Glossary of terms

Allotment Drainage	A system of field gullies, manhole chambers and underground pipes constructed within private property to convey flows through and from allotments.
Annual exceedance probability (AEP)	The probability of exceedance of a given discharge within a period of one year. AEP is generally expressed as 1 in Y [years]. The terminology of AEP is generally used where the data and procedures are based on annual series analysis.
Average Recurrence Interval (ARI)	The average or expected value of the period between exceedances of a given discharge. ARI is generally expressed as Y years. The terminology of ARI is generally used where the data and procedures are based on partial series analysis.
Bankfull Discharge	The channel flow rate that exists when the water is at the elevation of the channel bank above which water begins to spill out onto the floodplain. The identification of bankfull elevation is described in ARR (1998) Book 4, Section 2.11.3.
Backwater Curve Analysis	A procedure for determining water surface levels in open channels under gradually varied flow conditions.
Bio-Retention System	A well-vegetated, retention cell or pond designed to enhance water filtration through a specially prepared sub-surface sand filter. Bio-retention cells may be incorporated into grass or vegetated swales or may be a stand-alone treatment system. The system incorporates vegetation with medium-term stormwater retention and sub-surface filtration/infiltration. Also known as bio-filtration systems or biofilters.
Building	A habitable room; retail or commercial space; factory or warehouse; basement providing car parking space, building services or equipment; or enclosed car park or enclosed garage.
Bypass Flow	That portion of the flow on a road or in a channel which is not collected by a gully inlet or field inlet, and which is redirected out of the system or to another inlet in the system.
Channel Freeboard	Vertical distance between the design water surface elevation in an open channel and the level of the top of the channel bank.

Climate Change	Changes in the earth's climatic conditions as a result of natural and human activities.
Coastal Management Area	The area of land covering: • 40 metres landward from MHWS where there is no approved revetment wall; and • 10 metres landward from the seaward edge of an approved revetment wall. It is noted that State Marine Parks generally extend to HAT.
Coefficient of Runoff	A dimensionless coefficient, used in the Rational Method for the calculation of the peak rate of storm runoff.
Consequence	Outcome or impact of an event.
Constructed Wetlands	A shallow pool of water, characterised by extensive areas of emergent aquatic plants/macrophytes, designed to support a diverse range of micro-organisms and plants associated with the breakdown of organic material and trapping of nutrients. Wetlands may be designed as permanent wet basins (perennial), or ephemeral systems.
Critical Depth	The depth occurring in a channel or part full conduit at a condition of flow between subcritical and supercritical flow, such that the specific energy is a minimum for the particular flow per unit width.
Critical Flow	The condition of flow in a section of a channel or part full conduit when the flow is at critical depth.
Critical Velocity	The average velocity of flow in a section of a channel or part full conduit when the flow is at critical depth.
Cross Drainage	A system of pipes or culverts which convey storm flows transversely across or under a roadway.
Defined Flood Event	The flood event adopted by a local government for the management of development in a particular locality. It defines the natural hazard management (flood) area. It does not define the extent of flood-prone land.
Detention Basin	A large, open, free draining basin that temporarily "detains" collected stormwater runoff. These basins are normally maintained in a dry condition between storm events.
Development Category	Refers to the land use within a catchment. A specific "fraction impervious" and drainage design standard is usually defined for a given development category.
Drainage Catchment	The area of land contributing stormwater runoff to

the point under consideration.

Drainage System A system of gully inlets, pipes, overland flow paths, open channels, culverts and detention basins used to convey runoff to its receiving waters.

Enclosed GPTs A fully enclosed trash rack and/or sediment collection sump usually located at or near the end of a stormwater pipe.

Exfiltration Systems Large underground stormwater detention tanks/pit from where stormwater is allowed to infiltrate into the surrounding soil. An infiltration trench is just one type of exfiltration system.

Extended Detention A stormwater detention basin or tank designed to drain over a period of "days" rather than "hours" to enhance its pollution retention and solar treatment while minimising the adverse effects of coincident flooding downstream of the basin.

Extreme Flood The rare flood event for which the performance of a detention basin or similar structure should be checked in order to assess the economic and social risk that could be associated with overtopping or failure of that structure.

Filter Basin Large excavated stormwater retention basin incorporating a sand filter bed. Filter systems primarily drain to surface waters or a piped drainage system, rather than rely on soil infiltration.

Filter Strips Grassed slopes with an even-gradient across the slope used to filter and infiltrate "sheet" flow. They must be absent of any drainage depressions that may concentrate flow. Also known as buffer zones. They differ significantly from the "Grassed Filter Strips" used in construction-site sediment control.

Floating Boom A floating boom with mesh skirt anchored across a permanently wet channel, creek or river. Originally designed as an oil slick retention device, the boom collects floating or partially submerged objects.

Floating GPT A partial channel-width floating boom directing floating litter and debris into a floating pollutant retention cage.

Flood The temporary inundation of land by expanses of water that overtop the natural or artificial banks of a watercourse, including a drainage channel, stream, creek, river, estuary, lake or dam, and any associated water holding structures.

Flood water	Those waters causing land to flood.
Floodplain	A floodplain is defined as the extent of land inundated by the Probable Maximum Flood.
Floodway	That part of the floodplain specifically designed to carry flood flows and ideally capable of containing the "Defined Flood Event".
Fraction Impervious	That part of a catchment which is impervious, expressed as a decimal or percentage.
Freeboard	The difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation. (See also Channel Freeboard).
Frequency Factor	A factor which is multiplied by the coefficient of runoff for the 10 year ARI to determine the coefficient of runoff for the design ARI, for the location being considered.
Friction Slope	Sometimes referred to as the hydraulic gradient or pressure gradient and is the slope of the line representing the pressure head, or piezometric head in a pipeline.
Grass Swale	Shallow, low-gradient, grass-lined overland flow path used primarily for stormwater treatment.
Grate Inlet Screen	Typically a coarse screen placed across the face of a roadside kerb inlet to filter gross pollutants from stormwater. Pollutants are retained on the screen for later collection usually by a street sweeper.
Half-Bankfull Discharge	The channel flow rate that exists when the water level is midway between the channel invert and the elevation of the channel bank above which water begins to spill out onto the floodplain.
Hazard	A source of potential harm.
Head Loss Coefficient	A dimensionless coefficient which, when multiplied by the velocity head in the outlet pipe, gives the difference in hydraulic grade level between inlet and outlet pipe. It may be positive (indicating that the H.G.L. rises upstream) or negative (indicating that the H.G.L. is less upstream).
High Level Basin Outlet	The outlet of a detention or retention storage system provided for discharges that exceed the capacity of the low level outlet.

Hydraulic Design	The component of drainage design that involves the determination of velocities, heads and water levels as storm runoff passes through the drainage system.
Hydraulic Grade Line	A line representing the pressure head along a pipeline, corresponding to the effective (free) water surface elevation in the piped portions of the stormwater drainage system.
Hydraulic Gradient	The slope of the hydraulic grade line - see also Friction Slope.
Hydraulic Radius	The ratio A/P, A being the cross-sectional area and P the wetted perimeter – that is, the length of the line of contact (on the cross section) between the water and the channel boundary.
Hydrologic Design	The component of drainage design that involves determination of stormwater runoff, either discharge or volume.
Impervious Surface (Impervious Area)	A surface or area within a drainage catchment where the majority of rainfall will become runoff i.e. no infiltration e.g. roadways, car parks, roofs etc.
Infiltration Basin	Large, excavated basins designed to retain storm flows, allowing infiltration and evaporation.
Infiltration Trench	An excavated pit filled with uniform gravel or rock into which runoff is directed for short to medium-term detention before finally infiltrating into the surrounding soil. The surface of the trench is usually vegetated.
Intensity-Frequency-Duration Data (I.F.D.)	Basic rainfall data used in the calculation of rainfall runoff rates.
Integrated Catchment Management (ICM)	Managing natural resources within a “whole of system” approach. In a stormwater context, this requires a whole of catchment approach incorporating the total water cycle. Consideration is given to all associated land and water processes and values.
Junction Structure	A manhole, pit or chamber constructed at the junction of two or more pipes, or at a change of grade.
Land Use (Development Category)	The particular use or uses (actual or allowable) of land within a catchment.

Large Detention Storage	A large detention or retention storage such as a lake, pond, basin or large car park designed or able to significantly reduce and attenuate the peak discharge from a catchment.
Lawful Point of Discharge	A point of discharge which is either under the control of a Local Authority or Statutory Authority, or at which discharge rights have been granted by registered easement in favour of the Local Authority or Statutory Authority, and at which discharge from a development will not create a worse situation for downstream property owners than that which existed prior to the development.
Likelihood	Probability or frequency of an event.
Litter Basket	An in-pipe litter and debris collection basket installed within junction pit of a piped stormwater drainage system.
Local Authority	Any local or regional external authority—whether government or non-government, including local governments and the State Government—that has a legal interest in the regulation or management of a given activity, or the land on which the activity is occurring, or is proposed to occur. Reference to “the local authority” shall also imply the plural.
Local Government	The local city or shire council with jurisdiction over the land in which the activity in question is occurring, or is proposed to occur.
Low Level Basin Outlet	The outlet of a detention/retention storage from which discharge will first occur (usually via a pipe).
Major Design Storm	The rainfall event for the ARI chosen for the design of the Major Drainage System.
Major Drainage System	That part of the overall drainage system which conveys flows greater than those conveyed by the Minor Drainage System and up to and including flows from the Major Design Storm.
Major Overland Flow Path	An overland flow path that drains water from more than one property, has no suitable flow bypass, and has a water depth in excess of 75mm during the major design storms; or is an overland flow path recognised as “significant” by the local government.
Major Road	A road whose primary function is to serve through traffic. These roads include Collector Roads, Sub-Arterial and Arterial Roads. Refer to Department of Main Roads or AustRoads for further definition.

Manning's Roughness Coefficient	A measure of the surface roughness of a conduit or channel to be applied in the Manning's equation.
Mini Wetland	Small, usually ephemeral wetlands, usually located adjacent stormwater outlets or in association with a landscaped area. Mini wetlands differ from bio-retention cells in that they may or may not incorporate stormwater retention (though it is preferred) and they do not rely on sub-surface filtration due to the typical long-term saturation of the clayey soil bed.
Minor Design Storm	The rainfall event for the ARI chosen for the design of the Minor Drainage System.
Minor Drainage System	That part of the overall drainage system which controls flows from the Minor Design Storm e.g. kerbs and channels, inlets, underground drainage etc. for the purpose of providing pedestrian safety and convenience, and vehicle access.
Minor Road	A road whose primary function is to provide access to abutting allotments. These roads include Residential Streets. Refer to Department of Main Roads (Access or Local Roads, max. 1000 vpd) or AustRoads for further definition.
Oil & Grit Separator	Generally a two or three chamber underground retention tank designed to remove hydrocarbons, floating pollutants, coarse sediment and grit. The first chamber is used for sedimentation and the collection of large debris. The second chamber is used for oil separation. The third chamber (if used) collects and disperses flow into the stormwater system.
On-Site Detention (OSD)	A relatively small open basin or enclosed stormwater tank fully contained within a single allotment or group-title allotment.
Open GPT	Combined sediment basin and trash rack usually located at the downstream end of a stormwater pipe or constructed drainage channel.
Outlet Litter Cage	Solid trash and litter collection cage attached to the outlet of a stormwater pipe which screens gross pollutants from stormwater holding the pollutants within the cage usually elevated above normal water level.

Overland Flow Path	Where a piped drainage system exists: it is the path where storm flows in excess of the capacity of the underground drainage system would flow. Where no piped drainage system or other form of defined watercourse exists: it is the path taken by surface runoff from higher parts of the catchment to a watercourse, channel or gully. It does not include a watercourse, channel or gully with well defined bed and banks.
Pervious Surface (Pervious Area)	A surface or area within a drainage catchment where some of the rainfall will infiltrate thus resulting in a reduced volume and rate of runoff e.g. grassed playing fields, lawns etc.
Pollution Containment System	Typically an open, non-draining pond designed to capture pollution spills from traffic accidents. The trapped pollution is usually pumped from the system and removed from the area in tankers for off-site treatment and disposal. Stormwater detention/retention systems may operate as Pollution Containment Systems if the outlet system is suitably designed to allow quick shut down (usually through the use of a gate or stop boards) by emergency services or maintenance personnel.
Pond (stormwater treatment)	Large, open water treatment ponds often incorporating a heavily vegetated macrophyte (wetland) area.
Porous Pavement	Formally constructed porous, light-traffic pavements that allow runoff to infiltrate into the underlying soil or a sub-surface drainage system.
Pressure Change Coefficient	Refer to Head Loss Coefficient.
Probable Maximum Flood	The theoretically greatest runoff event from a particular drainage basin.
Probable Maximum Precipitation	The theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage basin.
Regulating Authority	Local Authority involved in the regulation of an industry or land use practice.

Release Nets	A litter collection net attached to a stormwater pipe outlet used to filter gross pollutants (excluding sediment) from stormwater. A release system allows the net to break free of the pipe outlet in the case of excessive hydraulic pressure caused by extreme flows or debris blockage of the net. A tether is used to secure the net to the outlet so that the released net and its captured pollutants do not wash downstream.
Retardation System	Any detention, extended detention or retention system, including on-site detention systems and rainwater tanks.
Retention Basin	A large, open, partially free draining basin designed to retain a portion of the storm runoff either for water quality treatment benefits, or to assist in reducing the effective volume of runoff. The free-draining portion of the basin may be designed to operate as a traditional detention or extended detention system.
Retention System	Any stormwater collection systems that "retains" stormwater runoff for water supply, replenishment of lake or wetland water, or as a long-term groundwater infiltration.
Risk	The chance of something happening that will have an impact on objectives. It is measured in terms of a combination of the consequences of an event and their likelihood.
Runoff	That part of rainfall which is not lost to infiltration, evaporation, transpiration or depression storage.
Sand Filter	Excavated pit or structure filled with a filter sand medium through which stormwater is allowed to pass. The filtered runoff is then collected by a drainage system and discharged. Filter systems primarily drain to surface waters or a piped drainage system, rather than rely on soil infiltration.
Sedimentation Basin	A permanent sediment collection basin as opposed to a temporary construction site "sediment basin". A tank or basin designed for low-velocity, low-turbulent flows suitable for settling coarse sediment particles from stormwater runoff.
Side Entry Pit Trap	Debris baskets placed within the collection pit of roadside gully inlets. The baskets are installed below the invert of the gutter.
Small Detention Storage	A small detention or retention storage such as a small car park or underground storage tank designed or able to reduce and attenuate the peak discharge from a catchment.

Specific Energy	The energy per unit weight of water at any section of a channel or part full conduit measured with respect to the invert or bottom of the channel or conduit.
Structural Soil	A surface soil profile which combines either synthetic or natural materials with in-situ soils to improve the strength or trafficability of the soil. Ongoing soil compaction is reduced which allows grassed surfaces to withstand light traffic.
Subcritical Flow	Flow in a channel or conduit which has a depth greater than the critical depth and a velocity less than the critical velocity.
Supercritical Flow	Flow in a channel or conduit which has a depth less than the critical depth and a velocity greater than the critical velocity.
Surcharge Outflow or Overflow	That portion of the flow which is forced out of a piped system at a kerb inlet, manhole or surcharge structure when the capacity of the downstream pipe system is exceeded.
Tidal Definitions:	
(a) Highest Astronomical Tide (HAT)	Highest tide level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions.
(b) Lowest Astronomical Tide (LAT)	Lowest tide level which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions.
(c) Mean High Water Springs (MHWS)	The long term average of the heights of two successive high tides when the range of tide is greatest, at full moon and new moon.
(d) Mean Low Water Springs (MLWS)	The long term average of the heights of two successive low tides when the range of tide is greatest, at full moon and new moon.
(e) Mean High Water Neaps (MHWN)	The long term average of the heights of two successive high tides when the range of tide is the least, at the time of the first and last quarter of the moon.
(f) Mean Low Water Neaps (MLWN)	The long term average of the heights of two successive low tides when the range of tide is the least, at the time of the first and last quarter of the moon.
(g) Mean Sea Level (MSL)	The average level of the sea over a long period.

(h) Storm Surge	The increase in sea level occurring during a cyclone or severe storm resulting from the combined effect of reduced atmospheric pressure and the build up of water against the shore caused by onshore wind (wind stress).
(i) Wave Setup	The raising of sea level inside the surf zone resulting from the momentum flux of broken waves.
Transition Loss Coefficient	Coefficient associated with head losses at open channel transitions.
Trash Rack	A series of metal bars located across a stormwater channel or pipe to trap litter and debris. The bars may be vertical or horizontal depending on hydraulic and environmental requirements (eg. fish passage issues), and may or may not be inclined to the horizontal.
Treatment train	A series of water quality treatment systems through which contaminated water flows and is treated where the treatment systems vary in both the type of treatment (ie. settlement, filtration, infiltration, adsorption) and the standard of treatment (ie. the equivalent of primary, secondary and tertiary wastewater treatment standard).
Velocity Head	A measure of the kinetic energy of flow in a pipe or channel and equal to ($V^2/2g$) where V is the average velocity of flow.
Volumetric Runoff Coefficient	The ratio of the volume of stormwater runoff to the volume of rainfall that produced the runoff. Different coefficients will be obtained when analysing single storm events compared to the assessment of the average annual runoff.
Water Sensitive Urban Design (WSUD)	A set of design elements and on-ground solutions that aim to minimise impacts on the water cycle from the built urban environment. It offers a simplified and integrated approach to land and water planning by dealing with the urban water cycle in a decentralised manner consistent with natural hydrological and ecological processes.
Water Surface Elevation (WSE)	The elevation of the water surface reached in a gully inlet, manhole or junction structure.
Water Surface Superelevation	The phenomenon where flow around a horizontal curve in an open channel is at a higher level at the outer edge than at the inner edge of the curve.

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1.00 Introduction

1.01 Use of the manual

This Manual has been prepared for the purpose of assisting engineers and designers in the planning and design of urban stormwater systems within Queensland. Reference to this document as a "Manual" should not infer that it is anything more than an engineering guideline.

The procedures outlined in the Manual should continue to encourage uniformity in urban drainage design practice throughout Queensland. Designers are nevertheless responsible for conferring with relevant local authorities to determine local design requirements.

The aim of the Manual is to provide details of technical and regulatory aspects to be considered during the planning, design and management of urban stormwater drainage systems, and to provide details of appropriate design methods and computational procedures. Both hydrologic and hydraulic procedures are considered as well as environmental and legal aspects.

The hydrologic procedures provided in the Manual are considered appropriate for small catchments of up to 500 hectares. These procedures are generally not considered appropriate for the determination of design flood levels along vegetated (i.e. non-grassed) waterways. Readers should refer to the latest version of Australian Rainfall and Runoff (ARR) for guidelines on:

(i) the assessment of urban catchments larger than 500 hectares;

(ii) determination of design flood levels along vegetated waterways.

Use of this Manual requires professional interpretation and judgement to ensure the guidelines are appropriately adapted to local conditions. The document is not a recipe book for persons acting outside their field of competence or experience. Users of the document must make informed decisions regarding the extent to which the guidelines are applied to a given situation, including appropriate consideration of local conditions and local data.

Throughout this document, use of the term "should" shall imply that all reasonable and practicable measures must be taken to achieve the intent/outcome of the clause in question. If the clause refers to an action or task, then an alternative solution may be adopted provided it has an outcome or performance at least equivalent to that presented in the clause. Where it is not considered reasonable or practicable to achieve the intent/outcome, the designer may be required to provide—to the satisfaction of the regulating authority—justification for the decision.

The Manual is not to be regarded as prescriptive. There will be circumstances and conditions where designers will need to adopt alternative design procedures, or innovative methods, commensurate with accepted engineering and scientific practice.

Regulating authorities may require designers to certify that they have designed and documented their proposed stormwater systems in accordance with this Manual, or at least to a standard no less than that presented in the Manual.

This Manual does not address catchment or regional planning, or provide detailed procedures for the design of stormwater treatment systems, waterway rehabilitation, or Natural Channel Design (NCD).

The reader should refer to the *Glossary of Terms* for the distinction this document makes between the terms "regulating authorities", "local authorities" and "local governments". In most case the term "local authority" will refer to either the local government or the State Government depending on which body has jurisdiction over specific activities on the land. Readers should also refer to the Glossary for the definition of a wide range of common industry related terms used within the Manual.

Any general reference to an external guideline, document or publication shall infer reference to the latest version of that publication or its replacement document.

1.02 Consideration of regional factors

An endeavour has been made in the preparation of this Manual to make it applicable across the wide variety of geologic and climatic conditions existing throughout Queensland. Issues that may influence the appropriate application of this Manual to local conditions include:

(i) local community expectations and their relative tolerance of drainage and flooding issues;

(ii) variations in the design standards specified by the various local governments;

(iii) a local government's ability, preference and willingness to fund various stormwater infrastructure construction, operational and maintenance activities;

(iv) regional climatic factors;

(v) the types of receiving environments, including variations in ecological characteristics;

(vi) geologic/soil conditions, e.g. natural nutrient sources and sinks, and variations in stormwater infiltration rates;

(vii) variations in pollutant runoff rates (collection and use of local data is always preferred);

(viii) variations in local building regulations and architectural design;

(ix) historic factors and the success of specific past practices within a given region.

1.03 Objectives of urban stormwater management

The primary aim of an urban stormwater management system is to ensure stormwater generated from developed catchments causes minimal nuisance, danger and damage to people, property and the environment. This requires the adoption of a multiple objective approach, considering issues such as (ARMCANZ and ANZECC, 2000):

- ecosystem health, both aquatic and terrestrial;
- flooding and drainage control;
- public health and safety;
- economic considerations;
- recreational opportunities;
- social considerations;
- aesthetic values.

The above issues may be developed into a list of broad stormwater management *Objectives*. All of the objectives presented below may not be relevant in all circumstances and individual objectives may be expanded to highlight site-specific issues.

(a) Protect and/or enhance downstream environments, including recognised social, environmental and economic *values*, by appropriately managing the quality and quantity of stormwater runoff.

(b) Limit flooding of public and private property to acceptable or designated levels.

(c) Ensure stormwater and its associated drainage systems are planned, designed and managed with appropriate consideration and protection of community health and safety standards, including potential impacts on pedestrian and vehicular traffic.

(d) Adopt and promote "water sensitive" design principles, including appropriately managing stormwater as an integral part of the total water cycle, protecting natural features and ecological processes within urban waterways, and optimising opportunities to use rainwater/stormwater as a resource.

(e) Appropriately integrate stormwater systems into the natural and built environments while optimising the potential uses of drainage corridors.

(f) Ensure stormwater is managed at a social, environmental and economic cost that is acceptable to the community as a whole and that the levels of service and the contributions to costs are equitable.

(g) Enhance community awareness of, and participation in, the appropriate management of stormwater.

These objectives may need to be addressed in a number of different contexts depending on the degree of past changes and the potential for future change. Such contexts would include the following:

- *retaining* or *restoring* natural stormwater systems;
- *rehabilitating* existing stormwater systems to ecologically sustainable, but not necessarily natural, systems;
- *creating* new, ecologically sustainable, stormwater systems within heavily modified environments.

Stormwater managers and designers should be aware that the establishment of engineered infrastructure—whilst still central to the delivery of stormwater management outcomes—is not the entire picture. There is a much wider range of measures that are used in addressing stormwater management issues (such as community education and enforcement of regulations) to ensure objectives are met, particularly in respect to water quality. This wider range of measures make-up an overall *Stormwater Management Strategy* (refer to Section 2.02).

The planning and design of stormwater management systems must appropriately integrate the following management philosophies:

(a) Integrated Catchment Management (ICM)

(b) Ecologically Sustainable Development (ESD)

(c) Water Sensitive Urban Design (WSUD)

(d) Construction site Erosion and Sediment Control (ESC)

(e) Best Management Practice (BMP)

Stormwater planners also need to ensure they meet the expectations of higher levels of government expressed through State legislation and national agreements such as the National Water Initiative and the National Framework for the Management of Water Quality, including stormwater management, which is presented within the National Water Quality Management Strategy (NWQMS).

Stormwater designers should also seek to manage several key design parameters in order to achieve the design objectives as outlined in Table 1.03.1.

Table 1.03.1—Key stormwater parameters and desired outcomes

Parameter	Desired Outcomes
Drainage	• Public health (e.g. mosquito control) • Pedestrian and vehicular safety • Minimisation of storm-related nuisance to public
Infiltration	• Runoff volume control • Delivery of high-quality, dry-weather and post-storm inflows to urban waterways through the maintenance of natural groundwater levels
Runoff volume	• Control of bed and bank erosion in waterways • Reduction in annual pollutant load to waterways • Optimum use of stormwater as a resource • Protection of aquatic ecosystems within receiving waters
Peak discharge	• Flood control • Minimisation of legal disputes between neighbouring landowners and communities • Control of bed and bank erosion in waterways
Flow velocity	• Pedestrian and vehicular safety • Control of bed and bank erosion in waterways • Protection of aquatic ecosystems within receiving waters
Flow depth	• Flood control • Pedestrian and vehicular safety • Minimisation of storm-related nuisance to public
Water quality	• Protection of aquatic ecosystems and public health • Optimum use of stormwater as a resource • Structural integrity of urban waterways through the control of sediment inflow
Aesthetics	• Appropriate integration of stormwater systems into the natural and built environments, including the retention of natural drainage systems • Protection/restoration of environmental values
Infrastructure & maintenance cost	• Acceptable financial cost • Sustainable operational and maintenance requirements

1.04 Integrated catchment management

Integrated Catchment Management (ICM) incorporates catchment-wide relationships between resource use and management. It embraces (ARMCANZ and ANZECC, 2000):

- a holistic approach to natural resource management within catchments, marine environments and aquifers, with linkages between water resources, vegetation, land use, and other natural resources recognised;
- integration of social, economic and environmental issues;
- co-ordination of all the agencies, levels of government and interest groups within the catchment; and
- community consultation and participation.

Stormwater management should consider the hydrologic, geomorphologic ecologic, soil, land use and cultural characteristics of a catchment and its watercourse network.

1.05 Ecologically sustainable development

Ecologically Sustainable Development (ESD) aims to meet the needs of existing communities, while conserving ecosystems for the benefit of future generations. This is achieved by designing management systems and new developments that improve the total quality of life in a way that maintains the ecological processes on which life depends.

While there is no universally accepted definition of ESD, in 1990 the Commonwealth Government suggested the following definition for ESD in Australia:

'Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.'

The principles of ESD as outlined in ARMCANZ and ANZECC (2000) are:

(a) The precautionary principle. Namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

(b) Inter-generational equity. The present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

(c) Conservation of biological diversity and ecological integrity. Conservation of biological diversity and ecological integrity should be a fundamental consideration.

(d) *Improved valuation, pricing and incentive mechanisms. Environmental factors should be included in the valuation of assets and services.*

1.06 Water sensitive urban design

Water Sensitive Urban Design (WSUD) is a holistic approach to the planning and design of urban development that aims to minimise negative impacts on the natural water cycle and protect the health of aquatic ecosystems. It promotes the integration of stormwater, water supply and sewage management at the development scale. The principles of WSUD are to:

- Protect existing natural features and ecological processes.
- Maintain natural hydrologic behaviour of catchments.
- Protect water quality of surface and ground waters.
- Minimise demand on the reticulated water supply system.
- Minimise sewage discharges to the natural environment.
- Integrate water into the landscape to enhance visual, social, cultural and ecological values.

It is recommended that the principles of WSUD be applied wherever practical to “greenfield” urban developments as well as to infill developments and urban redevelopment programs.

1.07 Erosion and sediment control

This Manual does not present guidelines on the design and application of Erosion and Sediment Control principles for construction and building sites; however, the importance of these pollution control measures to stormwater quality is recognised.

The need to protect permanent stormwater treatment systems from the adverse effects of sediment runoff during the construction phase of new development is also recognised as *critical* if these systems are to perform as designed.

1.08 Best management practice

Best Management Practice (BMP) refers to the design, construction and financial management of an activity which achieves an ongoing minimisation of the activity’s environmental harm through cost effective measures assessed against the measures currently used nationally and internationally for the activity.

BMP in stormwater quality management includes a broad range of treatment measures from those with a highly predictable performance outcome, to those that can be assumed to be beneficial, but for which a clear and predictable performance outcome has yet to be developed.

As noted previously in Section 1.05, *‘if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental* *degradation.'* Adoption of current Best Management Practice is required to ensure the delivery of an acceptable stormwater management system.

1.09 Principles of stormwater management

The recommended *Objectives* of an urban stormwater management system are presented in Section 1.03. The following discussion expands on those objectives to develop a set of key *Principles* that outline the current (2007) approach to the management of urban stormwater.

The following principles are presented as an overview and have been provided for educational purposes. It is not possible to outline which of the principles must be applied within the design of every stormwater system. The appropriate application of these principles requires experience and professional judgement. For example, even though it is highly desirable to ensure that the maintenance requirements and costs of a stormwater system are sustainable, it is not reasonable to expect a stormwater designer to conduct a detailed financial and technical capabilities study of the proposed asset manager (usually the local government) prior to designing the system. Also, in many cases the responsibilities of the designer will be limited by the requirements of the various design codes adopted by the local authority.

However, the above discussion does not negate the expectation that the designer will adopt a professional approach and seek such additional information from the local authority and/or client as necessary to facilitate a thorough design. For example, the designer should seek resolution of any unspecified parameters or issues considered relevant to the outcome of the design.

(a) Protect and/or enhance downstream environments, including recognised social, environmental and economic *values*, by appropriately managing the quality and quantity of stormwater runoff.

(i) <u>*Minimise changes to the quality and quantity of the natural flow regime of urban waterways.*</u>

The focus of stormwater management should not concentrate solely on the control of flow velocity and peak discharge, but also on minimising changes to a catchment's natural water cycle—including the volume, rate, frequency, duration and velocity of stormwater runoff.

By minimising changes to runoff volume and thereby minimising changes to the natural water cycle, the following economic, ecological and social benefits are likely to be gained:

- reduced pollutant runoff;
- reduced risk of increases in downstream flooding;
- reduced risk of accelerated erosion within urban waterways;

- reduced cost of providing stormwater detention systems for the control of post-development discharges;
- improved health of aquatic ecosystems through the replenishment of natural groundwater supplies;
- reduced demand on the provision of new potable water supplies through the use of stormwater as a secondary (non-potable) water supply.

(ii) *Identify and control the primary sources of stormwater pollution.*

The selection and design of stormwater treatment systems needs to be based local data that adequately reflects local conditions, land use practices and community values. The focus should firstly be on assessing and/or ranking the threats to the identified local values, then developing treatment systems commensurate with *actual* rather than *perceived* risks.

In most urban environments the greatest threat to stormwater quality will usually be associated with:

- Stormwater runoff from soil disturbances such as building and construction sites. On a site-by-site basis this may be a short-term activity, but across a developing catchment it can represent a long-term threat.
- Stormwater runoff from roads and car parks, particularly those areas where there is significant *turning* and *braking* by motor vehicles, such as off ramps, intersections and roundabouts.

(iii) *Develop stormwater systems based on a preferred management hierarchy.*

The preferred hierarchy for the selection of stormwater management practices is:

- Retain and restore (if degraded) existing valuable elements of the natural drainage system, such as natural channels, wetlands and riparian vegetation.
- Implement source control measures using non-structural techniques to limit changes to the quality and quantity of stormwater at the source of change.
- Implement source control measures using structural techniques to limit changes to the quality and quantity of stormwater at or near the source of change.
- Install in-system constructed management techniques installed within stormwater systems to manage stormwater quality and quantity prior to discharge into receiving waters.

(iv) *Develop robust stormwater treatment systems that do not rely on a single treatment system or focus on a single target pollutant.*

To achieve the best results, stormwater quality treatment systems should always be part of a comprehensive approach to controlling stormwater pollution. Such an approach would include regulation and enhanced community awareness, as well as structural controls.

Wherever practical, stormwater treatment systems should incorporate diversity so that the failure of one type of treatment system does not mean total system failure.

Stormwater treatment systems should also incorporate an appropriate balance of primary, secondary and tertiary treatment measures (refer to Section 11.04.3 – *Structural Controls*) so that the system is capable of working efficiently on a variety of pollutants over a wide range of typical storm intensities.

(b) Limit flooding of public and private property to acceptable or designated levels.

(i) *Preserve the alignment and capacity of major drainage corridors such as waterways and major overland flow paths.*

A fundamental consideration in the management of the flood risk to people and property is the preservation of major overland flow paths. Drainage corridors require space, and must be recognised as a legitimate "land use" that needs to be recognised during the planning of new urban developments and the redevelopment of existing areas.

(c) Ensure stormwater and its associated drainage systems are planned, designed and managed with appropriate consideration and protection of community health and safety standards, including potential impacts on pedestrian and vehicular traffic.

(i) *Establish and maintain a safe, affordable and socially equitable and acceptable level of urban drainage and flood control.*

Management objectives for the minimisation of public health and safety risks can include:

- Designing urban drainage systems to minimise the existence of dangerous waters and the risk of people entering or being trapped within such waters.
- Minimise the risk of injury to the public and asset managers resulting from the operation and maintenance of stormwater systems.
- Minimising public risks associated with such things as mosquitos and water-borne diseases.

(d) Adopt and promote "water sensitive" design principles, including appropriately managing stormwater as an integral part of the total water cycle, protecting natural features and ecological processes within urban waterways, and optimising opportunities to use rainwater/stormwater as a resource.

(i) *Minimise the quantity of directly connected impervious surface area***.**

There is growing evidence (Maxted & Shaver, 1996 and Walsh, et.al. 2004) linking the risk to aquatic wildlife in urban waterways to the degree of directly connected impervious surface area.

Minimising the total impervious surface area helps to reduce changes to the natural water cycle, pollutant runoff rates and the cost of providing stormwater management systems.

The adverse effects of increased impervious surface area can be further mitigated by minimising those areas that have a direct connection to an impervious drainage system. Surrounding impervious surfaces with a porous surface will reduce pollutant runoff, increase stormwater infiltration, and improve the quantity and quality of dry weather flows within urban streams through improved groundwater inflows. Where practical, stormwater runoff from roads and roofs should first pass as *sheet flow* over a grassed surface before being concentrated within a drain, whether or not the drain is lined with pervious or impervious materials.

(ii) *Identify and optimise opportunities for stormwater to be valued and used as a resource.*

Stormwater planning should be integrated with water supply and wastewater strategies during the planning and design of urban developments in a manner that uses water in a resource sensitive and ecologically sustainable manner.

Better management of the water cycle, both within a local and regional context, needs to be achieved to reduce demand on traditional water supplies. Where circumstances allow, urban stormwater can be used to recharge aquifers provided groundwater quality is protected. This requires very careful management as potential issues include rising water tables, salinity problems and disputes over groundwater extraction rights.

The *natural* stormwater drainage system can also provide social, environmental and economic resources. The loss or modification of natural urban streams can adversely affect the amenity of surrounding areas, ecological health and water quality.

(iii) *Maintain and protect natural drainage systems and their ecological health.*

The traditional focus of stormwater management has broadened to include issues of aquatic ecosystem and waterway health, including environmental flows, channel stability and the protection of riparian values.

Wherever practical, natural drainage channels and flow corridors should be preserved and/or rehabilitated to maintain the natural passage and flow times of stormwater through a catchment.

Effective protection of the natural drainage system and its ecological health not only relies on maintaining the pre-development catchment hydrology and pollutant export rates, but also on:

- maximising the value of indigenous riparian, floodplain and foreshore vegetation; and
- maximising the value of physical habitats to aquatic fauna within the stormwater system.

It is noted that the control of building/construction site soil erosion and sediment runoff is **essential** for the sustainable management of most natural drainage systems. Local Governments wishing to embrace the principles of *Natural Channel Design* must be prepared to actively control sediment runoff from building and construction sites.

(e) Appropriately integrate stormwater systems into the natural and built environments while optimising the potential uses of drainage corridors.

(i) *Ensure adopted stormwater management systems are appropriate for the site constraints, land use and catchment conditions.*

Stormwater management practices should reflect proposed land use practices, climatic conditions, soil properties, site constraints, identified environmental values, and the type of receiving waters.

Certain land uses produce concentrations of specific stormwater pollutants, thus requiring the adaptation of specialist stormwater treatment systems that may not be as effective in other areas of the catchment.

Certain receiving waters may also be sensitive to certain pollutant inflows, thus requiring a further refinement to the list of preferred stormwater management systems. As a general guide, large receiving water bodies, such as lakes, rivers and bays, benefit from any and all measures that reduce total pollutant loads, independent of when the pollutant runoff occurs. On the other hand, small receiving water bodies, such as ponds, wetlands and creeks, greatly benefit from stormwater systems that produce:

- high quality inflows during regular minor storm events; and
- persistent high quality groundwater inflows during the days or weeks following the less frequency moderate to major storm events.

Maintaining the natural infiltration rates of rainwater into the catchment soils can greatly benefit the ecological health of urban creek systems by helping to maintain natural groundwater inflows into these creeks. Thus the design of the stormwater system must reflect local soil conditions and their natural infiltration rates.

(ii) *Appropriately integrate both wildlife and community land use activities within urban waterway and drainage corridors.*

Waterways and drainage corridors can represent the most abundant, if not important, wildlife (terrestrial and aquatic) habitat areas and movement corridors within the urban landscape. These *values* can be greatly diminished if not appropriately integrated with the human activities, both passive and active, planned for the area. The development of a inter-catchment Wildlife Corridor Map is a highly desirable prerequisite to the development of an Open Space Plan, Master Drainage Plan or Waterway Corridor Map.

Urban waterways can also represent important vegetation conservation areas sometimes requiring the protection of corridor width greater than that required for flood control.

(f) Ensure stormwater is managed at a social, environmental and economic cost that is acceptable to the community as a whole and that the levels of service and the contributions to costs are equitable.

(i) *Assess the economics of stormwater management systems on the basis of their full lifecycle costs (i.e. capital and operational costs).*

Stormwater management systems should be based on solutions that are economically sustainable.

Developers of new urban communities must give appropriate consideration to the anticipated ongoing maintenance (operational) costs of stormwater management systems even if they are not required to furnish such maintenance costs.

Similarly, asset managers, including local governments, must wherever practical give appropriate consideration to the capital cost of new stormwater systems and the equitable flow-on costs to the community, even if they are not responsible for the initial funding of the system.

(ii) *Ensure adopted stormwater management systems are sustainable.*

Stormwater designers have a responsibility, within reason, to ensure that their design can function effectively throughout their specified design life based on the financial and technical abilities of the proposed asset manager. Such consideration should include:

- safety of the operating personnel;
- availability of required maintenance equipment;
- the expected technical knowledge of the asset managers, especially for systems intended to remain in private ownership;
- the provision of suitable maintenance access.

Where practical, stormwater treatment systems should separate high-maintenance and low-maintenance systems so that the function and aesthetics of the low-maintenance systems are not compromised by the regular disturbance of adjacent high-maintenance systems.

(iii) *Ensure appropriate protection of stormwater treatment measures during the construction phase.*

Stormwater treatment measures, especially filtration and infiltration systems, need to be isolated or otherwise protected during the construction phase of urban development so that their ultimate function is not compromised by sediment or construction damage.

(g) Enhance community awareness of, and participation in, the appropriate management of stormwater.

(i) *Engage the community in the development of parameters for the development and evaluation of stormwater management solutions.*

Stormwater management should focus on a "value" system where the identified values are used to set priorities and rank design objectives. Community values are constantly changing and stormwater managers should ensure that the adopted values reflect both current and, to the maximum degree practical, expected future community values.

Community participation helps to (ARMCANZ and ANZECC, 2000):

- *identify strategies which are responsive to community concerns;*
- *explore problems, issues, community values and alternative strategies openly;*
- *increase public ownership and acceptance of proposed solutions;*
- *generate broader decision making perspectives not limited to past practices or interests;*
- *reflect the community's life style values and priorities.*

1.10 References

ARMCANZ and ANZECC. 2000, *Australian Guidelines for Urban Stormwater Management.* National Water Quality Management Strategy, prepared by Agriculture and Resources Management Council of Australia and New Zealand & Australian and New Zealand Environment and Conservation Council, Canberra. ISBN 0 642 24465 0

Maxted, J. and Shaver, E. 1996, *Stormwater Impacts on Aquatic Life and the Use of Retention Ponds for Mitigation*. Conference proceedings "Stormwater 96!", Brisbane 9th September 1996, International Erosion Control Association, and the Stormwater Industry Association.

Walsh, C.J., Leonard, A.W., Ladson, A.R. and Fletcher, T.D. 2004, *Urban Stormwater and the Ecology of Streams.* CRC for Freshwater Ecology/CRC for Catchment Hydrology.