0074 STORMWATER DRAINAGE (DESIGN)

1. General

1.1. Responsibilities

1.1.1. General

Requirement: Provide design and documentation for stormwater drainage systems.

1.2. Cross References

1.2.1. General

Requirement: This is not a self-contained design document, conform to the following worksection(s):

- 0010 Quality Requirements for Design;
- 0022 Control of Erosion and Sedimentation (Design).

1.3. Standards

1.3.1. General

Standard: Conform to the following:

- Australian Rainfall and Runoff: To current version of Australian Rainfall and Runoff;
- Water sensitive urban design: To EA ARQ;
- AS3500 Plumbing and Drainage.

1.4. Interpretation

1.4.1. Abbreviations

General: For the purposes of this worksection the following abbreviations apply:

- AEP: Average exceedance probability;
- ARI: Average recurrence interval;
- GPT: Gross pollutant trap;
- IFD: Intensity-frequency-duration;
- HGL: Hydraulic grade line;
- OSD: On-site detention;
- SQID: Stormwater quality improvement devices;
- WSUD: Water sensitive urban design.

1.4.2. Definitions

General: For the purposes of this worksection the following definitions apply:

- Average exceedance probability: The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year;
- Average recurrence interval: The average or expected value of the period between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that the periods between exceedances are generally random;
- Catchment: A topographically defined area drained by a stream where all outflow is directed to a single point;
- Catchment area of any point: The limits from where surface runoff will make its way, either by natural or man-made paths, to this point;
- Dual drainage: The major/minor approach to street drainage;
- Major system: The network of planned and unplanned drainage routes providing safe, well-defined overland flow paths for rare and extreme storm runoff events. It includes roads, natural channels, streams, culverts, community retention/detention basins and other facilities;
- Minor system: The gutter and pipe network capable of carrying and controlling flows from frequent runoff events. It includes kerb and channels, inlet structures, open drains and underground pipes and on-site detention facilities;
- Primary treatment SQID: Removal of the majority of gross pollutants and coarse-medium grained sediments by screening or sedimentation, e.g. GPT's, trash racks, sediment trap;
- Redevelopment site: A site that had (or was originally zoned to have) a lower density development than is proposed;
- Secondary treatment SQID: Removal of the majority of coarse, medium and fine grained sediments, as well as a significant proportion of the pollutants attached to sediments, by enhanced sedimentation and filtration, e.g. infiltration basins and wet ponds;
- Stormwater management plan: A plan to manage the stormwater quantity and quality within a catchment and protect receiving water features, such as the protection of existing waterways, lakes and wetlands;
- Sub-catchment: A topographically defined area drained by a tributary or branch drain of a primary stream, river or main draining catchment;
- Tertiary treatment SQID: Removal of the majority of sediments, attached pollutants and dissolved pollutants by sedimentation, filtration and biological uptake, e.g. constructed wetlands;
- Time of concentration: The time required for storm runoff to flow from the most remote point on the catchment to the outlet of the catchment or to the inlet of a drainage structure within the catchment;
- Treatment train: Sequencing of SQID's to optimise treatment performance;
- Trunk drains: Large capacity channels or conduits which carry runoff from local street drainage systems to receiving waters including natural or artificial channels, transitions and hydraulic structures, culverts and road crossings, naturally occurring ponds and lakes, artificial detention or retention storages;

- Water sensitive urban design: Design principles aimed at improving the sustainable management of the urban water cycle. It integrates the planning and design of urban water cycle, water supply, waste water, stormwater and groundwater management, urban design and environmental protection.

2. Pre-Design Planning

2.1. Planning

2.1.1. Stormwater management

Requirement: Integrate management activities at the catchment, waterway and local development level in conformance with the NWQMS Document 10 and the following:

- Restore existing stormwater systems;
- Minimise the impacts of stormwater from new developments;
- Hydrological: Minimise the impacts of urbanisation on the hydrological characteristics of a catchment including wet weather and low flows. Mitigate pre-development inappropriate flows where practical;
- Water quality: Minimise the amount of pollution entering the stormwater system and remove residual pollution by implementing stormwater management practices;
- Vegetation: Maximise the value of indigenous riparian, floodplain and foreshore vegetation;
- Aquatic habitat: Maximise the value of physical habitats to aquatic fauna within the stormwater system;
- Processes for management: Implement processes for management for the following as applicable:
    - Runoff;
    - Water quality;
    - Riparian vegetation;
    - Watercourse and aquatic habitat;
    - Urban bushland;
    - Bridges and culverts across waterways.

Water sensitive urban design: Plan and design stormwater drainage using WSUD principles including the following:

- OSD;
- Capture and use of stormwater as an alternative source of water to conserve potable water;
- Use of vegetation for filtering purposes;
- Water-efficient landscaping;
- Protection of water-related environmental, recreational and cultural values;
- Localised water harvesting for re-use;
- Localised wastewater treatment systems.

2.2. Consultation

2.2.1. Council and other authorities

Requirements: Consult with the Council and other relevant authorities during the preparation of design. In addition to the requirements of this worksection, identify the specific design requirements of these authorities.

2.2.2. Public consultation

Requirements: Undertake public consultation on design in conformance with Council policy.

2.2.3. Utilities service plans

Existing services: Obtain service plans from all relevant utilities and other organisations whose services exist within the area of the proposed development. Plot these services on the relevant drawings including the plan and cross-sectional views.

Requirements for utility services: To the SOCC Guide to Codes and Practices for Streets Opening.

2.2.4. Calculations

Certified design calculations: Engage a qualified hydrologic and hydraulic design professional to perform all required calculations.

2.2.5. Major structures

Certified structural design: Engage a professional engineer for all bridges, major culvert structures and specialised structures in conformance with 0010 Quality Requirements for Design.

3. Design Criteria – Stormwater Drainage Systems

3.1. General

3.1.1. Design objective

Requirements: Design stormwater drainage for the development with the following objectives:

- Reduced frequency of flooding of private and public buildings in flood-prone areas;
- Control of surface flows to prescribed velocity/depth limits;
- Control of surface flows to minimise the effect on pedestrians and traffic in more frequent stormwater conditions;

- Retention of incident rainfall and runoff consistent with the planned use of the area, within each catchment;
- Conformance with the Australian Rainfall & Runoff (ARR) major/minor system concept;
- A constant ARI/AEP for existing and reconstructed works;
- Adoption of WSUD principles.

3.1.2. Control of erosion and sedimentation

Requirement: To 0022 Control of Erosion and Sedimentation (Design).

3.1.3. Design for stormwater harvesting and re-use

General: Design for re-use of locally generated roof water, stormwater where appropriate.

Stormwater re-use scheme: Design the re-use scheme for ease of operation and maintenance. Consider the following when designing for collection, storage, treatment and distribution:

- End use requirements for water quality and quantity;
- Reliability of supply;
- Estimated demand for water with regard to peak flow;
- Assessment of water balance for sizing and storage;
- Storage requirements considering average annual volume and diversion flow rates;
- Treatment system based on:
    - Diversion flow rates before storage;
    - Distribution flow rates both before and after storage.

Roofwater: Provide an integrated design with rainwater tanks, coordinate with the appropriate engineering consultation and conform to statutory and local authority requirements.

Stormwater runoff: Design for the utilisation of stormwater runoff at the following scales:

- Allotment scale;
- Subdivisional/regional scale.

3.1.4. Stormwater collection

Requirement: Design the stormwater collection system to meet the following objectives:

- Extraction of sufficient water to meet the end use requirements without compromise to downstream aquatic ecosystems;
- Ability to stop collection in the event that stormwater is contaminated by an incident within the catchment;
- Minimisation of the risk and/or impact of upstream flooding.

3.1.5. Stormwater storage

Requirement: Design the stormwater storage system to meet the following objectives:

- Storage of sufficient water to balance supply and demand;
- Minimisation of mosquito habitat (virus control), risks to public safety and risks to water quality in above-ground storage;
- Maximisation of dam safety.

3.1.6. Stormwater treatment

Treatment: Design appropriate stormwater treatment techniques to meet the following objectives:

- Minimisation of public health risks for the adopted public access arrangements;
- Minimisation of environmental risks;
- The integration of suitable gross pollutant traps into drainage networks.

3.1.7. Stormwater distribution

Requirement: Minimise the potential for:

- Contaminant inputs downstream of the final treatment facilities;
- Public exposure to untreated stormwater;
- Cross-contamination with mains water distribution networks or confusion with mains water supplies.

Irrigation: Design the irrigation system to the following requirements:

- Minimise run off, groundwater pollution and soil contamination;
- Minimise spray to areas outside the access control zone to reduce public health risks, if access control is adopted;
- Application rate of stormwater: Uniform for the irrigation scheme and less than the nominal infiltration rate to avoid surface runoff.

3.2. Hydrology

3.2.1. Design rainfall data

Design IFD: Derive rainfall relationships for a particular catchment from the following:

- ARR 2019 Book 2 – Rainfall Estimation;
- AS/NZS 3500.3 Appendix D;
- Bureau of Meteorology IFD tool website www.bom.gov.au;
- Geoscience Australia website www.ga.gov.au.

Design ARI/AEP:

- ARR 2019;
- AS/NZS 3500;
- Austroads AGRD05.

3.2.2. Catchment area

Catchment definition: To Austroads AGRD05A clause 2.6.3. If detailed survey of the catchment is not available, determine the extent of the catchment area from current topographical mapping, aerial photographs or field survey.

Site inspection: Verify catchment boundaries by site inspection and provide adequate documentation.

Catchment area land use: Establish catchment area land use based on current available zoning information.

Record: Document the design to the catchment areas plan.

3.2.3. Methods of analysis

Peak flows: Determine using the current recommendations in ARR 2019 and the ARR RFFE model where appropriate. Analysis should be carried out using a suitable and approved computer analysis program. For smaller less critical areas and where designers can provide justification and receive approval from Council, Rational Method Calculations may be used in conformance with ARR87 Book IV Section 1 (note ARR87 IFD's must be adopted in this case), and the requirements of this worksection.

Flow studies: Prepare flow studies including the following:

- A relevant range of ARI/AEP's for each sub-catchment;
- Calculation of total flows at junctions of existing drainage works;
- Assessment of allowable flows from catchment/sub-catchments for release to downstream areas or drainage systems;
- Assessment of release from dams/detention works affecting capacity of drainage works to avoid surcharge/inundation.

Run-off coefficients:

- ARR;
- AS/NZS 3500.3 clause 5.4.6.

Record: Provide details of adopted coefficients in the design documentation.

Percentage impervious: To ARR.

Time of concentration: Conform to the following:

- Minimum: 5 minutes;
- Maximum in an urban area: 20 minutes unless sufficient evidence is provided to justify a greater time.

Flow time: If the flow path passes through areas having different flow characteristics or includes property and roadway, calculate the flow time of each portion of the flow path separately.

Flow paths to pits: Document the flow path for each collection pit for the fully developed catchment on the catchment area plan. Consider the following:

- Fencing;
- Potential locations of buildings;
- Changes to individual flow paths due to the full development of the catchment;
- Proposed detention works.

Pipe and channel flow: Calculate pipe flow using the following:

- Mannings formula: To Austroads AGRD05A clause 6.6.11 or AS/NZS 3500.3 clause 5.4.9;
- Colebrook-White formula To Austroads AGRD05A clause 6.6.11 or AS/NZS 3500.3 clause 5.4.11.

Mannings roughness co-efficient ('n') for specific zonings:

- ARR.
- Austroads AGRD05A Table 5.3.

3.2.4. Alternative models and computer analysis

General: Use of other hydrological models or computer analysis is permitted. If using alternative models or computer analysis, conform to the following:

- Satisfy the requirements of ARR;
- Submit summaries of calculations;
- Submit details of all program input and output;
- Submit copies of the final data files.

3.3. Hydraulics – General

3.3.1. General

Major/minor drainage concept: To ARR and Austroads AGRD05A.

3.3.2. Hydraulic grade line (HGL)

Calculations: To ARR.

Record: Document hydraulic calculations including the following:

- A summary of design calculations;
- Detailed drawings of the grade line;
- Listing of all program input and output.

Downstream control: Adopt the appropriate downstream water surface level requirements from the following options:

- Known HGL level from downstream calculations including pit losses at the starting pit in the design event;
- If the downstream starting point is a pit and the HGL is unknown, adopt a level of 0.15 m below the invert of the pit inlet in the downstream pit;
- If the outlet is an open channel and the design storm is a minor event, the top of the outlet pipe is the downstream control;
- If the outlet is an open channel, the design storm is a major event and downstream flood levels are not known, the top of the outlet pipe is the downstream control;
- If the outlet is an open channel, the design storm is a major event and downstream flood levels are known, the downstream control is the ARI 100 years flood level.

Water surface limits: Limit the water surface in drainage pits as follows:

- Inlet pits: To 0.150 m below the gutter invert;
- Junction pits: To 0.150 m below the underside of the lid.

3.4. Hydraulics – Minor System

3.4.1. Criteria

Gutter flow width:

- Minor systems: To Austroads AGRD05A Table 5.1;
- Major systems: To Austroads AGRD05A Table 5.2.

Conduit sizes: Minimum conduit sizes as follows:

- Pipes: 375 mm diameter;
- Box culverts: 600 mm wide 300 mm high.

Velocity limits: To Austroads AGRD05A Table 6.2.

3.4.2. Pits

Inlet pit spacing: To Austroads AGRD05A clause 5.3.4 and as follows:

- Inlet efficiency is not affected by adjacent inlet openings;
- Locate at the upstream side of allotments, if possible.

Inlet capacity: Kerb inlet lengths to side entry pits as follows:

- Preferred maximum: 3.0 m;
- Maximum 5.0 m where the grade is 10% or more;
- Maximum 4.0 m where the grade is less than 10%.

Table 1: Allowable Inlet Capacities for Pit Blockage

Condition	Inlet type	Percentage of theoretical capacity allowed
Sag	Side entry	80%
Sag	Grated	50%
Sag	Combination	100% side inlet capacity only – grate assumed completely blocked
Continuous Grade	Side entry	80%
Continuous Grade	Grated	50%
Continuous Grade	Combination	90%

Access chambers: Provide as follows:

- For maintenance access;
- At changes of direction, grade level or class of pipe;
- At junctions.

Table 2: Access Chamber Spacing

Condition	Pipe size (mm)	Maximum spacing (m)
Generally	Less than 1200	100
	Greater than 1200	150
In tidal influence	All	100

3.4.3. Hydraulic losses

Pressure change coefficient K: Determined using appropriate literature and charts. Allowances made for the following:

- Reduction due to benching;
- Pipe bends;
- Clashes with existing sewer mains;
- Pipe junctions without an inlet structure.

Computer program default pressure change coefficient: Do not use unless consistent with that determined from the appropriate literature and charts.

Record: Document the literature/chart adopted and relevant coefficients in the design documentation and on the final design drawings.

Submissions: Before detailed design, submit for approval with sufficient information to permit evaluation the following:

- Proposed pipe bends;
- Pipe junctions without an inlet structure;
- Contraction from larger upstream to smaller downstream pipes.

Pipe friction: Design drainage pipe systems as follows:

- An overall system including upstream and downstream systems, not as individual pipe lengths;
- A gravity system flowing full at design discharge. Pressurise with the use of appropriate pits and joints;

Pipe sizing: To the Colebrook-White formula and roughness coefficients to AS 2200.

Service entry requirements: For roof and subsoil pipes from private properties entering Council's system, conform to the following:

- Pipe inlets larger than 225 mm: Enter the main pipe system at junction pits, finish flush and grout the sideline into the pit wall;
- Smaller inlets: Break into the drainage pipes for interconnection with the main line, finish flush and grout the sideline into the main line.

3.5. Hydraulics – Major System

3.5.1. Criteria

Surcharging of drainage systems: Not permitted where the water depth is above the top of kerb, except for the following:

- Storm frequencies greater than ARI 20 year event and only across the road centreline where the road pavement is below the natural surface of the adjoining private property;
- Flow across footpaths, where there is no flooding of private property, if approved by Council.

Velocity/depth criteria: Conform to the following for the design of velocity depth product flow across the footpath and within the road reserve:

- For safety of children and vehicles:
  - Maximum depth of water: 0.2 m;
  - Maximum velocity x depth product flow: 0.4 m^2/s.
- For safety of vehicles only:
  - Maximum velocity x depth product flow: 0.6 m^2/s.
- Open channels: Use the maximum velocity x depth product criteria or provide safe egress points from the channel for the safety of children.

Freeboard: Design for minimum freeboard for floor levels and levee bank levels from flood levels in roadways, stormwater surcharge paths and open channels as follows:

- Roadways:
  - 0.3 m freeboard between the 100 year flood level and floor levels on structures and entrances to underground car parks;
  - 0.1 m freeboard between the ponding level of water in the road and the high point in the footpath if the road is in fill or overtopping of kerbs and flow through properties may occur.
- Stormwater surcharge paths: 0.3 m freeboard between the 100 year flood level and floor levels on structures and entrances to underground car parks;
- Open channels: 0.5 m freeboard between the 100 year flood level and floor levels on structures and entrances to underground car parks.

Roadway reserve capacity flows: Calculate roadway reserve capacity flow for each carriageway used in the catchment and apply storage correction for each type to Austroads AGRD05A clause 2.6.3.

For levee bank works associated with protection of townships, consult with Council for specific requirements.

3.5.2. Open channels

Design criteria: To ARR, Austroads AGRD05B and the following:

- Contain the major system flow less any flow in the minor system allowing for blockage of the minor system;
- With smooth transitions and adequate access provisions for maintenance and cleaning;
- Open channels are permitted as follows:
    - To form part of the trunk drainage system;
    - To convey flows from a development site to the receiving water body, only if Council has approved the use of an open channel.

Channel roughness: Determine friction losses in open channels using Mannings 'n' values to **Table 3: Specific Channel Type 'n' Values**.

Safety of persons: If the average velocity x depth product flow for the design flow rate is greater than 0.4 m^2/s, design in conformance with ARR to provide for the safety of persons who enter the channel.

Side slopes on grassed lined open channels:

- Prefer 6H:1V;
- Maximum 4H:1V.

Channel inverts: Minimum cross slopes of 20H:1V.

Low flow provisions in open channels (man-made or altered channels): Provide as follows:

- Contain flows within a pipe system or concrete lined channel section at the invert of the main channel;
- Subsurface drainage in grass lined channels to prevent waterlogging of the channel bed;
- Width of concrete lined channel section equal to the width of the invert or at least to accommodate the full width of a tractor.

Hydraulic jumps: Design transition in channel slopes to avoid or accommodate hydraulic jumps without generating erosion.

Table 3: Specific Channel Type 'n' Values

Channel type	'n'
Concrete pipes or box sections	0.011 – 0.012
Concrete (trowel finish)	0.012 – 0.015
Concrete (formed without finishing)	0.013 – 0.018
Sprayed concrete	0.016 – 0.020
Bitumen seal	0.018
Bricks or pavers	0.014 – 0.016
Pitchers or dressed stone on mortar	0.015 – 0.017
Rubble masonry or random stone in mortar	0.020 – 0.035
Rock lining or rip-rap	0.025 – 0.030
Corrugated metal	0.020 – 0.033
Earth (clear)	0.018 – 0.025
Earth (with weeds and gravel)	0.025 – 0.035
Rock cut	0.035 – 0.040
Short grass	0.030 – 0.035
Long grass	0.035 – 0.050

3.6. Major Structures

3.6.1. Criteria

Design ARI for major structures in urban areas, including bridges and culverts: 100 year ARI storm event without afflux.

Afflux and upstream inundation: Permitted if the increased upstream flooding is minimal and does not inundate private property.

Minimum clearance for passage of debris without blockage: 0.3 m between the 100 year ARI flood level and the underside of the superstructure.

Minimum floor levels of dwellings: 0.5 m freeboard above the 100 year ARI flood level in the basin.

Routing: Model flood routing to ARR.

Pipe and culvert bedding: Design to minimise permeability and provide cut off walls and anti-seepage collars if appropriate.

Harvesting: Design stormwater harvesting options in locating diversion or detention systems.

3.6.2. Culverts

Culverts (either pipe or box section) shall be designed with due consideration given to the following:

- Inlet and exit losses;
- Inlet and outlet control;
- Scour protection.

3.6.3. Basins

Critical storm duration: For each ARI/AEP, consider a range of storm events to determine the critical storm duration, the peak flood level and discharge from the retarding basin. Provide a graph showing the range of peak flood levels in the basin and peak discharges from the basin for the storms examined.

Storm patterns: Adopt storm patterns given in ARR and review the sensitivity to storm pattern by reversing the storm patterns.

Public safety issues: Design for the following:

- Side slopes: Maximum 1V:6H to allow easy egress;
- Water depths: Maximum 1.2 m in the 20 year ARI storm event. If greater depths are required, submit for approval, including the design of safety refuge mounds;
- Depth indicators for maximum depth in the basin;
- Protection for the low flow intake pipe to reduce hazards for any person trapped in the basin and prevent blockages;
- Signage of the spillway to indicate the hazard;
- No ponding of water on private property or roads;
- No planting of trees in basin walls;
- No basin spillway located directly upstream of urban areas;
- Safety fence design to AS 1926.1.

Submission of design drawings to the Dam Safety Committee is required where any of these guidelines are not met or where Council specifically requires such submission.

High level outlet:

- Capacity capable: To contain a minimum of 100 year ARI flood event;
- Hazard category: To ANCOLD Guidelines;
- Spillway design: To clause 4.2.5 of this worksection - Open Channels;
- Stilling basin dissipaters: Provide appropriate dissipaters at high velocity outlets to prevent erosion.

Salinity prevention:

- Design basins to prevent surface drainage water leaking to the subsurface, recharging groundwater in areas known to be affected by high water tables and/or salinity of ground water;
- If discharging to natural watercourses, conform to the requirements of the land and water resources authority for salinity levels;
- Design the pipe system to contain the minor flow through the retarding basin wall;
- Outlet pipes: Provide rubber ring jointed with lifting holes securely sealed.

3.6.4. On-site stormwater detention

Stormwater detention: Required on work sites or redevelopment sites where under capacity drainage systems exist.
Salinity prevention: Locate basins for stormwater detention, stormwater treatment or sedimentation purposes to avoid known areas of permanent or seasonal groundwater discharge to reduce recharge into the groundwater.

3.7. Interallotment Drainage

3.7.1. Criteria

Requirement: Provide interallotment drainage as follows:

- For every allotment that does not drain directly to the frontage street or a natural watercourse;
- Within an easement, minimum 1.0 m wide, in favour of the upstream allotments;
- Capacity for concentrated drainage from buildings and impervious surfaces on each allotment for flow rates to the design ARI/AEP for the minor street drainage system.

Table 4: Runoff Contribution to Interallotment Drains

Development type	% of lot area impervious surfaces
Residential (2a)	40
Residential (2b)	70
Industrial	80
Commercial	90

3.7.2. Pipes

Requirement: Design pipes to flow full at the design discharge without surcharging inspection pits.

Minimum longitudinal gradient: 0.5%.

Pipe materials: To the following:

- Fibre reinforced concrete pipes: To AS 4139;
- Precast concrete pipes: To AS/NZS 4058;
- PVC pipes: To AS/NZS 1254;
- Polypropylene pipes: To AS/NZS 5065;
- Buried flexible pipes: To AS/NZS 2566.1 and AS/NZS 2566.2.

Pipe joints: Rubber ring joints.

3.7.3. Pits

Requirement: Design pits as follows:

- Locate interallotment drainage pits at all changes of direction;
- Minimum 600 x 600 mm internal plan dimensions;
- Concrete with 100 mm thick walls and floor and 100 mm concrete lid finished flush with the surface of works;
- Depressed grated inlets are acceptable;
- To resist flotation for high water table areas.

3.7.4. Sewer mains relationship

Interallotment drainage and sewer mains laid adjacent to each other: Design as follows:

- If the pipe inverts are approximately equal, space 1.5 m apart between pipe centrelines;
- If the pipe inverts are not equal, submit the spacing for approval;
- Document sewer mains on the interallotment drainage plan.

3.8. Gross Pollutant Traps (GPT) and Sediment Traps

3.8.1. General

GPT/sediment trap location: Determine location and catchment size in conformance with EA ARQ Section 8.4 and the following:

- Complementary with the strategic catchment treatment objectives;
- Available space;
- Proximity to pollutant source areas;
- Outlet approach: Use a single device to treat a whole catchment (up to 200 ha or more);
- Distributed approach: Target smaller individual catchments with many traps;
- Site constraints: Including topography, soils and geology, groundwater, space, access, odour problems, visual impacts, safety concerns and vermin.

3.8.2. GPT/sediment trap performance and type

Performance: To EA ARQ Section 8.5 including the following:

- Treatment objectives:
  - Gross pollutants: Remove litter and vegetation larger than 5 mm;
  - Sediment: Remove particles larger than 0.125 mm;
  - Remove 90% of all material greater than 0.125 mm.
- Operating design flows: 3 month ARI;
- Flood capacity: Analyse hydraulics of the drainage system including the headloss of the GPT and diversion weir under flood conditions. Review the design of the bypass system for impacts on the local drainage system and consequences on flooding;
- Trapped pollutant storage: Assess the pollutants that are likely to be collected and determine the holding capacity with respect to the maintenance operations and frequency;
- Maintenance requirements: Design the GPT for maintainability and operability including the following considerations:
  - Ease of maintenance and operation;
  - Access to the treatment site;
  - Frequency of maintenance;
  - Disposal.

Assessment of GPT performance: Include in the maintenance program requirements for validating the GPT performance by field monitoring, physical laboratory models or computer simulation.

Selection of the GPT: To the EA ARQ Appendix 8A checklist and the following:

- Life cycle costing;
- Footprint and depth of the unit;
- Hydraulic impedance and requirements;
- Disposal costs;
- Occupational health and safety.

Hydrocarbon management: If required, design and size water/oil separators or interception devices in conformance with EA ARQ Section 9.7.

3.9. Constructed Wetlands and Ponds

3.9.1. General

Treatment process: Determine in conformance with EA ARQ Section 12.3 and the following:

- Sedimentation;
- Filtration;
- Adsorption;

- Biological uptake;
- Pollutant transformation;
- Pollutant storage.

System design: Design the system in conformance with EA ARQ Sections 12.4 and 12.5 including the following:

- Hydrological effectiveness: Quantify the effects of the interaction between the following:
    - Volume of the detention system;
    - Hydraulic capacity of the outlet structure of the system;
    - Variability of runoff inflow to the system.
- Hydraulic efficiency: Control the flow patterns for uniform distribution throughout the system to provide optimal treatment on the inflow;
- Notional detention time: Select the design detention period;
- Facilitate and optimise water quality treatment processes;
- Locate ponds and wetland systems;
- Select treatment device or treatment train;
- Select wetland vegetation, fish or fauna.

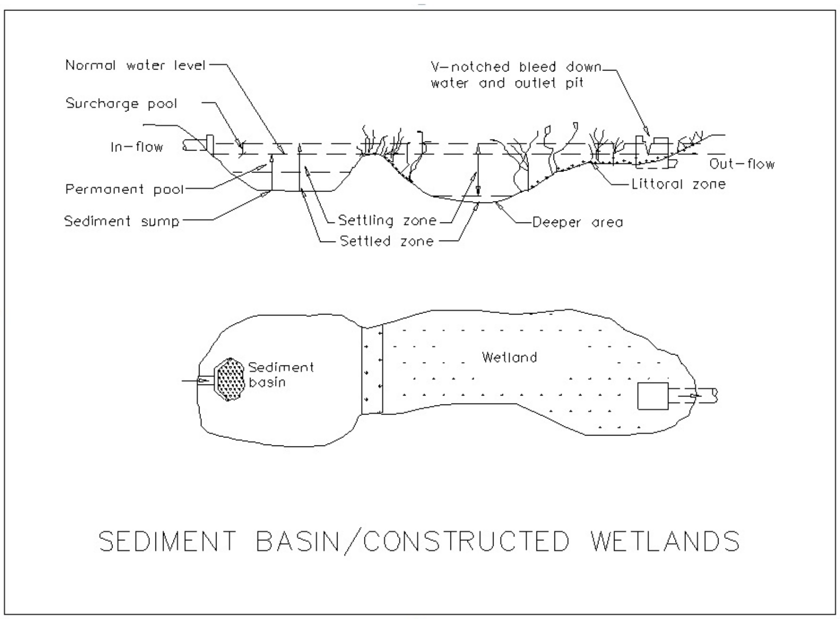

Figure 1: Sediment Basin / Constructed Wetland

3.10. Buffer Strips, Vegetated Swales and Bioretention Systems

3.10.1. Buffer strips

Urban catchments: Grassed areas that direct runoff from adjoining impervious areas to the stormwater discharge location.

Design: To EA ARQ Section 10.3 and consider the following:

- Maximum slope: 5%;
- Maximum velocities: 0.4 m/s;
- Usage of flow spreaders;
- Vegetation density;
- Distribution/spread of stormwater over the buffer strip;
- Prevention of rill formation through properly designed entry conditions and vegetation.

3.10.2. Vegetated swales

Design: To EA ARQ Section 10.4.

Location: At any point in the catchment and as follows:

- At the top of a catchment to serve minor drainage requirements;
- Downstream in the catchment with a parallel underground pipe network.

Geometry: Trapezoidal or parabolic shapes.

Side slopes: No steeper than 1V:3H.

Longitudinal slope: 1 – 4%. If greater or less than 1 – 4%, conform to the following:

- Slopes greater than 4%: Design for check dams;
- Slopes less than 1%: Design for under drains.

Maximum swale width: 2.5 m.

Maximum flow velocity: Conform to the following:

- For 1 year ARI: 0.5 m/s;
- For 100 year ARI: 1.0 m/s.

Mannings 'n' value:

- For flow conditions where depth of flow is below the height of the vegetation: 0.15 to 0.3;
- For 100 year event: 0.03.

3.10.3. Bioretention systems

Design: To EA ARQ Section 10.5 with two or three subsurface layers as follows:

- Base or drainage layer: Coarse and poorly graded material, placed to encase the perforated drainage pipe;
- Transition layer: Prevents filtration media washing into the perforated pipes;
- Filtration layer: Media through which water is filtered, typically consisting of sandy loam.

3.11. Infiltration Systems

3.11.1. General

Design: To EA ARQ clause 11.3.4 for the following:

- Unsuitable soils: Test soils for permeability and assess for suitability;
- Clearance distances to building footings and boundaries: To EA ARQ clause 11.3.1 for each soil classification;
- Rock and shale: Test for permeability and assess for suitability;
- Shallow soil cover over rock: Test for permeability and assess geology for weathered or fractured rock;
- Steep terrain: Check soil depth on a downslope and assess suitability;
- Watertable interaction with infiltration systems: Check watertable stability and salinity for suitability and the presence of any aquifers that may interact;
- Watertable affected by upstream infiltration devices: Assess geology for any likely upstream infiltration devices that may limit retention; Aquifer recharge/retrieval annual balance: Assess for continual equilibrium of local potentiometric levels;
- Water quality inflows to infiltration devices: Treatment to EA ARQ clause 11.2.3.

Flood control: On-site storage for flood control to EA ARQ Section 11.6.

Requirement: Submit calculations demonstrating the effectiveness of the infiltration device for successions of storms and hydrological effectiveness to EA ARQ Section 11.4.

3.12. Detailed Design

3.12.1. Conduits

Pipe bedding and cover: Conform to the following:

- Reinforced and fibre reinforced concrete pipes: To AS/NZS 3725;
- PVC pipes: To AS/NZS 2032;
- Polyethylene and polypropylene pipes: To AS/NZS 5065;
- Buried flexible pipes: To AS/NZS 2566.1 and AS/NZS 2566.2. Submit for approval for use.

Location: Locate drainage lines in:

- Road reserves behind the kerb line and parallel to the kerb;
- Easements over private property centrally within the easement.

Bulkheads: Design bulkheads on drainage lines where the pipe gradient exceeds 5%, including details of the size and position in the trench and the spacing along the line.

3.12.2. Pits

Design requirement: Provide as follows:

- Benching to improve hydraulic efficiency and reduce water ponding;
- Step irons and bicycle-safe grates for safe access and safety;
- Ventilation for pits and other confined structures requiring access for maintenance, inspection or repairs.

3.12.3. Stormwater discharge

Salinity prevention: Locate stormwater discharge to avoid recharging groundwater and creating or worsening salinity degradation of adjacent land.

Kerb and channel (gutter) termination: Extend kerb and channel (gutter) to drainage pit or natural point of outlet. Provide protection to prevent scour and dissipate the flow if outlet velocity is greater than 2.5 m/s or the kerb and gutter discharge would cause scour.

Recreation reserves: For piped stormwater drainage discharging to recreation reserves, conform to the following:

- Discharge through an outlet structure to a natural water course;
- Discharge into the nearest trunk stormwater line.

Drainage discharge onto area under the control of another statutory authority: Conform to the design requirements of that statutory authority.

3.12.4. Easements

Requirement: Identify points of discharge of gutters or stormwater drainage lines or any concentration of stormwater onto adjoining properties. Advise Council of the affected properties so that Council can obtain permission for the discharge of stormwater drainage over the properties and the required easements.

Easement width:

- Minimum: 3.0 m;
- Maximum: To contain the full width of overland flow or open channel flow in the major system design event.

3.12.5. Trench subsoil drainage

Subsoil drainage in pipe trenches: If pipe trenches are backfilled with sand or other pervious material, provide the following:

- 3 m length of 100 mm diameter agricultural pipes, butt jointed with joints wrapped with geotextile, or slotted PVC pipe of subsoil drain in the bottom of the trench immediately upstream from each pit or headwall;
- Seal the upstream end of the subsoil drain with cement mortar;
- Discharge the downstream end through the wall of the pit or headwall.

3.12.6. Durability

Requirement: Design for the service life of the drainage system including the following:

- Thickness and type of base material of drainage structures including pipes and culverts;
- Life expectancy of the coating;
- pH and resistivity of water and backfill material;
- Presence of impurities including chloride, sulfate and aggressive CO_2 in the groundwater or soil.

Soil chemical testing: Determine as follows:

- pH level: Test backfill, soil and water to AS 1289.4.3.1;
- Resistivity: Test backfill, soil and water to AS 1289.4.4.1;
- Chloride, sulfate and aggressive CO_2 concentration: Test groundwater or soil extract to AS 1289.4.2.1.

4. Documentation

4.1. General

4.1.1. Approvals

Requirements: Document the approval conditions advised by the appropriate authority which contribute to the basis of the design of the stormwater drainage.

4.1.2. Design reports

Requirements: Provide a design report including the following:

- Design criteria;
- Site investigation reports supporting the design.

4.1.3. Calculations

Design: Provide a design report incorporating the criteria, computer studies, calculations and references supporting the design of the stormwater drainage.

4.1.4. Design certification

Requirement: Provide a signed and dated design certificate.

4.2. Drawings

4.2.1. General

Requirements: Provide drawings and/or computer output defining the works and assumed operating and maintenance procedures.

4.2.2. Catchment areas plan

Catchment area drawings: Provide drawings showing the following:

- Contour interval: 1 – 2 m (closer if the area is very flat);
- Grade direction for kerb and gutter;
- General layout of the drainage system with pit locations;
- Catchment limits;
- Any other information necessary for the construction of the drainage system.

Scale 1:1000 or 1:5000.

4.2.3. Drainage system layout

Drainage system layout drawings: Provide drawings showing the following:

- Drainage pipeline location;
- Drainage pit location;
- Number and road centreline chainage;
- Size of opening;
- Drainage easements;
- Reserves and natural water courses;
- Location of buffer strips, vegetated swales and bioretention systems;
- Location and details of infiltration systems;
- Any other information necessary for the construction of the drainage system;
- If appropriate, combine with the road layout plan.

Scale 1:500.

4.2.4. Longitudinal section

Drainage system longitudinal sections: Provide drawings showing the following:

- Pipe size, class and type;
- Pipe support type to AS/NZS 3725 or AS/NZS 2032;
- Pipeline and road chainages;
- Pipeline grade;
- Hydraulic grade line;
- Any other information necessary for the construction of the drainage system.

Horizontal scale: 1:500.

Vertical scale: 1:100.

4.2.5. Open channels

Open channel cross sections: Provide drawings showing the following:

- The direction of the view of cross sections, normally downstream;
- Reduced levels to Australian Height Datum;
- Provide a data input file for the design flow rates.

Scale: 1:100.

4.2.6. Other documentation

Detailed drawings: Provide details including standard and non-standard pits and structures, pit benching, open channel designs and transitions to scales appropriate to the type and complexity of the detail being shown.

Submit hydrology and hydraulic summary sheets.

Computer data files and output: Submit final hydrological and hydraulic computer data files.

Landscape plans and planting plans: Provide for buffer strips, vegetated swales and bioretention systems.

4.2.7. Work as Executed drawings

General: Provide an additional set of final construction drawings for the purpose of recording the Work as Executed by the contractor.

4.3. Specifications

Construction documentation

Requirement: Prepare technical specifications using the AUS-SPEC Construction templates from the National Classification System workgroups 02, 03, 11, 13.

5. Annexure

5.1. Annexure – Referenced Documents

The following documents are incorporated into this worksection by reference:

AS/NZS 1254	2010	PVC-U pipes and fittings for stormwater and surface water applications
AS 1289		Methods of testing soils for engineering purposes
AS 1289.4.2.1	2020	Soil chemical tests - Determination of the sulfate content of a natural soil and the sulfate content of the groundwater - Normal method
AS 1289.4.3.1	2021	Soil chemical tests - Determination of the pH value of a soil - Electrometric method
AS 1289.4.4.1	2017	Soil chemical tests - Determination of the electrical resistivity of a soil - Method for fine granular materials
AS 1926		Swimming pool safety
AS 1926.1	2012	Safety barriers for swimming pools
AS/NZS 2032	2006	Installation of PVC pipe systems
AS 2200	2006	Design charts for water supply and sewerage
AS/NZS 2566		Buried flexible pipelines
AS/NZS 2566.1	1998	Structural design
AS/NZS 2566.2	2002	Installation
AS/NZS 3500		Plumbing and drainage
AS/NZS 3500.3	2021	Stormwater drainage
AS/NZS 3725	2007	Design for installation of buried concrete pipes
AS/NZS 4058	2007	Precast concrete pipes (pressure and non-pressure)
AS 4139	2003	Fibre-reinforced concrete pipes and fittings
AS/NZS 5065	2005	Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications
ANCOLD	2000	Guidelines on Selection of Acceptable Flood Capacity for Dams
Austroads AGRD		Guide to Road Design
Austroads AGRD05	2013	Drainage – General and Hydrology Considerations
Austroads AGRD05A	2021	Drainage – Road surface network, basins and subsurface
Austroads AGRD05B	2013	Drainage - Open channels, culverts and floodways
ARR	2019	Australian Rainfall & Runoff - A Guide to Flood Estimation
EA ARQ	2006	Engineers Australia - Australian Runoff Quality: A guide to Water Sensitive Urban Design
SOCC Guide	2018	Guide to Codes and Practices for Streets Opening
NWQMS Doc 10	2000	Australian Guidelines for Urban Stormwater Management