D (H in 2012 standard) *Typical Domestic Wastewater Flow Design Allowances* in AS/NZS 1547:2000.

- (4) The designer's report/design, at a minimum, must comply with the requirements of the AS/NZS 1547:2000. For the purposes of reporting, Table 3.1 of AS/NZS 1547:2000 Part B; Unsewered subdivision proposals, Sections 2 (Subdivision design) and Section 3 (System Design) as well as Section 4 of AS/NZS 1547:2000 are considered relevant and should be used as a primary guide for preparing reports as it outlines the essential stages and implementation processes required. To the extent relevant, reporting should also consider the requirements of the *Queensland Plumbing and Wastewater Code*.
- (5) The designer must undertake (or have undertaken) soil testing as necessary to enable an appropriate design to be completed. This may include but not be limited to the following: soil percolation tests; bore holes; test pits and soil textural analysis. The report should consider the following points when carrying out a site and soil evaluation:
 - (a) the determination of potential effluent disposal problems. These may include gullies, rock formations, hollows, or inconsistent soil texture, both on and off the property;
 - (b) the consideration of previous and current weather conditions in the determination of the site's suitability for effluent disposal;
 - (c) the demonstration that the disposal area is located above the 5 per cent AEP;
 - (d) the site plan showing the setback requirements (for buildings, pools, bores, permanent and intermittent water courses, vehicular traffic areas and drains etcetera) both on and off the property, which may influence the location of the disposal area;
 - (e) a proposed land application area that shall not be cut, filled or modified in any way after the site evaluation has been carried out. If this does occur the designer must be informed so that appropriate amendments can be made to the design; and
 - (f) the designer is to make their recommendation based on the site and soil evaluation carried out.

In addition to the above, the following must also be reported on:

- (i) topography and drainage;
- (ii) climate data and statistics;
- (iii) groundwater information (extractive bores, uses and quality);
- (iv) infrastructure (existing and proposed);
- (v) potential for cumulative effects on receiving environments;
- (vi) off-site impacts;
- (vii) presence of any fill material;
- (viii) geotechnical hazards;
- (ix) setback distances;
- (x) potential for environmental or public health impacts; and
- (xi) site plans (individual or multiple lots).

Much of the Townsville coastal plain is derived from Quaternary alluvium which in many places has been transported and reworked as a result of changes in drainage patterns over time. This has resulted in varying soil texture types occurring in both top and sub-soil zones with a variety of geometries that cannot be assumed on a broad-scale. In recognition of this fact, site soils assessments should form part of all future reports. This approach provides for a representative assessment of the respective area's soils and enables the determination of the land capability and hydraulic loading required for the development (eg LTAR, DIR/DLR).

The soil assessment should be able to provide information on the suitability of different methods of wastewater disposal based on soil textures and hydraulic properties of the actual soils in the area of interest. In order to develop an appropriate level of confidence in the results presented, the details, locations and results of soil sampling and hydraulic property testing should accompany any report submitted.

Site specific data relating to soil properties must be utilised for any method employed as this is the media through which any potential impacts or mitigation caused by wastewater disposal must pass through. Any assessment that does not include this data collection and input carries with it an inherent risk of inaccurate prediction of effluent transport and behaviour and may even accentuate the utilisation of inappropriate system and disposal methods.

- (6) Water tables in tidal areas are to be determined to the minimum accepted tidal water table in seaside areas that experience tidal influence (for example Cungulla, Magnetic Island, Cleveland Palms). The minimum water table level is taken to be the contour level of 2.25 m (Australian Height Datum). This allows for an astronomical tide of 4.1 m. Therefore, to determine vertical separation distances, this level must be taken into consideration. A site and soil evaluation may indicate the presence of a higher water table. This, along with wet weather water tables, shall be taken into consideration.

To assist applicants, the following report structure can be used in preparing an On-site sewerage disposal report, when read and applied in conjunction with relevant provisions found in AS/NZS1547:2000, including procedures outlined in sections 4.1.3.4 and 4.2.3.2 of AS/NZS1547:2000

- (a) Site and soil evaluation report (all references are to AS/NZS1547:2000)
- (i) Details of the site and soil evaluation personnel confirming:
 - past experience of site and soil evaluation assessments;
 - successful completion of an accredited training program (if applicable);
 - knowledge of the regulatory assessment requirements; and
 - professional liability for the interpretation of, conclusions drawn from and recommendations made as a result of the site evaluation.
 - (ii) desk top study as per relevant section of 4.1A2;
 - (iii) site and soil check as per relevant section of 4.1A3;
 - (iv) soil assessment items as per relevant section of 4.1A4; and

- (v) evaluation of results as per relevant section of 4.1.4.
- (b) Design report
 - (i) Details of land application facility designer confirming:
 - past experience designing on-site sewerage disposal facilities;
 - successful completion of an accredited training program;
 - knowledge of the regulatory design requirements; and
 - professional liability for the interpretation of, conclusions drawn from and recommendations made as a result of the design.
 - (ii) Documentation of the design process, including:
 - system selection as per section 4.2A4;
 - soils and LTAR/DLR values as per section 4.2A5; and
 - design flows as per section 4.2A6.
 - (iii) Reserve area as per section 4.2.3.4,
 - (iv) Distribution system as per section 4.2.3.6,
 - (v) Nutrients as per section 4.2.3.6
 - (vi) Rainfall surface flow control as per section 4.2.3.7
 - (vii) Land use activity as per section 4.2.3.8
 - (viii) Site plan
 - north point;
 - full property description;
 - name of person who evaluated the site;
 - scales of 1:200 or 1:500;
 - predominant wind direction;
 - location, height, density and type of vegetation;
 - access roads, tracks, vehicle manoeuvring areas, storage areas;
 - test boreholes/pits;
 - fall of land;
 - setbacks;
 - water supply bores, top banks of water courses, lakes, ponds, unlined stormwater drainage channels, dams;
 - buildings, fences, property boundaries, pedestrian paths, walkways, recreation areas, retaining walls, in-ground swimming pools, in-ground potable water tanks; and
 - primary and reserve land application areas.

It is the designer's responsibility to carry out their duties in accordance with the AS/NZS 1547:2000, the *Queensland Plumbing and Wastewater Code* (where relevant), and any other relevant legislation and supported by good engineering practice.

- (7) Design flows

Any consideration of design flow should utilise guideline appendices of AS/NZS1547:2000 and incorporate allowance for peak usage and occupancy.
- (8) System selection and land application design

The selection of the appropriate wastewater treatment system and disposal method should be based on the individual characteristics of the lot in question and any reporting recommendations based on investigation (as outlined in this policy sub-section). The assumption of a single type wastewater system being utilised across all lots in any subdivision application is not recommended.

Any system proposed for a lot should comply with all relevant Codes and Standards such as AS/NZS1546.1 and the *Queensland Plumbing and Wastewater Code*. Water balance and nutrient loadings need to be considered prior to the determination of appropriate lot sizes.

The assessment of soil properties (texture and hydraulic) assists in determining ideal rates of application and

also the suitability of proposed methods of disposal. The Queensland Water Recycling Guidelines (2005) provide indicative concentrations of total nitrogen (TN), total phosphorous (TP) and total dissolved solids (TDS).

It is recommended that a two stage approach be undertaken for supporting the final determination of lot sizes in a given subdivision and which is based on the suitability of the soils to certain methods of wastewater disposal, as well as any requirements of Townsville City Plan, including any applicable overlay provisions. The results of the site and soil assessment inform the selection of an appropriate system and subsequent land application design

SC6.4.3.10.3 Design considerations

(1) Set back distances

Set back distances are to comply with the requirements of the Queensland Plumbing and Wastewater Code and AS/NZS1547:2000.

Council may consider viral die off and nutrient decay calculations as a means of justifying a reduced set back distance from the following features:

- (a) top bank of an intermittent water course; or
- (b) easement boundary of an unlined open stormwater drainage channel or drain.

The consideration of reduced setback distances are subject to the requirements of the Townsville City Plan, which may require increased setback distances to watercourses or in some instances, development to be placed outside of riparian or wetland buffer areas as detailed in the Water resources catchment overlay code or the Natural assets overlay code. Furthermore, it will be necessary for applications to demonstrate that there will be no adverse environmental impacts, taking into consideration cumulative impacts from other development, to place infrastructure near a watercourse, wetland or open stormwater drainage channel/drain.

SC6.4.3.11 On-site water supply

SC6.4.3.11.1 Introduction

(1) Objectives

- (a) The objective of this sub-section is to outline the requirements for the design and supply of potable water and non-potable water where development is located outside of a reticulated water supply area.
- (b) Specifically, the following overall objectives are sought to be achieved as identified by the Townsville City Plan:
 - (i) to ensure adequate water supplies are available for people and fire-fighters to defend buildings from bushfires and to suppress other property fire;
 - (ii) ensure that development is provided with a reliable and safe supply of on-site water supply when located outside of a reticulated water supply area;
 - (iii) ensure that on-site water supply facilities are efficient;
 - (iv) ensure that on-site water supply facilities do not compromise environmental values;
 - (v) ensure that on-site water supply facilities are not subject to sources of contamination; and
 - (vi) ensure the safety and wellbeing of residents and the protection of water quality and other environmental values.

(2) Scope

- (a) This sub-section sets out the requirements for development located outside of reticulated water supply area for the provision of potable and non-potable water supply facilities.
- (b) This sub-section contains guidelines and statements for the design of potable water supply facilities and non-potable supply, including for fire protection.
- (c) This sub-section may be applied to areas where a reticulated water supply exists and an alternative supply is sought to supplement the reticulated supply.

(3) Applicability

- (a) This sub-section is to be used for assessment against the following codes where development is required to provide water supply outside of a reticulated water supply area:
 - (i) 6.6.1 Rural zone code (Cungulla Precinct);
 - (ii) 8.2.2 Bushfire hazard overlay code;
 - (iii) 8.2.9 Water resource catchment overlay code;
 - (iv) 9.2.3 Reconfiguring a lot (subdividing one lot into two lots) and associated operational work code;
 - (v) 9.4.4 Reconfiguring a lot code;
 - (vi) 9.4.5 Self-assessable works requirements code; and
 - (vii) 9.4.7 Works code.

(4) Terminology

Available roof area means the whole of the roof area of every building on the lot included in a development application

Blackwater is defined as:

- the waste discharged from the human body into a toilet; and
- the waste used for discharge.

Drinking water or potable water	water of a quality suitable for drinking, cooking and personal bathing. The standards that define potable water are described in the Australian Drinking Water Guidelines.
Drinking water supply system (water supply system)	all aspects from the point of collection of water to the consumer (can include catchments, groundwater systems, source waters, storage reservoirs and intakes, treatment systems, services reservoirs and distribution systems, and consumers).
Greywater	means wastewater from a bath, basin, kitchen, laundry or shower), whether or not that wastewater is contaminated with human waste.
Greywater treatment plant	a treatment plant, approved and installed under the <i>Plumbing and Drainage Act 2002</i> .
Hazard	a biological, chemical, physical or radiological agent that has the potential to cause harm.
Non-potable water	water that is not of drinking water quality, but which may still be used for other purposes, depending on its quality.
On-site water supply	is defined as a private, non-mains supply, such as water that is not provided as a reticulated council supply.
Required fire-fighting capacity	the volume of water required to comply with Part E of the <i>Building Code of Australia</i> .
Service reservoir/tank	a storage for drinking water, generally within the distribution system, used to meet fluctuating demands, accommodate emergency requirements and/or equalise operating pressures.

(5) Reference and source documents

- (a) Legislation
 - Food Act 2006*
 - Plumbing and Drainage Act 2002* (and associated Regulations)
 - Public Health Act 2005*
 - Water Act 2000*
 - Water Supply (Safety and Reliability) Act 2008*
 - Public Health Regulation 2005*
 - Standard Plumbing and Drainage Regulation 2003*
- (b) National codes and standards
 - Australia New Zealand Food Standards Code*
 - Building Code of Australia*
 - National Construction Code Volume 3 – Plumbing Code of Australia*
- (c) Queensland government
 - Queensland Development Code*
 - Queensland Plumbing and Wastewater Code*
 - Department of Health - Guidance on use of Rainwater tanks*
 - Department of Housing and Public Works – Rainwater tanks. A Guide to keeping your tank safe*
- (d) Standards
 - AS/NZS 5667.1:1998: *Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.*
 - AS/NZS 3500:2003: *Plumbing and drainage (Set)*
 - AS/NZS 4766:2006: *Polyethylene storage tanks for water and chemicals*
 - AS/NZS 3735:2001: *Concrete structures retaining liquids*

- (e) Standard Australia
NHMRC, NRMCC (2011) *Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy*. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.
Water made clear: A consumer guide to accompany the Australian Drinking Water Guidelines 2004. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra
HB230-2008 *Rainwater tank design and installation handbook*, Standards Australia

SC6.4.3.11.2 On-site water supply general requirements

- (1) This section outlines the on-site water supply systems suitable for use in the Townsville local government area.
- (2) The on-site systems may be used in combination with one another to deliver a reliable supply of potable and non-potable water.
- (3) Any on-site water supply should use water efficiently and minimise the whole of lifecycle cost for that infrastructure.
- (4) Any on-site water supply should not adversely affect environmental values.
- (5) Unless water is known to be of potable quality (e.g. from a drinking water supply system) it should be regarded as non-potable and used appropriately (fire fighting, irrigation of landscaping).
- (6) On-site water supplies must not be subject to hazards and hazards must be managed appropriately to ensure a safe supply is available at all times for potable use in addition to fire-fighting requirements.
- (7) Water supplied to the public must not constitute a public health risk
 - (a) Under the *Food Act 2006*, food businesses must ensure water used in their business (which may include roof harvested rainwater) complies with the requirements of the *Australia New Zealand Food Standards Code*, Standard 3.2.3.
 - (b) The *Australia New Zealand Food Standards Code*, Food Safety Standard 3.2.3 – *Food Premises and Equipment*, requires food businesses to use potable water for activities conducted on the premises. Where businesses do not have access to a potable water source, they must be able to demonstrate that the water is safe to use. Non potable water may only be used when it will not affect food safety i.e. the washing of non-food contact surfaces such as floors.
 - (c) The water must be of a potable quality unless the food business can demonstrate that the non-potable water will not adversely affect the safety of the food handled by the business.
 - (d) Food businesses must ensure the water they use for food related activities conducted at their premises is potable (safe for human consumption).

These activities include:

 - (i) washing food or ingredients;
 - (ii) cooking;
 - (iii) adding to food and drinks;
 - (iv) making ice;
 - (v) cleaning of food contact surfaces;
 - (vi) cleaning of food containers and utensils; and
 - (vii) personal hygiene.
- (8) Council may set conditions of approval dealing with the following matters (but not limited to):
 - (a) a maximum volume of ground water extraction for the development based on the findings of the groundwater resource assessment study;
 - (b) annual review of the effect of the authorised level of extraction in light of regional ground water level data collected from all relevant observation bores in the district. If regional ground water levels are declining, council may limit the previously authorised level of extraction, in terms of pumping rate or duration or both;
 - (c) maintenance of safe access to bores for inspections by council staff; and
 - (d) on-going monitoring, including:

- (i) provision of a report recording ground water levels each month for 6 months; and
 - (ii) regular testing of ground water quality (e.g. for nitrates and bacteria) if the ground water is to be used for potable purposes. If levels are found to be above the relevant drinking water quality standard, provision for an alternative potable source of water will be required.
- (9) The following on-site water supplies are permitted (SC6.4.3.11.12 Water resource catchment overlay):
- (a) rainwater harvesting (tanks);
 - (b) groundwater (bore water);
 - (c) surface water;
 - (d) carted drinking water;
 - (e) recycled water (reclaimed water); and
 - (f) greywater (non-potable from manual supply service).
- (10) The following on-site water supplies are not considered appropriate for supply:
- (a) recycled carted water; and
 - (b) greywater – (potable supply from permanent structure).

SC6.4.3.11.3 Water quality for on-site supplies generally

- (1) The *Australian Drinking Water Guidelines* (ADWG) are the standards for potable water for use in the Townsville area. SC6.4.3.11 Attachment A sets out the potable drinking water requirements to be achieved.

Editor's note—the current *Australian Drinking Water Guidelines* cover a range of topics, including management of water supply systems, water quality (microbiological, physical, chemical and radiological) and monitoring.

- (2) The following information should be used in undertaking testing of water quality.
References:

- (a) AS 5667.1:1998.

Editor's note—physical and chemical samples:

Use a bottle supplied by the laboratory or thoroughly clean a plastic bottle about one litre in volume (ie. Soft drink bottle), then rinse several times with the sample before filling.

Transport the sample directly to the laboratory on the day of sampling if possible, otherwise refrigerate and deliver within 24 hours of collection.

DO NOT FREEZE SAMPLE.

Editor's note—microbiological samples

Collect sample in sterile bottle provided by the laboratory, or in a 250 ml sterile container which can be bought from a Pharmacy. Do not rinse out the bottle with sample.

Remove cap, fill bottle leaving a small air space, then replace cap without touching the insides of the cap or bottle.

Transport the sample directly to the laboratory on the day of sampling if possible, otherwise refrigerate and deliver within 24 hours of collection.

DO NOT FREEZE SAMPLE.

Editor's note—pumped supply:

Pump for four hours to remove stagnant water from the bore hole and pipes before sampling.

If the bore runs dry before four hours are up, let it stand until it can be pumped again, then pump again until dry, repeat this process once more, then sample.

Note pumping time, type of pump, type of casing, depth, age of bore, etc. (this information can be useful to the laboratory for

SC6.4.3.11.4 Rainwater harvesting (tanks)

Editor's note—HB 230:2008 Rainwater tank design and installation handbook—provides practical information for the collection, use and storage of rainwater.

- (1) A tank installed for a building must have sufficient collection and storage capacity to provide an acceptable contribution for its external and/or internal connections and their associated water use, having regard to the following:
 - (a) the local rainfall pattern;
 - (b) the roof catchment area; and
 - (c) the area available for the location of the rainwater tank.
- (2) Installed tanks must ensure they comply with the requirements of the *Public Health Regulation 2005*. The legislation stipulates a "relevant tank"—a tank or other receptacle that is used or intended to be used for holding or storing water — must have at every opening:
 - (a) mosquito-proof screens that:
 - (i) are made of brass, copper, aluminium or stainless steel gauze;
 - (ii) have a mesh size of not more than 1 mm;
 - (iii) are installed in a way that does not cause or accelerate corrosion; and
 - (iv) stop mosquitos passing through the openings; or
 - (b) flap valves that, when closed, stop mosquitoes passing through the openings.
- (3) A tank must have suitable measures to prevent:
 - (a) insects (mosquitoes) and other fauna from breeding inside the tank;
 - (b) if a wet system supplies the tank— insect (mosquito) and fauna-proofing for each pipe opening that supplies the tank, with screen mesh with an aperture of no greater than 1 mm; and
 - (c) vermin from entering the tank.

The following are acceptable:

 - (i) screen mesh with an aperture of no greater than 1 mm, made of brass, copper, aluminium or stainless steel gauze to prevent the intrusion and breeding of insects (mosquitoes) and other fauna;
 - (ii) flap valves at each opening of the tank; and
 - (iii) a vermin trap.
- (4) A tank must have suitable measures to prevent contaminants from entering the tank especially having regard to the potential nature and level of contaminants within the locality and on-site uses.

A tank must have a minimum of 20 litres of first flush from the roof catchment area so that potentially contaminated rainwater is diverted and discarded before entering the tank where the tank is connected to:

- (a) a shower or wash basin; or
- (b) a swimming pool; or
- (c) kitchen or hot water service; or
- (d) another fixture required by a local government in a local planning instrument.

Editor's note—for those with a rainwater supply, it is important to check regularly to ensure that first-flush devices are working properly. It is also important to keep the roof catchment clean — bird droppings, peeling paint and dirt on the roof are the biggest sources of contamination. Guttering should be cleared regularly and overhanging branches should be kept to a minimum, because they can be a source of debris and allow birds and small animals access to the roof.

Editor's note—HB 230:2008 *Rainwater tank design and installation handbook*—provides practical information for the collection, use

and storage of rainwater.

- (5) The occupier of a place where a rainwater tank is installed (or if there is no occupier, the owner of the premises) must ensure that the tank is maintained at all times to ensure a reliable supply.
- (6) Where in a reticulated water supply area, water from a tank must not contaminate the potable water within a reticulated town water supply system. Where tank/s are installed, the reticulated town water supply system is protected from the potential of back-flow by the installation of:
 - (a) a back-flow prevention device that complies with AS/NZS 3500:2003; or
 - (b) for a tank, a dual-check valve with an atmospheric port.
- (7) A tank stand and the support base of a tank must be capable of withstanding loads likely to be imposed. The base of the tank is well supported by a ground treatment in accordance with the manufacturer's specifications and standard drawings for that tank.
- (8) Where a premises is providing tank water supply and required to also install a static water supply for fire fighting purposes, applicants will need to also comply with SC6.4.3.11.11 Requirements for fire fighting.
- (9) Where a tank is installed to supply water to the plumbing fixtures, the tank must have appropriate and clear signage to warn that the water in the tank is suitable for drinking.
- (10) All water tank overflows are to be connected to or able to discharge to a lawful point of discharge.
- (11) Development proposing to utilise a rainwater tank must determine that adequate rainwater volume can be collected to meet the annual water demand.

Editor's note—calculating the maximum amount of rainwater that can be collected from the available roof area can be completed using the following formula.

$$\text{run-off (litres)} = A \times (\text{Rainfall} - B) \times \text{roof area}$$

"A" is the efficiency of collection and values of 0.80-0.85 (that is, 80-85% efficiency).

"B" is the loss associated with absorption and wetting of surfaces and a typical value of 2 mm per month (24 mm per year) can be used.

"Rainfall" should be expressed in mm and "roof area" in square metres (m²).

For example, the run off from a 200 m² roof which receives 750 mm of rain per year, with an efficiency of collection of 80% (A = 0.80) and loss of 2 mm per month (B = 24) would be: Run-off = 0.8 x (750-24) x 200 = 116,160 Litres (or 116.2 kL).

- (12) If the maximum volumes are less than the annual water demand, then either the catchment area will need to be increased or water demand will need to be reduced or an alternative and supplementary source will need to be nominated.

SC6.4.3.11.5 Groundwater (bore water)

- (1) In Queensland, the Department of Natural Resources and Mines (DNRM) manages access to and use of underground water.

The right to take underground water is either established under the *Water Act 2000* (the *Water Act*) or granted under a "licence" or "water allocation". The drillers' licensing arrangements under the *Water Act* ensure all water bore drillers are properly skilled and that their work meets minimum standards.

Editor's note—information on water bore drillers and bore drilling requirements can be found on the DNRM website.

- (2) Each lot created or use proposed is to be provided with a proven and available long term sustainable resource of potable groundwater, properly licensed as required, supplemented where practical, with an alternative supply such as rainwater.

Editor's note—water from a deep, encased and well maintained bore and/or from a confined aquifer will generally not need treatment after addition to a rainwater tank, but the chemical quality of some groundwater is not suitable for drinking.

- (3) Only groundwater that is compliant with values cited in the *Australian Drinking Water Guidelines* (ADWG) should be used.

Editor's note—key health parameters for groundwater are arsenic, nitrate, fluoride and health-related heavy metals. Salinity is an important aesthetic parameter.

Editor's note—groundwater from shallow or unconfined aquifers is readily contaminated by agricultural, industrial or urban activities and generally should not be used as a source of drinking water unless it has been recently tested for microbial and chemical quality and is compliant with guideline values cited in the ADWG.

- (4) Water treatment devices/technologies to improve the aesthetic values, microbial and chemical quality of water are to be installed to ensure that all ground water achieves the guideline values cited in the ADWG. Methods used to treat groundwater must be certified by a registered professional in the field of ground water quality and must be installed and commissioned prior to occupation of the use (except where water supply is combined with fire fighting water).
- (5) Any proposed ground water extraction, when combined with existing levels of extraction in the area, is to be sustainable on both a local and regional level. The average annual demand for ground water must not exceed the average long term recharge in the area.

To demonstrate compliance with the above criteria, council may request that a Groundwater resource assessment be undertaken by a qualified hydro-geologist.

A Groundwater resource assessment should include, at a minimum:

- (a) consideration of information available from previous studies and new information collected as part of the investigation;
- (b) consideration of the maximum ground water extraction rate attainable, proposed pumping rates, land slope, flooding, drainage, geology, ground water recharge potential, local experience, proximity to and protection from potential contaminants, soil characteristics (colour, texture, structure, permeability and presence of rock), percolation testing, direction of ground water flow, seasonal fluctuation in ground water levels, and the current degree of district and local extraction;
- (c) a comparison between the average annual ground water demand and the average annual ground water recharge, on a local and a district level;
- (d) the results of drilling and testing of an adequate number of bores, supplemented with ground water modelling where necessary, to ensure a thorough and accurate investigation of the ground water resources available. Bores are required for two purposes, namely, for interference testing and for regional ground water level observation;
- (e) results of independent and simultaneous pumping of test bores, and measurement of water levels to check for localised pumping interference with any existing and proposed neighbouring bores. Pumping tests should be undertaken for a minimum of 8 hours duration and pumped at the rate the pump is intended to be operated in the proposed development. The available draw down in neighbouring bores during the test must not be reduced by greater than 20% when compared to available draw down in these bores prior to pumping;
- (f) if bore interference is found to be greater than 20% of the available draw down, supplementary pumping tests must be undertaken to measure the effect of reducing either the pumping rate, the duration of pumping, or both, until the resulting interference is within this level;
- (g) water quality testing to determine whether extracted water will be of a potable quality, including where relevant, written advice from a registered professional in the field of ground water quality. Appendix A outlines appropriate standards for bore water testing (potable uses);
- (h) investigation of previous land uses and the possibility of contamination of aquifers to determine the quality of ground water;
- (i) details of the pump type, capacity and pumping curve for bores; and

- (j) preparation of a report detailing all the studies and works undertaken, the resource assessment findings and assumptions made.
- (6) Methods used to treat groundwater to meet health and aesthetic guidelines must be certified by a registered professional in the field of ground water quality.
- (7) For licensing and construction requirements for underground water the local DNRM office should be consulted.

Editor's note—before considering sinking a water bore refer to fact sheet Drilling for water on the DNRM website.

- (8) The bore shall be constructed to ensure that contamination of the groundwater source does not occur, either during construction or operation.
- (9) The bore head shall be mounded to prevent ponding and stagnation of water around the bore to eliminate the possibility of mosquitoes breeding and problems caused by flies or odour.
- (10) All drainage shall be directed away from the bore.
- (11) Bores nominated to supply potable water supply are to be appropriately site away from sources of contamination, including on-site sewerage facilities. For further details relating to on-site sewerage facilities, refer to the sub-section SC6.4.3.10 On-site sewerage facilities for non-sewered properties.
 - (a) On-site sewerage treatment facilities shall be placed as far away as possible from ground water bores used for potable groundwater supply. Minimum allowable distances are to be in accordance with the *Plumbing and Drainage Act 2002* and relevant codes and regulations established pursuant to the *Plumbing and Drainage Act*, which are applicable at the time of making application for development approval.
 - (b) New land parcels or existing land within non-sewered areas must provide evidence prior to the sealing of the plan of survey or the commencement of the use that an appropriate on-site sewerage treatment facility can be designed and accommodated within each proposed lot in addition to the potable supply of ground water.

SC6.4.3.11.6 Surface water

- (1) Surface water includes water derived from dams, creeks, rivers and streams.
- (2) The use of surface water is generally considered permissible only when in a non-urban zone (excluding rural residential).
- (3) Surface water supplies are more prone to contamination from sources such as animal and human waste and algal blooms.
- (4) Due to the potential for contamination, surface water is not recommended as a source of drinking water unless additional treatment processes such as filtration and disinfection are in place.
- (5) Unless drinking water quality can be assured through disinfection and routine testing, surface water should be utilised for purposes other than drinking such as irrigation and toilet flushing and fire fighting. Treatment may still be necessary for non-drinking uses.
- (6) Water subject to potential contamination from human or livestock waste, such as dams, rivers and creeks, can contain a wide range of pathogenic organisms including chlorine-resistant *Cryptosporidium*. Water of this type may not be suitable for drinking even after disinfection.
- (7) Surface water that is protected from human and livestock waste can be used and should be demonstrated.
- (8) Surface water must be able to provide a reliable year round supply of water for both potable and fire-fighting purposes and should be demonstrated.
- (9) Potable water quality:
 - (a) When used, pumped or captured surface water should be added to a storage tank in one action, then treated and allowed to stand for at least one hour before use.
 - (b) Where surface water is to be the primary source of a potable water supply, the quality of water extracted is to be of a potable quality and meet aesthetic, chemical and microbial requirements.
 - (c) Water treatment devices/technologies to improve the aesthetic values, microbial and chemical quality of water are to be installed to ensure that all surface water achieves the guideline values cited in the ADWG.

- (d) Methods used to treat surface water must be certified by a registered professional in the field of water quality and must be installed and commissioned prior to occupation of the use (except where water supply is combined with fire fighting water).
- (10) Each surface water pump point must be metered (or where there are multiple, collectively recorded), with the meter maintained, read and the volume pumped recorded on a quarterly basis.
- (11) Any proposed surface water use is to be sustainable on both a local and regional level. The average annual demand for surface water must not exceed the average long term recharge in the area to ensure ground water supplies are maintained.
- (12) To demonstrate compliance with the above criteria, council may request that a groundwater resource assessment be undertaken by a qualified hydro-geologist.

SC6.4.3.11.7 Carted drinking water

- (1) The use of carted drinking water supply is only used as a supplementary/secondary supply measure to ensure a long term and sustainable supply of water to a premises.
- (2) Water cartage is necessary in some instances to supplement existing rainwater supplies.

Editor's note—if rainwater collection is limited by the size of storage tanks or roof catchment areas or a lack of rain, drinking water supplies may need to be augmented with carted water.

- (3) Carted water is not be used as a sole source of supply except as a temporary use.
- (4) Carted water is to be stored in water tanks as outlined in SC6.4.3.11.8 Rainwater harvesting tanks.
- (5) Drinking water is recognised as a food. Water carters/carriers may need to be registered as a food business if the supply of additional potable water is needed.
- (6) When using carted water, it is advisable to ensure the water carter can provide evidence that water supplied will be safe to drink. This evidence could include: any authorisations issued for the purpose of supplying drinking water; the identity and quality of the source water; proof that tankers used are suitable for the purpose of carrying drinking water (for example, not likely to have carried other materials that would contaminate drinking water).
- (7) Ensure that carted water supplied for drinking is disinfected at the point of supply (such as the rainwater tank) as this provides protection against contamination introduced during filling of the water tanker and during transport to the point of supply.

SC6.4.3.11.8 Recycled water

- (1) Recycled water is any water that has been used at least once and then supplied for reuse, either treated or untreated. Without appropriate treatment, recycled water may contain a range of contaminants.

Editor's note—for example, water used for the final rinse in a commercial laundry is only lightly contaminated and thus may be used again, untreated, for the first wash cycle. On the other hand, sewage must be treated at a sewerage treatment plant before it can be recycled for any purpose.

Recycled water from sewerage treatment plants is put into different classes depending on its microbiological quality. These classes range from Class A+ (the highest) to Class D (the lowest).

- (2) The use of recycled water can reduce the demand on alternative supplies that are potable.
- (3) Recycled water can be used where it is demonstrated that it is safe to do so and does not adversely affect the environment, adjoining properties or constitute a public health risk.
- (4) Recycled water is not to be used for potable water, food preparation or topping up of pools or spas, but may be appropriate for private and commercial purposes such as irrigation and possibly toilet flushing, car washing and dust suppression (or similar), including for fire-fighting.
- (5) Recycled water when used for watering plants and lawns (source of irrigation) can be an effective means of saving water provided some sensible precautions are undertaken, including watering several locations to

prevent salts and other contaminants from accumulating in the soil and rotation of irrigation using mains or rainwater to help flush salts from the soil.

- (6) Signage must be erected at sources of recycled water use to advise that the water is not suitable for drinking.
- (7) The static storage of recycled water must be separately stored from other sources of potable water.
- (8) The quality of the water will determine the permitted uses and businesses using recycled water are required to obtain approval and adhere to any specified conditions.
- (9) The storage of untreated water for more than 24 hours (bacteria and organic contaminants in water will cause it to turn septic and produce strong and offensive odours).
- (10) Recycled or untreated water is not allowed to pool or run-off onto other properties, into watercourses, public space or the stormwater system.

SC6.4.3.11.9 Non-restricted water supply risks

- (1) Selecting an alternative supply, consideration must be given to the potential health concerns, sensible practices and disinfection options available as well as the location, rainfall patterns, supply required and overall cost (initial and maintenance).

Editor's note—advice on the use of on-site water supply:

- ensure water is collected from the most suitable and safest source available;
- determine what microbial or chemical contaminants are in the surrounding environments and what effects they may have on the water used;
- treat water if necessary to make it safe. This could involve the removal of solids, chemicals and microorganisms;
- ensure collection sources for rain water such as roofs and gutters are kept free of extraneous matter such as leaves and bird droppings;
- ensure a first flush system is used for all rain water collection to ensure that the first water collected during a rain fall event is discarded thereby reducing the amount of microorganisms entering the tank;
- ensure tanks which are used to store water are cleaned out regularly to remove any build up of sludge or debris. This reduces the potential risks of chemical or microbiological contamination of the water;
- where water is supplied by a water carrier, it should be sourced from a potable water supply. The carrier should have hoses which are in good operating condition and are capable of being effectively cleaned and sanitised. The water carriers should only used for the purpose of carrying potable water, the operator should be able to provide documentation showing this;
- ensure all equipment that is used to collect and store the water is suitable and well maintained;
- ensure all equipment used in the collection and storage of water is well positioned to minimise the risk of contamination;
- ensure all water storage equipment is vermin proof; and
- monitor the water regularly to ensure that the conditions of the water have not changed and any treatments being undertaken are appropriate to ensure its safety. It is important to remember that some water sources such as bore water may have a very high mineral load. While this may not affect the safety of the water, it may affect the quality, flavour and hardness and have an undesirable effect on the equipment that is used. It is recommended that water is tested by an accredited laboratory on a regular basis to ensure the steps that have been put in place are still adequate to maintain the safety of the water.

For advice on what constitutes good quality water see the *Australian Drinking Water Guidelines 2011* available from the National Health and Medical Research Council's website.

SC6.4.3.11.10 Requirements for non-potable water supply

- (1) The *Plumbing Code of Australia* requires that a non-drinking water supply:
 - (a) must only be connected to outlets clearly identified for non-drinking use and must be limited to the uses specified in the Code; and
 - (b) is not to have a cross connection with a drinking water service.

Editors note—if non-potable water is adequately treated, its quality will improve and it can be used for a wider range of purposes.

Some examples of non-potable water used are:

- class A recycled water from a sewage treatment plant used for dust suppression, car washing, landscape irrigation or irrigation of sporting ovals;
- quarry water used for dust suppression and landscape irrigation;
- swimming pool backwash water used for toilet flushing;

- agricultural waste water used for crop irrigation; and
- creek, dam, and river water used for dust suppression.

SC6.4.3.11.11 Requirements for fire-fighting supply

Editor's note—fire fighting uses large amounts of water. If fire fighters need to leave a site to obtain more water, that site will be undefended and may be damaged or lost. If fire fighters don't have access to adequate water supplies at a site they may not even attempt to defend the site because it will be unsafe.

Editor's note - Where the building Code of Australia and applicable Queensland Building Codes provide standards for the installation of fire fighting appliances, the provisions of those standards shall prevail.

The purpose of this section is to outline adequate and accessible water supplies required for fire-fighting purpose and to ensure that they are available for people and fire-fighters to defend from fires. Suitable water supplies and appliances shall be provided and easily accessible at all times.

- (1) The minimum dedicated amount of water for fire-fighting purposes is 10,000L of stored (static water) for a property less than 2500 square metres in area and at least 20,000L of stored (static water) for property greater than 2500 square metres. The amount of stored static water must be available and accessible at all times.

Editor's note—some development may require more water to comply with the Building Code of Australia or to ensure that an adequate supply is available to service a particular development where that development is likely to require increased fire fighting capacity.

- (2) Fire-fighting water supply needs to be provided and easily accessible at all times, although it does not need to be drinkable (potable).
- (3) A dedicated water tank for the storage of fire-fighting water is the accepted standard. Where alternatives are provided, it should be demonstrated that the water supply will be available and accessible at all times.
- (4) Where not using a dedicated fire fighting storage tank, the outlet for the internal fixtures is located above the point at which the tank will contain the dedicated amount for fire-fighting purposes.
- (5) Fire-fighting water supplies (including pipelines, hydrants, fittings and storages) are:
 - (a) provided before building construction commences;
 - (b) designed, located and fitted to ensure reliability during a fire (eg: polypipes are buried or shielded - refer to the National Plumbing and Drainage Code AS3500);
 - (c) properly maintained and accessible at all times by emergency vehicles;
 - (d) tanks must be located so that a vertical clearance of 4m to overhanging obstructions is achieved (vegetation, power lines);
 - (e) a cleared area on either side of the tanks, a minimum of 6m, to allow fire-fighting vehicles and crews access to the tanks; and
 - (f) tanks should avoid being located on slopes, including access to, greater than 12 per cent.

Editor's note: A fire truck has to be within about 3 metres from a water supply to be able to pump from it.

Editor's note: Plastic tanks dedicated for fighting purposes are not recommended, however if they are submerged, they may be acceptable.

- (6) At least one tank is within 100m of the building which has fire brigade tank fittings. If the tank is underground, it has an access hole of 200mm (minimum) to allow access for suction lines.
- (7) A water supply for fire fighting purposes must be clearly marked and identified by emergency services and others. Where a dedicated tank for storage of fire fighting water is used, the tank must have appropriate signage to warn that the water in the tank is not suitable for drinking.

Editor's note—The following is applicable for development within the Water resource catchment overlay map OM-09 (Schedule 2 of Townsville City Plan) and where development is to address the assessment criteria of the Water resource catchment overlay code found in Part 8.2.9 of the Townsville City Plan.

SC6.4.3.11.12 Water resource catchment overlay

- (1) To demonstrate the protection of water quality, ecological values and other environmental values, applicants may be asked to provide groundwater resource assessment where the proposed development is to use any ground resource as outlined in SC6.4.3.11.5(5).
- (2) No on-site water supply infrastructure, including underground pipe, is to be located such that it will not change the physical integrity of waterways, wetlands, lakes, springs and riparian areas.
- (3) On-site water supplies may only be from harvested rainwater (tanks) or ground water (where undertaken and demonstrated sustainable by a ground water assessment) and may be supplemented by carted water.
- (4) Recycled water or greywater is not to be used to protect the water catchment from potential contamination.
- (5) The capture of ground surface water is not permitted.
- (6) A ground water level observation bore is to be installed adjacent to the site. The observation bore must be installed remote from all production bores to ensure there is no local interference to ground water levels at the observation bore.
- (7) Council may set conditions of approval dealing with the following matters:
 - (a) a maximum volume of ground water extraction for the development based on the findings of the groundwater resource assessment study;
 - (b) annual review of the effect of the authorised level of extraction in light of regional ground water level data collected from all relevant observation bores in the district. If regional ground water levels are declining, council may limit the previously authorised level of extraction, in terms of pumping rate or duration or both;
 - (c) maintenance of safe access to bores for inspections by council staff; and
 - (d) on-going monitoring, including:
 - (i) provision of a report recording ground water levels each month for 6 months; and
 - (ii) regular testing of ground water quality (e.g. for nitrates and bacteria) if the ground water is to be used for potable purposes. If levels are found to be above the relevant drinking water quality standard, provision for an alternative potable source of water will be required.

(Source) NHMRC *Australian Drinking Water Guidelines 2011*

Physical and chemical tests	Health	Aesthetic
PH	n/a	6.5 - 8.5
TDS (mg/L)	n/a	<600
Hardness (mg/LCCO ³) (incl Ca and Mg)	n/a	200
Aluminium (mg/L)	0.1 (dialysis patients)	0.2
Cadmium (mg/L)	0.002	n/a
Copper (mg/L)	2.0	1.0
Iron (mg/L)	n/a	0.3
Lead (mg/L)	0.01	n/a
Manganese (mg/L)	0.5	0.1
Zinc (mg/L)	n/a	3.0
Sodium (mg/L)	n/a	180
Chloride (mg/L)	n/a	250
Fluoride (mg/L)	1.5	n/a
Nitrate (mg/L)	50	n/a
Sulphate (mg/L)	500	250

SC6.4.3.12 Constructed lakes

SC6.4.3.12.1 Introduction

(1) Purpose

The purpose of the policy sub-section is to provide standards, advice and guidelines for the design, construction and maintenance of constructed lakes in the Townsville area.

Well designed and maintained lakes can add considerable value to the urban environment including improved visual amenity, recreational opportunities, and wildlife habitat.

Lakes built in the dry tropics region of Townsville operate under a range of challenging climatic conditions, and maintaining a healthy water body can be difficult to achieve. The extended dry season combined with high rainfall events during the wet season mean that lakes often undergo rapid changes in state. A healthy water body can very quickly develop poor water quality and algal blooms that are unsightly and a potential threat to public health.

A number of constructed lakes have been built in and around the Townsville area and are experiencing numerous problems. These include:

- (a) weed infestations (terrestrial and aquatic);
- (b) excessive siltation;
- (c) highly turbid waters;
- (d) poor water quality;
- (e) stratification;
- (f) frequent algal blooms;
- (g) fish kills; and
- (h) limited maintenance access to remove built up silt, debris and weeds.

The burden of rectifying these lakes and satisfying community expectations has been incurred by council. As a consequence, council has identified a need to regulate the construction of lakes within the Townsville area.

Editor's note—Part 9.4.2 Healthy waters code of the Townsville City Plan provides assessment matters for applications involving lakes to specifically consider, in addition to other relevant sections of the Townsville City Plan.

(2) Objectives

This sub-section outlines the information that should be lodged with a particular development application if that development includes a lake.

Note—this sub-section is intended to provide the necessary guidance to design a sustainable healthy lake in the Townsville area. However, due to the challenging climatic conditions experienced in Townsville and the low number of examples of constructed lakes, this sub-section does not guarantee performance, and proponents should be aware that lake designs in accordance with this sub-section do not exempt the proponent from any necessary post construction maintenance and rehabilitation prior to handover.

(3) Principles

- (a) Lake designs should aim to enhance biodiversity through revegetation, establish linkages with existing vegetation communities, and be supportive of public interaction and education. Lakes designs should provide enhanced landscape aesthetic and amenity for surrounding residents through the installation of improved passive recreation facilities i.e. paths and trails.
- (b) The primary intent and range of uses for the lake is to be clearly defined by the proponent. The design intent must be accompanied by concept plans showing location and layout with respect to the development. Council will consider applications that are sustainable for their intended use, have no negative impact on surrounding environments and have been designed to minimise on-going maintenance.

- (c) Uses preferred by council:
- (i) The preferred lake with regards to long term sustainability, weed and water level management is a saline lake. Although less diverse than fresh water lakes, the operation of saline lakes are considered more robust for Townsville conditions.
 - (ii) Where fresh water lakes are proposed, the proponent should consider other alternatives such as heavily vegetated constructed wetlands which can provide open water views and water treatment benefits (refer to SC6.4.3.9 Water sensitive urban design guidelines). The proponent must clearly indicate how water level variations will be managed and proposed alternative sources of water to maintain lake water levels within acceptable variations.
 - (iii) The following are not encouraged by council:
 - (A) brackish lakes, including saline lakes that receive large freshwater inflows;
 - (B) lakes that receive untreated stormwater (i.e. stormwater that has not been treated to achieve the requirements of the SC6.4.3.9 Water sensitive urban design guidelines, or untreated overflows);
 - (C) lakes that are greater than 3 m in depth from wet season normal water level to finished bed level;
 - (A) lakes that impact on the sustainability and health of local aquifers or adjacent waterways;
 - (B) lakes that promote primary and secondary human contact activities such as boating, swimming, fishing and skiing;
 - (C) lakes that are used for flood management purposes;
 - (D) lakes for stormwater harvesting;
 - (E) lakes that result in the removal of existing significant vegetation;
 - (F) lakes that disturb natural waterways i.e. are located within the natural waterway alignment; and
 - (G) lakes that are primarily designed as a source of fill for development (i.e. to raise the level of the development site).
- (d) Lakes should be constructed off-line to minimise any disturbance to the passage of aquatic fauna. Off-line systems facilitate lake draining and maintenance, if necessary. Should in-line diversion structures be proposed to supply constructed lakes (e.g. diversion weirs) suitable arrangements must be made to maintain connectivity (i.e. fish passage) and stream base flows or environmental flows.

(4) Terminology

Aquifer

A geological formation saturated with water that contains and transmits water.

Brackish lake

A lake that is permanently or temporarily in a state between fresh and saline. For the purposes of this policy salinity levels range between 1,000 – 15,000 mg/L. Brackish lakes include fresh water lakes with saline intrusions, groundwater dominated brackish lakes or saline lakes with freshwater input. Brackish lakes are not encouraged Townsville.

Constructed lake

An artificial body of permanent open water with recreational values with either an edge fringed with emergent macrophytes or a hard edge. While submerged macrophytes may occur throughout the water column, the dominant feature is open water.

For the purposes of comparing with a constructed wetland, a lake is a water body that has greater than 30% of its area as open water (i.e. less than 70% as emergent macrophytes).

For the purposes of this document, a constructed lake is considered to be a receiving water body, and does not contribute to the mandatory water quality improvements outlined by the State Planning Policy.

Constructed wetland	An artificial, shallow body of water that consists of heavily vegetated macrophyte zones and deep pools that support a range of aquatic vegetation across the majority of the waterbody area. A constructed wetland has less than 30% of its area as open water (i.e. more than 70% as emergent macrophytes). The inlet zone and deep pools of a constructed wetland may, for instance, resemble a pond, but the dominant feature of the system is the macrophyte zone, containing emergent marsh, rush and reed vegetation that can withstand wetting and drying cycles. The structure and function of constructed wetland systems means they can remove pollutants from stormwater runoff through enhanced sedimentation, fine filtration and biological uptake (refer to SC6.4.3.9 Water sensitive urban design guidelines).
Dam	An artificial body of permanent open water provided as a source of water. In the context of this policy a dam can be used as a storage mechanism to provide lake top-up water.
Environmental value	Values or uses of water that support healthy ecosystems and contribute to public benefit, safety and health. Environmental values are typically determined through a transparent process involving government, industry groups and the community. Environmental values require protection from the effects of pollution and discharges.
Fresh water lake	A lake that receives treated stormwater runoff inflows only and is not influenced by tidal inundations or saline groundwater intrusions. Typically salinity levels are less than 1,000 mg/L
Lake catchment	The area from which all stormwater runoff flows into a lake.
Macrophytes	Large, submerged or emergent aquatic plants.
Normal water level (NWL)	The normal operating water level of the lake system, as defined by the lake outlet.
Primary contact	With regards to constructed lakes includes recreational activities that result in the immersion of the body in the water. These include swimming, skiing, diving and wading.
Receiving water body	A water body that receives stormwater runoff from the catchment under consideration. For the purposes of this policy constructed lakes and natural wetlands are included in the definition of receiving waters, but constructed wetlands that have been built primarily for the purpose of stormwater (or wastewater) treatment, are not. Saline lake - A lake that is permanently in a saline state, whether tidally influenced or as a result of groundwater intrusions. Salinity levels are at or above 15,000 mg/L permanently.
Secondary contact	With regards to constructed lakes includes recreational activities that result in some contact with the water but not the immersion of the body in the water. These include boating and fishing.
Sediment	Solids (typically sand, silt and clay) that are transported by water and deposited from suspension. Considered to be a "contaminant" as defined in the <i>Environmental Protection Act</i> (1994) or any latest version of this act / legislation / documents.
Stormwater	Surface water that runs off land or structures on land following a rain event (including piped flows).

Stormwater quality improvement devices (SQIDs)	Devices used to improve the health of the receiving waters by reducing the amounts of pollutants that enter waterways from stormwater runoff. Types of SQIDs include trash racks, gross pollutant traps, sediment basins, constructed wetlands, bio-retention devices and swales.
Water body	A water body, whether constructed or natural, that has defined bed and banks. A water body can be fresh or saline and can be tidally influenced.
Waterway	Means any of the following (whether or not temporarily dry: river, creek, stream, gully or drainage channel, including the bed and bank, whether modified or not. This term includes waterways indicated on the Townsville City Plan maps.
Water quality indicators	A water quality indicator is a physical, chemical and biological property of water that can be measured in a quantitative way (e.g. pH, temperature). The resulting water quality data enables trends or changes in water quality to be determined over time.
Water quality objectives (WQOs)	Measurable values for the quality of receiving waters to ensure that Environmental Values of those waters are safeguarded.
Water sensitive urban design (WSUD)	WSUD is an approach to water management in urban areas with the “interactions between the urban built form (including urban landscapes) and the urban water cycle as defined by the three urban water streams being potable water, wastewater and stormwater” (Engineers Australia 2003).

(5) Reference and source documents

(a) Queensland state legislation

Editor’s note—design of a constructed lake may also need to consider relevant Queensland state legislative requirements as listed below or any latest version of these acts/legislation/documents.

Coastal Protection and Management Act 1995
Coastal Protection and Management Regulation 2003
Environmental Protection Act 1994
Environmental Protection Regulation 2008
Environmental Protection (Water) Policy 2009
Fisheries Act 1994
Local Government Act 2009
Soil Conservation Act 1986
State Planning Policy
Planning Act 2016
Vegetation Management Act 1999
Water Act 2000

(b) Queensland state authorities

Department of Environment and Heritage Protection, *Queensland Water Quality Guidelines 2009*
 Department of Environment and Heritage Protection, *Urban Stormwater Quality Planning Guidelines, 2010*
 Department of Environment and Heritage Protection, *Urban Stormwater Quality Planning Guidelines, December 2010.*
 Department of Energy and Water Supply, *Queensland Urban Drainage Manual*
 Department of Transport and Main Roads, *Road Drainage Manual: A Guide to Planning, Design, Operation and Maintenance of Road Drainage Infrastructure, 2010*

(c) Australian Standards

AS/NZS ISO 31000 *Risk management - Principles and guidelines*
 AS 1289 *Methods of testing soils for engineering purposes*

AS 1547 *On-site domestic wastewater management*

AS 4419 *Soils for landscaping and garden use*

(d) Other

ANZECC, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand,

Brisbane City Council (BCC), *Sediment Basin Design Guidelines* 2001

Brisbane City Council (BCC), *Stormwater Outlets in Parks and Waterways, Guidelines*, 2002

Brisbane City Council (BCC), *Natural Channel Design Guidelines*, 2000

Brisbane City Council (BCC), *Guidelines for Pollutant Export Modelling in Brisbane, Version 7 – Draft* 2003

Brisbane City Council (BCC), *Water Quality Management Guidelines*, 2000

Brisbane City Council (BCC), *Water Sensitive Urban Design Engineering Guidelines: Stormwater* 2006
Burge, K., and Breen, P.F. *Detention time design criteria to reduce the risk of excessive algal growth in constructed waterbodies*, Proceedings from 7th International Conference on Urban Drainage Modelling, Melbourne 2006

Cullen, E., Taylor, S., Leinster, S. and Eadie, M. *Design and management responses to address common constructed urban lake sustainability issues*

DesignFlow, 2010. *Constructed Water Bodies in Urban Areas of SEQ – Critical Analysis of Recirculation Strategy*. Prepared for Water by Design.

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Institution of Engineers Australia, Queensland Division (IEAQ), *Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites*, 1996

International Erosion Control Association (IECA), *Best Practice Erosion and Sediment Control*, 2008

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Mackay City Council, *Engineering Design Guidelines Constructed Lakes Planning Scheme Policy No. 15.15*, 2008

Melbourne Water, *Constructed Shallow Lake Systems, Design Guidelines for Developers*, Version 2, November 2005

Melbourne Water, *WSUD Engineering Procedures*, 2005

Moss, B., 1998. *Shallow Lakes, Biomanipulation and Eutrophication*. Scope Newsletter 29: 1-44.

NHMRC, 2008. *Guidelines for Managing Risks in Recreational Waters*. National Health and Medical Research Council, Australian Government, Canberra.

Paerl, H.W., 1988. *Growth and Reproductive Strategies of Freshwater Blue-green Algae (Cyanobacteria)*. In: (Ed. C.D. Sandgren) *Growth and Reproductive Strategies of Freshwater Phytoplankton*. Cambridge University Press, Cambridge, pp. 261-315.

QDOT, 1998. *Tide Tables for Queensland*. Queensland Department of Transport

Scheffer, M., Rinaldi, S. Gragnani, A. Muir, L.R. and Van Nees, E.H. 1997. *On the dominance of filamentous Cyanobacteria in shallow, turbid lakes*. Ecology, 78: 272-282.

Scheffer, M., 1998. *Ecology of Shallow Lakes*. Kluwer Academic Publishers, Dordrecht.

Scheffer, M., Carpenter, S., Foley, J.A., Folker, C., and Walker B., 2001. *Catastrophic shifts in ecosystems*. Nature 413: 591-596.

Scheffer, M., 2001. *Alternative attractors of Shallow Lakes*. The Scientific World 1: 254-263.

Townsville City Council, *Water sensitive urban design for the coastal dry tropics (Townsville): technical*

SC6.4.3.12.2 Minimum requirements

- (1) The proponent must clearly demonstrate through design, investigation and monitoring that the proposed lake will:
 - (a) be sustainable for its intended use;
 - (b) have no negative impact on surrounding environments;
 - (c) provide a high level of amenity to surrounding land uses;
 - (d) have no adverse impacts on flood capacity;
 - (e) be safe due to minimisation of hazards; and
 - (f) be designed to minimise on-going maintenance.

- (2) General requirements

A suitably qualified and Registered Professional Engineer of Queensland (RPEQ), with specific water sensitive urban design and lake design experience, must undertake or oversee all aspects of the constructed lake design. As constructed lakes will often involve significant landscape input, a suitably qualified landscape architect registered with the Australian Institute of Landscape Architects (AILA) should also work with the RPEQ.

The design must comply with all relevant requirements of:

- (a) the requirements of the Townsville City Plan and, specifically, Part 9.4.2 Healthy waters code and any other applicable development codes;
- (b) this sub-section;
- (c) reference and source documents listed in SC6.4.3.12.1(5), in general;
- (d) any development approval conditions relevant to the design; and
- (e) any specific relevant and reasonable request, sought by council in writing.

The RPEQ shall sign all plans associated with the lake, certifying that the design, subsequent construction and performance criteria complies with this section.

Regardless of final ownership of the proposed lake, the proponent is to follow the requirements of this sub-section.

- (3) Minimum functional requirements

The following are considered minimum requirements for the sustainable healthy operation of a lake:

- (a) lake depths of 1.5 m to 3 m to finished bed level at the wet season normal water level (preferably 2-2.5 m). A minimum lake depth of 1.5 m is considered necessary to allow maintenance equipment such as floating weed harvesters to access lakes;
- (b) sufficient inflow to sustain lake water levels within acceptable variations;
- (c) upstream water quality treatment devices (SQIDS) to ensure inflows to the lake meet the requirements of the State Planning Policy and SC6.4.3.9 Water sensitive urban design guidelines. Untreated overflows must by-pass constructed lakes;
- (d) floating aquatic vegetation minimised within the lake to reduce potential organic carbon loads;
- (e) shaped and oriented to minimise dead spots. Where possible lake shapes should be orientated in the direction of the prevailing wind to improve mixing;
- (f) suitable outlet configuration to manage lake water levels to facilitate plant and lake establishment, and on-going management actions (i.e. lower lake level by gravity);

- (g) measures to pass high flows (i.e. untreated over flows) around the lake;
- (h) sufficient liner (e.g. clay) at the lake floor to ensure the system minimises seepage losses, and in some cases to stabilise the lake bed (i.e. cover marine clays);
- (i) integration of the lake within the site constraints;
- (j) sufficiently strong embankments and overflow structures to manage peak flows and erosion;
- (k) suitable access for heavy machinery in various locations to enable management actions (i.e. de-silting, weed and debris removal);
- (l) edge treatments that minimise potential weed ingress;
- (m) consideration of public safety issues and hazards (i.e. edge treatments, access to water, CPTED principles, flood capacity);
- (n) sufficient measures to minimise algal bloom development (e.g. sufficient lake turnover and/or other strategies for managing algal growth such as mechanical aerators and mixers, ultrasonic treatments etc.);
- (o) protection and appreciation of existing natural assets such as significant trees, marine plants, billabongs and wetlands;

Editor's note—applicants should also refer to Part 8.2.5 Natural assets overlay code and SC6.9 Natural assets planning scheme policy for additional information.

- (p) sufficient measures to control pests (including bird population control) and mosquitoes including providing a habitat for predators;
- (q) enhanced biodiversity through revegetation; and
- (r) enhanced landscape aesthetic and amenity for surrounding residents through installation of improved passive recreation facilities i.e. paths and trails.

SC6.4.3.12.3 Development application requirements for constructed lakes

(1) Information for development applications

All drawings and documents submitted to council for approval shall be prepared by a suitably qualified person.

(a) MCU/ROL applications

The proponent will be required to submit a constructed lake concept design report with comprehensive management plans to support a development application for reconfiguring a lot (ROL) or material change of use (MCU) or operational works, where the proposed development includes a lake.

A separate stormwater quality management plan will be required to support the concept design report where a fresh water lake is proposed.

Table SC6.4.3.12.1 provides a checklist of items for submission at the MCU/ROL stage.

Additional plans/reports may be required to meet necessary state legislation requirements due to the proposed works, or other requirements of the Townsville City Plan.

(b) Operational works applications

Following approval from council and other relevant government agencies of concepts submitted as part of the ROL/MCU application, detailed design documents will be required for operational works approval. Detailed design documents shall be in both graphic and written form and contain sufficient information to enable council to assess compliance with the applicable codes.

The detailed design submission for operational works approval must include:

- (i) constructed lake detail design report (updated from the ROL/MCU submission);
- (ii) construction drawings – civil/landscape;
- (iii) constructed lake technical specifications;

- (iv) soil erosion sediment control plan;
- (v) constructed lake monitoring plan (updated from the ROL/MCU submission);
- (vi) constructed lake maintenance plan (updated from the ROL/MCU submission);
- (vii) groundwater assessment and management plan (updated from the ROL/MCU submission); and
- (viii) acid sulfate soils management plan, where required, and generally in accordance with the relevant State Planning Policy and its referenced documents.

Editor's note—additional reports/plans may be required to meet necessary regulatory and/or Townsville City Plan requirements due to the proposed works.

(2) Construction

Construction can only commence following operational works approval. Works are to be carried out in accordance with the approved drawings and specifications and any associated management plans as a result of the development assessment process.

(3) Constructed lake landscape plan

A constructed lake landscape plan is required at the ROL/MCU stage and is to be refined as part of the operational works submission in consultation with council.

Constructed lakes will most likely be included in developments to provide a high amenity focal point for residents. The lake designs should aim to enhance biodiversity through re-vegetation and establishing linkages with existing vegetation communities, public interaction and education.

Landscape plans are to be provided and prepared by a suitably qualified landscape architect/designer, registered with AILA.

The landscape plan should demonstrate that the lake blends into surrounding environment (built and natural) and protects and enhances natural features such as significant trees and existing aquatic habitats (i.e. streams, billabongs, freshwater wetlands, saltmarshes). Landscape designs are to consider the principles of crime prevention through environmental design (CPTED).

At the ROL/MCU stage plans are to be developed that show:

- (a) existing ground levels;
- (b) the proposed lake footprint with respect to the development;
- (c) road and lot layout;
- (d) existing and retained vegetation;
- (e) natural features and receiving environments;
- (f) edge batter treatments including provision for irrigation where applicable;
- (g) proposed lake operating levels (dry, normal and wet) and base levels;
- (h) topsoiling and lining;
- (i) adjacent levels including roads, property boundaries and floor levels;
- (j) setbacks, buffers and landscaping;
- (k) accesses;
- (l) inlets and outlets including treatments to minimise visual impact;
- (m) activities to be carried out in the area adjacent to the lakes e.g. parks and car parks;
- (n) photographs showing examples of design intent and character;
- (o) educational opportunities such as signage and public art; and
- (p) highest astronomical tide and 50 year flood levels.



Figure SC6.4.3.12.1 Example of a lake landscape plan

Constructed lake landscape plans are to be updated as part of the operational works submission, including planting details (refer to SC6.4.3.12.5(12) Step 12), landscape surface treatment plans, landscape details and specifications. The use of endemic plant species is to be encouraged.

Landscape design can play an important role in overcoming negative community perceptions to certain lake treatments such as tree plantings where residents in the past have deliberately removed trees and shrubs due to concerns with pests. Signage explaining the function of each element in the overall design can help educate local residents.

(4) Constructed lake recreation plan

A constructed lake recreation plan is required at the ROL/MCU stage and is to be refined as part of the operational works submission in consultation with council.

A recreational management plan is to be developed by a suitable qualified landscape architect/designer registered with AILA in association with a recreational consultant and must include details on proposed activities including pedestrian movement and signage.

Lakes designs should provide enhanced landscape aesthetic and amenity for surrounding residents through the installation of improved passive recreation facilities such as paths, trails, viewing platforms, picnic and playground nodes. Lake recreational areas are to be designed so that they are available to all groups of the population, i.e. it should consider all abilities. The lake design and associated parklands must be:

- (a) consistent with the area's social and recreational master plans; and
- (b) cognisant with local planning and other issues.

Designs should also be mindful of the amount of space a proposed lake will take and how this will impact on other recreational activities to ensure a balance land use outcome. Consideration should also be made to other amenity values such as shade, character and multi-use.

Linkages between the lake and recreational master plans are also to be provided (e.g. footpaths, cycleways, etc.).

(5) Constructed lake monitoring plan

A constructed lake monitoring plan is required at the ROL/MCU stage and is to be refined as part of the operational works submission. The monitoring plan is to set out the testing schedule and frequency for monitoring lake health. Water quality monitoring will be critical in assessing the on-going performance of the lake and provide the basis for remedial and adaptive management activities. Costs associated with monitoring must be included in the life cycle costing (SC6.4.3.12.5(18) Step 18) and must be separated from other costs.

The proponent will be required to develop a water quality strategy including water quality objectives to maintain environmental values of the lake, receiving waters and ground water, where applicable. Water quality objectives will be required to be derived for local conditions in accordance with the *Queensland Water Quality Guidelines 2009*. When deriving suitable values for the water quality strategy the proponent must take into consideration local water quality values of source and receiving waters, together with local aquifer water quality, if applicable.

A summary of all water quality results will also be required for handover purposes. Council will not consider handover until all monitoring results and reports are received.

Minimum monitoring requirements

- (a) weekly in-situ testing using a multi-probe for pH, turbidity, DO, temperature and EC at 0.5 m depth intervals from surface to lake bed at the lake inlet and outlet;
- (b) weekly laboratory testing (NATA approved) for algal counts, TN and TP. Surface samples at the inlet and outlet are required;
- (c) weekly measurements of lake water level;
- (d) monthly laboratory testing (NATA approved) for E.coli, TSS, turbidity, NH₃, TKN, Nitrate/Nitrite, TN, TP, FRP, Al (soluble). Surface samples at the inlet and outlet are required;
- (e) trapping of adult mosquitoes at the lake site (weekly during the wet season from the on-set of the first wet season rains, fortnightly to monthly other times);
- (f) larval surveys from shallow flooded vegetated areas around the lake (weekly during the wet season from the on-set of the first wet season rains, fortnightly to monthly other times);
- (g) fortnightly water level and EC measurements of groundwater from installed monitoring wells (where shallow groundwater is observed); and
- (h) annual bathymetry of lake bed to determine sediment accumulation.

Reporting

Quarterly reports are to be submitted to council summarising the water quality monitoring results. The reports shall also include summaries of local climatic conditions, including daily rainfall and shall also include any observations made during the period (e.g. visual water quality, odours, algal biomass, fish kills etc.). Copies of lab testing results are to be included in an appendix to the report. Water quality exceedences (considering trigger values derived to maintain environmental values of the lake, receiving water body and groundwater, if applicable) are to be clearly identified. The reports shall also detail any corrective measures that may have been taken.

Quarterly reports are to be submitted within 1 month of the last monitoring event in the quarter.

An annual report will be required to assess the overall performance of the lake based on the monitored and observed data throughout the monitoring period. The report should detail performance with respect to the intended design and actions taken to meet the intended performance.

Corrective actions and adaptive management

Table SC6.4.3.12.2 provides indicative target values for lake health relevant for Townsville for the range of physico-chemical indicators to be tested on a weekly basis. The values have been derived from the *Queensland Water Quality Guidelines* and are provided for guidance only.

The proponent must derive local water quality objectives in accordance with the procedures outlined in the

Queensland Water Quality Guidelines (DERM, 2009). This will involve definition of the water type, selection of indicators, selection of reference sites, collection of reference data and derivation of guideline values based on the reference data.

Parameter	Freshwater	Mid-Upper Estuarine
pH	6.5 - 8.0	7.0 - 8.4
DO	>6 mg/L	>6 mg/L
TDS	<1,000 mg/L	>15,000 mg/L
TN	0.35 mg/L	0.3 – 0.4 mg/L
TP	0.01 mg/L	0.025 – 0.04 mg/L
Turbidity	1 - 20 NTU	8 - 25 NTU
Chl-a	5 ug/L	4- 10 ug/L

Table SC6.4.3.12.2 Suggested target values for physico-chemical indicators.

Table SC6.4.3.12.3 provides target values for the management of cyanobacteria (blue green algae) and mosquitoes. The presence of cyanobacteria can present a significant hazard to lake users. The values for cyanobacteria have been derived from the *Guidelines for Managing Risks in Recreational Water*.

Parameter	Freshwater lake	Saline lake
Cyanobacteria	≤500 cells/mL <i>Microcystis aeruginosa</i> or biovolume equivalent ≤0.04 mm ³ /mL combined total of all cyanobacteria	Refer to guidance provided in the 'Guidelines for Managing Risks in Recreational Water' (National Health and Medical Research Council, 2008)
Mosquito larvae	1 larvae per 2 ladle dips (300mL ladle)	1 larvae per 2 ladle dips (300mL ladle)

Table SC6.4.3.12.3 Suggested target values for cyanobacteria and mosquito populations.

Where weekly testing indicates values above derived water quality objectives or biological indicators, corrective actions are to be taken as soon as possible. Exceedance or other lake health issues such as fish kills and odour problems shall be reported immediately to council and the Department of Environment and Heritage Protection (EHP). The source of the exceedance should be identified as soon as possible.

Typical corrective actions include:

- contacting council and EHP as soon as an exceedance is identified;
- identifying the cause of the water quality or biological indicator problem. This includes reviewing monitoring and operational data, climatic data, upstream sources, internal lake processes etc. Discussions with designers, council/EHP may be required to gain a better understanding of the problem and determine possible actions;
- increasing the frequency of monitoring of parameters of concern;
- minimising potential impacts to downstream receiving environments e.g. temporarily block outlets; and
- undertaking remedial action on items identified as potential sources e.g. upstream water quality improvement devices.

An important component of the monitoring plan will be the adaptive management strategies to be developed for algal blooms and mosquito outbreaks. The following provides guidance on suitable adaptive management strategies for a adaptive management of algal blooms and adaptive management of mosquito outbreaks.

Adaptive management of algal blooms

Design of lakes in Townsville must include an algal management strategy as defined in SC6.4.2.12.5(8) Step 8. The algal management strategy is intended as a proactive response and not a reactive response to cyanobacterial blooms.

When a cyanobacterial bloom occurs in a freshwater lake, it will be necessary to follow the recommended actions detailed in the *Queensland Water Quality Guidelines*. For algal blooms in saline lakes, refer to the algal guidelines for coastal and estuarine waters in the *Guidelines for Managing Risks in Recreational Waters*.

Adaptive management of mosquito outbreaks

Larval counts of 1 per 2 ladles (300 mL ladle) are indicative of possible mosquito problems for adjacent residents (Warchot and Whelan, 2008), however resident complaints or significant numbers of mosquitoes in adult trapping may also be cause for mosquito control.

Where mosquito problems are encountered a number of actions can be followed:

- identifying the source and cause of the breeding;
- rectification of surface depressions that may lead to isolated pools;
- clearing collected debris that may be in and around the lake;
- draining areas identified with large mosquito breeding;
- ensuring suitable native fish species are present in the lake; and
- use of a suitable insecticide/larvicides.

Use of insecticides can quickly control mosquito breeding, but is not recommended as a long term strategy due to potential issues with insecticide resistance, long term cost of maintaining a mosquito control program and the possibility of the insecticide applications not being able to target all areas of breeding (Warchot and Whelan, 2008).

Ecologically friendly insecticides include (Whelan and Warchot, 2008):

- *Bacillus thuringiensis* var. *Israelensis*;
- *Bacillus sphaericus*; and
- Methoprene.

(6) Constructed lake maintenance plans

A constructed lake maintenance plan is required at the ROL/MCU stage and is to be refined as part of the operational works submission in consultation with council. A final approved constructed lake maintenance plan will be required prior to asset handover.

The constructed lake maintenance plan shall be a living document that can be updated should there be any changes during construction. The plan must include all expected maintenance associated with the constructed lake and associated infrastructure such as pumps, recirculating wetland and landscape treatments.

The maintenance plan is intended to ensure that the lake functions as intended and is not prone to weed

infestations or decreased amenity values. The maintenance plan must clearly set out:

- (a) expected maintenance activities;
- (b) frequencies;
- (c) roles and responsibilities;
- (d) maintenance procedures;
- (e) equipment requirements;
- (f) product specifications;
- (g) occupational health and safety;
- (h) public safety;
- (i) environmental protection;
- (j) disposal;
- (k) accesses;
- (l) emergency responses; and
- (m) notification requirements.

Maintenance forms must be developed as part of the plan and filled in and stored during inspections and maintenance.

The costs of expected maintenance activities must be included in life cycle costing (SC6.4.2.12.5(18) Step18), and must be separated from other costs. The maintenance plan will need to consider lake monitoring and adaptive management to ensure maintenance responses to monitoring exceedences.

The maintenance plan must clearly describe activities required during establishment, defects liability period and those following asset handover. Intensive maintenance will most likely be required during the first few years during lake and plant establishment. This is also the time when the lake is most vulnerable to sediment loads from construction activities. Design drawings are to be included as part of the maintenance plan.

The maintenance plan must consider lake accesses as detailed in SC6.4.2.12.5(14) Step 14, and maintenance draining as outlined in SC6.4.2.12.5(10) Step 10.

Typical maintenance actions include:

- routine inspections of the lake for vegetation health, weed infestations, scour, litter and debris and mosquitoes;
- routine inspection of inlets and outlets for sediment build up, scour, litter and blockages;
- removal of litter and debris;
- removal and management of invasive weeds;
- periodic de-silting;
- replacement of plants that are damaged or have died with equivalent plants;
- regular irrigation of plants during establishment;
- repairs due to vandalism; and
- mosquito control including repair to lake edges to prevent the formation of isolated pools.

Inspections for removal of debris should be done regularly and removed whenever observed. Scour around the inlets and outlets should be checked following large storm events.

Construction drawings

All drawings submitted to council for approval shall be prepared by a suitably qualified person and shall conform to the standards detailed in SC6.4.2.5 Details on drawings.

Annual lake bathymetry surveys are to be provided to council with estimates of sediment accumulation from the original constructed levels.

As constructed plans are to be provided following handover to council either as an annotated set of the original plans (where variations to the original design are minor) or otherwise as a new site survey.

(7) Constructed lake technical specification

The technical specification shall clearly set out the scope of the works, roles and responsibilities, certification and sign-off and construction hold points. The specifications shall be in accordance with the construction plans and provide flexibility to allow additional field investigation and design modification due to unexpected conditions encountered during construction

(8) Soil erosion management plan

A soil erosion management plan shall clearly identify measures to manage erosion and sediment control during construction and be guided by principles set out in:

- *Best Practice Erosion and Sediment Control*; and
- *Erosion and Sediment Control – A Field Guide for Construction Site Managers*.

The soil erosion management plan shall include:

- (a) project and site description (topography, drainage, soils, rainfall);
- (b) potential impacts from construction activities including a risk assessment;
- (c) soil management measures including a plan showing proposed measures; and
- (d) responsibilities, monitoring and maintenance.

The plan must also detail contingencies in the event of unplanned discharges including remediation.

The plan should be a living document that can be modified if site conditions change or if the adopted measures fail to perform as expected.

(9) Soil and groundwater assessment and management plan

A soil and groundwater assessment management plan is required at the ROL/MCU stage and is to be refined as part of the operational works submission. This will be an update from the concept design phase in consultation with council and shall include assessment of any additional soil and groundwater information gained since the concept design stage. Refer to SC6.4.3.12.5(3) Step 3. The soil and groundwater assessment plan should include:

- (a) site description including local soil and groundwater characteristics;
- (b) field investigation work including any test pitting, monitoring well installation etc.;
- (c) laboratory testing and interpretation;
- (d) monitoring data and interpretation;
- (e) assessment of acid sulfate potential;
- (f) identification of problematic soils e.g. sodicity, dispersive soils, peats etc.;
- (g) assessment of the shallow groundwater regime, if present; and
- (h) groundwater risks and management options

(10) Acid sulfate management plan

When an acid sulfate management plan is deemed necessary, the plan should clearly identify the risk of contamination to the environment and measures to manage the risk. The plan must detail:

- (a) construction sequences;
- (b) impacts of dewatering;
- (c) liming requirements;

- (d) exposure of materials;
- (e) monitoring requirements;
- (f) action plans for unplanned acidification of ground or surface waters; and
- (g) responsibilities, reporting and auditing.

(11) Maintenance and handover

- (a) Necessary maintenance will be defined in the maintenance plans provided during the ROL/MCU submission and updated during the operational works approval stage. Updates may be required should the designs change during construction and may require the approval of council.

For the purposes of maintenance and the handover, a constructed lake is deemed to include the lake open water body and edge treatments. The limits of each are defined below:

- (i) lake water body: all areas to wet season normal water level; and
- (ii) edge treatments: all areas from lake wet season normal water level to the edge of the buffer zone (see below).

The lake buffer zone is considered necessary to provide sufficient width to allow maintenance activities (including access by machinery) to be undertaken to all areas of the lake, provide a passage for fauna and provide water quality buffering for untreated overflows entering the lake. A minimum width of 25 m is suggested. Where the proponent proposes a reduced width they must clearly demonstrate that the width is sufficient to maintain the aforementioned functional requirements of this edge treatment.

The proponent is also responsible for any rectification works on areas outside of the constructed lake should the operation of the lake negatively impact on outside areas.

- (b) Defects liability period

The defects liability period for the lake water body and edge treatments will commence following practical completion and continue for at least:

- (i) 5 years after 90% of all houses are constructed within the lake stormwater catchment, provided the lake is constructed, established and functioning at plan sealing; or
- (ii) 5 years after the lake is constructed, established and functioning where the lake is not directly fed from stormwater runoff.

Prior to establishing the lake system, the lake shall be drained and de-silted, where necessary, to establish the lake system as per the detail design.

- (c) Handover

At the completion of the defects liability period, a handover meeting will be scheduled between the developer (or representative), maintenance personnel and council.

The council may engage an independent auditor to assess handover and is under no obligation to accept the asset if it does not meet the performance requirements as described in the constructed lake conceptual design report, detailed design report and this sub-section.

Council will only accept the lake once the lake is demonstrated to meet the performance requirements as detailed in the design reports and monitoring plans. The council will require demonstration through a minimum of 5 years of continuous monitoring data (as defined in the monitoring plan) on the performance of the lake system.

Council will require a final survey of the lake floor prior to handover. Where sediment accumulation is in excess of that anticipated the proponent will be required to drain and de-silt the lake and re-establish the lake as per the design. Handover cannot occur until the re-established lake performance is demonstrated over a continuous 5 year period.

As constructed plans are to be provided following handover to council either as an annotated set of the original plans (where variations to the original design are minor) or otherwise as a new site survey.

SC6.4.3.12.4 Lake health considerations

- (1) A constructed lake is an artificial body of permanent water with either an edge fringed with emergent macrophytes or a hard edge. While submerged macrophytes may occur throughout the water column, the dominant feature is open water (typically at least 30% of the total area).

Urban runoff entering a constructed lake must have sufficient treatment.

For the Townsville region this includes load reduction from the urban runoff component of:

- 80% reduction in total suspended solids;
- 65% reduction in total phosphorous;
- 40% reduction in total nitrogen; and
- 90% reduction in gross pollutants.

The design of constructed lakes needs to consider the complex behaviour, in particular, the alternate states that lakes can operate under depending on a number of influences and stressors.

Key factors affecting lake health:

- (a) nutrients;
- (b) light and turbidity;
- (c) organic carbon loads;
- (d) lake detention time;
- (e) salinity;
- (f) water level and depth;
- (g) mixing; and
- (h) temperature.

The designer must also be aware that constructed lakes are community assets and issues such as pest and weed control and integration into the overall landscape design should be considered at the concept design and planning stage.

- (2) Lake conceptual model – alternate states

The conceptual model of how lakes transition between alternate states is presented in Figure SC6.4.3.12.2.

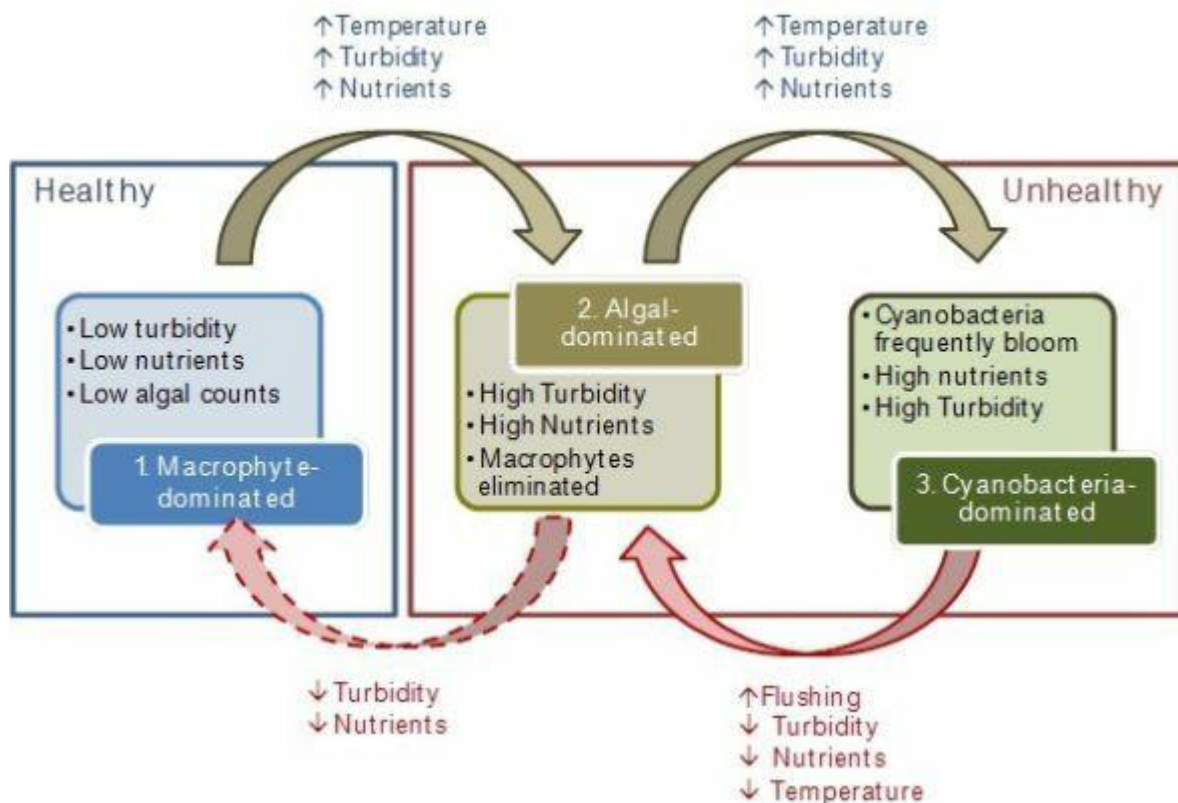


Figure SC6.4.3.12.2 Conceptual model of the alternative states observed in shallow lakes

The alternate states model considers that freshwater shallow lakes may exist as (after Moss, 1998):

- a macrophyte dominated state with clear water; or
- a turbid state dominated by phytoplankton; or
- a cyanobacterial (blue-green algae) dominated state

The key driving mechanisms between each of the alternative states are nutrient levels and turbidity. The switch between the alternative states is typically triggered by the exceedance of a critical turbidity threshold. The critical turbidity thresholds required to trigger a switch from one state to another are likely to differ between lake systems and are also influenced by other environmental factors, such as lake detention times and temperature (Scheffer, 1998). Figure SC6.4.3.12.3 (below) illustrates the switch between alternative states.

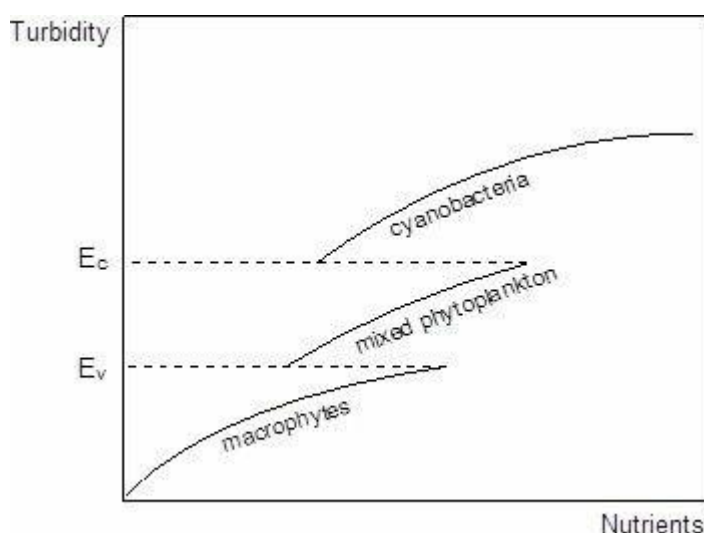


Figure SC6.4.3.12.3 Switch between alternative states

(a) Macrophyte dominated lake

A healthy lake is typically dominated by macrophytes (emergent and submerged water plants).

Macrophyte dominated lakes help maintain low turbidity via the uptake of nutrients, prevention of re-suspension of sediments and provision of refugia for zooplankton against predators (Scheffer, 2001).

Macrophyte dominated lakes are reasonably robust to increased nutrient loads, which allows the macrophyte biomass to increase and thereby maintain low turbidity (Scheffer et al., 2001) i.e. the macrophyte dominated system provides positive feedback to increases in nutrients, enhancing their own growing conditions (Scheffer et al, 2001).

(b) Macrophyte to Phytoplankton state

High nutrient concentrations can lead to an increase in phytoplankton biomass and biofilm growth on the macrophytes, leading to increased turbidity and decreased light penetration which can cause a rapid collapse of the macrophyte community (Scheffer, 2001).

The switch to a phytoplankton state is considered problematic with regards to lake health as this state inhibits the growth of macrophytes (mainly due to low light penetration) and maintains high turbidity levels. Once a lake has switched to a phytoplankton dominated state, restorative efforts to reduce turbidity and re-establish macrophyte communities are extremely difficult.

(c) Phytoplankton to Cynobacteria state

The switch from a phytoplankton dominated state to a Cynobacterial dominated state is generally triggered in response to increased turbidity and water temperatures (Scheffer, 1998). Whilst both Cyanobacterial and phytoplankton (non-Cyanobacterial) communities may dominate over a range of nutrient concentrations, a critical turbidity level exists above which the Cynobacteria will become dominant (refer to Figure SC6.4.3.12.4).

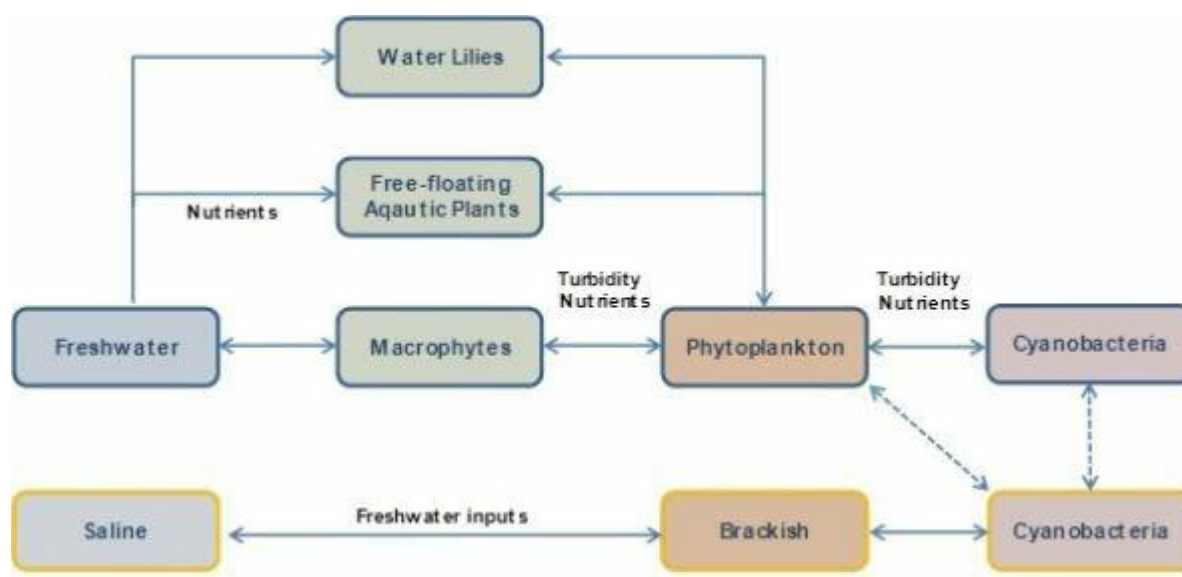


Figure SC6.4.3.12.4 Fresh and saline lakes alternate states

In saline lakes, alternate states are triggered by freshwater inputs, which result in brackish lakes that are highly susceptible to Cyanobacteria blooms. Brackish lakes do not tend to develop a phytoplankton state in response to freshwater inputs, unless salinity levels are reduced to fresh water levels (i.e. 1,000 mg/L TDS salinity or less).

(3) Factors affecting lake health

The following section relates to freshwater lakes, where algal management can be difficult to achieve in Townsville.

Saline lakes are generally less susceptible to algal blooms, although marine species of algae do exist. Saline lakes are less likely to experience aquatic weed infestations and seasonal water level variations are less problematic to manage.

(a) Nutrients

Nutrients of concern for urban lake health include nitrogen, phosphorous and trace metals. Nutrients (particulate and soluble) are typically delivered to lakes through stormwater runoff. Nutrients may also be delivered to lakes via in-situ soils, breakdown of organic matter and groundwater processes. Other site conditions such as perched water tables and waterlogged areas (e.g. where anaerobic condition exists) can also promote the formation of nutrients into bio-available forms.

Particulate nutrients associated with suspended solids will typically settle to the bottom of lakes and provide a reservoir of nutrients, which can be released back to the water column under appropriate conditions, whereas soluble inorganic nutrients are readily bio-available to phytoplankton.

High nutrient levels also favour growth of aquatic weeds such as *Salvinia* (*Salvinia molesta*), Water hyacinth (*Eichhornia crassipes*) and Water lettuce (*Pistia stratiotes*) and other floating species such as native and introduced water lillies. These floating species provide a continual source of organic matter (carbon) to lake sediments. The decomposition of organic matter can deplete oxygen within the lake water column and sediments, resulting in the release of soluble nutrients back to the water column which is then available for phytoplankton and Cyanobacterial growth. Depletion of oxygen and/or the development of Cyanobacterial blooms can also lead to fish kills, animal death and a risk to public health.

Many Cyanobacteria species are able to obtain nitrogen from the atmosphere, thus nutrient management in lakes typically focuses on phosphorous.

Note—guidance on suitable treatments is included in SC6.4.3.9 Water sensitive urban design guidelines. Areas close to the coast or water draining to the coast can be more susceptible to nutrient hazards. Regional hazard maps can be used to identify potential areas of concern where more detailed mapping and investigation (e.g. soil and groundwater analysis) can occur.

(b) Light and turbidity

Light penetration and turbidity are important factors that trigger switches between alternate states, as described earlier. Recent studies (Scheffer et al., 1997) have shown that the abundance of Cyanobacteria is more highly correlated to underwater light conditions than to phosphorous concentrations. In shallow lakes, the probability that Cyanobacteria will dominate the algal community will depend strongly upon diminishing light levels attributed to increases in turbidity (Scheffer, 1998). Increases in Cyanobacterial biomass therefore provides a positive feedback, further favouring the development of Cyanobacterial blooms.

Note—macrophyte dominated lakes help to maintain low turbidity, as well as providing a mechanism for nutrient uptake. This reduces the opportunity for phytoplankton or Cyanobacterial dominated states which are characterised by high turbidity. Submerged and emergent macrophytes should be encouraged, and floating aquatic plants which contribute to shading and organic carbon loads discouraged. In Townsville, constructed lake depths are limited to 3 m below wet season normal water level, which should encourage light penetration and establishment of submerged plants.

(c) Organic carbon loads

The primary source of organic carbon in urban lakes is typically from leaf litter in stormwater runoff, floating aquatic plants and emergent and submerged macrophytes when within the lake when they decompose. Floating aquatic plants provide a highly bio-available carbon source as they tend to have soft and non-fibrous tissues. Aerobic decomposition of accumulated organic loads at lake beds result in a depletion of oxygen and can cause anaerobic conditions (depending on the amount of organic load available). In situations where organic material is still available under anaerobic conditions, anaerobic bacterial activity can lead to the release of highly bio-available nutrients back to the water column (Lawrence and Breen, 1998). This can result in subsequent algal blooms and poor water quality.

Note—minimise the input of leaf litter into urban lakes through upstream treatment measures. Avoid floating aquatic plants where possible. Creating lake edges that encourage emergent macrophytes will inhibit the establishment of floating attached plants such as water lilies, which tend to grow from lake edges to the centre.

Floating aquatic weeds such as *Salvinia molesta* are more difficult to manage. Maintaining low lake nutrient levels will minimise proliferation. This includes the provision of submerged macrophytes, which maintain oxygen to lake sediments, reducing opportunities for nutrients to be available for floating plants and phytoplankton.

The lake design should provide suitable access to the lake water body for removal of floating aquatic weeds by mechanical harvesters. A minimum water depth of 1.5 m should be provided for harvesting equipment. Suitable access must also be provided heavy machinery to manoeuvre when collecting the weed and debris.

(d) Lake detention times

Lake detention time plays an important role in managing lake algal biomass and thus reducing the risk of Cyanobacterial growth. Lake detention time, simply put, is the time it takes for the entire lake volume to be displaced via inflows to the lake. Generally there are two ways in which lake water is displaced, either via episodic events that displace the entire lake volume (washout) or from constant inflows (flushing).

Algal growth rates are dependent on nutrients, light, temperature and hydrologic conditions. Algal population growth can occur rapidly, and algal bloom concentrations may develop within weeks. It is possible to manage the formation of algal blooms by removing algal biomass from lake systems via the manipulation of lake detention times.

In Townsville, urban lakes that rely on catchment inflows will typically experience long detention times (>100 days) during the dry season, significantly longer than the time required for algal populations to reach bloom concentrations. Probabilistic approaches, such as those used in Brisbane and Mackay (20 percentile detention time for a constructed lake should not exceed 20 days), are not particularly relevant for Townsville conditions, as these conditions cannot be demonstrated to be achieved on average, regardless of catchment to lake size, unless alternative sources of top up water are available.

Algal management is thus a key design consideration for urban lakes reliant on catchment inflows in Townsville. A number of options are available to the designer including a flushing and/or recirculation strategy. These are discussed in more detail in SC6.4.3.12.15(8) Step 8 – Algal management and SC6.4.3.12 Attachment A Alternative Strategies for Managing Cyanobacterial Growth.

During the short wet season, lake detention times are significantly shorter and the risk of algal blooms are less, although the potential still exists during summer drought conditions.

Note—where possible the designer should consider saline lakes with tidal flushes or consider alternative options to freshwater lakes such as constructed wetlands. Where freshwater lakes are proposed, a suitable algal management strategy will be a key design consideration. Lake depths should also be minimised where possible (preferably between 1.5 and 2.5 m) to reduce any necessary pumping requirements for recirculation.

(e) Salinity

Cyanobacteria dominance is highly sensitive to changes in salinity (Paerl, 1988). Brackish lakes are often dominated by Cyanobacteria due to the tolerance of many Cyanobacterial species to low salinity. Saline lakes subject to freshwater inflows, particularly during the wet season, are thus highly susceptible to Cyanobacteria blooms. In Townsville, brackish lakes (1,000 to 15,000 mg/L TDS), or saline lakes with freshwater inputs should be avoided.

Note—avoid brackish lakes or brackish conditions that may occur in lakes (e.g. saline lakes subjected to large freshwater inflows). Preference is for lakes to permanently operate as either saline (>15,000 mg/L TDS) or fresh (<1,000 mg/L TDS) at all times.

(f) Water level and depth

Lake water level variation and depth play an important role in maintaining macrophyte dominance, and thus resistance to algal blooms. Shallow lakes (<3 m) are more favourable to macrophyte growth, where light penetration is higher and conditions suitable for macrophyte reproduction and establishment. Shallow lakes will typically have a higher threshold turbidity level before switching to a phytoplankton

state (Scheffer, 1998), and therefore have more resistance to increased turbidity and nutrient levels.

Shallow lake depths (<3 m) are also less prone to stratification and subsequent problems associated with the release of nutrients from anaerobic sediments.

Water level variation due to evaporation in Townsville can be greater than 1 m in lakes reliant on catchment inflows. This has direct implications for the health and survival of edge treatments such as emergent macrophytes, which help to reduce the proliferation of floating aquatic plants and ingress of weeds, and thus play an important role in managing the health of urban lakes.

Alternately, saline lake edge treatments such as salt couch are highly sensitive to water level variations and do not survive well when exposed to extended periods of inundation.

Note—lake depths from normal wet season operating levels to finished bed level are limited to 3 m in Townsville, but preferably in the range of 2.0 to 2.5 m. A suitable impervious base (e.g. compacted clay liner) should be provided to minimise seepage losses for lakes reliant on catchment inflows. Lake edge treatments should be such that the width of the exposed batter due to water level variations is minimised. Within the zone of water level variation edge batters at 1V:3H are preferred.

For saline lakes water level variations should be minimised as far as possible, preferable to less than 0.3 m. Salt couch edge treatments are particularly sensitive to long periods of inundation.

(g) Mixing

Mixing and turbulence within lake systems limits the formation and accumulation of Cyanobacterial blooms (Wagner-Lotkowska, 2004). Well mixed conditions can be achieved by ensuring good hydraulic efficiency, shallow lakes (<3 m), maximising wind induced turbulence and providing lake flushing. Mixing can also be accomplished by mechanical means including aerators, mechanical mixers and internal recirculation.

Note—lake configurations should provide length to width ratios of 3L:1W or greater. Inlets and outlets should be at opposite ends of the lake. Dead end zones or square edges are to be avoided.

Where possible, align lakes in the direction of the prevailing winds to maximise wind induced turbulence. The prevailing wind for Townsville during the critical winter dry season is south easterly. The base of the lake should be flat to promote even wind mixing. Isolated deep pockets should be avoided.

(h) Weed control

Weed infestation is a major problem in the dry tropics and has been observed to be a significant maintenance burden for existing lakes in the Townsville area. To maintain amenity and minimise on-going maintenance the proponent must detail specific actions (design and management) to address potential weed ingress, both terrestrial and aquatic. Aquatic weed problems are mainly associated with fresh water lakes in the Townsville region and the following design notes are primarily related to weed control in fresh water lakes.

Note—provide a densely vegetated perennial lake edge to create a barrier for weed ingress. This vegetative barrier must be designed so as to be capable of surviving expected water level variations. This may include the provision of irrigation during the dry season.

Include submerged macrophytes to fresh water lakes, to maintain oxygen to lake sediments, thus minimising the opportunities for highly bio-available nutrients to be released and available for floating plants.

Minimise nutrient and organic loads to the lake.

Avoid the inclusion of floating aquatic vegetation (e.g. water lilies) that can contribute to organic loads to the lake, thus supporting weed infestations such as *Salvinia*, *Water hyacinth* and *Water lettuce*.

Provide suitable access for prompt removal of terrestrial and aquatic weeds.



Figure SC6.4.3.12.5 Examples of aquatic weeds - *Salvinia* (L) and Water Lettuce (R)



Figure SC6.4.3.12.6 Example of water lilies (L) and weed infestation at a lake edge (R)

SC6.4.3.12.5 Constructed lakes design steps

These guidelines are a step by step outline to support development applications where involving reconfiguring a lot (ROL) or material change of use (MCU), where a proposed development includes a lake, and subsequent Operational Works requirements. Council will require considerable detail at the ROL/MCU stage to fully assess the merits of proposed lake. This includes field investigations to characterise the soils and groundwater at the proposed site.

(1) Step 1: Design intent

The primary intent for the lake is to be clearly defined. The design intent must be accompanied by concept plans showing location and layout with respect to the development as well as existing vegetation and receiving environments. The principles in SC6.4.3.12.1(3) include constructed lake uses preferred by council.

(2) Step 2: Determine lake type

(a) Saline lake

In Townsville, due to the extended dry season, the preferred constructed lake with regards to long term sustainability, weed and water level management is a saline lake, where possible. Although less diverse than fresh water lakes, the operation of saline lakes are considered more robust for Townsville conditions. Saline lakes should not be configured to receive fresh water inflows as this can result in brackish conditions which are highly susceptible to the development of Cyanobacterial blooms. This can include stormwater runoff or pumped fresher inputs during the wet season where the source water is from estuaries. The proposed method of inflow, control and water level management must also be stated. Refer to SC6.4.3.12.5(4) Step 4 (e.g. pumped or gravity control).

(b) Fresh water lake

Where fresh water lakes are proposed, the proponent should consider other alternatives such as heavily vegetated constructed wetland systems which can provide open water views and water treatment benefits (refer to SC6.4.3.9 Water sensitive urban design guidelines).

In the case that a fresh water lake is decided upon, the proponent must demonstrate that the lake is configured to receive treated stormwater inflows only (as per the requirements of SC6.4.3.9 Water

sensitive urban design guidelines). Untreated overflows should by-pass constructed fresh water lakes. A separate Stormwater quality management plan (SQMP) must be submitted detailing upstream water quality devices and expected improvements via MUSIC modelling.

Editor's note—SC6.4.3.8 Stormwater quality management plans for development provides guidance to applicants on the preparation of SQMPs, including the use of MUSIC modelling.

The proponent must also clearly demonstrate how water level variations will be managed and proposed alternative sources of water to maintain lake water levels within acceptable variations (refer to SC6.4.2.12.15(7) Step 7).

(c) Brackish lakes

Brackish lakes should be avoided in Townsville. Freshwater Cyanobacteria are particularly responsive to changes in salinity, often resulting in dramatic alterations in dominance (Paerl, 1988). Brackish lakes are often dominated by Cyanobacteria due to the tolerance of many Cyanobacterial species to low salinity.

(3) Step 3 – Site soil and groundwater assessment

A soil and groundwater assessment will be required to characterise local soil and groundwater and demonstrate that the proposed lake will not negatively impact on the local groundwater (considering seasonal fluctuations) and avoids problematic soil areas (e.g. high organic contents, peats, sodic soils).

Where contaminated sites are identified, thorough soil and groundwater assessments will be required and remediation plans developed. Groundwater modelling will also be required to demonstrate that proposed lakes do not or are not negatively impacted by adjacent contaminated sites. Specialist geotechnical/hydrogeological advice will be required to assess risks and develop remediation plans.

A site and soil evaluation must be undertaken in accordance with AS/NZS 1547. Field investigations and laboratory testing are required to sufficiently classify soils, determine the requirements for lining, identify possible PASS and sodicity issues and seasonal groundwater fluctuations. More detailed investigations such as Acid sulfate soils testing will be required in the detailed design stage, if deemed necessary.

Editor's note—Part 9.4.2 Healthy waters code sets out requirements for acid sulfate soils, including the reporting and management requirements to be achieved.

Installation of a series of shallow groundwater wells will be required to sufficiently characterise the shallow groundwater regime (if this occurs) and possible groundwater related impacts and risks due to the proposed lake. Monitoring of water levels at fortnightly intervals over a continuous full dry and wet season will be required as a minimum to support the lake design. The monitoring wells will be required to be available following the lake construction for monitoring purposes, and should be provided with lockable standpipes. A typical shallow monitoring well is indicated in Figure SC6.4.3.12.7 below.

Soil and groundwater investigations must identify potential risks and possible management options and further testing and monitoring required. This also includes assessments on nutrient hazard, which will require soil and groundwater nutrient characterisation. Other site conditions such as perched water tables, waterlogged areas where anaerobic condition exists are to be identified as these can promote the formation of nutrients into bio-available forms.

Additional design and investigation may be required during the detail design stage to manage identified risks.

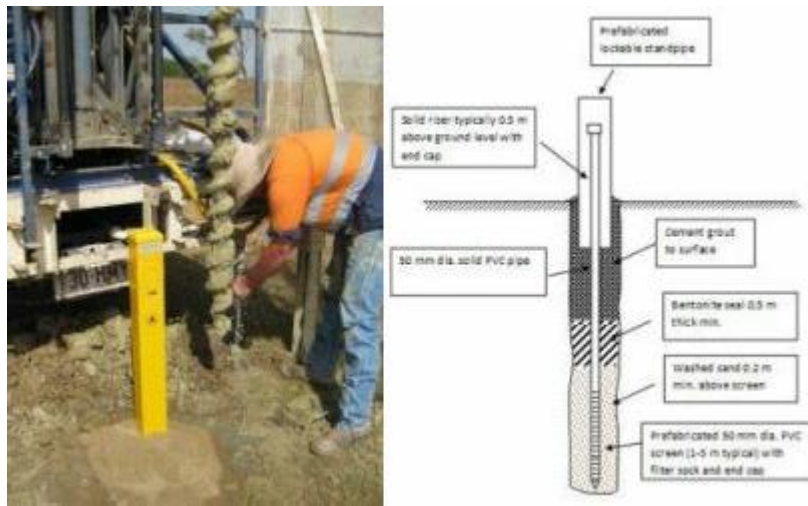


Figure SC6.4.3.12.7 Typical monitoring well installation

(4) Step 4 – Lake inflows and outflows

- (a) Lake inflows will depend on the type of lake proposed. Inflows to fresh water lakes will be governed by catchment dependent stormwater runoff. As the source of inflow is typically limited to urban runoff entering the lake, water level variations of one metre or more could be expected throughout the year.

Saline lakes typically have a constant source of water available, and as such water level variations will depend on the configuration of inlets and outlets in such cases. For example water level fluctuations can be maintained constant throughout the year with pumped delivery.

Whether designing saline or fresh water lakes, inlets and outlets must be configured to maintain the intended operation of the lake as either a saline or fresh water system, this includes preventing tidal influences to fresh water lakes, and large fresh water inputs to saline lakes (e.g. stormwater inflows or pumped fresh water during the wet season where the source of water is from estuaries).

Maintaining the intended type of lake (i.e. fresh or saline) will minimise possible detrimental impacts to the aquatic flora and fauna that establishes within the lake.

Lake outflows are typically associated with evaporation and seepage losses as well as overflows controlled by the lake outlet.

Depending on the lake system proposed sufficient information must be provided to council to define both inflow and outflow. Typical details that should be defined (where relevant) include:

- (i) catchment area draining to the lake, including characteristics (land use, per cent impervious);
 - (ii) drainage network connecting to the lake (existing and proposed);
 - (iii) upstream water quality improvements (applicable to freshwater lakes only);
 - (iv) source of water, quality and sustainability;
 - (v) pump or gravity diversions to the lake including required rates and necessary controls; and
 - (vi) outflow type including provision for water level manipulation and maintenance draining.
- (b) Freshwater lake considerations
- (i) Water quality improvements
- Catchment inflows contributing to freshwater lakes must be demonstrated to achieve the minimum water quality improvement targets. A separate Stormwater quality management plan is required detailing upstream stormwater quality improvement devices and demonstrates through MUSIC modelling expected water quality improvements.

Editor's note: SC6.4.3.8 Stormwater quality management plans for development provides guidance to applicants on the preparation of SQMPs, including the use of MUSIC modelling.

Target pollutant load reductions for new developments relevant to Townsville are:

- (A) 80% reduction in Total Suspended Solid;
- (B) 65% reduction in Total Phosphorous;
- (C) 40% reduction in Total Nitrogen; and
- (D) 0% reduction in gross pollutants (>5 mm particles).

Modelling is to consider 6 minute rainfall data for Townsville for the period 1970-1983 (mean rainfall 1,165 mm). Upstream stormwater quality improvement devices must be designed in accordance with SC6.4.3.9 Water sensitive urban design guidelines.

(i) Modelled catchment inflows

The expected inflow volume and seasonal variation is to be modelled, considering catchment characteristics and upstream treatment devices. Modelled inflows must only account for treated flows entering the lake, overflows are not to be included. Modelling of catchment inflows must be undertaken at a suitable time step to accurately model diversions to treatment devices. Typically this is at 6 minute intervals for urban catchments. Modelled inflows can be transformed to daily aggregates for further interrogation such as water balance modelling to review lake water level variation. MUSIC modelling used to demonstrate upstream water quality improvements can be adapted to provide catchment inflow series at daily time steps.

(5) Step 5 – Determine a preliminary lake layout

Develop a preliminary layout within the site constraints. The preliminary layout should consider:

- (a) soils and groundwater;
- (b) topography;
- (c) waterways and flood plains;
- (d) existing vegetation;
- (e) surrounding environments;
- (f) flora and fauna;
- (g) natural features such as significant trees, exiting aquatic environments (billabongs, wetlands, marine plants);
- (h) coastal management and erosion prone zones;
- (i) buffer distances; and
- (j) easements and service corridors.

Baseline surveys are critical at this stage to fully understand site constraints and opportunities. These include topographic, drainage, vegetation and flora and fauna surveys. Soils and groundwater assessments must be presented in a separate report as detailed in SC6.4.3.12.5(2) Step 2. Delineation of the highest astronomical tide (HAT) level and mean high water spring tide level (MHWS) will also inform the potential impact on erosion prone zones. For Townsville these levels correspond to:

- HAT = 2.254m AHD; and
- MHWS = 1.254m AHD.

Site reconnaissance and review of aerial photographs must be undertaken at this stage to fully understand the site constraints and opportunities.

Based on climatic conditions for Townsville, the maximum fresh water lake area (at wet season normal water level) is considered at 2.5% of the contributory catchment (considering 50% impervious fraction). Refer to SC6.4.3.12.5(7) Step 7. Smaller areas may be necessary for algal management (refer to SC6.4.3.12.5(8) Step 8).

The lake configuration should consider shapes that avoid dead end zones or result in poorly mixed waters.

Minimum length to width ratios of 3L:1W are recommended to ensure good hydraulic efficiency.

Where possible the orientation of lakes should be in a north west/south east alignment corresponding with the dry season prevailing wind. Lakes should not include islands as these can create poor water circulation and provide a refuge for birds that can contribute to nutrient loads to the lake.

Preliminary layouts should make provision for batters, edge treatments and buffers (refer to SC6.4.3.12.5(11) Step 11). These can add considerably to the overall lake area above the normal lake water level and can impact on the final layout.

Lakes should avoid areas where poorly structured soils (e.g. high organic content, peats, sodic soils), high acid sulfate potential and/or high nutrient hazard is identified.

Lake layouts must also demonstrate that the lake blends into surrounding environments and enhances natural features. Consideration must also be given to linking with recreational and landscape master plans for the area as well as public interaction and education opportunities.

Lakes should also avoid constricted flood ways where flow velocities can be high during flood events.

Editor's note: Applicants should refer to Part 8.2.6 Flood hazard overlay code for details of flood across the Townsville region.

(6) Step 6 –Lake bathymetry

A lake stage/storage/area curve must be developed for council review, including allowance for lake batters (refer to SC6.4.3.12.5(11) Step 11 for typical acceptable edge treatments). The bathymetry should consider the proposed shape within the site constraints. The depth of the lake must be between 1.5 and 3 m, preferably in the range of 2-2.5 m. Lake depth is considered from wet season normal water level to finished lake bed level.

Depths greater than 3 m are more prone to stratification, which can potentially lead to the release of nutrients to upper waters when they de-stratify, potentially increasing the risk of phytoplankton blooms, particularly Cyanobacteria (toxic blue green algae). A minimum depth of 1.5 m must be provided to allow maintenance equipment such as floating weed harvesters to access lakes.

(7) Step 7 – Undertake water balance modelling

Water balance modelling is required to review the seasonal water level variation of lakes. The proponent must demonstrate to council the expected water level variation over a minimum 10 year continuous modelling period.

The general form of the water balance equation is given by:

$$S=I-O$$

where

S=storage, I=inflow, O=outflow

(a) Inflows:

- (i) catchment runoff entering the wetland (see SC6.4.3.12.5(4) Step 4); and
- (ii) direct precipitation over the lake.

Other inflows such as groundwater and base flow are difficult to quantify and can only be considered where sufficient data supports their use. As a conservative approach these can be ignored.

(b) Outflows:

- (i) evaporation losses (determined from the stage/storage/area curve, as derived from SC6.4.3.12.5(6) Step 6 and typical daily evaporation rates for Townsville);
- (ii) lake outflows/overflows; and
- (iii) seepage losses.

(c) Water level variation

Water balance modelling must demonstrate that lake water level drawdown from wet season normal water level does not exceed 1 m once every 10 years on average and less than 0.7 m on a more frequent

basis (on average once every 2 years or less).

Based on climatic conditions for Townsville, the maximum fresh water lake area (at wet season normal water level) is considered at 2.5% of the contributory catchment (considering 50% impervious fraction).

- (d) The overall size of the lake will also need to consider algal management issues, as described in SC6.4.3.12.5(8) Step 8. Where algal management options consider recirculation through a wetland, water balance modelling must also include the impacts from inclusion of the recirculation wetland. Refer to SC6.4.3.12.5(8) Step 8.

Designers must be aware of the implications of water level variations with respect to edge treatment survival and visual amenity. Design steps should be taken to limit water level variation to no more than 1 m once every 10 years and 0.7 m once every 2 years, and this may require the inclusion of:

- (i) a lake liner to minimise seepage losses; or
- (ii) provision for lake top-up.

Designers may need to consider hard edge treatments to minimise visual impact in high amenity areas or supplementary irrigation to maintain lake edge vegetation. SC6.4.3.12.5(11) Step 11.



Photos: Shaun Leinster

Figure SC6.4.3.12.8 Examples of impacts due water level variations

- (e) Lake top-up

Where designers consider lake top-up to maintain lake water levels, suitable sustainable sources are to be considered. These may include the use of harvested stormwater and groundwater for fresh water lakes. Where groundwater is proposed the proponent must undertake necessary hydrogeological investigations to demonstrate that the proposed pumping does not detrimentally impact on the local groundwater resource. The quality of the groundwater must also be demonstrated to not negatively impact on the health of the lake.

Lake top-up for saline lakes must maintain the salinity of the lake at greater than 15,000 mg/L. This may require the provision for salinity control on pumped delivery to lakes from estuaries to ensure wet season fresh water pulses are not delivered to the lake.

Potable mains supply is not considered an acceptable source for lake top-up.

Where harvested stormwater is considered for lake top-up for fresh water lakes sufficient storage must be available. The volume of storage required can be estimated from the water balance modelling, but as a general guide is in the order of 15 ML per hectare of lake per annum to maintain constant water levels throughout the year, where the lake area is taken at the wet season normal operating level.

Storages can be constructed storages or use of natural underground aquifers. Constructed storages to provide sufficient top up for Townsville fresh water lakes are typically not considered practical due to the significant volumes that would be required (typically in the order of the total lake volume), although dedicated storage dams may be considered.

When considering aquifer storage opportunities, hydrogeological investigations will be required to determine the feasibility, which will include assessing the capacity of the aquifer to store water and the potential impact on the native groundwater and other users. Storage of water in shallow aquifers is not recommended due to the possible impact on adjacent structures and possible water logging. Design guidance on aquifer storage and recovery (ASR) is outside the scope of this guideline. Specialist hydrogeological advice must be sought should this option be pursued.

(8) Step 8 - Algal management

A key design consideration for algal management in lakes is the management of trigger mechanisms such as nutrients and turbidity, and the removal of algal biomass from the lake water body before bloom concentrations occur. Algal biomass removal rates should be at least equal to the in-situ algal growth rate. Algal biomass removal can be facilitated via a number of methods including lake flushing or removal through a recirculating wetland. Other methods are available and are included in SC6.4.3.12 Attachment A: Alternative strategies for managing Cyanobacterial growth.



Photos: Shaun Leinster

Figure SC6.4.3.12.9 Examples of blue-green algae

A probabilistic approach based on lake residence time has been adopted in Queensland, such as the Brisbane City Council's *WSUD guidelines for Pond and Lake Design* and also *Mackay Planning Scheme Policy 15.15 – Constructed lakes for minimising the risk of Cyanobacterial growth in constructed lakes*. These recommend a 20th percentile residence time for lakes not exceeding 20 days.

The Mackay Planning Scheme Policy 15.15 – Constructed lakes also stipulates that where the lake residence time criteria is exceeded, then water can be recirculated through a wetland at a rate that ensures lake turnover every 20 days. A minimum wetland residence time of 5 days is also stipulated to provide sufficient contact time (two growing cycles) for algal biomass removal.

The effectiveness of a recirculation strategy using surface wetlands for algal management in Townsville is still largely unknown and the required recirculation rates for Townsville conditions are also currently unknown. However recirculating lake water through surface flow wetlands is considered a sound approach with respect to removal of suspended solids (and thus turbidity) and nutrients in lake water, two key triggers for changes in state for shallow lakes.

Whichever algal management method is proposed, the proponent must clearly demonstrate that the strategy is effective in removing algal biomass to minimise the opportunities for algal blooms.

In the absence of further information, proponents proposing constructed lakes in Townsville must demonstrate that the entire lake volume is “flushed” through the lake within a 20 day period for the control of algal biomass. As rainfall dependent catchment inflows in Townsville will result in extended periods where full lake volume turnover is not achieved (e.g. >100 days during the dry season), other sources such as diverted surface water and groundwater will be required. The rate of diversion can be estimated simply as follows:

Required lake inflow rate (m³/d) = lake volume (m³)/20 days

Where flushing is adopted, the source of water used must have a nutrient, turbidity, algal bio-mass less than or equal to the lake water and salinity ranges should be maintained for the intended lake type (refer to Table SC6.4.3.12.2 Suggested target values for physico-chemical indicators).

(a) Recirculating wetlands

Where no external flushing supply is available, provision for a recirculating wetland for algal management should be made. The following design criteria are considered:

- (i) recirculation of the full volume of lake water through the wetland every 20 days;
- (ii) minimum wetland contact time of 5 days;
- (iii) treated water re-entering the lake must have turbidity, nutrient and algal biomass levels less than or equal to the lake water; and
- (iv) water re-entering the lake must be at opposite ends from where water is abstracted from the lake to avoid short circuiting of treated flows.

This strategy does not guarantee that no algal blooms will occur and proponents must also develop an adaptive management plan for algal blooms.

For the above design considerations, the approximate size of the recirculating wetland is 1.5 times the area of the lake based on an average wetland depth of 0.3 m. Smaller recirculating wetlands can be considered where the proponent can demonstrate that algal biomass removal rates are greater rates than those assumed in the above derivation. For example, ultrasonic treatments of recirculated lake flows can potentially reduce algal biomass concentrations, thus reducing the recirculating wetland size. A further alternative may be the use of floating macrophyte beds, which can remove bio-available nutrients from the water column, and can be used within the lake or as part of the recirculation strategy. This option will require regular harvesting of the floating macrophytes to reduce nutrient loads from the lake.

Design of the recirculating wetland must consider maintaining the health of the wetland and associated vegetation. This requires the recirculating wetland to be operated continuously throughout the dry season to maintain a permanent pool of water over the majority of the wetland area. To minimise recirculation rates the recirculating wetland is considered as a shallow planted system, without deep pool areas. This differs from stormwater treatment wetlands where deep pool zones are included, and typically cover up to 20% of the total area in the dry tropics (refer to SC6.4.3.9 Water sensitive urban design guidelines).

An average wetland depth of 0.3 m is considered sufficient for recirculating wetlands and will include shallow to deeper zones supporting a range of emergent macrophytes from shallow marsh (0-0.2 m), marsh (0.2-0.35 m) and deep marsh (0.35-0.5 m). The wetland area needs to be sized to provide a 5 day treatment time, considering the minimum recirculation rate determined for the lake volume (refer to above). In this case the wetland area can be estimated as follows:

Recirculating wetland area = 5 days x recirculating pump rate (m³/d)/ave wetland depth (0.3 m)

The overall configuration of the recirculating wetland must consider inlets and outlets at opposite ends and minimum length the width ratios of 5L:1W to maintain good hydraulic efficiency and thus mixing throughout the wetland. Wetland shapes must avoid dead end zones and possible short circuiting. Designers are directed to SC6.4.3.9 Water sensitive urban design guidelines for further advice on the design of constructed wetlands.

(9) Step 9 – Select final lake layout

Following approval of concepts presented to council, the final lake area must be selected considering the soil and site constraints from SC6.4.3.12.5(3) Step 3 and SC6.4.3.12.5(5) Step 5, depth ranges within those indicated SC6.4.3.12.5 (6) Step 6, acceptable water level variations derived from SC6.4.3.12.15(7) Step 7 and additional allowances where recirculating wetlands are proposed for algal management SC6.4.3.12.5(8) (Step 8).

The final lake configuration must consider shapes that avoid dead end zones or result in poorly mixed waters. Minimum length to width ratios of 3L:1W are to be provided to ensure good hydraulic efficiency.

The final lake layout will need to integrate with the approved landscape and amenity plans for the development, development road layouts, accesses and required civil works.

(10) Step 10 –Design of inlets, outlets and other hydraulic structures

Lake inlets and outlets should be located at opposite ends of the lake to promote uniform movement of water through the lake and avoid short circuiting of flow. The design of inlet and outlet structures will depend on the type of lake proposed. Inlets and outlets must be designed for minimum maintenance and must make provision for scour control at pipe outlets.

Inlets and outlets must not be subject to blockage through excessive silt and debris build up and/or excessive vegetation. Design actions may include:

- provision of stone pitching at inlets and outlets to prevent vegetation growth; or
- suitable screens to minimise debris ingress.

Inlets and outlets structures are to result in minimal visual impact and may be hidden under boardwalks or amongst rocks, for example.

The proponent is to provide engineering calculations for the design of lake hydraulic structures, the design of which will differ depending on whether a fresh water or saline lake is proposed. The designer is directed to other parts of SC6.4 Development manual planning scheme policy as relevant, the *Queensland Urban Drainage Manual*, and the *Road Drainage Manual* for more design guidance on specific hydraulic design of pipes and pits and erosion protection at pipe outfalls.

The influence of tidal variation including storm surge, wave setup and impacts of climate change must be detailed to council. For the purposes of design the following tide levels are noted for the Townsville region (Townsville Harbour, QDOT, 1998):

Tidal plane	mAHD
Highest Astronomical Tide (HAT)	2.254
Mean High Water Springs (MHWS)	1.254
Mean Sea Level (MSL)	0.1
Mean Low Water Springs (MLWS)	-1.13
Lowest Astronomical Tide (LAT)	-1.86

The designer must consider the potential impacts of sea level rises due to climate change and make provisions in the design for such increases.

In the case of saline lakes proponents must clearly indicate how lake flushing will be achieved and any necessary pumping equipment, control and telemetry systems that may be required to facilitate operation.

(a) Inlets

Inlets to lakes may be gravity diversion of treated stormwater runoff or pumped delivery from adjacent water bodies (e.g. from estuarine river systems).

Stormwater inflows

In the case of piped stormwater flows to lakes, pipe inverts from upstream catchments should be set no lower than lake wet season normal operating level. This will avoid permanent water within the pipe drainage system and maintain hydraulic capacity of the connecting pipe drainage. Suitable erosion protection at the pipe outfall must be provided to prevent scour. Refer to QUDM, 2007.



Photos: Shaun Leinster

Figure SC6.4.3.12.10 Examples of concealed inlets to lakes

Provision for a gross pollutant trap may also be required to capture litter and leaf matter prior to discharge to the lake.

Where a separate inlet sedimentation zone is proposed, the designer is directed to the SC6.4.3.9 Water sensitive urban design guidelines for further advice.

Pumped inflows

Pipe outfalls to lakes for pumped delivery may be submerged, however suitable backflow prevention devices must be installed to prevent possible draining of the lake.



Photos: Ralph Williams

Figure SC6.4.3.12.11 Pump intake from Ross River – note blocked screen (L), and pumping infrastructure including sump and control equipment (R)

Pumped delivery systems must consider aspects such as the control of delivery to the lake. This may include the control of the pumping regime through tidal cycles and preventing fresh water being pumped to the lake. The expected pumped volumes with respect to the lake volume should be demonstrated to allow sufficient flushing. A flow meter on the discharge side of the pump is recommended. Suitable arrangements must be made in case of pump failure to ensure minimum flushing rates are maintained. This may include a standby pump. Provision for internal lake recirculation may also be required where extended periods of fresh water during the wet season at the source of pumping prevent delivery to the lake.

(b) Outlets

Lake outlets can be configured in a number of ways and will determine the normal wet season operating level. Lakes for flood mitigation purposes are not encouraged in Townsville region and should by-pass high flows, thus the design of lake outlets will only need to consider design inflows (e.g. connecting pipe capacity or pumped diversion rate) and any incidental rain over the lake.

Impacts of possible tailwater effects at pipe outlets must be considered when sizing outlet pipes. Refer to QUDM, 2007 for further guidance.

In the case of fresh water lakes, ingress of tidal waters to the lakes must be prevented. Water levels to HAT (2.15 m AHD) must be considered in this case. Allowances for tidal surges should also be made.

Outlets must be designed to minimise potential blockage. An overflow path (e.g. weir) should be provided in case of outlet structure blockage. This will minimise potential damage to vegetated edge treatments.

Overflow pit and discharge pipe

Overflow pits can be located within the lake water body, with the crest of the pit defining the normal lake wet season operating level.

The design should consider:

- (i) pit dimensions such that pit capacity is greater than the connecting culvert capacity;
- (ii) suitable pit grate to protect against clogging by debris;
- (iii) minimal visual impact;
- (iv) prevent local fauna such as ducks from entering the pit; and
- (v) capacity to drain the lake for maintenance.

Additional guidance is provided in the SC6.4.3.9 Water sensitive urban design guidelines.

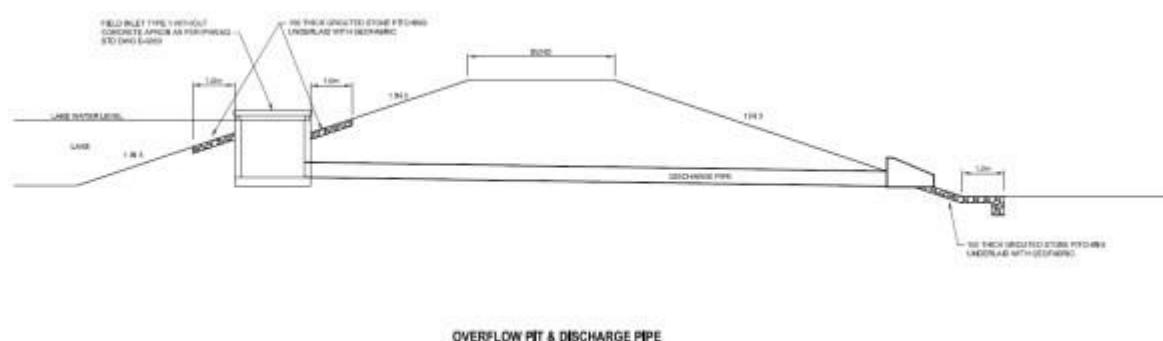


Figure SC6.4.3.12.12 Typical overflow pit and discharge pipe details

Outlet pit and discharge pipe

Outlets may also consider submerged pipes connecting the lake to an outlet pit with a discharge pipe. The lake normal water level may be set via an open ended riser pipe or a weir plate in the outlet pit. Either can be configured to be easily removed to facilitate maintenance draining.

must consider:

- (i) maintaining good hydraulic efficiency and mixing between water bodies;
- (ii) minimising head losses between water bodies during operation;
- (iii) maintaining access between the lake water bodies; and
- (iv) provision for lake drawdown during maintenance.

Where open channel/weir connections are proposed, the designer must consider the potential impact of any necessary recirculation strategy. In such instances, preference is for submerged pipe connections, to maintain hydraulic interconnection between lake water bodies during the dry season when lake operating levels are below wet season normal water levels. As lake water level variations of up to 1 m are considered, submerged pipes obverts should be at least 1 m below normal wet season operating levels.

Where gravity drainage is proposed for lake maintenance, interconnecting pipes will need to consider inverts that facilitate adequate drawdown of all connected water bodies.

(d) Maintenance drain

Provision for a maintenance drain must be made to allow the lake to be drained for periodic maintenance. This drain can be a manually driven gravity drain or where gravity drainage is not possible provision for pumping must be made. The proponent must state the proposed method of draining and where pumping is proposed suitable access must be allowed for pump maintenance. The cost of pumping must also be considered in any life cycle costing (refer to SC6.4.3.12.5(18) Step 18).

The operation of the maintenance drain should ideally allow lake drawdown within seven days, although for large lakes this may not be possible.

The proponent must consider impacts of lake draining on potential acid generating conditions that may occur as well as the potential impacts on downstream receiving bodies due to the draining.

The maintenance drain must also facilitate water level management during establishment, particularly for establishing lake edge vegetation.

(11) Step 11 - Design of lake edges and batters

Lake edges play an important role in weed management for lakes. Edge treatments must also consider large water level variations (up to 1 m are allowed on an infrequent basis and 0.7 m on a more frequent basis, refer to SC6.4.3.12.5(7) Step 7), including visual amenity aspects and survival of edge vegetation. Edge treatments must consider public safety (refer to SC6.4.3.12.5(17) Step 17).

To minimise exposed edge width due to water level variations, batter slopes at a minimum 3H:1V are preferred. Flatter slopes above wet season normal water level are permitted depending on the final treatment. Where turf areas are proposed batter slopes of no more than 5H:1V must be provided to allow mowing. Typical edge treatments for both fresh and saline lakes are indicated in Figure SC6.4.3.12.15.

At the ROL/MCU stage the proponent must indicate the type of edge treatments proposed, including the structure and mix of edge treatment (refer to SC6.4.3.12.5(12) Step 12).

At the operational works stage, lake edges must be considered based on an updated water balance based on the final lake layout to confirm expected water level variations established from preliminary layouts.

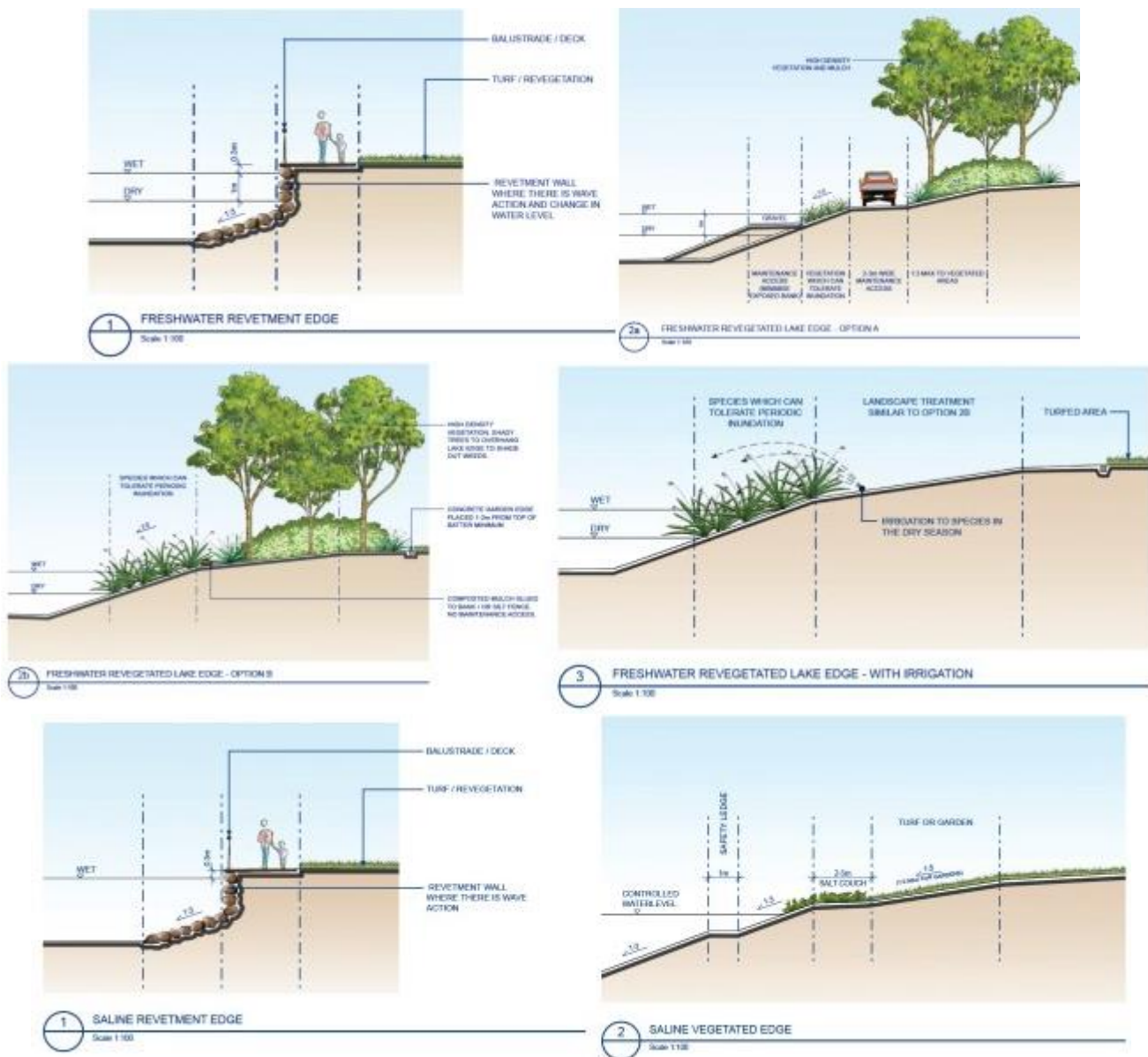


Figure SC6.4.3.12.15 Typical examples of edge treatments for fresh and saline lakes

(12) Step 12 –Vegetated lake edge treatments

Editor's note—applicants should also refer to [9.4.39.3.3](#) Landscape Code and Development manual planning scheme policy sub section SC6.4.3.6 Landscape policy.

The structure and mixture of vegetation of the proposed lake edge will be a key design consideration for a well performing edge treatment. Lake edge treatments should aim to re-establish a mix of local indigenous species including trees, shrubs, groundcovers and grasses that complement and enhance the amenity of the area. Adjacent parkland vegetation may consider similar species to lake edges to integrate the lake with the surrounds, or alternatively different species may be used to provide a contrast to highlight the lake as a feature within the landscape.

At the ROL/MCU stage the proponent should indicate the proposed structure and mix of vegetation for the proposed lake, together with the proposed methods for establishing and maintaining healthy vegetation. The expected lake water level variations are also required.

Editor's note—guidance on typical options for varying lake edge conditions are presented previously in SC6.4.2.12.5(11) Step 11, and can be adapted to suit specific requirements of the proposed lake.

For operational works approval the proponent should clearly detail proposed treatments including:

- plant species;
- location with respect to lake water level;
- planting density and layout; and
- planting methods.

Planting details should be indicated in plan and section in the detail design drawings. Guidance on plant species suitable for the Townsville region is provided in SC6.4.3.9 Water sensitive urban design guidelines and SC6.4.3.6 Landscape policy.

Various types of treatments can be used and the type and density will be a key design consideration for the effective performance of the treatments. Broadly edge treatments can include:

- perennial sedges and rushes (emergent macrophytes);
- ground covers;
- shrubs;
- turf;
- trees; and
- mulches.

A minimum planting of 1 m vertically above wet season normal water level is considered necessary to provide stable edge treatments.

Successful establishment of vegetated lake edges will include:

Good soil preparation including a minimum 200 mm topsoil. Soils are to be amended where necessary to be considered as agronomically acceptable. Topsoils are to be laboratory tested to AS4419-2003 *Soils for landscaping and garden use* to ensure topsoil suitability for plant growth. Topsoils must not contain weeds or susceptible to acid generation which may kill off plants. Amendments such as lime and gypsum may be required.

- selection of an appropriate planting time. Planting toward the end of the dry season is preferred to take advantage of early wet season rains.
 - maintaining good moisture for plant growth during establishment. This may include; supplementary irrigation and mulching;
 - protection from disturbance during establishment;
 - replacing damaged or dead plants; and
 - removing weeds both prior to and during establishment.
- (a) Perennial sedges and rushes (1.0 m below to 0.2 m above wet season NWL)
- Sedges and rushes provide a soft natural edge to lakes. The use of sedges and rushes are important in minimising weed ingress and provide a dense barrier to the lake edge minimising human contact with water and thus reducing safety risks. It is important that sedges and rushes are planted in high densities (20 plants/m²) and permanently occupy the edge to limit the opportunities for weed establishment. Typically dense vegetation at least 1.2 m high and 2-3 m wide will be suitable.



Photos: Shaun Leinster

Figure SC6.4.3.12.16 Examples of edges treatments with sedges and rushes

Plant selection must be able to survive the expected water level variations and may require supplementary irrigation to ensure survivability during the dry season. Tall, small diameter stemmed, self-sustaining plants that distribute themselves by producing large quantity of seed are preferred.

Where possible, shade should be provided over sedges and rushes to minimise the potential ingress of weed species such as Para grass. Shade can be provided through planting of trees species adjacent to the lake edge. Aspect also plays an important role for shade considerations, with south facing banks providing good shade opportunities to lake edges.

- (b) Ground covers and shrubs (greater than 0.2 m above wet season NWL)
Groundcovers and shrubs can be provided above the lake normal water level to help stabilise lake batters and provide aesthetic/landscape feature. Groundcovers and shrubs should be less than 1 m in height to maintain open visible areas. Groundcovers and shrubs are particularly useful where batter slopes greater than 3H:1V are proposed. For slopes greater than 3H:1V, ground covers with matting and rhizomatous root systems can assist binding the soil surface during establishment.



Photos: Shaun Leinster

Figure SC6.4.3.12.17 Examples of edge treatments using ground covers

- (c) Turf
Turf treatments can be used to highlight the water body as a feature within the landscape and encourage recreational use adjacent to the lake. For maintenance purposes, batter slopes for turf treatments must be not greater than 5H:1V. Supplementary irrigation will most likely be required to maintain turf health.

For saline lakes, salt couch is a typical suitable edge treatment. Salt couch is particularly sensitive to extended periods of inundation and should be above the normal wet season water level. Salt couch extending 2-5 m from the water edge over a wide flat (10H:1V) area is preferred.



Photos: Shaun Leinster

Figure SC6.4.3.12.18 Example of a turf and salt couch edge treatment

(d) Trees

Trees provide an important function in the overall performance of lake edges where perennial sedges, rushes and shrubs are proposed. Trees provide shade which helps minimise ingress of weeds such as Para grass. In such cases, the tree location must be within close proximity to the edge such that shading is achieved. Tree densities of 1 2 per m² are recommended.

When selecting tree species, preference is for deep rooted species. Careful consideration must be made when grass and tree species are mixed together as grasses can kill off trees when establishing. Use of ground covers around trees are preferred. Ground cover legume species are preferred with trees, however legume tree species should be avoided (e.g. acacias).

It is likely that suitable education signage will be required around areas with tree planting to describe the function of trees with respect to the lake. Past experience with lakes in residential areas around Townsville has seen residents removing trees due to the desire for increased lake views and the perception that the native vegetation encourages snakes.

(e) Mulches

A variety of mulches are available to provide erosion protection and aid vegetation establishment at lake edges. The suitability of mulches will depend on the vegetation proposed and batter slopes. Typically, mulches should be bio-degradable and are usually 50-100 mm thick. Typical mulches include:

- (i) straw/sugar cane mulches: are particularly useful for grass establishment where water for irrigation is limited. They are also useful where dispersive clay soils exist. Typically used in flat slope areas (less than 10H:1V), but can be used on steeper;
- (ii) slopes with the use of tackifiers or with biodegradable mesh anchoring;
- (iii) hydromulching: typically used for grass establishment, but will usually require greater watering requirements than straw mulch treatments. Adhesive binders and fertilizers are typically incorporated into hydromulch mixtures, together with fibrous matrix of wood or paper pulp and grass seed. Hydromulching is particularly suited to steeply sloping sites or areas with difficult access;
- (iv) bush mulches: includes mulches such as bush mulch, bark and wood chip and are most suited to shrub and tree areas. They are not suited to areas where grasses are proposed and should only be used where tube stock planting is planned;
- (v) compost blankets: particularly suited to revegetation of steep slopes with grasses and plants. Also useful when topsoil placement is difficult or insufficient topsoil is available;
- (vi) bonded fibre matrix: a fibrous glued type mulch, highly suitable for vegetating steep slopes, particularly in wet environments. This form of mulch treatment can be moulded to form effective erosion control barriers, and may be suitable in lieu of silt fences near lake edges; and
- (vii) rock mulching: mostly applicable to areas where plants establishment is difficult or in high amenity areas. Rock mulches are prone to siltation and should only be used when absolutely necessary.



Photos: Shaun Leinster

Figure SC6.4.3.12.19 Examples of the use of mulches at or near lake edges

(13) Step 13 – Maintaining flood capacity

The proponent must demonstrate to council that the operation of the lake must have no adverse impact on flood capacity, this includes the capacity of upstream catchments contributing to the lake and regional flooding where lakes are located on floodplain areas. Specialist hydraulic advice will need to be sought to confirm flood capacity.

Lakes in Townsville are not intended for flood management purposes. High flow by-pass provisions will be required where applicable. Standard design procedures such as Manning's equation can be used to size the high flow channels. Suitable stabilisation such as turfing must be provided and must be suitable for the expected velocity ranges.

Lakes must also make provision for an emergency overflow in the case outlets become blocked. This may include an overflow spillway (refer to SC6.4.3.12.5(10) Step 10) or demonstration that embankments are sufficiently strong to withstand overtopping. Erosion protection must be provided at overflow points.

(14) Step 14 - Lake maintenance access

The proponent must clearly indicate the location of accesses for lake maintenance. The minimum access requirements for lakes include:

- (a) de-silting including dewatering pads at specified locations;
- (b) debris removal;
- (c) weed removal (floating and terrestrial);
- (d) inlets and outlets and other hydraulic structures; and
- (e) pumps and switch gear, where applicable.

Accesses should be blended into the general landscape of the lake so as to soften the impact. This may include incorporating perimeter access track as walking trails, screening of high impact accesses or incorporating into viewing areas.

Accesses must be sized to provide sufficient space to undertake the work, including sufficient turnaround areas.

Accesses for heavy machinery (e.g. excavator) must be designed for a 20 tonne capacity and of sufficient width to allow turnaround. Access provisions must also consider the maximum reach of heavy machinery (e.g. 10 m for an excavator). Access ramp slopes are to be no greater than 5H:1V. Public access to heavy machinery access points must be restricted.

The location of accesses for debris removal will need to consider prevailing wind conditions during both the wet and dry season together with lake orientation. This will determine likely collection zones for debris. Prevailing wind directions for Townsville are:

- April to November: South easterly; and
- December to March: North easterly.

Note—dewatering pads must be of sufficient distance from residential dwellings and commercial premises so that odours are unlikely to cause offense.

Provision for access to the main lake water body must be made to allow access for mechanical weed harvesters for removal of floating or submerged weed. A boat ramp type access is considered acceptable.



Photos: Jason Lange, and Sunshine Coast Regional Council and Ecological Engineering

Figure SC6.4.3.12.20 Examples of aquatic weed removal methods

Provision for de-silting must be made at lake inlet zones. This includes a suitable ramp to the base on the inlet zone. Provision of a hard base to the inlet bay must be made to indicate when the floor of inlet zone is reached by machinery operators. A hardstand dewatering pad at the inlet zone must be provided and graded to drain back to the inlet zone. Other de-silting accesses may be necessary should sediment accumulation be anticipated at other areas of the lake.

Suitable access must be available at all inlet and outlet structures. Where inlets and outlets are concealed under decks, amongst rocks and plantings, the proponent must demonstrate how access will be achieved at these points.

Vehicle access around the lake perimeter is to be provided for incidental monitoring and maintenance such as mowing, weed removal, mosquito larvae monitoring and removal. This can be incorporated as part of pedestrian trails around the lake.

Access to all pump and switch gear installations must be made and must allow for provision for pump replacement (i.e. crane access).

Where lake fountains are proposed pumping equipment should be located at the shoreline and not within the lake to allow easier access for maintenance.

Sufficient accesses must be provided to minimise vehicles driving on lake edges where wheel ruts can form. These can potentially provide a habitat for mosquito breeding.

(15) Step 15 - Vector control

A mosquito baseline survey/audit must be completed for all proposed lakes to establish the existing mosquito populations prior to construction. This baseline information should consider seasonal variations in mosquito populations and would likely require regular monitoring for an entire wet and dry season period prior to lake construction.

The proponent must detail design actions that minimise the occurrence of mosquitoes due to the proposed lake and associated installations such as any necessary recirculating wetlands and pump sumps. Standard design practices to minimise mosquito breeding include (adapted from SC6.4.3.9.5(2)(i) Designing to avoid mosquitoes):

- (a) providing access for mosquito predators, such as fish and predatory insects, to all parts of the water body (avoid stagnant isolated areas of water). Native fish species must be used;
- (b) where possible, incorporating a steep slope into the water, preferably greater than 3H:1V;

- (c) wave action from wind over open water will discourage mosquito egg laying and disrupt the ability of larvae to breathe;
- (d) providing a bathymetry such that water draws down evenly so isolated pools are avoided;
- (e) providing sufficient gross pollutant control at the inlet such that human delivered litter does not accumulate and provide a breeding habitat;
- (f) providing suitable access to likely debris collection points (refer to SC6.4.3.12.5(14) Step 14) for removal of any accumulated debris;
- (g) providing ready access for field operators to monitor and treat mosquito larvae, if required;
- (h) ensuring maintenance procedures do not result in wheel rut and other localised depressions that create isolated pools when water levels fall;
- (i) ensuring pits and sumps are provided with lockable galvanised lids that prevent access to mosquito adults;
- (j) ensuring overflow channels do not have depressions that will hold water after a storm event;
- (k) aquatic plants such as Water Hyacinth, Salvinia and water lilies can provide a breeding medium for some mosquito species whose larvae attach to these plants under water. These plants should be removed immediately if encountered. Suitable access must be provided to facilitate floating weed removal (refer to SC6.4.3.12.5(14) Step 14);
- (l) appropriate landscaping in areas surrounding lakes to ensure proper drainage. Surrounding areas with poor drainage (e.g. flat lake edge batters) can become mosquito breeding grounds; and
- (m) limit water level variations where possible.

Further advice on suitable native fish species for mosquito control is available from the Department of Primary Industries. Permits for stocking lakes with native fish local to the area are not required. Care must be taken with the suitable fish selection to ensure no environmental harm from fish stocked in lakes, which can easily make their way into downstream rivers and creeks etc.

A mosquito monitoring program must be established for the proposed lake. Monitoring is to include adult trapping, at the lake site and larval surveys for areas that include water retained in shallow flooded vegetated areas. Typically monitoring frequencies will be intensive (weekly) during the wet season (December to March), and less frequent during other times (fortnightly to monthly).

Larval surveys can be undertaken by sampling water with a 300 mL ladle. As a general guide a larval density of 1 larvae per 2 ladle dips or higher is likely to indicate a potential mosquito problem for adjacent residents (Warchot and Whelan, 2008). Mosquito problems may also be identified from adult trapping indicating significant pest numbers or resident complaints.

An adaptive management strategy must also be developed for control of mosquitoes.

(16) Step 16 - Bird control

Lake designs must consider actions that discourage the establishment of large waterbird populations. Large bird populations can cause lake water quality issues due to additional nutrient and faecal contamination, and reduce local biodiversity by damaging native vegetation. Large bird populations in urban residential areas also can create nuisance issues such as noise and faecal droppings.

A number of design actions are available to control bird populations. These include:

- (a) densely vegetating lake edges with sedges and rushes to inhibit access to shallow water for feeding;
- (b) selecting non-roosting trees such as eucalyptus;
- (c) avoiding ground covers and shrubs that support roosting or breeding of species such as ibis (e.g. some melaleuca species);
- (d) discouraging opportunities for feeding including educational signage; and
- (e) providing suitable refuse collection around picnic areas.

(17) Step 17 - Public safety

Lake designs must consider public safety and be designed in accordance with the crime prevention through environmental design (CPTED) principles. The proponent must demonstrate how the lake will achieve and manage these outcomes.

Lake edge treatments play an important role in public safety. Various suitable lake edge treatments are provided in SC6.4.3.12.5(11) Step 11 and SC6.4.3.12.5(12) Step 12. Lake edge treatments can be formed to create a barrier to open water access through dense edge plantings or balustrades where revetment edges are planned.

Where vegetated edges are proposed, the designer must consider the requirement for steeper batter slopes (3H:1V) below normal operating levels to minimise exposed edge width. Suitable vegetation selection will be important where a vegetated barrier is provided. Safety ledges can also be provided just below normal operating level where access to the water body is available. Refer to SC6.4.3.12.5(11) Step 11.

Lake designs must minimise areas of concealment and ground covers should be chosen to maintain an open visible aspect.

Lake boardwalks and viewing platforms must be demonstrated to be safe for public use, including suitable barriers for children.

Adequate signage must be provided to indicate suitability for recreation activities (e.g. no swimming), and potential threats from local fauna (e.g. beware of crocodiles).

Passive recreation facilities such as paths and trails must not create a trip hazard and designed so that they are available to all groups of the population i.e. it should consider all abilities. Safe distances from paths to lake edges should be considered.

(18) Step 18 –Life cycle costing

Life cycle costs for the proposed lake must be determined over a life span of 30 years. The life cycle costs must include acquisition, construction, establishment, operation, monitoring, maintenance, replacement and disposal costs. The costs must also clearly indicate “who pays,” i.e. developer costs and council costs. This includes costs associated with pumping infrastructure, including power and carbon offsetting costs and those associated with monitoring (e.g. water quality, mosquito monitoring).

Comparisons of lake life cycle costs with a similar parkland area not containing a lake are to be provided to council.

The life cycle cost plan is to include an extended dry season and a longer than normal wet season every 5 years.

This information will be used by council to assess the financial sustainability of the lake system, to make design refinements with the proponent and to identify whether additional funds will be sought from proponents to manage the lake following handover to council ownership.

SC6.4.3.12 Appendix A - Alternative strategies for managing Cyanobacterial growth

The following is taken from DesignFlow, 2010. “*Constructed Water Bodies in Urban Areas of SEQ – Critical Analysis of Recirculation Strategy*”. Prepared for Water by Design.

Mechanical removal

Cyanobacterial surface scums may be mechanically removed using booms dragged behind boats and the concentrated Cyanobacterial scum on the surface pumped off. This technique is not widely used for the management of Cyanobacterial blooms as Cyanobacterial biomass will be present throughout the water column, and therefore only a small proportion of the algal biomass will be removed.

Atkins *et al.* (2001) reported the use of flocculation and mechanical removal techniques to manage a *Microcystis aeruginosa* bloom in the Swan River, Perth. A mixture of bentonite clay and polyaluminium chloride was used to flocculate and sink the *Microcystis cells* prior to mechanical removal using oil spill equipment.

The mechanical removal of Cyanobacterial biomass offers the advantage of also removing nutrient loads from the water body, however the disposal of the odorous and often toxic biomass may be problematic.

Ultrasonic treatment

Ultrasonic irradiation of Cyanobacterial cells is a relatively new strategy that has been proposed for managing Cyanobacterial growth in lakes. Many of the common bloom forming Cyanobacteria are characterised by the presence of gas vacuoles which enable the Cyanobacterial cells to regulate their position within the water column. The presence of gas vacuoles provides a competitive advantage to Cyanobacteria over the majority of other algal groups, as it enables the Cyanobacteria to scavenge nutrients from the hypolimnion (lower strata of the water column) and to optimise their exposure to light within the epilimnion (upper strata of the water column).

Lee *et al.*, (2001) investigated the use of ultrasonic irradiation as an alternative strategy for controlling Cyanobacteria, and found that the gas vacuoles of Cyanobacteria (*Microcystis viridis* and *M. aeruginosa*) were disrupted following brief exposure to ultrasonic irradiation, resulting in about 80% of the Cyanobacterial cells settling out. Decreased photosynthetic activity was observed following irradiation, suggesting that the ultrasonic treatment also inflicted damage to the photosynthetic apparatus of the Cyanobacteria.

A potential risk associated by exposing Cyanobacterial cells to ultrasonic irradiation is that the cell membranes may rupture, potentially releasing cyanotoxins into the water column. Interestingly, Lee *et al.*, (2001) observed that ultrasonication of the *Microcystis* cells did not increase the concentration of cyanotoxins in the water column. More recent research has shown that ultrasonication of Cyanobacterial cells (for periods less than 5 mins) does not increase cyanotoxins (in this case Microcystins) but cyanotoxins may also degrade in the ultrasonic fields (Ma *et al.*, 2005). The effects of ultrasonic irradiation upon other cyanotoxins such as cylindrospermopsin (*Cylindrospermopsis* and *Aphanizomenon*) and saxitoxins (*Anabaena*) have not been tested.

The evaluation of ultrasonic irradiation to control Cyanobacterial growth in lakes thus far has resulted in mixed outcomes. Nakano, *et al.* (2001) trialled the use of ultrasonic irradiation coupled with flushing in a large shallow hyper-eutrophic lake (1 m depth, 33 Ha) that was plagued by Cyanobacterial blooms. Whilst the use of the ultrasonic irradiation of reduced peak concentrations for chl-a from 200 ug/L to 130 ug/L (Lee, *et al.* 2002), the study was unable to conclusively demonstrate the effectiveness of the ultrasonic treatment upon Cyanobacterial growth.

Ahn, *et al.* (2007) used ultrasonic irradiation to control Cyanobacteria in a small eutrophic lake (2 m depth, 0.9 Ha). During the period of the year when Cyanobacterial blooms dominated the lake, chl-a concentrations remained low at approximately 10 ug/L compared to an adjacent control lake where chl-a concentrations varied between 20-87 ug/L.

The potential impacts of utilising ultrasonic irradiation to control Cyanobacteria upon other aquatic organisms are hitherto largely unknown. Ahn *et al.* (2007) reported that larger organisms (fishes and aquatic insects) did not seem to be affected by ultrasonication. Kotopoulis *et al.* (2009) found that acoustic pressures produced during ultrasonication surpassed the Nato Undersea Research Centre rules and procedures (NURC) by 35 dB, and cautioned the use of ultrasonication in aquatic environments.

The use of ultrasonic irradiation of Cyanobacterial cells appears to offer a potential strategy to control of Cyanobacterial growth in small lakes where lake water can be readily recirculated through an ultrasonic unit. Further research is required to determine how this strategy might best be applied to small lakes, and to the effects of ultrasonication on aquatic ecosystems and cyanotoxin release and decay.

Sediment removal

The removal of the upper sediment layers from the lake bottom is a commonly used strategy for removing phosphorus loads from highly eutrophic lakes. One of the advantages in removing the upper sediment layer is that any Cyanobacterial resting cells (e.g. akinetes) will be also be removed.

Sediment removal should be considered a "last resort" option for reducing the risk of Cyanobacterial growth in constructed lakes. The removal of sediments from a lake may have a profound influence upon benthic organisms,

including the removal of macrophytes and fauna from the lake. In addition, sediment removal is generally confined to small lakes due to the costs associated with the removal and disposal of the contaminated sediments.

The removal of upper sediment layers may not be an effective strategy for managing Cyanobacteria in constructed lakes, particularly where stormwater inputs contribute nutrient loads sufficient for Cyanobacterial growth to occur. Lake systems with high submerged macrophyte cover are particularly susceptible to sediment removal, as the ensuing turbidity following the sediment removal may inhibit macrophyte recolonisation, which results in the reversion of the lake to an algal/Cyanobacteria/Cyanobacterial-dominated state.

Sediment capping

Sediment capping of in situ sediments involves the placement of a cover over the sediment to seal it off, thereby minimising the release of contaminants (nutrients) to the water column (Hart et al., 2003). Sediment capping may involve placing a physical barrier over the sediment (e.g sand or gravel) or providing an active barrier (Hart et al., 2003).

Active barrier systems are generally pervious geochemical materials that are capable of actively demobilising contaminants in the sediment pore water by adsorption or precipitation processes. A number of active barrier systems have been tested in lakes including calcium carbonate, zeolites, modified clays and kaolin amorphous derivatives (Jacobs and Forstner, 1999; Hart et al., 2003).

Both sediment capping methods offer effective strategies for reducing phosphorus release from sediments. Generally, physical barriers need to be placed during construction or following drawdown of lake water levels. Active barrier systems can be very expensive to use, and there is little information available detailing the long term effectiveness of these systems. The use of sediment capping in constructed urban lakes is unlikely to be a successful long-term strategy for managing Cyanobacterial growth due to the influence of stormwater pollutant loads upon in lake water quality.

Phosphorus precipitation and inactivation

The strategy involves the use coagulants to reduce the overall available load of phosphorus available for Cyanobacterial growth. The coagulants are added to the lake water, where the coagulant binds to the bio-available phosphorus, then precipitates out of the water column as "flocs". The flocs settle down to the sediments where the phosphorus is effectively removed from the water column and locked up in a form that is unavailable for phytoplankton growth.

Coagulants commonly used to precipitate phosphorus within lakes include aluminium-sulphate, zirconium, iron and calcium salts, and some clay materials (Cooke, et al., 2005; Scheffer, 1998),

The effectiveness of coagulants in shallow lakes is generally low where macrophytes are present, or when the external loading of phosphorus (via stormwater) exceeds the phosphorus binding capacity of the coagulate (Welch and Cooke, 1999). The constant re-suspension of sediments due to wind action in shallow lakes also renders the use of coagulants ineffective.

Artificial destratification

Artificial destratification refers to the mixing of the hypolimnetic and epilimnetic layers within stratified lakes. Stratification generally occurs within deep lakes >5 m, although diurnal stratification will often occur in much shallower lakes.

Stratification occurs when a density gradient develops within the water column between the warmer upper layer (epilimnion) and the colder and denser bottom layer (hypolimnion). When lakes are stratified, the hypolimnion becomes depleted of oxygen and reducing conditions develop, releasing nutrients such as ammonia and phosphorus from the sediments. Under stratified conditions, Cyanobacterial species that are able to regulate their buoyancy are able to access both nutrients in the nutrient-rich hypolimnion and sunlight for photosynthesis in the epilimnion.

Aerators are commonly used in stratified lakes continually mix the water column, thus eliminating the competitive advantage of Cyanobacterial buoyancy over other non-buoyant algae (Reynolds et al., 1984). Whilst artificial destratification has been used successfully in Australia for controlling the release of nutrients from lake sediments, only limited success has been achieved controlling Cyanobacteria (McAuliffe and Rosich, 1990). It is expected that

improvements in destratification technology (e.g. mixer design) will increase mixing efficiency and improve the control of Cyanobacterial growth (Brookes et al., 2002).

Hypolimnetic withdrawal

Hypolimnetic withdrawal involves the removal of nutrient rich hypolimnetic water from stratified lakes (Nurnberg, 1987). The removal of hypolimnetic water effectively decreases phosphorus concentrations in the epilimnetic layers of stratified lake systems, thereby limiting the potential for excessive Cyanobacterial growth to occur (Nurnberg, 1987).

Hypolimnetic withdrawal is a widely used strategy for managing water quality (risk of Cyanobacterial growth) in a range lakes, varying in depth from 4.5 – 25 m (Cooke *et al.*, 2005). Hypolimnetic withdrawal is only applicable to lake systems where the amount of discharged water can be replaced with sufficient inflow, so that the water level remains constant (Cooke et al., 2005).

Whilst hypolimnetic withdrawal is a relatively simple and cost effective strategy, it is unlikely that this technique could be used to effectively manage water quality within constructed urban lakes. Most urban lakes have a shallow depth profile and are relatively well mixed (in some cases shallow lakes may also exhibit diurnal stratification). Furthermore, hydraulic retention times in urban lakes are usually high, and sufficient inflow is unlikely to be available in order to maintain constant water levels.

Constructed urban lakes which regularly exhibit stratification may benefit from hypolimnetic withdrawal, however due consideration would also need to be given to the disposal of the poor quality hypolimnetic water downstream.

Algicides

Chemical control of algal and Cyanobacterial growth within reservoirs has been a widespread water quality management practice for over 100 years (Burch et al., 2002).

The most common algicides used to control Cyanobacteria in reservoirs are copper sulfate or chelated forms of copper. These are extremely effective as they act rapidly and are toxic phytoplankton (and Cyanobacteria) at concentrations that do not represent a health risk to humans (Steffensen *et al.*, 1999). The chemical composition of the receiving water, particularly pH, alkalinity and dissolved organic carbon influence copper speciation and complexation, thus greatly influencing copper toxicity. Copper algicides are economical, easy to apply and are generally considered to not to cause extensive environmental damage (Burch et al., 2002).

Recent studies have shown however, that sediment bound copper and other heavy metals may impact benthic communities, zooplankton, fish and invertebrates. Copper is not biodegradable, and once it has entered the environment, its potential toxicity is controlled by its speciation or physico-chemical form (Burch et al., 2002). One of the major problems associated with the use of copper-based algicides to control Cyanobacterial growth is that copper lyses the algal cells, resulting in the release of intracellular toxins and other odorous compounds into the surrounding water (if present). This can exacerbate health risks to humans and other animals. Currently, there is little information on the minimum withholding period in relation to toxin degradation (Burch et al., 2002).

Other algicides used to control Cyanobacterial growth in lakes include potassium permanganate, simazine compounds, chlorine, lime and barley straw (Burch et al., 2002; House and Burch, 2002). Potassium permanganate, simazine and chlorine are lethal to algal cells and may result in the release of cyanotoxins. Lime is used as an algicide to coagulate and precipitate algal cells from the water column, and does not appear to cause cell lysis and toxin release (Burch et al., 2002). Recent studies have shown that the use of lime is most effective in hard water lakes (Murphy and Prepas, 1990), however dosing rates are quite high and this technique has not been extensively tested within Australian waters (considered soft waters) (Burch et al., 2002).

Considering the potential environmental and human health risks, the use of algicides is not recommended for the sustainable long-term management of Cyanobacterial growth in constructed lakes.

Biomanipulation

The biomanipulation method is often referred to as “top-down control”, and refers to the management of higher trophic organisms to maximise grazing of algae, and therefore a reduction in Cyanobacterial biomass in the lake system. There is no information on the use of biomanipulation to manage Cyanobacteria in constructed lakes.

In a review of 33 whole-lake biomanipulation experiments, Reynolds (1994) concluded that top-down effects on the lower trophic levels (phytoplankton) were inconclusive. Reynolds (2006) postulated that the manipulable linkages between phytoplankton, zooplankton, planktivorous fish and piscivores apply only to truly pelagic systems.

Boon et al. (1994) reviewed the potential use of top-down control of Cyanobacteria and concluded that zooplankton assemblages in Australian waters are quite different in composition from those of the Northern Hemisphere, and therefore unlikely to respond to manipulations of trophic structure in a similar way. The study concluded that the manipulation of trophic structure in Australian fresh waters to control Cyanobacterial blooms is therefore unlikely to be effective.

Floating macrophyte beds

Floating macrophyte beds have been increasingly used to manage water quality in lakes where other methods of water quality treatment may be constrained. This is particularly the case in many golf courses, where high nutrient concentrations in the stormwater runoff often stimulates excessive algal growth in the waterways.

The use of floating macrophytes has been widely used within the United States for well over 20 years to treat wastewater and stormwater runoff (Reddy and DeBusk, 1987). Floating macrophyte beds can be effective for managing algal growth in lakes as they remove bioavailable nutrients from the water column, thereby reducing nutrient availability to Cyanobacteria or other algae. Floating macrophyte beds are relatively simple and cost effective, and regular harvesting of the macrophytes serves to further reduce nutrient loads from the lake system.

Basil, tomato and silver beet plants growing in aquaponic units (floating plant beds) were recently trialled at Rio Tinto's Kestel Mine (Central Queensland) in order to control blue-green algal growth in a number of lake systems (Fabbro and Duivenvoorden, 2004; L. Fabbro pers. comm.). The research showed that the basil, tomato and silver beet plants were particularly effective at removing phosphorus and molybdenum from the water, essential elements that are required for Cyanobacterial growth (L. Fabbro pers. comm.).

The use of floating macrophyte beds offers a range of potential options for managing water quality in constructed urban lakes. Floating macrophyte beds could be used in situ (within the lake) or within dedicated bays as part of a lake recirculation system.

Sub-surface wetlands

Recirculating lake water through sub-surface flow wetlands may be an alternative option for removing Cyanobacterial biomass from lake systems. Sub-surface wetlands are most commonly used to treat municipal sewage, and also wastewaters from agriculture, industry and landfill, and less commonly to treat stormwater runoff.

Sub-surface wetlands remove a wide range of pollutants including nutrients, suspended solids and organic matter from the water by fine filtration, adsorption and biological processes (uptake, aerobic/anaerobic degradation, nitrification/denitrification) (Vymazal, 2005).

SC6.4.3.13 Townsville road hierarchy

SC6.4.3.13.1 Introduction

The Townsville road hierarchy is a planning tool to guide good-practice transport planning and management, with the aim of balancing the needs of both the land use and the roadway system. A road hierarchy establishes each roadway function such that appropriate objectives for that roadway and design criteria, can be developed and implemented. These objectives and design criteria are aimed at achieving an efficient road system whereby conflicts between the roadway and the adjacent land use are minimised, and the appropriate level of interaction between the roadway and land use is permitted. The road hierarchy also forms the basis of ongoing planning and system management aimed at reducing the conflict between existing incompatible functions.

The use of road hierarchy categories as part of the land use and transport network planning process enables optimisation of the relationships and key roles associated with accessibility, connectivity, amenity, and safety for all road/land users, including vehicles, bicycles, pedestrians, and public transport. The road hierarchy categories and sub-categories contained herein are pertinent and appropriate with the current transport environment in the Townsville area. As time passes, and the transport system and its relationship with land uses changes, these road hierarchy principles will require further development and refinement.

Editor's note—this sub-section deals mainly with issues relating to "Roads". Issues relating to "Streets" are dealt with in more detail in other parts of the Development manual planning scheme policy.

(1) Integrated Regional Transport Planning Framework

Integrated land use and transport planning must be embedded and applied in a wide range of circumstances – from strategic planning to detailed design for one mode or across all modes. This road hierarchy sub-section contains specific information for managing the interface between land use and roadway systems. This sub-section is to be used with regard for the overarching planning framework. The Integrated Regional Transport Planning (IRTP) Framework for Queensland (Queensland Government, 2003) is a preliminary transport planning guide that can provide the more general guidance not covered by this road hierarchy sub-section and has been adopted by Townsville City Council.

The IRTP Framework, applies to all facets of transport planning, including:

- (a) public transport, walking and cycling networks;
- (b) road upgrades;
- (c) new road, rail or multi-modal corridors;
- (d) heavy-vehicle safety and efficiency;
- (e) policy positions; and
- (f) entire local government areas or regions.

The IRTP Framework aims to:

- (a) reduce the need to travel and the length of trips;
- (b) provide a choice of travel options for people and goods, and promote sustainable choices;
- (c) make it safe and easy for people to access goods, services and destinations, particularly by public transport, walking and cycling;
- (d) increase the share of trips by public transport, walking and cycling;
- (e) provide for the safe and efficient delivery of freight;
- (f) minimise the need for new transport infrastructure; and
- (g) achieve desired outcomes using the most cost-effective package of measures.

(2) Structure of the road hierarchy

Based on the desired outcomes, directions and principles contained in the IRTP Framework, this sub-section establishes a four level road hierarchy that manages the interface between land use and roadway system and

guides system planning and management in urban and rural areas. Figure SC6.4.3.13.1 shows the basic structure of the four level road hierarchy, and the four levels are explored in more detail in SC6.4.3.13.3, and in SC6.4.3.13 Attachment A: Urban and rural traffic environments map, SC6.4.3.13 Attachment B.1: Road hierarchy elements and their objectives in urban areas, B.2: Road hierarchy elements and their objectives in rural areas, C.1: Townsville road hierarchy map (existing), C.2: Townsville road hierarchy map (future), D.1: Road hierarchy desirable performance criteria in urban areas and D.2: Road hierarchy desirable performance criteria in rural areas.

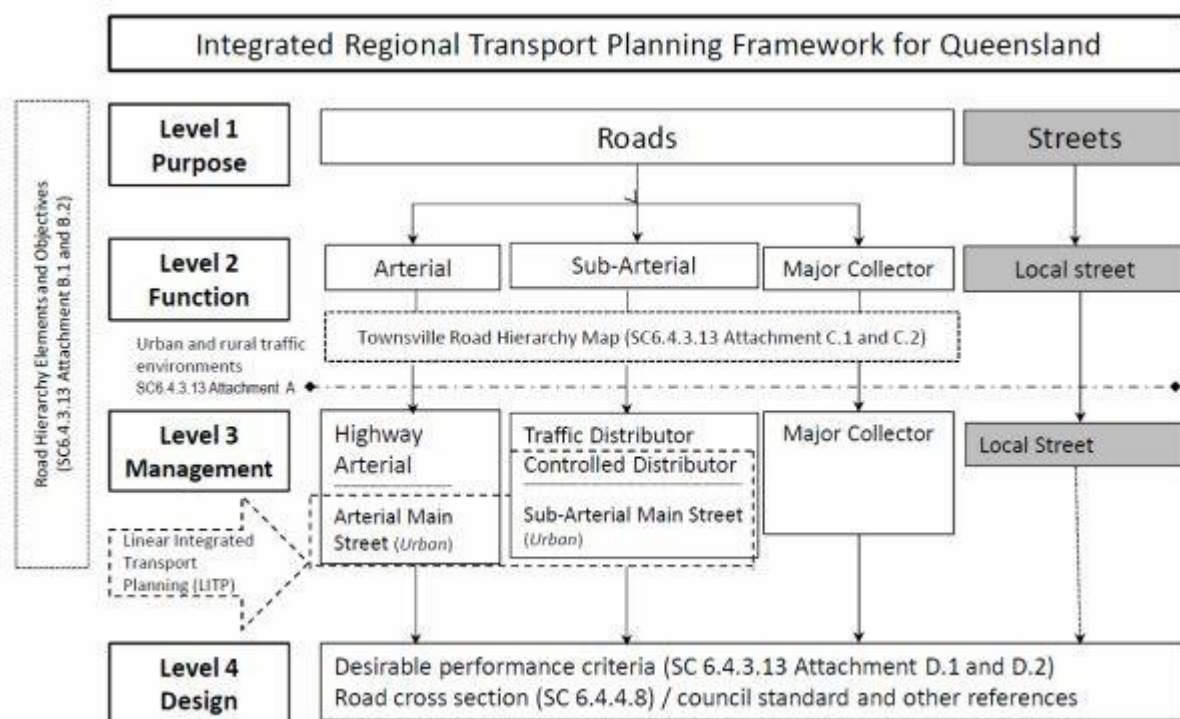


Figure SC6.4.3.13.1 Structure of the four level road hierarchy

(3) Road hierarchy objectives

The four level road hierarchy aims to meet the following objectives, and will assist council and the state government with meeting appropriate standards for roadway construction:

- (a) to systematically classify roads into a framework around which council and the state government can plan and implement various land use, infrastructure construction, maintenance, and management schemes and projects such as:
 - (i) identifying the effects of development decisions in and on surrounding areas and roadways within the hierarchy; and
 - (ii) developing design that facilitates urban design principles such as accessibility, connectivity, efficiency, amenity and safety;
- (b) to guide network planning and management for all modes (private, passenger and commercial/industrial transport) and users (motorised and non-motorised); and
- (c) to clarify policies and decisions in designing new networks and in managing existing road systems in order to provide a rational basis for management of the network under the current or future planning schemes, for example:
 - (i) enabling investment and traffic management efforts to be concentrated on those links able to cope efficiently with transport needs;
 - (ii) enabling council and the state government to adopt appropriate standards of construction on traffic routes; and
 - (iii) enabling the network to be optimised to accommodate access and non-transport functions.
- (d) The ways in which these objectives may be implemented within a well-formed road hierarchy include:

- (i) concentrating longer distance flow onto routes in less sensitive locations;
- (ii) ensuring land uses and activities that are incompatible with traffic flow are restricted from routes where traffic movement should predominate;
- (iii) preserving areas where through traffic is discouraged;
- (iv) identifying treatments such as barriers, buffers, and landscaping to preserve amenity for adjacent land uses;
- (v) ensuring activities most closely related to frontage development, including social interaction and parking, can be given more space when environmental and access functions are allowed to predominate;
- (vi) ensuring safe traffic operation by controlling access onto roads, and separating different types of traffic in higher order road corridors;
- (vii) ensuring efficient traffic operation for through traffic whilst designing new roads as part of a safe system approach;
- (viii) enabling the orderly planning of heavy vehicle and dangerous goods routes;
- (ix) planning for and providing public transport routes;
- (x) planning for and providing pedestrian and bicycle routes; and
- (xi) identifying facilities for pedestrians, cycles and public transport.

(4) Scope

This document is a planning tool for all road agencies and authorities involved in land use and transport planning/management processes in Townsville. The road hierarchy elements can be applied in areas such as:

- (a) planning – in designating a Strategic Transport Network for a region, consisting of roadways and other facilities for the movement of goods and people;
- (b) management - in designating and programming improvements to achieve the desirable performance criteria over time for each element of the road network;
- (c) environment – in managing the road network to facilitate efficient operation, which will assist in achieving environmental sustainability and improve amenity to the region's inhabitants;
- (d) safety – in managing the road network by controlling access onto traffic carrying roads, providing appropriate design standards, and proper use of the network by the vehicle fleet to facilitate safe movement of all road users; and
- (e) congestion management – in planning and managing the road network to ensure traffic volumes carried are appropriate to roadway functional and management attributes.

(5) Definition of urban and rural

The application of the road hierarchy requires the terms urban and rural to be defined for the purpose of this policy.

Urban

developed area which may comprise densely developed uses such as residential, commercial, industrial, education, recreation or a mix of these. In general, this is characterised by evenly spaced street lighting, kerbed streets, frequent closely spaced driveways (preferably none on traffic carrying roads). This will also include land designated for future urban development.

Rural

sparsely developed area which may comprise rural development, rural residential development, isolated pocket of urban development and environmental area. In general this is characterised by unkerbed streets, both sealed and unsealed roads, infrequent driveways and large tracts of undeveloped land. Street lighting may only be at intersections and points of safety concerns.

These terms do not necessarily align with definitions within legislation but relate to the character of the land for the purpose of providing access and thoroughfare. For the specific purpose of showing urban and rural traffic

environments for the Townsville road hierarchy, a map has been provided in SC6.4.3.13 Attachment A.

If a rural development is located in the adjacent urban fringe area or adjoined/contained a part of continuous existing network connection, it may be required to be designed similar to the adjacent road network environment, e.g. urban road cross section.

(6) Terminology

Category	Those elements of the road hierarchy defined at Level 2 of the road hierarchy.
DTMR	Department of Transport and Main Roads.
Environmental cell	Contains local streets with a slow speed and pedestrian priority environment, and generally bounded by major collector roads.
LITP	Linear Integrated Transport Plans: a means of planning between the roadway and the adjacent environment in an integrated manner.
MUTCD	<i>Manual of Uniform Traffic Control Devices.</i>
RPT	Regular public transport.
Specific cell	A part of the urban fabric that is contained within a block bordered by traffic carrying roads or other physical boundaries.
Sub-category	Those elements of the road hierarchy defined at Level 3 of the road hierarchy.
VPD	Vehicles per day.

SC6.4.3.13.2 General principles

(1) Network Linkage

Ideally, only roadway elements with the same place in the hierarchy, or one position higher or lower in Level 2 of the hierarchy, should intersect.

For example:

- (a) arterial roads should only intersect with sub arterial roads and other arterials;
- (b) sub-arterial roads should only intersect with arterials, other sub-arterials, or major collectors;
- (c) major collectors should only intersect with sub-arterials, other major collectors, or local streets; and
- (d) local streets should only intersect with collectors or other local streets.

However, road networks have evolved out of step with this linkage principle in practice.

In certain situations it may be acceptable for roadway categories separated by two positions within Level 2 of the hierarchy to intersect. For instance, a local street may intersect with a sub arterial road, or a collector with an arterial, without significant adverse ramifications. In other cases, a permeable grid local network creates too many street-road intersections, and some of these have to be blocked off to limit points of access for vehicles (creating cul-de-sacs). Paved footpath access into the local area for pedestrians and cyclists could be maintained, providing the desired pedestrian and cyclist access onto the arterial roads, without adverse impact on traffic flow, safety and local amenity.

It may even be acceptable for roadway categories separated by three positions in Level 2 of the hierarchy to intersect in certain cases. That is, a local street may intersect with an arterial road, provided it is not an uninterrupted flow facility, without significant adverse effects. This may be the case, for example, where a service road provides access directly to a two or four lane arterial road in an urban area, or two lane highway in a rural area.

Despite their development history and desired function in the road hierarchy, local streets may need to be compromised to provide connectivity for the public transport network.

(2) Size of precincts free from unwanted traffic

The spacing of arterials or traffic routes has the effect of defining the size of development areas that are penetrated only by streets. The size of these "cells" has a direct influence on issues such as the local traffic environment, whether or not "difficult traffic routes" can be avoided, the feasibility of sustaining low vehicle speeds in the local area, the number and frequency of connections to surrounding arterials, and access to bus routes around and through the area. Traffic should be distributed appropriately amongst the local streets to ensure that amenity levels are not exceeded and adequate connectivity is maintained.

The specific area and environmental cell concepts can be accommodated with relative ease as part of a new subdivision plan but it is often more difficult to impose the specific area concept onto an existing system. However, it is important to have a target in mind when assessing the requirements of the road systems in a particular area.

(a) Urban areas

While the size and shape of a specific area is commonly constrained by fixed elements such as existing infrastructure, topography and property boundaries, the idealised form is of the order of 1 km × 1 km for an urban specific area. This size would typically encompass four environmental cells, each 0.5 km × 0.5 km. The boundaries of the specific areas will be partially defined by the existing major road system, which in turn has generally been developed to a large extent as a result of historical events rather than recent planning initiatives. Other features may also be used as boundaries.

The aim is to define specific areas which:

- (i) are relatively homogeneous in land use;
- (ii) have only that traffic necessary for the functioning of the area, i.e. they are free of non-essential or through traffic; and
- (iii) have a balance between the volume of essential traffic and the nature of the area. For example, higher volumes may be more acceptable in industrial areas than in residential areas.

(b) Rural areas

While the specific area concept is most relevant to an urban area, it also applies to rural areas, although in a slightly different context. Specific areas in rural areas should be linked by a system of through traffic carrying roads. The dimensions and form of a specific area will vary in rural areas due to the reduced development densities. As a result, specific area sizes in rural areas will be significantly larger than in urban areas.

(3) Abutting development and access to it

Restriction of access points to abutting land uses is one of the key parameters in the road hierarchy. Decisions on access points to new developments are linked to the strategic function of the road and the types of traffic and trips that it serves, as well as the type of environment intended to result. The allocation of accesses as part of a management regime is not identical to a "road classification" system, but may supplement it.

Decisions on network types, especially at the local level, will have long-term effects on the traffic character of an area, and inevitably the quality of service on the surrounding traffic routes. The road hierarchy provides a means of classifying and designing a roadway according to its purpose, function and management. It is intended that this process be carried out within the constraints of the network, as it is imperative that corridor continuity be considered. Notwithstanding past decisions that have resulted in existing constraints, this may mean that corridor continuity may need to be targeted as a long term goal.

In addition to corridor continuity, future development potential should also be addressed in the road hierarchy. The planning scheme earmarks a considerable quantity of land for future urban development, industrial, commercial or residential. Classification of existing roadways in these areas should support future amendments to the hierarchy and the associated changes in performance criteria. For example, an existing road may currently serve a collector function, but as the area is subdivided into urban development in the future, the potential future function of the road may require allowances to be conformed at an earlier time so that the

performance criteria of its future function can be met.

It is important to note that some non-residential land uses such as schools, parks and local shops have to be located within or near the specific areas they serve. These may be accessed by a sub-arterial road, or, if this is not possible, it is desirable that they are accessed via a major collector road rather than the local street environment. The conflicting land use requirements in these circumstances mean that network considerations must be carefully examined in terms of connectivity, network efficiency and compatibility between private vehicle, public transport, non-motorised and freight networks. Integrated land use and hierarchical transport planning can overcome this shortcoming to a large extent.

(4) Relationships between networks

"Cells" may be sized and have access limited to manage entry of unwanted traffic. However, different networks will have different entry criteria. As mentioned in SC6.4.3.13.2(1) above, network linkage principles may vary between motorised vehicles and active transport modes such as public transport, pedestrian and bicycle. For example, passenger transport networks are often focused on middle order roads to balance point to point travel times, network reach, connectivity and passenger safety. Similarly, freight networks will be based on specific freight criteria and result in different networks for freight when compared to other traffic networks. In some areas, freight networks may enter into small industrial cells and utilise low order roads to access depots. The overlay of modal networks is a key consideration in establishing the functional category for a specific link in the road network.

SC6.4.3.13.3 Four level road hierarchy

A four level road hierarchy has been developed, based on the functional objectives of each category or sub-category within the hierarchy. Level 1 begins with a broad distinction between roads and streets, and the following three levels listed with an increasing degree of detail with respect to functional objectives. The Levels are defined as follows:

Level 1. Purpose relates to the primary objective of the element, whether to carry through traffic or provide direct property access.

Level 2. Function relates to the relationship between the roadway and land use it serves (i.e. how the roadway serves the land use). This level of the hierarchy is common to traditional road hierarchy concepts.

Level 3. Management relates to the implementation of policies to achieve the envisaged function based upon the attributes of the element and of the adjacent land uses.

Level 4. Design relates to specification of the form of the element in order to achieve its functional objectives.

Note—the relevant standard drawings include SD-002 Typical Road Cross Sections – Collector Roads , SD-003 Typical Road Cross Sections – Sub Arterial Roads and SD-004 Typical Road Cross Sections – Arterial Roads.

(1) Hierarchy Level 1 - Purpose

Level 1 of the hierarchy defines roadways as either:

- (a) roads to carry through traffic; or
- (b) streets for access to property and collection of local traffic.

This classification applies to both rural and urban areas.

The definition of a roadway in one particular category serves to indicate a planning intent in relation to the functions that will be permitted on that roadway. Thus, measures are likely to be adopted on streets that relate to amenity and environmental capacity, for example, by removal of through traffic, or direction of local traffic to a particular collector road. At the other end of the scale, treatments on arterial roads will principally be related to increasing traffic carrying capacity. This would tend to be by removal of some incompatible lower order functions, such as limiting access to properties, disallowing any further new accesses, or reducing the number of intersecting roads.

Figure SC6.4.3.13.2 below illustrates the relationship between traffic mobility and land access in a functionally

classified roadway system.

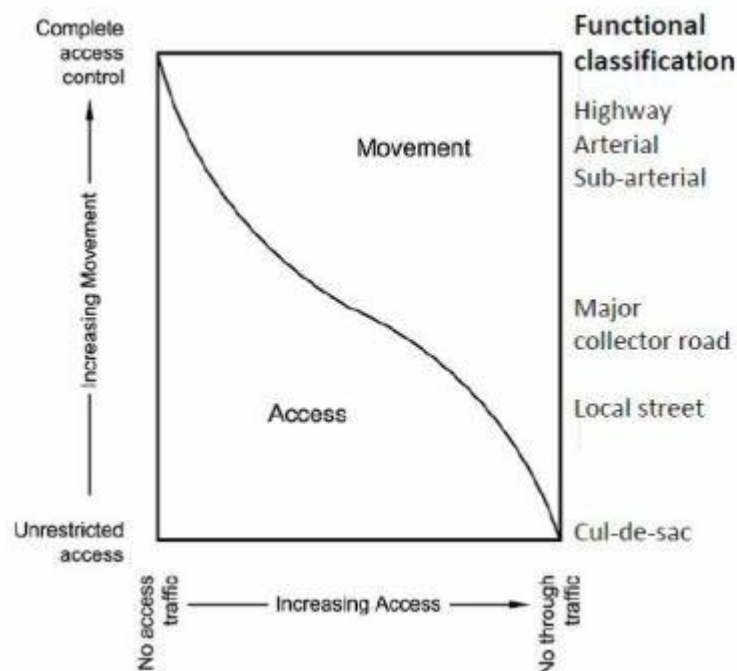


Figure SC6.4.3.13.2 Relationship between traffic mobility and accessibility

Source: Adapted from a figure in NCHRP Report 348, Access management Policies and Guidelines for Activity Centres, Transportation Research Board, Washington DC, 1993.

Note—the functional classification has been modified to suit the Townsville context.

(2) Hierarchy Level 2 - Function

Within the two broad groups of roads and streets in the first level of the hierarchy, four functional roadway categories have been identified, reflecting the different ways in which they serve land use and carry traffic.

The functional classification indicates the relative importance of the traffic mobility function as opposed to the amenity/access functions, and how these conflicting aims are to be prioritised and managed.

The four functional categories in Level 2 of the hierarchy are:

- arterial road – to carry long distance through traffic external to specific areas;
- sub arterial road – to carry through traffic between specific areas and arterial roads in a supporting role to the latter;
- collector road – to provide connectivity between the environmental cells and the traffic carrying road and to provide grouped property access; and
- local street – to provide direct property access and immediate local movements.

Based on the current and future land use zoning in the Townsville City Plan, the Townsville road hierarchy map (see SC6.4.3.13 Attachment C.1 Townsville road hierarchy map (existing) and SC6.4.3.13 Attachment C.2 Townsville road hierarchy map (future)) has been developed all Level 2 categories. To enable easier application of the road hierarchy, the same overarching objectives and category names have been applied for both urban and rural areas. It should be noted that some links are identified as a conceptual location with respect to spacing, hierarchical connectivity and continuation of links between start and end points. Therefore, if significant development is planned to occur in a large or multiple parcels of undeveloped land in either an urban or rural area, then it may be necessary to reassess that area road hierarchy plan within a whole network.

(a) Arterial road

The primary objective of arterial roads is to provide major through routes for traffic. All longer distance traffic movements should be directed onto the arterial roads. Arterial roads should form a principal

connection between major regional centres and towns. It can also serve a line haul function for public transport. Arterial roads will often be elements of the various networks with high order functions. For instance, the network of over dimension freight routes is likely to be primarily on arterial roads.

These corridors should provide for regional cycle movements, but travel speed, volume and composition is such that cycle movements should desirably be kept separate from general traffic. In general, arterial roads have high design standards for efficiency and no direct frontage access.

In rural areas it is recognised that many arterial roads have direct property access. This results from the large size of properties, the reality of limited road infrastructure and the infrequent number of vehicles with direct access. On such roadways the main goal is to provide a highly efficient traffic flow (increased speed and increased capacity), balanced with safe access.

For all arterial roads it is desirable that, over time, no new accesses are permitted and that existing accesses be removed, or at least consolidated, or turning movement restricted.

(b) Sub-arterial road

Sub-arterial roads carry through traffic and should be more convenient than using the "streets" network; therefore a high level of efficiency and safety should be provided. In general, sub-arterials do not serve the longer distance regional movements and do not provide continuity across arterials. However, they do serve to provide connections between arterial roads and may be used to provide such additional connections for through movements.

In urban areas, sub-arterial roads typically provide connection between residential, commercial or industrial areas and arterial roads. They will normally be the lowest order of road to be traversed by scheduled public transport in performing a line haul function. They may also serve to provide access to public transport at stops. These corridors may provide for cycle and pedestrian connections between local areas and the regional cycle system (if such exists). These connections would preferably be bicycle lanes on the shoulder or outer lane of sub-arterial roads rather than on the roadway with general traffic. These roads can provide consolidated access to commercial and retail developments and as a result can also cater for pedestrian movements, especially in the vicinity of such developments. The provision of consolidated access allows for turning movements to be focussed at specific, controlled locations rather than at high frequency along the roadway, thus minimising interruptions to through traffic.

In rural areas, sub-arterial roads in particular provide connections between adjacent suburbs and/or between arterials. Access may also occur, and be necessary, but these will be more widely spaced due to the larger lots.

(c) Major collector road

The objective of collector roads is to provide for the connection between the local area (local streets) and the traffic carrying roads. The form of linkage provided should predicate against the usage of collector roads within a particular area by longer distance traffic unless the trip is relevant to the area. In residential areas particularly, amenity and safety should be the most important consideration, as these roads are also intended to provide direct access to grouped properties, commercial premises, schools or community facilities.

These roads will carry public transport operating in a sweeper role, and these are likely to be school bus routes. It is necessary to ensure that the connectivity to achieve an efficient bus route does not encourage penetration by through traffic. Typically, scheduled bus routes would begin a service on collector roads, as a sweeper service, and then move to higher order links in the bus network to run as limited stop or express services.

As these roads serve as access to adjacent grouped properties, whether in residential or commercial/industrial areas, pedestrian movements need to be accommodated off the roadway. Traffic volumes should be balanced to accommodate local cycle movements on the road, and road design should create a safe environment for these vulnerable road users.

(d) Local street

The objective of local streets is to provide access to properties. In residential areas, these should be in a form to encourage a liveable and safe street environment where the motor vehicle is secondary to the pedestrian and cyclist. Through traffic should be discouraged on these streets and a lower speed environment is desirable for safety. Given the low traffic volume and potentially lower speed environment, it is appropriate for cyclists and pedestrians to share the road space. Similarly, specific facilities for pedestrians (crossings or concrete footpaths) are generally not required due to low traffic volumes and speeds. However, depending on the degree of abutting land use activity or pathway network planning, concrete pathways would provide for safety and a continuation of the pathway network.

The role of collector and local streets is complicated further as all freight, and motorised and non-motorised passenger networks can ultimately operate on these roadways, often without specific treatments.

(3) Hierarchy Level 3 - Management

Ideally, all roadways within the same category of Level 2 would be treated in the same manner. This may be achievable in a new development but existing situations or other constraints often dictate that a variety of treatments need to be available. These situations may arise for a number of reasons, not the least of which is the mixture of access and traffic functions already prevalent on many roadways.

Level 3 manages these issues through splitting the Level 2 categories into sub categories, which relate to more particular attributes of the roadway. Each sub category has objectives that are more specific than the category objectives for Level 2. The management sub categories are described broadly as follows (listed under each Level 2 category):

Arterial road

- Highway - serves longer distance movements as well as regionally and nationally significant movements. (A motorway is a highway that provides for a very high standard of travel by restricting non-motorised traffic and using only grade separated intersections.).
- Arterial - caters for longer distance movements, for example, connections between major centres.
- Arterial Main Street - caters for through traffic and, due to past land use decisions, serves adjacent retail/commercial land uses. This sub category is included in order to acknowledge its existence, and to provide for special cases, but it is not an option recommended for the future due to the difficulties of managing the conflicting access and mobility functions.

Sub-arterial road

- Traffic distributor - connects traffic generated in specific areas to the arterial roads and provides access to major developments.
- Controlled distributor - serves a similar function to traffic distributors but needs to be controlled for a particular reason, for example, it may provide frequent access for existing individual residential properties.
- Sub-arterial main street - connects traffic generated in specific areas to the arterial roads and, due to past land use decisions, serves adjacent retail/commercial land uses. This sub category is included in order to acknowledge its existence, and to provide for special cases, but it is not an option recommended for the future due to the difficulties of managing the conflicting access and mobility functions.

Major collector road

- Major collector - provides a connection between the other streets in a specific area and the traffic carrying roads, and provides access to large sites with restricted or controlled access (for example, schools, shops and multi-unit residential developments).

Local street

- Provides a connection between the other streets in a specific area and the low traffic carrying streets, i.e. less than 3,000 vpd. As it has low traffic volumes, a lower speed or a shorter length, it is better suited to

providing access to individual properties. It also provides pedestrian and recreation use service with a local traffic or pedestrian priority.

It should be noted that the arterial main street and sub arterial main street sub categories have been excluded from rural areas on the basis that these are characterised by adjacent land use/activities that are associated with urban development.

(a) Performance criteria

The preceding sections and SC6.4.3.13 Attachment B.1 and SC6.4.3.13 B.2 identify individual road hierarchy categories and their functional objectives. For the hierarchy to be an effective planning tool, means of achieving these objectives need to be identified. This has been done by specifying desirable performance criteria for each classification in Level 3 of the road hierarchy framework. It is apparent that for some management categories, a distinction needs to be drawn, with respect to performance criteria, between roadways in an urban or rural environment. Accordingly, the thresholds of the performance criteria differ between the urban and rural areas for Level 4 of the road hierarchy.

The desirable performance criteria are subdivided into three groups and described below.

(i) Functional Characteristics specify the functions or functional aspects of a roadway element.

- (A) dominant linkage – what type of areas should the roadway provide service to/from;
- (B) traffic carrying function – whilst volumes are not intended to define the category into which the roadway falls, this criterion provides some guidance as to the maximum volumes anticipated. These maximum volumes may not be met in non-urban areas due to the low density of development;
- (C) residential, commercial, industrial access – what degree of access to each of the land use types is appropriate;
- (D) desirable traffic speed environment – the desirable speed anticipated. This is not intended to define the maximum speed limit, which should be done in accordance with the MUTCD;
- (A) heavy vehicle movement – whether the roadway is appropriate for heavy vehicles, other than for local access. Note that heavy vehicle volume will be important in defining road pavement and design form;
- (B) dangerous goods movement – whether the roadway is appropriate for the passage of dangerous goods vehicles, other than for local access;
- (C) public transport facilities – what role should the roadway serve for public transport (consistent with any public transport network planning);
- (D) cycle facilities – what type of cycle facilities should be provided in the roadway corridor (consistent with any bikeway network planning). Cycle facilities would only be provided where sufficient demand is proven; and
- (E) paved footpath – what type of paved footpaths (not for crossing the roadway) should be provided along the roadway. These should only be provided to satisfy a proven demand.

Note—the term paved footpath refers to a paved concrete footpath as per council standard.

The desirable performance criteria for these functional characteristics have been set to ensure the network operates effectively, efficiently and safely for its users.

(ii) Frictional Characteristics relate to the way roadside activity affects traffic use.

- (A) access control – constraints imposed on direct access to adjacent development sites;
- (B) parking provision – what provision for parking within the road reserve is appropriate;
- (C) bus stopping provision – what provision for bus stops within the road reserve should be made

Note—indented bays also refer to bays which are clear of the through lanes as per council standard.

- (D) pedestrian crossings – what type of facilities should be provided to allow pedestrians and

cyclists to cross the roadway, for example, signalised crossings, zebra crossings or pedestrian refuge islands;

Note—crossings must meet council standards and MUTCD guidelines.

- (E) typical intersection spacing – the typical distance between successive intersections along that roadway;

Note—generally, 300m intersection spacing is not favourable for a corridor signal coordination plan.

- (F) preferred intersection treatments – what form of intersection control is appropriate where the roadway intersects another of equal or higher classification; and
- (G) number of traffic lanes – what function of road hierarchy and ultimate traffic demand should be considered.

Note—a road cross section is identified in terms of a type of kerb and channel, divided or undivided carriageways, parking, bike lanes and verge in Level 4 of the hierarchy (see SC6.4.3.13 Attachment D.1 and SC6.4.3.13 D.2).

The desirable performance criteria for these frictional characteristics are set with the intent of improving the efficiency of traffic flow and thus reducing its environmental consequences, in balance with access needs.

- (iii) Impact characteristics relate to the relationship between a roadway element and amenity for adjacent land use:

- (A) abutting land use types – in general, what type of land use would be appropriate or compatible with the roadway function; and
- (B) land use impact amelioration – in general, what type of measures are appropriate on this roadway to reduce the immediate social and environmental impacts of traffic. Such treatments include barriers (fences, walls), buffers (vegetation), setbacks (distance to property lines and/or building fascias), streetscaping and environmental street design.

To achieve the desired traffic levels and conditions, a combination of actions will often be necessary to reduce traffic flows on some elements of the network and to increase traffic flows on other elements of the network. In order to minimise the use of lower order roads, such as local residential streets, it will be necessary to manage arterial roads in a way that makes their use more attractive than the lower order roads. Lower order roads must then be managed in a way that discourages traffic through environmental street design, such as street closures, street element length and design speed. If reactivity treatments are applied in existing areas, they must be undertaken on an area-wide basis to ensure that problems are not simply shifted from one street to another.

The desirable performance criteria for these impact characteristics are set with the intent of reducing negative social and environmental impacts of traffic flow on adjacent land uses.

The impact characteristics are important in making the adjacent land use areas more liveable and to address issues associated with the social interaction between transport and land use. Level 3 management principles for urban and rural roads are reflected in the design principles in Level 4 of the road hierarchy.

- (b) Linear integrated transport plans (LITP)

There may be cases where a roadway does not readily fit into any category within the road hierarchy, due to incompatibility with the performance criteria. Under these cases, it is recommended that an LITP be developed specifically for the roadway under consideration. For example, with a key public transport corridor such as Ross River Road and Charters Towers Road, there is a need to satisfy both the traffic carrying roadway objectives, as well as the access and amenity to adjacent properties objectives. Each LITP will need to assess the roadway under consideration on an individual basis, and will therefore have

to satisfy individually tailored criteria. Figure SC6.4.3.13.3 below describes a general methodology for developing an LITP.

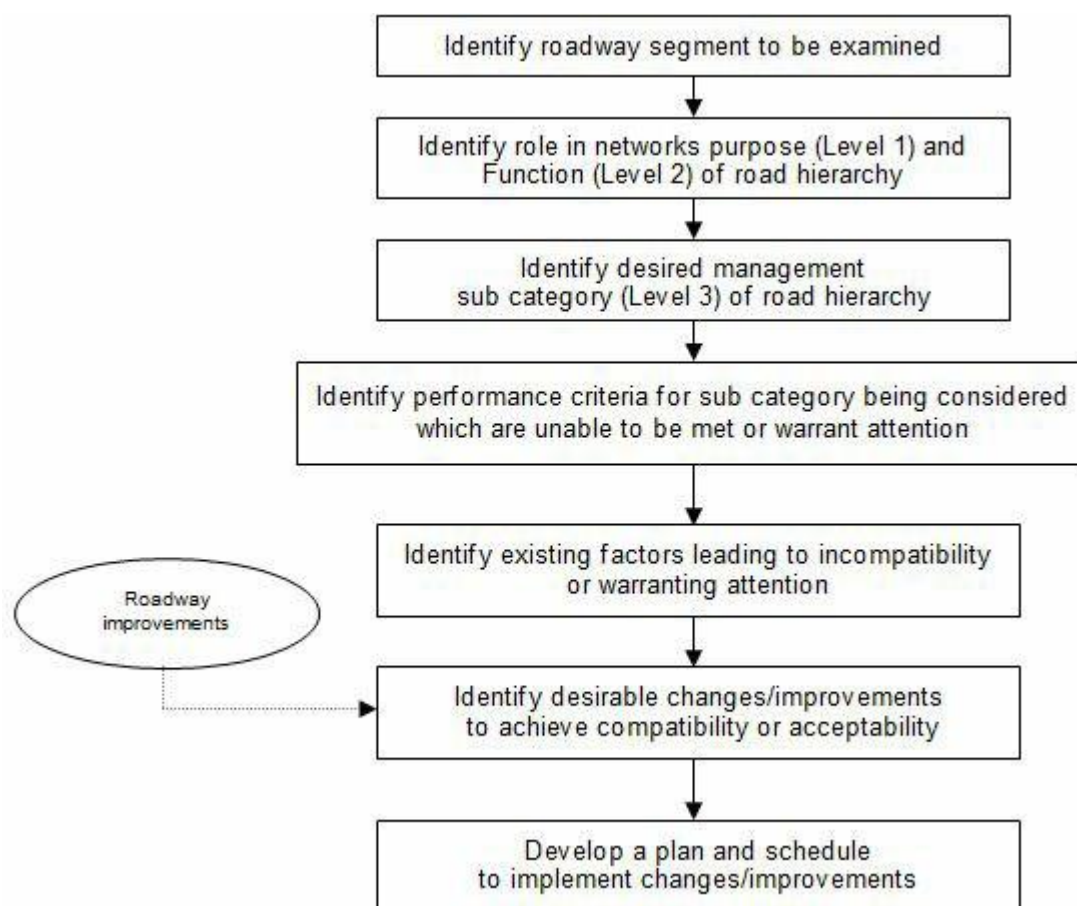


Figure SC6.4.3.13.3 Linear integrated transport planning (LITP) process

(4) Hierarchy Level 4 - Design

The fourth level of the road hierarchy framework relates to specific design criteria that are applicable to each sub category in Level 3. Level 4 aims to provide the tools with which to specify the form required of individual road hierarchy elements in order that they achieve their functional objectives. The roadway design should meet safety objectives as well as capacity and amenity objectives, where relevant. In conjunction with Level 3 objectives, it should also dictate the type of facility and design form for pedestrians, cyclists and public transport.

For each roadway, there are design elements that combine to produce a cross section or form for the roadway. SC6.4.3.13 Attachment D.1 and SC6.4.3.13 Attachment D.2 provide a set of desirable performance criteria for urban and rural areas and SC6.4.4.8 Standard drawings also includes a set of road cross sections. The design elements identified are those applicable to the road cross section away from intersections (i.e. mid-block cross section). Intersection requirements will dictate other specifications. For example, widening at intersections and future planning are an important part of defining these overall requirements. These design element details and the cross sections have been prepared for new roadways; council recognises that there will need to be variations to this to suit existing roadways (i.e. existing road forms and existing road reserve widths) in the process of network design.

It is important to note that the Level 4 specifications represent preferable specifications. There will be other constraints (e.g. topography, role in the range of networks, existing land uses, road reserve, and physical elements), which mean that the specifications may be varied from time to time. Whilst this flexibility needs to exist, it is important to keep an appropriate balance between mandatory standards, desirable objectives and constraints in order to develop an appropriate road form for each individual situation whilst still maintaining some consistency in the overall road network. The objectives and performance criteria should be maintained wherever possible.

In any case, all design criteria should be considered in line with relevant documents and proper guidelines, for example, other parts of the Development manual planning scheme policy, DTMR guidelines, AUSTROADS, MUTCD, Australian Standards, Queensland Streets, and Complete Streets for the local street level.

Note—posted speed limits are to be designated in accordance with the MUTCD-Part 4, and are required to be approved by council.

(a) Arterial

Administrative responsibility for roads is based on historical and political decisions as well as function within the hierarchy. Highways are administered by DTMR. The need to combine local activity planning with road planning could lead to greater local government involvement in the management of Arterial main streets. Arterials span these areas and responsibility may lie with either the state or local government.

Highway/motorway in urban/rural areas

These roads serve regionally and nationally significant movements and longer distance movements. To provide for a high standard of travel, speed environments of 100km/h or more are desirable, together with no frontage access. If frontage access does occur, then elimination of direct access from the abutting land use should be pursued.

These roads should also provide the primary freight routes and dangerous goods routes, and carry coach traffic between centres and regular public transport (RPT) bus traffic under a line haul mode. Any pedestrian and cycle facilities in urban areas should be located separately from the carriageways and protected accordingly. Crossing provisions should be grade separated. Grade separated intersections are desirable for all facilities in this category, although this will essentially be driven by volume demand or safety issues rather than hierarchy.

The road reserve width will often be dictated by the need for adjacent service roads, buffer zones and ancillary uses in the road corridor (e.g. cycle facilities, bus lanes). Divided carriageways are desirable to optimise safety and driver comfort. However, a two lane undivided cross section may be appropriate for low traffic volumes on a rural highway, provided there are sufficient overtaking opportunities. Whilst cycle facilities, pedestrian paths and bus lanes may be provided in the overall corridor, these facilities should desirably be separated from the through roadway and therefore represent an additional carriageway within the overall corridor. In rural areas, it is recognised that the demand for these adjacent facilities will generally be low.

Abutting land use types should be non-sensitive to vehicular traffic and generally not have frontage or direct access to the roadway. Uses associated with traffic such as highway service centres with amenities may be deemed appropriate in some locations based upon a needs assessment. In such cases, these would be provided with high quality direct access. Design standards for highways will primarily be set according to a high design speed and to maximise road user safety. In particular, the provision of wider shoulders is important in high speed locations.

In urban areas, grade separated intersections on urban roadways should be spaced at least 2 km apart. Intersections at grade on existing highways should be spaced no less than 1 km apart and are generally found to be between 1 km and 2 km apart.

In rural areas, if some land use provides for frontage access due to historic events, then any works undertaken to reduce this frontage access will enhance the traffic carrying capability of the highway in terms of both volume and speed. Whilst volumes may be low, the high traffic speeds mean that safety issues are important at access locations and reductions in the frequency of accesses will reduce the crash rate. Provision of pedestrian and cycle facilities will generally be related to demand and the need for a link associated with network planning. Grade separated intersections should be spaced between 4 km and 8 km, with a maximum spacing of 12 km.

Arterial in urban/rural

Arterials cater for external or intra-regional traffic and traffic between suburbs or major centres. These facilities should preferably have no direct access for all land uses. However, they often do have direct

accesses due to past land use decisions, so longer term access limitations and land use amalgamation should be pursued so that the traffic carrying role can be progressively enhanced.

The design standards are set to achieve a balance between safety and efficiency. In this case, spacing of intersections will often control the design speed and hence other design elements. There will be many existing situations where the road design is constrained by elements such as the road reserve, property access and road width. In such situations, an individual design form will need to be developed to suit the constraints, whilst still achieving the arterial road objectives.

The policy is to pursue no direct access from individual properties to arterial roads. Examples of alternative treatments include:

- (i) side street entry to corner blocks; and/or
- (ii) combining driveways; and/or
- (iii) creating rear lane access; and/or
- (iv) creating easements to service multiple properties.

To facilitate efficient traffic movement, a higher speed environment is desirable. Limits of 80 km/h for new arterial roads and 70 km/h for existing arterial roads and where physical constraints exist in urban areas, and up to 100 km/h in rural areas are recommended. Speeds in excess of the above stated speed are generally not appropriate with intersections at grade and high traffic volumes.

These roads may provide the primary freight routes and often provide secondary freight routes. Selected routes may be appropriate for dangerous goods movement. They accommodate inter urban and inter centre coach traffic and RPT bus traffic under a line haul mode with priority treatment. Any bus stops should be separate from the through traffic lanes.

Pedestrians should preferably be located separately from the carriageways, and pedestrian crossings provided at signalised points. Cycle facilities can be provided in exclusive bike lanes or on the road shoulder on roads with a speed limit less than 80 km/h, provided AUSTROADS guidelines are met. In locations where the speed limit is higher than 80 km/h, and where a high percentage of school cyclists are likely, or where there is a cycle accident history or identified potential, consideration should be given to locating these facilities separate from the carriageway.

A number of traffic lanes have to be acquired, with a minimum of a four to six lane carriageway for ultimate traffic growth, and provision made for a proper width to cater for kerb and channel, medians, bus stops and bike lanes. For the interim, a two lane undivided cross section may be appropriate for a low traffic volume environment whilst achieving affordability, sufficient overtaking opportunities, vehicle breakdown, stopping or turning vehicles and bicycles. However, divided carriageways are desirable to optimise safety and driver comfort.

The abutting land use should preferably be less noise sensitive, or alternatively should include building and site designs that minimise impacts from adjacent traffic flows.

In urban areas, intersections are generally configured at grade for this sub-category. Signalised or roundabout control is generally appropriate although high volumes may necessitate grade separation. Intersections should be spaced a minimum of 500 m apart.

In rural areas, direct access can be tolerated due to low volumes and limited frequency. However, appropriate safety levels must be achieved and the aim should be to remove such accesses over time. Intersections are generally configured at grade for this sub-category. Priority control is generally appropriate and intersections should be spaced a minimum of 1km apart due to the higher speed environments. However, a proper intersection type has to be assessed and determined using traffic analysis.

Arterial main street in urban areas

This category is directed at existing situations in urban areas, including villages, where a group of commercial land uses exists, generally on both sides of an arterial road. In these situations a decision

needs to be made, dependent on the value of these uses, whether the traffic carrying and access functions should coexist, or whether a bypass or parallel route upgrade is warranted. If it is decided that these functions should coexist, whether in the short or long term, measures will need to be developed as part of an LITP to address this mix.

These design standards are primarily aimed at safety and ensuring pedestrian mobility in conjunction with parking and vehicle access. Traffic volumes may be so high that amenity to roadside activities is limited. However, as these are arterial roads, traffic volumes should not be moderated except by bypassing where feasible.

Speeds on these facilities should be kept sufficiently low to provide for safe pedestrian crossing at controlled points and to maintain environmental amenity for adjacent land uses, but still allow for efficient traffic movement. These roads should provide for pedestrian movement on both sides with crossing at controlled points, and with bicycle lanes on the road to avoid mixing with denser pedestrian traffic.

Limiting the frequency of property access is important for the traffic carrying capacity and also for the amenity levels associated with significant pedestrian traffic in the 'main street precinct'. Streetscaping would assist in ameliorating visual and audible land use impacts.

A number of traffic lanes will have to be acquired to enable four lane or six lane carriageways (if a corridor is likely to take a key public transport route associated with the adjacent land use, e.g. potential exclusive PT lane) for ultimate traffic growth and provision made for proper width to cater for kerb and channel, medians, indented bus bays to reduce delay to through traffic and bike lanes. Opportunities should be sought to bypass freight movements. This category is generally inappropriate as a dangerous goods route.

Intersections may be closely spaced along these facilities due to past planning and land use decisions. Desirably, to avoid queue interaction, intersections should be spaced a minimum of 150m apart.

This sub category is included in order to acknowledge its existence, and to provide for special cases, but it is not an option recommended for the future due to the difficulties of managing the conflicting access and mobility functions. Within the rural road hierarchy, "Arterial Main Street" is not considered appropriate.

(b) Sub arterial road design standards

(i) Traffic distributor in urban/rural

These traffic carrying roads are the key supplement to the arterial road network. They should connect between arterials and specific areas and should be more convenient than using the internal streets. Consequently, a higher level of efficiency and safety should be provided. Volumes are carrying preferably up to 25,000 vpd for amenity, as abutting land uses should be non-sensitive.

To make these roadways more attractive than internal streets, a higher speed environment is desirable. Speed environments of between 70 km/h~80 km/h in urban and up to 100 km/h in rural areas are recommended. The policy is to pursue no direct access to individual properties.

Examples of treatments include:

- (A) side street entry to corner blocks;
- (B) combining driveways;
- (C) creating rear lane access;
- (D) creating easements to service multiple properties.

In the preferred design form, access should be restricted and be managed through treatments such as amalgamated entry points or side streets as discussed above. This would be the treatment pursued as part of any new development. Access for major developments, multi-unit

dwelling, schools, child care centres, and/or commercial uses may be provided along these routes, provided it is controlled through channelisation or signals.

These roads may serve as secondary freight routes. Nominated routes may be appropriate for dangerous goods movement. They could accommodate RPT traffic under a sweeper mode. Any bus stops should be located separately from the through traffic lanes.

In most circumstances, specific provision for control of pedestrian movements should be provided and roadside parking will be discouraged. Usually, the prime concern will be the movement of traffic, so traffic management techniques could be applied (such as access minimised by consolidation of development accesses or side road access to sites). Noise and visual amenity impacts on surrounding uses should be managed through site considerations and/or road treatments.

Cycle facilities can be provided in exclusive bike lanes or on the road shoulder on roads with a speed limit less than 80 km/h, provided AUSTROADS guidelines are met. In locations where the speed limit is higher than 80 km/h, where a high percentage of school cyclists are likely or where there is a cycle accident history or identified potential, consideration should be given to locating these facilities separate from the carriageway.

A number of traffic lanes have to be acquired, with a four lane carriageway for ultimate traffic growth, and provision made for a proper width to cater for kerb and channel, medians, bus stops and bike lanes. For the interim, a two-lane undivided cross section may be appropriate for a low traffic volume environment whilst achieving affordability, sufficient overtaking opportunities, vehicle breakdown, stopping or turning vehicles and bicycles. However, divided carriageways are desirable to optimise safety and driver comfort.

In urban areas, paved footpaths are required on one or both sides depending on the demand of pathway usage to abutting land use and traffic facilities (e.g. bus stops) with pedestrian crossings at controlled points. Intersections at grade are appropriate for this management type. Signalised or roundabout control is generally appropriate although priority controlled intersections may be acceptable; this will be determined by a traffic analysis study. Intersections are typically spaced 250~400m apart.

In non-urban areas, although access is restricted in the preferred design form, individual lot accesses are acceptable, particularly if the access points are widely spaced and properties are well set back. Pathways are only required where the road serves an identified pedestrian linkage, with pedestrian crossings at controlled points. Roundabouts or priority control are generally appropriate, although this will be determined by a traffic analysis study.

(ii) **Controlled distributor in urban/rural**

The hierarchical objective of this sub-category is to maintain the traffic carrying function as a primary role but also to allow frontage and parking (with appropriate conditions) to achieve an environment whereby "overlooking" can enhance personal safety. The controlled distributor should be used where adjacent frontage development exists, or is planned. It can be expected to be used where residences are within reasonable walking and cycling distance of regularly accessed community destinations, e.g. schools, shops.

A number of traffic lanes have to be acquired, with a four lane carriageway for ultimate traffic growth and provision made for a proper width to cater for kerb and channel, medians, bus stops and bike lanes. For the interim, a two lane undivided cross section may be appropriate for a low traffic volume environment whilst achieving affordability, sufficient overtaking opportunities, vehicle breakdown, stopping and turning vehicles and bicycles. However, divided carriageways are desirable to optimise safety and driver comfort.

To satisfy the competing demands of traffic carrying efficiency and property access/on street parking, it is important to separate parked cars and turning vehicles from the through traffic lanes.

This will require carriageway widths greater than a traffic distributor. The verge widths need to include landscaping, pathways and separation. This will be an important factor in subdivision planning when determining the lot layout and road reserve needs.

These design standards are primarily aimed at safety and ensuring pedestrian mobility in conjunction with parking and vehicle access.

In the conventional sub-arterial design case it is desirable to have no direct access to individual properties; however, consolidated access along the controlled distributor would be acceptable if the appropriate form of traffic control can be provided at these points.

This category of road is a response to relatively unique situations and often evolves as a result of previous planning decisions. By definition, these are roads where an aspect such as speed or vehicle composition up to 20,000 vpd is controlled. Such control may be:

- (A) limiting speed to 60 km/h where frequent direct residential or commercial frontage exists;
- (B) limiting volumes to avoid excessive pressure on abutting land uses;
- (C) limiting heavy vehicle usage to protect the amenity of abutting uses; and
- (D) limiting speed and/or usage of particular vehicle types where alignment constraints exist.

On roads where frequent access to adjacent land uses exists and cannot be removed or consolidated, measures should seek to achieve safe access while retaining the convenience and efficiency of the route for through traffic. This may include a lower speed environment, but it should not be so low as to cause rat running elsewhere, for example, 60 km/hr in urban areas and 60~80 km/h in rural areas. Other measures could include the protection of adjacent parking by indented bays, bicycle paths, and landscaping. A longer term aim should be to reduce access if opportunities arise.

Access for individual lots should be controlled using one or more of the following measures:

- central median (no right turns) ;
- turning lane separate from through traffic lane;
- large lot frontage;
- lot layout to avoid on street visitor parking (large lots); and
- adjacent properties having adjacent driveways.

When a road is designated as a controlled distributor, an LITP should be prepared to identify the need to control any aspect(s) of this road, and the most appropriate form(s) of control.

(iii) **Sub arterial main street in urban areas**

This category is directed at situations where a group of commercial land uses exists, generally on both sides of a sub arterial road. On these stretches of road a decision needs to be made, dependent on the value of these uses, whether the traffic carrying and access functions should coexist, or whether a bypass or parallel route upgrade is warranted.

If the traffic carrying and access functions need to, or should coexist, whether in the shorter or longer term, management measures will need to be developed as part of an LITP to address the coexistence of these two functions.

In contrast to the arterial sub-category, the traffic environment on sub arterial roads may be restricted to improve the amenity for pedestrians and users of the adjacent developments. Measures may be taken to reduce some traffic use of the road, for example, during peak periods, and opportunities should be sought to bypass freight movements.

This category is generally appropriate as a bus route, and indented bays should be provided to reduce delay to through traffic. This category is generally inappropriate as a dangerous goods route.

Speeds should be kept low to improve amenity to pedestrians and abutting land uses, and should be no greater than 60 km/h. Volumes should be no greater than 15,000 vpd in order to maintain amenity to abutting land uses. These roads required a balance between accessibility and mobility, using environmental street design or streetscaping.

In special cases, a number of traffic lanes will have to be acquired to enable four lane or six lane carriageways for ultimate traffic growth (if a corridor is likely to take a key public transport route associated with the adjacent land use, e.g. potential exclusive PT lane), and provision made for a proper width to cater for kerb and channel, medians, bus stops and bike lanes. For the interim, a two lane undivided cross section may be appropriate for a low traffic volume environment, whilst achieving affordability, sufficient overtaking opportunities, vehicle breakdown, stopping and turning vehicles and bicycles. However, divided carriageways are desirable to optimise safety and driver comfort.

This category should provide for pedestrian movement on both sides with crossings at controlled points, and with bicycle lanes on the road to avoid mixing with denser pedestrian traffic. Intersections should be controlled by way of signalisation or roundabouts, although priority intersections may be appropriate. Spacing of intersections is site specific, based on past planning and land use decisions, although a minimum spacing of 150m is desirable to avoid queue interaction. Within the non-urban road hierarchy the 'Sub-Arterial Main Street' is not considered appropriate.

(c) Major collector road

Major collector roads provide a connection between the local streets and the traffic carrying roads and mark a shift in the environment between roads and streets. The design standards place a greater emphasis on travel time efficiency and strict guidelines for safety and environmental amenity should be adhered to on these roads.

Traffic flow levels commonly accepted range from 3,000 vpd up to 12,000 vpd. Access to multi-unit residential developments, schools or shopping centres may well be via major collectors. Individual residential lot access to these roads should be restricted, and generally a speed environment of 60 km/h to provide for safety and amenity while ensuring travel times are reasonable. Heavy vehicle and dangerous goods movement should be restricted in residential areas, with the exception of service vehicle movement. Buses will generally operate in a sweeper role and indented bays may be required to maintain safety at some locations.

Pathways and bicycle lanes should be provided on one or both sides of the road. However, in non-urban areas, pathways are generally not required unless network planning deems it appropriate. Some controlled pedestrian crossing points may be required in urban areas, particularly where traffic volumes are higher. Kerbside parking could be provided for in urban areas.

Intersections are typically spaced 80m to 100m in urban areas and up to a maximum 200m in non-urban areas. Intersection control would generally be either by roundabout or priority control. These roads should have two or four lane carriageways, depending on the degree of frictional and impact characteristics criteria that apply.

Environmental street design may be required in urban areas to moderate speeds and minimise through traffic penetration. Streetscaping would also assist in ameliorating visual and noise impacts to abutting land uses.

(d) Local streets

Level 3 sub categories mainly relate to managing and providing treatments for residential streets in the road hierarchy. However, consideration must also be given to non-residential local streets, e.g. in industrial and commercial areas. It should be noted that this document will not deal specifically with

"streets" (as per Level 1), but the following principles may be appropriate for general application across various council standards and requirements.

Streets have as their function to facilitate public interaction and movement through a place or neighbourhood. Local Streets must allow for the safe and efficient movement of all users, provision for parked vehicles, the provision of public utilities, access to allotments and streetscaping.

The management of these streets is less restrictive due to low traffic volumes, property access and parking. Volumes should be limited to below 3,000 vpd and the speed environment to 30~50 km/h in urban areas to ensure amenity for abutting land uses, it is noted that posted speeds will be at 50 km/hr, and to a maximum 60 km/h in rural areas to ensure reasonable travel times.

Heavy vehicles and dangerous goods movement should be restricted in residential areas, with the exception of service vehicles and public transport. Kerbside bus stops are generally appropriate, although indented bays may be required to maintain safety at some locations.

The provision of pathways is generally not necessary, although this may be appropriate in some instances as a requirement of network planning. No specific pedestrian crossing provision is required. No special cycle facilities are needed as these users should be able to share the road space due to the low traffic volumes and speeds.

No specific parking provision is required on these streets.

Intersection spacing is a minimum of 40~60m in urban areas and 100m in rural areas. Some intersections may be controlled by roundabouts; otherwise, priority control should be sufficient. These streets should have a two lane cross section, or one lane where necessary, with reasonable travel efficiency.

Environmental street design may be required in urban areas to moderate speeds and minimise through traffic penetration. Streetscaping would also assist in ameliorating visual impacts on abutting land uses.

If significant development occurs in the future in rural areas, then it may be appropriate to reclassify these streets as 'major collector' if the catchment size or density increases significantly. Accordingly, allocations should be made in the network planning.

In urban areas, the primary design objective is to maximise safety and amenity for adjacent properties and adjacent activities/users (i.e. pedestrians, cyclists, car parking, children playing). The most important design standard in this regard is the maximum design speed. Travel time efficiency will be compromised over safety and amenity aspects by appropriate subdivision design. Such design includes consideration of the maximum volume (by catchment size), the design speed (by street length) and the travel time efficiency (by connectivity of streets). It is this category of roadway whereby design standards are well defined because of the clear principles set out in such documents as *Queensland Streets* and *Complete Streets*.

In rural areas, the primary design objective is to minimise the cost of roadway provision whilst still maintaining acceptable performance levels (as a result of the very low volume use). Travel time efficiency will be compromised over safety and amenity aspects. There may be an issue with dust nuisance, which may be one of the factors considered when determining whether the road should be sealed or not. The low traffic volumes anticipated on some collector streets requires the need for a single lane cross section alternative, as well as the two lane form. There may also be a demand for the provision of horse trails within the road verge, and in this case a widened verge may be required to cater for these.

(e) Non residential local street

Similar roles apply to collector streets in commercial (including CBD) and industrial areas. Generally, higher traffic volumes can be tolerated on such streets than accepted in residential areas. Fewer lots would be served in commercial and industrial areas by these streets than low density residential areas,

SC6.4.3.13 Attachment B1 Road hierarchy elements and their objectives in urban areas

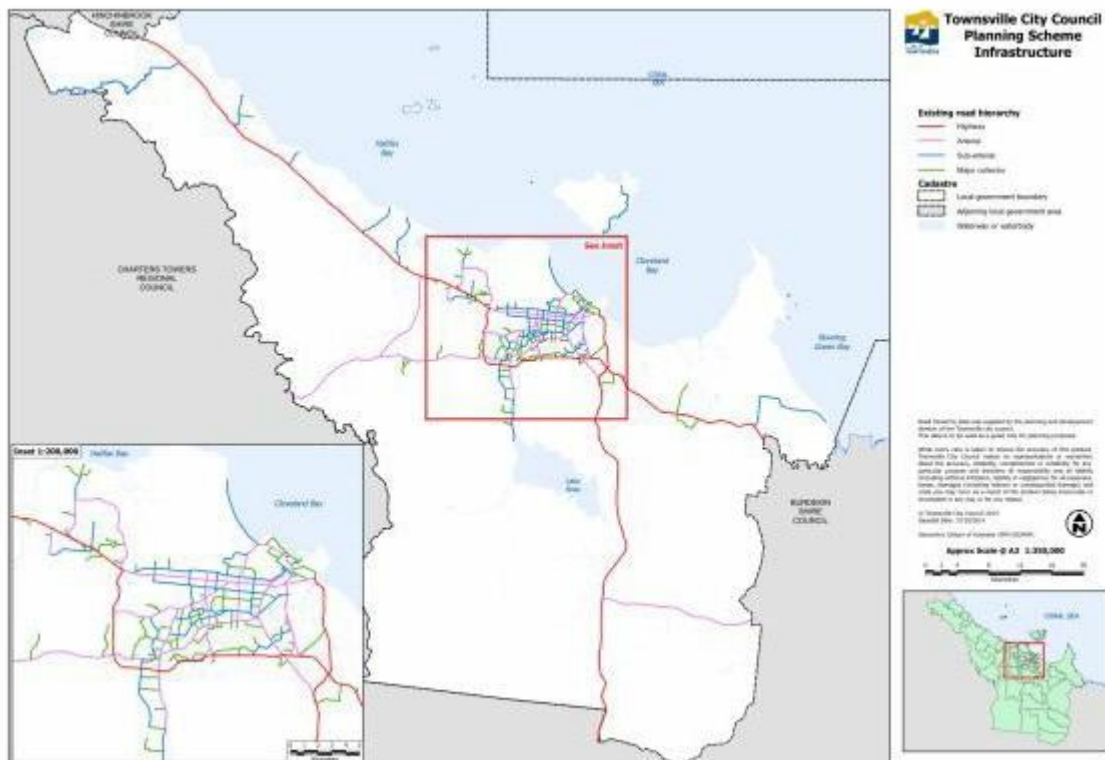
LEVEL 1: PURPOSE					
Roads					Streets
to carry through traffic					- to provide local property access; and - to collect local traffic
LEVEL 2: FUNCTION					
Arterial roads		Sub-arterial roads	Major collector roads	Local streets	
- through traffic movements across town; - longer distance strategic traffic movements; - primary connection between suburbs and employment, economic, education or entertainment centres; - line haul public transport task; - primary freight and dangerous goods routes; and - regional cycle movements.		- through traffic between arterial roads; - connections between local areas and arterial roads; - access to public transport; - through movement of public transport; - regional – local cycle movements; and - pedestrian movements.	- balance between carry traffic and access within the specific area; - direct access to grouped properties; - access to public transport; - pedestrian movements; and - local cycle movements.	- direct access to properties; - pedestrian movements; and - local cycle movements.	
LEVEL 3: MANAGEMENT					
Highway/ Motorway	Arterial	Arterial main street*	Traffic distributor	Controlled distributor*	Sub-arterial main street*
The aim of management policies for these categories will be to facilitate:					
- longer distance traffic movements between towns; and - regionally and nationally significant movements.	longer distance traffic movements between suburbs and other centres	- longer distance traffic movements; - access to commercial properties; - car parking; - pedestrian movements Treatment may involve preservation of aspects of local amenity in balance with traffic operation	- connection of local areas to arterial roads; - through movements between arterial roads; and - access to major developments	- connection of local areas to arterial roads; - access to properties (certain existing cases) - car parking; and - pedestrian movements Treatment may control some aspects of traffic operations to ameliorate impacts	- connection of local areas to arterial roads; - access to commercial properties; - car parking; and - pedestrian movements Treatment may involve preservation of aspects of local amenity in balance with traffic operations
- connection of local streets to carrying roads; and - access to individual adjacent properties; - connection to other local streets					
LEVEL 4: DESIGN					
According to relevant guidelines and codes including SC6.4 Development manual planning scheme policy, DTMR guidelines, AUSTRROADS, MUTCD, Queensland Streets, Australian Standards and Complete Streets for the local streets level					

Note – Only permitted in existing cases or special cases. Therefore treatment may involve preservation of existing land use but discouraging further access points to the adjacent land development.

SC6.4.3.13 Attachment B2 Road hierarchy elements and their objectives in rural areas

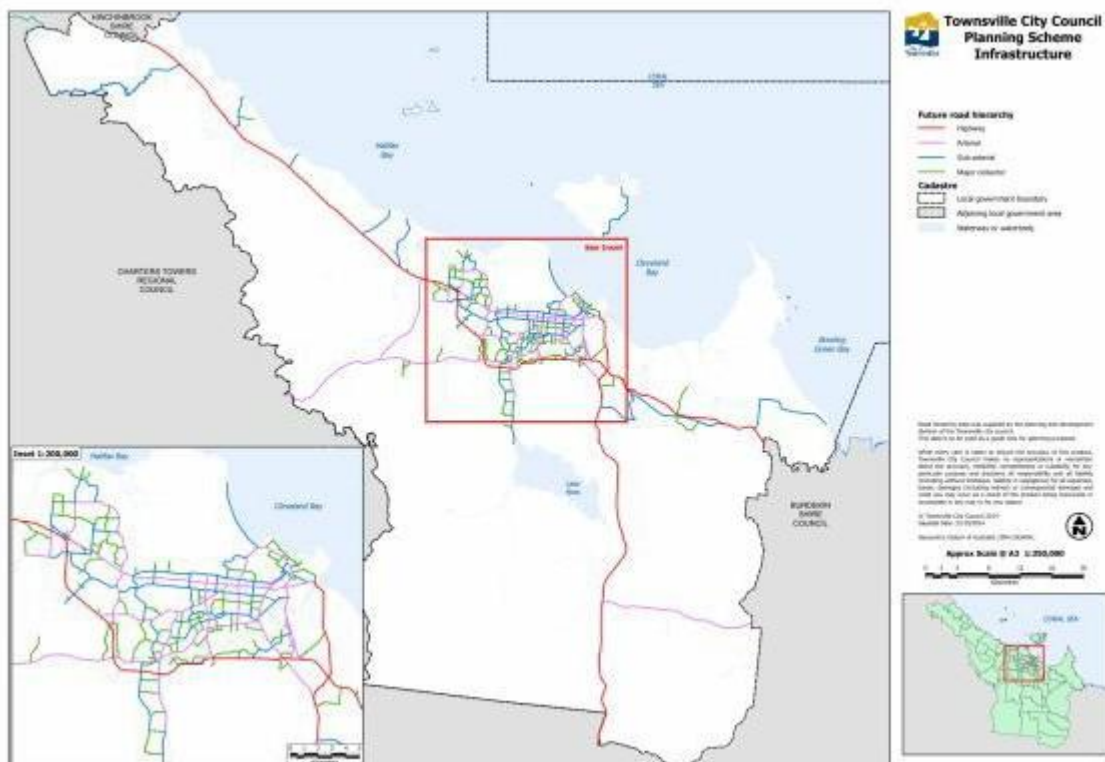
LEVEL 1: PURPOSE					Streets	
					- to provide local property access, and - to collect local traffic	
LEVEL 2: FUNCTION						
Arterial roads					Local streets	
- through traffic movements between towns; - longer distance strategic traffic movements; - primary connection between town and employment, economic, education or entertainment centres; - line haul public transport task; - primary freight and dangerous goods routes; and - regional cycle movements.					- direct access to properties; - pedestrian movements; and - local cycle movements.	
LEVEL 3: MANAGEMENT						
Highway/ Motorway					Local street	
The aim of management policies for these categories will be to facilitate: - longer distance traffic movements between towns; and - regionally and nationally significant movements.					- access to individual adjacent properties; and - connection to other local streets	
LEVEL 4: DESIGN						
According to relevant guidelines and codes including the SC6.4 Development manual planning scheme policy, DTMR guidelines, AUSTRROADS, MUTCD, Queensland Streets and Australian Standards. Note:— "Only permitted in existing cases or special cases. Therefore treatment may involve preservation of existing land use but discouraging further access points to the adjacent land development."						

SC6.4.3.13 Attachment C1 Townsville road hierarchy map (existing)



[Click here to view PDF high resolution map.](#)

SC6.4.3.13 Attachment C2 Townsville road hierarchy map (future)



[Click here to view PDF high resolution map](#)

SC6.4.3.13 Attachment D1 Road hierarchy desirable performance criteria in urban areas

Criterion	Roads							Streets
	Arterial roads			Sub arterial roads			Major collector roads	Local streets
	Highway/ motorway	Arterial	Arterial main street*	Traffic distributor	Controlled distributor*	Sub arterial main street*	Major collector	
Functional Characteristics								
Dominant linkage	Regional	City, Suburbs, Major centres	City, Suburbs, Major centres	Specific area	Specific area	Specific area/ main sites	Main Sites/ Environmental cell	Refer to SC6.4.4 Design specification and standard drawings
Traffic carrying function	Volumes not restricted	Volumes not restricted	Volumes not restricted	preferably <25,000vpd	preferably <20,000vpd	preferably <15,000vpd	<12,000vpd	
Residential access function	Nil	Nil	Nil, consolidated/ no new access	Nil	Nil desirable, site specific- subject to negotiation with council/ no new access	Nil desirable, site specific- subject to negotiation with council/ no new access	Limited-subject to negotiation with council	
Commercial access function	Nil	Nil	Site specific	site specific- subject to negotiation with council	site specific- subject to negotiation with council	site specific- subject to negotiation with council	site specific- subject to negotiation with council	
Industrial access function	Nil	Nil	Nil	Nil	Nil	Nil	site specific- subject to negotiation with council	
Desirable traffic speed environment	>=100km/h	70-80km/h	60km/h	60-80km/h	60km/h	60km/h	50~60km/h	
Heavy traffic movement	Primary freight routes	Primary/ secondary freight routes	Should bypass except for access	Secondary routes	Should bypass except for destination or return only	Should bypass except for destination or return only	Destination or return only	
Dangerous goods movement	Primary routes	Selected routes only	Inappropriate except for access	Selected routes only	Selected routes only	Inappropriate except for destination or return only	Inappropriate except for destination or return only	
Public transport facilities	Line haul, priority treatments use high frequency, limited stops, peak express, local and feeder	Line haul, priority treatments	Bus route, bus lanes where required	Bus route	Bus route, bus lanes where required	Bus route, bus lanes where required	Bus route	

Cycle facilities	Trunk Routes, off carriageway	Trunk Routes, off carriageway or cycle lanes on road	Trunk/ District routes, cycle lanes on road	Trunk/ District routes, cycle lanes on road	Trunk/ District routes, cycle lanes on road	Trunk/ District routes, cycle lanes on road	District/ Neighbourhood routes, cycle lanes on road
Paved footpath <i>As per council standard</i>	Only where linkage required, separate from road	Only where linkage required	Both sides	One or both sides	One or both sides	Both sides	One or both sides
Frictional Characteristics							
Preferred access control	No access	No access	Selective access control	Combined sites only tolerated	Selective access control tolerated	Selective access control tolerated	Combined site access preferred
Parking provision	No parking on roadway	No parking on roadway	Selective routes or corridors	No parking on roadway	Selective routes or corridors	Selective routes or corridors	Provide for kerbside parking
Bus stop provision	None on road	None on road	Indented bays	Indented bays	Indented bays	Indented bays	Indented bays
Pedestrian crossing Locations	Grade separated	Signalised	Controlled points	Controlled points	Controlled points	Controlled points	Some controlled points
Typ. Intersection spacing	1-2km highway >=2km motorway	500-1000m	500m desirable, 150m minimum	200-500m	200-500m	150-500m	80-200m
Preferred intersection treatments	Grade separated	signal/ roundabout	Signal/ roundabout/ priority	Signal/ roundabout/ priority	Signal/ roundabout/ priority	Signal/ roundabout/ priority	Signal/ roundabout/ priority
Number of traffic lanes	Volume driven, desirably divided	4-6 lanes, desirably divided	4-6 lanes, desirably divided	4 lanes, desirably divided	4 lanes, desirably divided	4 lanes or 6 lanes where PT needed, desirably divided	2-4 lanes, could be divided
Impact Characteristics							
Abutting land use types	Non sensitive	Non sensitive, vehicle associated	Retail/ commercial	Non sensitive to traffic	Preferably non sensitive to traffic	Retail/commercial	As specified under zoning
Land use impact amelioration	Barriers/ buffers/ Setbacks	Buffers/ streetscape/ setbacks	Streetscape	Streetscape/ Setbacks	Streetscape	Environmental street design/ streetscape	Environmental street design/ streetscape

Note— Only applied in existing cases or special cases.

A bus stop provision is required to be integrated with the paved footpath system traffic study will determine. e.g. TIA (Traffic Impact Assessment).

SC6.4.3.13 Attachment D2 Road hierarchy desirable performance criteria in rural areas

Criterion	Roads					Streets
	Arterial Roads		Sub Arterial Roads		Collector Roads	Local Streets
	Highway/ Motorway	Arterial	Traffic Distributor	Controlled Distributor*	Major Collector	
Functional Characteristics						
Dominant linkage	Regional	Intra-regional, suburbs	Specific area	Specific area	Local area	Refer to SC6.4.4 Design specification and standard drawings
Traffic carrying function	Volumes not restricted	Volumes not restricted	Volumes not restricted	preferably <15,000~25,000vpd	preferably <10,000~15,000vpd	
Residential access function	Nil	Nil	Nil	Nil desirable, consolidated/ no new access	Consolidated	
Commercial access function	Nil	Nil	Consolidated	Consolidated	Desirably consolidated, site specific	
Industrial access function	Nil	Nil	Nil	Nil desirable, consolidated/no new access	Desirably consolidated, site specific	
Desirable traffic speed environment	>=100km/h	80-100km/h	80-100km/h	60~80km/h	60km/h	
Heavy traffic movement	Primary freight routes	Primary/secondary freight routes	Secondary routes	Should bypass except for access	Access only	
Dangerous goods movement	Primary routes	Primary/secondary routes	Nominated routes only	Nominated routes only	Inappropriate except for access	
Public transport facilities	Line haul, priority treatments	Line haul, priority treatments	Bus route	Bus route	Bus route	
Cycle facilities	Regional, off carriageway	Regional, on or off carriageway	Regional/local, on or off carriageway	Regional/local, on or off carriageway	Local on or off carriageway	
Pedestrian movement facilities	Separate from road where linkage required	Separate from road where linkage required	Separate from road where linkage required	Separate from road where linkage required	Separate from road where linkage required	
Frictional Characteristics						
Preferred access control	No access	No access	Selective access control	Selective access control	Combined site access preferred	
Parking provision	Nil	Nil	Nil	Nil	No specific provision	
Bus stopping provision	None on road	Dedicated bays where appropriate	Dedicated bays where appropriate	Dedicated bays where appropriate	Dedicated bays where appropriate	
Pedestrian crossing Locations	Grade separated	Controlled points	Controlled points	Controlled points	May require controlled points	
Typ. Intersection spacing	4-8km (maximum 12km)	>1km	>300m	>300m	>200m	

Preferred intersection treatments**	Grade separated/ priority	Roundabout/ priority	Roundabout/ priority	Roundabout/ priority	Roundabout/ priority
Number of traffic lanes	Volume driven	Reservation for 4~6 lanes	Reservation for 4 lanes	Reservation for 4 lanes	Reservation for 2~4 lanes
Impact Characteristics					
Abutting land use types	Non sensitive, vehicle associated	Non sensitive, vehicle associated	Non sensitive to traffic	Preferably non sensitive to traffic	As specified under zoning
Land use impact amelioration	Setbacks	Setbacks	Setbacks	Setbacks	Setbacks

Note— Only applied in existing cases.

A bus stop provision is required to be integrated with the paved footpath system

Traffic study will determine, e.g. TIA (Traffic Impact Assessment)

SC6.4.3.14 Traffic impact assessments

SC6.4.3.14.1 Introduction

A traffic impact assessment (TIA) is a process of compiling and analysing information on the impacts that a specific development proposal is likely to have on the operation of roads and transport networks. The assessment will not only consider general impacts relating to traffic management (road efficiency and safety), but will also consider specific impacts on land use environment and all road users including on-road public transport, pedestrians, cyclists and heavy vehicles.

Developers should refer to the *Guide to Traffic Management* produced by Austroads as a primary reference, and in particular, *Part 12: Traffic Impacts of Development*. The TIA sub-section has been produced to supplement Part 12 by establishing criteria for low, moderate and high traffic impact developments, and to supply additional information pertinent to particular land uses, climate and traffic characteristics in Townsville. If a discrepancy exists between this document and the *Guide to Traffic Management*, this sub-section will prevail.

(1) TIA scope and purpose

(a) TIA purpose

Council requires a TIA in order to:

- (i) assess the adequacy of the existing or future transportation system to accommodate additional traffic generated by a proposed development, redevelopment or land use change; and
- (ii) to assist in determining what improvements may be required to transport infrastructure (e.g. roadways, pathways, public transport and traffic facilities, parking, etc.) to maintain a satisfactory level of service for the Townsville community.

Within the context of the matters outlined above, the aim of this sub-section is to ensure that:

- traffic impact assessment of developments is undertaken in a uniform manner leading to consistent treatment of similar developments;
- the level of impact assessment is appropriate for the level of potential impacts;
- a road or a road network continues to operate at an agreed level of service following the opening of a development;
- both "soft" solutions (e.g. road use management such as alternative routes) and "hard" solutions (e.g. changes to infrastructure) are considered when mitigating impacts;
- the needs of all road users are considered and appropriate facilities (e.g. bicycle lanes, footpaths, bus lanes, intersection widening or upgraded intersection controls) are provided in a timely manner;
- a development is considered within its proposed environment and not in isolation from nearby features such as intersections, footpaths and other driveways;
- cumulative impacts on transport networks of other developments in an area or region are considered; and
- road safety and environmental impacts (both natural and built) are considered.

(b) TIA scope

A TIA may be required where a development affects the function, safety and efficiency of the transport network. The requirements for a TIA are outlined in this policy sub-section.

The scope of a TIA will depend on the location, type and size of the development and the ability of the road network to handle traffic generated by the development. Therefore, some developments will require an extensive and detailed TIA, while others will require only a brief TIA.

(2) How to use this document

The following steps will guide the applicant in determining the level of TIA required with regard to land use and traffic environment perspectives.

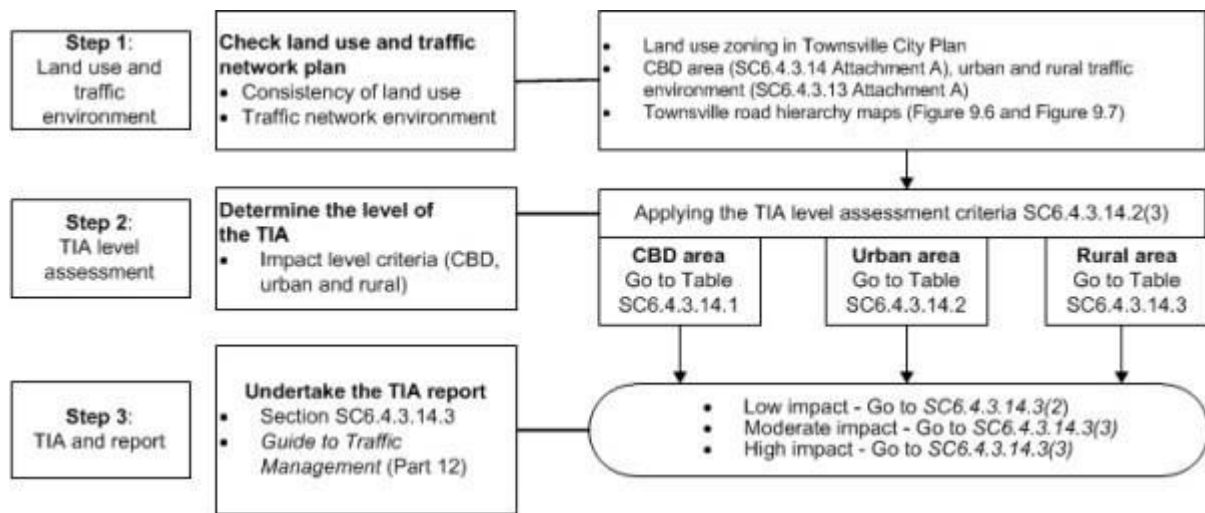


Figure SC6.4.3.14.1 How to use SC6.4.3.14 Traffic impact assessment guidelines

(3) Terminology

AADT	Annual Average Daily Traffic
CBD	Central Business District as per the <i>Townsville CBD Master Plan</i> or Attachment A.
DTMR	Queensland Department of Transport and Main Roads
DoS	Degree of saturation
Inconsistent development	development that is not consistent with the planning scheme, or development that is inconsistent as described in Section 650 in the <i>Planning Act 2016</i> .
Level of service (LOS)	a qualitative measure using a sequence of letters from A through F to describe the quality of operational conditions within an intersection, transit or a roadway link. Refer to the <i>Highway Capacity Manual</i> for details.
PCE	Passenger Car Equivalent
PCU	Passenger car unit
PT	Public transport
TIA	Traffic impact assessment
Traffic facility	roads, streets, bikeways, highways, their networks, terminals, traffic signs, public transport/car park and abutting lands related to all modes of transportation, i.e. people, vehicles, goods.
Transportation demand management (TDM)	the application of strategies and policies to reduce travel demand (specifically that of single-occupancy private vehicle), or to redistribute this demand in space or time.
Trip	a single or one-direction person or vehicle movement.

Trip generation	the total number of trips measured in trip ends (i.e. trip production or trip attraction) entering and exiting the site for the defined period, e.g. one hour, one day etc.
VPD	Vehicles per day

(4) Reference and source documents

- (a) Legislation
Planning Act 2016
Transport Infrastructure Act 1994
- (b) Australian Standards
AS2890 Parking facilities (Part 1: Off-street car parking, Part 2: Off-street commercial vehicle facilities, Part 3: Bicycle parking facilities, Part 5: On-street parking, Part 6: Off-street parking for people with disabilities).
- (c) Austroads
Cycling Aspects of Austroads Guides, 2011
Guide to Traffic Management, 2009 (in particular, Part 12)
- (d) Townsville City Council
CBD Master Plan (2013)
SC6.4.3.5 Car parking and public transport facilities
SC6.4.3.13 Townsville road hierarchy
- (e) Queensland Department of Transport and Main Roads,
Guidelines for Assessment of Road Impacts of Development, 2006 (GARID)
Manual of Uniform Traffic Control Devices (MUTCD), 2003
Traffic and Road Use Management Manual (TRUM)
Road Planning and Design Manual (TRUM)
Roads and Maritime Services NSW (RMS), Guide to Traffic Generating Developments 2002 Version 2.2
- (f) Other
Transportation Research Board, *Highway Capacity Manual (HCM)*, 2010

SC6.4.3.14.2 Determining the level of the TIA

The scope, intent and degree of traffic impact will vary. This will depend on the land use of the proposed development, direct access locations and current land use zoning. For example:

- development based on the current land use zoning and character of the locality;
- location of the development: CBD, urban, rural area;
- the existing and future planned transport network;
- direct access to the external road hierarchy system;
- staging, size and type of the development;
- the traffic environment at the time of the proposal;
- existing approved (but not delivered) development within the area;
- current development applications within the area; and
- any strategic planning determining future land uses such as the Townsville State Development Area.

(1) Land use environment

Due to the different desirable service standards in the CBD/Urban and Non-urban areas, council has different impact assessment thresholds depending on whether the development is in the CBD, urban or rural traffic environments. These areas are defined as follows:

- (a) *The CBD* (see SC6.4.3.14 Attachment A); or
- (b) *Urban area* – with the exception of the CBD, refer to the map in SC6.4.3.13 Attachment A; or
- (c) *Rural area* – areas not in the urban area, or CBD, refer to the map in SC6.4.3.13 Attachment A.

These TIA land use traffic environment definitions relate to the character of the land for the purpose of assessing the traffic impacts on the site and the adjacent network.

(2) Three levels of the TIA

For each of the development locations identified above, and in conjunction with the defined Townsville Road Hierarchy system, (SC6.4.3.13 Townsville road hierarchy) there are three different levels of traffic impact assessment. The anticipated level of impact will require different methodologies of traffic forecasting and analysis, as described below.

Low impact (SC6.4.3.14.3(2) Low TIA report):

The development is likely to have a very minor impact as the land use is consistent with the Townsville City Plan but a review is still required to ensure potential traffic issues are assessed in terms of traffic safety and amenity issues, etc. A low level TIA report will comprise of a statement of impact, and a corresponding statement of proposed mitigation measures and measures to optimise the network.

Moderate impact (SC6.4.3.14.3(3) Moderate/High TIA Report):

The development is likely to have a moderate traffic impact on the surrounding existing and future land uses, traffic network and operations. For a moderate level TIA Report, either a manual forecasting or mesoscopic traffic simulation modelling (e.g. SIDRA Network, Aimsun or an equivalent model) or microscopic traffic simulation modelling (e.g. Aimsun or an equivalent model) (Refer to SC6.4.3.14.4.2(a)) may be a suitable methodology of traffic forecasting due to:

- a moderate threshold, in terms of additional or new traffic generated as defined by the CBD/Urban/Non-urban TIA impact level assessment criteria;
- insignificant impact on existing and future transport and traffic systems, e.g. no additions or changes to the road hierarchy system; and
- the characteristics of the road network in the immediate vicinity of the development.

Note—if broader traffic network modelling (e.g. masterplan) has been recently done in that area (i.e. less than two years old), a high impact assessment may be assessed at the moderate level (upon confirmation with council), as long as the development is consistent with the land use or assumptions made within the previous modelling study.

High impact (SC6.4.3.14.3(3) Moderate/High TIA Report):

The development is likely to have a high impact on the surrounding existing and future land uses, traffic network and operations. For a high level TIA report, which does require a comprehensive assessment approach, council encourages the use of an appropriate traffic modelling program, e.g. EMME (for strategic traffic modelling), Aimsun, or an equivalent model, (Refer to SC6.4.3.14.4.2(a)) particularly where:

- additions or changes to the road hierarchy system are proposed, i.e. a new/changed arterial, sub-arterial or major collector road; or
- significant trip behaviour changes and impacts are expected, as defined by the CBD/Urban/Non-urban TIA impact level assessment criteria, e.g. trip generation, trip distribution, mode choice and trip assignment; or
- changes to council's and/or DTMR's future major traffic network programmes are proposed.

Note—occasionally a TIA may have a high anticipated impact, but the area of impact is restricted to a corridor rather than a network within the TIA area. In this circumstance, either a manual forecasting or mesoscopic traffic simulation modelling may be a suitable methodology of traffic forecasting.

(3) Applying the TIA impact level assessment criteria

Use Table SC6.4.3.14.1 to Table SC6.4.3.14.3, whichever is relevant to the location of the development, i.e. CBD, Urban, or Non-urban area, and assess the development against the TIA impact level assessment criteria whilst also taking into account the following:

- (a) the applicant must consider the actual or potential traffic impacts of all land/development under their common ownership or control (for example, by a joint venture agreement), at one location.

Editor's note—The phrase "at one location" means all adjacent land of the applicant, the property lines of which are contiguous or nearly contiguous at any point, or separated by other land of the applicant, or a public or private street, road, highway, or utility right-of-way or other public or private right-of-way.

An applicant must not avoid the intent of this policy sub-section, and that of Townsville City Plan, by submitting partial or segmented applications or approval requests for development plans, subdivisions, etc. If the properties will form an integrated or complementary development, council expects the applicant to submit one consolidated TIA report based on the integrated level of impact;

- (b) if the criteria that apply are spread across two or more impact columns, the highest level of impact will apply. For example, if the development is low for all criteria, except for one criterion that is in the high column, a high level TIA will be required;
- (c) Council may require additional information as part of the traffic impact assessment at the Information and Referral stage of an application for a Development Permit, which will be decided on a case by case basis;
- (d) if the proposed development land is zoned for rural purposes but the development proposed is an urban land use that will either be surrounded by a rural traffic environment or adjoin an urban area, Table SC6.4.3.14.2 Urban TIA impact level assessment criteria must be used, rather than Table SC6.4.3.14.3 Rural area TIA impact level assessment criteria;
- (e) council may request a more thorough analysis if negative impacts on traffic facilities have been identified, or if particular factors of the development cause concern to the safety, efficiency and operation of the transport network; and
- (f) if the proposed development has roads that are not identified in the Road Hierarchy Map (e.g. in the development of new subdivision plans), a new link(s) road hierarchy in the subjected development area may be proposed by the developer, with council's agreement.

Note—if any of the above conditions apply, or more details are required, council encourages a pre-lodgement meeting to be arranged prior to commencing the TIA.

Table SC6.4.3.14.1 CBD area TIA impact level assessment criteria

Criteria	Impact		
	Low	Moderate	High
Trip generation	New or additional trip generation in a peak hour of <10 trips directly accessing a street ¹ .	New or additional trip generation in a peak hour of 10 to 100 trips directly accessing a street. New or additional trip generation in a peak hour <100 trips directly accessing a major collector, sub-arterial, arterial, or highway ¹ .	New or additional trip generation in a peak hour of more than 100 trips.
Commercial vehicles	3 or less new or additional commercial vehicles per day.	More than 3 and up to 100 new or additional commercial vehicles per day.	More than 100 new or additional commercial vehicles per day.
Car parking	An increase or decrease of 9 or less on-site car park spaces. Loss of 2 or less line marked on-street car parks and no loss of loading zones.	An increase or decrease of 10 or more on-site car park spaces. Loss of 3 or more line marked on-street car parks, or any loading zones.	

Public transport	No impact on any bus zone or taxi operations.	Relocation of any bus zone or taxi rank. Impacts on the bus interchange or bus routes.	
Transport system	No change to existing transport network operation.	Change to permitted vehicle movements at a T-intersection.	Change of permitted vehicle movements at a crossroads or multiple intersections.

Note—1. Refer to Figure 9.6 Townsville road hierarchy map (existing) and Figure: 9.7 Townsville road hierarchy map (future).

Table SC6.4.3.14.2 Urban area TIA impact level assessment criteria

Criteria	Impact		
	Low	Moderate	High
Trip generation	New or additional trip generation in a peak hour of <20 trips directly accessing a street ¹ .	New or additional trip generation in a peak hour of 20 to 300 trips directly accessing a street. New or additional trip generation to a major collector, sub-arterial, arterial, or highway ¹ .	New or additional trip generation in a peak hour of more than 300 trips directly accessing a road system.
Commercial vehicles	5 or less new or additional commercial vehicles per day in a residential area. Less than 10 new or additional commercial vehicles per day in a non-residential area.	More than 5 and up to 300 new or additional commercial vehicles per day in a residential area. More than 10 and up to 300 new or additional commercial vehicles per day in a non-residential area.	More than 300 new or additional commercial vehicles per day.
Car parking	Increase or decrease of 9 or less on-site car park spaces. Loss of 2 or less line marked on-street car parks, or loading zones.	Increase or decrease of 10 or more on-site car park spaces Loss of between 3 or more line marked on-street car parks, or loading zones.	
Public transport	Relocation of any bus zone or taxi rank.	Impacts on the bus interchange or bus routes.	
Transport system	No change to existing transport network operation.	Changes to the connectivity between local streets and collector roads.	Changes to the connectivity between arterial and sub-arterial roads.

Note—1. Refer to Figure 9.6 Townsville road hierarchy map (existing) and Figure: 9.7 Townsville road hierarchy map (future).

Table SC6.4.3.14.3 Rural area TIA impact level assessment criteria

Criteria	Impact		
	Low	Moderate	High
Trip generation	New or additional trip generation in a peak hour of less than 30 trips directly accessing a street ¹ .	New or additional trip generation in a peak hour of 30 to 300 trips directly accessing a street. New or additional trip generation directly accessing a sub-arterial, arterial, or highway ¹ <300.	New or additional trip generation in a peak hour of more than 300 trips.
Commercial vehicles	Less than 30 new or additional commercial vehicles per day.	More than 30 and up to 300 new or additional commercial vehicles per day.	More than 300 new or additional commercial vehicles per day.
Public transport	Relocation of any bus zone or taxi rank.	Impacts on the bus interchange or bus routes.	
Transport system	No change to existing transport network operation.	Changes to the connectivity between local streets and collector roads.	Changes to the connectivity between arterial and sub-arterial roads.

Note—1. Refer to Figure 9.6 Townsville road hierarchy map (existing) and Figure: 9.7 Townsville road hierarchy map (future).

(4) Collaborative traffic impact assessments

If the anticipated traffic impact is determined to be of significant impact on the existing or future transportation system due to its location, development type, or land use characteristics, the traffic impact assessment may require a more strategic and holistic assessment to be prepared collaboratively with council and any other relevant stakeholders.

(5) Associated reports

Road Safety Audit - If the TIA Report indicates that significant safety issues may occur, the developer must engage a qualified road safety engineer to undertake an independent Road Safety Audit, in line with the *Guide to Road Safety Part 6*, Austroads 2006-2009c.

Noise - A road noise assessment may be required if there is a forecasted volume that will increase traffic over 3000 VPD (link traffic) in the subjected TIA study scope, or if noise sensitive receptors are identified. Refer to sub-section SC6.4.3.15 Noise and vibration assessment guidelines for more information.

SC6.4.3.14.3 TIA report requirements

The TIA will be used to help evaluate whether the development is appropriate for the site and what type of transportation improvements may be required. The TIA Report should address any traffic issues outlined in this document and the *Guide to Traffic Management Part 12: Traffic Impacts of Development* (Austroads, 2009).

The TIA report must identify the type and amount of additional traffic expected to be generated by the proposed development on the adjacent transport network and include recommendations on any site specific and external upgrading or network management works required to cater for short-term and long-term traffic and transportation planning.

It is important that early contact be made with the Planning and Development Division of council during the TIA process. This should commence at the outset and continue as required during the course of TIA preparation. For example, if council's concerns about access to the council road network are identified early, this may be able to be addressed through minor amendments to the on-site layout of the development. For larger developments, it may be appropriate to consult with council regarding consideration of the project's scope, methodology and other possible planning consideration during the development of the initial project concept.

(1) General requirements

The TIA Report must demonstrate that the proposed development is consistent with the traffic and transportation aims of the planning scheme for that area. The intent of the TIA is to evaluate *worst case traffic scenarios*. For example, if several different uses are proposed, the land use with the greatest overall traffic impact must be assumed in the study, unless the applicant specifies the uses for the site.

(a) TIA consultant qualifications

A low impact TIA report may generally be prepared by the developer. However, if existing traffic facilities need to be changed, then recommendations for mitigation must be made by a Registered Professional Engineer of Queensland (RPEQ) qualified person at a minimum. The moderate or high impact TIA is to be prepared by an impartial professional traffic/transportation consultant who is appropriately experienced and holds current RPEQ qualification. The document must be certified by the appropriately qualified and experienced RPEQ.

(b) Report documentation

The TIA Report must fully document the approach, methodology, and assumptions of the analysis. It must clearly explain the reasons for any adjustments to the trip generation rates and assumptions used for trip distribution and assignment. Figures (drawings and maps) are to be used to help illustrate these assumptions. The report must summarise the results of the Level of Service (LOS) calculations in tabular or map form, and include figures showing the traffic volumes for the project alone and for each scenario. The report must also include any mitigation measures, appropriately tested by the model. All worksheet and analysis input and output data must be included as appendices to the report, if applicable.

(c) Impact on other stakeholders

If there are other jurisdictions or stakeholders impacted within the area of influence, for example, DTMR, Queensland Rail (QR), or Bus/taxi companies, the consultant should arrange a scoping meeting with all relevant agencies to discuss the issues. This will provide improved coordination and reduce the potential for later revisions to the TIA.

(d) Updating an existing TIA

A TIA requires updating when the amount or character of traffic is significantly different from an earlier study; for example, changes to the land use, road hierarchy or road networks. Any traffic study may also need to be revised if the study is older than 2 years and council determines that the existing conditions have changed enough to invalidate the study results or if the initial study assumes an incorrect build out period. A TIA may require updating sooner in rapidly developing areas and not as often in slower developing areas. In these cases, consultation with council is recommended.

(e) Possible additional requirements

At times, council may extend the study to additional street segments and/or intersections on the public street system. Council will make this determination based on the scale, location, and/or nature of the proposed development and the condition or state of development of the street network in the vicinity of the site.

(2) Low TIA report

1. Justification for low impact assessment;
2. A brief description of the development in terms of site location, direct site access(es), land use, size and expected year of completion;
3. Analysis/Findings, e.g. impact on existing traffic facilities, heavy vehicles turning path and other safety issues;
4. Recommendations and Mitigation; and
5. Appendices if applicable.

(3) Moderate/high TIA report

Executive summary

- a brief description of the development (site location, internal layout, all site access(es), land use/size and year of completion);
- a brief overview of trip generation and analysis result (LOS), Degree of Saturation (DoS) and Average Delay;
- parking demand; and
- mitigation plan and conclusion/recommendation.

Note—desirably, the executive summary should be no longer than five pages, complete in itself, and not dependent on supplementary data included by reference.

1. Introduction and summary

1.1 Justification for moderate or high impact assessment

1.2 Study objectives and scope

- Time horizon - year of completion assuming full build-out and occupancy and 10 years after total completion. This also needs to be assessed at key stages of the development, or if traffic environment changes have occurred in the meantime
- TIA Area – where:
 - (a) the amount of additional traffic likely to be generated is more than 5% of existing total links and intersection volumes during a peak hour; or
 - (b) the likely increase in the proportion of heavy vehicle traffic is more than 5% during a peak hour associated with the development.

2. Proposed development

2.1 Land use and intensity;

2.2 Site plan/layout;

2.3 Phasing and timing; and

2.4 Specific information of the proposed development (operation hours, number of employees, type of service vehicles, etc.).

3. Existing conditions

3.1 Study area land use:

- existing land use/zoning; and
- anticipated future development (background); land use/traffic network.

3.2 Existing traffic analysis:

- roadway system;
- traffic volumes and analysis;
- active mode facilities (public transport stops/route, pathway, bike lane, trip end facilities);
- parking (car park type, operation, existing/potential car park demand);
- traffic accident data (traffic safety); and
- other.

4. Traffic forecasting and analysis

4.1 Method of projection.

4.2 Background traffic (each horizon year):

- traffic model calibration or validation if applicable; and
- forecasting and analysis.

4.3 Site traffic (each horizon year): • trip generation; • trip distribution; • modal split; • trip assignment; and • analysis. 4.4 Summary of analysis (with/without development scenario).
5. Improvement analysis 5.1 Improvements to accommodate background traffic. 5.2 Additional improvements to accommodate all site traffic. 5.3 Alternative improvement. 5.4 Need for any improvements (e.g. TDM). 5.5 Status of improvements already funded, programmed, or planned. 5.6 Independent road safety audit, if required. 5.7 Summary.
6. Parking 6.1 Method of projections 6.2 Parking demand forecasting and analysis (including all service vehicles and bikes) 6.3 Site circulation and parking layout (including all service vehicles)
7. Public transport and pathway 7.1 Possible/desirable PT system. 7.2 Internal/external pathway network system (type, location).
8. Recommendation 8.1 Site access/circulation plan. 8.2 Roadway improvement: • on-site; • off-site; and • phasing, if appropriate. 8.3 PT, bicycle and pathway system. 8.4 Other.
9. Conclusion
10. Special analysis/issues (if applicable, refer to SC6.4.3.14.4(8))
11. RPEQ Certification
Appendices

SC6.4.3.14.4 Essential technical guidance

- (1) Existing conditions
 - (a) Traffic count data

Traffic trends and counts data may be available from DTMR and council. Traffic data must reflect existing normal conditions and should not be used if more than two years old at the time of the TIA submission or if significant changes have occurred at or near the count location or as otherwise requested by council. The traffic consultant or the applicant is responsible for providing traffic counts that are not available through DTMR or council.
 - (b) Traffic accident and safety

Accident data is available from the State traffic accident reporting system and can be obtained through Data Analysis at the Queensland Department of Transport and Main Roads. Accident data requests should be made as early as possible to enable the information to be provided in a timely manner.

(2) Traffic forecasting and analysing

(a) Townsville Strategic Traffic Model 2011 (TSTM11)

Townsville Strategic Traffic Model 2011 (TSTM11 on the Emme platform) has been developed and calibrated with various Townsville traffic survey results, 2011 demographics and network conditions. Its ownership has been established between council and DTMR.

Associated with land use development, council has used the Townsville Growth Model to develop future demographic data, in 5 year intervals up to 2036.

Upon request, or following a pre-lodgement meeting agreement, TSTM11 and future demographic data are available to use under license among council/DTMR and the applicant. Also, depending on the process of council/DTMR traffic model development, meso/micro simulation models for other areas will be available, such as CBD SATURN. Council encourages the use of these models, as they have been developed for the agreed network structure and their methodology is transparent and consistent for all users. For background traffic forecasting, the use of data TSTM11 must be used in the first instance. Data obtained from TSTM11 for background traffic forecasting must be calibrated to existing traffic volumes at the time of analysis.

All traffic modelling data should be calibrated and validated at the time of the assessment prior to using the data and details of this process are required to be included in the report. It should be acknowledged that TSTM11, especially, is intended for use with high level traffic network modelling and is not designed for small size or individual lots of development. It is important to apply the correct level of traffic modelling work/methodology to forecast the traffic demand associated with the development.

Council retains intellectual property ownership rights to the latest data for council purposes. Applicant must ensure that any consultants engaged to undertake this work are aware of this stipulation.

Any updated or developed input/output traffic modelling data as part of the TIA study, must be submitted. If the applicant intends to develop new traffic modelling as part of the TIA report, council encourages the use of the same platform of traffic modelling, i.e. EMME, Sidra Intersection and Aimsun. If the applicant uses an alternative equivalent traffic model, this must be agreed to by council prior to the TIA commencing. The agreement will cover issues such as network structure, demographic data and methodology.

(b) Trip generation rates

The trip generation rates for the residential component of dwellings are 8 VPD per dwelling in non-urban areas and 10 VPD per dwelling in CBD/Urban areas, unless actual survey data is available. In the same manner, all considered trip generation rate data must be provided in the TIA Report as source or reference data. Consideration must also be given for other ancillary uses proposed on the land. In the absence of specified trip generation rates within council documentation, the DTMR's Guidelines for Assessment of Road Impacts of Development, 2006 and Road Planning and Design Manual must be used.

(3) Traffic analysis performance criteria

The results of the traffic analysis must be compared using the Measure of Effectiveness (MOE), as set out in Table SC6.4.3.14.4 below.

Table SC6.4.3.14.4 MOE based on the traffic characteristics and type

Facility	Type	Measure of effectiveness (MOE)
Intersections	Unsignalised or prioritised control	Average delay (seconds per vehicle) Delay to critical movements (seconds) Degree of Saturation (DOS) Queue length for critical movements (metres or vehicles)
	Traffic signals	Average delay (seconds per vehicle) Delay to critical movements (seconds) Degree of Saturation (DOS) Queue length for critical movements (metres or vehicles)
	Roundabouts	Average delay (seconds per vehicle) Delay to critical movements (seconds) Degree of Saturation (DOS) Queue length for critical movements (metres or vehicles)
Interrupted flow, e.g. Urban/CBD network		Average travel speed (km/hr) Volume/Capacity ratio
Uninterrupted flow, e.g. Non-urban/highway network		Density (PCU/km/lane) Volume/Capacity ratio
Two-lane uninterrupted flow, e.g. Non-urban/highway network		Average travel speed (km/hr) Volume/Capacity ratio
Pedestrian		Space (m ² /person) in queuing area Speed (person/min/m) in walkway
Transit		Headway (minutes or veh/hr) Passenger loading (m ² /person) Reliability (%)

Source :Transportation Research Board, *Highway Capacity Manual*, 2010.

The type and level of analysis and evaluation will include documentation of LOS for intersections. A saturation flow rate and all parameters for analysis should be considered in accordance with the SIDRA Intersection user guide and default parameters unless field measurements at the study area would indicate a more appropriate value. In this case, all source or reference data must be provided in the TIA report.

(4) The conversion of vehicle numbers to PCE

Table SC6.4.3.14.5 shows the conversion of vehicles (as classified by Austroads) to comparative number of passenger car equivalent (PCE) for the determination of trip generation, intersection capacity and LOS analysis.

Table SC6.4.3.14.5 Calculating passenger car equivalent

Austroads <i>Guide to Traffic Management Part 12</i> vehicles classifications	Passenger Car Equivalent (PCE)
Classes 1 to 2 i.e. short vehicles	1 PCU
Classes 3 to 5 i.e. light to medium trucks	2 PCU
Classes 6 to 9 i.e. heavy trucks	3 PCU
Classes 10 to 12 i.e. B-doubles, Triple Road Train	5 PCU

(5) Desirable service standard for links

According to the given MOE in Table SC6.4.3.14.4, the threshold for acceptable operation is the upper limit of LOS 'D' for CBD/urban roads and LOS 'C' for rural roads although the next level of LOS 'E' or 'D' could be accepted where weekend peaks are the defining event and occur on recreational routes.

(6) Desirable service standard for intersection/access

Any intersection analysis should demonstrate that the delays would be less than that shown in Table SC6.4.3.14.6 up to the ten year horizon after completion of the development. If they are not, improvements to the intersection layout and/or changes to the proper method of control must be assessed.

Table SC6.4.3.14.6 Desirable Service Standard for intersection/access operation

Criteria	Acceptable levels	
	CBD and urban	Rural
Signalised intersection	Control delay less than 55 seconds per vehicle (LOS D) or Degree of Saturation less than 0.9	NA
Roundabout	Control delay less than 35 seconds per vehicle (LOS D) or Degree of Saturation less than 0.85	Control delay less than 25 seconds per vehicle (LOS C) or Degree of Saturation less than 0.8
Priority intersection or give-way stop controlled intersection	Control delay less than 35 seconds per vehicle (LOS D) or Degree of Saturation less than 0.8	Control delay less than 25 seconds per vehicle (LOS C) or Degree of Saturation less than 0.7
Left or right turning lanes	Less than available storage length within 95 percentile queue	Less than available storage length within 90 percentile queue

Note—The delays above equate to the upper limit delay of Level of Service C or D for approach-based and intersection wide assessment. LOS is defined solely by control delay (2010 *Highway Capacity Manual*). LOS E means the intersection/approaches are at capacity.

(7) **Parking**

Adequate parking must be provided to meet site-generated demands and be consistent with the most current version of the references. If the consultant conducts a survey, or uses other source data, the car parking demand must be compared against SC6.4.3.5 Car parking and public transport facilities guidelines, with the greater car parking demand being applied. In considering car parking for a specific type of development, the consultant must use data from at least two different sources, or use the data compiled from both a survey and one source data, with the greater level of car parking demand being applied. All surveys or source data must be from a similar land use to the proposed development.

Specific dimensions, parking angles, and parking ratio requirements are addressed in the planning scheme and planning scheme policies (SC6.4.3.5 Car parking and public transport facilities guidelines), and Austroads Cycling Aspects of Austroads Guides.

Editor's note - From time to time, council may introduce incentive programmes that impact on parking requirements. Information on any incentive programmes is available from council.

(8) **Special analysis/issues**

Council may request specific traffic analyses relevant to the proposed development. These include details about access management, a TDM plan, cut-through traffic and residential quality of life analysis, truck estimates, Intelligent Transport System (ITS) strategies, pedestrian/bicycle safety, signage and access, safe routes to school, emergency routes, etc.

(9) **Mitigation plans and conclusion**

All mitigation plans identified as necessary to serve the proposed development should be listed in the TIA report, along with the timing of implementation.

During construction, private approaches should be located, and configured in such a manner as to avoid disruption to the public street system. If changes to traffic controls are proposed, warrants should be reviewed and documented in the report. Reference should also be made to SC6.4.6.30 Control of traffic.

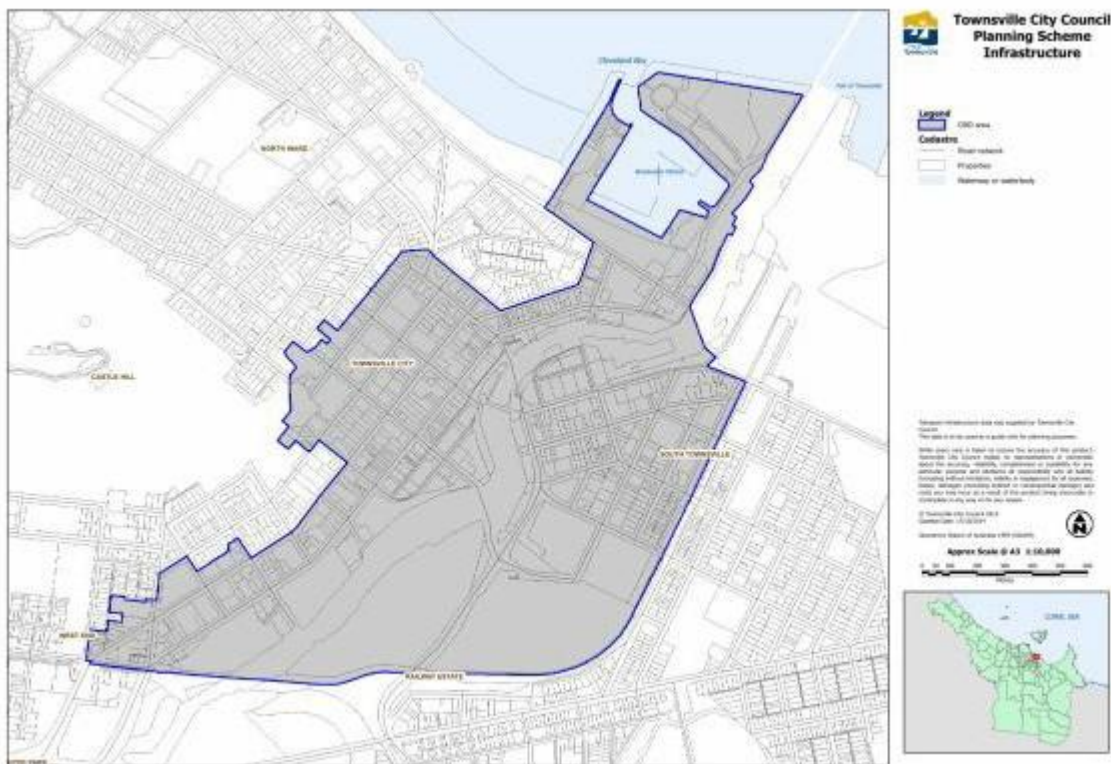
The TIA report must provide a preliminary overall master plan map, and recommendations, and include the status (funded, programmed, or unfunded) of any existing traffic upgrading plans.

(10) **TIA report appendices**

The following appendices should be included in the TIA report submitted to council:

- (a) raw traffic count data - average daily and peak hour turning movement traffic count data collected and/or obtained from other sources;
- (b) printouts of analysis results - input/output; e.g. aaSIDRA;
- (c) all traffic network modelling work as an electronic copy - e.g. network attribute data, demographic data and other relevant files (macro, excel etc);
- (d) photographs of the site;
- (e) additional tables or figures not included in the TIA report;
- (f) description of methodologies and assumptions used in analysis;
- (g) worksheets used in analysis - i.e. signal warrant, LOS, queuing, capacity etc.;
- (h) notes on the outcomes of any meetings in regards to the development; and
- (i) variations to the standard report (template) – RPEQ certification of any non-conformances with requirements.

SC6.4.3.14 Attachment A: Map of the CBD



[Click here to view PDF high resolution map.](#)

SC6.4.3.15 Noise and vibration assessments

SC6.4.3.15.1 Introduction

(1) Purpose

The purpose of this sub-section is to:

- (a) provide information to developers and other related parties for use during the planning, construction, and operational stages of a development;
- (b) provide guidance on preparing a noise or vibration impact assessment report; and
- (c) ensure that development is managed in a way which prevents nuisance from the effects of noise and vibration on the health, community well-being and quality of life of an individual or the community, and wildlife.

(2) Terminology

Unless noted otherwise all terms have the same meaning as given in the most recent version of the *Environmental Protection Act 1994*, the *Environmental Protection Regulation 2008*, the *Environmental Protection (Noise) Policy 2008* and the relevant standards. If a definition given in the relevant standards is inconsistent with the Act or Regulation, the Act or Regulation prevails to the extent of the inconsistency.

Background creep a progressive increase in background noise levels due to new noise generating activities locating in an area.

(3) Reference and source documents

(a) Queensland authorities/legislation:

Department of Transport and Main Roads (DTMR) – *Policy for development on land affected by environmental emissions from transport and transport infrastructure*, 10 May 2013

Department of Transport and Main Roads (DTMR) – *Road Traffic Noise Management: Code of Practice*

Department of Transport and Main Roads, Main Roads Technical Standard, *MRTS15 Noise Fences*
Environmental Protection Act 1994

Environmental Protection (Noise) Policy 2008 (EPP Noise).

Queensland Development Code MP Part 4.4 – Buildings in a Transport Noise Corridor.

(b) Australian standard/guideline:

Department Environment Heritage Protection - *Noise Measurement Manual 2013*

Department Environment Heritage Protection - *Planning for Noise Control 2016*

Environment Protection Authority (NSW) NSW Industrial Noise Policy 2000

AS1055.2: *Acoustics – Description and measurement of environmental noise – Application to specific situations*.

AS2107: *Acoustics – Recommended design sound levels and reverberation times for building interiors*.

(c) Austroads

AP-R277/05 - Modelling, Measuring and Mitigating Road Traffic Noise

Guide to Road Design Part 6B: Roadside Environment

SC6.4.3.15.2 Noise and vibration

Noise is often described as unwanted sound and, by its very nature, can cause varying degrees of nuisance. Some sounds are considered to be annoying by some people but not by others. However, in general, the louder the sound, the greater the annoyance or nuisance caused.

The nature and character of a sound, even at low levels, may also cause annoyance. Sound can have a number of characteristics and can be described in many ways. It is not possible to fully categorise every form of sound.

However, this policy is intended to provide guidance for the majority of commonly experienced sounds. "Noise" has become synonymous with "sound" in common language. In this policy, noise will generally mean sound.

Furthermore, sound is defined in Queensland legislation to include vibration and therefore levels of acceptable vibration

are also included.

SC6.4.3.15.3 Development assessment

Preventing noise problems is always better than attempting to rectify noise impacts after the development and trying to resolve problems may not be always possible and can be costly. The management hierarchy under the Environment Protection (Noise) Policy 2008 (EPP Noise) is "to the extent that is reasonable to do so".

- (1) Firstly - avoid; or
- (2) Secondly - minimise; or
- (3) Lastly - manage.

Council encourages development that is sympathetic to the amenity of a location, and minimises the occurrence of background creep. Where proposed uses are likely to increase noise levels at a locality, or be affected by existing noise sources, a noise (and vibration) impact assessment may be required or requested.

If the noise impact assessment report reveals that the use or activity has the potential to create nuisance or exceed acoustic quality objectives as prescribed by *Environmental Protection (Noise) Policy 2008* (EPP Noise), the developer will need to demonstrate by way of a noise (and vibration) control plan how the environmental values (noise) will be enhanced or protected to meet the standard as part of any submission for an operational works permit, or a compliance permit.

SC6.4.3.15.4 Noise and vibration impact assessments

- (1) Subdivision layouts must be designed to ensure that acoustic mounds and acoustic fences over 1.8m are not included in lots with setbacks adjacent to the acoustic structure of 3m or less.

In support of the assessment provisions specified in the Townsville City Plan, a noise (and/or vibration) impact assessment report maybe in situations where:

- (a) a new development is proposed that will create significant noise (e.g. new industry, or commercial premises with refrigeration, air conditioning or exhaust equipment); or
- (b) a new noise-sensitive development is proposed in an area where existing noise sources are present (e.g. an existing industrial site, or a future or existing major road, is located nearby); or
- (c) a new development will generate a significant amount of traffic noise, i.e. traffic volumes increase by around 3000 vehicles per day or more (determined by a Traffic Study Assessment); or
- (d) building work including rock breaking, drilling or piling or other noisy activities are proposed; or
- (e) it is required by council in order to complete an assessment of the proposed development.

The assessments are to be undertaken by a suitably qualified and experienced acoustic practitioner (e.g. a member of the Australian Acoustical Society, the Institution of Engineers, the Association of Australian Acoustical Consultants or a person with other appropriate professional qualifications).

- (2) Information provided in an assessment report should include at least the following:
 - (a) background:
 - (i) the name and qualifications or experience of the person(s) preparing the assessment;
 - (ii) the project description, including proposed or approved hours of operation; and
 - (iii) the relevant guideline or policy that has been applied.
 - (b) impact assessment process:
 - (i) results of background and any other noise measurements (noise impact assessments need to consider not only existing developed property adjacent to the planned facility, but also any nearby undeveloped residential land);
 - (ii) meteorological conditions (wind speed and direction, temperature, atmospheric pressure and humidity) and other relevant details at the time of the measurements;
 - (iii) details of instruments and methodology used for noise measurements (including reasons for

- settings and descriptors used, frequency weighting, height of microphone above the ground and distance to reflective surfaces calibration details);
 - (iv) a site map showing all noise sources, measurement locations and potential noise receivers; and
 - (v) any tonality impulsiveness or other noise characterises and all assumptions of noise propagation and attenuation due to distance, topography, barrier, etc, and
 - (vi) noise criteria applied to the project.
- (c) impact mitigation and compliance:
- (i) noise predictions for the proposed activity;
 - (ii) a comparison of noise predictions against noise criteria;
 - (iii) a discussion of proposed mitigation measures, the noise reduction likely and the feasibility and reasonableness of these measures; and
 - (iv) how compliance can be determined practically.

Editor's note—where it is demonstrated that noise and/or vibration is to have an adverse impact on a sensitive development to an acceptable and manageable level, attenuation treatments will need to be incorporated into the development to ensure that the sensitive development is protected from the identified adverse impacts. Treatments may need to address specific zone code requirements, particularly where street activation is sought from development.

SC6.4.3.15.5 Noise and vibration control plans

Where an impact assessment demonstrates that noise is likely to exceed thresholds contained within the *Environmental Protection (Noise) Policy 2008* or other relevant document or Australian Standard, a noise (and vibration) control plan will need to be submitted.

Editor's note—the noise assessment should have regard to the following – Queensland Development Code Part 4.4 – *Buildings in a Transport Noise Corridor*. Australian Standards AS1055.2 and AS2107; or *Department Environment Heritage Protection Noise Measurement Manual 2013* or *Environmental Protection Act 1994* and *Environmental Protection (Noise) Policy 2008* (EPP Noise); or *Department of Main Roads Road Traffic Noise Management – Code of Practice*.

Note—where in the vicinity of an airport, detailed designs showing how construction can ameliorate noise impacts are to be submitted in accordance with AS2107.

SC6.4.3.15.6 Information to include in a noise and vibration control plan

Aim	Typical actions
Community Relations Editor's note—noise and vibration control plans should describe the approaches to be applied when consulting with, and notifying the community where necessary. Large projects may also be required to develop a community relations plan which includes consultation, notification, and complaint management. Where this is the case the following is to be included in any noise (and vibration) control plan.	(a) Identify all noise and vibration sensitive receivers. Include characteristics of, and risks exposed to, existing buildings, fences, trees, property boundaries and services (within at least 1km for blasting operations). (b) Contingency actions must be developed if the relevant noise/vibration limits will be exceeded. (c) A complaints management system should be devised which includes corrective and preventative actions. (d) Consultation with and information supplied to nearby residents and other sensitive uses.
Hours of operation/construction schedule	Information regarding opening hours or hours of operation in accordance with the relevant planning scheme provisions. For construction hours, refer to SC6.4.5.2.1(2) Hours of work. Scheduling works at periods where people are least affected will also reduce impacts, and should flow on from consultation with the community (as above).

Potential noise and vibration generating activities	The choice of plant and equipment employed on the project can have a direct effect on noise and vibration levels. By selecting equipment of an appropriate size with low vibration generation characteristics, and by ensuring that the equipment is being operated correctly and that noise and vibration reduction devices are operating efficiently, the number of complaints received can be greatly reduced.
Potential noise and vibration mitigation methods	For construction, rock breaking, drilling, and/or piling the following mitigation methods should be considered: (a) maximising the distance between the noisy activities and noise sensitive land uses; (b) undertaking noisy fabrication work offsite where possible; (c) maintaining any pre-existing barriers or walls onsite as long as possible; (d) including construction barriers in the project design; (e) using building and stockpile materials as noise barriers during the earthworks phase which may be used in the final landscape design; and (f) installing purpose built noise barriers, acoustic sheds and enclosures. Road and rail noise attenuation will be considered in the following order of preference; a combination may also be provided: (g) a buffer between noise receptor and receiver; (h) service roads between noise receptor and receiver; (i) larger lots closest to the noise source that allow dwelling units to be set back from the noise source to achieve the applicable reduction level; (j) architectural treatments For class 1-4 buildings see <i>MP 4.4 Buildings in a transport noise corridor</i>. (k) incorporating mounding and landscaping into the design Noise barriers are to be provided in accordance with the principles of the Department of Transport and Main Roads <i>Code of Practice Chapter 5: Integrated Noise Barrier Design</i>; and (l) providing an acoustic fence: A detailed design is to be submitted as soon as possible in the planning process. Design and construction of barriers must meet MRTS15 <i>Noise Fences</i>. The acoustic fence must not be located on the road reserve, but within the boundary line of the abutting property. Refer to SC6.4.4.8 Standard drawings SD002, SD003 and SD004. Where acoustic reports identify that levels will be exceeded, all uses should be provided with attenuation requirements designed by suitably qualified consultants that will enable the use to meet the prescribed standard.
Noise and vibration monitoring	Where appropriate in relation to the use or activity. Include details such as monitoring equipment, standard employed, monitoring frequency, on-site meteorology, activity logs, and results handling procedure.

SC6.4.3.16 Rear lane design

SC6.4.3.16.1 Introduction

The following design principles set out standards, advice and guidelines for consideration where a proposed development includes the creation of a new rear lane or development of land that has a frontage to an existing or historic rear lane.

- (1) Purpose of rear lanes:
 - (a) to provide vehicular access to the rear of premises;
 - (b) by nature and by design, to provide streets where pedestrians, cyclists and vehicles have shared use, but which do not create a more direct through route than provided by the adjoining street network;
 - (c) used to alleviate access difficulties along frontage roads, such as where the lots are narrow, or along roads or streets carrying high volumes of traffic; and
 - (d) in some cases, to improve both the streetscape and to relate the domestic environment more closely to the street frontage;
- (2) Design of rear lanes should be undertaken in accordance with other relevant sections of the Development manual planning scheme policy including SC6.4.4.1 Geometric road design, SC6.4.4.2 Pavement design and SC6.4.3.6 Landscape policy.
- (3) Design of rear lanes should have regard to the *Crime Prevention through Environmental Design Guidelines for Queensland* (CPTED).

Editor's note—for all setbacks, please refer to the relevant parts of the Queensland Development Code.

SC6.4.3.16.2 New rear lanes - development standards

This section outlines development standards and provides guidance and advice to inform appropriate development outcomes for the creation rear lanes associated with new development.

- (1) Design outcomes
 - (a) Rear lanes should be functional and provide good visibility and manoeuvrability. Development of rear lanes should:
 - (i) provide enough width to allow safe vehicle passage and turning into an out of garages, movement of pedestrians and cyclists, and with sufficient room for service vehicles;
 - (ii) enable easy and safe access from driveways;
 - (iii) utility services must be located with easy access for maintenance (including water, sewerage, stormwater drainage, gas, electricity, telecommunications, etc.) with appropriate clearances in accordance with minimum requirements;
 - (iv) ensure that subdivision of lots with rear lane frontage addresses the principal street, for example, that the letterbox is on the street and not the rear lane; and
 - (v) a minimum of one and a half on-street car spaces (unmarked) must be provided within 25m walking distance to each allotment. The car park may not be located within the rear lane.
 - (b) Rear lanes are to be designed having regard to *Crime Prevention Through Environmental Design Guidelines for Queensland* (CPTED) principles, in particular:
 - (i) ensure rear yards of properties can be fenced in accordance with CPTED principles;
 - (ii) lighting of the rear lane is to meet road safety requirements and CPTED principles, while minimising overspill of light into abutting properties, impacting on amenity; and
 - (iii) ensure that boundary treatment and landscaping do not conceal recesses or provide opportunities for anti-social behaviour.
 - (c) Rear lanes should be designed to accommodate the needs of abutting property owners and the streetscape, in particular:
 - (i) landscaping is to be designed to be low maintenance, without impacting on CPTED requirements;
 - (ii) landscaping to rear lanes should not impede any pedestrian or vehicle access; and

- (iii) landscaping within rear lanes should not create recesses or provide uninvited opportunities for anti-social behaviour. As a guide, grass, ground cover, or visually permeable low-level vegetation are acceptable. Trees and shrubs that provide visual screening of activity are to be discouraged;

Editor's note—landscaping should otherwise be undertaken in accordance with the [9.4.39.3.3](#) Landscape code of Townsville City Plan.

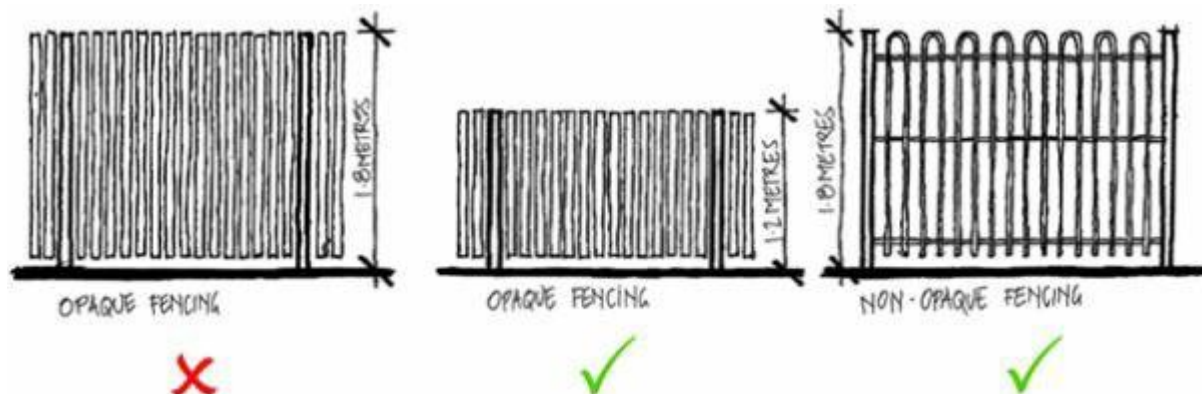


Figure SC.6.4.3.16.1 Inappropriate and appropriate screen fencing types at various heights

- (iv) landscaping must not obstruct traffic movements and sightlines, particularly at driveways and intersections;
- (v) the use of rear lanes as a short-cut route should be discouraged, as this may introduce through traffic travelling at high and unsafe speeds and reduce the amenity; and
- (vi) a minimum of one off-street car park is to be provided per allotment.
- (vii) fencing can be provided to the boundary fronting rear lanes to provide security, discourage uninvited access and enhanced amenity. The following advice is provided in respect of fencing, which should be in accordance with CPTED principles. Figure SC6.4.3.16.1 provides examples of inappropriate and appropriate fencing for rear lanes, in addition to the following:
 - (A) screen fencing and gates that are opaque should not be more than 1.2m in height;
 - (B) screen fencing and gates may be more 1.2m in height if they are non-opaque (e.g. pool fencing) but should not be greater than 1.8m in height;
 - (C) screen fencing and gates that are opaque and higher than 1.2m should be setback a minimum of 3 m from the rear lane boundary; and
 - (D) boundary fencing between properties, if opaque and higher than 1.2m, is to taper down to 1.2m to the rear lane boundary from a setback distance of 3m.

(2) Rear lane design standards

- (a) Traffic flows on rear lanes should not exceed 100 vpd.
- (b) Reserve widths for rear lanes must allow for:
 - (i) a road reserve width appropriate to allow for vehicle turning paths to access allotments and to contain stormwater drainage flows;
 - (ii) all services located within the rear lane maintaining appropriate clearance as per relevant standards and requirements;
 - (iii) water mains and connections for allotments provided to correlate to the addressing of the properties;
 - (iv) sewer mains and connections for allotments provided in accordance with SC6.4.3.21; and
 - (v) stormwater in accordance with SC6.4.4.4 Stormwater drainage design.
- (c) Rear laneways should not exceed 75m in length, in order to maintain a maximum design speed of 30km/hr based on an intersection speed of 20km/hr.

- (d) Horizontal and vertical alignment should incorporate curves to encourage low vehicle speeds by creating an environment where drivers are actively discouraged from driving above 30 km/hr.
 - (e) Traffic calming can be achieved through acceptable geometric methods.
 - (f) Rear lanes must be designed so that they are used as a short-cut between streets.
 - (g) street lighting must comply with SC6.4.3.20.
 - (h) intersections of rear lanes with other lanes and other streets must comply with SC6.4.4.1.
- (3) Consideration of the final desired built form of adjacent lots being serviced will be a consideration to ensure sufficient operating space and clearance is achievable for waste collection vehicles. Access for emergency vehicles must also be a consideration.

Editor's note—the Development manual planning scheme policy sub-section SC6.4.3.22 Waste management provides additional information regarding waste collection standards.

SC6.4.3.16.3 Historic rear lanes

- (1) The following design standards, advice and guidance are provided for consideration when addressing applications for reconfiguring a lot and involving a historic rear lane and where a historic rear lane forms a road frontage to the development.

Editor's note—while the following information is provided to guide development involving the historic rear lanes of Townsville, the principles may be useful for consideration of other existing rear lanes that are not historic.

SC6.4.3.16.4 Development intent for historic rear lanes

- (1) Rear lanes are an inherent part of the historic make-up and character of some of Townsville's oldest suburbs, particularly South Townsville and Railway Estate. Historic rear lanes have been identified through studies undertaken by council as being worthy of preservation, as they contribute towards the unique character and amenity of Townsville's older suburbs. Importantly, historic rear lanes have influenced the character and built form.
- (2) The purpose of this section is to ensure the character of historic rear lanes does not diminish, and to enhance the existing character provided by the rear lanes. Further, it is intended to discourage inappropriate development outcomes adjacent to these rear lanes.
- (3) This part seeks to clarify the characteristics of development that are appropriate to historic rear lanes and therefore provide guidance and certainty to all stakeholders, whilst also adhering to best practice with regard to CPTED principles.

SC6.4.3.16.5 Description of historic rear lanes

- (1) Description

Principally, rear lanes are found in Railway Estate and South Townsville. The use of the term "historic rear lanes" generally refers to historic rear lanes associated with land zoned as Character residential zone under Townsville City Plan.

The dominant physical characteristics of the historic rear lanes are as follows:

- (a) rear lanes are typically 6m wide;
- (b) they are between 50m and 350m long, with the majority being approximately 110m long;
- (c) rear lanes are straight and occasionally intersect with other rear lanes;
- (d) where sealed, the bitumen is approximately 2.7m to 3m wide and is in the centre of the rear lane. The space on either side of the bitumen is an unsealed landscaped grass verge;
- (e) some rear lanes have not been sealed;
- (f) rear lanes are generally one lane with two-way access;
- (g) most properties with access to a rear lane have primary access via the street, however, some properties fronting Boundary Street, for example, have primary access via the rear lane only; and
- (h) rear lanes are sometimes the primary point of access for local infrastructure such as sewerage and

SC6.4.3.16.6 Development standards

- (1) This section outlines development standards to guide appropriate development to retain and enhance the historic character of rear lanes.

Development affecting rear lanes should:

- (a) ensure rear lanes remain functional and provide good visibility and manoeuvrability;
 - (b) provide appropriate width to enable safe and efficient vehicle movement, including for service vehicles;
 - (c) enable easy and safe access into and out of sheds, carports and garages;
 - (d) not create a more direct through-route alternative for vehicles, cyclists or pedestrians than the adjoining street network;
 - (e) be designed to ensure rear yards of properties can be fenced in accordance with CPTED principles (Queensland);
 - (f) ensure that boundary treatment and landscaping do not conceal recesses or provide opportunities for anti-social behaviour; and
 - (g) ensure that subdivision of lots with rear lanes addresses the principal street, for example, that the letterbox and water connection are on the street and not the rear lane.
- (2) Waste collection vehicles will not service a rear lane unless the design facilitates safe vehicle access and operating conditions for a waste collection vehicle.

Editor's note—the Development manual planning scheme policy sub-section SC6.4.3.22 Waste management provides additional information regarding waste collection.

- (3) Subdivision of lots in areas with rear lanes should be "vertical", down the centre of the block (see "b" in Figure SC6.4.3.16.2), creating two similar-sized rectangular blocks (approximately 10 m wide). This is consistent with lot sizes in parts of Workers Cottage precinct and South Townsville precinct in the Character residential zone, where the existing character of the lot sizes of some sites in Townsville's older suburbs is 10m wide by either 40m or 50m deep.
 - (4) Where subdivision of lots in areas with rear lanes is proposed to be "vertical", down the centre of the block, primary vehicular access via the rear lane is permitted.
 - (5) Where lots are configured in a "hatchet" configuration, as shown in "a", "c" and "d" in Figure SC6.4.3.16.2, primary vehicular access is not permitted via the rear lane. Generally, primary vehicular access to the block is to be from the street, with the exceptions as noted in Figure SC6.4.3.16.2 (b and c).
 - (6) Some properties that border Boundary Street in South Townsville may have exceptional circumstances in relation to the scenarios outlined in Figure SC6.4.3.16.2. These will be assessed on their individual merits.



Figure SC6.4.3.16.2 Unacceptable and acceptable lot reconfiguration and access for properties adjacent to rear lane

(7) Crime prevention through environmental design considerations.

Editor's note—applicants should also have regard to *Crime Prevention through Environmental Design Guidelines for Queensland* in addition to the below specific guidelines.

- (a) Lighting should be provided for buildings with vehicular or pedestrian access to rear lanes. Appropriate lighting may include sensor lighting, installed overlooking the driveway or pathway respectively.
- (b) Tilt panel doors or other doors should not open directly onto the rear lane.
- (c) Rear yards of properties may be fenced to support CPTED principles and improve amenity, security (casual surveillance) and vistas.
- (d) Rear boundary fence gates to rear lanes are encouraged to increase activation of the space.
- (e) Fencing can be provided to the boundary fronting rear lanes to provide security, discourage uninvited access and enhanced amenity. The following advice is provided in respect of fencing and should be provided with regards to the principles of CPTED. Figure SC6.4.3.16.1 provides an example of inappropriate and appropriate fencing for rear lanes, in addition to the following:
 - (i) Fences or walls along a street frontage have a maximum height of 1.2m where solid, or 1.8m where that portion of the fence above 1.2m high is at least 50% transparent.
- (f) Historic rear lanes are generally not used for on-street parking with the exception of short-term parking by service vehicles. Parking should be discouraged through approved treatments, including landscaping, surface finish and limited signage (if necessary).

(8) Landscaping and driveways

- (a) Landscaping, where provided to rear lanes should create local amenity and beautification of its environs and must be in keeping with established character of the particular rear lane.
- (b) Landscaping, where provided within rear lanes should not conceal recesses or provide uninvited opportunities for anti-social behaviour. This can be achieved with grass, ground cover, or visually permeable low-level vegetation. Trees and shrubs that provide visual screening of activity are to be discouraged.
- (c) Landscaping must not obstruct traffic movements and sightlines, particularly at driveways and

intersections.

- (d) Driveways are to be constructed in accordance with the sub-section SC6.4.3.17 Driveways.

SC6.4.3.17 Driveways

SC6.4.3.17.1 Introduction

This sub-section details standards and provides advice and guidelines to assist in the design and construction of driveways (domestic, industrial, commercial and rural property access), location, and other aspects in relation to their impact on pedestrians, cyclists, other vehicles, stormwater and neighbours.

Note—the technical details depicted and described in SC6.4.4.8 Standard drawings must be adhered to.

- (1) Reference and source documents to be read and applied in conjunction with this policy sub-section are as follows:

- (a) SC6.4.4.8 Standard drawings

SD-006 Typical Road Cross Sections – B-Double Turning Path and Access Plan Example Drawing
SD-020 Concrete kerbing
SD-025 Kerb Ramp
SD-030 Driveway access urban residential properties
SD-031 Driveway access industrial
SD-032 Driveway crossovers urban residential
SD-090 Driveway Access Rural Properties Type 1 - Access With Invert Slab $H < 300\text{mm}$
SD-091 Driveway Access Rural Properties Type 2 - Conc. Access With Culvert Cast Insitu With Grate $H \geq 300\text{mm}$
SD-092 Driveway Access Rural Properties Type 3 - Gravel Access With Culvert Cast Insitu With Grate $H \geq 300\text{mm}$
SD-093 Driveway Access Rural Properties Type 4 - Conc. Access With Culvert Inverted Pre-cast Box Culvert $H \geq 325\text{mm}$
SD-094 Driveway Access Rural Properties Type 5 - Gravel Access With Culvert Inverted Pre-cast Box Culvert $H \geq 325\text{mm}$
SD-095 Driveway Access Rural Properties Type 6 – Access With Culvert Cast Insitu $H \geq 450\text{mm}$
SD-096 Driveway Access Rural Properties Type 7 - Conc. Access With Culvert $535\text{mm} < H < 685\text{mm}$
SD-097 Driveway Access Rural Properties Type 8 - Gravel Access With Culvert $535\text{mm} < H < 685\text{mm}$

- (b) Townsville City Council Local Laws

Local Law No. 1 (*Administration*) 2011

Local Law No. 4 (*Local Government Controlled Areas, Facilities and Roads*) 2011

Subordinate Local Law No. 1.1 (*Alteration or Improvement to Local Government Controlled Areas and Roads*) 2011

Subordinate Local Law No. 1.15 (*Carrying Out Works on a Road or Interfering with a Road or its Operation*) 2011

- (c) Australian Standards: AS2890.1 *Off-street car parking*

- (d) Queensland Development Code: NMP1.1 *Driveways*

- (e) Austroads

Guide to Road Design Part 3 – Geometric Design

Guide to Road Design Part 4 - Intersections and Crossing - General

- (2) Terminology

Driveway

unless stated otherwise, the term driveway in this sub-section refers to the access between the road and the property boundary; ie. on council-controlled land. This sub-section does not provide advice on the vehicular movement area within the private property.

Crossover

the part of a driveway that is located crossing the kerb and channel.

Local Road	a road under the control of a Local Government.
Property owner	entity, applicant, developer or owner/s who is responsible for the driveway at the time.
Queuing area	the area of a circulation roadway between the property boundary and the vehicle control point, available for the queuing of vehicles.
Regulated parking	parking controlled by traffic signs or line marking.
Rural area	an area where the urban criteria are not met as specified in the Townsville City Plan.
Road corridor permit	a permit issued by the Department of Transport and Main Roads authorising works on a State-controlled Road.
Road works permit	a permit issued by council authorising works within the road reserve on a Local Road; the area of land under the council's control, dedicated, notified or declared to be a road for public use.
Sight stopping distance	means the distance to enable a normally alert driver, travelling at the design speed on wet pavement, to perceive, react and brake to a stop before reaching a hazard on the road ahead. Refer to the <i>Austroads Guide to Road Design Part 3 – Geometric Design</i> .
State-controlled road	means a road under the control of the Department of Transport and Main Roads, including national highways.
Urban area	an area where the urban criteria are met in accordance with SC6.4.3.13.

Note—types of driveways include:

New driveways - must comply with the requirements of council's standard drawings. Works are at the property owner's cost and to the satisfaction of council.

Non-conforming driveways - existing driveways which do not meet council requirements that must be reassessed in the event of a redevelopment of the site. Works are at the property owner's cost and to the satisfaction of council.

Redundant driveways – existing driveways that are no longer in use and must be removed. Works are at the property owner's cost and to the satisfaction of council.

Unapproved driveways - driveways that have not been approved by council. Council may require these driveways to be removed or modified. Such works are at the property owner's cost and to the satisfaction of council.

Modified driveways - modifications to existing driveways must comply with the requirements of council's standard drawings. Works are at the property owner's cost and to the satisfaction of council.

Temporary driveways - Temporary property access during construction. Works are at the property owner's cost and to the satisfaction of council.

SC6.4.3.17.2 Responsibility

- (1) The driveway is the responsibility of the property owner to construct and maintain. A Road Works Permit is required for all works within the road reserve under council control.
- (2) Costs
The property owner is responsible for the cost to:
 - (a) prepare and obtain the appropriate permit(s);

- (b) design and construct the driveway and associated works; and
- (c) maintain the driveway.

SC6.4.3.17.3 Location

The location and layout of a driveway must consider the type of frontage road, land use of the property, and the type and volume of vehicles likely to use the access. It must be located to avoid being a hazard to any pedestrian and cyclist, through movement of traffic, and to minimise damage to the verge and vegetation/ landscaping. A separate, clearly distinguishable access for pedestrians and cyclists is to be provided.

The property owner must ensure that there are no impacts on stormwater, upstream or downstream, due to the driveway (refer to SC6.4.3.8 Stormwater) being constructed.

Rural driveway location and layout must also consider the through traffic volume, turning volume, vehicle type, speed environment, road layout, land use and general topography. It may be necessary to widen the shoulder or provide a turning lane to enhance safety for turning vehicle and through traffic.

- (1) For all driveways, the location of the driveway should be:
 - (a) as far as practical from intersections to minimise points of conflict and confusion, and to improve safety. Driveways should not be situated within the functional area of at-grade intersections;
 - (b) to a road of a lower hierarchy where reasonable access can be provided;
 - (c) at least 6m from the tangent point, or where no tangent point exists, at least 12m from the intersection of two street property boundaries; and
 - (d) positioned to achieve adequate sight distance for all traffic movements associated with property accesses. Desirably, a driver has at least stopping sight distance available to react to a potential conflict and come to a stop.

Editor's note—refer to *AS2890.1 Off street car parking*.

- (2) All driveways should avoid being located:
 - (a) opposite the terminating road of a T-junction on non-residential streets;
 - (b) within the signalised area (defined by extension of the signal stop lines to the road boundaries), within 25m of a signalised intersection, and not adjacent to auxiliary lanes, depending on the property frontage width. Access may be permitted if it can be demonstrated to council that the location of the driveway will be safe;
 - (c) within a roundabout area, nor desirably within 25m of the roundabout entrances or exits. Access may be permitted if it can be demonstrated to council that the location of the driveway will be safe;
 - (d) opposite or within 6m of a median opening in a major road; and
 - (e) within the bus stop boarding area and on the downstream side of the bus stop.

Note—on-site parking bays must be located clear of queuing areas. This allows vehicles to drive completely onto the property without having to stop for other vehicles to complete on-site parking manoeuvres.

- (3) Driveways must be constructed at a right angle to the kerb line/road centreline unless demonstrated that it is not safe to have the driveway at a right angle.
- (4) Driver visibility at the property line to pedestrians, cyclists and other vehicles must be clear of obstruction (e.g. fencing and landscaping), and should account for changes in grades or curves in road alignment.

Note—if sight distance is not adequate then a mirror, or other approved device, will be required to be installed at the property owner's cost.

SC6.4.3.17.4 Amenity

- (1) The driveway should not adversely affect, impede or cause a nuisance to neighbouring properties.
- (2) The driveway crossover of one property should not encroach onto the frontage of any adjacent property, except where it is required to achieve the desired outcome and has received approval from council.
- (3) The driveway should minimise the vehicle headlight impact on the adjacent neighbourhood.

SC6.4.3.17.5 Materials

The driveway must be constructed in accordance with SC6.4.4.8 Standard drawings.

SC6.4.3.17.6 Clearances

The driveway must be constructed in accordance with SC6.4.4.8 Standard drawings.

SC6.4.3.17.7 Gradient

The driveway must be constructed in accordance with SC6.4.4.8 Standard drawings.

Note—this may not be practicable in some particularly hilly residential locations. Driveways with higher gradients can be constructed by using the expertise of a professionally qualified engineer and with the approval of council.

SC6.4.3.17.8 Number of driveways

- (1) The number of driveways will be one per lot.
- (2) Two may be permitted where:
 - (a) there will be more than ten metres or less than four metres between the driveways; and/or
 - (b) the property has two street frontages; and
 - (c) an analysis of on-street parking demonstrates that on-street parking will continue to be adequate even if a second driveway is constructed.

Where parking bays are marked on the street including service bays and bus stops and alteration to these bays is required to accommodate the second driveway, there is to be no loss of use. Displaced bays can be included in the off street parking component of a commercial development where considered appropriate. The applicant is responsible for the alterations to the line marking and signage.

- (3) Commercial and industrial properties with separate entry and exit points or two or more entry levels or multiple ramps can have more than two driveways. Where two or more access driveways are permitted for industrial or commercial sites, the two access driveways must be separated by a minimum spacing of ten metres from the edge of the driveway at the kerb and channel.

SC6.4.3.17.9 Stormwater

- (1) The property owner must ensure that there are no impacts upstream or downstream as a result of the works.
- (2) In rural areas in particular, the driveway must not block or significantly impede stormwater flow along the road table drain.
- (3) Where a box culvert is installed under the access, the minimum clearance below the level at the property boundary or the edge of the bitumen roadway (whichever is the lower) to the top of the access is provided in accordance with SC6.4.4.8 Standard drawings. This clearance must be achieved to allow water flowing in the drain to surcharge over the access before entering onto the roadway or the adjacent property.

SC6.4.3.18 Geotechnical investigations

SC6.4.3.18.1 Introduction

(1) Purpose

This policy sub-section provides advice and guidance and assist applications

- (a) on the preparation and assessment of geotechnical investigation reports;
- (b) on the expected level of geotechnical investigation required for development based on the level risk or hazard identified; and
- (c) information council may request for a development application.

(2) Background

Development on steep lands presents a unique set of design and engineering challenges, often requiring a greater degree of detail in the design and approval of allotments, earthworks, roads, services and built form.

There is a growing awareness of the risks, environmental values, and ongoing costs associated with development on steep slopes, which has resulted in an expectation of an improved standard of design in these environmentally and geologically sensitive areas. This is supplemented by an increased mindfulness of the risks and financial cost to construct and maintain the servicing in these areas and the need to consider these factors in the assessment of applications involving a landslide hazard.

Editor's note—certain existing steep land or hillside developments have demonstrated how inappropriate forms of land use and servicing can permanently damage local environmental features and diminish valued natural assets, particularly scenic qualities. In addition, it has been noted how the costs to maintain associated infrastructure can become a burden on the wider community due to the specialist nature of this infrastructure and the generally lower density in these areas. Whilst these areas do contribute to the diversity of housing choice, the pricing of lot and housing prices usually exceed the ability for the local economy to include these as affordable housing options.

(3) Application

This sub-section applies to development affected by the Landslide hazard overlay maps OM-07.1 and OM-07.2.

(4) Reference and source documents

Australian Geomechanics Society (AGS), *Australian Geomechanics*, Volume 42 No 1 March 2007.

Fell, R., Hungr, O., Leroueil, S. Riemer, W., 2000: *Keynote Lecture – Geotechnical engineering of the stability of natural slopes, and cuts and fills in soil*, GeoEng2000, 1, 21-120. Invited Papers, Technomic Publishing, Lancaster, ISBN: 1-58716-067-7, November 2000.

SC6.4.3.18.2 Geotechnical investigations

(1) Requirement of a site-specific geotechnical investigation report.

- (a) Where development is subject to assessment against Part 8.2.7 Landslide hazard overlay code, an applicant will be required to undertake a geotechnical investigation of the likely impacts of the proposed development and to determine the measures to avoid or mitigate unacceptable risk and other adverse impacts.
- (b) Table SC6.4.3.18.1 Guidelines for applicability of geotechnical assessment techniques in landslide hazard categories specifies the level of investigation required for the particular hazard level affecting the subject land. Where the subject land has more than one hazard level mapped, the assessment technique shall be for the higher hazard level mapped. Table SC6.4.3.18.2 Applicability of site investigation methods to slope classes should be considered in conjunction with Table SC6.4.3.18.1.
- (c) The planning and design of future development should consider the level of professional geotechnical input commensurate to the landslide hazard category which the development is subject to. In general, it is appropriate that geotechnical input for development be carried out in accordance with the reporting standards proposed by the AGS, 2007c Landslide Risk Management (Reference 8). This requires the

practitioner to consider not only the issues surrounding the landslide hazard (if one exists) but also the consequences if a landslide were to occur (i.e. the assessment need to be couched in a risk assessment context).

- (d) The extent and detail of the investigation will vary dependent upon the level of hazard identified on the Landslide hazard overlay maps OM-07.1 and OM-07.2 and the nature of the development being proposed. Council will require each report to demonstrate a scope and depth of investigation appropriate to the level of hazard identified, for the specific site characteristics and the proposed development and works.
- (e) Geotechnical reporting needs to clearly indicate whether the risk assessment is based on existing slope conditions or with risk treatment measures implemented (or both).

(2) Preparation of a site-specific geotechnical investigation report

- (a) A geotechnical investigation report must document the following:
 - (i) introduction to the proposal including a description of the subject land, locality and proposed development;
 - (ii) description and investigation of existing conditions of the development site, including assessment of land stability and geotechnical constraints to development (see SC6.4.3.18.2(3) Investigation information requirements);
 - (iii) assessment of the suitability of the site for the development. This should include an assessment of the likely effects and impacts of the development upon slope stability or landslide hazard (see SC6.4.3.18.2(3) Investigation information requirements);

Editor's note— assessments should be undertaken and give sufficient consideration of the final intended development outcomes for the subject site, including staging of development and associated works.

- (iv) measures recommended to mitigate impacts including siting, design, engineering, and any other necessary mitigation measures; and
 - (v) conclusion and recommendations (see SC6.4.3.18.2(3) Investigation information requirements).
- (b) Geotechnical investigation reports are to reference Australian Geomechanics Society (AGS) Volume 42 No 1 March 2007, or any later guideline of the AGS as agreed by council.
- (c) Geotechnical investigations are to be undertaken and certified by an appropriately qualified and experienced engineering geologist, geotechnical engineer or registered professional engineer appropriately experienced in slope stability investigations in accordance with Australian Geomechanics Society Volume 42 No 1 March 2007.
- (d) The findings, recommendations and specific works of the geotechnical investigation report must be implemented and complied with to ensure that the risk level for the development will be no more than "low". If the engineer's assessment report finds that the site will be "low risk" after development without the need for specific works to achieve this, certification need not be required.
- (e) Laboratory testing is required to be undertaken by a National Association of Testing Authority (NATA) certificated laboratory. All investigations, testing and design should be undertaken in accordance with industry practice and the provisions of relevant Australian Standards.

(3) Investigation information requirements

- (a) Geotechnical investigations should cover the matters set out below, and may include, but need not be limited to:
 - (i) review of existing data sources including regional geology, topographic maps and geotechnical reports;

Editor's note— applicants may also refer to SC6.4.3.7 Steep land development design guidelines for further information.

Note—where a geotechnical investigation has been previously undertaken and the report provided as supporting documentation to council for a previous application over the subject land, these documents must be clearly referenced in the report prepared for the subsequent application. Such supporting documentation must be made available to council and be current and specifically relevant to the proposed development.

- (ii) stereoscopic viewing of vertical air photo pairs to facilitate terrain mapping;
- (iii) preparation of site plan showing results of geomorphic and engineering geological mapping (to scale);
- (iv) subsurface investigations including drill holes, auger holes, shafts and test pits with locations shown on to scale site plan;
- (v) results of laboratory testing of samples recovered from the subsurface investigation;

Note—the results of all laboratory tests must be included in the geotechnical report, including the location and level (including datum).

- (vi) groundwater and surface water studies including recording of groundwater conditions in sub surface investigation and mapping of surface seepages;
- (vii) preparation of cross section(s) showing interpreted geotechnical and groundwater conditions with cross section location identified on site plan;
- (viii) evidence of past slope stability performance;
- (ix) evidence of history of slope instability with assessed trigger events, including in relation to adjoining land;
- (x) identification of landslides, shown in plan and on section, and discussed in terms of the site geomorphology and slope forming process;
- (xi) assessment of consequences to property and life for each landslide and or type of landslide with basis therefore;
- (xii) assessment of risk for each landslide and or type of landslide;
- (xiii) assessment of landslide frequency (probability) and or type of landslide;
- (xiv) risk assessment in relation to tolerable risk criteria (e.g. published criteria where appropriate); and
- (xv) risk mitigation measures and options, including revised risk assessment following implementation.

- (4) Guidelines for applicability of geotechnical assessment techniques in landslide hazard categories
- Table SC6.4.3.18.1 has been prepared for the standard geotechnical techniques identified in AGS, 2007c which are applicable for the assessment of landslide risk. The various investigation techniques have different levels of applicability for the different hazard categories shown on the Development constraints overlay map – Landslide hazard OM-07.1 and OM-07.2. Table SC6.4.3.18.1 should therefore be considered as a guideline as to the applicability of professional geotechnical input for any hazard category.

Table SC6.4.3.18.1 Guidelines for applicability of geotechnical assessment techniques in landslide hazard categories

Investigation techniques	Landslide hazard				
	Landslide hazard Map OM-07.1				OM-07.2
	Very Low	Low	Medium	High	>23degrees
1. Review of existing data sources including regional geology, topographic maps and geotechnical reports	B	A	A	A	A
2. Stereoscopic viewing of vertical air photo pairs to facilitate terrain mapping	B	B	A	A	A
3. Preparation of site plan showing results of geomorphic and engineering geological mapping (to scale)	B	B	A	A	A
4. Subsurface investigations including drill holes, auger holes, shafts and test pits with locations shown on site plan.	C	B	A	A	A
5. Results of laboratory testing of samples recovered from the subsurface investigation	D	C	B	A	A
6. Groundwater and surface water studies including recording of groundwater conditions in sub surface investigation and mapping of surface seepages	C	B	B	A	A
7. Preparation of cross section (s) showing interpreted geotechnical and groundwater conditions with cross section location identified on site plan.	C	B	B	A	A
8. Evidence of past slope stability performance.	B	B	B	A	A
9. Evidence of history of slope instability with assessed trigger events, including in relation to adjoining land	B	B	B	A	A
10. Identification of landslides, shown in plan and on section, and discussed in terms of the site geomorphology and slope forming process	C	B	B	A	A
11. Assessment of landslide frequency (probability) and or type of landslide.	C	B	B	A	A
12. Assessment of consequences to property and life for each landslide and or type of landslide with basis therefore	C	B	B	A	A
13. Assessment of risk for each landslide and or type of landslide	C	B	B	A	A
14. Risk assessment in relation to tolerable risk criteria (e.g. published criteria where appropriate).	D	C	C	B	A
15. Risk mitigation measures and options, including revised risk assessment following implementation	C	B	B	A	A

Note— A – Strongly Applicable B – Applicable C – May be applicable D – Seldom applicable

(5) Applicability of site investigation methods to slope classes

Table SC6.4.3.18.2 summarises the applicability of various site investigation techniques for natural and constructed slopes of various scales. The requirements for site investigations shown in Table SC6.4.3.18.1 should be considered in the context of the hazard categories given in Table SC6.4.3.18.2.

Note—

1. A – Strongly applicable, B – Applicable, C – May be applicable, D – Seldom applicable.
2. In similar areas.
3. SPT, CPT, CPTU.
4. Permeability.
5. During construction.

Table SC6.4.3.18.2 Applicability of site investigation methods to slope classes

Site investigation method	Natural slopes				Constructed slopes			
	Small/shallow	Medium	Large	Existing cut	New fill	New cut	New fill	Soft clay
Topographic mapping and survey	A	A	A	A	A	A	A	A
Regional geology	A	A	A	A	A	A	A	A
Geological mapping of project								
Area	B	B	A	A	B	A	B	C
Geomorphological mapping	A	A	A	B	B	B	B	D
Satellite imagery interpretation	D	D	C	D	D	D	D	D
Air photograph interpretation	A	B	A	C	C	C	C	C
Historic record	A	B	B	A	B	B (2)	B (2)	B (2)
Dating past movements	B	C	B	D	D	D	D	D
Geological methods	C	C	B	C	C	C	D	C
Trenches and pits	B	A	B	B	B	B	B	C
Drilling/boring	C	A	A	C	B	B	B	A
Downhole inspection	C	B	B	C	D	C	D	D
Shafts and tunnels	D	C	B	D	D	D	D	D
In situ testing of strength								
Permeability	C (3)	C (3)	C (4)	D	B (3)	C	C	A (3)
Strength and permeability monitoring pore pressures, rainfall, etc.								
	C	A	A	A	A	C	C	A (5)
Monitoring of displacements	C	B	A	B	B	B (5)	C (5)	A (5)
Laboratory testing	C	A	B	B	B	B	C	A
Back analysis of stability	C	B	A	C	B	B (2)	C (2)	C (2)

Source: (Fell, Hungr, Leroueil and Reimer, 2000)

SC6.4.3.19 Road and street naming

SC6.4.3.19.1 Introduction

(1) Objectives

The objectives of this sub-section are to:

- (a) provide a consistent procedure and setting of standards for road and street naming within the Townsville City Council Local Government Area to contribute towards a legible road and street network;
- (b) ensure urban and rural addressing are simple as possible, unique and clearly identifiable;
- (c) identify the information council may request for a development application or as a condition of approved; and
- (d) provide guidance or advice about satisfying an assessment criteria.

(2) Terminology

Estate	an Estate is a group of homes and other buildings built together as a single development (e.g. housing development).
Roadway	is considered to be any public or private land- based thoroughfare or course navigable by vehicle or foot that can be used for assigning addresses or allowing access between points or to a feature. Examples of roadways include alleyways, roads, streets, highways, laneways, fire tracks, bike paths and walking tracks.
Roads	are generally through routes for the movement of vehicular traffic.
Streets	are generally for providing property access, pedestrian and cycle movement with more localised vehicular traffic.

(3) Reference and source documents

- (a) Australian standards
AS/NZS 4819 – *Rural and urban addressing*
- (b) SC6.4.4.8 Standard drawings
SD065 Street Name Sign and Installation Details
SC6.4.6.2 Minor concrete works
SC6.4.6.24 Signposting

SC6.4.3.19.2 Information requirements

- (1) In order for council to consider a name for a new road or street, the following information is required, in support of the request:

Note—an application for road/street name approval must be submitted to and approved by council prior to the submission of any operational works application.

Editor's note— fees are to be paid in accordance with the *Planning and Development Schedule of Fees and Charges* for formal applications for road and street naming approval. *Planning and Development Schedule of Fees and Charges* – Schedule 1 can be found on council's website.

- (a) for new developments not associated with an Estate, three proposed names for each proposed road/street;
- (b) for a new Estate, a list of proposed names to be used within the Estate; and
- (c) the origin of each name should be clearly stated on the submitted proposal for consideration. Requests

for roads/streets to be named after significant individuals are to be accompanied by a summarised autobiography of each individual to be recognised. For groups of names with similar origins, a bulk explanation is acceptable if the theme generated is from the same source.

Editor's note - For roads/streets that are existing gazetted roads, whether constructed or not, names must be submitted to council for approval

Editor's note - The approved road/street names as well as the road/street type must be shown on the engineering drawings submitted for subsequent operational works approval.

SC6.4.3.19.3 Criteria for the naming of roads and streets

The following criteria will be used in assessing requests for road and street naming:

(1) Australian standard (AS/NZS 4819 – *Rural and urban addressing*)

This sub-section adopts the parts of AS/NZS 4819 – *Rural and urban addressing* identified below, for use in the naming of roads and streets:

- (a) **Section 1** – Scope and General;
- (b) **Section 4** – Road definition and naming; and
- (c) **Appendix A** – Road types – Australia.

Where this sub-section is silent on a matter, Sections 1, 4 and Appendix A of AS/NZS 4819 shall apply and, further, they will prevail to the extent of any inconsistency with this sub-subsection.

(2) Name duplication

Name duplication (both existing names and approved names) within the Townsville City Council Local Government Area will not be approved. This requirement is to ensure consistency and to avoid confusion and misunderstanding in the delivery of goods or services or in the dispatch of emergency vehicles.

(3) Sources

- (a) The preferred sources for road and street names include:

- (i) indigenous names of significance to the area, subject to prior approval of the relevant local Aboriginal or Torres Strait Islander Land Council via council's Aboriginal and Torres Strait Islander Advisory Committee;

Note—the relevant local Aboriginal or Torres Strait Islander Land Council should be consulted via council's Aboriginal and Torres Strait Islander Advisory Committee when choosing Aboriginal or Torres Strait Islander names, unless council already has an agreed list of appropriate names.

- (ii) flora and fauna, generally using the common name and excluding lengthy or complex scientific names;
 - (iii) names of founding mothers and fathers, prominent citizens or identities, excluding living persons;
 - (iv) war casualty lists;
 - (v) local heritage values; and
 - (vi) existing road/street naming themes in the suburb or area.
- (b) Names should be appropriate to the physical, historical or cultural character of the area concerned.
- (c) The origin of each name should be clearly stated on the submitted proposal for consideration. Requests for roads/streets to be named after significant individuals are to be accompanied by a summarised autobiography of each individual to be recognised. For groups of names with similar origins, a bulk explanation is acceptable if the theme generated is from the same source.
- (d) A variation to these sources will be considered on the individual merits of the proposal.

Note—all proposed names will be considered on their individual merit.

(4) Communication

- (a) Names should be reasonably short, easy to read, spell and pronounce in order to assist service providers, emergency services and the travelling public. Proposed names should not be similar in spelling or sound to existing names.
- (b) Names must not be offensive or discriminatory.
- (c) Unduly long names and names composed of two or more words should be avoided:
 - (i) a given name should only be included with a family name where it is essential to identify an individual or where it is necessary to avoid ambiguity, e.g. Angus Smith Drive, John Melton Black Drive, Sir Leslie Thiess Drive etc. The use of given names should generally be avoided; and
 - (ii) whilst street and cul-de-sac names should have only one word it is recognised that some roads require a two word name because of their geographic relationship e.g. Old Common Road, Ross River Road etc.

(5) Spelling

- (a) Where it is intended that a road/street have the same name as a place or feature with an approved geographical name, then particular care should be taken to ensure that the correct spelling is adopted.
- (b) Where names have been changed or corrupted by long established local usage, it is not usually advisable to attempt to restore the original form; that spelling which is sanctioned by general usage should be adopted.
- (c) Generally, road/street names proposed or approved should not contain abbreviations. For example, the "Creek" in "Wallaby Creek Road" must not be abbreviated. There is, however, one exception: "ST" should always be used in place of Saint.

(6) Form

- (a) "The" must not be used in place of a name followed by a road type for example, "The Boulevard".
- (b) Prepositions in road names should not be used, for example, "Hampton on Boulevard".
- (c) No directional indicators are to be used, for example, "Gold Road West" and "Gold Road East".
- (d) Prefixes such as "Upper", "New", "North" or "South" must not be used unless the name has been specifically derived from a name that includes these.
- (e) The apostrophe mark must be omitted in the possessive case, e.g. 'Smith's Road' should be "Smiths Road".
- (f) Hyphens are not to be used.
- (g) Full stops are not to be used.
- (h) No symbols, diacritical marks or special characters are to be used. The exception is macrons for Maori names.
- (i) Numerals are not to be used. Any numbers in a name must be written in full. Only standard A to Z alphabet characters may be used.

(7) Road types

- (a) Particular attention should be paid to the use of street, road, court, crescent, drive etc., to ensure that the road type is representative of the road being described. Road/Street types are to be in accordance with AS 4819 Appendix A and read in conjunction with section 4.3 of AS 4819.
- (b) The road/street type/s is required to be submitted to council as part of the application for consideration of road/street names. The road/street type/s is to be submitted for checking by council on plans associated with operational works approval. The road/street type must be appropriate for the road layout.

(8) Holding of approved names

Approved names remain valid for the following periods:

- (a) 5 years for developments not associated with Estates; and
- (b) for Estates, the applicant is to advise council at the time of the request for approval of names, the proposed, estimated time period for the completion of the Estate. Approved names will be held for this time period.

SC6.4.3.19.4 Street name signs

The street name signage must be in accordance with standard drawing SD065 Street Name Sign and Installation Details and installed and constructed in accordance with SC6.4.6.28 Minor concrete works and SC6.4.6.24 Signposting.

SC6.4.3.20 Public lighting and utility services

SC6.4.3.20.1 Introduction

(1) Purpose

The purpose of the Public lighting and utility services sub-section is to provide standards, advice and guidelines for the design, installation and construction of public lighting and utility services.

(a) Public lighting is provided to:

- (i) allow for the use of and safe movement in public spaces;
- (ii) provide improved safety and security for the community at night; and
- (iii) enhance the public amenity.

Council encourages the design and use of efficient lighting systems that support council's commitment to sustainability and meet the requirements of AS/NZS 1158 *Lighting for roads and public spaces*.

(b) Utility services

A purpose of a road reserve is to provide a corridor for the delivery of utility services such as water supply, sewerage, gas, telecommunications (including future telecommunications) and electricity to all properties fronting the road, street or rear lane. The verge or footpath area between the road reserve boundary and the edge of the roadway provides the space for these service corridors and these guidelines are designed to achieve the following aims:

- (i) provide a convenient location for the installation and safe access to all utility services for maintenance and retrofitting purposes;
- (ii) provide a corridor for street furniture including road lighting poles;
- (iii) minimise possible conflict with other underground services; and
- (iv) provide an opportunity for street landscaping.

Council standard drawings (SC6.4.4.8 Standard drawings) for service corridors provide details of utility alignments within the footpath/verge and should be read in conjunction with SC6.4.4.1 Geometric road design

(2) Scope

(a) Public lighting includes:

- (i) road lighting (urban and rural);
- (ii) lighting for footpaths and cycle paths;
- (iii) lighting for parks;
- (iv) lighting for sports grounds and sports complexes;
- (v) lighting for public buildings;
- (vi) lighting for off-street car parks; and
- (vii) feature lighting which may include bollards and in ground lighting.

(b) Utility services include (but are not limited to):

- (i) reticulated water supply;
- (ii) reticulated sewerage supply;
- (iii) reticulated gas supply and its supporting infrastructure;
- (iv) reticulated telecommunications network, including future services (fibre optic);
- (v) reticulated electricity, both underground and overhead supply; and
- (vi) lighting networks, including road, open space, community facilities and off-street parking.

(3) Consultation

Developers and sporting groups are encouraged to consult with council and the relevant servicing authority and determine any requirements these authorities may have before undertaking any detailed design.

Developers should obtain service plans from all relevant public utility authorities and organisations whose services may exist within the area of the proposed development. These services are to be plotted on the relevant drawings including the plan and cross-sectional views.

If there is an expectation that an application may have higher servicing demands, details of these additional demands should be provided to council and the servicing authority.

(4) Reference and source documents

- (a) Council specifications and drawings
SC6.4 Development manual planning scheme policy - all specifications and drawings for design and construction.
- (b) Australian Standards, in particular
AS/NZS 1158 - *Lighting for roads and public spaces*
AS/NZS 1596 - *The storage and handling of LP gas*
- (c) Other
Australian Government, *Disability Standards for Accessible Public Transport 2002*
Electricity Act 1994
Electrical Safety Act 2002
Energy Queensland, *Developer's Tool Kit* (web-based)

Editor's note—the *Developer's Tool Kit* can be found on the Energy Queensland website.

SC6.4.3.20.2 Public lighting (urban and rural)

(1) Public lighting general

There are a number of types of public lighting infrastructure which meet a range of different needs. Infrastructure associated with public lighting generally consists of poles, outreach arms, lamps, luminaires, photoelectric cells, switch gear, footings and connections to a supply. The size and type of lighting infrastructure will be determined by the size and type of the use, the intensity of lighting required, remoteness from supply and the time of operation.

All lighting designs must be prepared and certified by an appropriately qualified Registered Professional Engineer of Queensland prior to submission to council with a development application.

Road and public space lighting must be designed in accordance with AS/NZS 1158 and Energy Queensland's requirements.

(2) Road lighting general

Lighting infrastructure must be chosen from the list of products supported by Energy Queensland, unless specifically otherwise agreed by council. Road lighting chosen from the list of products supported by Energy Queensland will become infrastructure owned by Energy Queensland, on a Rate 2 Tariff.

All Category P lighting in new residential areas must be LED lights as approved by Ergon Energy.

If other road lighting infrastructure is preferred by a developer for aesthetic or other reasons including for environmental protection, which the developer expects to hand to council for ongoing maintenance, justification must be provided on how this will fit into any lighting master plans for the area. Without approval council gives no guarantee that this infrastructure will be adopted by council, and if it is adopted, that it will be maintained in that form. Any "non standard" road lighting would be on a Rate 3 Tariff.

Editor's note—council does not support shading of lights on the basis that it would be a penalty to road users, particularly cyclists and pedestrians.

- (a) Road lighting in rural residential areas
Flag lighting is to be provided at:
 - (i) all intersections on roads;

- (ii) on curves where the advisory speed through the curve is 15 km/h lower than the gazetted speed limit of the road; and
- (iii) at the ends of cul-de-sacs.

A maximum 150W luminaire should be used at a mounting height of 10.5m.

Lighting on roads under the control of the Department of Transport and Main Roads must be designed to meet their requirements.

(b) Road lighting in urban areas

Lighting must be provided in accordance with the relevant sections of AS 1158 and the following:

- (i) Category V3 Lighting on arterial and sub-arterial roads;
- (ii) Category V5 Lighting on major collector streets;
- (iii) Category P4 Lighting on, access Streets, access Places, industrial streets, and commercial precincts unless otherwise determined by council, e.g. higher lighting levels to assist with CCTV surveillance; and
- (iv) lighting in public transport infrastructure (compliance to the *Disability Standards for Accessible Public Transport 2002*).

(c) Lighting for bicycle, pedestrian and shared paths

Lighting Category P1 – P4 for bicycle, pedestrian and shared paths as advised by council after consideration of location, hours of use and risk to the public.

(d) Lighting for parks

Lighting requirements for parks will be determined by council based on where the park fits into the hierarchical structure. A point of supply is required to most parks and where required, the precise location of the supply will be advised by council. This lighting may have a sub-metered supply.

(e) Lighting for sports grounds and sports complexes

Lighting requirements for sports grounds and sports complexes will be determined by council based on where the park fits into the hierarchical structure.

A point of supply is required to most parks and where required, the precise location of the supply will be advised by council.

(f) Lighting for public buildings and spaces

Lighting requirements for public buildings and spaces will be determined based on a risk assessment considering location, time of use, number of people, relevant building codes and AS/NZS 1158.

(g) Lighting for off-street car parks.

Lighting must be provided in accordance with the relevant sections of AS 1158. A point of supply is required to most off-street car parks. Lighting shall be provided in accordance with the lighting master plan for the area, unless otherwise approved by council. This lighting must have its own separate metered point of supply.

(3) New subdivision marketing banners on light poles

It is common practice for developers to place marketing banners on light poles along local roads within the boundary of the new subdivision. Banners are lightweight and made of a non-rigid material.

The developer must obtain approval from Ergon Energy to erect marketing banners on light poles and comply with all Ergon Energy conditions. Banners on light poles must not be a driver distraction on the road or at an intersection. Banners must not interfere with an official traffic sign, distract a drivers attention at a critical time, obscure the drivers view of a road hazard, give instructions to stop, imitate an official traffic sign, nor be an obstruction to the road or a hazard to all other road users. A high level of safety for road users must be maintained.

At the time of on maintenance council may accept the marketing banners on light poles, but the developer must indemnify council for all matters arising from the banners erected on light poles. The banners may remain on the light poles for twelve (12) months. If banners are required beyond this time then the developer must

submit a request to council for a twelve (12) month extension of time. Council may request the developer to remove any marketing banner on any light poles at any time.

Editor's note – there may be additional related requirements in Subordinate Local Law No. 1.4 (Installation of Advertising Devices) 2011.

Council will not give consent for advertising banners to be placed on street lights that are owned and maintained by council.

SC6.4.3.20.3 Utility services

- (1) All utility services are to be underground.

All services to new developments must be constructed underground unless otherwise approved by council. Layout plans for all service installations must be submitted to council as part of the development application.

- (2) Alterations to existing services

Care should be taken during the design to avoid other existing underground services, and where this is unavoidable it will be the developer's responsibility to undertake the necessary alterations to the satisfaction of the asset owner at the developer's cost.

Where it is necessary to install conduits under existing roads, this installation must be undertaken by boring unless otherwise approved by council.

Telecommunication cabinets and electricity supply pillars

The proposed location of on street telecommunication cabinets and electricity supply pillars must be shown on plans and be located clear of access driveways to properties, and clear of any water and gas services in accordance with any requirements of the relevant authority.

- (4) Electricity supply general

An overhead supply approved by the relevant energy authority where in the rural residential zone, special purpose zone or high impact industry zone or where on a lot of less than 2,500 m² within an area where the existing supply is overhead is acceptable.

In exceptional circumstances, remote access properties in the rural zone may be permitted provide an electricity supply that is not connected to the grid. It shall be demonstrated by the applicant that an adequate and reliable supply that maintains standards for safety, environmental, health and amenity is achievable. Acceptable alternatives may include solar or other similar self-generating system.

Electricity and/or telecommunications services must be designed in accordance with the relevant utility provider's guidelines. Electricity design plans submitted to council with an RPEQ certification are only accepted by council to permit the utility provider (e.g. Energy Queensland) to formally approve the design.

In the construction phase only conduits for both electricity and telecommunications utilities are installed, with the relevant utility provider installing the actual service after the works are complete.

- (5) Gas supply

Where it is proposed to provide a reticulated gas supply to a development, the gas service pipe must be installed in the verge or footpath on the alignment shown on SC6.4.4.8 Standard drawings.

If a storage cylinder is proposed as part of the development, the cylinder must be installed and maintained on a separate freehold parcel of land in accordance with all safety regulations contained in the AS/NZS 1596 *The storage and handling of LP gas*. Details for servicing the gas cylinder must be provided to council as part of the development application.

SC6.4.3.21 Townsville Water planning and design guidelines

SC6.4.3.21.1 Introduction

(1) General

This sub-section has been developed by the Programs and Technical Support (PATS) department within Townsville Water and Waste, to document the procedures undertaken during the delivery of their services.

(2) Intent of the sub-section

This sub-section has been developed to detail relevant information pertaining to planning and design projects and to collate Townsville Water and Waste practices not documented elsewhere. Its intended use is as a reference manual for:

- (a) internal Townsville City Council staff including Townsville Water and Waste and Planning and Development (Infrastructure Planning Unit and Development Assessment);
- (b) external consultants engaged to perform specific commissions; and
- (c) developments that include water and wastewater infrastructure.

(3) Application

These guidelines shall apply to sewerage and water supply distribution, collection, pumping and treatment and effluent reuse in the areas of:

- (a) planning;
- (b) design;
- (c) technical specifications for approval;
- (d) preparation of technical contract documentation; and
- (e) collection and submission of as-constructed details.

It excludes: information on the presentation of drawings.

(4) Purpose

The purpose of these guidelines is to ensure that:

- (a) all water supply, sewerage and effluent reuse works are designed and constructed to common standards throughout Townsville city, and comply with codes and standards established by the relevant government authorities;
- (b) the reticulation and pumping systems provided are hydraulically adequate for the demands from the currently planned stage of development within any particular Water Supply/Sewerage Scheme at any point in time;
- (c) the total system of reticulation pumping and treatment is progressively developed with adequate capacity to meet the ultimate requirements of the particular Water Supply/Sewerage Scheme; and
- (d) the quality of water supplied and the quality of effluent disposed by Townsville Water and Waste meets acceptable minimum standards established by the relevant government authorities.

(5) Triple bottom line

Any new works undertaken by Townsville Water and Waste and development must meet the requirements of a triple bottom line approach to sustainable development, and be economically, environmentally and socially viable.

(6) Acceptance of designs and documentation

The design of infrastructure shall comply with the requirements that are detailed in Townsville Water and Waste's Total Management Plans where relevant.

Externally produced designs and documentation including drawings shall be certified by a Registered Professional Engineer of Queensland (RPEQ).

SC6.4.3.21.2 Water supply design

(1) Introduction

(a) Scope

The work to be carried out under SC6.4.3.21.2 includes the design of a water supply system either as a stand-alone project or as part of a development.

(i) Inclusions

SC6.4.3.21.2 covers the design of:

- (A) pump stations;
- (B) storage reservoirs;
- (C) water mains – including trunk and reticulation mains; and
- (D) property connections.

(ii) Exclusions

SC6.4.3.21.2 does not cover requirements for:

- (A) bulk water storage – dams etc.; and
- (B) water treatment plant design considerations.

Bulk water supply infrastructure will be planned and designed by council in conjunction with experienced specialist consultants.

(b) Documents

(i) Reference and source documents

SC6.4.3.21.2 is to be read in conjunction with the current version of the following documents.

Australian Drinking Water Guidelines (National Health and Medical Research Council)

Planning Guidelines for Water Supply and Sewerage, Department of Energy and Water Supply
(DEWS Guidelines)

(WSA 03) *Water Supply Code of Australia*

Workplace Health and Safety Queensland, *Safe Design of Structures – Code of Practice*

(ii) Document precedence

The order of precedence (highest to lowest) of documents shall be:

- (A) SC6.4.4.8 Standard drawings;
- (B) this sub-section;
- (C) WSA 03; and
- (D) DEWS Guidelines.

(c) Standard drawings

SC6.4.4.8 Standard drawings shall be read in conjunction with this sub-section. Standard drawings other than water and sewerage (such as road crossings) also contain information on water and sewerage infrastructure and shall also be referred to.

(i) Amendments to WSA 03

The design of water supply systems shall comply with *WSA 03 Water Supply Code of Australia* unless otherwise specified herein, and shall be constructed in accordance with *WSA 03 Water Code of Australia Construction Specification*. Amendments required by Townsville Water and Waste to WSA 03:2011 are included in Table SC6.4.3.21.1. Any conflicting information in later codes shall be referred to Townsville Water and Waste for clarification.

Table SC6.4.3.21.1 Amendments to WSA 03:2011 – Water Supply Code of Australia

WSA 03 Section	Amendments to WSA 03 – Water Supply Code of Australia:
2.3	Demand parameters are set in SC6.4.3.21.2(2). Variations from these parameters are to be approved by Townsville Water and Waste.
Figures 2.1(a) and 2.1(b)	Dead end mains are not permitted.
2.4	Minimum mains sizing – DN100 (with fire service provision) on one side of the street, in conjunction with DN63 (rider main) to the other side.
2.5.3	Minimum service pressure shall be 22 m at the service connection under peak flow conditions, with a minimum service flow rate of 30 L/minute.
2.9	Storage reservoirs shall be sized to not empty under 7 consecutive days of 95% peak day demands.
3.1.5	Water supply systems shall be designed for fire fighting capability in accordance with parameters set out in Table SC6.4.3.21.3.
3.3 and 3.8	Minimum Class of pipe shall be PN16.
4.7	GRP pipe is not permitted.
5.6	Shared Trenching is not permitted without prior written approval.
5.10	Dead end mains are not permitted.
5.11 and 15.8	Property Service and Water Meters shall only be installed by Townsville Water and Waste upon application.
9.2.2	Longitudinal section drawings shall be provided for water mains DN200 and above.
14.2, 16.0	Pipe embedment and support: For flexible pipes refer to AS2566.2, Tables G1, G2 and G3 for suitable material types.
15.20.1	An access hatch is required on the steel main to reinstate cement mortar lining.

(2) Water supply planning

(a) Scope

Water supply system planning covers the requirements of the water distribution and reticulation system from the bulk supply system to the service connections. This includes pump stations, storage reservoirs, trunk water mains, and reticulation mains.

(b) Hydraulic loading assessment

(i) General

Hydraulic loadings shall be determined in terms of equivalent persons (EP) and developed into flows using the unit loading factors and peaking factors detailed in the following sections.

(ii) Equivalent population estimations

The ultimate equivalent population (EP) used to determine design flows shall be determined from the following:

- (A) designated value of EP per hectare for each zone type provided in Section 4.2.11 of Part 4 of Townsville City Plan;
- (B) the location of various zone types as specified in Townsville City Plan;
- (C) an assessment of the ultimate population, including the expected peak occupancy rates and the quantity of undeveloped land for each zone type listed in Townsville City Plan; and
- (D) estimation of contributing loads for “Special Purpose” zonings (university, refineries, hospitals, etc.) shall be determined by an analysis of historic consumption and consultation with the institution regarding future development.

Editor's note - Where staging of the works is necessary, the planner is to consider the expected growth rate for the area to develop loadings for intermediate planning horizons. This shall be based on the Townsville City Council Growth Model which is available from Planning and Development (Infrastructure Planning Unit). This model is based on population projection information available from the Planning Information Forecasting Unit (PIFU), Office of Economic and Statistical Research within the Queensland Government, Department of Treasury and Trade.

- (iii) Design flows
Peak demands are to be calculated from Table SC6.4.3.21.2.

Table SC6.4.3.21.2 Water supply unit demand parameters

Parameter	Unit Demand	Peaking Factor
Average Day (AD)	600 L/day/EP	
Mean Day Max Month (MDMM)	900 L/day/EP	1.5 AD
Peak Day (PD)	1125 L/day/EP	1.25 MDMM
Peak Hour (PH)	0.033 L/s/EP	2.56 PD

In addition to the residential demand, the AD irrigation demand is 60L/EP.

- (iv) Design criteria
Water supply systems shall be sized in accordance with the requirements of:
- *Planning Guidelines for Water Supply and Sewerage.*
- The design criteria for water supply infrastructure are summarised in Table SC6.4.3.21.3.

Table SC6.4.3.21.3 Water supply infrastructure design criteria

Design Criteria	Value
<i>System Pressure</i> NB: measured immediately upstream of the customer's water meter not downstream of water meter. Max Head loss through a water meter is 25kPa i.e. 2.5 m (AS3565.1)	
Minimum Operating Pressure	22 m to the meter
Maximum Operating Pressure	80 m to the meter
<i>Fire Fighting Requirements</i>	
System Pressure	12 m minimum at the property boundary and any point within the system
Fire Flow	Rural Residential (Zone 1 or 2) – 7.5L/s Residential – 15 L/s Commercial and industrial – 30 L/s
Background Demand	PH > 3,000 person communities 2/3 PH < 2,000 person communities Linear interpolation between 2/3PH and PH for 2000 and 3000 persons communities
Reservoir level	Mid-water level
<i>Reservoir Storage</i>	
Ground Level Storage	7 days of 95% PD Demand; Cases where inflow is MDMM Demand this equates to:- $7 \times (0.95 \times 1.2 \times \text{MDMM} - \text{MDMM}) = 1.31 \text{ MDMM}$
Elevated Storages	$6 \times (\text{PH} - 1/12 \text{ MDMM}) + \text{Fire fighting reserve (150 kL)}$
<i>Pumping Capacity</i>	
Duty Pump Capacity	Sized for MDMM flows with 20 hours operation
Pumps serving Elevated reservoirs	$(6 \times \text{PH} - \text{Operating Volume}) / (6 \times 3600)$
Standby pump capacity	To match the capacity of the largest pump in the station

Design Criteria	Value
<i>Pipeline Design</i>	
Pipe Capacity - Distribution Mains	Sized for MDMM flows.
Pipe Capacity - Reticulation	Based on peak instantaneous demands; of PH and Fire Flow.
Fire Services Pumps	TWW preference is for pumped fire services to be connected downstream of a fire tank. If fire pump is directly connected to the water reticulation main applicant must provide evidence that the selected pumps will not have adverse impact on the surrounding network.

Friction factors to be adopted for the pipe network modelling are detailed in Table SC6.4.3.21.4.

Table SC6.4.3.21.4 Hazen Williams pipe friction coefficients

Mains	Diameter (mm)	Adopted “C” Values	
		Cement Lined Pipe	Plastic Pipe
Distribution	< 300	110	130
	300-600	120	140
	> 600	125	150
Reticulation	<= 150	100	120
	225 – 300	110	130
	> 300	120	140

(c) Network planning

(i) Purpose

The purpose of network planning is to determine the most effective means of providing a service to an area through analysis of both infrastructure and non-infrastructure based solutions. The determination of the most effective solution should be made through analysis of whole of life costs and consideration of non-financial aspects such as operations, maintenance, and environmental obligations.

Section SC 6.4.3.21.2(2)(c) details the circumstances under which a network plan should be prepared.

When preparing planning reports for both water and sewerage assets, the author shall refer to Section 6 of the DEWS *Planning Guidelines for Water and Sewerage*.

(ii) Network modelling

A water network model is required for all code or impact assessable material change of use (MCU) and reconfiguring a lot (RoL) applications where:

- (A) new trunk and/or reticulation mains are to be constructed as part of a development;
- (B) the development requires trunk infrastructure identified in council's Plans for Trunk Infrastructure to be constructed ahead of its planned date, or out of sequence identified in master planning;
- (C) the proposed land use results in an increase in demand greater than what is presently allowed for Townsville City Plan; or
- (D) water mains are required to be relocated or reconfigured as part of the proposed works, and these works are expected to change the hydraulics of the existing supply.

TCC also requires the development of a network model for:

- the preparation of Infrastructure Master Plans; and
- the preparation of Priority Infrastructure Plans (and Plans for Trunk Infrastructure).

Network modelling shall be undertaken in accordance with SC6.4.3.23 Water and sewerage network modelling guidelines.

(iii) Levels of assessment

Depending on the type of works in question, simplified or detailed modelling may be required to demonstrate compliance with these guidelines. Simplified or detailed assessments are defined below:

- (A) “Simplified Assessment” – an assessment that demonstrates network capacity through manual calculations, or through the use of simplified network models (schematic style models); and
- (B) “Detailed Assessment” – an assessment involving the preparation of detailed network models based on proposed design and/or development layouts.

SC6.4.3.23 Water and sewerage network modelling guidelines outline the process to be followed to obtain council advice as to what level of assessment is required.

(iv) Timeframes

Master planning shall be undertaken over a 30 year timeframe. The capacity of the existing network to service ultimate demand should be assessed and any system augmentations to service ultimate requirements identified. The staging of infrastructure works is an essential consideration and should be incorporated into the planning and design process. Staging of infrastructure works should be also considered at no greater than 10 year intervals until the ultimate horizon.

For developments being completed in less than a 5 year timeframe, network modelling shall be undertaken for existing case, and full development.

Council may request that master planning consider provision to adjacent developments to enable an efficient trunk network.

Net present value cost analysis should be undertaken using a range of interest rates (typically 3%, 5% and 7%), as well as the rate for weighted annual cost of capital (WACC) which can be sourced from council. Timeframes of 10, 20, and 30 years shall be applied.

Longer timeframes will enable assessment of the impacts of major replacement and upgrade works on the viability of the system. Council may require longer timeframes for analysis.

Cost assessments should only consider an engineering cost assessment, with loan interest and depreciation considered separately by council when considering a business case for a particular project. The following on-cost allowances should be made:

Establishment	2%
Project management/engineering design/council management costs	15%
Contingency	30%

(3) Bulk water storage and water treatment

(a) General

New bulk water storages and storage upgrades, new water treatment process design and upgrades are complex and site specific, and are typically undertaken as one-off projects and performed by experienced designers/consultants with the necessary qualifications, specialist skills and experience to carry out the planning, assessment, design and delivery processes for the project.

Generally, Townsville Water and Waste will prepare a detailed design brief and requirements for the engagement of specialist consultants suitable to carry out the project.

(b) Re-chlorination

At locations within the distribution system it may be necessary to re-chlorinate the water supply to maintain the free chlorine residual within the target range of 0.5 – 1.5 mg/L.

Re-chlorination stations should be located either at pump stations or at reservoir sites.

For safety, re-chlorination stations are to be fitted with appropriate signage and alarms to comply with

(4) Pump stations

(a) General

This section covers the design of:

- (i) bulk water supply pump stations to service reservoirs; and
- (ii) smaller booster pump stations to boost pressure in the distribution system. Booster pump stations should be avoided wherever practical by appropriate reticulation design, and will only be permitted with written approval by Townsville Water and Waste.

(b) Capacity and pump sizing

- (i) Pump station capacity
Pump stations shall be sized to meet the system requirements for the planning horizon. Multiple pump units can be used to achieve the required pump duty.
- (ii) Booster pump stations
Pump stations acting as reticulation boosters will supply the range of flow and head duties from Minimum Flow to Peak Hour conditions.
- (iii) Hydraulic analysis
Hydraulic analysis is to be used to determine the flow and head requirements for the pump station.
- (iv) Pump and rising main sizing
Pump size in combination with the delivery main size is to be designed to minimise whole of life costs covering capital, operating and maintenance costs.
- (v) System resistance curves
System Resistance Curves covering all expected duties of the pumps, including maximum and minimum head cases shall be prepared. A net positive suction head available (NPSHA) curve shall also be prepared.
- (vi) Pump selection
Pump selection shall achieve all expected duties as per the system resistance curves.

Redundant (standby) pump capacity shall be provided. Standby pump capacity shall be at least equal to the capacity of the largest pump unit.

(c) Building structure and general arrangement issues

(i) Materials

Pump stations shall be contained in above ground structures, constructed from reinforced masonry block and/or reinforced concrete walls with concrete or metal (Colourbond) roofs.

In undeveloped areas metal clad buildings may be acceptable subject to suitable compliance with noise emission requirements and adequate site security/vandalism restraint, and with approval from Townsville Water and Waste (See SC6.4.3.21 Attachment C).

(ii) Buildings general

- (A) Permits – a development permit is required for building work (IDAS Form 2) for permanent pump station buildings.
- (B) Location - pump station location and visual appearance shall be approved by Townsville Water and Waste, and shall generally complement the amenity of the local area. Pump stations in built-up areas should have appropriate external appearance to match the surrounds.
- (C) Security – pump station shall be secure, and protected against vandalism, vermin and birds. Buildings shall be designed for Importance Level 3 (minimum) in accordance with the *Building Code of Australia* Table B1.2a as well as with designs shown in SC6.4.3.21 Attachment C.
- (D) Level – pump station floor to be located a minimum of 300 mm above 1% AEP flood level,

be subject to a flood risk assessment, and shall be approved by Townsville Water and Waste.

- (E) Noise management – pump stations shall be designed to comply with the relevant noise emission legislation, regulations and policies.
 - (F) Ventilation – ventilation or air-conditioning where required shall be provided as necessary to control heat from equipment within the building. Independent ventilation of chlorinator rooms shall be provided to meet work, health and safety requirements.
 - (G) Internal drainage – provision shall be made to drain leakage/flows from pumps/pipework away from the building without flooding of switchboards and electrical components.
 - (H) Safety – Pump station structures shall be designed in accordance with Safe Design of Structures – Code of Practice.
- (iii) Structure sizing
Pump stations structures shall be sized to:
- (A) provide adequate access around all pumps and associated pipework, generally 1 m minimum clearance and for maintenance access to pumps, pipework, valves etc.;
 - (B) house the pump station electrical switchboard and telemetry;
 - (C) house necessary craneage (see also (v));
 - (D) house chlorination systems (where required) – a separate room is generally required for chlorination systems, independently ventilated; and
 - (E) wherever practical the pump station structure shall be sized to accommodate the pumps and equipment necessary to achieve the proposed ultimate pump station capacity.
- (iv) Site access
All weather sealed access for maintenance vehicles shall be provided, including:
- (A) sealed asphalt access road, minimum pavement width 4 m;
 - (B) provide access during a minimum 1% AEP flood event; and subject to a flood risk assessment;
 - (C) on-site turn-around for maintenance vehicle; and
 - (D) road geometry suitable for use by light vehicles and single axle trucks.
- (v) Lifting requirements
Design of the building shall enable the use of mobile cranes for lifting of pump units, motors and other equipment.

Where this is not possible, permanent craneage is to be provided within pump stations to allow maintenance of equipment, consisting of a minimum of a monorail crane accessing the pumps and motors. Set-down areas shall be provided:

- (A) within the pump station adjacent to large maintenance doors where the area can be accessed externally by a crane truck; or
 - (B) externally by extending the monorail outside the building to allow loading onto the back of flat bed vehicle (bed height 1.2 m).
- (d) Pipework
- (i) Each pump shall be provided with suction and discharge isolation valves and a non-slam non-return valve on the pump discharge.
 - (ii) At least one easily removable piece of pipework is required on each pump to enable efficient removal and replacement.
 - (iii) Steps and walkways in accordance with AS1657 Fixed platforms, walkways, stairways and ladders - Design, construction and installation shall be provided over pipework such that access is readily available to both sides of each pump.
- (e) Disinfection system
- (i) Chlorine residual booster stations shall be provided when required.

- (ii) Chlorine dosing will be by the use of sodium hypochlorite solution or chlorine gas. Dosing control (either flow paced, fixed rate or other) is to be approved by Townsville Water and Waste.
- (iii) Sodium hypochlorite or chlorine gas storage and dosing equipment shall be housed in a separate room, independently ventilated. The chemical unloading, storage and dosing facility should comply with the handling and safety requirements for the chemical.
- (iv) Chlorine dosing should be into the pump station discharge pipework.
- (v) A safety shower and eyewash facility and appropriate signage is to be provided to meet work, health and safety requirements.
- (f) Power supply and telemetry/instrumentation
 - (i) Power supply for the site shall be provided in accordance with the requirements of SC6.4.3.21.4.
 - (ii) Backup power is not normally provided within water pump stations. Where deemed necessary emergency power shall be provided in accordance with SC6.4.3.21.4.
 - (iii) Telemetry/instrumentation - All pump stations shall be provided with telemetry monitoring. Reticulation system booster pump stations typically are controlled to maintain a constant pressure at the pump station discharge. Pump stations are normally monitored but not controlled by the Telemetry system. Control of the pumps is performed locally.
- (g) Land tenure

The required land tenure for a pump station site is council-owned freehold title.

The land tenure for access to the pump station in order of suitability is:

 - (i) public road; or
 - (ii) council-owned freehold land; or
 - (iii) water supply easement in the name of Townsville City Council.

(5) Storage reservoirs

(a) Scope

This section covers the design of water supply reservoirs, including the requirements for on-ground storages and elevated tanks on steel tank stands.

Refer to SC6.4.3.21.2(5)(c) for structural design of reservoirs.

Editor's note—Townsville Water's Program and Technical Support maintains a set of internally used Standard Drawings for Reservoirs, which can be made available on request.

(b) Site

(i) Location selection

Selection of reservoir site shall be approved by Townsville Water and Waste and shall consider the following:

- (A) proximity to the area(s) to be served and length of mains necessary to supply into the reservoir and distribute to the service area;
- (B) elevation of land to achieve required top water level (TWL) and bottom water level (BWL), and minimum operation level for the reservoir;
- (C) environmental impacts, including visual impact;
- (D) access to site;
- (A) ability to achieve required land tenure;
- (B) geotechnical issues;
- (C) impacts on other services and infrastructure;
- (D) landscaping of the site should be provided where necessary to minimise the visual impact of the facility; and
- (E) where the reservoir is not readily accessible from a public road, particular attention to the

following criteria is required:

- vehicle access and site manoeuvrability;
- access road cross section and drainage; and
- width of land required for access road.

(ii) Visual appearance

The location and visual appearance shall complement the amenity of the local area.

If deemed necessary, a landscape architect shall be engaged to design fast growth plantings to provide a visual screen.

(c) Reservoir tank design

(i) Size and design life

The reservoir and associated inlet and outlet pipes shall be sized in accordance with the planning requirements of this section.

The reservoir design life shall be 80 years minimum.

(ii) General arrangement

Reservoirs shall be circular where possible to provide the most economic construction.

Foundations – the entire tank structure shall be founded on undisturbed parent material. Founding on fill material is not permitted.

The reservoir shall include, but not be limited to:

(A) steel floor, walls and roof support columns:

- a zincalume (or Colourbond Ultra) double sided coated roof on zincalume coated steel purlins (with down-turned lip on bottom flange) and beams;
- inlet and outlet pipework with valves;
- scour pipework with valve;
- overflow pipe;
- lockable access ladders (external only);
- fall arrest system for safe roof access in form of a permanent static line from roof access hatch platform to centre of reservoir;
- davit arm provision for vacuum cleaning by divers;
- telemetry control and monitoring;
- flow meter;
- level sensor;
- natural vermin proof roof ventilation; and
- telemetry control on inlet valve.

(B) all reservoirs shall be roofed and made vermin and bird proof. Drainage from the roof shall not enter the tank; and

(C) personnel access – access shall be provided into the reservoir:

- external access consisting of a galvanised steel ladder to AS 1657;
- lockable roof access opening minimum dimensions 1 m x 1 m;
- minimum one wall access hatches with sampling tap; and
- external accesses shall incorporate features to prevent use by unauthorised persons.

(iii) Materials

The following applies:

(A) the reservoir shall be constructed from plate steel;

(B) steel reservoirs shall be cathodically protected; and

(C) painting – the interior and exterior of the reservoir shall be painted with an approved epoxy paint system, approved for immersion in potable water supply. Colours will be advised by Townsville Water and Waste.

(iv) Pipework

The following applies:

- (A) reservoirs shall be provided with separate inlet and outlet pipes, on opposite sides of the reservoir tank to achieve circulation. the inlet shall have a bend to facilitate circulation;
- (B) a control valve shall be provided on the inlet pipework where specified by Townsville Water and Waste;
- (C) a non-return valve shall be provided on the outlet pipework only where specified by Townsville Water and Waste;
- (D) scours shall be sized to enable the reservoir to be completely drained from full within 24 hours. Scours are to be specified to stormwater; and
- (E) an overflow capable of carrying the ultimate design inflow shall be provided, with connection to scour pipework.

(d) Geotechnical

Geotechnical investigations shall be undertaken for reservoir sites to ascertain sub-surface conditions for the tank design and for stability of batter slopes. Founding must be on undisturbed ground. Construction on fill is not permitted. The following must be taken into consideration:

- (i) slope stability for the reservoir site;
- (ii) site excavation;
- (iii) stability of excavation batters; and
- (iv) design parameters for the access road pavement.

(e) Security

Fencing is required around reservoir sides. Refer to SC6.4.3.21.5(4) for details.

(f) Telemetry/instrumentation

Minimum telemetry monitoring requirements for reservoirs should be reservoir level by submersible pressure transducer.

(g) Land tenure

The required land tenure for reservoir sites is council-owned freehold title.

The land tenure for access to the reservoir site in order of suitability is:

- (i) public road; or
- (ii) council-owned freehold land; or
- (iii) reserve for water supply purposes; or
- (iv) water supply easement in the name of Townsville City Council.

(6) Water mains

(a) General

(i) Scope

This section covers the design of distribution and water supply reticulation mains:

- (A) distribution mains – provide for the transfer of bulk water between treatment and storages infrastructure within the water supply network; and
- (B) reticulation mains – provided for supply from the bulk water system to consumers through the reticulation network.

(ii) Extent

Mains shall be provided to service all properties within the development and where relevant also include bulk mains to service the declared water service area.

(b) Water main sizing

(i) Demands

Mains shall be sized to meet demands (including fire flows).

(ii) Network modelling and whole of life costs

Where specified by Townsville Water and Waste, appropriate network modelling shall be

undertaken to determine mains sizes within the development.

Where distribution mains are pumped, the main size is to be determined in conjunction with the pump size to minimise whole of life costs for the system including capital, operating and maintenance costs.

(c) Mains layouts and general arrangements

(i) Configuration

(A) Distribution mains shall comply with the following:

- configuration and extent of the main is to be determined to suit the requirements of the ultimate development to the approval of Townsville Water and Waste; and
- connections to reticulation mains network and consumers are not permitted, unless required under the project and approved by Townsville Water and Waste.

(B) Water reticulation mains layout shall comply with the following requirements:

- water mains are required down both sides of roads where service connections are provided. Cross-road service connections are not permitted, except in the Rural residential zone where a main on one side of the roadway is acceptable;
- Low density residential zone and Character residential zone streets shall have a minimum of DN 100 (with fire hydrants) on one side of the street and a minimum of DN 63 PE service main on the other;
- water mains (DN100 minimum with fire hydrants) are to be provided on both sides of the road in the cases of divided carriageways, centre, industrial, and medium or high density residential zones. In centre, industrial or high-rise building areas, one of the mains in the street shall be DN150 minimum; and
- permanent dead end mains are not permitted.

(ii) Temporary dead ends are not permitted for more than 12 month defect liability period, temporary loops are to be installed prior to end of defect liability period. Temporary ends/loops are to be design to allow for future connection without shutdown to existing residents, which may include in-line thrust block, valve and FH.

The location for water mains in order of preference is in:

- (A) council controlled roads; or
- (B) main roads controlled by State or Federal Governments; or
- (C) reserves and unallocated state land; or
- (D) council owned freehold land; or
- (E) easements in privately owned freehold land.

Distribution mains alignment shall be as follows:

- the alignment of distribution mains is to be resolved with the appropriate control authority for the road, land or easement, and approved by Townsville Water and Waste.

Reticulation mains alignment shall be as follows:

- the alignment within a road reserve shall be in accordance with SC6.4.4.8 Standard drawings SD-015 Verge Service Corridors, General Type, Sections.

(iii) Cover requirements

Cover requirements shall comply with WSA 03 (Section 5.4.2) plus:

- (A) distribution mains – minimum cover is to provide for the structural integrity of the pipe, meet the requirements of the appropriate control authority for the road, land or easement; and
- (B) reticulation mains:
 - minimum pipeline cover requirements for water mains shall be in accordance with standard drawing SD-325 Embedment and Trench Fill, Typical Arrangement; and
 - maximum cover for maintenance purposes – 1.5 m.

(iv) Services and alignments

Consideration is to be given to other services in the area when selecting alignments.

Refer to WSA 03 Table 5.5 and SC6.4.4.8 for minimum clearance requirements from other services.

Minimum clearance requirements and/or conditions may be imposed by the service owner. Specific conditions apply to construction near services including:

- (A) fibre optic cables;
- (B) high pressure gas or oil mains;
- (C) underground power; and
- (D) overhead power - consider overhead power when selecting pipeline alignments for:
 - safety and clearance issues with construction under or near overhead power lines; and
 - the designer should avoid locating continuously welded steel pipelines in parallel to high voltage power lines (WSA 03, Section 5.4.12).

(v) Shared trenches

Shared trenching of water mains with other services will not be permitted without approval from Townsville Water and Waste.

(vi) Easements

Easements shall be taken over water mains constructed in private property.

The easement width shall be a minimum 3 m. For >DN375 mains, easement width shall be approved by Townsville Water and Waste.

Easement corridor widths shall be suitable to accommodate all water mains for the ultimate development, and approved by Townsville Water and Waste.

(d) Pipe

(i) Materials

Allowable pipe materials include:

- (A) PVC-U, PVC-O, PVC-M (OD compatible with DICL fittings);
- (B) ductile iron cement lined (DICL);
- (C) mild steel cement lined (MSCL);
- (D) ABS;
- (E) polyethylene (PE);
- (F) copper; and
- (G) stainless steel.

Pipeline materials shall be in accordance with WSA 03.

Pipe shall be minimum pressure class of PN16 for all pipe sizes.

(ii) Pipe design

Pipeline material structural design shall be undertaken in accordance with WSA 03 for all internal and external loads applied to the pipeline.

The "PN" rating shall be selected to suit the pipeline design pressures.

In selecting the PN rating for plastic pipes, pressure de-rating for transient loads (water hammer) and temperature shall be taken into account (refer to WSA 03).

(iii) Pipe jointing

Pipelines should generally be rubber ring jointed. Mild steel cement lined pipes will normally be rubber ring jointed unless there are specific reasons for installation of continuously welded pipe segments. PE pipe shall be connected by butt thermal fusion or by electrofusion couplings. Up to 50 mm ID PE pipe may use compression fitting connections.

The following applies for flanged Joints:

- (A) Flanged pipework shall be used where necessary at connections, to transfer thrust, or provide beam action for the pipeline to span;
- (B) Flange classes shall be selected to suit the pipeline design pressures; and

- (C) Flange classes shall be to AS/NZS 4087 *Metallic flanges for waterworks purposes* except where connecting to existing flanges from a different standard. Minimum flange classes shall be:
- Class 14 for Steel Cast Iron; and
 - Class 16 for DICT.
- (iv) Pipe anchorage
- Water mains with unrestrained flexible joints shall be designed to resist the total unbalanced thrust and transmit all thrust loads to the adjacent native soil or rock.
- Pipe anchorage and thrust blocks shall be provided in accordance with WSA 03.
- Alternatively, TYTON-LOK joints or similar may be approved by Townsville Water and Waste in special circumstances. Marker tape shall be provided above the pipe to clearly show the extent of the restrained jointing.
- (v) Concrete encasement
- Concrete encasement of pressure mains is not permitted without written approval of Townsville Water and Waste.
- (vi) Above ground water mains
- Above ground construction is to be approved by Townsville Water and Waste.
- Where a section of water main is to be laid above ground, the pipe materials, support and restraint for the pipes and fittings shall be in accordance with WSA 03, and the pipe manufacturer's recommendations.
- (vii) Cathodic protection
- Cathodic protection (CP) for steel mains laid through corrosive environments may be required if specified by Townsville Water and Waste.
- CP shall be designed by an experienced specialist in accordance with WSA 03.
- (viii) Pipe bedding
- Pipe bedding for water mains shall be in accordance with WSA 03.
- (ix) Restoration
- Refer to WSA 03 for construction specification.
- For restoration under roadways refer to standard drawing SD-055 Road Crossing and Footpath Reinstatement for Trench Laid Services.
- (x) Geotechnical
- Geotechnical matters shall be considered in accordance with WSA 03.
- (xi) Trenchless construction
- Where specified by other infrastructure owners or Townsville Water and Waste, trenchless construction methods may be required. Circumstances requiring trenchless construction methods may include:
- (A) crossing of major roads;
 - (B) where the land controller specifies (e.g. rail and main roads); and
 - (C) crossing environmentally sensitive areas.
- The designer is to provide the details of trenchless construction techniques proposed.
- QR National requires compliance with their Specification: *MCE-SR-16 Requirements for Services under the Railway Corridor (Non-QR Services)*. Common forms of trenchless pipeline construction include:
- pipe jacking;
 - horizontal direction drilling; and
 - micro tunnelling.
- The designer shall identify where trenchless construction techniques are necessary or economical during the design process.
- (xii) Road and rail crossings of existing pipes

Road crossings for existing above ground pipes shall comply with the requirements of the standard road crossing drawing provided in SC6.4.3.21 Attachment B. Rail crossings will be designed on a case by case basis.

For existing underground pipes where road/rail upgrades or new roads/rails are proposed protection or relocation may be required. Concrete encasement may be approved on a case by case basis, preference however is for envelopers. This often is required at major road crossings, at rail crossings and sometimes at waterway crossings. Enveloper designs for road and rail crossings shall be undertaken in accordance with the Land Corridor controller's requirements. Where no specific requirements are provided refer to the standard drawings of WSA 03 and Townsville Water and Waste for further details.

The void between enveloper and carrier pipe shall be grouted at each end using low strength grout on completion of the pipe installation unless other arrangements are required by the Land Corridor controller.

(xiii) Disinfection

The designer shall specify the disinfection of all water mains after satisfactory testing in accordance with WSA 03.

(xiv) Pipeline drawings

Drawings shall include a Plan (1:500) for all mains, and Longitudinal Sections (1:1000 (H); 1:100(V)) for mains DN200 or greater.

(e) Pipeline appurtenances

(i) Hydrants

Hydrants shall be located such that:

- (A) existing and future development lots are or will be within 40 m of the nearest hydrant;
- (B) the spacing between hydrants does not exceed 80 m;
- (C) hydrants are also provided at all high and low points of distribution mains and at (temporary) dead ends; and
- (D) hydrants shall be located in accordance with SC6.4.4.8 Standard drawings SD-305 Street Positioning of Mains, Valves, Hydrants and Domestic Water Service connections and SD-355 Typical Valve and Hydrant Installation – Hydrants and Air relief Valves.

Hydrants may not be located within 10m of pole/pad mounted transformer.

Hydrants located within mixed commercial/residential zones must be installed on a tee with a valve to allow maintenance of hydrant without shutdown of the water main.

(ii) Stop valves

The following applies:

- (A) stop valves for reticulation shall be provided in accordance with the requirements of WSA 03;
- (B) stop valves shall be provided so that a maximum of ten dwellings are isolated for maintenance purposes, and a maximum of four valves to be closed to isolate any section of reticulation main (maximum of one block to be shutdown within the ten dwellings);
- (C) valves shall be located to avoid conflicts with driveways, telephone house service pits, and underground electrical boxes;
- (D) stop valves shall be anti-clockwise closing;
- (E) maximum of 200m between valves; and
- (F) stop valves are to be located on either side of a road crossing.

(iii) Valve and hydrant installation

Valve and hydrant installation shall be in accordance with the following standard drawings:

- (A) SD-305 Street Positioning of Mains, Valves, Hydrants and Domestic Service Connections;

- (B) SD-345 Valve and Hydrant Identification – Identification Markers and Marker Posts;
 - (C) SD-350 Typical Valve and Hydrant Installation – Valve Arrangement; and
 - (D) SD-355 Typical Valve and Hydrant Installation – Hydrants and Air Relief Valves.
- (iv) Air valves
- Air valves are to be provided at high points in distribution water mains. It is not normal practice to provide air valves in reticulation mains as air can be exhausted through hydrants and property connections.
- Air valves shall be designed in accordance with WSA 03 and SC6.4.4.8 Standard drawings SD-355 Typical Valve and Hydrant Installation – Hydrants and Air Relief Valves.
- (v) Scours
- Scours shall be provided at low points in distribution mains and larger reticulation mains for maintenance purposes.
- Scours are not normally provided in smaller reticulation systems. This function is performed using hydrants.
- Scour design will be in accordance with WSA 03 and SC6.4.4.8 Standard drawings SD-360 Typical Appurtenance Installation – Scour Arrangement.
- (vi) Pressure and flow control devices
- The detailed design of a water reticulation system shall identify the need for pressure and flow control devices.
- The designer shall specify, for ease of valve maintenance, fittings located within concrete valve chambers. Valve types shall be selected such that, wherever possible, servicing of the valve can be effected without its removal.
- Pressure and flow control valve design shall be in accordance with WSA 03.
- The designer is to refer to WSA 03 for detailing requirements for valves chambers.
- (vii) Envelopers
- Enveloper pipes shall be used where necessary, and as required by Townsville Water and Waste.
- Enveloper designs for road and rail crossing shall be performed in accordance with the land corridor controller's requirements. Where no specific requirements are provided, refer to the standard drawings of WSA 03.
- QR National requires compliance with their Specification: *MCE-SR-16 Requirements for Services under the Railway Corridor (Non-QR Services)*.
- Suitable casing spacers/insulators shall be fitted to the pipe to ensure adequate spacing from the enveloper. The void at each end between enveloper and carrier pipe shall be grouted on completion of the pipe installation in accordance with SC6.4.4.8 Standard drawings SD-376 Buried crossings, Bored and jacked encasing detail.

(7) Property connections

(a) General

In most circumstances property service connections are not provided by the developer as part of the development, but are installed by Townsville Water and Waste on application from the property owner. Where small and/or narrow lots are created, and there is only one option for service connection location; or council has agreed to service connections within the road reserve or under concrete footpaths or driveways, they must be provided by the developer and located within a valve box to protect the service and to provide easy access.

(b) Property service mains

The following applies:

- (i) distribution mains – Property connections from distribution mains are not permitted; and
 - (ii) reticulation mains – Property connections not permitted from reticulation mains > DN225. A smaller service main shall be provided for property service connections where necessary.
- (c) Sub-metering
- Sub-metering shall be in accordance with WSA 10 and subject to Townsville Water and Waste approval.

Point of supply for properties with sub-meters will be the master meter. Any equipment between the master and sub-meters is the responsibility of the property owner.

SC6.4.3.21.3 Sewerage system design

(1) Introduction

(a) Scope

The work to be undertaken in SC6.4.3.21.3 includes the design of a sewerage system either as a stand-alone project or as part of a development.

(i) Inclusions

SC6.4.3.21.3 covers the design of:

- (A) property connections;
- (B) gravity sewers;
- (C) sewage pump stations;
- (D) pressure mains; and
- (E) reuse systems.

(ii) Exclusions

SC6.4.3.21.3 does not cover requirements for sewage treatment plant design considerations. Bulk sewerage infrastructure will be planned and designed by Townsville Water and Waste in conjunction with experienced specialist consultants.

(b) Documents

(i) Reference and source documents

This section is to be read in conjunction with the current version of the following documents.

Department of Energy and Water Supply *Planning Guidelines for Water Supply and Sewerage* (DEWS Guidelines)

Department of Energy and Water Supply, *Water Quality Guidelines for Recycled Water Schemes*, November 2008

National Water Quality Management Strategy, *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)*, 2006

National Water Quality Management Strategy, *Australian Guidelines for Water Recycling: Treated sewage and stormwater to augment drinking water (Phase 2)* 2008

Public Health Regulation 2005

Workplace Health and Safety Queensland, *Safe Design of Structures – Code of Practice*

WSA 02 *Sewerage Code of Australia*

WSA 03 *Water Supply Code of Australia* (as referenced by WSA 02)

WSA 04 *Sewerage Pumping Station Code of Australia*

WSA 07 *Pressure Sewerage Code of Australia*

(ii) Document precedence

The order of precedence of documents shall be:

- (A) SC6.4.4.8 Standard drawings;
- (B) this sub-section;
- (C) All WSA codes; and
- (D) DEWS Guidelines.

(c) Standard drawings

SC6.4.4.8 Standard drawings shall be read in conjunction with this sub-section. Standard drawings other than water and sewerage (such as road crossings) also contain information on water and sewerage infrastructure shall also be referred to.

(i) Amendments to WSA 02

The design of sewerage systems shall comply with *WSA 02 Sewerage Code of Australia* unless otherwise specified herein, and shall be constructed in accordance with *WSA 02 Sewerage Code of Australia Construction Specification*.

Amendments required by Townsville Water and Waste to WSA 02:2014 are included in Table SC6.4.3.21.5. Any conflicting information in later codes shall be referred to Townsville Water and Waste for clarification.

Table SC6.4.3.21.5 Amendments to WSA 02:2014 Sewerage Code of Australia and WSA 04:2005 Sewage Pump Station Code

WSA 02 Section	Amendments to WSA 02 – Sewerage Code of Australia:
2.3	A sewerage Master Plan is to be submitted by the Developer for approval at the discretion of Townsville Water and Waste.
2.4.2	Townsville Water and Waste requirement is ADWF of 230 L/EP/day.
5.2.8	Easements over gravity sewers are not required in Queensland. Easements over pressure sewers may be required in certain situations. Refer to Townsville Water and Waste.
Table 7.6.5	Maximum of four internal drops into a manhole.
7.0	Maintenance Structures (Manholes (MH), maintenance holes, maintenance chambers) required at a maximum spacing of 90 m (industrial zones 40m). Maintenance Shafts (MS and TMS), are not permitted except those approved by Townsville Water and Waste.
6.4.2	Multiple property connections (i.e. combine house drains) are not lawful in Queensland
7.6.9	Ladders, step irons and landings are not permitted.
8.2	Water seals are not permitted.
8.6	Inverted Siphons are not permitted.
8.9	Wet weather storage is not required, as it is impractical in tropical conditions. However, it may be considered upon written application to Townsville Water and Waste.
4.6.2	PVC Sewer Pipe – minimum SN10 for DN100 and SN8 for other sizes is required.
Construction Section	<i>Internal Epoxy Coating of Manholes – normally only required at Pressure Main receiving manholes.</i>
Construction Section	<i>Pipe embedment and support – For flexible pipes refer to AS2566.2 Tables G1, G2 and G3 for suitable material types.</i>
Appendix B	<i>Estimation of EP Flows – Townsville Water and Waste's alternative method is to apply EP densities from Townsville City Council Headworks Policy (EP per hectare for each zone type provided in Section 4.2.11 of Part 4 of the Townsville City Plan)</i>
Appendix C	<i>Refer to comments above.</i>
General	Townsville Water and Waste's preference is to convey sewage by gravity systems only. Therefore, Townsville Water and Waste's written approval is required for a Pumping Station proposal, and its particular requirements including current electrical and telemetry standards, overflow and emergency arrangements, and compliance with Townsville Water and Waste's current Licence conditions.
WSA 04 Section	Amendments to WSA 04-2005, Sewage Pump Station Code
9.1.2	Minimum size of discharge pipework is DN100.
10.5.4	In selecting the PN rating, pressure de-rating for transient loads (water hammer) and temperature shall be taken into account (refer WSA 03 Planning and Design).
WSA Drawing	Comments/Amendments to WSA Drawings
All	These drawings shall be read in conjunction with SC6.4.4.8 Standard drawings: Where there is a conflict, the standard drawings take precedence.

(2) Sewage collection system planning

(a) Scope

Sewage collection system planning covers the requirements of the sewage collection system from service connection to treatment facility. This includes collection sewers, trunk sewers, pump stations and pressure mains.

(b) Hydraulic loading assessment

(i) General

Hydraulic loading shall be determined for all catchments being assessed. Loadings shall be determined in terms of equivalent persons (EP) and developed into flows using the unit loading factors and peaking factors detailed in the following sections.

(ii) Equivalent population estimations

The ultimate equivalent population (EP) used to determine design flows shall be determined from the following:

- (A) designated value of EP per hectare for each zone type provided in Section 4.2.11 of Part 4 of Townsville City Plan;
- (B) the location of various zone types as specified in Townsville City Plan;
- (C) an assessment of the ultimate population, including the expected peak occupancy rates and the quantity of undeveloped land for each zone type listed in Townsville City Plan; and
- (D) estimation of contributing loads for “Special Purpose” zonings (university, refineries, hospitals, etc.) shall be determined by analysis of historic consumption and consultation with the institution regarding future development.

Where staging of the works is necessary, the planner is to consider the expected growth rate for the area to develop loadings for intermediate planning horizons. This shall be based on the Townsville City Council Growth Model which is available from the Infrastructure Planning Unit. This model is based on population projection information available from the Planning Information Forecasting Unit (PIFU), Office of Economic and Statistical Research within the Queensland Government, Department of Treasury and Trade.

(iii) Design flows

The flow in a sewer comprises domestic sewage, industrial wastes, groundwater infiltration, stormwater inflows and rainfall dependent infiltration.

Design sewage flow shall be calculated in accordance with WSA 02 with the following amendments:

$$\begin{aligned}\text{Design Flow(PWWF)} &= 5 * \text{ADWF} \\ \text{PDWF} &= C2 \times \text{ADWF} \\ \text{Where} \quad \text{ADWF} &= \text{Average Dry Weather Flow} = 230\text{L/EP/day}; \text{PDWF} = \text{Peak Dry Weather Flow} \\ C2 &= 4.7 \times (\text{EP})^{-0.105}\end{aligned}$$

(iv) Sewage pump station design flows

Design flows for sewage pumps stations shall be determined in accordance with SC6.4.3.23 Water and sewer network modelling guidelines.

(c) Network planning

(i) Purpose

The purpose of network planning is to determine the most effective means of providing a service to an area through analysis of both infrastructure and non-infrastructure based solutions. The determination of the most effective solution should be made through analysis of whole of life costs and consideration of non-financial aspects such as operations, maintenance, and environmental obligations.

Section 6.4.3.21.3 (2)(c)(ii) Network modelling details the circumstances under which a network plan should be prepared.

When preparing planning reports for both water and sewerage assets, the author shall refer to Section 6 of the DEWS *Planning Guidelines for Water and Sewerage*.

(ii) Network modelling

A sewer network model is required for code and impact assessable material change of use (MCU) and reconfiguring a lot (RoL) applications where:

- (A) the proposed land use results in an increase in load greater than what is presently allowed for in the planning scheme; or
- (B) the development requires trunk infrastructure identified in council's Plans for Trunk Infrastructure to be constructed ahead of its planned date, or out of sequence identified in master planning; or
- (C) the development requires the construction of new trunk infrastructure not already identified on council's Plans for Trunk Infrastructure; or
- (D) existing sewer infrastructure is required to be relocated as part of the development, and such relocation may impact the hydraulics or operational functionality of the system. End of line works are excluded from this requirement.

TCC also requires the development of a network model for:

- the preparation of Infrastructure Master Plans; and
- the preparation of Priority Infrastructure Plans (and Plans for Trunk Infrastructure).

Network modelling shall be undertaken in accordance with SC6.4.3.23 Water and sewer network modelling guidelines.

(iii) Levels of assessment

Depending on the type of works in question, simplified or detailed modelling may be required to demonstrate compliance with these guidelines. Simplified or Detailed assessments are defined below:

- (A) "Simplified assessment" – an assessment that demonstrates network capacity through manual calculations, or through the use of simplified network models (schematic style models); and
- (B) "Detailed assessment" – an assessment involving the preparation of detailed network models based on proposed design and/or development layouts.

SC6.4.3.23 Water and sewer network modelling guidelines outline the process to be followed to obtain council advice as to what level of assessment is required.

(iv) Timeframes

Master Planning shall be undertaken over a 30 year timeframe. The capacity of the existing network to service ultimate demand should be assessed and any system augmentations to service ultimate requirements identified. The staging of infrastructure works is an essential consideration and should be incorporated into the planning and design process. Staging of infrastructure works should be also considered at no greater than 10 year intervals until the ultimate horizon.

Council may request that master planning consider provision to adjacent developments to enable an efficient trunk network.

For developments being completed over a shorter timeframe, network modelling shall be undertaken for existing case, full development.

Net present value cost analysis should be undertaken using a range of interest rates (typically 3%, 5% and 7%), as well as the rate for weighted annual cost of capital (WACC) which can be sourced from council. Timeframes of 10, 20, and 30 years shall be applied. Longer timeframes will enable assessment of the impacts of major replacement and upgrade works on the viability of the system.

Council may require longer timeframes for analysis.

Cost assessments should only consider an engineering cost assessment, with loan interest and depreciation considered separately by council when considering a business case for a particular project. The following on-cost allowances should be made:

Establishment	2%
Project Management/Engineering Design/Council Management Costs	15%
Contingency	30%

(d) Sewerage systems

(i) General

Where possible the sewer system shall be designed to use gravity to convey the sewage.

Proposals for systems including pumping stations and rising mains require Townsville Water and Waste's written approval, including particular requirements for current electrical and telemetry standards, overflow and emergency arrangements, and compliance with Townsville Water and Waste's current Licence conditions. Undulating terrain or other economic considerations may preclude the viability of a purely gravitational system.

As such, Townsville Water and Waste may opt for sewage pumping stations and pressure mains to transport wastewater into an adjacent catchment or direct to the WWTP and will be at the approval of Townsville Water and Waste.

(ii) Alternative sewer systems

Alternative sewer systems (e.g. common effluent drains, vacuum sewerage, pressure sewer systems, etc.) will only be considered with an analysis showing the benefits of such systems using a triple bottom line approach, and require Townsville Water and Waste's written approval.

(iii) Sewers

Sewer layouts, pipe sizing and grading shall be determined in accordance with WSA 02, unless detailed elsewhere in this guideline.

(iv) Sewage pump stations and pressure mains

Sewage pump stations are to be provided where gravity systems cannot be utilised or sewers become uneconomically deep (usually > 5m).

Sewage pump stations are to be provided where approved in writing by Townsville Water and Waste.

Pump stations shall be planned and designed to optimise construction, operation and maintenance costs for the total-life cycle of the infrastructure and equipment. This shall include the pump station along with the discharge pressure main.

Pump station and pressure main planning shall be undertaken in accordance with WSA 02 and WSA 04 and as amended by this guideline. Unless detailed elsewhere in this guideline.

(3) Property connections

(a) Scope

SC6.4.3.21.3(3) covers the design of property connection sewers (PCS).

(b) Location

Location of property connection points shall generally be in accordance with WSA 02 and the following constraints:

- (i) to connect directly to maintenance holes where possible Industrial/Commercial properties connections must be to maintenance holes;
- (ii) the property connection jump-up must be 1.5 m from the property boundary, unless council has agreed to the service connection being located within the road reserve, in which case the jump up must be located within a valve box that is easily identifiable and located for access and maintenance;
- (iii) combined sanitary (house) drains are not permitted; and
- (iv) dual connections to a single jump-up are not permitted and no property connections are allowed to trunk mains.

(c) Maximum depth

The depth at the property connection shall not exceed 1.5 m.

Property connections shall not be made into sewers >3 m deep. In cases of deep sewers private connections must be
MHs or construct a shallow sewer.

(d) Type

Property connections shall be buried interface method in accordance with WSA 02 (Type 2 and 4 Appendix H).

Water Seals on property connections are not permitted.

(e) Size

Minimum size shall be DN100.

(residential) or DN150

(commercial/industrial).

(f) Length

The maximum length of property connection sewers shall be:

(i) DN100 – 10 m

(4) Gravity sewer design

(a) Scope

SC6.4.3.21(4) covers the design of gravity sewers.

(b) Sewer layout

(i) Extent

Sewer layouts shall be prepared to demonstrate drainage of the specified catchment, including the “most disadvantaged lot”.

The sewer configuration is to be developed to minimise the overall length of sewers.

Sewers are to be designed to control the whole of the area of each allotment being sewered, except in industrial areas where a lesser area of control can apply if approved by Townsville Water and Waste.

Sewers are to be extended to the boundaries of the site to serve existing lots and potential upstream development sites where specified by Townsville Water and Waste.

(ii) Configuration

The sewers shall comply with the following additional requirements:

(A) be a minimum of DN150 (except property connections);

(B) located at the rear of allotments, except

- in areas where safe work area for staff and equipment, including access from the road frontage to the infrastructure (in particular the maintenance structures) cannot be achieved, sewers may be located in the front clearance area of the lot.
- in small and narrow lots where the alignment is within the road reserve at an alignment agreed to by council and in accordance with the considerations in WSA02
- in industrial and commercial developments where the alignment is within the property 1.5 m back from street frontage; and

(C) alignment is 1.5 m from property boundary. Environmental considerations are must be taken into account when selecting sewer alignments.

The designer must refer to WSA 02 for additional considerations such as alignment with road reserves and pathways. Sewers in road reserves are only permitted when:

- environmental considerations preclude alignments within the properties; and
- approved by Townsville Water and Waste.

(c) Sewers

(i) Sewer loading

- Sewer loading shall be determined in accordance with this sub-section.
- (ii) Sizing and grading
- Sewers shall be sized to carry the design flow with the depth of flow no greater than 70% of internal diameter for initial and any future conditions (WSA 02).
- The design flow shall be calculated by the method nominated in this sub-section.
- Refer to WSA 02 for minimum sewer sizes and grades to meet required pipe capacities.
- (iii) Minimum cover and services clearance requirements
- Refer to WSA 02 for minimum cover requirements over sewer mains and requirements for minimum clearance from other services.
- (iv) Above groundsewers
- The following applies:
- (A) above ground sewers are to be avoided where possible;
 - (B) above ground sewers are to be constructed from DICL or MSCL pipe unless otherwise approved by Townsville Water and Waste; and
 - (C) the designer of an above ground sewer shall take into account the considerations listed in WSA 02.
- (v) Pipe material
- The following applies:
- (A) pipeline materials shall be in accordance with WSA 02;
 - (B) PVC pipe shall be a minimum of SN10 for DN100 and SN8 for other sizes;
 - (C) DICL and MSCL sewers shall be Cement Mortar Lined
 - (D) FRC and concrete pipes are not permitted; and
- (vi) Pipe jointing
- Pipelines shall be rubber ring jointed or butt welded in the case of PE pipe.
- If flanged pipe is required, minimum flange classes shall be AS4087 Class 14 for Steel pipes and Class 16 for DICL.
- (vii) Concrete encasement
- Concrete encasement of sewers is not permitted except with the approval of Townsville Water and Waste.
- (d) Maintenance structures
- (i) Maintenance holes
- The design and location of maintenance structures shall be in accordance with WSA 02.
- Requirements include:
- (A) maximum spacing between MHs is 90 m;
 - (B) a MH is required at the end of all sewers (except PCS see WSA 02);
 - (C) MHs are to be provided at all sewer changes of directions or grade;
 - (A) MHs on sewers within industrial subdivisions are to be either at 40 m maximum centres or on every second property;
 - (B) MH may have up to 4 internal drops;
 - (C) the top of a standard MH must be 150 mm higher than the finished surface level or known flood level (100 year ARI);
 - (D) MHs may be constructed from pre-cast concrete or cast in-situ concrete;
 - (E) full depth cylindrical MHs shall be used in lieu of a taper tops;
 - (F) step irons, ladders or landings are not permitted within MHs for safety considerations; and
 - (G) internal epoxy coating of MHs is not normally required (except at pressure main receiving MHs).
- (ii) Maintenance chamber

- (A) Maintenance chamber will only be permitted with the approval of Townsville Water and Waste.
 - (B) The use of terminal maintenance chamber will not be approved. Maintenance Shafts (as per WSA02-2014) will not be permitted.
- (iii) Pressure main discharge maintenance hole
 - (A) Pressure main discharge MHs shall be in accordance with SC6.4.4.8 Standard drawings SD440A Pressure Main Discharge to Manhole.
 - (B) Discharge MHs shall be internally epoxy coated.
 - (C) Discharge MHs shall be vented in accordance with SC6.4.4.8 Standard drawings SD-450 Vents at Sewerage Rising Main Receiving Inspection Chambers and Pump Stations.
- (e) Pipe bedding

Pipe bedding for sewers shall be in accordance with WSA 02.

For flexible pipes refer to AS 2566.2 *Buried flexible pipelines - Installation*, Table G1, G2 and G3 for suitable material types.
- (f) Restoration

Refer to WSA 02 for construction specification.

For restoration under roadways refer to SC6.4.4.8 Standard drawings SD-055. For state controlled road restoration should be design and constructed in accordance with their standards and requirements.
- (g) Geotechnical

For geotechnical matters that should be considered refer to WSA 02.
- (h) Envelopers

Enveloper pipes shall be used where necessary at major road crossings, at rail crossing and at major waterway crossings.

Enveloper designs for road and rail crossing are to be undertaken in accordance with the requirements of the Land Corridor controller's requirements. Where no specific requirements are provided refer to the standard drawings of WSA 02.

QR National requires compliance with their specification: MCE-SR-16 Requirements for Services under the Railway Corridor (Non-QR Services).

Suitable casing spacers/insulators shall be fitted to the pipe to ensure adequate spacing from the enveloper. At each end of the void between enveloper and carrier pipe is to be grouted on completion of the pipe installation.

- (i) Land tenure

Easements are not required over gravity sewers.
 - (j) Emergency relief structures

All pumped catchments shall be provided with an "Emergency Relief Structure" in accordance with SC6.4.4.8 Standard drawing SD-445 Overflow Maintenance Hole Arrangement.
 - (k) Inverted syphons or water seals

Inverted syphons or water seals are not permitted.
 - (l) Colour coding pipes

Where sewer pipes are to be located in close proximity to other services pipes or where there is the likelihood of the pipes not being recognised as sewerage pipe the designer shall provide for the pipes to be colour coded (in accordance with WSA02 Table 4.1) and shown on the drawings accordingly.
- (5) Sewage pump station design
 - (a) Scope

This section covers the design of sewage pump stations within the sewerage collection system, and also incorporates the requirements for the sizing of sewage pressure mains.
 - (b) Pump station design

(i) Pump station types

(A) Type 1 - Low lift pump stations

Low lift pump stations are characterised by short pressure mains with the ability of sewage to overflow into the downstream sewer;

(B) Type 2 - Small submersible pump stations (up to 30 L/s)

Small submersible pump stations consist of a single circular 1.8 - 2.3 m diameter wet well containing two submersible pump units;

(C) Type 3 – Medium size submersible pump stations (30 L/s to 200 L/s)

Medium size pump stations consist of a submersible type pump station with total pumping capacity of up to 200 L/s. They may consist of one single large diameter pump well housing multiple pumps or multiple smaller diameter wells housing individual or multiple pumps; and

(D) Type 4 – Large pump stations (>200 L/s)

Large pump stations are the major pump stations often delivering to the sewage treatment works. These stations may be wet well or wet/dry well configuration.

(ii) Design guidance

The *WSA 04 Sewerage Pump Station Code* and DEWS Guidelines shall be consulted in conjunction with this sub-section for Pump Stations Types 1, 2 and 3. These guidelines are based on twin pump submersible configurations in a duty/stand-by arrangement.

Type 4 pump stations require specialist input and shall be designed by experienced pump station design engineers.

Pump stations shall be designed to comply with the Code of Environmental Compliance, ERA 63(3) - Sewage Treatment (EHP) as applicable.

However refer to Townsville Water and Waste for the latest agreement with EHP for this guideline as some sections are not regarded as appropriate.

(iii) Importance level

Buildings shall be designed for Importance Level 3 (minimum) in accordance with the *Building Code of Australia* Table B1.2a.

(c) Pump system design

(i) General

The design of the pressure main and pump station should be considered together.

Pump system design requires the consideration of the interaction of the pump station and pressure main. The design principle is to determine the whole-of-life least cost solution for the pump station and pressure main considering both initial construction costs and on-going operating costs.

The sewage pressure main system within Townsville City consists of two general configurations:

(A) pressure mains that discharge into gravity systems or other sewerage pump stations; and

(B) pressure mains that connect into combined pressure main systems from a collection of pump stations.

The major sewage transport systems within Townsville City are characterised by combined pressure mains. The combined pressure main systems tend to consist of a major trunk pressure main with individual pump stations mains delivering to the trunk main through separate pressure mains up to several kilometres in length.

These combined systems can result in very significant variations in the operating head requirements of the pump depending upon the instantaneous flows from other stations within the combined system.

To service the wide variation in pressure head requirements for the differing conditions it may be

- necessary to have several different capacity pumps to cover all conditions.
- (ii) Design loading
Design loading for the pump station shall be determined in accordance with this sub-section.
- (iii) Design flow
The design flow for the pump station shall be determined for both dry weather and wet weather (peak flow) conditions.
Dry weather flow:
(A) peak dry weather flow (PDWF) shall be based on 2*ADWF unless better information is available.
Wet weather flow:
(B) the peak wet weather flow factor (PWWFF) is defined by:
Peak wet weather flow (PWWF) = PWWFF * ADWF.
- The PWWFF shall be determined based on an analysis of the existing pump station flows but in no case should PWWFF be less than 5.
- (iv) Pump and pressure main sizing
Pump units shall be sized for the full range of operating conditions that the pump delivery system will be exposed to. This includes initial and long term operational conditions.
- Pump units and pressure main sizing shall be:
- optimised for normal ADWF conditions; and
 - be capable of performing under PWWF conditions.
- For Type 2, 3 and 4 pump stations it may be necessary to provide for each duty.
- Pump and pressure main sizing shall be performed in accordance with WSA 04 with the following additional conditions:
- (A) a minimum of two pumps shall be provided in a duty/standby arrangement;
- (B) pump stations may utilise all pumps within the station to achieve PWWF;
- (C) if different size pump units are provided within the station, an environmental assessment shall be performed on the consequences of overflow to determine if a redundant (standby) unit is required for the large pump, and is subject to written approval from Townsville Water and Waste. If the consequences are acceptable Type 2 and 3 pump stations may use a single pump unit for PDWF and a single pump unit for PWWF conditions; and
- (D) pumps are able to operate within their safe operating range under all conditions. VSD, high speed and grinder types may be considered, subject to written approval from Townsville Water and Waste.
- Pump size in combination with the delivery main size is to be designed to minimise whole of life costs covering capital, operating and maintenance costs.
- (v) System resistance
System resistance curves shall be developed for the pump station covering the full range of pump operating conditions. System curves shall be developed in accordance with WSA 04 with the following additional requirements:
- (A) separate system curve bounds are to be developed for PDWF conditions and PWWF conditions;
- (B) upper and lower bound curves shall be prepared for each case;
- (C) upper bound curves are to be based on:
- minimum Hazen “C” value;
 - well at pump stop level; and
 - in the case of a combined rising main, with all contributing pumps operating; and
- (D) lower bound curves are to be based on:
- maximum Hazen “C” value;
 - well at pump start level; and

- in the case of a combined rising main, with no other contributing pumps operating. For Hazen “C” values actual figures shall be derived from calibration data where possible. Where data is not available the values in Table SC6.4.3.21.6 may be used.

Table SC6.4.3.21.6 Range of Hazen C Values

Material	Min C	Max C
Cement Lined and FRC	100	150
Plastic pipes	110	160

Complex pressure main systems will require pipe network analysis packages to assist with the development of the curves.

A net positive suction head available (NPSHA) curve shall also be prepared.

(vi) Pressure mains

Pressure mains shall be sized in conjunction with the pump stations to optimise overall whole-of-life costs.

(vii) Pressure main velocity

The minimum velocity for pressure mains should comply with the requirements of *DEWS Guidelines*. The target velocity at the duty point of the pump is 1.0 m/s with a range of 0.75 m/s to 1.5 m/s.

The minimum velocity in pressure mains is to be 0.75 m/s. Where a small and large pump combination is proposed, 0.5 m/s for the smaller pump may be permissible if the larger pump flushes the main regular intervals of no greater than weekly. Acceptance by Townsville Water and Waste will be based on the individual merits of the design. Pump operation is described in TCC24, Standard Specification for Electrical Switchboards, clause 18.2.

The maximum velocity in pressure mains shall not exceed 1.5 m/s (single) and 2.5 m/s (all pumps).

(viii) Pressure main hydraulic models

Wherever possible pump and pressure main system hydraulics shall be performed using calibrated hydraulic models.

Townsville Water and Waste has a number of network models for the complex pressure main system. These hydraulic models have been developed in SewerGEMS modelling software.

These models shall be used for the analysis of pumping system that is part of the pressure main network system in conjunction with Townsville Water and Waste.

(d) Pump well sizing

Pump well sizing shall be performed in accordance with WSA 04.

The required pump operating volume shall be calculated as follows:

$$V = 900 \times Q^P/S$$

where:

V = cut-in/cut-out volume (L);

Q^P = pump capacity (L/s); and

S = allowable number of starts per hour.

The maximum number of starts per hour shall be:

(i) Motors $\leq$ 50 kW: 12 Starts per hr; and

(ii) Motors $>$ 50 kW: 5 Starts per hr.

For fixed speed pumps, the pump capacity shall be based on the capacity of the largest pump unit within the well.

For variable speed pumps, the pump capacity should be based on the flow rate associated with the minimum velocity requirements of the pressure main.

Operating and control levels within the well shall be in accordance with WSA 04.

(e) Overflow management

(i) General

Systems shall be designed to minimise overflow of sewage to the environment.

All pumped catchments shall be provided with an emergency relief structure accordance with SC6.4.4.8 Standard drawing SD-445. Refer to other sections of this sub-section and ERA 63(3), Code of Environmental Compliance, on requirements for pump station failure or overload management.

An environmental assessment shall be performed to determine the most appropriate overflow location.

The system shall provide, as a minimum, 6 hours of ADWF flow as emergency storage. For remote sites this may need to be increased dependent upon emergency response times.

Methods for limiting the risk of sewage overflows include:

- (A) emergency storage;
- (B) provision of emergency power at the site; and
- (C) inter-catchment overflows.

Pump stations shall be fitted with telemetry monitoring to communicate alarms of system failures to emergency operations personnel.

(ii) Level and location of relief structures

The level of relief structures shall be designed to prevent sewage from exiting through disconnector gullies or maintenance hole lids. Relief structures shall be located as close as practical to pump station.

(iii) Emergency storage

Emergency storages shall be provided in accordance with the requirements of WSA 04.

(iv) Emergency power

Stand-by generators are required at all Type 2, 3 and 4 pump stations.

Sufficient fuel shall be stored to operate the pump station at full capacity for 24 hours.

The electrical system shall be equipped with an automatic change-over switch and start system for the stand-by generator in the event of mains power failure.

(f) General arrangement and site infrastructure

(i) Location and layout

Issues to be considered when sighting a pump station are discussed in WSA 04.

(ii) Standard drawings

Type 2 pump stations shall be in accordance with standard drawing SD-420 Small Sewerage Pump Stations Typical Plans, Sections and Details

(iii) Flood level

Pump stations are to be constructed 300 mm above 1% AEP flood level (refer WSA-04).

(iv) Site fencing

Security fencing is not normally required.

In urban areas where site fencing is deemed to be necessary, fencing shall be in accordance with SC6.4.3.21.5(4).

(v) Landscaping

Sites shall be landscaped to minimise visual impact whilst not compromising access to the pump station and equipment. For landscaping requirements refer to WSA 04.

(vi) Water supply

Water supply shall be provided to all pump stations for wash-down purposes and general amenity. Backflow prevention is required on the water supply service.

Water services shall be provided in accordance with WSA 04.

(vi) Power supply

The power supply connection to the pump station site shall be underground.

Refer to other sections of this guideline for the provision of power for the site.

(vii) Site buildings

If specified by Townsville Water and Waste, site buildings shall be provided for pump stations to house large switchboards and other associated equipment.

Buildings shall be architecturally designed.

A Development Permit is required for buildings.

(ix) Lifting requirements

Permanent crane or davits are not normally required. Exceptions to this are where equipment is located within buildings and require removal on a basis of more than once every 10 years.

If specified by Townsville Water and Waste, permanent crane or davits shall be incorporated into the design of the pump station or building. The design shall be approved by Townsville Water and Waste.

Set-down points of the crane equipment shall be:

- (A) in an area able to be reached by a crane truck where the mass and reach are within the crane truck capacity;
- (B) paved access is provided for the crane truck to reach the necessary position;
- (C) on back of flat bed vehicle (bed height 1.2 m) elsewhere; and
- (D) if these requirements are impractical, other lifting arrangements may be considered such as removable roof or local lifting equipment with provision for trolleying to a suitable crane pick-up point.

(x) Valve pits

Valve non-return and isolation pits shall be provided and be in accordance with the general concepts detailed in *WSA 04:2005*.

(xi) Ventilation pole

Ventilation poles are required.

(g) Vehicular access

(i) Access road

Sealed access road shall be provided to pump stations to enable all-weather access for maintenance vehicles. Access requirements shall be in accordance with WSA 04 with the following additional requirements:

- (A) sealed asphalt access road;
- (B) provide access during 1% AEP flood event;
- (C) minimum road width of 4 m;
- (D) on-site turn-around for maintenance vehicle; and
- (E) parking area provided adjacent to all equipment to be lifted for a crane truck maintenance vehicle. Parking is only required for a single vehicle.

Design of access is to be approved by Townsville Water and Waste.

(ii) Maintenance vehicle reconfiguration

Allowance shall be made for maintenance vehicles that are 10 t (8.8 m long) crane-trucks Medium Rigid Vehicles (AS 2890.2 *Parking facilities - Off-street commercial vehicle facilities*) with

- mounted crane positioned centrally on the rear end of the vehicle.
- (h) Odour control and septicity control
- (i) General
- If directed by Townsville Water and Waste, odour and septicity control shall be incorporated into the design of the pump station, and the design shall be approved by Townsville Water and Waste.
- The generation and release of hydrogen sulphides can result in odours as well as increasing the corrosiveness of the environment within and around the pump station.
- The extent of hydrogen sulphide generation is related to the age and retention time of the sewage, and the turbulence generated when discharged from pressure mains.
- For further readings on the generation and management of odours, refer to:
- (A) WSA 04;
- (B) *Hydrogen Sulphide Control Manual*; Volumes 1 and 2, Technological Standing Committee on Hydrogen Sulphide Corrosion in Sewerage Works (1989); and
- (C) DEWS Guidelines.
- (ii) Management
- On-site odour management shall be designed. Options management in order of preference include:
- (A) passive control of odour release from sewage (by appropriate pump station design);
- (B) odour scrubbing with activated carbon; and
- (C) chemical masking.
- Air and oxygen injection are not preferred.
- (i) Durability
- (i) General
- The following applies:
- (A) pump station structures and equipment shall be designed for the design lives set out in accordance to other sections of this sub-section;
- (B) all metalwork within the wells shall be grade 316 stainless steel. Connections to concrete shall be by stainless steel chemical anchors;
- (C) all pipework within the wells shall be coated with a fusion bonded coating or high build epoxy coating system that provides long term protection;
- (D) submersible pumps shall be provided with stainless steel lifting chains;
- (E) guide rails shall be in accordance within other sections of this sub-section; and
- (F) covers for wells and pits shall be fabricated from aluminium.
- (ii) Well type
- Refer to SC6.4.3.21.5(3)(g) Pump stations and wet well materials
- (j) Safety
- The following applies:
- (i) ladders shall not be provided into confined spaces. This includes the pump well and valve pits;
- (ii) pits and wells shall be designed for confined space entry access of a person lowered from a tripod system;
- (iii) forced ventilation shall be provided for all pump station dry wells;
- (iv) the designer shall make provision for temporary fencing around well openings, and permanent grates for times when the covers are open; and
- (v) signage shall be provided in accordance with the work, health and safety regulations identifying confined space areas and appropriate actions for entry.
- (k) Flotation
- Structures shall be designed to resist flotation in accordance with AS/NZS 1170 *Structural design*

actions.

(l) Instrumentation requirements

Control level probes shall be provided in accordance with other sections of this sub section.

Type 3 and 4 pump stations shall be provided with electromagnetic flow meters to measure the entire pump station outflow. Selected Type 2 pump stations may require electromagnetic flow meters – consult with TWW.

(m) Land tenure

The land tenure for the pump station and any associated infrastructure including valve pits, vent poles, etc., is in order of preference:

- (i) council owned freehold land; or
- (ii) council controlled road or reserve; or
- (iii) easement over freehold land.

(n) Documentation

All new pump stations, and any modification works to existing pump stations, require a comprehensive documentation suite including: design and as constructed drawings, equipment operation and maintenance manuals and initial procurement and logistics data.

(o) Operations and Maintenance Manual (O&M Manual)

The Operations and Maintenance Manual comprises all relevant documents for the pump station. The document structure for the O&M manual shall be adhered to and not altered unless approved by TWW.

Where modifications are being undertaken to an existing pump station, TWW shall provide any existing available O&M manual or relevant documentation to the designer for update.

(p) Document Requirements Schedule (DRS)

The DRS is a control document summarising all documents required in the O&M manual, quantities of each document to be provided at completion of commissioning (Practical Completion, or date of "On Maintenance").

The DRS lists up to 4 hold points during the design and construction process where TWW require review of documentation. Some elements of documentation may be deleted from the DRS/O&M Manual at the discretion of TWW. The DRS, including necessary documentation and hold points shall be discussed and agreed with TWW prior to commencing detailed design. Hold points shall be adhered to through the design and construction process.

The baseline DRS schedule to be used as a starting point for development of sewage pump station documentation can be made available on request.

(q) Process and Instrumentation Diagram (P&ID)

A Plant and Instrument Diagram (P&ID) is to be delivered with each new pump station and existing P&ID are to be revised by any project modifying or upgrading a pump station.

The P&ID provides the standard symbols and naming/tagging conventions for all equipment delivered. This includes piping, Instrumentation and Mechanical process equipment.

The TWW Process and Instrumentation Sheet includes relevant symbols to be applied to P&IDs. This information can be provided on request.

Unique Tag numbers developed in accordance with the Tagging conventions are to be allocated to each equipment item delivered and included on the P&ID. The tag numbers are to be used as the reference for each document delivered for that specific equipment item. Tag numbers should be used to refer to equipment in Inspection and Test Plans (ITP's) and as much design documentation as is practical.

(r) TWW Sewage Pump Station Equipment Schedule (TWW SPS Equip Schedule)

An equipment schedule is to be prepared for each new pump station and existing equipment schedules are to be revised for any project modifying or upgrading a pump station. The document is referenced by Tag number and lists, in summary, critical design and performance data for mechanical, electrical, radio and telemetry, and instrumentation and control equipment. The schedule is a required document in all O&M manuals.

The schedule is the cross reference document between the tag number and the actual equipment item delivered. The schedule is a useful tool when selecting equipment as it contains relevant process parameters for each equipment item. The sample Equipment Schedule to be used and can be provided on request.

(6) Pressure main design

(a) Scope

SC6.4.3.21.3(6) covers the design of sewage pressure mains.

(b) Pressure main sizing

Pressure mains shall be sized in association with the pump stations. Refer to SC6.4.3.21.3(5)(c) for guidance on sizing.

(c) Alignment

(i) Location

The location for pressure mains in order of preference is in:

- (A) council controlled road; or
- (B) council owned freehold land; or
- (C) easement in privately owned freehold land.

The alignment within the Road shall be in accordance with SC6.4.4.8 Standard drawings SD 015.

(ii) Service allocations

The designer is referred to the sub-section SC6.4.3.2 Building over or adjacent to services in selecting alignments in other areas:

(iii) Minimum cover

Minimum pipeline cover is 600 mm in accordance with SC6.4.4.8 Standard drawings SD-325 and WSA codes.

(iv) Services and alignments

Refer to WSA 04 for minimum clearance requirements from other services.

Minimum clearance requirements and conditions imposed by other services owners shall be complied with. Minimum clearance requirements may be imposed by the service owner. Specific conditions apply to construction near:

- (A) fibre optic cables;
- (B) high pressure gas mains; and
- (C) underground power.

Refer to the service owner for conditions on clearances.

Consider overhead power when selecting pipeline alignments. Construction with excavation equipment under or near overhead power lines has difficulties with monitoring and clearance requirements.

(d) Pipe

(i) Materials

Allowable pipe materials are:

- (A) PVC-U, PVC-O, PVC-M
- (B) DICI;
- (C) mild steel cement lined; and
- (D) polyethylene.

Pipeline materials shall be in accordance with WSA.

Pressure mains shall be a minimum of PN12.

In selecting the PN rating for plastic pipes, pressure de-rating for transient loads (water hammer) and temperature shall be taken into account (refer to WSA 03).

(ii) Pipeline material structural design shall be carried out in accordance with WSA 03.

(iii) Pipe jointing

Pipelines shall be rubber ring jointed or butt welded in the case of polythene pipe.

Flange classes shall be selected to suit the pipeline design pressures. Flange classes should be AS/NZS 4087 *Metallic flanges for waterworks purposes* except where connecting to existing flanges from a different standard.

Minimum flange classes shall be Class 14 for Steel and Cast Iron and Class 16 for DICT.

(iv) Concrete encasement

Concrete encasement of pressure mains are not permitted, unless approved by Townsville Water and Waste.

(v) Above ground pressure mains

The design of above ground pressure mains will be in accordance with WSA 03.

(e) Appurtenances

(i) Air releases

Air releases shall be provided on all high points along the pipeline, unless specifically omitted by Townsville Water.

Air release shall be avoided wherever possible by maintaining a continuous rising grade away from the pump station.

Manual air releases shall be used where the release is located in developed residential areas where odours will be noticed. Automatic air valves can be used at other locations. Automatic air valves shall be suitable for use with sewage.

(ii) Scours

To the greatest reasonable extent, a designer shall avoid the occurrences of low points within a pressure system to prevent the use of scours. If a low point is unavoidable, a scour shall be used to assist with clearing of accumulated solids.

Scours shall be directed back into the pump station or adjacent sewer where possible. Where not possible, the scour shall be directed into a manhole designed to allow pump-out into a tanker.

(iii) Isolation valving

Isolation valves shall be provided at the following locations:

- (A) outside of pump station;
- (B) on the branch of any tees;
- (C) at 500 m maximum spacing;
- (D) either side of significant waterways; and
- (E) either side of major road crossings.

(f) Colour coding of pipes

Where pressure mains are to be located in close proximity to other services pipes or where there is the likelihood of the pipes not being recognised as sewerage pipe the designer shall provide for the pipes to be colour coded to Australian Standard and shown on the drawings accordingly.

(g) Pipe bedding

Pipe bedding for pressure mains shall be in accordance with:

- (i) WSA 02 for sewers; and
- (ii) WSA 04 for pressure mains.

For flexible pipes refer to AS/NZS 2566.2 *Buried flexible pipelines - Installation*, Table G1, G2 and G3 for suitable material types.

(h) Restoration

Refer to WSA 02 for construction specification.

For restoration under roadways refer to SC6.4.4.8 Standard drawings SD-055.

(i) Geotechnical

Refer to the following for geotechnical matters:

- (i) WSA 02, Section 8.6 for sewers; and
- (ii) WSA 03, Section 5 for pressure mains.

(j) Marker tape

Detectable marker tape is required on non-metallic pressure mains (refer to SC6.4.4.8 Standard drawings SD325) and shall be in accordance with WSA PS-3.18 Marking Tape, Detectable.

(7) Scope

Wastewater treatment process design is complex and site specific.

New plants and plant upgrades are typically undertaken as one-off projects and performed by experienced wastewater treatment plant designers/consultants with the necessary qualifications, specialist skills and experience to carry out the planning, assessment, design and delivery processes for the project.

Generally, Townsville Water and Waste will prepare a detailed design brief and requirements for the engagement of suitable specialist consultants to undertake the project.

(8) Recycled water systems

(a) General

(i) Scope

SC6.4.3.21.3(8) covers the design of recycled water distribution infrastructure.

(ii) Design criteria

Design of a recycled water scheme shall comply with the requirements of the documents referenced in SC6.4.3.21.3(1)(b).

The design of a proposed recycled water project shall address, as a minimum, the following issues:

- (A) be consistent with council's latest practices
- (B) quality of treated water appropriate to proposed usage;
- (C) maintenance of treated water quality standards within the storage and distribution system; and
- (D) distribution system infrastructure including, storage, pumping and mains distribution network and irrigation networks.

Details of the proposed design are to be submitted to Townsville Water and Waste for review and approval.

(b) Infrastructure

(i) Sizing

The methodologies used for the sizing of water supply infrastructure of mains, pump stations and reservoirs can be applied to recycled water.

Reservoirs, pump stations, and mains are required to be sized to maintain the desired flow and minimum pressure at the property connection.

Refer to SC6.4.3.21.2 Water supply design for design requirements, and SC6.4.3.21.3(2) Sewage collection system planning for guidance on sizing requirements.

(ii) Colour coding

All recycled mains and connections and outlets shall be colour coded to AS 2700 *Colour standards for general purposes* to differentiate from other infrastructure.

Mains, taps and meters shall be coloured Lilac P23.

(c) Reticulation mains layout

(i) Extent

- Mains shall be provided to service intended connections within the area being serviced.
- (ii) Mains
Mains shall be designed with isolating valves, pressure and control regulating valves (as required), air valves and scours to WSA 03.
 - (iii) Scours
Scours from recycled water mains shall be directed into sewers where possible.
 - (iv) Meters
Water meters are to be provided on all service connections. Left-hand threads shall be used on all fittings to prevent accidental cross connection to potable water.

SC6.4.3.21.4 Electrical and mechanical

(1) Introduction

(a) Scope

SC6.4.3.21.4 addresses the electrical and mechanical design considerations applicable generally to water and sewerage pump stations but can extend to treatment plants.

(b) Treatment plants

New treatment plants and plant upgrades are typically undertaken as one-off projects and performed by experienced treatment plant designers/consultants with the necessary qualifications, specialist skills and experience to carry out the planning, assessment, design and delivery processes for the project.

Generally, Townsville Water and Waste will prepare a detailed design brief and requirements for the engagement of specialist consultants suitable to carry out the electrical aspects of the project including issues of supply, transformers, HV, plant and motor control and monitoring.

(c) Legislative requirements

Electrical designs and works shall consider relevant legislative requirements including:

- (i) *Electrical Safety Act 2002* including associated regulations and Codes of Practice;
- (ii) *Electricity Act 1994* and associated regulations;
- (iii) *Electricity National Scheme (Queensland) Act 1997*;
- (iv) *Building Act 1975* and associated regulations; and
- (v) *National Electricity Rules*.

(d) Reference and source documents

The following documents shall be referred to.

TCC – 24 *Townsville City Council Standard Specification for Electrical Switchboards*

WSA 02 *Sewerage Code of Australia*

WSA 03 *Water Code of Australia*

WSA 04 *Sewerage Pump Station Code of Australia*

Townsville City Council Standard Specification for Standby Generators

(e) Standards

In general the following standards, codes and manuals are applicable to the design and documentation of typical pumping stations.

Workmanship and design:

Standard	Name
Australian Standards	All relevant Australian Standards
IEC and British Standards	Relevant International Electrotechnical Commission (IEC) and British Standards where no Australian Standard exist.
BCA	Building Code of Australia
NER	National Electricity Rules
ECMM	Queensland Electrical Connection and Metering Manual

Preparation of electrical drawings:

Standard	Name
AS1100	Technical Drawings
AS1102	Graphical Symbols for Electro-technology
AS3702	Item Designation in Electro-technology
TCC24	Townsville City Council Standard Specification for Electrical Switchboards

(2) Electrical supply requirements

(a) General

(i) Provision of power supply

Energy Queensland is the electrical distribution entity responsible for the connection of power supplies to all Townsville Water and Waste infrastructure assets.

The designer shall where possible, commence discussions with the electrical distribution entity at an early stage as part of the overall planning process for the proposed construction of new water and sewerage infrastructure or for the augmentation of existing water and sewerage infrastructure. Early involvement of the distribution entity shall be sought in order to resolve network considerations and availability to meet the anticipated electrical loads. Budget costs where possible shall be obtained from the distribution entity for any required upgrading of the existing power supply network, and provided to Townsville Water and Waste for inclusion in project budgets. The current distribution entity policy is that no cost estimates are provided unless the full application process is completed with a detailed design. This shall be considered in the design program.

The designer shall obtain plans of existing infrastructure in the vicinity from the Dial Before You Dig service of the existing and proposed electricity supply network in the vicinity of the proposed infrastructure. The location of the existing network will have a bearing on the proposed locations of the infrastructure, and electrical “point of supply”. The optimum location for the electrical “point of supply” should be as near as practicable to either the largest electrical loads or the proposed location of the electrical main switchboard and/or motor control centre.

The designer shall seek advice from suitably experienced people where information from the distribution entity is not forthcoming as to potential electrical supply issues.

Electrical power supply connections shall comply with the requirements of the *Queensland Electrical Connection and Metering Manual* available from their web site.

(ii) Energy retailer

The energy retailer may not necessarily be the energy supplier to the infrastructure asset. As the Queensland electricity market is a contestable market, Townsville Water and Waste may decide to obtain electrical energy from another Energy Retailer. The designer shall consult with Townsville Water and Waste to determine current Townsville Water and Waste commercial agreements in regard to energy retailer contracts to be applied to the new infrastructure.

(iii) Clearances

The location of water and sewerage structures such as treatment plant and pump station buildings shall be such that minimum clearances are maintained from overhead and underground electrical cables. These clearance distances are contained within the *Electrical Safety Act 2002* and *AS/NZS 3000 Electrical installations (Australian and New Zealand Wiring Rules)* and are dependent upon variables including the voltage of the overhead power lines. Guidance shall be sought from the distribution entity regarding the voltages of overhead power lines to ensure adequate clearance distances are maintained. The supply authority normally prohibits the construction of structures beneath overhead power lines. The designer shall also consider clearance distances for craneage during construction maintenance and demolition of these structures.

(iv) Ownership of HV infrastructure

Townsville Water and Waste's preference is for ownership and on-going maintenance of high voltage transformers and switchgear to remain with the distribution entity.

Where the designer seeks to have Townsville Water and Waste retains ownership and on-going maintenance of the high voltage supply assets, a detailed financial breakdown of the cost of ownership including initial capital cost and on-going maintenance costs shall be undertaken.

(v) Connection of power supply

It is Townsville Water and Waste's practice that costs associated with the connection of the required power supply to each location (including the distribution entity capital contribution) is normally included in the contract price by the Contractor performing the works. Tender documentation shall state this requirement.

All forms required to be submitted for the connection of the power supply shall be completed by the Contractor and forwarded to Townsville Water and Waste for signature. Submission of the forms shall be by the Contractor. However, circumstances may arise where the arrangements for power connection may be excluded from the contract and undertaken by Townsville Water and Waste directly with the distribution entity, including:

- (A) requirements for a capital contribution by the distribution entity; and
- (B) extended application timeframes within Energy Queensland and design program requirements where costs may not be known at the time of tendering the works.

(b) Submission of application to distribution entity

The designer shall be responsible for the calculation of the electrical loads for the proposed infrastructure or the additional electrical loads where existing infrastructure is proposed for augmentation. These shall be submitted with the application in the format required by the distribution entity.

(c) Fault levels

In order to determine the applicable fault level for the installation, particularly for HV connections, advice will be required from the distribution entity as to the applicable fault levels at the site connection. This information can then be used during the design process to calculate the fault levels throughout the site and to enable equipment selection.

In practice, this information, particularly for LV connections, is generally not forthcoming from the distribution entity within typical project design time frames. To enable design progression, suitable experienced designers shall by site inspection determine as far as possible the existing LV networks configuration and based on anticipated works determine the most likely fault level for the site.

Suitable allowance for future augmentation of the proposed infrastructure shall be taken into account when calculating the prospective fault levels. The designer shall seek advice from Townsville Water and Waste to determine any proposed future upgrading at the facility.

(d) Retail energy metering

All retailer energy metering shall be designed, installed and connected in accordance with the relevant retailer requirements.

Metering locations shall be accessible to the retailer's meter reading personnel during normal working hours. Typically for new installations, the metering panel is not located within a building or locked compound. Where old facilities are being refurbished, the designer shall relocate the meters to an accessible location.

Phone line connections etc. should be provided at each metering location in accordance with the requirements of the distribution entity. Where the installation of GSM modems for remote downloading of energy readings is required, the location of the meter panel shall be such that adequate mobile telephone coverage is achieved.

(e) Energy tariff

(i) Tariff selection

Should it be determined that the site will be connected as a regulated energy tariff connection

rather than as a contestable site then:

- (A) the designer shall provide a detailed analysis of energy consumption at the site, taking account of equipment run times and hours of operation. The analysis shall provide indicative comparison; and
 - (B) submit details of the energy consumption along with monthly metering charges and all other additional costs payable to Townsville Water and Waste, and seek their approval prior to the installation and connection of energy meeting.
- (ii) Energy cost minimisation

The electrical design shall encompass all energy cost savings applicable due to off-peak electrical consumption. Where pumps and other large electric motors are installed, control systems shall be configured to only operate pumps within high energy cost periods to maintain minimum levels in reservoirs and pump stations where possible. Major pumping shall occur during periods of off-peak low energy costs. These tariff control measures shall be provided with manual override facilities both locally and as part of any SCADA based control system.

Other constraints particularly in the sewerage network (e.g. pump station storage, or peak flows into sewerage treatment plants) may prevent the use of “off-peak”, for example the storage then delivery of large quantities of raw sewerage to biological treatment plant processes.

Retailer energy charges are in Queensland presently based on real energy measurement with regulated limits on the amount of reactive power that may be produced or consumed at each site.

Some other states in Australia also charge for reactive power consumption, the rate for reactive power is generally higher than real power providing ability to determine a return on investment for power factor correction devices (other than by simple regulatory compliance).

Given potential for Queensland to alter present charging strategies in regard to reactive power design consideration should be given to provision of space for future ability to retrofit power factor correction equipment to the site. This provision may include space, switchgear, and busbar extension, and so on as required.

(3) Emergency power supply

(a) General

(i) Generator requirements

Each water and sewerage site shall have provision for either the permanent connection of a standby diesel generating set, or as a minimum be provided with facilities for the connection of a portable generating set as required by TCC24.

A formal risk assessment of the criticality of a particular infrastructure asset shall be made by the Designer in order to assess whether the standby generating set shall be permanently located and connected or provision made for connection of a portable generating set.

For sewerage pump stations the following general guidelines apply for the provision of standby generating sets:

- (A) where a sewerage pump station has inter-area overflow capabilities, the installation of a manual transfer switching arrangement and plug-in type connection socket as a minimum is required; and
- (B) where the sewerage pump station does not have inter-area overflow capability, a permanently connected standby generating set with automatic changeover facilities mounted within the electrical switchboard is required.

For water pump stations, it is not normal practice to provide permanent standby generators as water is normally continued to be supplied by gravity from reservoirs during power failures. The exception is where supply to consumers will fail during power outages. In such cases permanent generators are required.

Standby generating sets shall be sized to ensure that the largest pump load combination required at the site can be successfully started and run. Manual transfer switching arrangements shall also be sized for the largest electrical pump load combination required at the site.

Generators shall be fitted with protective circuit breakers on the supply cables.

Technical requirements for the generator are provided in the council's *Standard Specification for Standby Generators*.

(ii) Site location

The generator set shall be located on the site to allow for easy and safe access for servicing and maintenance (including removal from the site where necessary). This may require a suitable hardstand area.

Access shall allow all panels on the generating set to be easily opened without hindering access to the electrical switchboard or pump station.

Vandal proofing shall be to TCC24 minimum requirements.

(iii) Fuel storage requirements and alarms

The generator set shall have a fuel capacity for a minimum of 24 hours operation based on 100% of the rated load of the generating set.

The designer shall also take into account the reliability of fuel supplies to specific locations after severe storm and cyclone events which may prevent access to the sites for re-fuelling. Where the designer determines unacceptable risk to the supply of fuel to a critical site, additional fuel storage shall be provided to Townsville Water and Waste's satisfaction.

Remote locations (e.g. Magnetic Island, rural areas) shall be considered as special cases and the availability of fuel supplies at the site after severe weather events shall be a consideration in resolving the quantity of fuel stored on-site.

A low fuel alarm from fuel storage tanks shall be connected to the telemetry and SCADA systems. The alarm shall operate when the fuel level in the tank has fallen to a level which only provides two hours of remaining operation of the standby generating set at full load.

(iv) Environmental considerations – generating sets

Fuel containment - The generating set shall be located within a bunded area which provides drainage to a low point. A lockable draw-off valve shall be provided for discharge of liquid from the bunded area. Alternatively, suitable fuel containment and drip trays shall be provided within the emergency generator set base frame.

Noise - The generator shall be fitted with sound attenuation systems to meet the environmental requirements for allowable noise emissions.

(v) Battery charging

Each generating set shall have a battery charger powered from a dedicated circuit from the main sites switchboard or distribution board.

(b) Indoor standby generating sets

Where the electrical main switchboard and/or motor control centre are contained within a building structure, the standby generating set shall also be located within the same building structure.

The generating set shall be contained within a fire rated sound attenuated room that provides adequate airflow for cooling purposes. Airflow requirements shall be based upon the individual generating set manufacturer's recommendations.

Bulk fuel storage shall be located externally to the building. The bulk fuel storage shall have a lockable fuel cap.

A smaller day storage tank may be provided within the room. Automatic transfer of fuel between the

external bulk fuel storage tank and the smaller day tank shall be provided.

The location of the refuelling point and ability to access safely shall be considered for each site such that it allows accessibility for the delivery of fuel by the selected method.

(c) External standby generating sets

Where the electrical switchboard is either plinth or pole mounted externally, the generating set shall also be located externally provided requirements such as noise attenuation can be met.

Permanently connected standby diesel generating sets shall be fully enclosed and sound attenuated. Generating set enclosures shall offer easy access to all maintainable parts for maintenance personnel.

Externally installed generator installations shall be vandal resistant. No glass or plastic panels are to be provided on the generator exterior housing. All covers (including radiator and fuel caps) are to be pad-lockable. No controls (eg emergency stop) are to be external or accessible without opening a locked door or cover.

There should be no exposed "hot" parts, such as exhausts. It should not be possible to drop items down the exhaust pipe.

Surface treatment of the generator and acoustic enclosure and other exposed parts shall be selected for the environment at the site, and to provide a 15 year minimum design life.

(4) Determining electrical site loads

(a) General

The designer shall determine the site loading in accordance with AS/NZS 3000 *Electrical installations* requirements, and with consideration of the proposed pump/equipment operation combinations and sequencing. Load calculations shall be approved by Townsville Water and Waste prior to being forwarded to the electrical distribution entity.

The designer shall be responsible for the early submission of electrical load calculations to the electrical distribution entity to minimise delays with electrical connection works.

The designer shall ensure that the calculated motor drive sizing can be achieved by a recognised pump manufacturer selected from Townsville Water and Waste's preferred equipment lists.

The electrical load calculations shall take into account Townsville Water and Waste's planned future augmentation of the infrastructure. Where no future augmentation is planned, the electrical loads shall be calculated on the anticipated connected loads plus 25% extra.

(b) Pump stations

Electrical load calculations shall be based on the method of operation of the pumps to be supplied and installed e.g. Duty-Duty, Duty-Standby, Duty1-Duty2-Standby etc. The proposed method of operation shall also be discussed with the distribution entity to determine any potential network issues with the proposed arrangements. The design for motor starting shall meet the requirements of the distribution entity and TCC24.

(5) Electricity point of supply

The preferred method for the connection to the point of supply shall be by underground cabling.

The final location for the point of supply shall be agreed between the distribution entity and Townsville Water and Waste and shall be compatible with access to the site. Parts of the overall area serviced by Townsville Water and Waste are prone to flooding. All electrical infrastructure susceptible to flood damage shall be located above the design inundation levels adopted for the proposed site. Flood inundation level information is available from Townsville Water and Waste to assist in the location of electrical infrastructure above predicted inundation levels.

The point of supply within residential locations shall be via a galvanised steel property pole or underground URD

pillar. Where galvanised steel property poles are used, the pole location shall be such that the final consumer's mains cabling length is kept to a minimum. No aerial cables are permitted to cross over infrastructure or vehicle working areas.

All connectivity at points of supply shall be accessible for maintenance purposes.

(6) Cabling

(a) Consumer's mains cabling

The consumer's mains cabling shall be sized by the designer in accordance with the calculated electrical load at the particular site and the requirements of AS/NZS 3000 *Electrical Installations*.

Cabling shall generally be Cu PVC/PVC/XLPE installed underground in HD uPVC conduits run between the nominated point of supply and the site electrical Main Switchboard.

Where external cabling enters a building, the cabling may be installed on cable ladder or cable tray with mechanical protection as required under AS/NZS3000.

Where underground HD uPVC electrical conduits are installed, the designer shall provide for spare conduits, generally in the ratio of one spare conduit of the same diameter of the conduit installed for each conduit containing electrical cables.

(b) Sub-mains cabling

Sub-mains cabling shall be sized by the designer in accordance with the calculated electrical load at the particular location and the requirements of AS/NZS 3000.

Cabling shall consist of single or multi-core copper PVC/PVC or PVC/XLPE conductors generally installed underground where run external of structures in suitably sized cable ducts or within cable trays where run internally of building structures.

(c) Power and control cables

Power and control cables shall be circular type cabling to facilitate ease of waterproofing cable entries. Consideration shall be given to use of flexible type cabling to pumps to facilitate ease of removal and installation.

Power cables shall be a minimum of 2.5 mm². Control cables shall be a minimum of 1.5 mm². A minimum of two spare cores shall be provided for all control cables following installation. Only one control voltage shall be contained within any control cable.

Where the designer has deemed a higher risk of further mechanical damage, Steel Wired Armoured (SWA) cabling or other protection method shall be provided.

(d) Variable frequency drive cables

Cables run to motors driven by VFDs shall be flexible type cabling to facilitate ease of termination and removal from pumping equipment. Cabling type, length and installation method shall be selected to meet the applicable Electromagnetic Compliance (EMC) requirements. Typically a screened cable would be used with screen continuous from the motor terminal box to the VFD terminals.

(e) Instrumentation cables

Instrumentation wiring and cabling required to carry signals to the PLC or process instrumentation shall be selected to suit the intended application.

Generally, overall screened cables shall be used for digital signal while overall and individually screened pairs shall be used for analogue signals. Analogue and digital signals shall not be provided within the same cable.

Cables shall generally be Dekoron or approved equivalent of minimum conductor size of 0.75 mm². Adequate separation shall be provided between instrumentation cables and other cabling to ensure non-interference from AC power and control cables. As a minimum, cable trays shall have adequate partitions and instrumentation cabling not in trays shall be run in separate conduits.

Provision of surge suppressing transient barriers shall be provided for all instrumentation cabling run external of buildings.

(f) Control systems networks

Control system networks shall be designed to suit specific application by a control system specialist.

(g) Pump power cable connection

Power cable termination for pump units shall be determined in consultation with Townsville Water and Waste. The following applies:

- (i) typical all electrical equipment shall be hardwired; and
- (ii) remote sites or high maintenance sites shall be connected by decontactor style plug and socket connections.

Where plug-in connections are used, the designer shall ensure that cableways from the plug to the motor are sized to permit plugs to be withdrawn with all other cables in place.

(h) Lighting and power sub-circuits

Cabling for lighting and power circuits shall be sized in accordance with the requirements of AS/NZS 3000 *Electrical installations*.

Generally, sub-circuit cabling shall be circular multiple stranded 0.6/1kV Copper PVC/PVC insulated and sheathed conductors where not enclosed in ducting and single insulated where enclosed by ducting.

The following minimum cable cross sectional areas shall apply:

Lighting sub circuit cabling	1.5 mm ²
Power sub circuit cabling	2.5 mm ²

(i) Cable identification

All cables shall have an identification number engraved on a non-corrodible metallic tag secured by a non-corrodible metallic tie. Tags shall be fitted to both ends of every cable.

(7) Wiring enclosures

(a) General

Cables shall be installed within wiring enclosures to provide the required degree of mechanical protection in accordance with AS/NZS 3013 *Electrical installations - Classification of the fire and mechanical performance of wiring system elements*. The wiring enclosures shall typically consist of cable ladder or conduits.

<u>Wiring System Classification (AS3013)</u>	<u>Conduit Type</u>
WSX1	Light Duty uPVC or equivalent
WSX2	Heavy Duty uPVC or equivalent
WSX3	Metallic Rigid Conduit or equivalent

(b) Cable ladder

Cable ladders shall typically be a heavy-duty aluminium type conforming to NEMA20B. In wet or corrosive areas stainless steel ladder may be required. Cable ladder shall be the primary method of support for surface run cables. Ladder support systems shall be designed such that loadings on ladders shall not cause deflection in excess of 1:200 of span length. Typically supports for horizontal ladders shall not exceed 3000 mm spacing and for vertical ladders, 1500 mm. In no case shall manufactures guidelines be exceeded. Ladders installed external to buildings shall be fitted with covers – horizontal ladders shall have peaked covers; vertical ladders shall have flat covers. Cables on ladders shall not be exposed to direct sunlight. It may be necessary to fit covers to the underside of some ladders. Bends, Tees and other fittings shall be of the same manufacture as the cable ladder. All fixings shall be stainless steel. Cables shall be secured in ladders utilising ties or clamps. Where external to a building, the ties/clamps shall be a non-corrodible metallic type.

(c) Conduit

Conduits shall have a minimum diameter of 20 mm and shall be run as directly as practical with a minimum number of bends or sets. Surface run conduits are to be as inconspicuous as possible and shall be run parallel to walls, floors and ceilings where ever practical. Conduit fittings shall be of the same manufacture and be compatible with the conduit. Elbows and Tee type fittings shall not be used. Long radius bends/sets or suitably sized junction boxes shall be used. Metallic conduits installed in wet or

corrosive environments shall be stainless steel or aluminium. Corrugated PVC conduit shall not be acceptable.

Underground conduits shall typically be installed to a Category A system as classified in AS 3000. The depth of burial shall be selected to suit the site environment. Sand shall be used as a bedding material – the type and grade selected to provide the required thermal properties for the installation.

Underground cable systems shall use cable pits at each change of direction and every 50 m on straight runs. The pits, lids and method of installation shall be suitable for the maximum wheel loads that may occur in the area in which they are installed. Typically “plastic” pits shall never be used where they might be subject to vehicle traffic. The pits shall be sized to suit the number of conduit entries and size/type of cables to be installed. Ensure that cable manufacturer’s minimum bending radius is never compromised. All conduit entries shall be bell-mouthed.

Underground cable routes shall be identified at each end, each change of direction, each pit entry and every 30 m along straight runs by a non-corrodible metallic plate with direction arrow, set in a concrete block.

(d) Flexible conduit

Flexible conduit shall be used to make the final connection to an item of plant. The flexible conduit shall typically be a PVC sheathed metallic liquid tight type, though in certain environments other materials may be more suitable, e.g. in wet, chemical or hazardous area environments. The flexible conduit shall be terminated with correct fittings from the same manufacturer as the conduit. The length of flexible conduit shall be kept to the minimum required to make a final termination to an item of plant. Corrugated PVC conduit shall not be acceptable.

(8) Switchboard design guidelines

(a) General

The following applies:

- (i) electrical switchboards including motor control centres, distribution boards etc. shall be constructed in accordance with the requirements of the TCC specification TCC24 and accompanying standard drawings;
- (ii) these typical drawings shall be adapted to suit the application and the proposed switchboard general arrangement;
- (iii) the switchboard main switch shall be rated for 125% of the current rating of the consumer mains cabling;
- (iv) generator control and/or connectivity shall be included;
- (v) switchboard design shall include shrouding of live terminals to prevent inadvertent contact;
- (vi) sections of switchboards required to be accessed by non-electrical personnel shall be physically segregated from other sections of the switchboard and be supplied by extra low voltage 24VDC power supplies. Where this requirement is not achievable, lockable hinged escutcheons shall be provided to prevent access to electrical equipment by unauthorised persons;
- (vii) where the electrical energy metering is included in the overall switchboard design, a separate compartment with pad-lockable access door shall be provided in where required by the energy retailer;
- (viii) switchboards located adjacent to sewerage pump stations shall be mounted on a concrete plinth to the side of the well;
- (ix) sufficient concrete hardstand area shall be provided for maintenance personnel servicing the switchboard. Switchboards shall be located such that the access doors do not open towards an access road or the actual pump well; and
- (x) galvanised steel bollards filled with concrete shall be erected in the vicinity of external electrical switchboards to minimise accidental vehicular damage to the switchboard and to protect maintenance personnel.

(b) Design documentation

The following list contains the minimum design documentation required for switchboard and electrical design to be submitted to Townsville Water and Waste for approval:

- (i) Detailed electrical drawings including but not limited to the following:
 - (A) power single line diagrams;
 - (B) control circuit drawings;
 - (C) PLC control and network drawings;
 - (D) switchboard general arrangement drawings; and
 - (E) layout drawings.
- (ii) Detailed electrical calculations including but not limited to the following:
 - (A) electrical maximum demand calculations;
 - (B) fault level calculations;
 - (C) cable calculations; and
 - (D) earth fault loop impedance.
- (iii) Detailed electrical schedules including but not limited to the following:
 - (A) cable schedules;
 - (B) I/O schedules;
 - (C) single line diagrams;
 - (D) electrical equipment lists; and
 - (E) technical data sheets.

(c) Switchboard construction

Switchboard construction and equipment shall be in accordance with TCC24 specification, including:

- (i) construction from 316 grade brushed stainless steel (the use of zinc anneal switchboard enclosures may be considered in internal locations with air-conditioned switch room);
- (ii) all switchboard hardware, including, but not limited to, hinges, locking devices etc. shall also be manufactured from 316 grade stainless steel;
- (iii) padlockable, vandal resistant swing handle type locking mechanisms are preferred for enclosures to suit the standard keying system. The overall number of lockable compartments shall be kept to a minimum; and
- (iv) ventilation/cooling requirements to ensure internal temperatures do not exceed manufacturer's recommendations for any equipment contained in the switchboard.

External switchboards shall be painted colours that provide reflection of direct sunlight to minimise heat build-up within the switchboards, and shall be orientated to minimise risks of direct sunlight affecting internal electronic components.

Externally mounted switchboards and control panels shall be provided with sunhoods to minimise heat build-up within the control panels and to provide cover to maintenance personnel when working on the switchboards in rain.

- separate compartments to locate electronic soft starters > 22kW;
- separate compartments for PLC and telemetry hardware, with associated cabling terminated on suitably rated terminal strips; and
- VFD equipment in external boards may require suitable mechanical refrigeration/cooling systems to extend equipment life.

Motor starters, motor protection, and switchboard instrumentation shall be in accordance with the requirements of TCC specification TCC 24.

Major main switchboards and distribution boards shall include arc detection and VESDA protection.

(d) Electrical switchrooms

Dedicated electrical switchrooms shall be provided for large scale pump stations, treatment plants or where required to suit equipment types or the application.

Switchrooms shall conform to the requirements of AS/NZS 3000, the Building Code of Australia (BCA), and Townsville Water and Waste's operational requirements. Emergency lighting and fire extinguishers shall be provided at each Main Switchboard located within a dedicated switchroom as a minimum.

(e) Lightning and surge protection measures

Transient and surge protection devices shall be provided as recommended by the relevant Australian Standards including:

- (i) AS 1768 *Lightning protection*; and
- (ii) AS 4070 *Recommended practices for protection of low-voltage electrical installations and equipment in MEN systems from transient over-voltages*.

(9) Monitoring/control guidelines

(a) Design outputs

Control loop and P and ID drawings shall be provided for all major infrastructure including treatment plants and large pump stations.

Functional specifications shall be produced for proposed PLC and SCADA based control systems. Integration works are to be approved by Townsville Water and Waste.

For design and construct works, control loop and P and ID drawings shall be provided as part of the evaluation phase.

(b) Monitoring/control methodology - pump stations

Pump stations shall generally be controlled as per TCC-24 including local automatic / local manual and system control mechanisms.

All pump stations are to be remotely monitored by the telemetry and SCADA system.

(c) Monitoring methodology - reservoirs

Reservoir level monitoring shall be performed using submersible pressure transducers or external differential pressure transmitters.

Where flow to the reservoir is controlled by a pump or control valves, the pressure transducer shall be used for pump and/or valve control.

(d) Monitoring/control methodology - treatment plants

Treatment plants shall be controlled by PLC and SCADA based control systems, utilising optical fibre communication cabling.

Systems shall be to Townsville Water and Waste's current requirements, and systems for plant augmentations shall be compatible with existing systems. SCADA system shall be Citect or ClearSCADA (Townsville Water and Waste to confirm). PLC equipment shall be Siemens S7 series.

A functional specification for the monitoring/control of treatment plant systems including design and redundancy is to be included in the detailed design brief for each project.

(e) Float switches

Encapsulated float switches are to be provided in sewerage pump stations to indicate high level alarms. The installation of float switches must allow for the float to be accessed from the top of the pump well without the need to enter the well.

(10) Field equipment installation, wiring and terminations

(a) General

Field equipment installation, wiring and terminations shall generally encompass all electrical works external to the switchboards and motor control centres including but not limited to the installation of field cabling and cable support systems, local control stations, marshalling boxes, motor and equipment isolation and field instrumentation.

Important considerations include:

- (i) preferred method of support and environmental conditions - includes consideration of flood levels, UV and damage by insects or vermin;

- (ii) segregation of cabling - separation of differing cable types;
 - (iii) cable carrier capacity - capacity for present and planned expansion;
 - (iv) cable bend limitations;
 - (v) cable labelling requirements; and
 - (vi) cable mechanical protection.
- (b) Field instrumentation and installation
- (i) General

Field instrumentation shall be supplied and installed in accordance with the process requirements and the manufacturers' recommendations. The location and height of each instrument shall be shown on the relevant "Layout" drawings.

Field instruments shall be located as close to their primary connection to ensure instrument accessibility while still facilitating ease of access for operation, inspection and maintenance.

An optimum working and/or viewing height for each instrument shall be 1500 mm above grade or finished surface level.

No LCD screens for instrumentation or other plastic components that may be susceptible to damage from UV radiation shall be exposed to direct sunlight and potential vandalism shall be considered when locating equipment.

Where process instrumentation is installed on process pipework, suitable isolation devices shall be provided to allow for instrument removal.

All power supplies to instrumentation shall be surge protected and filtered.
 - (ii) Installation

Instrument enclosures suitable for the prevailing environment and any potential hazardous area classification of the area shall be provided for all field instrumentation and shall be installed in safe accessible locations.

Transmitters shall be enclosed in their own weatherproof enclosure and in addition, those mounted outdoors shall be shaded by 316 stainless steel covers with sides, drip hood and back as a minimum. All brackets and mounting bolts etc. for sensors and transmitters shall be 316 grade stainless steel.

Instrumentation shall not be supported from handrails or from steel work or plant which may be subject to vibration. All brackets and supports shall be constructed of 316 grade stainless steel and be constructed so that vibration from wind, operation of surrounding equipment, etc. is negligible.
 - (iii) Specific instrument requirements

Pressure transmitters where installed shall be fitted with valve manifold blocks.

Hydrostatic type level sensors shall be installed such that they are not affected by turbulence by the use of either stainless steel weighted cables or stilling tubes.

Impulse lines shall be fitted with valves and strainers. Lines shall be constructed of either copper or stainless steel and be provided with draining facilities for cleaning and maintenance. Cables shall be identified by an engraved metallic tag with SS fixings.
- (c) Labelling of equipment
- Equipment labels in the form of "traffolyte" labels shall be provided at each field mounted instrument to identify the instrument and at each local isolator or stop/start station to identify the item of plant that the isolator or control stations controls. Labels shall be fixed to equipment with stainless steel screws.

(11) Radio telemetry and SCADA system

(a) General

Townsville Water and Waste operates a telemetry system to monitor and/or control sewage pump stations, water supply pump stations and reservoirs. The system is based on Schneider Scadapack Hardware Controls (previously Serck/Hunter Watertech) PDS and Enet hardware connected by narrow band analogue and digital UHF radio networks. Human machine interface is provided by various SCADA software.

Automated and manual alarm dial outs are provided from SCADA alarms.

(b) New facilities

All new sewerage pump stations, water supply pump stations and reservoirs are required to be connected to the Telemetry system for the purposes of monitoring and control as required in TCC 24.

Functional system requirements such as network and repeater interfaces for the site and frequency details shall be determined during the design in consultation with council's electrical systems engineer.

(12) Mechanical services

(a) Pump design - general guidelines

(i) Pump selection

Pump selection shall be based on the following criteria:

- (A) Townsville Water and Waste preferred equipment lists;
- (B) system resistance curves (refer SC6.4.3.21.2 Water supply design; and SC6.4.3.21.3 Sewerage system design [SC6.4.3.21.3(5) Sewage pump station design]). Pump selection shall achieve all expected duties as per the system resistance curves;
- (C) redundant (standby) pump capacity shall always be provided. Standby pump capacity should be at least equal to the capacity of the largest pump unit;
- (D) availability of local product support for maintenance purposes; and
- (E) whole of life costs.

For all pumps supplied as part of contracted works, the NPV shall be based on a 15-year design life and 8% real discount rate.

(ii) Motors

All pump motors shall be afforded a minimum of IP56 and be tropic proofed.

(iii) Water void protection

Water void protection shall be provided for all water pumping applications. Water void protection on large installations shall typically consist of limit switches mounted on an extended shaft of the non-return valve.

On smaller applications, flow switches may be used for water void protection.

(iv) Document requirements

The following documentation shall be provided as a minimum by the Contractor and/or pump supplier:

- (A) details of all recommended spare parts and servicing tools including a priced list of the costs for each individual item;
- (B) operations and maintenance manuals which adequately detail servicing intervals and requirements, dismantling instructions, itemised parts lists;
- (C) pump performance – pump/motor factory test curves;
- (D) the results of specific pump/motor performance testing to AS2417, showing flow rate, pressure, current, efficiency, and NPSH as a minimum; and
- (E) pump/motor specification plates – shall be fixed to the pump and motor. Two additional sets of specification plates shall be supplied, one for inclusion into the switchboard.

(b) Pumping applications

Types of pumps for typical applications shall generally be as follows:

- (i) sewage pump stations shall be provided with wet well submersible centrifugal pumps for all new

locations. Existing pump stations that are planned for upgrades shall be converted to dry well mounted submersible centrifugal type pumps. Grinder style pumps may also be offered where conditions exist that may prevent an 80 mm sphere being passed through the pump and discharge pipework;

- (ii) water pumping stations shall generally be centrifugal pumps, with the number of pump stages to suit the duty point required;
- (iii) RAS and WAS pumps at Sewage Treatment Plants shall generally be centrifugal submersible type controlled by VVVF Drives; and
- (iv) positive displacement type pumps shall generally be installed for sludge handling applications.

Where sand infiltration causes excessive abrasion at pump stations, wear rings with increased hardness shall be fitted to the pumps and consideration given to ceramic coatings on the wearing surfaces.

Where pumps are provided with a double mechanical seal, a barrier fluid conductivity probe shall also be provided. This type of system shall be capable of producing an alarm which will be registered in the pump's switchboard and possibly the telemetry system when a change in conductivity is sensed. It is assumed that this will alarm due to a mechanical seal fault.

(c) Chemical dosing pumps

Dosing pumps shall generally be small diaphragm type pumps with either electronic or manual stroke adjustment depending on the application. Pump type and material is to be suitable for the chemical to be dosed.

Critical dosing pumps may require installation with automatic alarm considerations and feedback signals to the telemetry or PLC. These dosing pumps will generally be installed with means of electronically recording/confirming the flow in the dosing line and a means by which the flow in the dosing lines can be diverted back to the dosed fluid reservoir.

Dosing pumps may be required to be flow paced. Flow pace settings shall be manually adjustable.

Larger dosing pumps for dosing rates of between 5 and 50 L/hr shall generally consist of centrifugal pumps with magnetic drive. In this instance fluid void protection is to be provided.

Mass balance dosing systems are not desirable.

Generally Sodium Hypochlorite tank levels shall only be monitored in treatment plant applications.

Townsville Water and Waste's standard P and ID control and pipework drawing shall be used for all dosing pump installations.

(d) Pumping equipment

- (i) Motor cable
The designer is to consider the future application of the pump, including if future conversion to VVVF operation is required. Pumps with present or future VVVF Drive requirements shall be fitted with screened flexible cable.
- (ii) Guide rails
Guide rails for removal of submersible pumps shall generally be stainless steel pipe, SCH 40 or better and shall be a minimum of 40 mm diameter.
- (iii) Lifting chains
Lifting chains shall be provided at each submersible sewage pump station. Lifting chains shall be selected to be suitable tensile strength to lift the attached pump and shall be manufactured from coated or galvanised steel.
- (iv) Pressure gauges
Pumps for water pumping applications shall be supplied with suction and discharge pressure gauges.

(e) Vibration monitoring

Pumps shall generally be provided with the following vibration monitoring devices in three axis locations.

Motor Size	Vibration Monitoring Requirements
10 kW and under	No requirement for vibration monitoring devices
Over 10 kW and up to 99 kW	Vibration monitoring pads
100 kW and above	Inbuilt vibration monitoring devices

Inbuilt vibration monitoring devices shall have all alarms connected to the telemetry and/or SCADA-based monitoring system.

(f) Pump work testing

Works testing of pumps shall be performed for units rated at 5 kW and above. All other pumps shall be provided with a Type Test Certification from the pump manufacturer.

Works testing shall be performed to AS 2417 *Rotodynamic pumps - Hydraulic performance acceptance tests - Grades 1 and 2*:

- (i) Class 1 for water supply pumps greater than 20 kW; and
- (ii) Class 2 otherwise.

The pump supplier shall provide copies of all test certification prior to the pump being dispatched from the manufacturer's factory.

Works testing will normally negate the requirement for a draw-down test to be conducted at each individual site. Where specified draw-down tests may be used to judge the performance of the pumps installed.

(g) Mixers

Mixers shall be either of the submerged type or stool mixers.

(h) Manual valves

Pressure reducing valves shall generally be Derot 300 series (or approved equivalent) with throttling plugs. Vee Port valves shall only be used with the permission of Townsville Water and Waste.

(i) Actuated valves

Actuated valves shall generally be installed with AUMA or Rotork electric actuators (or approved equivalent), in accordance with Townsville Water and Waste's preferred equipment lists.

Electrically actuated valves shall be three phase 415 V rated.

Pneumatically actuated valves shall generally be installed with Tyco Keystone pneumatic actuators, limit switches and/or positioners. In general, "spring close" is required for this type of installation.

All actuated control valves shall have analogue 4-20 mA signal position feedback into PLC and SCADA based monitoring and control systems. Where the actuated valve is not a control valve, limit switches may suffice for positioning.

(j) Air supply blowers

Air supply blowers for treatment plant applications shall generally be lobe type or roots blowers. Townsville Water and Waste's preference is for Robuschi manufactured blowers (or approved equivalent) of the positive displacement rotary type.

Blowers shall be provided with sound attenuation devices to limit the operating noise to levels that are within the limits that provide a safe working environment without the need for ear protection and are in accordance with the relevant local laws and environmental requirements.

(13) Equipment manuals

When purchasing equipment the designer shall specify that, detailed operations and maintenance manuals are to be provided.

As a minimum operation and maintenance manuals shall contain details of:

- (a) general description of systems and equipment;
- (b) operation and maintenance of systems and equipment instructions which adequately detail servicing

intervals and requirements, dismantling instructions, itemised parts lists Maintenance of Systems and Equipment Instructions;

- (c) equipment schedules;
- (d) manufacturer's literature;
- (e) as-constructed equipment drawings; and
- (f) commissioning and test data.

The following copies of the manual shall be provided:

- three hard copies of the manuals; and
- one PDF copy of all documentation.

Specific requirements for sewerage Pump Stations shall refer to SC6.4.3.21.3(5)(n).

SC6.4.3.21.5 Structural and civil design

(1) Introduction

(a) General

SC6.4.3.21.5 sets out the minimum requirements for:

- (i) the design of new steel and reinforced concrete structures;
- (ii) modifications to existing Townsville Water and Waste steel and reinforced concrete structures; and
- (iii) design of civil works including fencing and security, roads and access, site works and landscaping for Townsville Water and Waste infrastructure.

(b) Reference and source documents

SC6.4.3.21.5 is to be read in conjunction with the following documents.

WSA 02 *Sewerage Code of Australia*

WSA 03 *Water Supply Code of Australia*

WSA 04 *Sewerage Pumping Station Code of Australia*

Workplace Health and Safety Queensland – *Safe Design of Structures – Code of Practise*

(c) Codes and standards

All designs and materials shall conform to these guidelines, the relevant current versions of the following general codes and standards in Table SC6.4.3.21.7, and also to the standards referred to within following Sections (2) to (6).

Table SC6.4.3.21.7 Townsville Water and Waste general codes and standards

Code/Standard	Description:
General	
Building Code of Australia (BCA)	Structures shall be designed for a minimum Importance Level of 3 according to the Building Code of Australia Table B1.2a
AS/NZS 1170.0	Structural design actions; Part 0: General principles
AS/NZS 1170.1	Structural design actions; Part 1: Permanent, imposed and other actions
AS/NZS 1170.2	Structural design actions; Part 2: Wind actions
AS/NZS 1170.4	Minimum design loads on structures; Part 4: Earthquake loads
AS 1657	Fixed platforms, walkways, stairways and ladders – design, construction and installation
AS 1418.1	Cranes (including hoists and winches); Part 1: General requirements
Structural Steelwork	
AS 1210	Pressure vessels
AS 4100	Steel structures
AS 4600	Cold formed steel structures
AS 1163	Structural steel hollow sections
AS/NZS 1594	Hot-rolled steel flat products
AS/NZS 3678	Structural steel – hot-rolled plates, floorplates and slabs
AS/NZS 3679.1	Structural steel – Part 1: Hot-rolled bars and sections
AS/NZS 3679.2	Structural steel – Part 2: Welded I sections
AS 3828	Guidelines for the erection of building steelwork

Code/Standard	Description:
AS/NZS 1554.1	Welding of steel structures
AS/NZS 1554.5	Welding of steel structures subject to high levels of fatigue loading
AS/NZS 2312	Guide to the protection of iron and steel against exterior atmospheric corrosion
AS 1627	Metal finishing – Preparation and pretreatment of surfaces; Part 0 to Part 9
AS/NZS 2311	Guide to the painting of buildings
AS 4020	Products for use in contact with Drinking Water
AS/NZS 4680	Hot-Dip Galvanised (Zinc) Coatings on Fabricated Ferrous Articles
AS/NZS 4791	Hot-Dip Galvanised (Zinc) Coatings on Ferrous Open Sections, Applied by an In Line Process
AS/NZS 4792	Hot-Dip Galvanised (Zinc) Coatings on Ferrous Hollow Sections Applied by a Continuous or Specialised Process
AS 2832.4	Cathodic Protection of Metals – Internal Surfaces
AS 3774	Loads on Bulk Solids Containers
Australian Institute of Steel Construction.	Structural Design of Steel Bins for Bulk Solids
API 650	Welded steel tanks for liquid storage
AWWA D100	Welded carbon steel tanks for water storage
Concrete Design	
AS 2870	Residential slabs and footings
AS 3600	Concrete structures
AS 3610	Formwork for concrete
AS 3700	Masonry structures
AS 3735	Concrete structures retaining liquids
AS 2159	Piling design and installation
AS 5100	Bridge design
AS/NZS 4671	Steel reinforcing materials
AS 1379	The specification and manufacture of concrete
AS 1478	Chemical admixtures for concrete
AS 1012	Methods of testing concrete

Where a discrepancy exists between this sub-section and the documents referenced herein, this sub-section shall take precedence.

(d) Certification

All designs shall be certified by a Registered Professional Engineer of Queensland (RPEQ).

Designs shall require a structural design certificate signed by an RPEQ prior to acceptance by Townsville Water and Waste. Acceptance of the design by Townsville Water and Waste does not relieve the designer of their legal or contractual obligations.

(2) Structural steelwork design

(a) General

(i) Scope

This section sets out the minimum requirements for the design of new steel structures and modifications to existing Townsville Water and Waste steel structures.

Typical Townsville Water and Waste steel structures include:

- (A) reservoir tanks;
- (B) monorails
- (C) walkways / platforms and ladders; and
- (D) buildings and sheds.

These guidelines do not apply to the design of other types of structures or the following materials:

- aluminium structures (except aluminium walkways/platforms and ladders);
- stainless steel; and
- composite structures.

Design incorporating these materials or relating to other structures shall be performed by suitably

- experienced and competent persons.
- (ii) Design and materials
All steelwork designs and materials shall conform to these guidelines, the relevant current versions of the standards listed in Table SC6.4.3.21.7 and the standards referred to within them.
 - (iii) Connections
The following applies:
 - (A) minimum design actions for connections shall be as per the relevant loading codes;
 - (B) generally bolted connections shall be designed to be a minimum of 2 x M20 8.8S bolts through 10mm thick cleats. Generally weld sizing shall be designed by using GP welds using E48XX welding electrodes;
 - (C) seal plates, where required, shall be a minimum of 6 mm thick;
 - (D) cast in bolts for structural purposes shall be galvanised and at least M12 diameter. Structural fixings to insitu concrete or masonry shall be a minimum of 2 x M12 bolts; and
 - (E) base plates shall be a minimum of 10 mm thick and grout shall be a minimum of 35 mm thick.
 - (iv) Protective coating systems
The following applies:
 - (A) generally, the protective coating system of the steelwork shall conform with current version of AS/NZS 2312 and Standards and documents referred to therein;
 - (B) painting where adopted shall conform with the current version of AS 1627 and AS/NZS 2311, and standards and documents referred to therein;
 - (C) all painting on the internal surface of water storage structures shall conform with the requirements of AS 4020 *Products for use in contact with Drinking Water*;
 - (D) galvanising, where required, shall conform with the current version of AS/NZS 4680, AS/NZS 4791, AS/NZS 4792, and standards and documents referred to therein;
 - (E) the design and detailing of members to be hot dipped galvanised shall take into account the recommendations of the Galvanizers Association of Australia;
 - (A) protection of steelwork by a protective wrap shall be in accordance with the manufacturer's recommendations and specifications and to the satisfaction of the designer; and
 - (B) protection of internal surfaces of water storage tanks by cathodic protection shall be in accordance with the current version of AS 2832.4 and standards and documents referred to therein.

(b) Reservoirs

Reservoir structures shall be designed for a minimum importance level of 3 according to the *Building Code of Australia* Table B1.2a.

Townsville Water and Waste has a preference for circular steel reservoirs, with a steel floor and roof structure. Typical "standard" reservoir details can be made available by Townsville Water and Waste, on request.

"Non-standard" reservoirs shall be designed using the principles outlined in AS 3774 *Loads on Bulk Solids Containers and Structural Design of Steel Bins for Bulk Solids* published by the Australian Institute of Steel Construction.

Reservoir Design criteria shall incorporate:

- (i) bird and vermin proofing;
- (ii) the roof shall ensure adequate ventilation and sufficient fall to ensure adequate drainage for the adopted roof sheeting;
- (iii) steel purlins shall have downturned lips to the bottom flange and be oriented to prevent ponding of moisture;
- (iv) roof falls shall allow for rafter and purlin deflections. The exposure of the site will determine the roof

sheeting finish and type;

- (v) a lockable access cover shall be provided through the roof to allow access for internal cleaning. No permanent access to the interior of the reservoir shall be provided. Access shall be via temporary means only;
- (vi) the design of the reservoir shall incorporate an access ladder or stairway from ground level to roof level, with lockable cage to restrict unauthorised access;
- (vii) the roof design shall incorporate sufficient fall arrest restraints or hand railing around the perimeter;
- (viii) the design of the floor shall consider cleaning and maintenance required in the future; and
- (ix) the foundations of the entire tank structure shall be founded on undisturbed parent material. Founding on fill material is not permitted.

(c) Monorails

The following applies:

- (i) monorail beams and supports shall be designed in accordance with AS 4100 and AS 1418.1;
- (ii) the safe working load (SWL) shall be clearly and permanently marked (not painted) on all monorails beams;
- (iii) the minimum SWL shall be determined by the functional requirements of the monorail, but shall not be less than a minimum lift weight of 1000 kg;
- (iv) unless known otherwise, monorail beams shall be designed based on the assumption that the centre of bearing of the trolley wheels is on the edge of the beam flange;
- (v) deflections of monorails beams and supports shall not impair the functioning of the monorail but in no instances shall exceed the span/500;
- (vi) the number of load cycles shall be calculated for each individual monorail based on a minimum design life of 50 years;
- (vii) all monorail beams shall be load tested after erection; and
- (viii) the design of the monorail beam shall consider future maintenance requirements.

(d) Walkways/Platforms and Ladders

The following applies:

- (i) walkways, platforms and ladders shall be designed in accordance with AS 1657;
- (ii) generic products conforming with the above Standard may be utilised;
- (iii) all ladders greater than 2.5 m high shall be provided with a cage complying with AS 1657;
- (iv) walkways, platforms and ladders may be galvanised, stainless steel or aluminium;
- (v) where possible riser and going dimensions on stairs shall conform with both AS 1657 and the BCA; and
- (vi) no ladders or stairs shall be designed for access to confined spaces as defined by workplace health and safety unless approved by council.

(e) Sheds

Typically, design of sheds will be outsourced to suitably experienced and competent persons.

(3) Concrete design

(a) General

(i) Scope

This section sets out the minimum structural requirements for the design of reinforced and plain concrete members, and reinforced concrete masonry block work for Townsville Water and Waste. Specifically, this section provides guidelines for the design of the following types of structures:

- (A) thrust blocks, valve and fittings pits associated with pipelines;
- (B) bored piers;
- (C) slabs on ground;
- (D) concrete pavements

- (E) manholes;
- (F) pump stations and wet walls; and
- (G) retaining walls.

These guidelines do not apply to the design of post tensioned concrete. Design incorporating post tensioned concrete or relating to other structures shall be performed by suitably experienced and competent persons.

(ii) Design and materials

All concrete and false work designs and materials shall conform to these guidelines, the current relevant versions of the standards listed in Table SC6.4.3.21.8 and standards referred to within them.

All reinforcement and concrete materials shall be sourced from a quality assured manufacturer of such products.

Splicing and lapping of reinforcement shall be as per the requirements of AS 3600. All exposed corners shall be designed for a 25 x 25 chamfer.

The use of low ductility mesh as reinforcement in suspended concrete should be avoided.

(iii) Minimum concrete requirements

Concrete grades and cover for reinforcement shall be in accordance with the appropriate exposure classification in AS 3600 and AS 3735 with minimum values as set out in Table SC6.4.3.21.8.

Table SC6.4.3.21.8 Minimum concrete strengths

Construction Element	Minimum Concrete Strength
Access cover (sewer and stormwater)	N32
Thrust blocks	N20
Concrete surrounds for sewerage house connection branches	N20
Bored pier footings	N25
Pump stations and wet wells	N40
General concrete works (sign post bases, bases for post and rail fences etc.)	N20

Minimum reinforcement in reinforced concrete members shall conform with the requirements of AS 3600, AS 3735, AS 5100 or AS 2159.

(b) Thrust blocks and valve pits

Thrust blocks shall be sized in accordance with SC6.4.4.8 Standard drawings SD-371 Thrust Block Details – Concrete Blocks.

Valve pits shall be sized to provide adequate clearance around valves, pipes and fittings to allow for operations, maintenance and repair of the equipment. Pits required to provide in-line thrust shall be designed accordingly, taking into account the allowing bearing capacity of the soils. Pits shall be provided with lockable aluminium lids; and the designer is to refer to WSA-03 for detailing requirements for valve chambers.

(c) Bored piers

Bored pier design shall take into account the design loads and soil parameters. Soil parameters for the design of piers may be assessed visually by suitably experienced and competent persons if deemed suitable for the application.

Typically bored piers for building applications shall be a minimum size of 450 mm diameter by 900 mm deep in undisturbed ground. When steelwork is cast into piers the top surface of the concrete pier shall be worked to provide a positive fall away from the steelwork to the outside of the pier.

(d) Slab on ground

Slabs and footings for habitable buildings shall be generally designed and constructed in accordance with AS 2870. Assessment of site reactivity shall be in accordance with requirements of AS 2870. Beam

layouts and depths shall be as per AS 2870 except that all footings shall be continuous at re-entrant corners.

Non habitable buildings shall be designed using the guidelines in *Guide to Industrial Floors and Pavements* published by the Cement, Concrete and Aggregates Australia. The possible future uses of the building should be considered in determining the appropriate design for the slab and footings.

Minimum slab thickness shall be 100 mm and minimum reinforcement shall be SL72. Slab thicknesses and reinforcement shall be sufficient to support any loads from plant and maintenance equipment and sufficient to provide adequate cover to any slab fixings.

(e) Concrete pavement

Concrete pavement shall only be designed by suitably experienced and competent persons. Concrete pavement shall be designed in accordance with sub-section SC6.4.4.2 Pavement design and all standards and documents referred to in them.

(f) Access covers

Access covers shall be circular, and sized in accordance with the current version of the following standard drawings:

- (i) SD-510 Maintenance Holes; Typical Manhole Cover Arrangements;
- (ii) SD-205 Stormwater Manhole Details;
- (iii) SD-210 Precast Stormwater Manhole Slab Top Details; and
- (iv) SD-475 Typical MH Cover Arrangements.

(g) Pump stations and wet well materials

Pump station buildings shall be constructed from reinforced concrete and/or reinforced masonry block. Wet wells shall be constructed from reinforced concrete. Drainage of below ground structures shall be considered in the design.

Other materials (e.g. GRP) are subject to approval from council.

The structure shall be sized to allow for adequate clearances for maintenance and replacement work, with appropriate clearances for different valves and fittings. No permanent access ways shall be constructed within pump stations or wet wells. The size of the structure shall be the most cost effective combination allowing for concrete, reinforcement and formwork costs.

(4) Fencing and security

Townsville Water and Waste assets will generally require an assessment of fencing and security issues, some security designs are shown in Attachment C: General facility security.

(a) Reference and source documents

The following references shall be consulted.

Disaster Management Act 2003

AS/NZS 4360 Standard for Risk Management

Emergency Management Australia - *Critical Infrastructure Emergency Risk Management and Assurance* handbook to support AS/NZS 4360

Queensland Government - *Securing Queensland's Critical Infrastructure: Guideline for Owners/Operators*

LGAQ - *Local Government Counter Terrorism Risk Management Kit*

The National Security Australia web site www.nationalsecurity.gov.au

(b) Minimum fencing requirements

The minimum requirement shall be a 2.8 m high chain mesh fence with 4 barb extensions with top and bottom rails, with double access gates 6 m minimum width determined by site requirements as per SC6.4.3.21 Attachment C.

All gates shall be provided with the standard Townsville Water and Waste padlock.

Some installations may require additional interlocked padlocks for access by other services.

(5) Roads and access

(a) General

This section sets out the minimum requirements for the design of roads and accesses to Townsville Water and Waste facilities.

The facilities typically encountered include pump stations, storage reservoirs and roads, access and parking at treatment plants.

(b) Design standards

All roads, accesses and carparks shall be designed in accordance with the following sub-sections:

- (i) SC6.4.4.1 Geometric road design; and
- (ii) SC6.4.4.2 Pavement design.

(c) Minimum requirements

All weather sealed access for maintenance vehicles shall be provided including:

- (i) sealed asphalt access road, minimum pavement width 4 m (spray sealed access roads may be considered for longer accesses or lower longitudinal grades in areas where vehicles do not manoeuvre);
- (ii) special surface treatments e.g. pavers may be required for aesthetic reasons or usage/transport of chemicals at some facilities;
- (iii) provide access during a 1% AEP flood event;
- (iv) road geometry suitable for use by light vehicles and single axle trucks, including vertical alignment check to ensure vehicle clearance. All turning movements shall be analysed with turning path software. Three point turns are allowed for access at pump stations;
- (v) bunding of tanker unloading areas will be necessary as well as associated storage and pump-out facilities; and
- (vi) all accesses shall be provided with suitable signage and line marking.

(6) Stormwater drainage

(a) General

This section sets out the minimum requirements for stormwater drainage at Townsville Water and Waste facilities.

(b) Design standards

All stormwater drainage shall be designed in accordance with SC6.4.4.4 Stormwater drainage design.

(c) Minimum design requirements

The following are minimum requirements for consideration during stormwater design:

- (i) all Townsville Water and Waste facilities shall be above the 1% AEP flood level plus 300 mm freeboard and above the 0.2% AEP storm surge level;
- (ii) all accesses shall be above the 1% AEP flood level, where possible;
- (iii) the design shall allow for both primary and secondary drainage paths;
- (iv) the issue of contaminated water shall be addressed and pollution traps may be necessary; and
- (v) erosion and sediment control plans shall be prepared for all projects.

(7) Site regrading

(a) General

This section sets out the minimum requirements for site regrading at Townsville Water and Waste facilities.

(b) Design standards

(c) All site regrading shall be designed in accordance with SC6.4.4.5 Earthworks. Minimum design requirements.

The following are minimum requirements for consideration during site regrading design:

- (i) a geotechnical investigation may be necessary by a suitably qualified consultant;
- (ii) excavation may expose acid sulfate soils and this must be addressed in accordance with

- legislation;
- (iii) excavation may expose hazardous substances and this is to be addressed in accordance with workplace health and safety legislation; and
- (iv) if blasting is necessary suitably qualified personnel are to be consulted and all safety approvals and public consultation requirements are to be addressed.

Note—SC6.4.3.24 Geotechnical investigations, specifies requirements for undertaking geotechnical investigation works. Part 9.3.2 Healthy Waters Code of Townsville City Plan has requirements regarding ASS/PASS and accords to State requirements.

(8) Landscaping

Where specified, some Townsville Water installations will require landscaping. Refer to requirements in SC6.4.3.6 Landscaping policy.

(9) Blasting activities

All purposed blasting activities must be designed and certified by an RPEQ and specifically state that there will be no structural impact on council infrastructure. Refer to SC6.4.5 Construction management and SC6.4.6.10.4 Blasting general, for use of explosives during construction.

(10) Drafting deliverables

All drafting shall be to current Australian Standards.

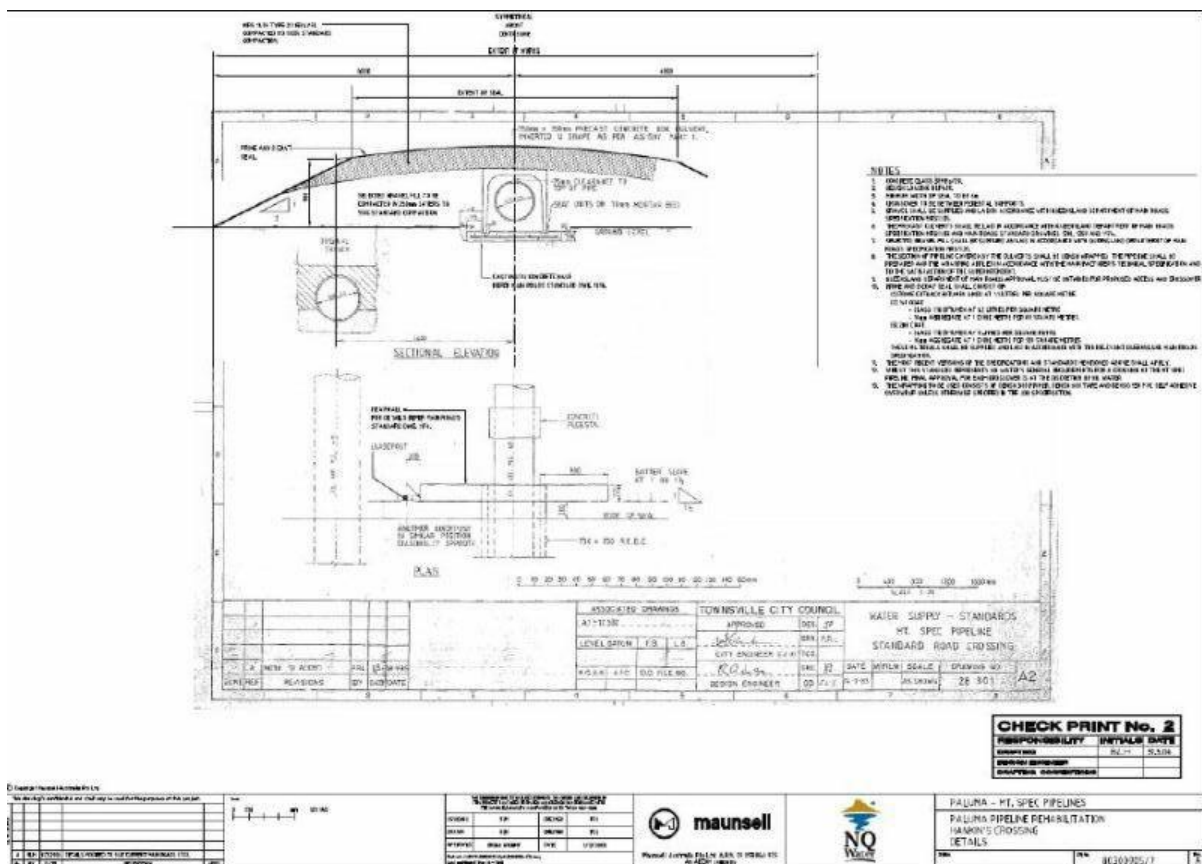
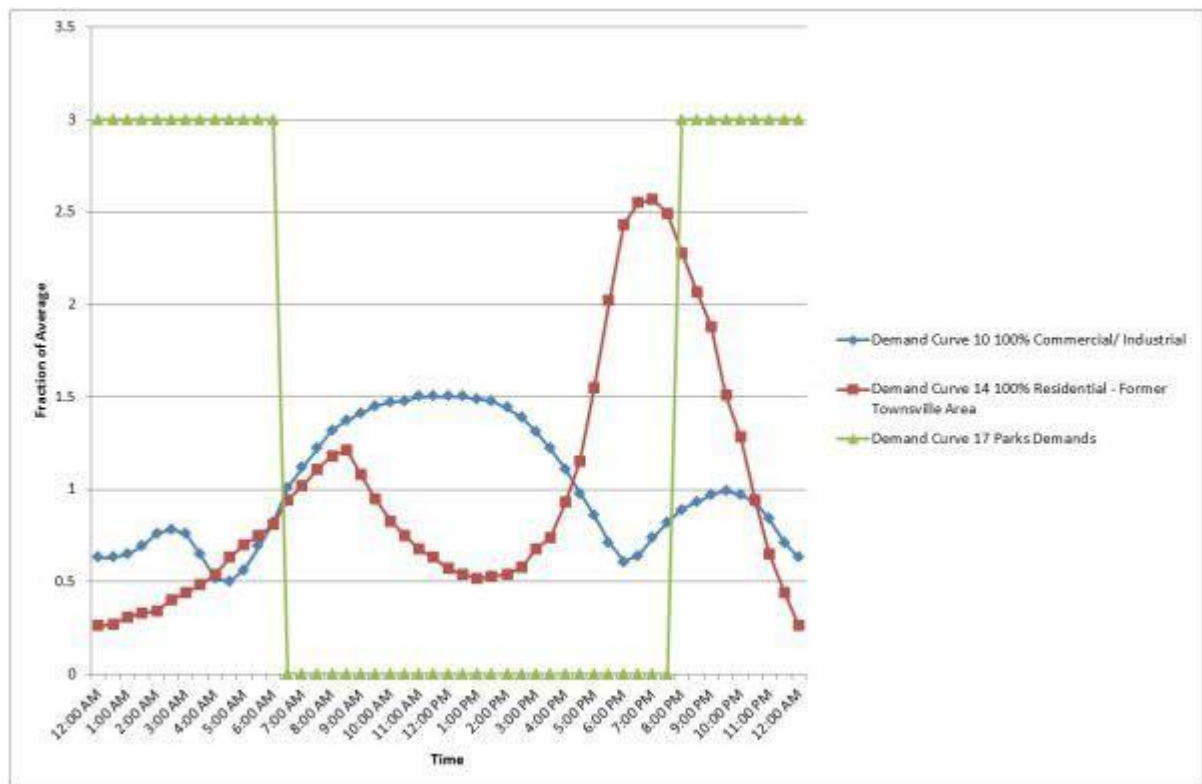
All drawings submitted for approval shall be provided in A3 size paper format or digital PDF format as determined by the Townsville Water and Waste project officer.

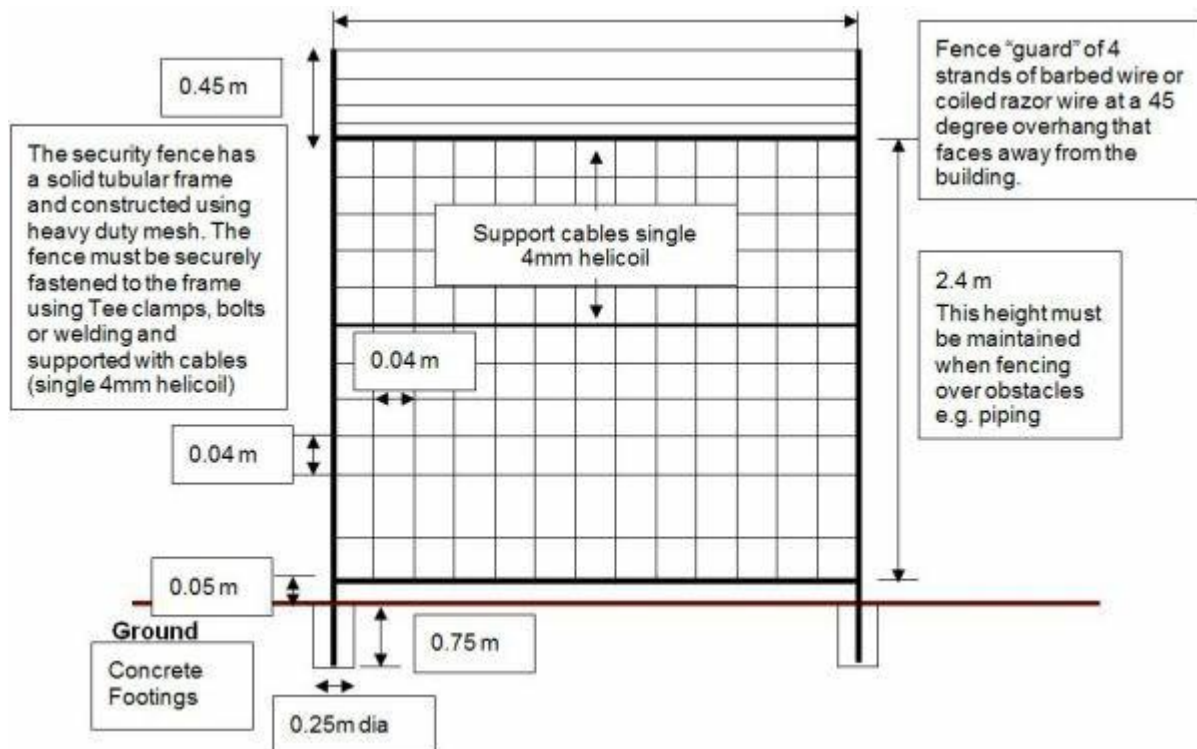
Final drawing submission shall comprise the following:

- (a) digital DWG file in AutoCAD 2008 format on CD;
- (b) digital PDF file on CD; and
- (c) one x A3 size paper copy.

SC6.4.3.21 Attachment A – Water supply diurnal patterns

TIME	Demand Curve 10	Demand Curve 14	Demand Curve 17
	100% Commercial/ Industrial	100% Residential - Former Townsville Area	Parks Demands
12:00 AM	0.63	0.26	3
12:30 AM	0.63	0.27	3
1:00 AM	0.65	0.31	3
1:30 AM	0.69	0.33	3
2:00 AM	0.76	0.34	3
2:30 AM	0.78	0.40	3
3:00 AM	0.76	0.44	3
3:30 AM	0.65	0.48	3
4:00 AM	0.52	0.54	3
4:30 AM	0.50	0.63	3
5:00 AM	0.56	0.70	3
5:30 AM	0.69	0.75	3
6:00 AM	0.82	0.81	0
6:30 AM	1.01	0.94	0
7:00 AM	1.12	1.02	0
7:30 AM	1.22	1.11	0
8:00 AM	1.32	1.18	0
8:30 AM	1.37	1.21	0
9:00 AM	1.41	1.08	0
9:30 AM	1.45	0.95	0
10:00 AM	1.47	0.83	0
10:30 AM	1.48	0.75	0
11:00 AM	1.50	0.68	0
11:30 AM	1.50	0.63	0
12:00 PM	1.50	0.57	0
12:30 PM	1.50	0.54	0
1:00 PM	1.49	0.52	0
1:30 PM	1.48	0.53	0
2:00 PM	1.44	0.54	0
2:30 PM	1.39	0.58	0
3:00 PM	1.31	0.68	0
3:30 PM	1.22	0.74	0
4:00 PM	1.11	0.93	0
4:30 PM	0.98	1.15	0
5:00 PM	0.86	1.55	0
5:30 PM	0.71	2.02	0
6:00 PM	0.61	2.43	0
6:30 PM	0.64	2.55	0
7:00 PM	0.74	2.57	0
7:30 PM	0.82	2.49	0
8:00 PM	0.89	2.28	3
8:30 PM	0.93	2.07	3
9:00 PM	0.97	1.88	3
9:30 PM	0.99	1.51	3
10:00 PM	0.97	1.28	3
10:30 PM	0.93	0.94	3
11:00 PM	0.84	0.65	3
11:30 PM	0.71	0.44	3
12:00 AM	0.63	0.26	3

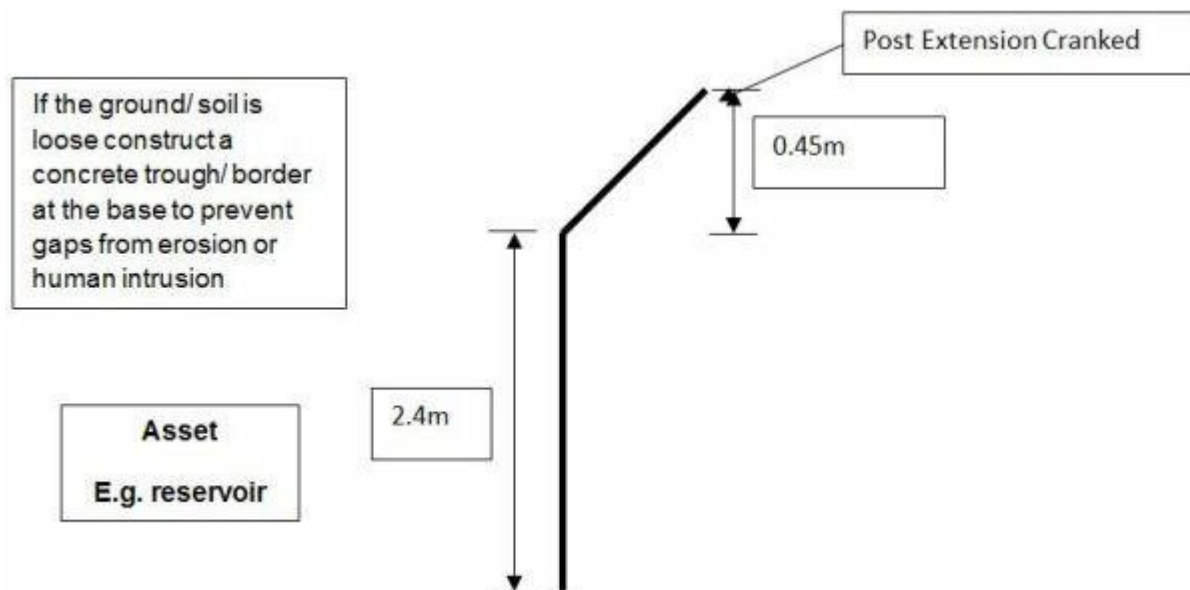




Security Fence Design Specifications

Figure SC6.4.3.21.1 Front view

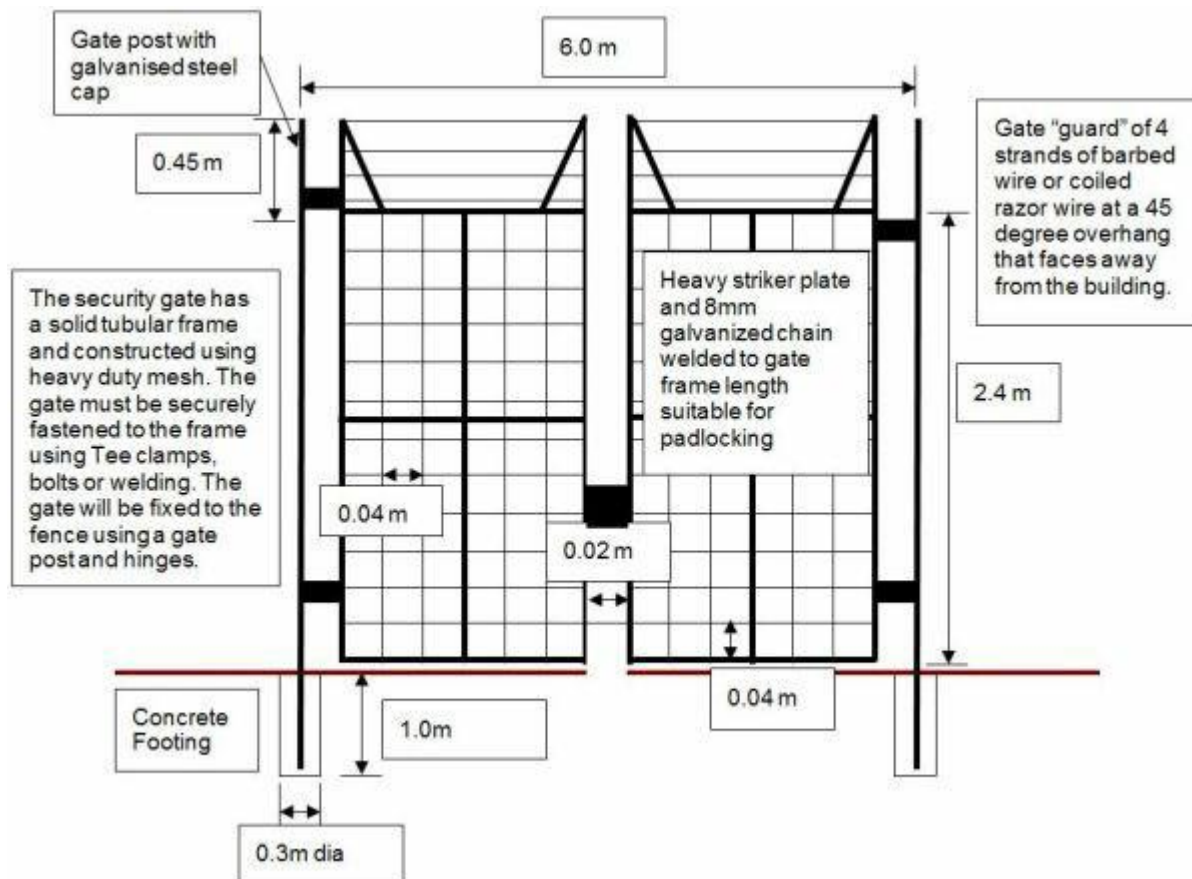
SC6.4.3.21 Attachment C – General facility security



Security Fence Design Specifications

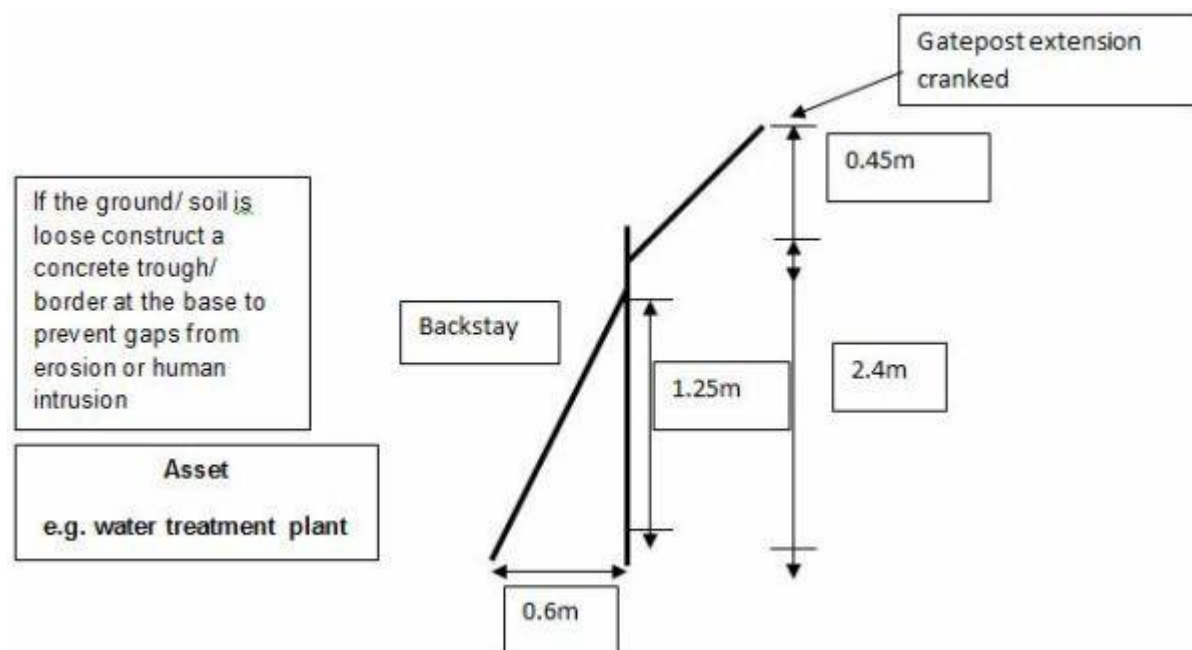
Figure SC6.4.3.21.2 Side view

SC6.4.3.21 Attachment C – General facility security



Security Gate Design Specifications
Figure SC6.4.3.21.3 Front View

SC6.4.3.21 Attachment C – General facility security



Security Gate Design Specifications
Figure SC6.4.3.21.4 Side View

SC6.4.3.21 Attachment C – General facility security

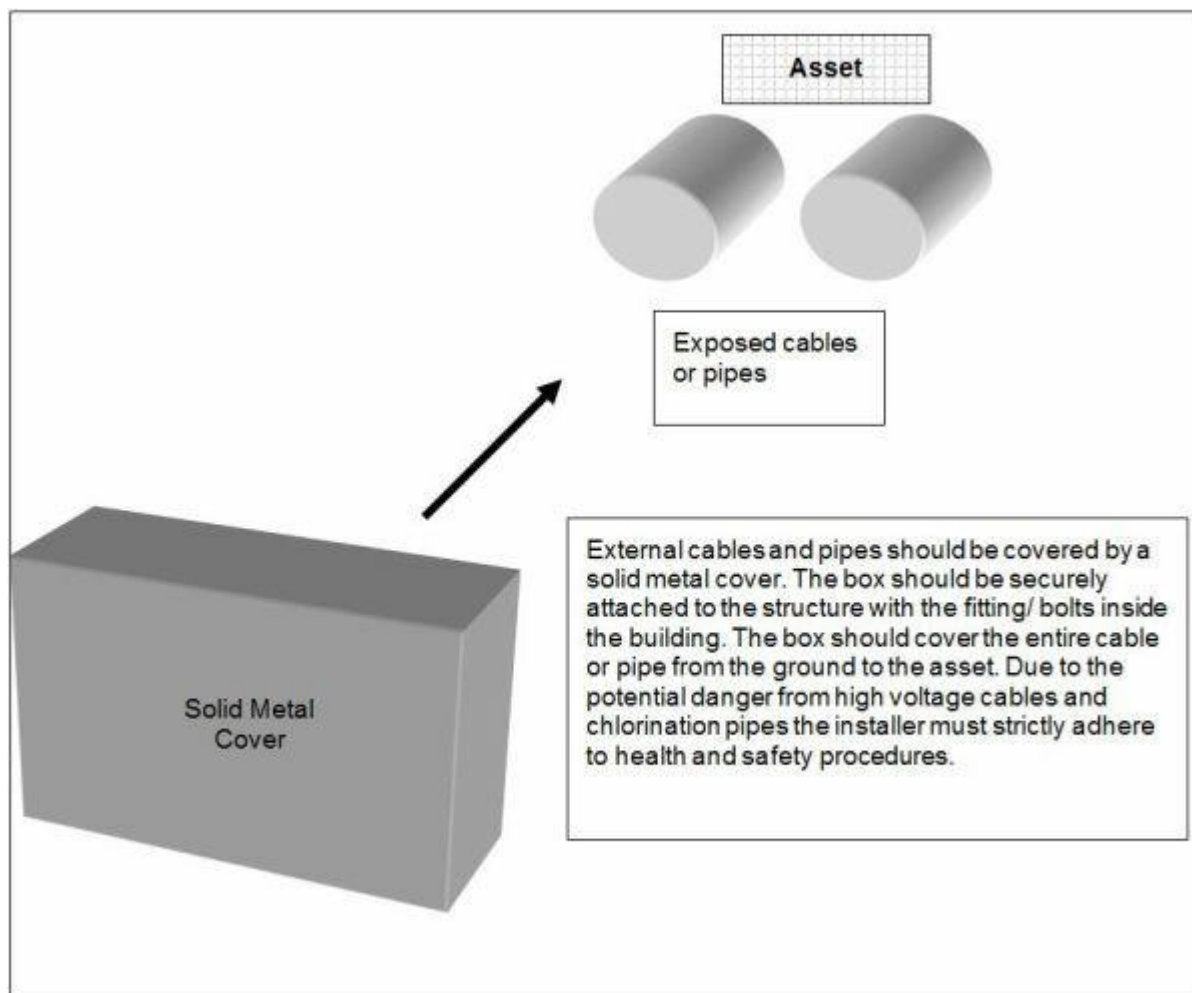


Figure SC6.4.3.21.5 External Cable and Pipe Cover Design Specifications:

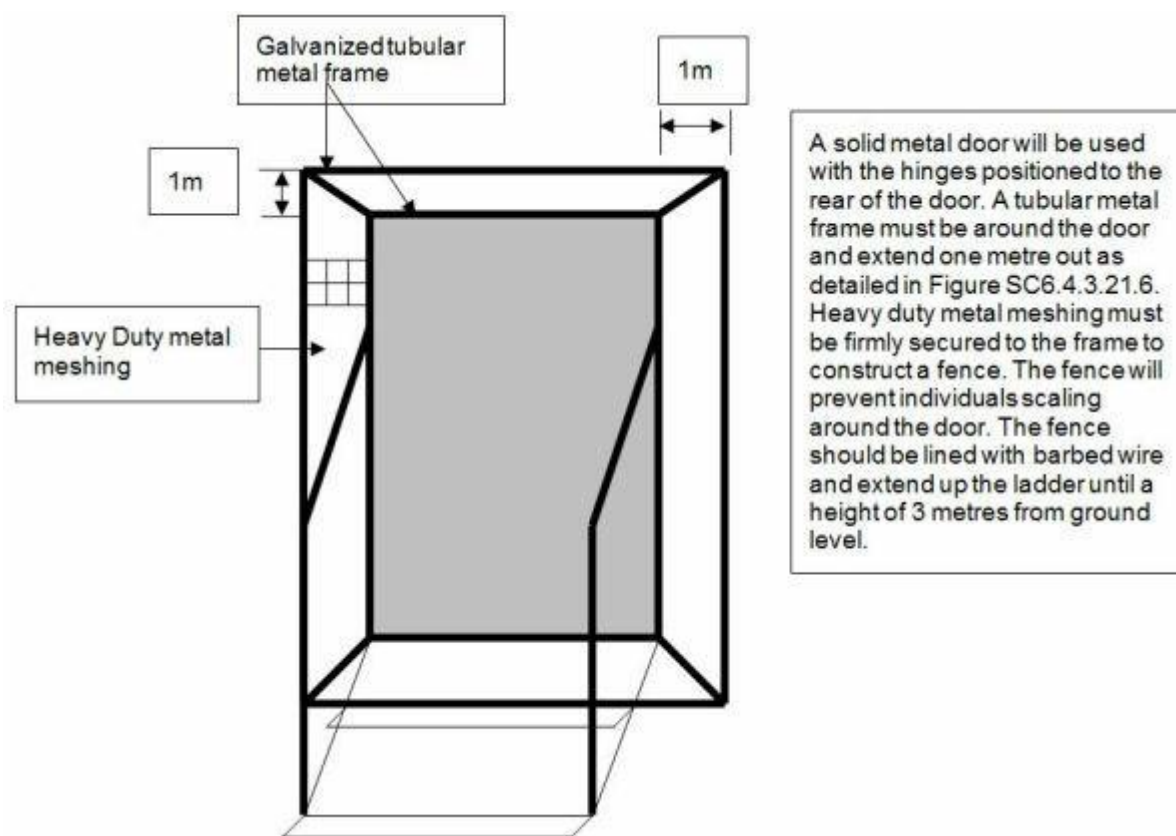


Figure SC6.4.3.21.6 Front View

Stairs or Bridge Gate Design Specifications:

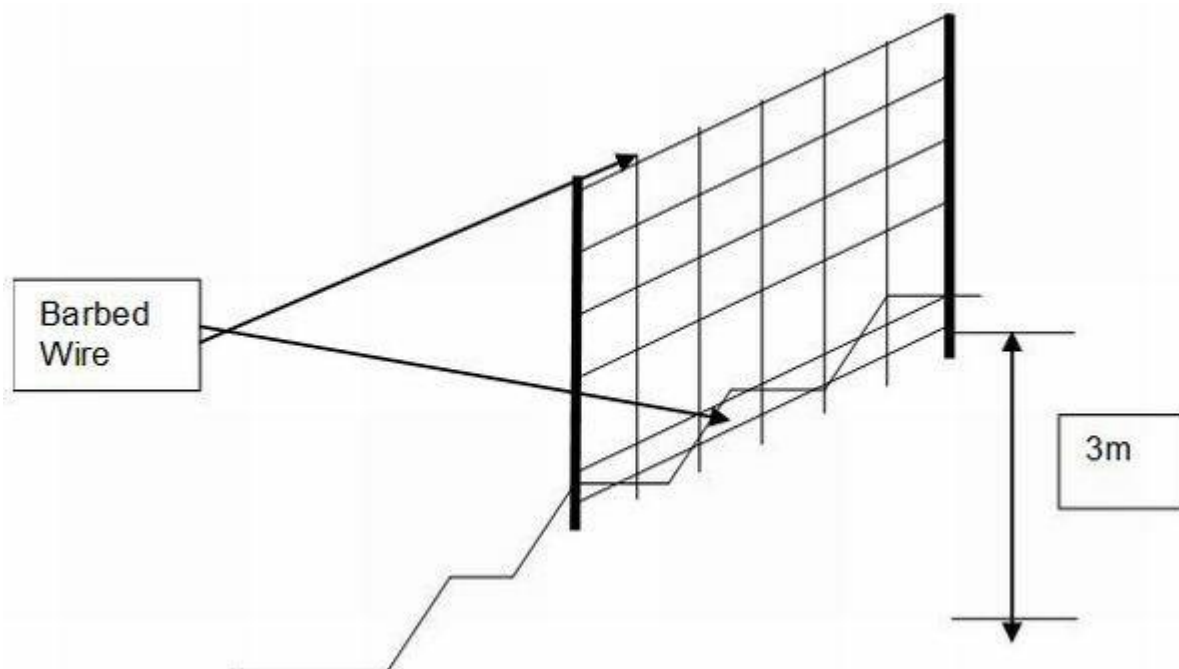


Figure SC6.4.3.21.7 Side View

Stairs or Bridge Gate Design Specifications:

SC6.4.3.22 Waste management guidelines

SC6.4.3.22.1 Introduction

(1) Purpose

The purpose of the Waste management guidelines is to:

- (a) ensure development provides for the functional management of waste in a manner which is environmentally acceptable, safe and efficient and that does not have adverse amenity impacts on external properties or internal development;
- (b) provide general guidelines and advice about achieving waste management outcomes of Townsville City Plan and satisfying any assessment criteria which identifies this planning scheme policy sub-section as providing that guidance or advice;
- (c) state standards for waste management, storage and servicing identified in assessment criteria and which identifies this planning scheme policy sub-section as providing the standards; and
- (d) provide guidelines about the preparation of a waste management plan.

(2) Reference and source documents

Reference and source documents and other policy sub-sections listed below shall be used, applied and read in conjunction with this planning scheme policy sub-section.

- (a) Development manual planning scheme policy sub-sections that are to be read and applied in conjunction with this policy sub-section are as follows:
 - SC6.4.3.5 Car parking and public transport facilities guidelines
 - SC6.4.3.6 Landscaping
 - SC6.4.3.17 Driveways
 - SC6.4.4.1 Geometric Road Design
- (b) Legislation
 - Environmental Protection Regulation 2008*
 - Environment Protection (Water) Policy 2009*
 - Environmental Protection (Waste Management) Regulation 2000*
- (c) Townsville City Council
 - Townsville Waste Services Requirements for Waste Chute Guidelines, 2012*
 - Liquid Trade Waste Policy, 2009*
- (d) Australian Standards
 - AS/NZS 3816 - *Management of clinical and related waste*
 - AS/NZS 2890 - *Parking facilities*
 - AS 4123 – *Mobile waste containers*

SC6.4.3.22.2 Waste management plans

Where proposed developments are likely to generate unusual or large amounts of waste, a waste management plan (WMP) may be required in demonstration of providing appropriate waste storage and waste servicing.

(1) Council may require submission of a waste management plan for development involving the following development thresholds:

- (a) a residential use with more than 10 dwellings;
- (b) a business/commercial/industrial use with a gross floor area greater than 500m² or any use likely to generate large or unusual amounts of waste, including educational establishment, rooming accommodation, hotel major sport, recreation and entertainment facility;
- (c) an environmentally relevant activity (as defined by Schedule 1 of the *Environmental Protection Regulation 2008*) and/or development involving the use of a hazardous materials or chemicals;
- (d) operational works involving substantial waste materials resulting from removal and construction of new infrastructure or demolition and major earthworks; and
- (e) another use or activity where identified as having significant waste management requirements.

- (2) Where WMPs are required to support a development application, it should be tailored to the needs of the proposal.
- (3) Short-term activities or small-scale, uncomplicated developments require relatively simple and short WMPs.
- (4) Larger proposals will require detailed plans covering the different stages of the development, operations or works program.
- (5) A WMP should be submitted detailing how the proposal will meet the requirements of the Townsville City Plan and consider the following issues:
 - (a) Residential applications:
 - (i) types and amounts of waste that may be generated based on number of dwellings;
 - (ii) how the waste will be disposed including number of mobile storage bins or nomination of a suitable size bulk bin;

Note—all residential waste must be removed by council.

- (iii) access and egress for council waste collection vehicles;

Editor's note—applicants should refer to sub-sections SC6.4.3.5 Car parking and public transport facilities guidelines and SC6.4.3.17 Driveways for additional information on design and access requirements.

- (iv) screening of waste facilities by landscaping or other suitable means and where required, nomination of separation distances to property boundary or other residential buildings;

Editor's note—applicants should refer to sub-section SC6.4.3.6 Landscaping for additional information regarding landscape treatments.

- (v) design of facility incorporating requirements from SC6.4.3.22.3 Waste management for development and Table SC6.4.3.22.1 General requirements;
 - (vi) sensitivity of the receiving environment and neighbouring residents (adequate setbacks of waste areas from adjoining property boundaries so as to prevent odour, dust or noise nuisance);
 - (vii) nomination of collection times where bulk refuse containers are required to protect nearby and on-site sensitive land use; and
 - (viii) designated bin wash down facilities to be identified for the contained cleaning of waste bins.

Note—bin washing water is not to be disposed of into stormwater facilities.

- (b) Commercial and industrial applications:
 - (i) types and amounts of waste that may be generated by the authorised activities;
 - (ii) how the waste will be dealt with, including a description of the types and amounts of waste that will be dealt with;
 - (iii) procedures for identifying and implementing opportunities to minimise the amount of waste generated, promote efficiency in the use of resources, and otherwise improve the waste management practices employed, including recycling;
 - (iv) access and egress for those disposing waste and waste collection vehicles;

Editor's note—applicants should refer to SC6.4.3.5 Car parking and public transport facilities guidelines and SC6.4.3.17 Driveways for additional information on design and access requirements.

Note—if the waste is stored in a secured underground shelter, then the waste must be taken out and presented to Townsville Waste Services on collection day.

- (v) noise management for collection (collection methods and times);
- (vi) screening of waste facilities by landscaping when used in combination with other suitable means and where required, nomination of separation distances to property boundary or other sensitive land uses;

Editor's note—applicants should refer to sub-section SC6.4.3.6 Landscaping for additional information regarding landscape treatments.

- (vii) details of any accredited management system employed, or planned to be employed, to deal with the waste;
- (viii) how often the performance of the waste management practices will be assessed;
- (ix) the indicators or other criteria on which the performance of the waste management practices will be assessed;
- (x) staff training on matters relevant to waste management;
- (xi) details of the responsible person for implementing the WMP;
- (xii) procedures for dealing with accidents, spills and other incidents;
- (xiii) sensitivity of the receiving environment, and neighbouring residents (adequate setbacks of waste areas from adjoining property boundaries so as to prevent odour, dust or noise nuisance);
- (xiv) management of odour;
- (xv) extent and life of the proposed activities;
- (xvi) details of bunding arrangements to contain waste where appropriate; and
- (xvii) designated bin wash down facilities to be identified for the contained cleaning of waste bins.

Note—bin washing water is not to be disposed of into stormwater facilities.

- (6) Council may request other reasonable management strategies in relation to individual developments.
- (7) The WMP must be implemented during construction and at commencement of the use or the signing of the survey plan.
- (8) WPMs should take into account any staging of a development.
- (9) Consideration of screening treatments will include ensuring structural safety, durability to minimise whole of life costs, and where practical, integration into the building design and constructed from similar materials used in the building design (integration). Screening must be to a minimum of the height of the bins used and should ensure screening addresses adjoining uses and public spaces.
- (10) Any amendments to a WMP must not be implemented until approval from council is received.

SC6.4.3.22.3 Waste management for development

- (1) The waste management standards for development are identified in the following section and in Table SC6.4.3.22.1 General requirements.
- (2) In addition to the requirements of Table SC6.4.3.22.1 General requirements, the following standards shall be considered for development:
 - (a) access for a refuse collection vehicle to an on-site or kerbside bin or a compactor is maintained at all times; or
 - (b) "No Standing Any Time" signs are to be installed in designated refuse truck turning areas including residential developments, cul-de-sacs and other locations to enable safe access for waste refuse vehicles; or
 - (c) a development application is to indicate the days and times that a refuse removal service is to operate. If evidence from a refuse collection contractor indicates that collection will occur outside normal service/delivery or business times, it may be permissible to allow a refuse collection vehicle to utilise

service bays or parking spaces on the site for access; or

- (d) where applicable, development is to provide the vertical and horizontal clearances for the service to safely and efficiently operate. Unless otherwise stated in Table SC6.4.22.1 General requirements, the minimum vertical clearance required for movement of a refuse collection vehicle is 6.5m. Larger operational clearance dimensions may be required depending on site specific requirements; or
- (e) where applicable, a development that proposes to utilise a waste collection system requiring clearances less than 6.5m for vehicle movement is to include a written confirmation from the proposed waste collection provider giving full details of the proposed system, bin sizes, number of bins, frequency of collection and the refuse collection vehicle size; or
- (f) all refuse collection for residential development is to be collected by council, whilst office refuse may be collected by the council or a private operator and retail, shop or industrial refuse collection is to be collected by a private operator; or
- (g) whether domestic refuse collection is from a bulk storage area or bins located throughout a unit development, all circulation and access roads utilised by a refuse vehicle are to be a minimum of 6.5m wide; or
- (h) where a development has access onto a road, all refuse collection is from within the site. For access to a road the refuse truck is required to enter and leave the site in a forward direction; or

Editors note - Applicants should refer to SC6.4.3.13 Townsville road hierarchy for additional information.

- (i) industrial development is to indicate the location of the refuse collection area in the development application and provide an indication of the proposed method of disposal of refuse and waste, including trade waste. Where disposal of industrial or commercial liquid waste by discharge to a road tanker application is necessary, the road tanker is able to stand totally on-site and comply with all other relevant regulations; or
 - (j) the owner/occupier must keep the bins clean, in good repair and securely covered.
 - (k) the property must be designed to store the bin/s at ground-level, and generally located towards the rear of the premises or, if not, out of sight of the general public, except when put out for collection (one day maximum); or
 - (l) where required, the property must be designed to facilitate the placing of the bin/s out (on the specified collection day) as follows:
 - (i) on, or as close as possible to, the kerb adjacent to the premises, with the bin axle away from the road;
 - (ii) with no structure or obstacle preventing the waste/ recycling crew from picking the bin up; and
 - (iii) with at least 500mm spacing between the bins; or
 - (m) particular serviced premises may be required to keep the bin on an elevated platform or an imperviously paved area, enclosed and/or with drainage; or
 - (n) council may also instruct certain residential premises to dispose of their waste by an approved environmental licensed authority.
- (3) Applications must ensure that adequate unhindered access for waste collection vehicles is possible, ensuring that not only the road reserve widths accommodate a waste collection vehicle, but that vehicles can safely and efficiently collect kerb side waste.
- (4) Waste collection from properties in cul-de-sac heads or hammer heads may require kerb side concrete hardstand areas to be constructed to ensure that kerb side collection remains possible. SC6.4.3.22.5 Concrete hardstand design for wheelie bins provides the design specification for kerb side domestic wheelie bins.

Editor's note—applicants may be asked to submit a plan demonstrating the location of waste collection points.

- (5) Waste collection from a laneway is only permitted when the laneway has through access, sufficient width to accommodate the waste collection vehicle and the identification of wheelie bin collection points. Overhead

services also need to be clear of the waste collection area.

- (6) Private access handles where multiple lots may be serviced from are not accessible by a waste collection vehicle. In such instances, a safe designated kerb side collection point is to be nominated. SC6.4.3.22.5 Concrete hardstand design for wheelie bins provides the design specification for kerb side domestic wheelie bins.

Editor's note—applicants may be asked to submit a plan demonstrating the location of waste collection points.

- (7) Where waste collection points are nominated away from the property being serviced (cul-de-sacs, laneways, access handles), nominated collection points are not permitted adjacent to a park and are not to compromise the safe use or access to pedestrian or other utility service.

Editor's note—applicants may be asked to submit a plan demonstrating the location of waste collection points.

- (8) Where staged residential estates result in temporary no through connection roads (for example, until subsequent stage construction is complete), compacted gravel (or equivalent) is required to be created at the end of a constructed road within a public tenure (i.e. road reserve).

Editor's note—waste collection vehicles will not be permitted to use privately owned land to turnaround.

- (9) In instances where roads terminate to adjoining land and adjoining land is in separate/different ownership or not subject to the development application, applicants will need to provide a turnaround area within the development site until future through connection can be established. In this instance, the turnaround area will need to be constructed of durable material.

- (10) If a rear lot, the frontage is to include an additional truncated area to provide sufficient space for the servicing of mobile waste containers. These truncated collection points are to avoid obstructing any driveway or encroachment onto neighbouring frontages.

- (11) If there are two or more rear lots, no more than two adjoining truncated areas are provided for the servicing of mobile waste containers.

- (12) Collection points are not located:

- (a) near intersections;
- (b) near roundabouts or traffic calming devices (or other traffic management devices);
- (c) on arterial road frontages;
- (d) in narrow lanes (where refuse collection vehicle access is difficult or impossible); and
- (e) near bus stops.

- (13) Where on-street (kerbside) waste collection is proposed for standard domestic waste containers sufficient kerbside space is provided adjacent to the frontage of the premises for the required number of bins and such space is:

- (a) clearly separated from car parking bays, loading bays and other similar no-standing areas;
- (b) clear of overhanging branches, awnings and other such hindrances to servicing by a lifter arm;
- (c) clear of footpaths and pedestrian access connections to the road;
- (d) not in front of shop entrances or private residential premises;
- (e) not blocking the vision of vehicles using the roadway or entering and exiting the property;
- (f) capable of being serviced safely without the collection vehicle impeding traffic flow during servicing; and
- (g) capable of being serviced while the collection vehicle travels forward (i.e. without the vehicle needing to

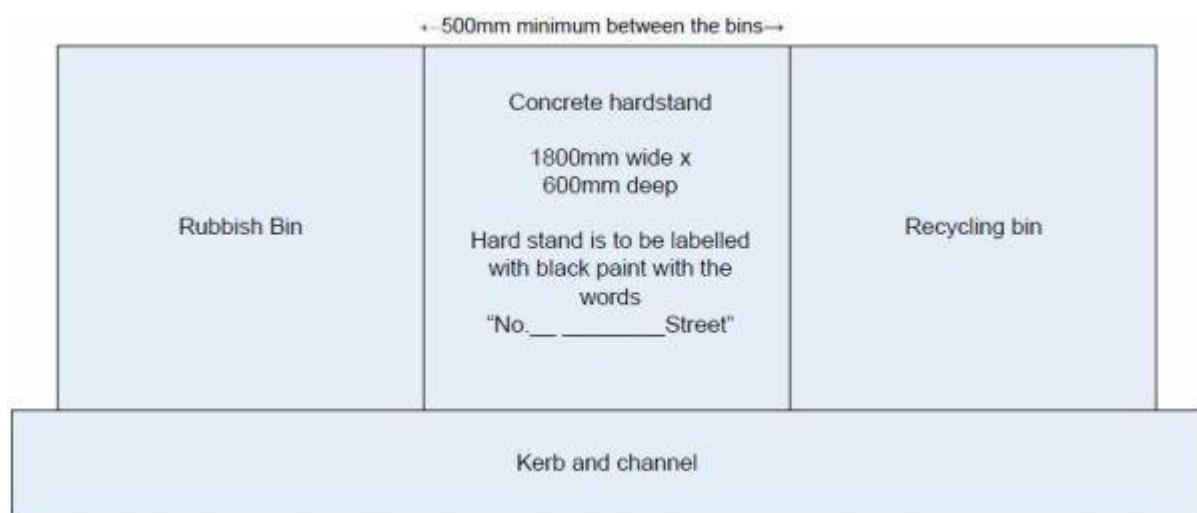
reverse).

SC6.4.3.22.4 Regulated waste guidelines

- (1) Regulated waste is administered by the Department of Environment and Heritage Protection.
- (2) Transport, storage, recycling or disposal of regulated wastes are environmentally relevant activities.
- (3) Environmentally relevant activities that are prescribed activities are generally industrial activities but can also include some agricultural activities. A full list of all of the prescribed ERAs can be found in Schedule 2 of the *Environmental Protection Regulation 2008*.

SC6.4.3.22.5 Concrete hardstand design for wheelie bins

Where waste collection vehicles are unable to collect wheelie bins directly in front of a property due to access restrictions, owner/occupiers must take the bin/s to a designated collection point. The diagram below demonstrates the dimensions required for a hardstand for these bins at the designated collection point.



SC6.4.3.22.6 Examples of bin storage area



Figure SC6.4.3.22.1 Concrete hardstand for mobile waste containers or a bulk bin



A: Courtside entrance: The height of the roof is 1m in the middle receding downwards.

B: Interior: The height is 2.5m to the top of the pillar/ gutter level.

C: Exterior entrance: The gate is 1.9m of the total 4m depth and is accessed by a key.

D: Kerbside view.

Figure SC6.4.3.22.2 Enclosed concrete hardstand for bulk waste and recycling mobile waste containers

SC6.4.3.22.7 Bulk bin specifications

Note—refer to AS 4123 for the standard sizing of bulk bins. Bulk bins must be ordered well in advance to ensure availability.

Table SC6.4.3.22.2 Bin dimensions in litres (L) and cubic metres (m³)

Recycling and Waste bins available for units, multi-dwelling units and commercial units	
	240 L plastic
	360 L plastic (recycling)
Bulk Recycling and Waste bins available for multi-dwelling units and commercial units	
	660 L plastic/metal
	1100 L metal
Bulk Waste bins available for multi-dwelling units and commercial units	
	0.75 m ³ metal
	1 m ³ metal
	1.5 m ³ metal
	3.0 m ³ metal
Bulk Waste bins available for commercial units	
	4.0 m ³ metal

Table SC6.4.3.22.3 Weekly bin collections in relation to bulk bin size

Number of units (dwellings)	Bulk bin Size	Collection frequency (per week)
6	0.75 m ³	Twice
6	1 m ³	Twice
6	1.5 m ³	Once
12	1.5 m ³	Twice
12	3 m ³	Once
24	3 m ³	Twice

Table SC6.4.3.22.1 General requirements

	General details	Access and collection	Locality of storage areas/design of facility
Residential (dwelling house dual occupancies)	Mobile waste containers (240 L) are used for both waste collection and recycling. Owner/occupiers may also choose to pay a small additional charge for a 360 L recycling bin.	Where sloping areas exist ($\geq 15\%$), an adequate level hardstand area with sufficient space to accommodate all bins for collection is to be made available along the street frontage for the collection of mobile waste and recycling containers collected fortnightly. Refer to SC6.4.3.22.5 for an auto court concrete hardstand design for wheelie bins. Other arrangements may be negotiated.	Mobile waste containers must be stored at a location within the property boundary that avoids nuisance to neighbouring properties.

Residential (including multiple dwelling, residential care facility retirement facility and the like)	Developments containing a maximum of 10 dwellings will be issued with new mobile waste containers unless there is insufficient footpath to place the waste and recycling bins for collection.	Access roads must be designed and constructed to accept vehicle loadings of not less than G.V.M. 33 tonnes. If the road system is incapable of allowing waste vehicle access, tailored solutions will be negotiated with the developer in association with the Waste Services Division. Vehicles must be capable of exiting the site in a forward gear. A turning circle of 25m is required. Waste collection facilities are to be located within the curtilage of the premises in an accessible location to receive the service.	For multiple dwellings where there is sufficient room for each dwelling to store their mobile waste containers; the resident of each dwelling is responsible for the storage of their bins (including recycling bins).
	Where on-street access for collection of mobile garbage (wheelie) bins is not available, or multiple dwellings contain more than 10 dwelling (or similar) the developer must provide bulk refuse facilities. Refer to SC6.4.3.22.7 for more information on bulk bin collections.		Where there is insufficient space for individuals to accommodate their bins, a common waste storage area must be provided of a sufficient size to accommodate all bins (including recycling bins). Storage areas must provide convenient access for owners, tenants and collection vehicles. Refer to SC6.4.3.22.6 for examples of bin storage areas.
	Recycling bins will be allocated at the rate of:	Facilities should be sited in front of any entry gates to the building. Where security gates cross the driveway restricting vehicular access to the site, bin storage areas are to be located within property boundaries on the street side of the gate. A minimum overhead clearance of 6.5m is required (with an additional 2m if located near powerlines). This must be unobstructed by anything overhead such as trees, wires, sails, awnings, fascia or other structures.	Facilities must provide a suitable level enclosure with a concrete slab floor, graded and drained through an approved sediment/silt trap to a legal sewer connection.
	1-4 dwellings per dwelling	1 bin	
	5-10 dwellings	5 bins	
More than 10 dwellings per 2 dwellings	1 bin		
	If constructing waste chutes, refer to council's Waste Chute guidelines.	Where sloping areas (≥15%) such as steep road reserves exist, an adequate level hard stand area with sufficient space to accommodate all bins for collection is to be made available along the street frontage for the collection of mobile waste containers (collected weekly), and recycling mobile waste containers (collected fortnightly).	A hose cock and hose must be fitted in close proximity to the enclosure. Enclosure dimensions for bulk bins must exceed the size of the nominated bin size by at least 300mm at the rear and both sides and 600mm at the front; and be oriented to allow convenient access for collection. Where mobile waste containers are in use, an adequate storage area must be provided.
			Facilities must be enclosed/screened such that they are not visible from any street frontage.

Commercial and business industrial	The proprietor is to arrange for the removal of waste from the premises by a suitably licensed waste transport contractor. Putrescible waste arising from activities undertaken on this development must be collected and removed at periods not exceeding seven days. (a) The collection of waste is to be undertaken to minimise, so far as reasonably practicable, excessive noise to neighbouring occupants. The collection method must ensure that waste is adequately managed to prevent escape or contamination. (b) Where the development has the potential to generate or handle clinical and regulated waste material; clinical and medical related waste is to be handled in accordance with AS/NZS 3816; and the <i>Environmental Protection (Waste Management) Regulation 2000</i>. (c) Where practicable, all loading and unloading shall take place within the containment area (storage area). This area is to be constructed in such a way that any spills from loading or unloading are not permitted to escape to areas exposed to storm water. No clinical and related wastes shall be disposed of via the storm water drainage system. (d) Trade Waste is to be managed in accordance with council's Liquid Trade Waste Management Plan 2009.	Access roads and driveways must be designed and constructed to accept vehicle loadings of not less than G.V.M. 33 tonnes. Vehicles must be capable of exiting the site in a forward direction. A turning circle of 25m is required. A minimum overhead clearance of 6.5m is required (with an additional 2m if located near power lines). This must be unobstructed by anything overhead such as trees, wires, sails, awnings, fascia or other structures.	Facilities are to be located within the curtilage of the premises in an accessible location to receive the service. Facilities should be sited in front of any entry gates to the building. Where security gates cross the driveway restricting vehicular access to the site, bin storage areas are to be located within property boundaries on the street side of the gate. Adequate provision must be made for the collection of the waste storage containers within the premises. Storage of waste must not cause odour, dust or noise related nuisance to neighbouring properties. Facilities must provide a suitable level enclosure with a concrete slab floor, graded and drained through an approved sediment/silt trap to a legal sewer connection. A hose cock and hose must be fitted in close proximity to the enclosure. Bulk bin enclosure dimensions must exceed the size of the nominated bin size by at least 300mm at the rear and both sides and 600mm at the front; and be oriented to allow convenient access by the collection vehicle. Where mobile waste containers are in use, an adequate storage area must be provided. Facilities must be enclosed/screened such that they are not visible from any street frontage.

SC6.4.3.23 Water and sewer network modelling guidelines

SC6.4.3.23.1 Introduction

(1) General

Water and sewerage network models are important engineering technical tools that are used to inform both forward infrastructure planning and network design. Where used appropriately as part of the planning and design process, models can assist to achieve the following outcomes:

- (a) value for money infrastructure delivery;
- (b) utilisation of existing infrastructure to its full capacity; and
- (c) provision of accurate information for future infrastructure planning decisions.

(2) Purpose

The purpose of these guidelines is:

- (a) to outline an approach to the development of new models to enable a consistent approach to modelling to be followed by both council, external service providers and developers;
- (b) to provide guidance regarding modelling approaches to demonstrate compliance of designs with SC6.4.3.21 Townsville Water planning and design guidelines; and
- (c) to provide details on reporting requirements to be submitted as part of design reports and planning reports.

(3) pe

SC6.4.3.23 Water and sewer network modelling guidelines are to be used in conjunction with:

- (a) SC6.4.3.21 Townsville Water planning and design guidelines;
- (b) Townsville City Plan; and
- (c) *Planning Guidelines for Water and Sewerage*, Department of Environment and Water Supply (Latest version).

Editor's note - These guidelines are not intended for use in building hydraulic services or irrigation design.

(4) Terminology

AD	Average Day Demand
ADWF	Average Dry Weather Flow
CSS	Customer Service Standards
DAU	Development Assessment Unit Within TCC
DSS	Design Service Standards
EP	Equivalent Population
FF	Fire Flow Demand
GWI	Groundwater Infiltration
HGL	Hydraulic Grade Line
IP	Infrastructure Planning Unit Within TCC
MDMM	Mean Day Maximum Month
PD	Peak Day Demand
PDWF	Peak Dry Weather Flow
PIA	Priority Infrastructure Area
PIP	Priority Infrastructure Plan
PFTI	Plans For Trunk Infrastructure
PH	Peak Hour Demand
PWWF	Peak Wet Weather Flow
RPEQ	Registered Professional Engineer of Queensland
TCC	Townsville City Council
TWW	Townsville Water and Waste (The Water Service Provider)

SC6.4.3.23.2 Determining when to complete a network modelling analysis

The circumstances under which a network model is required is listed under clauses SC6.4.3.21.2 Water supply design and SC6.4.3.21.3 Sewerage system design of SC6.4.3.21 Townsville Water planning and design guidelines. The process flow chart in SC6.4.3.23 Attachment A demonstrates the decision process that is to be followed when considering the requirement for a network analysis.

(1) Available information

Planning demand and loading rates for water and sewerage infrastructure design are listed in Part 4 Priority infrastructure plan of the Townsville City Plan.

Council has established a number of sewer network models covering service catchments across the city. A map showing sewer catchments, modelling status and latest planning report information can be requested from the Development Assessment Unit (DAU) of council.

A city wide water network model is also available for use.

Editor's note—Access to council's city wide water network model is available to appropriately qualified users approved by the Infrastructure Planning Unit of TCC. Refer to SC6.4.3.23.3 (2).

Plans for Trunk Infrastructure (PFTI) are available and detail trunk infrastructure that is planned for by council to service the Priority Infrastructure Area (PIA). These should also be referred to in order to determine if your development may affect or should take into consideration planned infrastructure in its vicinity.

(2) Preparing a preliminary needs analysis

An applicant for a development must complete a "Preliminary Needs Analysis" form (SC6.4.3.23 Attachment B) for their development which enables identification of any potential impacts on the water and sewer network. Where an impact is anticipated, it is likely that an analysis will be required to demonstrate compliance with design standards. The level of modelling assessment required is dependent on the impact expected.

Editor's note - If your preliminary analysis results in a modelling assessment being required, you should contact the DAU of council to confirm the level of modelling necessary. It is encouraged that this assessment be completed prior to application lodgement to ensure an efficient approval process.

The completed "SC6.4.3.23 - Attachment B - Form M1 - Network model needs analysis form" is required to be included with your analysis and application to justify the level of analysis undertaken.

Editor's note—The "Preliminary Needs Analysis" will determine if:

- (a) a network analysis is not required; or
- (b) you are required to do a simplified network analysis; or
- (c) you are required to do a detailed network analysis, involving establishment of a new model, or use an existing model; or
- (d) you need to incorporate a network modification in your application, with details specified by council.

If a network analysis is required, it must be done in accordance with these guidelines

SC6.4.3.23.3 Provision of the TCC Network Model Data

(1) Requesting information to inform your analysis

Modellers may request boundary condition information from council, and/or access to council's network models by submitting a "Request for Network Modelling Information" form included in SC6.4.3.23 Attachment C - Form M2 - Request for network modelling information.

Editor's note—"SC6.4.3.23 Attachment C - Form M2 - Request for network modelling information" is an electronic form.

In most cases it is desired that boundary condition information is sufficient to enable a modeller to prepare their own network model. However, depending on the size or impact of the development being considered, it may be necessary for the modeller to utilise council's network models to demonstrate:

- (a) in the case of the sewer network:

- (i) receiving network capacity is sufficient; and
- (ii) modified or realigned infrastructure as a result of the development has not adversely affected existing or planned for system hydraulics; and
- (b) in the case of the water network:
 - (i) network supply capacity is sufficient; and
 - (ii) existing network hydraulic capacity is not adversely affected by any changes to the supply network as a result of the proposed development.

Generally, where trunk infrastructure may be affected by the proposed works, council's network models must be used to verify the impact and identify required mitigation/augmentation options.

(2) Access to council models

Access to council's network model/s is available to appropriately qualified users approved by the Infrastructure Planning Unit of TCC.

Editor's note—For information on the approval process applicants should contact the Infrastructure Planning Unit of TCC.

Council will make available at their offices a computer to enable analysis of a development or for viewing existing network model information. The applicant must apply for access to council's network model/s by submitting the "SC6.4.3.23 - Attachment C - Form M2 - Request for network modelling information" form. The modeller will need to agree to council's terms of use on this form.

SC6.4.3.23.4 General requirements for network models

(1) Scale and spatial reference

"Simplified Models" may be developed as representative schematics of the proposed network. Manual calculations without the use of network modelling software may be permitted.

"Detailed Models" shall be constructed based on proposed design and/or development layouts. The layouts may be schematic but should remain representative of the proposed development layout. In order to enable import of models into council's existing network models, they shall be developed to the GDA1994 MGA Zone 55 coordinate system unless otherwise notified.

(2) Modelling timeframes

Timeframes for modelling shall be as per clauses SC6.4.3.21.2(2) and SC6.4.3.21.3(2) of SC6.4.3.21 Townsville Water planning and design guidelines.

(3) Model calibration

Where possible, calibrated models shall be used to verify system capacity.

(4) Modeller experience and qualifications

Network modelling must be carried out by professionals suitably experienced and qualified in the undertaking of network modelling analysis and design. Models, associated reports and designs must be certified by the appropriately qualified and experienced RPEQ.

SC6.4.3.23.5 Water network modelling

(1) Scope

A water network model is required where listed under the requirements of SC6.4.3.21.2(2) of SC6.4.3.21 Townsville Water planning and design guidelines.

(2) Model requirements – simplified assessment

A simplified assessment involves the use of manual calculations or simplified network models to demonstrate compliance with design standards. A simplified assessment must include:

- (a) assessment of design demands in accordance with SC6.4.3.23.5 (3)(d) of this sub-section;
- (b) where necessary, hydraulic calculations based on fixed boundary conditions for both peak hour and fire-fighting demand;
- (c) calculations can be undertaken manually, using spread sheets or using network modelling software. Where modelling software is used, the model files shall be provided to council as part of the submission;

and

- (d) a brief report covering the requirements of SC6.4.3.23.5 (3)(f) of this sub-section. Sketches of results are to be provided where they make it easier to interpret results.

(3) Model requirements – detailed assessment

(a) Format

Bentley WaterGEMS must be used for the development of new water network models. Models shall be set up such that all scenarios and options considered for the study are incorporated into a single model file. The model file(s) shall be provided to council as part of the submission.

(b) Scenario planning

A scenario plan must be developed by the modeller prior to commencing modelling such that each scenario required for analysis is identified and that differences between scenarios are clearly understood.

The modeller must utilise parent and child scenarios and alternatives such that common information for each scenario is inherited to child scenarios, and that unique changes are clearly identifiable. A “parent” scenario should be applied for each design horizon or stage, and ultimate development. The following model structure provides an example of a model scenario structure.

---Scenario 1000- Existing Peak Day Demand (Extended Period Analysis)
-----Scenario 1100- Existing Peak Hour Demand (Steady State Analysis)
-----e.g. Scenario 1110 - Existing Peak Hour with Infrastructure Option 1
-----e.g.Scenario 1120- Existing Peak Hour with Infrastructure Option 2 (Preferred)
-----Scenario 1121- Existing Fire Fighting Assessment (Steady State analysis, automated)
---Scenario 2000- Ultimate Peak Day Demand (Extended Period Analysis)
-----Scenario 2100- Ultimate Peak Hour Demand (Steady State Analysis)
-----e.g.Scenario 2110- Ultimate Peak Hour with Infrastructure Option 3 (Preferred)
-----Scenario 2111- Ultimate Fire Fighting Assessment (Steady State analysis, automated)

As shown the scenario structure naming should be clear and transparent as to which design case it represents and the preferred option applied for the design should be marked.

(c) Technical specification

(i) Hydraulic method

Modelling must be undertaken using the Hazen Williams hydraulic calculation method, with pipe friction coefficients as listed in Table SC6.4.3.21.4 of SC6.4.3.21 Townsville Water planning and design guidelines.

(ii) Losses across valves

Where control valves are required in the system, the valve should be modelled with appropriate loss factors/curves. The modeller must ensure that loss factors applied for design of a system can be achieved in reality by available products, and where possible apply the loss factor or curve for a design valve.

(iii) Pump curves

A design duty (single point pump curve) may be used initially when designing a pumping system however the modeller is to ensure that the pump duty proposed can be achieved by readily available pumps. Where possible an actual pump curve for a design pump shall be applied for modelling purposes.

(iv) Pump controls

Pumps shall be modelled with simple controls where possible. The modeller must consult with council when applying pump controls to ensure it meets the requirements of Townsville Water operators.

(v) Reticulation

Master Planning Models shall model trunk infrastructure only. Refer to Part 4.7 Definitions of the Townsville City Plan for the definition of trunk infrastructure.

Design Models shall model reticulation down to a DN63 pipe.

(d) Demands

(i) General

Design demands are to be calculated in accordance with SC6.4.3.21.2(2) of SC6.4.3.21 Townsville Water planning and design guidelines.

Demands must be applied as Peak Day demand in litres per second (L/s), with the appropriate diurnal pattern applied for the particular land use.

Demands should be applied at the nearest network node, and within 40 m of the property boundary.

Where a node represents demands generated from different land uses, separate demand entries should be applied to the node to enable quick identification of the source of the demand.

(ii) Use of unit demand factors

WaterGEMS enables unit demand factors to be applied, such that the resultant demand from the unit load, loading rate and peaking factors are calculated as part of the modelling process. The use of this feature is required for master planning models, enabling tracking of design EPs modelled.

(iii) Diurnal patterns

Diurnal patterns represent fluctuations in demand load across a day. Patterns for various land uses are included in SC6.4.3.21 Attachment A of the Townsville Water planning and design guidelines.

(e) Scenarios

(i) Extended period analysis

Extended period analysis is used to demonstrate compliance with SC6.4.3.21 Townsville Water planning and design guidelines. Extended period analysis must be utilised when considering networks that incorporate reservoirs, pump stations or other hydraulic controls.

Extended period analysis enables assessment of the bulk water transportation capacity of the network to ensure that:

- (A) reservoirs never empty;
- (B) reservoir minimum contingency storage levels are maintained;
- (C) the reservoir supply system has a net delivery capacity equal to or greater than Peak Day;
- (D) pumping systems are designed within operational limits; and
- (E) system pressures are achieved across a day.

(ii) Council requires two scenarios of extended period analysis to be modelled:

3 day extended period analysis

Boundary conditions:

- reservoirs commencing water level 90% capacity;
- pump stations – all pumps in station initially off; and
- demand applied: Peak Day demand.

7 day extended period analysis

Boundary conditions:

- reservoirs commencing water level 90% capacity;
- pump stations – all pumps in station initially OFF; and
- demand applied: 95% of Peak Day demand.

(iii) Steady state analysis

Peak hour

Where a peak day analysis is required for a model, a separate steady state analysis to demonstrate compliance with design standards for Peak Hour is not necessary. Rather, the results at Peak Hour on the Peak Day may be reported at that specific time step.

Peak hour analysis is used to assess network pressures at Peak Hour to ensure the design requirements of SC6.4.3.21 Townsville water planning and design guidelines are met.

Boundary conditions:

- (A) demands may be applied directly as Peak Hour demand, or at Peak Day demand with peaking factor to represent Peak Hour.

Fire-fighting analysis

Fire fighting analysis is used to assess network capacity of the network water mains with respect to the design requirements listed the SC6.4.3.21 Townsville water planning and design guidelines.

Use of automated analysis, where fire-fighting conditions are tested at each node/hydrant within the network, should be employed.

Boundary conditions:

- (A) reservoirs commencing at mid water level; and
- (B) demand applied: Peak Hour unless otherwise advised by council.

(f) **Reporting requirements**

A water network modelling report must be prepared to document the process, assumptions and analysis employed through modelling to develop the infrastructure design and/or master plan.

The following provides details of sections to be incorporated into the modelling report. The modeller may provide further information as needed to justify decisions made through the modelling and design process.

(i) **Introduction:**

- (A) development locality, lot/plan description, application number (if applicable);
- (B) objectives of study – design/master plan; and
- (C) brief methodology – describe level of modelling undertaken (simplified/detailed), software used, reference to model overview in appendix.

(ii) **Population and demand assessment:**

- (A) population assessment based on land use categories, site plan showing layout and land use;
- (B) demand assessment showing demand calculation and peaking factors applied;
- (C) summary table showing total demand, with breakdown for each land use category, Average Day (kL/d), Peak Day demand (kL/d or L/s); and
- (D) summary table showing demand breakdown for each service catchment, where applicable.

(iii) **Modelling assessment:**

- (A) modelling method – simplified or detailed assessment;
- (B) scenarios analysed, including description or reference to design standards applied;
- (C) modelling assumptions;
- (D) existing network description, including proposed connection points; and
- (E) modelling assessment:
 - existing system capacity;
 - existing system + ultimate development; and
 - augmentations, new infrastructure options analysis including assessment of options at interim stages - 10y/20y/ultimate horizons.

(iv) **Options analysis:**

- (A) triple bottom line analysis; and
- (B) net present value assessment.

(v) **Summary:**

- (A) preferred option, justification, capital works program.

(vi) **RPEQ Certification statement as detailed in SC6.4.2.**

(vii) Appendix:

- (A) for detailed models, model overview to be included in appendix (covering scenario structure, options and clearly outlining which scenario represents the design solution);
- (B) model map showing model layout (nodes, pipes, labels and any relevant boundary conditions, e.g. reservoirs or head points applied); and
- (C) tabulated data and results – to be provided at peak hour analysis and fire fighting analysis:

Nodes	• Element ID • Node Elevation • Peak Hour Demand • Calculated Hydraulic Grade (m) • Calculated Pressure (m) - For fire-fighting analysis • Available fire-fighting flow • Available pressure at fire fighting demand
Pipes	• Element ID • Pipe diameter • Material and class • Length • Start node • Stop node • Hazen Williams C value • Flow rate • Velocity • Headloss gradient
Pump Stations	• Element ID • Pump type (fixed, variable speed) • Pump configuration (duty/standby etc.) • Pump curve, if selected
Reservoirs	• Element ID • Reservoir Capacity • Top Water Level • Bottom Water Level

- (D) pump stations - system resistance curve with pump curve overlaid. Pump curve may be duty point however the designer shall consider the capability of pumps on the market to meet such a duty (i.e. it needs to be physically achievable).

SC6.4.3.23.6 Sewer network modelling

(1) Scope

A sewer network model is required where listed under the requirements of clause SC6.4.3.21.3 of SC6.4.3.21 Townsville water planning and design guidelines.

(2) Model requirements – simplified assessment

A simplified assessment involves the use of manual calculations to demonstrate compliance with design standards. A simplified assessment must include:

- (a) assessment of design loads in accordance with SC6.4.23.6(3)(d) of this sub-section;
- (b) where necessary, hydraulic calculations based on fixed boundary conditions for Peak Wet Weather Flow loading;
- (c) calculations can be undertaken manually, using spreadsheets or using network modelling software. Where modelling software is used, the model files shall be provided to council as part of the submission; and
- (d) a brief report covering the requirements of SC6.4.23.6(3)(f) of this sub-section. Sketches of results are to

be provided where they make it easier to interpret results.

(3) Model requirements – detailed assessment

(a) Format

Bentley SewerGEMS sanitary must be used to undertake detailed assessments of sewer networks. This will enable models to be incorporated into council's existing network models.

Models shall be set up such that all scenarios and options considered for the study are incorporated into a single model file.

(b) Scenario planning

A scenario must be developed by the modeller prior to commencing modelling such that each scenario required for analysis is identified and that differences between scenarios are clearly understood.

The modeller must utilise parent and child scenarios and alternatives such that common information for each scenario is inherited to child scenarios, and that unique changes are clearly identifiable. A "parent" scenario should be applied for each design horizon or stage and ultimate development. The following provides an example of a model scenario structure.

---Scenario 1000- Existing Average Dry Weather Flow
-----Scenario 1100- Existing ADWF Overflow Storage Assessment
-----Scenario 1200- Existing Peak Wet Weather Flow
---Scenario 2000- Ultimate Average Dry Weather Flow
-----Scenario 1100- Ultimate ADWF Overflow Storage Assessment
-----Scenario 1200- Ultimate Peak Wet Weather Flow
-----Scenario 1210- Ultimate PWWF Infrastructure Option 1
-----Scenario 1220- Ultimate PWWF Infrastructure Option 2 (Preferred)

(c) Technical specification

Hydraulic method

Mannings formula must be used for calculation of gravity network hydraulics, in accordance with the requirements of the *Sewerage Code of Australia* (WSA 02-2002).

Hazen-Williams method must be applied for pressure pipe systems in accordance with SC6.4.3.21 Townsville Water planning and design guidelines.

Inflow/Infiltration

Inflow/Infiltration shall be modelled intrinsically as a part of the calculated design loads, in accordance with SC6.4.3.21 Townsville Water planning and design guidelines.

Pump curves

A design duty (single point pump curve) may be used initially when designing a pumping system however the modeller is to ensure that the pump duty proposed can be achieved by readily available pumps. Where possible an actual pump curve for a design pump shall be applied for modelling purposes.

Pump controls

Pumps must be modelled with simple controls where possible. The modeller must consult with council when applying pump controls to ensure it meets the requirements of Townsville Water operators.

(d) Sewage flow calculation

Design loads are to be calculated in accordance with SC6.4.3.21.3(2) of SC6.4.3.21 Townsville Water planning and design guidelines.

Loads must be applied to the model as an Average Dry Weather Flow (ADWF) base demand. A peaking factor multiplier applied as a fixed pattern on the load must be used to generate Peak Wet Weather Flow (PWWF).

Where a manhole represents demands generated from different land uses, separate demand entries must be applied to the node to enable quick identification of the source of the demand.

(e) Scenarios

(i) Static vs. dynamic modelling

Sewer network models should be run dynamically (i.e. over an extended period) to enable:

- (A) assessment of system storage prior to overflow;
- (B) ensure model stability when system is fully loaded; and
- (C) ensure the interaction of pumps on a common system are assessed.

A minimum 24 hr simulation period is therefore recommended. The user should report results at the appropriate timestep (i.e. maximum conditions in system).

(ii) ADWF analysis

ADWF analysis is used to assess basic system performance under dry weather flow conditions. This analysis is also used to assess the amount of system storage available before an overflow is activated within the catchment (being inter-area or environmental).

(iii) PWWF analysis

PWWF analysis is used to assess network performance in respect to the design requirements listed in SC6.4.3.21 Townsville Water planning and design guidelines.

(f) Reporting requirements

A sewer network modelling report must be prepared to document the process, assumptions and analysis employed through modelling to develop the infrastructure design and/or master plan.

The following provides details of sections to be incorporated into the modelling report. The modeller may provide further information as needed to justify decisions made through the modelling and design process.

(i) Introduction:

- (A) development locality, lot/plan description, application number (if applicable);
- (B) objectives of study – design/master plan; and
- (C) brief methodology – describe level of modelling undertaken (simplified/detailed), software used, reference to model overview in appendix.

(ii) Sewage flow/loading assessment:

- (A) population assessment based on land use categories, site plan showing layout and land use;
- (B) load assessment showing calculation of ADWF and PWWF flows; and
- (C) summary table showing total load, with breakdown for each pump station catchment or network subcatchment, average dry weather flow (L/s), (kL/d), peak wet weather flow (L/s), (kL/d).

Where an existing council model is being updated, a table comparing previous catchment loads to updated catchment loads must be provided.

(iii) Modelling assessment

- (A) scenarios analysed, including description or reference to design standards applied;
- (B) modelling assumptions;
- (C) existing network description, including proposed connection points; and
- (D) modelling assessment:
 - existing system capacity;
 - existing system + ultimate development;
 - augmentations, new infrastructure options analysis including; and
 - assessment of options at interim stages - 10y/20y/ultimate horizons.

(iv) Options analysis:

- (A) triple bottom line analysis; and
- (B) net present value assessment.

- (v) Summary:
 - (A) Preferred option, justification, capital works program.
- (vi) RPEQ Certification statement in accordance with SC6.4.2.
- (vii) Appendix:
 - (A) model overview to be included in appendix (covering scenario structure, options and clearly outlining which scenario represents the design solution);
 - (B) tabulated results of the manhole, gravity and pressure main outputs:

Manholes	• Element ID • Node Elevation • Design Load
Pipes - gravity and pressure mains	• Element ID • Pipe diameter/material and class • Grade • Upstream manhole • Downstream manhole • Pipe flow depth as percentage of diameter PWWF (gravity mains) • Flow velocity at PWWF (pressure mains) • Flow velocity under single pump operation (pressure mains)
Pump Stations	• Element ID

- (viii) pump stations - system resistance curve with pump curve overlaid. Pump curve may be duty point however the designer shall consider the capability of pumps on the market to meet such a duty (i.e. it needs to be physically achievable).

SC6.4.3.23.7 Copyright and ownership of submitted models

When a technical report or study is submitted to council as part of a development application, this report/study, along with all components of the submission, can be made available to the public as part of the notification stage. The report can be provided to anyone seeking the report during this stage and following the approval. Use of the report for any third party use will be at the complete risk of the third party. It should be noted that only the approved report including any council requested amendments, will be referred to in future.

Once a development application is approved council is permitted to use the model for incorporation into its overall city water and sewer models to inform its infrastructure planning.

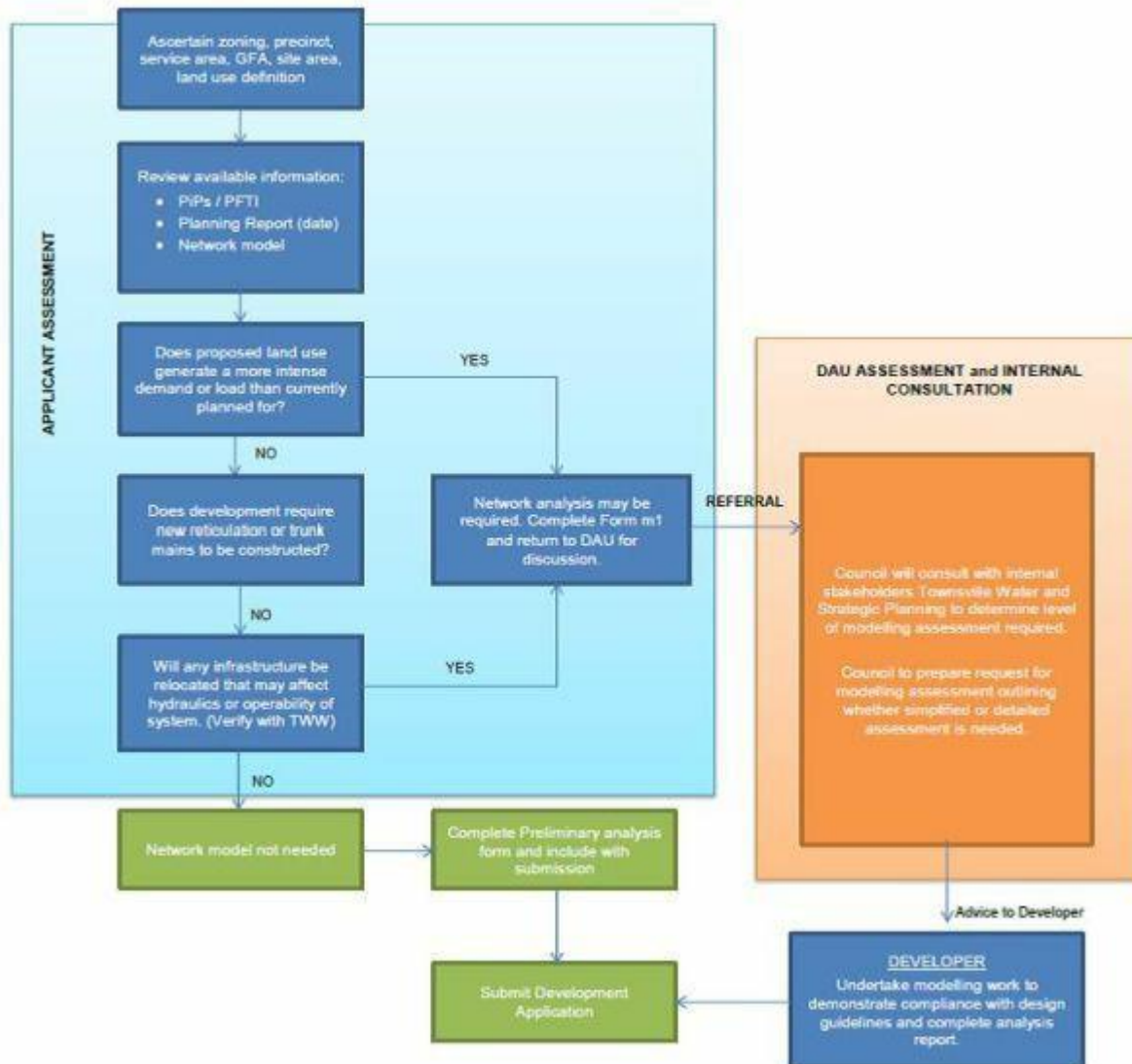


Figure SC6.4.3.23.1 Network model needs analysis, assessment and consultation process

Attachment B Preliminary needs analysis

Click here to obtain a copy of the following form.

Attachment C Form: Request for network modelling information

Click here to obtain a copy of the following form.

Attachment D Model setup summary

Click here to obtain a copy of the following form.

Attachment E Model submission checklist (water and sewer)

Click here to obtain a copy of the following form.