5.0 INFRASTRUCTURE REQUIREMENTS

5.1 RECONFIGURING A LOT

5.1.1 General

Provision should be made within subdivisions for roof and surface water to be satisfactorily discharged. Whilst in most cases piping to the street or to an underground pipe system may be the best solution, the applicant should nevertheless consider alternative ecologically sustainable solutions outlined in Section 4.

5.1.2 Low Density Residential Areas

Lots falling to the street

In residential streets, an approved full height kerb adaptor should be provided in the kerb, 400 mm from the projected low side boundary for each lot. In collector roads or in streets where footpaths will be constructed, kerb adaptors as per above with a length of UPVC pipe (sewer class SN8) extended from the adaptor to beyond the concrete footpath is required as per Standard Drawing UMS 354.

Lots falling away from the street

All lots that do not fall directly towards the road should be provided with a rear allotment roofwater drainage system. This system will also be required where lots fall towards parkland. Roofwater drainage systems will be classified as private drains with the responsibility for future maintenance lying with the property owners. This system is detailed in Standard Drawing UMS 351.

Easements in favour of Council will be required over roofwater lines as shown in Table B2.4. An easement is required irrespective of pipe size when the roofwater line is designed for more than 3 lots. Refer Section 2.4 - Easements. The pipes at each property may be sized in accordance with *QUDM* assuming 10 L/s for each 180 m^2 of roof.

TABLE B2.4 EASEMENTS OVER ROOFWATER LINES

No. of lots (nominal 180 m^2 roof area at each lot)	Minimum pipe diameter	Easement width	Minimum pipe slope
1-3	150 mm	Not required	1.0%
4-6	225 mm	1.5 m	0.5%
7-10	300 mm	1.5 m	0.5%

Roofwater inspection pits

Roofwater inspection pits should be in accordance with Standard Drawing UMS 352. Roofwater pits/rnanholes should be provided every 100 m and/or at changes in pipe sizes and/or where direction changes more than 15° and/or where the line terminates.

Connection points

At least one connection point should be provided on the main line for each property. This connection should be in the form of Y-junctions or directly into an inspection manhole with the property branch line diameter being a minimum of 100 mm. Engineering drawings should have dimensions to show the exact location of the connection points.

Discharge points

Generally, all rear of allotment (roofwater) drainage reticulation systems of this nature should discharge into the back of a suitably located stormwater gully or manhole in the street. Where the private roofwater reticulation system outlet is so isolated from a stormwater gully or manhole that connection is not reasonable, discharge may be allowed into the kerb and channel from an inspection manhole or inspection opening located 0.6 m maximum inside the property.

The maximum permissible discharge to the kerb and channel should be limited to 30 L/s (ie maximum 3 single house lots), and twin 100 mm diameter pipes (equivalent 150 mm diameter) with approved kerb adaptors should be used. Unless approved otherwise by Council Delegate, discharge into the high side kerb of a one-way crossfall street is generally not permitted. Consideration will only apply to single house roofwater drains.

Kerb adaptors

Only approved full height kerb adaptors, complying with *Reference Specification S150 Roadworks*, are permitted in Brisbane City. The Class C (medium duty) kerb adaptors should be used in local access and neighbourhood access roads, and the Class D (heavy duty) kerb adaptors used on industrial access and higher order hierarchy roads. The kerb adaptors should be placed in a location where service pits on the footpath will not conflict with the future pipe location.

Where hot dipped galvanised RHS is used as an alternative to prefabricated kerb adaptors, the ends of the section protruding through the kerb should be cut flush with the face of the kerb and treated with an appropriate corrosion treatment.

5.1.3 Industrial/ Commercial/ High Density Residential Areas

The level IV drainage connection requires the provision of a minimum 600 mm diameter inspection manhole (refer Standard Drawing UMS 353) inside the lot at the low side boundary, with a minimum 375 mm diameter pipe connecting to a suitably located stormwater gully or manhole in the trunk drainage network. All lots that do not fall directly towards the road should be provided with a rear allotment drainage system that discharges into the back of a suitably located stormwater gully or manhole in the street.

5.2 MATERIAL CHANGE OF USE

5.2.1 General

Scope

Developments pertaining to material change of use include Community Titles Scheme, commercial and industrial developments.

Driveway grids

The use of collection grids across driveways at the property boundary is not permitted unless approved by Council Delegate. (Driveway grids usually require high maintenance. The inevitable lapses in maintenance can lead to potential blockage, which may cause inconvenience to road users during a heavy storm.) Wherever possible, the paved area should be shaped in such a manner so as to divert the runoff towards grated field inlets. If driveway grids are used, these must be bolted down.

Connection to kerb and channel

Level III drainage (connection to kerb and channel) is only permitted if the total discharge from the development including any external catchment does not exceed 30 L/s. Full height kerb adaptors in accordance with Section 5.1.2 should be provided where practicable. Alternatively, multiple hot dip galvanised rectangular hollow sections (RHS) 125/150/200 mm wide x 75 mm high can be used. In multi-unit residential developments, circular pipes may be used only if there is sufficient depth of cover and depth of kerb and if approved by Council Delegate.

Pipe size and type

The minimum pipe size for internal underground site drainage is 150 mm nominal diameter. Where the pipe also conveys stormwater from an adjoining upstream property (now or in future), the minimum pipe size is 225 mm diameter.

The pipe types and classes should comply with the following requirements.

- Domestic applications (low density residential) should be in accordance with *AS 1254 - UPVC Pipes and Fittings for Stormwater and Surface Water Applications*.
- Commercial, industrial, medium and high density residential applications should be in accordance with *AS 1260 – PVC Pipes and Fittings for Drain, Waste and Vent Applications*. The minimum pipe class is UPVC sewer class SN6.

Pipe drainage systems

Where the existing underground pipes that service the external catchments traverse the site, these pipes must be preserved from damage or structural loading (refer Section 2.6). In the absence of an Infrastructure Charges Plan that specifies the development contribution for stormwater facilities and where the existing drainage system is inadequate, the Developer is generally responsible for upgrading the pipe drainage to the appropriate design standard in accordance with these Guidelines. Easements will be required in accordance with Section 2.4. In all cases where there is developable land upstream of the site, the development must provide a suitable drainage inlet for future upstream developments and consider these fully developed catchment flows in their design. Further cut-off drains and the like should be provided to prevent overland flow from adjacent properties causing problems on the developed land.

Localised overland flow paths

All developments must provide an overland flow path for the Q_{50} design storm less the piped flow. Refer Section 5.3 for design limitations. In residential developments where the difference in levels of the dwelling adjacent to the local overland flow path is minimal, calculations must be provided to demonstrate that the habitable floor levels have the required immunity.

The development must not cause ponding of stormwater or nuisance from discharge of stormwater on adjoining properties. Filling, retaining walls, buildings, fences, or other obstructions should not block overland flow. Furthermore these obstructions must not cause the overland flow to be diverted to, or concentrated onto, another property.

Channels and watercourses

If open cut channels and natural watercourses are permitted within the site, easements including access areas adjacent to the channel will be required.

5.2.2 Roof and Surface Water Hydraulic Requirements

Development of a site requires the design and construction of a drainage system to collect roofwater and surface water runoff from within the site and runoff from external catchments traversing or concentrated on the site, and to discharge the water to a lawful point of discharge. Even though the focus of this section is on the conventional underground pipe drainage system, the alternative water sensitive urban design techniques should be considered.

Pipe drainage of on-site roofwater and surface water from paved and unpaved areas should comply with *AS 3500.3*, *QUDM* Section 5.13 Level III, IV and V, and Standard Drawing UMS 353. Pipes should be located clear of any driveways and should not cross footpaths in front of adjoining properties.

The internal pipe drainage system is required to collect the discharge from individual roofwater systems and from the paved common areas, including internal roads and parking bays. If the pipe drainage system collects only ‘internal’ runoff and roofwater, the system is a private drainline and is owned by the property owners. In these circumstances, no easements will be required. Where the underground drainage system collects water from an external road reserve, the drainline ownership should be formally transferred to Council and easements provided.

Provision must be made for the future orderly development of upstream properties with respect to pipe drainage. The need for future developments having to resort to pumping of stormwater to a discharge point rather than by gravitational drainage must be avoided. Pipe drainage must be installed to allow for the future connection by adjoining properties when they are developed, which, by virtue of topography and/or existing developments, should discharge stormwater by gravity feed through the subject site. This drain must be a minimum 225 mm diameter (300 mm diameter for industrial) running from the boundary to the discharge point and be covered by an easement, a minimum of 1.5 m wide, in favour of Council.

If drainage cannot be gained by a gravity system a pump will be required. Refer Section 2.5 - Pumped Stormwater Drainage.

5.3 OVERLAND FLOW PATHS

5.3.1 General

The *Brisbane City Plan* defines an overland flow path as:

- Where a piped drainage system exists, the path where floodwaters exceeding the capacity of the underground drainage system would flow.
- Where no piped drainage system or other form of defined watercourse exists, the path taken by surface runoff from higher parts of the catchment. This does not include a watercourse or gully with well defined banks.

Any proposed development, especially those involving filling, needs to take account of existing or created overland flow paths and make due provision in the design. Overland flow paths must be clearly indicated on the drawings.

Developments within any overland flow paths are generally not permitted unless the applicant can satisfactorily demonstrate compliance with all the flood immunity and trafficability requirements set out in Chapter 1 of Part A of this document.

In residential subdivisions, overland flow paths must be located in roadways, parks or pathways and not through private allotments. Details and calculations are required when overland flow within the road reserve is directed into narrow pedestrian pathways. Calculations should demonstrate that overland flow does not enter the adjacent blocks during the 50y ARI flow.

Council will not permit substantial blockage (eg by filling or erection of buildings and retaining walls) of overland flow paths to be offset by the provision of an underground drainage system to convey major overland flows. This alternative is unacceptable for the following reasons:

- Additional maintenance costs to Council.
- Loss of storage.
- Potential adverse flooding impacts in extreme storms.
- Safety hazards at inlets and outlets.
- Major adverse flooding impacts when inlets are blocked.

Drainage calculations, cross sections and plan layouts, should be provided for any proposed overland flow path. The Consultant must ensure that the as constructed levels are consistent with those shown on the approved engineering drawings.

In site developments such as apartment buildings or townhouses where the sites are filled to provide suitable falls to the roadway, the Developer must pay particular attention to the preservation of existing overland flow paths, the obstruction of which may cause flooding or ponding of stormwater on adjoining properties. Particular attention must also be given to overland flow in many of the older inner city areas, as the underground drainage may not meet current standards and there is the likelihood of substantial overland flow paths being associated with the route of the pipe drains through properties. Overland flow paths should be located along the driveways (usually applies to built up inner city areas) and protected by an easement.

Special attention should also be paid to localised overland flow and site drainage in small lot subdivisions or where 'built to the boundary' building envelopes will apply. Additional pipe drainage, easements and concrete lined drains may be required along the rear boundary in such situations.

In all circumstances, easements will be required for overland flow paths within private properties. Proposed easements for the design overland flow should be shown on the engineering drawings. Refer also Section 2.4 - Easements.

5.3.2 Design Criteria

Overland flow paths not in designated channels (channels usually have clearly defined bed and banks) must conform to the following requirements for the 50 year ARI design storm event.

- A depth velocity product of no greater than 0.6 m^2/s (0.4 m^2/s applies to high risk areas where there is an obvious likelihood of injury or loss of life).
- A maximum depth of 0.3 m applies to vehicular accommodation (limited to uncovered short term car parking bays or unclosed car parking associated with a house) and access areas.

Development levels of residential properties must be set using a Manning's 'n' of 0.10 to take into account of any future planting and garden beds that may occur, ancillary structures (eg fences, sheds) that may be erected, and any other obstructions that cannot be regulated.

5.4 UNDERGROUND PIPE DRAINAGE

5.4.1 Pipes

≥ 375 mm diameter

All Council owned drains must be 375 mm diameter or greater. The following types of pipes, conforming to *Reference Specification S160 Drainage*, are acceptable to Council.

- Steel reinforced concrete pipes.
- Fibre reinforced pipes. These are preferred in situations where the pipe may be subject to tidal waters.
- Type B flexible pipes. Polypropylene/polyethylene pipes or fittings with plain inside surfaces and a solid or hollow helical or annular ribbed or corrugated external surfaces.

< 375 mm diameter

Generally pipes within these diameters are used as roofwater drainage pipes. Fibre reinforced concrete or UPVC (minimum sewer class SN6 should be used for inter-allotment roofwater drainage) pipes should be used. Galvanised steel RHS are required from development sites across the footpath to the kerb and channel, if permitted.

Pipe grade limits

The minimum grade of 1%, as specified in AS 3500.3 – Stormwater Drainage, will apply to pipes ≤150 mm diameter. The minimum grade of 0.5% will apply to pipes 225-300 mm diameter. The minimum grade of 0.3% will apply to pipes ≥375 mm diameter. For flow velocity and pipe grade limits, refer *QUDM* Sections 5.11 and 5.12.

CCTV inspection

A closed circuit television camera (CCTV) inspection is required shortly (no more than two weeks) before the On Maintenance inspection and prior to the formal acceptance of On Maintenance, to demonstrate that the standard of the constructed stormwater system is acceptable to Council. The CCTV inspection report and video must be viewed by an RPEQ prior to submission to Council. Any defects that require attention should be identified and remedial measures recommended by the RPEQ. Remedial measures for all defects identified must be submitted to Council for approval. Once the remedial measures have been completed, a follow up survey is required to demonstrate that they have been carried out to Council's satisfaction. Refer to Section 2.6.3 for more details.

Pipe cracking

During the 1994/95 and 1997 audits carried out by Council on a number of subdivisions, the problem of premature cracking of concrete stormwater pipes was found to be widespread in pipes smaller than 900 mm diameter. The major cause was attributed to pipe overload by construction equipment rather than typical service loads for which the pipes were designed. Compliance with all the following criteria is required to counteract premature pipe cracking.

1. The design and selection of the pipe type and class must consider construction loading (compaction equipment and construction traffic), which is usually the critical load case for pipes <900 mm diameter.
2. Drainage plans issued for construction must show, for each drainline, the following:
   - Pipe type and class.
   - Installation type.
   - Construction method (layer thickness, compaction plant).

   Design aids available from concrete pipe manufacturers may be used and are recommended. These include software for calculation of loads on pipes to *AS 3725*, tables and charts. It is recommended that charts showing the relationship between compaction equipment and pipe class are also included with the engineering drawings.
3. Delivered pipes and installed pipes must comply with the inspection and acceptability criteria detailed in *Reference Specification S160 Drainage*.
4. CCTV inspections.

5.4.2 Pipework Layout

Underground stormwater pipework layout should, in most cases, be the conventional herringbone layout.

5.4.3 Gully to Gully Drainlines/ Gully Manholes

In the gully to gully systems, pipes are connected between gully pits instead of manholes, with both the inlet and outlet pipes connected to the gully pit walls. (Note: The conventional gully pit has only the outlet pipe connection to the main trunk drainage line). Refer Figure B2.2.

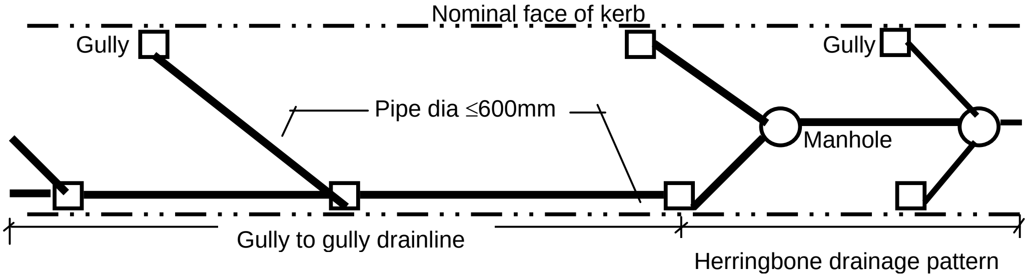

FIGURE B2.2
TYPICAL GULLY LAYOUT

Gully to gully drainlines are acceptable for pipes 600 mm diameter or less, provided that all the following Council requirements are satisfied.

1. Gullies are consistent with Council's standard drawings.
2. Acute angles in connecting pipes are avoided to minimise head losses.
3. Potential interference with other utility services on the footpath is avoided.
4. The major drainage line (spine) of the gully to gully system is constructed on one side of the road only. Any gullies on the opposite side of the road should be connected directly across the road. Under no circumstances are spines of gully to gully systems permitted on both sides of the road.
5. The gully pit is appropriately benched.

Gully manholes in Brisbane City are not permitted without written approval from the Principal Engineer Strategic Infrastructure Management. The stringent approval process ensures that Council's performance and maintenance objectives are met to maximise the serviceability of the asset, and to achieve sustainable level of ongoing maintenance and replacement program by using standardised components to the maximum practicable extent.

Gully manholes may be approved subject to compliance with all the following criteria.

1. The inlet and manhole is at the same point eg at the sag of the road.
2. It is the only alternative to a multi-grated inlet eg in relief drainage works where utility services locations pose major constraints.
3. Written advice from the responsible utility authority is submitted, stating that the existing services will preclude the construction of the conventional herringbone drainage pattern.
4. Council's standard components such as lintels and grates should be used wherever possible. Hydraulic analysis and structural testing data should accompany any request for approval to use alternative components.

5.4.4 Manholes/ Chambers

Manholes and chambers must be provided in accordance with Standard Drawings UMS 321 to UMS 329. Fixed ladder access in accordance with *AS 1657* must be installed to manholes/chambers >3.0 m deep. Step irons must be installed to manholes/chambers with depths between 1.35 m and 3.0 m.

Unless approved otherwise by Council, the desirable minimum and maximum manhole depths should be limited to 1.2 m and 3.0 m respectively. The nominated maximum depth of 3.0 m is based on the upper physical limit of undertaking an inspection without entering the manhole, as any person entering a manhole must conform to safe working procedures for confined space. Other workplace health and safety provisions that may apply to deep manholes include intermediate landing and ladder cage requirements.

The minimum distance between inlet pipes into a manhole or chamber is 150 mm. Benching is required on the floor of manholes (usually half the diameter of the outlet pipe) in order to properly direct the flow of water and prevent silt build up in the corners.

Precast manholes from an approved supplier may be used provided they are installed in accordance with the manufacturer's recommendations. The access hole diameter must conform to Council's standards. Chambers will require certification by a Registered Professional Engineer Queensland (RPEQ).

5.4.5 Inlets/ Outlets

Inlets and outlets should be provided generally in accordance with Standard Drawings UMS 341 and UMS 342. Where safety is an issue precautionary measures must be incorporated. Pillar inlets will be required as temporary inlets at stage boundaries. Special consideration is necessary at inlets and outlets to ensure all measures are taken to produce structures that are safe, with low maintenance and fitting in with the amenity of the area. Reference should also be made to the publication *Stormwater Outlets in Parks and Waterways Guidelines* (Brisbane City Council, 2003) for design guidance.

5.4.6 Gullies/ Field Inlets

Field inlets (Standard Drawing UMS 337) are usually constructed using standard gully grates or headwalls with a concrete apron surround. The size of field inlets must be designed with an expected 50% blockage. Special consideration will be necessary in regard to safety, maintenance and amenity of the area. A raised grated inlet with a lock down grate may be used where debris is expected. However, raised horizontal screens are generally not acceptable adjacent footpaths, bikeways or public accessible areas.

Standard gullies must not be located on sharp horizontal curves (≤10 m kerb radius). New gullies must be constructed in accordance with Standard Drawing UMS 330. The lip in line gully offers improved bike-safe feature and rideability, reduced maintenance costs, hydraulic efficiencies in most applications, and ease in pavement construction. Lip in line gullies are generally undesirable in areas subject to high pedestrian traffic (eg bus stops, taxi ranks, passenger set down zones, shop fronts, etc) unless appropriate measures are implemented (eg landscaping and installing street furniture on the verge) to restrict public access to the gully. The use of kerb in line gullies (Standard Drawing UMS 331) must be limited to established areas where the existing verge widths are narrow (generally less than 2 m) or where pedestrian impacts cannot be managed in a satisfactory manner.

Special attention must be considered at turnouts, to ensure the gully is not required in the turnout. The depth to the pipe crown at the gully pit must be a minimum of 0.45 m, noting that this dimension is not the minimum cover required for construction and service loadings to the pipe. Unless approved otherwise by Council, the desirable maximum gully depth must be limited to 1.35 m to enable safe maintenance access without the aid of step irons.

Antiponding gullies in accordance with Standard Drawings UMS 334 and UMS 335 are only permitted in special circumstances at intersections when the road geometry does not allow the kerb and channel to drain to the standard gully at the tangent points. The inlet capacities of these gullies must be excluded from the calculations.

Precast gully tops from an approved supplier may be used provided they are installed in accordance with the manufacturer's recommendations.

5.5 SURFACE DRAINAGE

5.5.1 Overland Flow Paths

Overland flow paths will need to be designed considering the following points:

- Depth by velocity product and maximum flow depth should not exceed the specified values in Section 5.3.
- The surfacing should prevent erosion.
- The ongoing functionality should not be affected.
- The amenity of the area should not be affected.

In new subdivisions, overland flow paths are not permitted through private property and must be restricted to parks or road reserves or pathways. Overland flow paths within parks must be designed to ensure safety, useability for park purposes when dry, high visual quality, and ease of maintenance.

5.5.2 Table Drains

Table drains are generally only permitted in the road reserve for rural locations and when a new half road is constructed. In these instances, table drains are required to manage the road runoff in the absence of kerbs and channels. Table drains must be separated from the carriageway by regularly spaced delineator posts. To prevent erosion and to minimise maintenance, table drains must be free draining and designed in accordance with the *Table Drains Erosion Control Guidelines* (Brisbane City Council, January 2001).

5.5.3 Swales

These drainage structures are used to collect and improve the water quality of runoff. Care needs to be taken that collected water is not directed in a concentrated form onto adjoining properties. The long term functionality of the device must be considered. Refer to publication *Water Sensitive Urban Design Engineering Guidelines: Stormwater* (Brisbane City Council, August 2005) for details on design principles and application.

5.6 OPEN CHANNELS

5.6.1 General

Designed open channels should not only satisfy hydraulic requirements, but also to enhance the environmental and amenity aspects of the area. In addition to the design requirements set out in Section 8.00 of *QUDM*, the following requirements of Sections 5.6.2, 5.6.3 and 5.6.4 will also apply. The preferred treatment for open channels should be in accordance with the publication *Natural Channel Design Guidelines* (Brisbane City Council, 2003).

CHAPTER 2 STORMWATER DRAINAGE

5.6.2 Types of Designed Open Channels

The Stormwater Management Code of the *Brisbane City Plan* promotes the use of natural channel design and water sensitive urban design principles (refer Section 4.4). Alternative treatments of channels should be considered and discussed with Council Delegate prior to commencement of design.

Where grass lined channels are proposed the aesthetic value of these channels should be enhanced by the liberal inclusion of native canopy trees. The tree species and planting density should be selected to enable:

- Easy maintenance (mowing).
- Sufficient light penetration to not only sustain the grass cover but also minimises weed growth.

The hydraulic conveyance of a drain under major flows should be designed to include the impacts of long term vegetal growth. The possible effects of scouring at the grass/concrete interface as indicated in *QUDM* should be assessed and works to overcome any problems should be incorporated in the proposal. The use of linear wetlands and off-line wetlands whilst encouraged, needs to be agreed to by Council Delegate. Care should be taken to ensure that the wetlands do not continually run dry.

5.6.3 Manning's Roughness Coefficients

Manning's 'n' for a grassed open channel is determined by a number of factors including vegetal retardance and hydraulic radius. The table and charts set out in *QUDM* Section 8.04 provide sufficient correlation to determine Manning's n for most developments.

Council's minimum landscaping requirements for open channels dictates a minimum Manning's 'n' of 0.08 although greater values may be directed by Council where deemed appropriate. A sensitivity analysis should always be undertaken for a Manning's 'n' of 0.15 to ensure the freeboard is not exceeded in a design.

Table B2.5 provides a semi-quantitative approach towards the evaluation of various Manning's roughness coefficients. Source reference: *Natural Channel Design Guidelines* (Brisbane City Council, 2003).

TABLE B2.5 FLOODPLAIN REVEGETATION DENSITY GUIDELINES FOR VARIOUS MANNING'S ROUGHNESS VALUES

Manning's 'n'	Description
0.03	Short grass with the water depth >> grass height.
0.04	Short grass with the water depth >> grass height on a slightly irregular earth surface. Trees at 10 m spacing and areas are easy to mow.
0.05	Long grass on an irregular (bumpy) surface with few trees and irregular ground could make grass cutting difficult. Alternatively, trees at 8 m spacing on an even, well grassed surface, no shrubs, no low branches.
0.06	Long grass, trees at 6 m spacing, few shrubs. Easy to walk through vegetation. Area not mowed, but regular maintenance is required to remove weeds and debris.
0.07	Trees at 5 m spacing, no low branches, few shrubs, walking may be difficult in some areas.
0.08	Trees at 4 m spacing, some low branches, few shrubs, few restrictions to walking.
0.09	Trees at 3 m spacing, weeds and long grasses may exist in some locations. Walking becomes difficult due to fallen branches and woody debris.
0.10	Trees at 2 m spacing, low branches, regular shrubs, no vines. Canopy cover possibly shades weeds and it is difficult to walk through.
0.12	Trees at 1.5 m spacing with some low branches, a few shrubs. Slow to walk through.
0.15	Trees and shrubs at 1 m spacing, some vines, low branches, fallen trees, difficult and slow to walk through. Alternatively, a continuous coverage of woody weeds with sparse leaves and no vines.
0.20	Trees and shrubs at 1 m spacing plus thick vine cover at flood level and fallen trees, very difficult to walk through. Alternatively, a continuous coverage of healthy shrubs and woody weeds from ground level to above flood level.

5.6.4 Hydraulic Considerations

All hydrologic and hydraulic calculations for major watercourses or creeks for the purpose of determining ultimate flood levels and development fill and flood levels are based on:

- Q_{100} flows for a fully developed catchment. The effects of lesser flows should also be investigated.
- A fully vegetated waterway corridor using a Manning's n of 0.15, unless the scope of full revegetation is not possible due to an unacceptable increase in flood levels. The restricted revegetation areas are usually identified in available Council studies such as the Stormwater Management Plans, Waterway Management Plans, and Flood Studies. In general, the planting of trees and shrubs impedes the passage of flow, thereby leading to increased flood levels. The high vegetal roughness coefficient allows for generally unrestricted planting of vegetation.

The proposed development should not cause any adverse flooding, nor make matters worse with respect to flooding of developed or developable areas, erosion potential, or the general amenity of the area. The Developer should not assume that the downstream drainage will be upgraded at a future date thereby allowing its proposal to be of a lower standard. Developers cannot rely on future maintenance by Council to support a proposal.

5.6.5 Velocity

An open channel with critical or supercritical conditions is not acceptable. The velocity should be limited to less than 90% critical velocity in the major storm event. The maximum velocity allowed in an unlined channel is set out in *QUDM* Section 8.07 for earth and vegetated channels and should not exceed 2 m/s unless approved by Council Delegate.

The velocity used to determine the time of concentration for the designed channel should not be less than the velocity in the design channel or alternatively, an average value of 2 m/s is adopted. Unless the actual velocity in drainage system upstream is determined, the adopted pipe velocity should not be less than 3 m/s.

Channel velocity checks should assume that downstream undersized culverts will be upgraded to current design standards at some time in the future. The afflux caused by any roadway crossing over a watercourse should not affect the adjoining properties.

5.6.6 Freeboard

Refer flood immunity levels specified in Chapter 1 of Part A of this document and *QUDM* Section 8.03.

5.6.7 Batters, Landscaping and Maintenance Access

The side slope of the channel banks should not be steeper than 1V:4H (vegetated) and the preferred side slope is 1V:6H (grassed or vegetated). Boulders can be provided intermittently in localised areas to improve the aesthetic appearance of the channel.

Landscaping of the open channel is very important from a visual amenity perspective and future maintenance. The Developer should submit landscape plans prior to hydraulic calculations commencing so that Council is satisfied that the channel will be a feature and not merely ‘a drain’. The preferred treatment for designed open channels should be in accordance with the publication *Natural Channel Design Guidelines* (Brisbane City Council, 2003).

Berms of 6.0 m (minimum) should be provided along each side of the open channel for maintenance, environmental and recreational purposes. Access locations to potential trouble spots within the channel should also be provided.

5.6.8 Minimum Longitudinal Grades

If a channel is proposed in a low lying drainage problem area where grades are relatively flat (minimum velocity 0.6 m/s), the submission must consider the sensitivity of the proposed waterway/channel to siltation which may cause eventual flooding of surrounding land. The hydraulic analysis must include the effects of siltation in the order of 150 mm having been deposited. The provision of a concrete invert and access to facilitate the removal of sediment must be considered. A further consideration is the provision of silt traps at the head of the drain to minimise the environmental effect of silt removal along the full drain lengths.

5.6.9 Outfalls and Outlets

Pipe drainage outfalls to open channels and natural creeks must be designed to control the discharge velocity to spread the concentrated discharge to avoid erosion to the bed and banks and to enhance the water quality by stripping contaminants. Plunge pools are more desirable at outlets on environmental and aesthetic grounds. Outlet diffusers must be set back into the creek bank to allow for future migration or erosion of the creek. Similarly manholes must not be located on the assumption that the creek morphology is stable. Reference should also be made to the publication *Stormwater Outlets in Parks and Waterways Guidelines* (Brisbane City Council, 2003) for design guidance.

5.6.10 Energy Dissipators

Energy dissipators to control the outlet velocity should be designed using a recognised design practice and supported with calculations and references to the chosen design method. Generally plunge pools with rock bottoms are preferred over baffle blocks, as the latter may pose a safety hazard if any children are trapped in the stormwater drain during a storm.

Energy dissipators should be free draining. Designs based upon downstream ponding are not generally recommended; however, such design will be considered if health and maintenance aspects have been adequately addressed. Debris collection around baffle blocks should be a design consideration. It should be noted that wide baffle blocks would trap less debris than narrow blocks.

The spacing between blocks transverse to the flow should be designed to suit individual site conditions. Spacing between transverse blocks would normally be at least 1.5 times the block width, the spacing between consecutive baffle blocks parallel to the direction of flow being at least 4 times the block height if fully drowned conditions are assumed to occur around the blocks.

Energy dissipators, outlets and drop structures etc, when located in parkland, should address aesthetics, maintenance and safety issues. Refer the publication *Stormwater Outlets in Parks and Waterways Guidelines* (Brisbane City Council, 2003) for further details.

5.6.11 Drop Structures

Drop structures may be divided into two categories (ie high drop when the depth of flow < drop height or low drop when the depth of flow > drop height). Generally drop structures should be avoided where environmental concerns are an issue, for example, where aquatic life, migratory routes, and faunal corridors are to be maintained within a creek. Drop structures should also be avoided wherever possible for safety reasons.

There is only a limited amount of literature available for the design of drop structures and generally this literature is restricted to the design of drops in rectangular channels. The use of trapezoidal or irregular shaped channels can introduce a three-dimensional flow pattern if the approach flow is allowed to accelerate toward the drop. Experience has shown that this flow pattern can significantly reduce the efficiency of the downstream hydraulic jump, resulting in a submerged jet that is unable to be modelled by simple hydraulic calculations.

It should therefore not be assumed that a hydraulic jump would occur downstream of a non-rectangular drop structure. Similarly it should not be assumed that uniform flow conditions exist near any drop structure. Fully drowned drop structures can be analysed by a simple backwater analysis using appropriate expansion/contraction loss coefficients and representative cross sections.

Guidelines (if applicable) for the design of drop structures can be obtained from the following references:

- Brisbane City Council, 2004, *Erosion Treatments for Urban Creek Guidelines*.
- *Urban Storm Drainage - Criteria Manual Vol. 2*. Denver Regional Council of Governments Ed. Wright - McLaughlin Engineers, March 1969.
- *Training Workshop on Integrated Urban Stormwater Management Vol 3,* AWWA Canberra Branch and Hydrological Society, Canberra Ed. Brett C. Phillips.
- Peterka, A.J. 1984, *Hydraulic Design of Stilling Basins and Energy Dissipaters*, U.S. Department of the Interior Bureau of Reclamation Engineering Nomograph No. 25, Washington, U.S.A.
- *Water Under the Bridge - Aspects of Culvert Design - Part 1*. G.M. Witheridge, R. Tomlinson.
- *Drop Structure Design Problems*. G.M. Witheridge.

Where several drop structures are required to descend a steep grade reference should be made to the design of stepped spillways. A suitable reference being:

- *Hydraulic Design of Stepped Spillways*. CIRIA Report 33 I.T.S. Essery and M.W. Horner

Council preference is that drop structures be cast in situ reinforced concrete or natural rocks. Rock filled mattress type protective works has created maintenance problems in the past and are only to be considered under special circumstances.

5.6.12 Service Crossings above Channel Bed

Isolated service pipe crossings located above the bed are not allowed where such a structure will affect visual amenity. If Council is satisfied that visual amenity is not compromised, afflux from the structure should not exceed 150 mm and is contained within the site area. It is preferable that the level of the crossing be as low as possible or above the flood level. The crossing should be designed to avoid debris collection and to take account of scour at the bank entry or in the bed below the pipe.

5.6.13 Service Crossings below Channel Bed

Pipe crossings which are located below the bed of an unlined channel should have at least one metre clear cover or additional scour protection may need to be provided along the open channel in the vicinity of a pipe crossing. If mitigation works have already been undertaken on the watercourse or if the channel is in a stable condition, this requirement may be relaxed at the discretion of Council Delegate, provided appropriate protection works are undertaken. The Consultant's submission should include a plan and cross section of the proposed works and a longitudinal section of the bed.

5.6.14 Erosion Control

The possible effects of scouring at the interface of lined and unlined sections should also be incorporated to the proposal. For more information about erosion and sediment control in general, refer to Part C - Water Quality Management Guidelines, of this document.

5.7 FOULWATER LINES

Foulwater lines used to drain both the greywater and roofwater from properties. When the sewerage reticulation network in Brisbane was constructed, the greywater was redirected to sewer but the roofwater remained connected to the foulwater lines. However new stormwater connection to foulwater lines is not permitted, nor is it acceptable to assume that these lines are redundant. Therefore the proposed development should not damage these lines and any proposed diversion should connect to the stormwater system.

5.8 CONCRETE INVERT AT ROAD INTERSECTION

The use of concrete invert (generally along line of the through street) at any road intersection is not permitted. Instead the road geometry should be designed to accommodate an underground drainage system of gully pits/manholes and pipes as appropriate.

5.9 DETENTION AND RETENTION SYSTEMS

5.9.1 General

When a development is likely to increase runoff to such an extent that the downstream drainage cannot cater for the additional capacity or adverse impacts are created, it may become necessary to incorporate a detention basin. These basins can be either dry (detention basin) or wet (retention basin). Off-line basins can lessen the risk of a sequential over-topping. Both types may have multiple uses eg pollution control, environmental wetland, recreational, as well as hydraulic functions. Also refer Part C - Water Quality Management Guidelines, of this document. As a general rule, larger detention storage is usually required at the top one-third of the catchment, no detention storage is required at the bottom one-third of the catchment, and intermediate requirements at the middle part of the catchment.

A community-based asset (such as from a subdivision) must be located in Council owned or Council controlled land. Council approval of the location is required at the conceptual design stage.

Detention systems on private land (on-site stormwater detention systems) will only be permitted in developments pertaining to material change of use such as Community Titles Scheme, commercial and industrial developments. The registered proprietor(s) of the lot(s) is required to enter into a covenant pursuant to Section 97A of the land Title Act 1994, with Brisbane City Council as Covenantee, to ensure management of the on-site stormwater detention system is in accordance with the approved report and plans. (Note: A statutory covenant cannot deal with matters subject to an easement.)

Aboveground detention basins are preferred as it is considered that they are more readily maintained than underground storage facilities. Council will not support the installation of on-site underground detention facilities unless there is no alternative suitable above ground option, nor will Council support underground detention facilities on public land.

The floor of the detention basin should be well graded to prevent permanent ponding. A minimum grade of 0.7% applies to underground storage and paved areas, and a grade of 1.5% to landscaped areas.

5.9.2 Data Requirements

The detailed design submission must be prepared and certified by an RPEQ suitably qualified in the field of drainage/hydraulic investigations. The following information must be included in the submission:

- Calculations for each storage.
- Where WSUD components are proposed, calculations and details of both the detention/retention system and WSUD components are required to demonstrate the interaction of the integrated system.
- Calculations verifying that the flow paths/floodways, drainage systems and any overflow weirs have sufficient capacity.
- Design plans (refer Section 2.11 of Chapter 2 of Part D of this document for details).
- Maintenance plan (refer Section 5.9.12 below).

5.9.3 Design Approach

The design of retention/detention basins should be undertaken in accordance with *QUDM* Section 6, unless the specific requirements of this chapter or other Council references dictate otherwise.

5.9.4 Sizing

Runoff routing and reservoir (basin) routing calculations are required to estimate the size of the detention basin, where the inflow and outflow hydrographs for a range of storm duration for the design ARI events are determined. Initial sizing may be undertaken, using manual techniques, in order to determine the order of magnitude of the storage required. However the final sizing should be completed with the aid of computer models such as DRAINS (ILSAX), RAFTS, or RORB.

In addition to local catchment analysis, the assessment should also demonstrate that the detention basin proposal is sustainable on a catchment wide basis. Where the detention storage has limited outlet capacity, the impact of antecedent rain on the available storage should be considered. Antecedent conditions should be based on the actual rainfall records from the closest meteorological station. Where required, Council can provide information on these ‘duration independent storms’.

5.9.5 Overland Flows

Overland flows that enter the site from surrounding properties should be collected and conveyed through the development, but kept isolated from the any on-site detention basin systems for all storm events.

5.9.6 Hydraulic Control

On-site detention should be gravity drained. Pumped systems are not permitted. However alternatives such as suspended pipelines and recycled stormwater would be considered, but the onus is on the designer to provide details on permanency of construction, reliability of performance and suitable aesthetic treatment.

An important element in preserving the integrity of on-site detention system is ensuring that the system functions independently of the street drainage network. The on-site facility is not intended to handle surcharge flow from the street drainage network. Due to the possibility that the street system could surcharge, the starting hydraulic grade line level of the detention system should be set at the top of the kerb and channel at the discharge point to the street system. The outlet control device should be set above this level regardless whether the detention system is connected to the underground drainage system or to the kerb and channel, to ensure that the on-site facility is unaffected by downstream hydraulic grade line or water surface levels.

5.9.7 Visual Aesthetics

Once authorised to have a basin in parkland or other Council controlled land, an important design criterion is that the basin does not look like a hydraulic structure but rather has special character. This will involve the use of variable slopes, the retention of upstream gullies, the camouflage of inlets and outlet structures and the like. A rectangular or geometrically shaped basin is generally undesirable. Landscape plans must be lodged for approval.

Detention storage in open space areas within a development must not be visually intrusive but incorporate a variety of plant species. The facility must not be located in the front yard unless it is a visual feature. The maximum height difference between the natural ground level and the basin invert must be limited to 0.5 m.

5.9.8 Embankments

Grassed and landscaped embankments should not be steeper than 1V:6H and 1V:4H respectively. The selected use of boulder retaining walls is encouraged to provide variety. In some instances (eg occurrence of rapid drawdown), geotechnical investigations/designs may be required to assess the embankment stability.

5.9.9 Inlets and Outlets

General

Low-level outlet structures generally consist of orifice plates (fixed to pipe inlets) or culverts placed at a low level in the basin to cater for the discharge of normal outflows. The diameter of the low flow outlet pipes should not be less than 375 mm. High-level outlet structures should cater for the discharge of major or extreme outflows. Overflow weirs or spillways should be designed to convey the 100y ARI peak discharge, assuming that the basin storage is full and the low-level outlet(s) are blocked. The overspill should not inundate nor concentrate flows onto adjoining properties.

Discharge control pits

Discharge control pits should be located in a suitable position and designed to achieve the following performance characteristics.

- Minimise risk of debris blockage.
- Can be readily inspected.
- Can be accessed for cleaning.
- Minimise risk of vandalism.

The minimum pit size of 600 mm x 600 mm (to internal wall dimensions) should be restricted to a depth of less than 0.8 m. For pits exceeding 0.8 m depth, the minimum size should be 600 mm x 900 mm. Step irons are required for pits exceeding 1.35 m depth. Subsoil drainage should be provided around discharge pits in aboveground storage systems to prevent the ground from becoming saturated during prolonged wet weather.

A sump is required in the base of the discharge control pit to assist in minimising turbulence near the pit floor from affecting the hydraulic performance of the orifice outlet. The sump would also prevent silt and debris from blocking the orifice outlet and facilitate simple installation of the orifice plate. The invert of the sump should be at least 1.5 times the orifice diameter or 200 mm (whichever is greater) below the centre of the orifice outlet. Sufficient weepholes should be installed in the sump floor and be kept unblocked.

Orifice plates

Orifice plates should be manufactured from corrosion resistant stainless steel plate with a minimum thickness of 3 mm (5 mm where orifice diameter exceeds 150 mm), with a central circular hole machined to 0.5 mm accuracy. The orifice diameter should not less than 35 mm and the machined hole should retain a sharp edge. The plate should be permanently fixed to the pit wall and epoxy sealed to prevent the entrance of water around the edges. The plates should be engraved with the orifice diameter and an identifying mark, and the orifice diameters certified by the manufactures.

Grates and trash screens

The intake to a detention basin outlet should be protected against blockage and to reduce hazard for persons trapped in the basin during a storm. Inflows to the orifice should be screened.

Screening (hot dipped galvanised) should be provided at a rate of not less than 50 times the orifice diameter, and incorporate handle(s) for easy removal. Generally, galvanised Lysaght RH3030 Maximesh (or approved equivalent) with galvanised angle steel frame is suitable for use as an internal trash screen to small on-site detention basins. The screens should be fixed at least 150 mm from the orifice and positioned as close to vertical as possible. Pits up to 0.6 m depth should have screens no flatter than 45°. In pits over 0.6 m depth or in remote positions, the installation angle should be increased to 60°.

For aboveground detention storage, the grates should be set inconspicuously into the embankments of the basin. Vegetated screenings should be provided, but these should not affect the hydraulic performance of the inlet and outlet structures.

5.9.10 Underground Storage

Underground detention facilities are not preferred and may not be feasible in many areas of the City where the storage levels are below the controlling downstream hydraulic grade line. The design of underground detention storage should address a number of public health and pollution issues. The storage should be self-cleaning, well ventilated, does not cause accumulation of noxious gas, and facilitate easy maintenance and inspection. The following requirements should be met in order to achieve the performance objectives.

- The base has a suitable fall to the outlet (minimum grade 0.7%) and is appropriately shaped to prevent permanent ponding.
- Provision of a minimum 600 mm x 1000 mm maintenance access opening. The lifting weight of the grated lid should not exceed 20 kg.
- Installation of step irons to storage pits greater than 1.35 m depth.
- Where the storage is not sufficiently deep (< 1.2 m), access grates should be placed at the extremities of the tank and at intervals not exceeding 3 m. This should allow any point in the tank to be flushed or reached with a broom or similar implement, without the need to enter the tank.
- The minimum clearance height for accessible tanks is 1.2 m. Tanks less than 0.75 m high must be precast to avoid difficulties with removing formwork.
- To enable visual observation of the entire base of the storage pit, at least 30% of the roof surface area should be grated. Grates should be a minimum of 600 mm wide by 1000 mm long, and arranged in a continuous lengths along the storage pit. Both the access point and the grated areas should be secured to prevent public access.

5.9.11 Safety and Amenity

The danger to children moving in and out of the basin during times of inundation should be carefully considered. The outlet/inlet grates should be designed such that any child will be able to crawl away from the grate under all operating conditions. Dense landscaping can be used to deter access.

Sensitive signing should be erected at strategic locations alerting people to the possible hazards of the detention basins. Where detention basins are located directly upstream of a dedicated roadway or residential property, safety and damage consequences as a result of basin collapse or overtopping to the road users/residents should be carefully evaluated.

The maximum depths of ponding in the detention storage facility should be limited to minimise safety hazards and preserve amenity values.

- Public parkland: 20y ARI ponded depth of 1.2 m.
- Parking or paved areas: 50y ARI ponded depth of 0.3 m.
- Unfenced landscaped areas: 50y ARI ponded depth of 0.5 m.
- Underground storage: No depth limit.
- Fenced areas: No depth limit.
- Roof areas: Depth limit dictated by structural integrity or usage (such as rooftop car parking).

5.9.12 Maintenance Plan

All detention and retention systems must be designed with simple, safe, cost-effective maintenance in mind. A maintenance plan that documents all the maintenance requirements and responsibilities must be developed in parallel with the design process. The plan must set out how the system should be maintained by addressing issues such as inspection, likely clean-out frequency, procedures, access, occupational health and safety requirements, and likely annual maintenance costs.