STORMWATER DRAINAGE

1. GENERAL

This chapter addresses stormwater design for the development of land (principally as greenfield subdivision sites), and does not assume coincidental influence from Hunter River flooding beyond normal flow levels, nor addresses drainage structures which may be affected by flooding of the Hunter River. Drainage structures inundated by such flooding are not prohibited by this Manual, although particular requirements may apply.

Stormwater drainage systems shall be designed to achieve the following goals:-

- An underground “minor system” of conduits that eliminates inconvenience to traffic and pedestrians.
- An overland “major system” that conveys stormwater flows within suitable velocity/depth limits, generally located within public land, or where approved or unavoidable, within private land covered by an easement.
- Detention of stormwater flows that mimics natural, pre-developed flows for all storm events up to and including the 100 year ARI event.
- Retention of stormwater flows to achieve target water quality standards.
- Control of stormwater flows to minimise the impacts of erosion and sediment in the environment.
- Consideration of upstream and downstream catchments in their ultimate developed state to achieve a total system which does not adversely affect existing systems or properties within the flow path and catchment.
- Minimisation of the maintenance burden of Council
- Enhancement of the urban landscape.
- Employment of principles of Water Sensitive Urban Design and Stormwater Reuse.

2. DESIGN STANDARDS

Drainage design for roads, reserves and inter-allotment systems the subject of this chapter, shall adopt the principles of a major/minor drainage system in accordance with the publication Australian Rainfall and Runoff (AR&R) and Australian Runoff Quality (ARQ) and as specified in this Manual. Other accepted reference material may be used, with acknowledgement.

All calculations must be carried out by competent persons, qualified and experienced in hydrologic and hydraulic design, utilising drainage models that are accepted as current industry standards.

The requirements of Council’s Hunter River Floodplain Management DCP shall be observed for all developments.

3. HYDROLOGY

3.1. RAINFALL DATA

Design Intensity Frequency Duration (IFD) relationships shall be derived in accordance with Australian Rainfall and Runoff for the particular catchment. (See tables in appendix C)

MUSIC Input Parameters for the Maitland area are available from Council.

3.2. RECURRENCE INTERVAL

Minimum design Average Recurrence Intervals (ARI) for the major/minor systems are:-

MINOR SYSTEM AVERAGE RECURRENCE INTERVAL

MINOR SYSTEM	ARI (YRS)
Residential 'R1' & 'R5' (Streets and IAD)	10
Business 'B' & General Industrial 'IN' (Streets and IAD)	10
Public & Drainage Reserves (acting as flow paths)	10 (1)
Rural 'RU' - Longitudinal Drainage	5

MAJOR SYSTEM AVERAGE RECURRENCE INTERVAL

MAJOR SYSTEM	ARI (YRS)
Urban trunk drainage conduit at road crossing	20 min(2,3)
Rural – Low-point Culvert Crossings	20 (4)
Overland flow paths & trunk drainage	100
Structural adequacy of major drainage items	PMF (5)
Land depressions with no outlet	PMF

<u>Notes:</u>

(1) May be reduced (minimum being 2 year ARI) only in special circumstances, subject to specific design merits
(2) Freeboard at the road reserve may be ignored
(3) Depending on road hierarchy. Typically (subject to Council approval), Distributor Roads and higher should provide flood-free access up to the 100 year ARI. Lower order roads may be inundated, with a design aim to maintain at least single-lane traffic movement in the 100 year ARI event.
(4) Applies to minor roads. The 100 year ARI event shall be catered for, typically including a causeway with signposting and water depth markers.
(5) Probable Maximum Flood

As a first step approach, the designer should attempt to contain the whole of the major storm discharge within the road and footway cross section. (see AR&R technical note 5 & table 1.12). Where flow widths and depths within the road reserve are critical, the designer may provide for greater pipe capacity based on the inlet pit capacities with blockage factors applied.

Other than for large, or residue, lots with traversing natural gullies, potential for stormwater surcharge across private property will only be accepted if the piped system is designed for the 100-year ARI flows, with a 50% blockage factor applied for pit entry capacities. An emergency overland flow path, over or adjacent to the piped system, shall be provided, covered by an easement. The easement surface/shape shall be protected against alteration or by obstruction by a "restriction" on the property title.

Council may require that the design ARI's for the subject drainage system be varied in certain circumstances.

3.3. CATCHMENTS

The catchment at an outlet is defined as the limits from where surface water will make its way by either natural or man made features to this outlet.

Catchment area land-use shall be taken into consideration and be based upon current and possible future planning constraints and zonings. The ultimate developed state of each catchment shall be adopted. Notwithstanding the table below, in some areas Council may nominate design parameters regarding higher urban density uses.

Catchment plans showing the proposed pipeline layout shall be included in Engineering Design plans.

3.4. FRACTION IMPERVIOUS

Hydraulic calculations shall be based on the following fraction impervious figures:

FRACTION IMPERVIOUS RATES FOR LAND USES

LAND USE	FRACTION IMPERVIOUS
Residential Lot size < 1000m^2	0.6
Residential Lot size > 1000m^2	0.4
Road Reserve	0.7
Business Areas	1.0
Industrial Areas	0.9
Public Recreation Areas (mowed and with improvements)	0.5
Parkland, Natural Public Reserve	0.1

3.5. COEFFICIENT OF RUNOFF

Coefficients of runoff shall be determined in accordance with Australian Rainfall and Runoff. Full details of coefficients used shall be provided in the calculation documents.

Fraction impervious effects on the coefficient of runoff, "C", shall be consistent with the following table:

RUNOFF COEFFICIENTS

FRACTION IMPERVIOUS	C_1	C_5	C_{10}	C_{20}	C_{100}
0.0 - 0.1	0.35	0.41	0.43	0.46	0.52
0.2	0.39	0.46	0.49	0.51	0.58
0.3	0.43	0.51	0.54	0.56	0.65
0.4	0.47	0.56	0.59	0.62	0.71
0.5	0.51	0.61	0.64	0.67	0.77
0.6	0.55	0.66	0.69	0.73	0.83
0.7	0.60	0.71	0.74	0.78	0.89
0.8	0.64	0.76	0.80	0.84	0.96
0.9	0.68	0.81	0.85	0.89	1.00
1	0.72	0.86	0.90	0.95	1.00

3.6. PARTIAL AREA EFFECTS

Partial area effects shall be considered in the design process. In urban catchments this applies, for example, where large paved areas are directly connected to the pipe inlet, and the sub-catchment discharge is based on a larger pervious area. Similarly, partial area effects can also occur where a large open space catchment, contributes to an urban catchment, with a time of concentration substantially different to the urban catchment. Other factors of influence may be catchment shape, or variation in slope and land use within the catchment.

In areas where this is critical, such as industrial or high density residential development, a partial area check, based on times of concentration of impervious areas directly connected to the pipe system, is necessary.

3.7. RATIONAL METHOD

Rational method calculations to determine peak flows shall be carried out in accordance with Australian Rainfall and Runoff, utilising the Kinematic Wave equation or an appropriate computer programme. See Appendix C for an overland travel time aid derived from Technical Note 3 in Australian Rainfall and Runoff.

3.7.1. Time of Concentration

The time of concentration (tc) is the time required for storm runoff to flow from the most remote part of the catchment to the catchment outlet. The adopted time of concentration shall be for the ultimate developed catchment, catering for the greatest flow. Care should be exercised in adopting a time of concentration that is a reasonable estimation for the upper reaches of the drainage system within a developed catchment.

The general maximum time of concentration, in urban areas shall be 20 minutes, unless justification is provided to the contrary. The time of concentration in rural areas shall be calculated in accordance with Australian Rainfall and Runoff.

Where the flow path traverses areas having different flow characteristics or various surface types, the flow-time of each portion of the flow path shall be calculated separately.

3.7.2. Coefficient of Roughness

The surface roughness coefficient (n*) is similar to, but not identical with, Mannings "n" for open channel design. Whilst Australian Rainfall & Runoff provides typical values, Council's recommended values should be adopted from the table below.

ROUGHNESS COEFFICIENT

SURFACE TYPE	ROUGHNESS COEFFICIENT N*
Parks	0.35
Large-lot Residential R5 X-Z	0.35
Urban Residential R1 to R5-V	0.21
Industrial	0.06
Business	0.04
Asphalt	0.02
Concrete	0.01
Gravel	0.02

3.8. ALTERNATE HYDROLOGICAL MODELS

Alternate models may be utilised, providing the requirements of Australian Rainfall and Runoff are met. Summary of calculations shall be provided within Engineering plans. Where computer analyses are used, details of all programme input parameters and output data files shall be provided. The following DRAINS (or their equivalent) parameters shall be used:

MODELLING PARAMETERS

PARAMETER	VALUE
Soil Type	as reported
Antecedent Moisture Content	3
Grassed Depression storage	5mm
Paved Depression storage	1mm

4. HYDRAULICS

4.1. HYDRAULIC GRADE LINE

Hydraulic calculations shall substantiate the hydraulic grade line (HGL) adopted for the design of the system and shall be shown on the drawings.

Controls for a downstream hydraulic grade line design are as follows:-

- Hydraulic grade line levels based on downstream calculations including pit losses at the starting pit in the design event.
- If the downstream start point is an existing pit and the HGL is unknown, a level of 0.15 metres below the pit inlet in this pit shall be adopted.
- If the downstream start point is an outlet into an open channel and;

  i) the design storm is the minor event, the outlet pipe shall be the downstream control,

  ii) the design storm is the major event, and the design flood levels in the channel are unknown, the top of the outlet pipe shall be the control,

  iii) The flood levels are known, the control shall be the 100 year ARI flood level.

- Where appropriate the Hunter River Flood shall be considered as an outlet control.
- The HGL level in drainage pits shall be not higher than 150mm below the top of the inlet grate, gutter or lid.

4.2. UNDERGROUND DRAINAGE SYSTEM

Drainage systems shall generally be designed as gravity systems and as an overall pipe design having due regard to upstream and downstream systems.

4.2.1. Pipe Conduits

Minor drainage pipe/conduit systems shall conform to the following requirements:-

PIPED CONDUIT REQUIREMENTS

PARAMETER	REQUIREMENT
Minimum pipe size	375mm
Minimum box culvert size	600mm wide x 300mm high
Minimum flow velocity	0.6m/sec.
Maximum flow velocity	8.0m/sec (1)
Minimum pipe grade	0.5% (2)
Minimum pipe class	'2' normally, and '3' for road crossings (subject to cover)

Notes:

(1) Subject to scouring considerations and velocity/depth coefficient.
(2) Unless otherwise approved by Council.
(3) Pipe size reduction, from large upstream pipes to smaller downstream pipes is not permitted, unless approved by Council.

The designer shall nominate on the plans all specific pipe details and their alignment and level. All drainage pipes within Council controlled drainage systems shall be of steel reinforced concrete (SRC) or fibre reinforced concrete (FRC), rubber ringed jointed spigot and socket type. Concrete pipes shall comply with AS 4058 "Precast Pressure and Non-Pressure Pipes". The class of pipe proposed will be determined to suit the design-use and shall comply with the Concrete Pipe Association of Australia (CPAA) minimum cover or Australian Standard 3725 "Loads on Buried Pipes" requirements.

Conduits that will not be under Council ownership/control (such as IAD systems) may be, concrete (as detailed above), polyethylene, or UPVC complying with AS 1254 for un-plasticized PVC (UPVC), and PE & PP pipes.

Pipes should be provided with sufficient cover to avoid conflict with service conduits, to ensure adequate protection from damage during construction and, (at a minimum), to ensure that pipe collars do not protrude into the road pavement.

4.2.2. Box Conduits

Precast reinforced concrete box culverts (RCBC) shall comply with AS 1597. The minimum size shall be 300mm high by 600mm wide.

4.2.3. Pipeline Radii

The minimum radius on which pipes may be laid shall not exceed the manufacturer's recommendation. Where smaller radii are required, the designer should consider short pipe lengths, extended collars or alternative chord configuration.

4.3. TRENCH STOPS

Thrust blocks/collars shall be provided generally where pipe grades exceed 12% and/or in embankments for storing water, to prevent seepage piping.

4.4. PITS

4.4.1. Pit inlet capacity

Shall be provided to satisfy the chart attached at appendix C. Blockage factors of 0.5 (50% blocked) for sag and 0.8 (20% blocked) for on-grade pits shall apply.

4.4.2. Pit locations

shall be provided to:

- prevent ponding,
- allow change of alignment, grade or pipe size/number
- enable adequate vehicle entry points to lots. Preferably, pits should be located:
  i) in the central section of lot frontage in residential areas, and
  ii) at the high side of each lot in industrial areas, immediately downstream of the prolongation of the common side boundary, in order to provide direct discharge points for each individual lot, and/or IAD drainage systems
- prevent gutter flows crossing an intersection and/or a pram ramp
- limit flow widths to table below:

OVERLAND FLOW PARAMETERS

ROAD TYPE	CARRIAGEWAY WIDTH (M)	WIDTH OF FLOW (M)	DEPTH IN GUTTER (MM)
Local-Place & Minor	8	3.0	105
Local-Secondary & Primary	8	2.0	75
Collector-Primary & Secondary	8-11	2.0	75
Distributor-Secondary & Primary	14-15	2.5	100
Arterial or Sub Arterial	15.4	3.0	115
Rural Residential (R5-V)	7.5	2.5	90

Subject to the above table, the maximum recommended spacing of pits is:-

RECOMMENDED PIT SPACINGS

PIPE SIZE (MM)	SPACING (M)
Less than 1200	80
1200 or larger	100

4.4.3. Pit construction

Pit Construction shall conform to Council's standard drawings. Non- standard pits, greater than 2.5m high or 900 long, or 1450 wide and with oversized soffits, shall be designed by an engineer, and the details provided in Engineering design plans.

4.4.4. Extended Kerb Inlet (EKI)

Lintels shall have a desirable maximum nominal length of 3.6 metres and a minimum nominal length of 1.8 metres. The general maximum in industrial areas shall be 2.4m to avoid potential breakage due to heavy loads. Nominated kerb inlet length refers to clear opening length, (refer to SD039 for details). A 150mm minimum race depth shall be provided at lintels.

4.4.5. Step irons

Step Irons shall be provided in pits deeper than 1.2 m

4.4.6. Benching

Benching shall be provided in all pits.

4.4.7. Grates

Grates shall be provided at all pits unless directed by Council or as specified on the plans. Grates in road/public reserves shall be provided with lock-down 'J' bolts. Road gutter grates shall be a minimum of 900mm long and shall include RHS steel reinforcement supports of the grate at both the lip line and the gutter line. Grates in pathways shall be "bicycle safe" to avoid tyres entering grate, to the manufacturer's recommendations.

Grate loadings shall conform to the intended use of the grate or adjacent area.

Class B type grates may be utilised in parks and reserves. Class D type grate shall be utilised in roads.

Grates within flowpaths such as table drains, catch drains and watercourses, shall be "raised" (see SD041).

Grates which may be subject to blockage by tree branches, twigs, leaf litter etc, shall, unless approved otherwise by Council, be typically an RMS "median pit" raised grate (RMS Drawing No. MD.R11.B33.A.1 or similar), providing a grid opening of 150mm x 200mm.

4.5. HYDRAULIC LOSSES

The pressure change coefficient "K" shall generally be determined from the 'Missouri Charts' and the 'Hare Equations'. The Hare Equations shall only be used as a guide and the Missouri Charts shall have precedence where discrepancies between the two exist.

Computer program default pressure change coefficients (K) shall not be acceptable unless they are consistent with the above statement.

Pipe friction losses and pipe sizes in relation to discharge shall be determined using the Colbrook White Formula with the following coefficients for roughness, unless circumstances exist that may give effect to "poor" pipe surface quality:-

PIPE FRICTION LOSSES

PIPE TYPE	ROUGHNESS COEFFICIENT
Concrete Pipes	0.15
FRC, PVC, PE, PP	0.03

5. OVERLAND FLOW PATHS

5.1. GENERAL

Flow paths shall be provided to convey runoff from rainfall events that exceed the minor pipe system capacity. Flow paths shall cater for the 100-year ARI flows. These flow paths should generally be public roads and pathways linked to provide a continuous flow at acceptable velocities and depths.

For reasons of public safety, the coefficient of velocity and depth, should not exceed 0.4 for the major storm event (v.d < 0.4). Higher velocity, depth products may be permitted by Council where a risk assessment shows limited adverse affect to public safety such as in rural areas.

Where flow paths other than the normal road reserve are necessary, the minimum width shall be 3.5m (see chapter 4), and shaped to contain the 100-year flows.

Overland flow paths within a pathway should generally have, as a minimum treatment, a concrete invert, and the remaining area of the flow path fully turfed with couch grass (beyond any concrete paving). The flow path shape shall provide reasonable access for vehicles where necessary for maintenance purposes and on the low side of a road should incorporate a weir within the section of the footway crossing, ensuring that property boundary levels are flood-free (with 100mm minimum freeboard), thence graded to direct the major storm flow downstream. A Typical flow path section is shown on standard drawing SD037.

5.2. FREEBOARD

For the calculated 100-year ARI flow level in the road gutter and for major flow paths in drainage reserves, a minimum of 100mm freeboard (being measured from the top of water level) shall be provided to properties boundary surface levels. Particular care should be given to properties at levels lower than the footpath or reserve. Where design allows, greater freeboard heights should be achieved.

6. OPEN CHANNELS

Open channels generally form part of the trunk drainage system that cater for major 100-year ARI events and shall be designed with smooth transitions with adequate access for maintenance and cleaning.

Design of open channels (including safety and maintenance matters) shall be in accordance with Australian Rainfall and Runoff providing:

- A minimum of 300mm of freeboard to the top of the channel (600mm in mine subsidence areas).
- A minimum of 500mm freeboard to adjacent dwelling floor levels.
- Maximum side slopes on conventional grass lined channels shall be 4H :1V.
- Friction losses in open channels shall be determined using Mannings “n” values, or as approved by Council.
- Provision for low flow structures within open grass lined channels shall be provided. In addition subsurface drainage may be required to prevent water-bogging of the channel bed. The low-flow design parameters shall be nominated in the design and be approved by Council.

The following design features should be avoided:-

- Hydraulic jumps/supercritical flow
- Transitional changes in cross section
- Superelevated flows

Channels shall be signposted with a "WARNING" sign in accordance with standard drawing SD038.

7. MAJOR DRAINAGE STRUCTURES (BRIDGES & CULVERTS)

Major structures shall be designed to cater for the ARI event referred to in section 3.2. Major structures in rural areas shall be designed to accommodate flood events as nominated by Council. Bridges shall generally be designed to provide a waterway area catering for the 100 year ARI event for the contributing catchment, including afflux (300mm mimimum).

A certified structural engineer's design shall be required for bridges and major structures and shall be in accordance with Australian Standard AS5100, and culverts designed in accordance with Austroads Waterway Design.

8. STORMWATER FLOW & QUALITY CONTROL

The purpose for the control of flow-rate and quality of stormwater runoff from new development is to minimise potential adverse affects generated from development on the downstream environment, and to maintain as close as practically possible the pre-developed flow regime, with the employment of storage structures for retention such as earth basins, usually incorporating pollution control facilities (wetlands, GPT's etc).

8.1. DETENTION BASINS

8.1.1. Type & Location

Detention basins may be typically "wet" or "dry". Wet basins may include an artificial wetland facility, usually incorporating a deep water zone.

Dry basins drain to empty but may include a bio-retention treatment and/or a localised silt trap at pipe inlets. Within a "dry" detention basin, trickle flow channel or pipe drainage, together with a grid of subsoil drainage shall be provided across the basin floor. The minimum slope of a dry basin floor should be 2%.

Basins should be located where they are readily accessible for inspection and for maintenance vehicles from a public road, and should be contained within the Public Road or a Public or Drainage Reserve.

Where a basin is located in a flood plain the design should achieve its maximum elevation (RL) to limit inundation by flood waters. The lowest desirable level of the spillway should aim to be higher than the 20 year ARI event in the flood plain.

8.1.2. Capacity & Discharge

Detention basins retaining stormwater runoff shall be designed so that peak discharges from new development are not increased beyond that of the pre-developed environment for nominally the critical 1, 10 and 100 year ARI storm events. Basin design should result in a "flowrate which fills the basin to the greatest extent, or possibly the longest time. Where a drainage system is complex, it is likely that storms of different durations will be critical for various parts of the system" (AR&R – 1.6.3). To satisfy this requirement it is expected that a multi-staged outlet will be necessary to control the outflow, ensuring adequate flow-rate control for the more frequent storm events. A drainage report and calculations shall accompany the detailed design proposal.

Flood routing should be modelled by methods outlined in this Manual and shall include assessment for a basin catering for the total contributing catchment, inclusive of the catchment with its potential of being fully developed.

8.1.3. Overflow

The overflow weir, or high-level outlet for any basin shall be set at a level and have the capacity to maintain the 100-year ARI flood event for the pre-developed catchment.

The overflow weir (and spillway) should be designed in accordance with weir design principles. The weir crest shall be constructed in concrete, keyed into the embankment, and be designed to avoid possible failure in extreme storm events (greater than the 100yr event). The spillway down the embankment wall and at its toe should be protected from erosion with, as a minimum treatment, an approved robust stabilised (reinforced) earth/turf treatment including protection against turbulence/erosion at the embankment toe.

8.1.4. Outlet

Pipe systems shall contain the design outflow through the detention basin embankment with suitable bulkhead (trench-stop) protection to prevent water infiltration and "piping" between the conduit and the surrounding material. The pipe inlet structure shall be designed to avoid blockages, where a catchment may be the source of significant amounts of vegetation matter (see "Grates" above). Outlets shall include a device for energy dissipation.

8.1.5. Water Depth

Temporary water depth calculated for the 20-year ARI event, in either a wet or a dry basin, shall be limited to a maximum of 1.2m. Where justified by reason of restrictive access, available area or other reasons, a greater depth may be considered.

8.1.6. Embankment

Permanently inundated side slopes shall be no steeper than 6H:1V (excluding deep water zones). Maximum embankment slopes for mowing purposes shall be 5:1 (4:1 may be considered where available area or topography is restrictive). Naturally vegetated external slopes at 3:1 may be considered where maintenance is not required.

The embankment shall be designed, and supervised in construction, by an engineer. The embankments shall be founded on and bonded to sound natural clay material incorporating a keyway and be compacted to (density and moisture) specifications prepared by a geotechnical engineer. Full details shall be shown on the plans. The embankment, batters and basin floor shall be fully turfed with couch grass.

8.1.7. Dams

Existing dams that are intended to remain or be adjusted for use as part of a detention system shall be reported by geotechnical investigation for adequacy for the purpose. The report shall be submitted as part of the engineering design.

8.1.8. Gross Pollutant Traps & Basin Inlets

All basins should incorporate permanent Gross Pollutant Traps (GPT), to collect silt, trash and litter from the road drainage system.

As a temporary arrangement, road drainage discharge should be treated, within the basin floor with a sediment-pond/silt-trap. This area should generally be confined to the basin inlet pipe discharge point(s), being located and/or protected (eg. off-line to accept minor flows only) to avoid scour and dislodgement of sediment. Such traps may eventually become redundant upon stabilisation of the subdivision catchment, and may be removed by Council.

A note shall be included on the plans to ensure that the pollutant traps shall be cleaned out prior to issue of "practical completion".

Where practical, basin inlet pipes for inter-allotment drainage may be separated from the road inlets and associated pollution controls due to the relatively "clean" nature of the stormwater discharge.

8.1.9. Safety

Detention basins shall be signposted with a "WARNING" sign in accordance with standard drawing SD038.

The designer shall take into account the requirements (in terms of potential risk/threat to downstream property/community) of the NSW Dams Safety Committee regarding a basin/dam proposal making reference to the NSW Dams Safety Act.

8.2. STORMWATER QUALITY

Stormwater runoff from areas that may be a source of pollutants, such as roads and gardens, shall be treated to provide a means of "polishing" of the runoff prior to its discharge beyond the site. Constructed wetlands, bio-retention filters, silt traps, gross pollutant traps etc, shall be employed for this purpose. Exposed areas of soil/gravel shall be stabilised against erosion.

Design and construction parameters for constructed wetlands, silt traps, swales, bio-retention filters, etc, shall be determined with recognised computer software such as *MUSIC*, with supporting reference made to the publication "*The Constructed Wetlands Manual*" (1988); Water by Design publication "*Construction and Establishment Guidelines - Swales, Bioretention Systems and Wetlands*"; Landcom publication "*Managing Urban Stormwater – Soils & Construction*" or their equivalent.

The following table shall be used as a target for pollutant retention goals.

POST CONSTRUCTION STORMWATER MANAGEMENT TARGETS

POLLUTANT	RETENTION CRITERIA
Suspended Solids	80% of average annual load
Total Phosphorus	45% of average annual load
Total Nitrogen	45% of average annual load
Gross Pollutants >5mm	70% of average annual load
Litter > 50mm	Retention up to the 3 month ARI peak flow
Oil and Grease	90% of average annual load

The above retention criteria relate to "reduction of average annual load" of stormwater pollutants that may be expected from a fully developed catchment or site.

8.3. CONSTRUCTED WETLANDS

For wetlands to operate efficiently they should be "off-line" accepting, typically, flows up to the 1-year ARI storm event. General objectives for wetland area design are as follows:

- The shape of the wetland should be designed to optimise the treatment of the flows with lengthy flowpaths through the wetland.
- Wherever possible, existing natural drainage gullies should form part of a stormwater and runoff drainage management system incorporating detention basins and/or wetlands to alleviate stormwater peaks and retain pollutants.
- Wetlands should be well-designed creating an attractive, safe amenity and be highly visible for both the adjoining residents and passers-by.

- Walking paths should have frequent contact adjacent to the wetland edge
- Vegetation should be designed such that generous unobstructed view of the wetland is provided, but with dense planting where access should be restrictive, such as near deep water
- The design should ensure that emergent macrophytes are minimal and manageable
- Surrounding slopes to wetlands should be gentle and offer convenient tractor-mowing access – general maximum of 5H:1V

The planting list for each section of the wetland shall be provided with the design. (See council's preferred species list available in standard drawing SD048).

A management plan, including lifecycle costing (MUSIC), shall be submitted with the design indicating a Programme of On-Going Maintenance, appropriate for the particular wetland design. All wetlands shall be provided with a valve/pipe mechanism (other than mechanical pumping) to drain to the lowest possible level for periodic "clean-out" and harvesting of vegetation growth. A typical cross-section of a constructed wetland utilising the general objectives above is shown in standard drawing SD050.

For wetland maintenance purposes, vehicle access around the wetland, and an all-weather access road and standing area to GPT's shall be provided.

Wetlands shall be signposted with a "WARNING" sign in accordance with standard drawing SD038.

8.4. SWALES

Swales assist in the attenuation of flow and the removal of pollutants. Swales are most effective as source controls as opposed to end of pipe solutions.

Vegetated swales are suitable for catchments where they are able to convey flows longitudinally, with ultimate relief into a drainage conduit, device or system, and are commonly used as an alternative to kerb and gutter within the road. Swales are intended to be non-trafficable and should only be employed where vehicle crossing is not required, such as within medians of dual carriageways and adjacent to reserves.

Where for a particular reason vehicle access is required, a concrete driveway may be provided across swales either within the swale invert or with a culvert/pipe.

Swale velocity depth coefficient should be kept below 0.4 and longitudinal slope of the swale should be kept between approximately 1% and 4%.

Swales must be fully vegetated on a sandy loam topsoil to ensure maximum filter effectiveness, and plantings, other than couch grass, will be considered on their low-maintenance merits, having regard to flow capacity and long-term maintenance. Woodchip is not permitted. Refer to SD046.

8.5. BIO-RETENTION SYSTEMS

Bio-retention systems are filtration devices usually located within detention basins which comprise of porous subsurface soil layers and pipes and in some circumstances suitable vegetation (other than grass turf) to filter stormwater.

Like swales, these systems must be non-trafficable and designed for easy maintenance.

8.6. OTHER WSUD TREATMENTS

Examples of other common WSUD treatments that may be provided include:

Primary Treatments:

- Pit inlet protectors
- Trash Racks
- Gross Pollutant Traps (eg. Baramy Traps, CDS Units, ECOSOL Units, Humeceptor, Humeguard or other manufacturer's equivalent)

Secondary Treatments:

- Wet Basins
- Bio-retention swales
- Infiltration systems
- Vegetated Filter Strips
- Sand Filters
- Surface Retention
- Porous Paving

Tertiary Treatments:

- Constructed Wetlands
- Bio-retention

8.7. REFERENCES FOR WSUD DESIGN

- WSUD Technical guide for Western Sydney (Upper Parramatta Catchment Trust 2004)
- WSUD Basic Procedures for "Source Control" of Stormwater – a handbook for Australian Practice (Argue 2004)
- WSUD Engineering Procedures Stormwater (Melbourne Water 2005)
- Australian Runoff Quality – A guide to WSUD (Engineers Australia)
- SE Qld WSUD Engineering Design Guidelines (Healthy Waterways, June 2006)
- Water Smart Model Planning Provisions (HCCREMS 2007)
- Water Smart Practice Notes 1 to 11 (HCCREMS 2007)

8.8. FENCING

Warrants for fencing of permanent water wetlands, ponds, basins, and GPT's shall be determined based on a risk assessment. Where pool-fencing style is approved, the fence shall be installed with tamper-proof screws (as approved by Council) or be welded to deter vandalism/theft.

See also standard drawing SD057 for Council's "wire rope" style fence option.

9. ALLOTMENT DRAINAGE

This section addresses in principle major subdivision works with multiple lot connections. For small projects such as two or three lot subdivisions refer to Chapter title *Developments*.

9.1. PIPES

Inter-allotment drainage (IAD) shall be provided to every lot that cannot adequately drain to its street frontage. The drainage shall be designed to accept concentrated developed flows from each lot for 10 year ARI event. Where new lots adjoin existing properties minor/major flows from those existing uphill properties shall be catered for, with a pipe/pit/flowpath system. Depending on circumstances benefiting easements may be necessary.

Pipes shall be a minimum diameter of 150mm UPVC, PE or PP and have minimum cover of 300mm (where not subject to vehicle loads), designed to flow full without surcharging at pits. Minimum grade shall be 0.5%. Where IAD pipes are laid parallel to sewer mains, a clearance of 750mm between pipe centrelines should be provided. Where pipes are 300mm diameter or greater, the clearance shall be 450mm. If practical, the sewer shall be laid closest to the dwelling being served.

Subject to hydraulic design the following pipe sizes may be used as a guide.

INTER-ALLOTMENT DRAINAGE LINE PIPE SIZES

NO. OF DWELLINGS SERVED	PIPE DIAM (MM)
Up to 2	150
3 to 6	225
7 to 10	300

For single-allotment drainage, each lot within a subdivision that drains to the road, shall be provided with a galvanised steel pipe or rectangular hollow section (RHS) with a minimum sectional area equivalent to a 100mm diameter pipe (7850mm^2) across the footway. The conduit shall be located adjacent to the side boundary or at the lowest point of the lot frontage, connected to kerb outlet insert and extended into the lot being serviced.

9.2. PITS

Grated pits shall be provided to the low corner of each lot serviced, in accordance with standard drawing SD043, unless otherwise approved. Pits shall be concrete, to the following dimension:

INTER-ALLOTMENT PIT DEPTH : SIZE RELATIONSHIP

DEPTH (MM)	SURF. DIM. (MM)
< 900	450 x 450
900 - 1200	600 x 600
> 1200	600 x 900

Pits shall be depressed 100mm below the surrounding ground level, to provide efficient surface water inflow. A 450mm wide turf strip shall be laid around the perimeter of the pit. Segmental pit risers shall be adequately sealed at the joints

Each pit shall have a capped stub for the dwelling connection, and all pit/pipe joints mortared. (Refer SD043). Where pit depth is designed to drain low areas of lots, the riser shall enter the pit at its base.

10. DRAINAGE EASEMENTS

Within lots, easements shall be provided over pipe systems and overland flow paths. The minimum width of easements shall be as follows:-

PIPED DRAINAGE EASEEMNT WIDTHS (MINIMUM)

TYPE AND DIAMETER	EASEMENT WIDTH (M)
IAD up to and including 300mm dia.	1.5m [(1)]
IAD greater than 300mm dia.	2.5m
Public Drainage System up to & including 1200mm dia.	3.0m
Public Drainage System 1350mm dia and greater	5.0m

Notes:

(1) Where site constraints exist, such as in-fill developments, 0.9m wide IAD easements may be considered.

For pipe diameters larger than specified and for multiple pipe systems, the minimum clearance from the edge of the pipe to the easement limits shall be of 1.0m.

The specified easement widths may require widening where excessive pipe depth occurs.

11. STORMWATER OUTLET

Permanent, durable, and effective scour protection and/or energy dissipaters shall be provided at pipe outlets (and inlets where warranted).

In the absence of a defined natural watercourse or stream, points of discharge of concentrated stormwater onto an adjoining property, shall not be permitted without the agreement of the affected property owner. Where an agreement is reached with the adjoining owner, a letter and a drawing shall be signed and submitted to Council or the accredited certifier as evidence of the agreement, prior to issue of the Construction Certificate. Drainage easements shall be created, as necessary, prior to or upon certification under part 4A of the EP&A Act.

Where permitted, piped discharge shall be in a suitable watercourse and shall extend a minimum of 10 metres past a building or future building envelope.

Similarly, discharge through parks or reserves, if permitted under the plan of management, should be directed to suitable watercourses. Easements may be required.

12. SUBSOIL DRAINAGE

Subsoil drainage shall be designed for installation in areas that are susceptible to groundwater seepage into the pavement and subgrade, and may be in the form of pipes, strips and/or mats.

Subsoil drains shall be placed on each side of all road pavements and in all stormwater pipe trenches within the road pavement in accordance with standard drawing SD035 & SD003 with flush points placed behind the kerb (level with the kerb), as a screw-locked plastic fitting in a concrete surround and should be placed at approximately 60m intervals. Flush points within drainage pits are not permitted.

The design should indicate a subsoil drain “lead-in”, 3.0m long installed in Inter-Allotment Drainage lines where the line connects to the road pit, and at every second pit upstream within the IAD pipeline.

Subsoil drainage shall be shown at new pavement interfaces with existing pavements.

All subsoil pipes shall be, nominally, 100mm diameter, and be “socked” with geotextile fabric.

13. ACCESS RESTRICTION TO DRAINAGE STRUCTURES

A risk assessment shall be undertaken on any open drainage structure that could be readily accessed by the public. If that assessment indicates a necessary treatment, and/or at Council’s discretion, a barrier grate shall be provided.