DEVELOPMENT DESIGN SPECIFICATION

D5

STORMWATER DRAINAGE DESIGN

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Amendment Record for this Specification Part

This Specification is Port Macquarie-Hastings Council's edition of the AUS-SPEC generic specification part and includes Council's primary amendments.

Details are provided below outlining the clauses amended from the Council edition of this AUS-SPEC Specification Part. The clause numbering and context of each clause are preserved. New clauses are added towards the rear of the specification part as special requirements clauses. Project specific additional script is shown in the specification as italic font.

The amendment code indicated below is 'A' for additional script 'M' for modification to script and 'O' for omission of script. An additional code 'P' is included when the amendment is project specific.

Amendment Sequence No.	Key Topic addressed in amendment	Clause No.	Amendment Code	Author Initials	Amendment Date
0	New edition - Major rewording and reformatting for clarity	All	AOM	GC/CT	January 2009

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DEVELOPMENT DESIGN SPECIFICATION - D5
STORMWATER DRAINAGE DESIGN

5.1 INTRODUCTION

All drainage design and construction within the Port Macquarie-Hastings Council shall be in accordance with this Specification. It includes but is not limited to, construction, operation and maintenance of the following:

- Subdivisions and private developments,
- Council drainage works including road works,
- Drainage structures and surrounds,
- Earthworks, dams, lakes

This specification details information relating to the management of stormwater quantity requirements needed to accompany development applications (DAs), Section 68 applications and construction certificates (CC). Or in the case of Council or Authority works, Part V assessments and detailed engineering plans.

Note: Where AS 3500 does not apply this document shall be used.

5.1.1 General

Drainage design within the Port Macquarie-Hastings Council shall be in accordance with the provisions of *Australian Rainfall and Runoff, Volume 1 a guide to flood estimation, (2001)* unless varied by this specification.

Water Sensitive Urban Design (WUSD) methods shall be incorporated in all developments in accordance with the Australian Runoff Quality manual (ARQ) and Auspec D7 Stormwater Management.

Drainage design shall give consideration to the entire drainage catchment, not just the area included in the subdivision or development. Designers shall base the calculated peak flow on the full potential development of both the project site and upstream areas for normal flow situations as well as the overland flooding caused by pipe blockages, general flooding and high tailwater levels.

The design shall consider the effects of Climate Change. The Designer shall refer to DECC guideline document *Practical Considerations of Climate Change (2007).*

Prior to commencing detailed design, the Design must address the existing zoning and any foreseeable zoning changes to all the external catchment areas contributing to the drainage system within the subdivision or development. This may require consultation with the Council's planning and engineering departments.

5.1.2 Objectives

The general objectives of urban drainage design are:

- To control and manage all stormwater generated within the development;
- To control and manage all stormwater passing through the development from the surrounding catchment;

- To provide an effective legal point of discharge for all collected stormwater, from the development to a natural watercourse, Council drainage system or approved outfall; and
- To achieve these objectives without detrimentally affecting the environment, surface and subsurface water quality, groundwater infiltration characteristics, the adjoining landowners and other landowners near the drainage outlet and watercourses either upstream or downstream of the subdivision.
- To provide a safe and convenient environment for pedestrians and traffic.
- To incorporate principles of Ecological Sustainable Development (ESD).

5.2 STORMWATER MANAGEMENT PLANS

5.2.1 Objectives

The objectives of the Stormwater Management Plan are as follows:

- To develop conceptual stormwater management plans that meets council's stormwater drainage requirements.
- To ensure compliance with planning scheme, development consent and Development Control Plan (DCP) requirements, particularly where overlays exist;
- To ensure that adequate information is provided at initial planning stages to allow the orderly review of land development;
- To ensure that developments provide effective and economical infrastructure that service the area;
- To ensure that staged or multi-developer projects are able to be delivered in a safe, efficient and effective manner; and
- To ensure that infrastructure is planned for the full potential of development and that unnecessary duplication or over-sizing of infrastructure is avoided.

5.2.2 General

A Stormwater Management Plan will generally be required for all development with the only difference being the level of detail and complexity. Precinct or area Stormwater Management Plans will generally be required for any of the following developments:

- Where the land is subject to a **rezoning;**
- Multiple-staged subdivision development;
- Developments where neighbouring properties are potentially affected;
- Single staged subdivisions with more than 10 allotments; and
- Problem areas identified by council or where directed by Council.

A precinct or area Stormwater Management Plan may have already been prepared by others and consultation with the council is essential.

The Stormwater Management Plan shall generally be prepared by an experienced consultant appointed by the developer, or a group of developers. Council assistance may be given, however the Stormwater Management Plan shall be undertaken at the cost of the developer or developers.

Stormwater Management Plan should be submitted for review with a written report to the provisions in the DCP, and guidelines contained within AUSPEC.

Unless agreed otherwise, any submission and review of a Stormwater Management Plan may require a meeting with Council's planning and engineering staff. Relevant service authorities should be invited to attend this meeting.

5.2.3 Requirements

Any Stormwater Management Plan submitted for consideration by Council shall include the following:

- Existing surface level contours to Australian Height Datum (AHD) extending into all surrounding properties for no less than 10m;
- Existing features and adjoining property features that may impact upon the engineering design;
- Proposed surface level contours that will enable the development to be 'self-draining' during normal and minor system blockage conditions for up to and including the 1 in 100 year annual recurrence interval (ARI) event;
- General layout of allotments, indicating approximate size, range, shape and orientation of allotments;
- Overall road network and intersection concepts;
- Location and approximate size of public open space;
- Drainage and flooding provisions, including location and size of drainage reserves, and drainage retardation and treatment systems;
- Water Sensitive Urban Design philosophy; and

Engineering design requirements for a Stormwater Management Plan proposal are as follows:

- Surface flow paths must have practical and satisfactory destinations.
- Surface flow should be directed on road reserves or through Council's reserve.
- Surface flow paths should not be directed through property easements unless re-directed into piped systems. Surface flow paths re-directed through piped systems will only be considered in exceptional situations. In this instance, these systems shall be designed for the peak flow resulting from up to and including the 1 in 100 year ARI storm event.

In addition to the engineering information to be provided on the Stormwater Management Plan, additional information will be required in support of the proposal. This may include, but not be limited to the following:

- The management of both quantity and quality of stormwater. This includes stormwater arriving from upstream, passing through, and moving downstream from the site;
- Evidence of a written agreement from the adjoining owners to allow discharge via a registered easement(s);

5.3 DESIGN REQUIREMENTS

5.3.1 Objectives

The objectives of these design requirements are as follows:

- To ensure expediency for developers by providing clear guidelines regarding the engineering requirements of Council;
- To ensure that new and upgraded infrastructure is of consistent standard across the local government area (LGA);

- To ensure that the works are designed such that they will fulfil the purpose for which they are intended;
- To ensure that minimum design standards are achieved and that works meet Councils' legislative and Common Law obligations;
- To ensure that community amenity will be improved through development;
- To ensure that public and employee safety during and after construction is considered;
- To minimise drainage life cycle costs; and
- To ensure that maintenance requirements are considered at the planning and design stages.

5.3.2 General

Comprehensive design criteria included in AUSPEC conveys engineering requirements for the internal or external delivery of design, construction and acceptance of drainage infrastructure, while considering local conditions and the requirements of the Council.

For developer's representatives AUSPEC provides the basis for expedient acceptances for works built by Developers for incorporation into the infrastructure systems controlled by the Council.

DRAINS is preferred by Council for the design/analysis of stormwater drainage systems. Base data and rainfall files are available from Council for use within this program.

5.3.3 Developer's representatives

It is not the responsibility of the Council to design or supervise the construction of drainage infrastructure for private land development. It is the responsibility of the developer to engage suitably qualified and experienced personnel who will carry out these functions to the satisfaction of the Council.

The developer shall ensure that these persons:

- Possess a professional indemnity insurance policy that covers the necessary design, construction and supervision tasks and includes a provision for a maximum possible claim;
- Do not have a pecuniary interest with either the developer, or in the due completion of the works, and in particular that any such person is not responsible for the supervision and control of labour and material inputs into the development;
- Comply with the requirements of draft *DCP 17, Section 2.10*; and
    - Are acceptable to Council with a minimum of 5 years experience in the relevant engineering field.

Unless approved otherwise by the Council, all Council drainage designs and construction works shall be certified by an **Appropriately Qualified and Practicing Consultant**, experienced in the field or a company Director or Owner.

Unless approved otherwise by the Council, all subdivision drainage construction supervision shall be undertaken by an **Appropriately Qualified and Practicing Consultant**, experienced in the field or alternatively council may accept the certification by a company Director or Owner that construction works are suitable.

For the purpose of this specification, in all matters relating to the design of drainage works, the Designer shall be deemed to be the developer's representative.

For the purpose of this specification, in all matters relating to the construction and handover of the drainage works, the Developers Superintendent shall be deemed to be the developer's representative.

5.3.4 Variation from design guidelines

Any proposal to deviate from AUSPEC guidelines at any stage of the works shall be made in writing with supporting reasons and must be approved in writing by Council prior to commencement of any work involving the proposed variation. The Designer will be held responsible for the sufficiency of any such design variation.

It is the responsibility of the Designer to review any DA conditions and determine whether any engineering acceptance for design variation requires a modification to the DA conditions, and to arrange application to Council for development consent amendment, if required.

Variations approved for a particular development does not imply acceptance for other current or future proposals.

5.3.5 Design works commissioned by council

For drainage design works commissioned by Council all designs, engineering plans and documentation shall be submitted at three separate stages during the design process for review by Council's environmental engineering staff. Submissions shall comply with the following sections.

5.3.5.1 Concept Design Submission

Preliminary engineering plans are to be submitted to Council's environmental engineering staff for review. The submission must note key engineering assumptions specific to the proposed development. This submission can occur before or as part of a DA application (if applicable).

The in concept design submissions shall be in accordance with this specification. The Designer shall initially provide adequate data on the proposed drainage for the development to enable acceptance in principle to be issued by the Council.

Drainage Design: The submission shall include one hardcopy set (A3 plans) of the overall drainage strategy showing:

i. Total catchment area, nominated sub-catchment areas and co-efficient of runoff for each sub-catchment;

ii. Layout of proposed drainage systems with approximate sizes;

iii. Natural surface contour lines to the AHD;

iv. 1 in 100 year ARI flood levels where applicable;

v. Preliminary design contour lines to AHD;

vi. Nominated overland flow path for 1 in 100 year ARI storm events;

vii. Nominated drainage discharge point and any treatment concepts;

viii. Existing drainage services and proposed connection points to both existing and future developments; and

ix. Details of any staging of the development and impact on the drainage network.

It is expected that the concept design submission be accompanied by a concept design report outlining key engineering issues and their proposed treatment. Connectivity to existing infrastructure should be demonstrated, as should relevant social and community linkages.

By determining in principle design at this preliminary stage, the designer can proceed to detailed design with confidence that their adopted strategies are acceptable to Council.

5.3.5.2 Preliminary design submission

Once acceptance concept designs have been received, design work should be carried through to a near-to-complete stage. This work should then be submitted to Council's Engineering - Development section for review of the design and documentation. It is intended that submission as preliminary design shall negate the need to produce excessive numbers of copies should further amendment be needed. Preliminary design acceptance may be granted subject to minor amendments. Should significant amendments be required, documents shall be required to be resubmitted for preliminary design acceptance.

Preliminary design documentation shall be prepared on the basis of AUSPEC in accordance with general engineering principles, the DA conditions (if applicable) and all other information collated from the site, service authorities and the like.

Two (2) hardcopy sets and one (1) electronic copy of draft plans are to be submitted to Council for comment, prior to lodging final design plans for acceptance.

Documentation shall be prepared in accordance with **5.4 DOCUMENTATION**, and will include a services plan. The services plan shall show the overall layout of all services within the limit of works and shall include both existing and proposed services.

With the preliminary design submission the designer shall also provide a copy of hydraulic calculations showing aboveground and underground flows in and out of the system for major and minor storm events.

5.3.5.3 Final design submission

Once preliminary design acceptance has been received, design work should be carried through to completion and then submitted to Council for review of the final design documentation.

On completion of the final design plans and specifications, the designer shall provide **three (3) hardcopies and one (1) electronic copy** of these to the Council's Engineering - Development section with a covering letter certifying that these fully comply with the guidelines of AUSPEC, except for approved variations.

It is not the responsibility of Council to guarantee thorough checking of all calculations and design details. It is the entire responsibility of the designer submitting the documents to ensure that designs and specifications comply with AUSPEC, relevant Australian standards and relevant local, state and federal government legislation.

Final design acceptance is conditional on the above basis and does not relieve the developer from rectifying any errors and omissions that become evident during construction. If the engineering works have not substantially commenced within a five-year period, Council may engage consultants to revise engineering drawings and construction specification as necessary.

Upon final design acceptance one (1) copy of stamped & signed plans and specifications shall be returned to the designer.

Final design acceptance should be received prior to construction commencement.

5.4 DOCUMENTATION

5.4.1 Objectives

The objectives of these documentation requirements are as follows:

- To provide consistency in the presentation of design information;

- To eliminate duplication of data entry into various record systems;
- To provide an 'as constructed' record of Councils' assets;

5.4.2 General requirements

The engineering department of Council will generally arrange or undertake the registration, storage and maintenance of engineering plans in hardcopy format.

In addition to this, Council operates an electronic data management system for all correspondence to and from the organization, including plans. Letters, forms, certificates and minor reports (generally up to 20 pages) that are received are transferred to electronic format by its records department, however, major reports and all plans larger than A3 are required to be submitted in electronic and hardcopy format.

5.4.3 Plans

Plans shall be prepared as outlined in the following sections. Electronic submissions of plans will be such that any reproduction from the electronic files will achieve a hardcopy that is an exact duplicate of any hardcopy submission.

5.4.3.1 Sheet Size

Plans shall be submitted on A1 or A3 sheets that comply with councils D15 (CAD Specification).

5.4.3.2 Scales

For general consultation prior to DA or construction certificate (CC) issue, plans may be submitted as A1 or A3 sheets as appropriate to the size of the development.
Stormwater Management Plans (precinct) shall generally be submitted on A1 sheets at scale of 1:1000.

When requesting concept acceptance for small scale Stormwater Management Plans the scale shall be appropriate depending on sizes of development area.

When requesting preliminary design review, final design acceptance or providing as constructed information, plans shall be submitted on A1 sheets with the following scales:

- Layout Plans 1:500
- Longitudinal Sections
  - Horizontal 1:500
  - Vertical 1:100
- Intersection Plans 1:200 or 1:100
- Details 1:10 or 1:25
- Cross Sections 1:100

5.4.3.3 Datum

All levels shall be no Australian Height Datum (AHD). Plans shall nominate a minimum of two (2) State Survey Mark (SSMs) and their respective numbers/identification, and any temporary benchmarks (TBMs) relevant to the works.

5.4.3.4 Standard Details

Generally all construction details shall comply with the Council's standard drawings. Where special structures or modifications to standard drawings are required, details of such works shall be submitted with the detailed construction plans for preliminary design review.

5.4.3.5 Drawing Numbers

Plans shall display drawing numbers consistent with the Council's drawing registration system. Alternative drawing numbers may be displayed or referenced in addition to Council-nominated drawing numbers. Plans shall reference DA/CDC/Council Approval numbers. This DA number will, as a minimum, be clearly shown on the cover sheet or face sheet of any drawing set.

Plans prepared by consultants or designers on behalf of Council, should be allocated drawing numbers by Council's Technical Services Section at the time of appointment.

Plans prepared by consultants or designers on behalf of a developer, shall be allocated drawing numbers by the design unit at the time of when preliminary design plans are submitted.

5.4.4 Standard Drawings

The designer shall adopt details as shown on the Council's standard drawings where possible. While standard infrastructure is considered highly desirable across the LGA, the standard drawings shall only be used where the item/structure and application is considered appropriate. The standard drawings are not to be used in lieu of responsibly engineered and detailed structures. Where the standard drawings are not considered appropriate for the application, variations from the standard details shall be fully documented to the satisfaction of the Council. Cross-referencing standard drawings with variations made by note will only be accepted where those variations are considered minor and where directions are clear.

Standard drainage drawings are available in AUSPEC. Refer to the following:

- 200 Series – Roads,
- 300 Series – Drainage, and
- 600 Series – Environmental.

It is the responsibility of the designer to ensure that the standard drawing used is correct for the application and consultation with Council may be necessary.

5.4.5 Specifications

Project specifications shall ensure that all works are undertaken to meet the requirements of the Council, and that there can be no outstanding liabilities when the projects are handed over at completion.

Specifications for contracted works shall include a quality assurance section, nominating minimum hold points, including as a minimum, those inspections nominated in **5.5.4 Hold points.**

Specification for assets must ensure that the design life as listed below can be achieved:

- Concrete structures generally 50 years
- Concrete pipe 80 years
- uPVC pipe 50 years

5.4.6 Information to be shown on plans

The designer is responsible for ensuring that information on plans is shown in sufficient detail to enable works to be constructed in accordance with its design intent.

Information to be shown on plans shall include, but is not necessarily limited to those items listed in **APPENDIX A – INFORMATION TO BE SHOWN ON PLANS.**

5.5 CONSTRUCTION PHASE

5.5.1 Objectives

The objectives of these construction requirements are as follows:

- To ensure that the works are constructed such that they fulfil the purpose for which they were intended;
- To ensure that long-term maintenance requirements are considered;
- To ensure that there is no detrimental effect on other existing assets in the locality;
- To ensure that the works are safe, both during and after construction; and
- To ensure that environmental impacts are minimised both during and after construction.

5.5.2 Public Liability Insurances

Contractors engaged on development works within the LGA shall take out Public Liability Insurance to the minimum value of $10 million. The policy should specifically indemnify Council from all claims arising from the execution of the works.

5.5.3 Construction supervision for developers

As described in **5.3.3 Developer's representatives**, all drainage construction supervision shall be undertaken by the Developers Superintendent appointed by the Developer. Council staff is not responsible for carrying out the functions of the 'Superintendent' as defined in the *General Conditions of Contract – AS 4000*. The Construction Superintendent, or some other person appointed by the Developer, is required to carry out this function. Correspondence during the defects liability period shall be directed to the Developers Superintendent or the Developer as applicable.

A Council officer may undertake random audits to ensure that the works are constructed in accordance with Council requirements and the approved plan. It is not the role of Council to give a Contractor a direct instruction regarding the works, however as much guidance and assistance as possible will be given on site to assist the construction program.

5.5.4 Hold points

The Developers Superintendent shall be responsible for inspections at each hold point relating to drainage construction as detailed below. The minimum hold points are as follows:

- Establishment of erosion and sediment control.
- Prior to backfilling stormwater drains.
- Prior to backfilling subsoil drains.
- Prior to installation of GPT's, litter traps, etc

The Council may choose to be present for specific hold point that relate to drainage construction and documentation should reflect this.

5.5.5 Acceptance of works for developers (Practical Completion)

When the works are completed the Developer's Representative shall arrange for acceptance of the works by the Council. Acceptance will only occur when the information and procedures detailed herein have been complied with.

The Developer's Representative shall arrange for a joint inspection of the works to be made, together with the Council Representative, Developers Superintendent and Principal Contractor. The purpose of the inspection shall be to identify any outstanding items or minor defects for recording, and to determine whether works are completed to the Council's satisfaction so that the Defects Liability Period can commence.

It is the responsibility of the Developer's Representative to determine that all works are completed in accordance with the approved plans, prior to calling for the joint inspection.

Subsequent to the 'Acceptance of Stormwater Works' inspection the Developer's Representative shall forward to the Council:

- Certification that the works have been completed in accordance with the documents previously approved by the Council;
- 'As Constructed' or 'Works as Executed' drawings in hardcopy format and in electronic format compatible with Council's Asset Management system. Refer to **D14 - Work As Executed Plans**;
- Operation and maintenance (O&M) manuals for gross pollutant traps (GPTs) and any other infrastructure as required;

Any operations and maintenance manuals necessary for the drainage system are to be handed over to Council at commencement of the Defects Liability Period.

Following the inspection, and after receipt of the above-mentioned documentation, Council's Natural Resources Section shall directly notify the Councils Engineering-Development section that the physical stormwater works have been completed and are of sufficient standard that the Defects Liability Period can commence. This notification may include a list of minor defects that are to be corrected within one (1) month of the inspection, or other period nominated.

Satisfactory site inspection of stormwater works is not to be taken as acceptance for the release of the Subdivision Certificate for the development. It is only one step in the Subdivision Certificate process, as there may be other conditions on the DA to be addressed.

5.5.6 Work as Executed information

Following the completion of civil works in a development 'Work as Executed' information shall be prepared by a Registered Surveyor. The 'Work as Executed' plans shall be endorsed by the Developers Representative and forwarded to Council prior to lodging a request for Subdivision Certificate.

Plans shall be prepared in accordance with **APPENDIX A – INFORMATION TO BE SHOWN ON PLANS** and **D14.**

For works constructed by Council's internal works departments, 'Work as Executed' shall be prepared in accordance with **APPENDIX A – INFORMATION TO BE SHOWN ON PLANS** and signed off by the construction representative**.**

5.6 DEFECTS LIABILITY PERIOD

5.6.1 Objectives

The objectives of the Defects Liability Period are as follows:

- To ensure that assets which are to handed over to Council have been constructed to Council's standard and are suitable for the purpose that they have been built;

- To ensure safety to the community and users is not compromised by delays in rectification to works resulting from defects.

5.6.2 General

A Defects Liability Period shall apply to all drainage infrastructure that is to become a public asset, and shall relate to any fault, deficiency or inadequacy of the works from defective design, workmanship or materials.

During the Defects Liability Period the Council shall carry out operational maintenance in accordance with its normal practice, unless specified otherwise. The developer shall be held responsible for all maintenance costs arising from design error, defective workmanship and/or defective materials.

5.6.3 Commencement of Defects Liability Period

The Defects Liability Period shall commence no earlier than from the date of release of the Subdivision Certificate or Occupancy Certificate or acceptance by council as applicable for all works. Unless specified otherwise the Defects Liability Period shall be **12 months for all drainage infrastructure.**

If a period of greater than eight (8) weeks has elapsed between the 'Acceptance of Works' inspection and the issue of Subdivision Certificate or Occupancy Certificate or acceptance by council as applicable, then Council may request that a further handover meeting be held prior to commencement of the Defects Liability Period to review and amend any outstanding minor defects and site-specific issues.

The Developer shall enter into an agreement with Council regarding defects responsibilities for maintenance and correction of defects during this period. The agreement shall be signed prior to issue of Subdivision Certificate or Occupancy Certificate or acceptance by council as applicable.

5.6.4 Bond of Stormwater Work

Unless agreed otherwise in writing, the Developer shall post a Bond for all infrastructure works including Stormwater work with Council prior to the issue of Subdivision Certificate. The Bond shall be in accordance with draft DCP 17, Section 8.4.

The Bond shall be to the value of 10% of the total cost of drainage works and the calculated amount shall be based on the tendered Bill of Quantities. The guarantee shall be lodged with the Council for the term of the Defects Liability Period.

The Bond shall be released at the termination of the Defects Liability Period, subject to the satisfactory completion of all defect rectification works.

5.6.5 Defective Items

Defective items becoming apparent during the Defects Liability Period will be referred to the Developer's Representative for remedial action by the Developer. Failure by the Developer to comply with such instruction to rectify works shall result in forfeiture of part or the entire bond, as required, for the Council to undertake remedial/maintenance works. Similarly if the required works are of an emergency nature, rectification works will be undertaken or arranged by the Council at the Developer's expense. The final Letter of Release referred to in **5.6.6 Release from Defects Liability** will not be issued until payment for such repairs has been received.

It must be noted that during the Defects Liability Period the Developer no longer has possession of site, and works within the Road Reserve require approval under Section 138 of the *Roads Act 1993*.

5.6.6 Release from Defects Liability

A maximum of seven (7) days before the end of the Defects Liability Period, the Developer's Representative shall arrange for a joint inspection of the works to be made, together with the Council's representative, Developers Superintendent and the Primary Contractor. The Developer should be invited to attend. The purpose of the inspection shall be to determine if there are any defective items requiring rectification by the Developer.

Council requires one week's notice for this inspection.

Following this inspection, and after rectification of defective items, the Developer shall submit an application requesting the release of any bond/retention money. The Council shall forward the 'Letter of Release' to the Developer's Representative to release the Developer from any further defects liability. The balance of the Bond shall be returned to the Developer.

5.7 MAJOR AND MINOR DRAINAGE SYSTEMS

The Designer shall adopt the 'major/minor' approach to urban drainage systems as outlined in *Australian Rainfall and Runoff*. The 'Minor' system generally refers to the underground system but also applies to surface structures. The minor system is designed to an Average Recurrence Interval (ARI) as shown in section **5.10 AVERAGE RECURRENCE INTERVAL (ARI)** of this document. The 'Major' system refers to overland flow paths that are to be designed to convey the major storm flows when the capacity of the minor system is exceeded.

The minor system generally refers to a pipeline network with sufficient capacity to contain nuisance and low flows from nominated storm events. See **5.10 AVERAGE RECURRENCE INTERVAL (ARI)**. These pipelines prevent stormwater damage to properties and also limit the frequency and quantity of surface water to a level that is acceptable to the community. The pipelines do not always follow the natural drainage paths and are usually aligned along property boundaries and the roadway kerb and channels.

A major drainage system caters for the runoff from storms of higher intensity than for which the minor drainage system has been designed. The major drainage system is designed to handle flows resulting from rare storm events up to and including a 100-year ARI. These flows shall follow a designated overland flow path, which shall be:

- A road if the catchment area is small; and/or
- A drainage reserve if it is impractical for unsafe for a road to carry the excess flows.

The finished floor level of buildings shall be above the 100 year ARI flood level and in accordance with the council's current flood policy.

5.8 HYDROLOGY

Stormwater runoff estimation for urban, rural, commercial and/or industrial developments shall be based upon hydrological methods and data contained within the latest edition of *Australian Rainfall and Runoff*, unless otherwise specified within this manual. Generally the Rational Method is acceptable to be used for determining the Peak Flow within an urban drainage system.

Partial areas effects shall be taken into account when determining peak flows. Particularly in instances where the catchment contains sub areas, such as reserves, that may have relatively large time of concentration in conjunction with a small coefficient of runoff. In some instances a partial area design discharge may result that is less (or the same) than a discharge that has been calculated at some upstream point. Careful checking of the partial area flows may be required to determine the largest flow. The largest flow shall be used for the design of the stormwater system downstream of the connection point.

It may be more appropriate in some instances to use a simple Unit Hydrograph or a more complex Non-Linear Run-Off Routing model, particularly when assessing the major drainage system. It is the responsibility of the Designer to determine the most appropriate methodology for each application. Various drainage tools, programs and construction methods are available to the Designer to achieve the objectives of the drainage system. Regardless of the technique or method used, detailed documentation including certification shall be required to be submitted.

Two recognised runoff estimation methods shall be used for catchment areas greater than 50 hectares to enable comparison of runoff estimates. The *Probabilistic Rational Method (PRM)* may be used as a check.

5.8.1 Catchment Area

The catchment area of any point is defined by the limits from where surface runoff will make its way, either by natural or man made paths, to that point. Consideration shall be given to likely changes to the existing catchment areas due to the full development of the catchment.

The drainage design shall include a drainage catchment plan showing the total catchment area and sub areas that are the basis of the design, together with drainage computations.

Catchment boundaries and characteristics are to be confirmed by field inspection.

Catchment plans shall detail all catchment and sub-catchment boundaries, overland flow paths, and discharge points for each parcel of land.

5.9 RAINFALL DATA

The rainfall intensities given in the Intensity/Frequency/Duration table (IFD) located in **APPENDIX B – INTENSITY/FREQUENCY/DURATION TABLES** and are to be used for drainage design purposes.

5.10 AVERAGE RECURRENCE INTERVAL (ARI)

For underground drainage systems the following average recurrence intervals shall be adopted:

AVERAGE RECURRENCE INTERVALS FOR DRAINAGE DESIGN

Drainage System	Capacity
Parks and recreation area (Minor)	1 in 1 yr ARI
Urban Residential Areas (Minor)	1 in 5 yr ARI
Rural residential area (Minor)	1 in 5 yr ARI
Inter-allotment drainage	1 in 20 yr ARI
Commercial/industrial area (Minor)	1 in 20 yr ARI
Main (Trunk) drainage systems (Minor)	1 in 20 yr ARI
Major system in all developments	1 in 100 yr ARI

The capacity of the road reserve in urban areas inclusive of the underground system shall be 1 in 100 yr ARI. Overland flow paths must be clearly demonstrated.

5.11 CO-EFFICIENT OF RUNOFF

The Designer shall determine the actual impervious areas for the development using the C10 equation in AR&R. However, where this is impracticable the following minimum percentage impervious shall be adopted. These should only be used for large catchment or where the future nature of the development is unknown.

Catchment Type	Percentage Impervious (%)
Forest	20
Woodland	25
Agricultural	30
Open Space & Parks	35
Rural & Rural Residential	40
Low Density Urban Residential	60
Medium Density Residential	70
High Density & Unit Development	90
Industrial	98
Commercial	95
Residential road reserves	75
Landscaped areas	25
Paved areas	95

Note: Where there is a likelihood of further subdivision occurring of allotments (eg. town houses, units etc) in new subdivisions the coefficient for the future 'development lot' must reflect the ultimate proposed scenario. Ie. a future townhouse development lot must have a f = 90%). This avoids the need for on-site detention for these future developments.

In all cases the co-efficient of runoff shall be checked against *Australian Rainfall and Runoff*. For large catchments or special use areas, e.g. schools, community centres, sporting developments etc, an investigation is to be carried out to determine the likely percentage of impervious area.

5.12 TIME OF CONCENTRATION (tc)

The initial time of concentration from building to property boundary shall be **six (6) minutes** in urban residential areas. Special consideration will be necessary for other areas.

The Designer shall determine the actual time of concentration for the development using the Kinematic Wave Equation. However, where this is impracticable the following shall be adopted.

Flow paths to pits shall be representative of the fully developed catchment considering such things as fencing and the likely locations of buildings and shall be shown for each collection pit on the catchment area plan. Consideration shall be given to likely changes to individual flow paths due to the full development of the catchment.

5.13 ROUGHNESS CO-EFFICIENTS (n)

Surface roughness co-efficient "n" shall be derived from *Australian Rainfall and Runoff* using the Kinematic Wave Equation. Indicative values applicable to specific surface types and overland flow path types are given below:

Surface type	***co-efficient "n"***
Concrete or asphalt	0.010 – 0.013
Bare sand	0.010 – 0.016
Gravel	0.012 – 0.030
Bare clay-loam soil eroded	0.012 – 0.033
Sparse vegetation	0.053 – 0.130
Short grass	0.100 – 0.200
Lawn	0.170 – 0.480

5.14 HYDRAULIC DESIGN

For drainage systems within the Port Macquarie-Hastings Council area, stormwater hydraulic design shall be based upon hydrological methods and data contained within the latest edition of *Australian Rainfall and Runoff,* unless otherwise specified. All drainage designs shall be undertaken and certified by an **Appropriately Qualified and Practicing Consultant**.

Designs shall be based on hydraulic grade line (HGL) analysis using appropriate pipe friction and drainage structure head loss coefficients. The following hydraulic grade line design parameters shall apply:

- The hydraulic grade line shall be 150 mm below the invert of the kerb for minor flows.
- The hydraulic grade line shall be 150 mm below the underside of all pit lids for minor flows.
- The hydraulic grade line shall be less than 250 mm above the invert of the kerb for major flows.
- The hydraulic grade line due to partial full flows is to be ignored, and assumed to match the obvert of the pipe. However part full velocities must be checked.
- Where the downstream starting point is a pit and the hydraulic grade line is unknown, a level of 150mm below the invert of the downstream starting pit inlet is to be adopted.
- Where the outlet is an open channel and the design storm is the minor event the top of the outlet pipe shall be the downstream control.
- Where the outlet is an open channel and the design storm is the major event, the downstream control shall be the 1% probability flood level.
- For pipes designed to flow full and under pressure, the pipe parameters are to be based on the Colbrook – White formula. True pipe diameters are to be used in any formula.
- All pipelines shall be designed to continue in the future unless the discharge point is directly to receiving water. Temporary outlets shall be designed to include future pit losses.
- For pipes designed to flow full and not under pressure, the pipe parameters are to be based on Manning's formula, considering the following table.

PIPE ROUGHNESS VALUES

Pipe Material	**n**	**K**

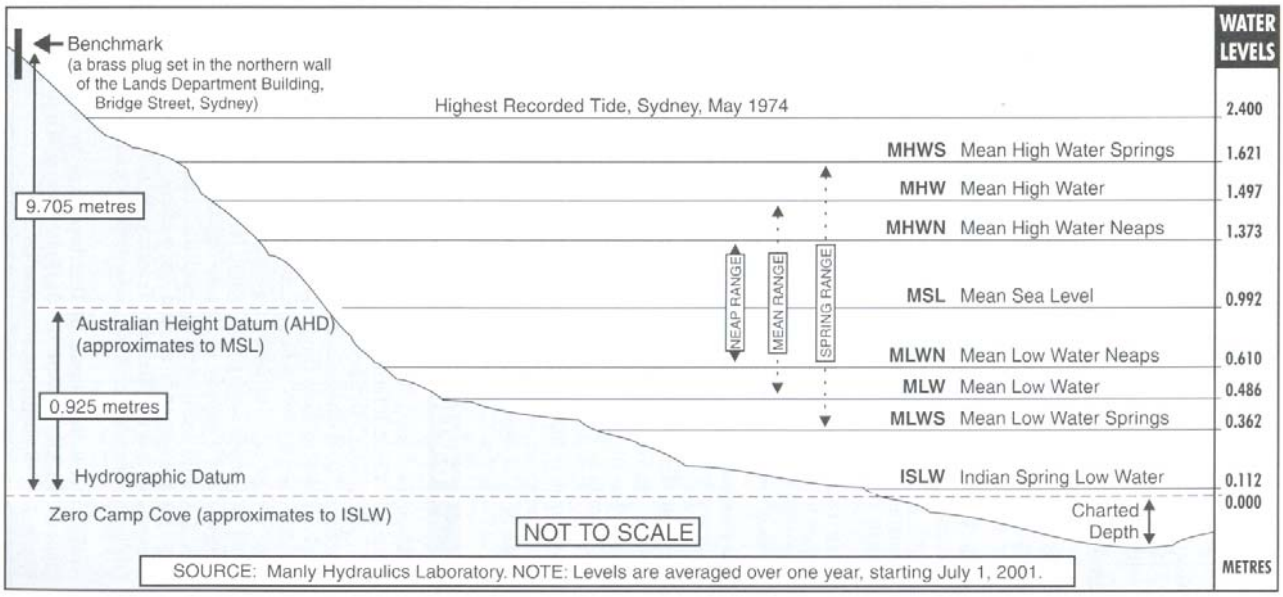
Spun precast concrete	0.0013	0.6
Fibre reinforced concrete	0.011	0.3
UPVC	0.009	0.06

- Where the outlet is tidal the following parameters shall be considered. Refer to the *Queensland Urban Drainage Manual,* section 7.0 for appropriate methods and procedures.

TAILWATER LEVELS FOR DISCHARGE TO TIDAL WATERWAYS

Design Condition	Design Tailwater Level
Minor storm	Mean High Water Springs (MHWS)
Major storm	Highest Astronomical Tide (HAT)
Climate change (sea level rise)	300mm additional

The following graph is provided for tidal interpretation.



- An allowance of climate change shall be included. This allowance shall consider sea level rise and changes in rainfall intensities. A sensitivity analysis is to be undertaken in accordance with the NSW Department of Environment and Climate Change (DECC) draft guidelines *Practical Consideration to Climate Change (2007).*
- All pipe inlets from private pipe systems, including roof and subsoil pipes, shall enter the main pipe system at pits. These shall be finished flush with and be grouted into the pit wall. Council may consider connections to the gutter where a pit connection is impracticable.
- Construction of pipe network junctions without a pit shall not be permitted.
- Transitions to smaller downstream conduits shall not be permitted.

5.14.1 Pipe Velocities

Design pipe velocities shall be as follows:

Minimum – pipe running full – 0.60 m/s

Maximum – pipe running full – 6.00 m/s

5.14.2 Minimum Pipe Grades

In general the absolute minimum grade of a stormwater pipe is to be 1:200 (0.5%). However for larger pipes flatter grades may be approved where it is demonstrated the velocities are greater than 0.60 m/s. In this instance each pipe length shall be checked during construction for level before backfilling.

5.14.3 Minimum Pipe Cover

The minimum cover shall be as per:

- The Port Macquarie-Hastings Council Standard Drawings,
- Determined from the Concrete Pipe Association - *Concrete Pipe Guide*,
- *AS 3725 – Loads on buried concrete pipes*.

For uPVC pipes, the requirements shall be to *AS 2032 – Code of practice for installation of uPVC pipe systems*.

Pipe classes shall be determined in accordance with proposed cover.

Wherever an external area contributes to the system, the drain shall be designed at a depth sufficient to serve the total upstream area.

Any exceptions to the minimum cover requirements are to be discussed with Council's development/ environmental engineering staff.

5.14.4 Curved pipelines

Curved pipelines are <u>not permitted</u>.

5.14.5 Pipe alignments

The following shall apply for the alignment of pipes at pits:

- Pipeline systems are to be rationalised where possible to reduce head losses at pits.
- Opposing flows entering at pits shall be discouraged.
- Where practical, the pipes at junctions should be aligned such that the projected area of the upstream pipe is wholly contained within the downstream pipe.

Drainage lines in road reserves shall be located behind the kerb line and parallel to the kerb, unless otherwise approved by council.

Drainage lines in easements shall be centrally located within easements.

5.14.6 Pit losses

Pit losses to be allowed for shall be calculated on the basis of:

$h_s = K.V^2/2g$

h_s = pressure change at a structure

K = pressure change coefficient

Values of K for various pit configurations are given in the *Queensland Urban Drainage Manual*, *volume 1, section 5.21.8 and volume 2, charts 30-60*.

Refer to *AR&R, Book 8, section 1.5.7(iv)* for further information

5.14.7 Pit locations

Inlet pits shall be spaced so that the gutter flow width is limited in accordance with **5.14.8 Gutter flow width** and so that the inlet efficiency is not affected by adjacent inlet openings, kerb variations and upstream carriageway narrowing. It will be necessary to consult pit inlet capacity charts to confirm capacities.

Pits are to be located clear of kerb returns. Pits are to be located to prevent flow across intersections during the minor storm event.

The maximum recommended spacing of pits where flow widths are not critical are given below:

SPACING OF PITS

Pipe Material	Pipe Size (mm)	Spacing (m)
Generally	Less than 1200	60
	1200 or larger	100
In tidal influence	All	60

Channel flow approaching an intersection is to be collected before the tangent point.

Side Entry Pits are to be clear of radials, kerb crossings and driveways.

Double side entry pits shall be used where approach grades to intersections are in excess of 6% and at all low points in roads.

In all cases, design consideration shall be given to pit location and pit inlet capacities.

All pits shall be provided:

- To enable access for maintenance.
- At changes in direction, grade, level or class of pipe.
- At junctions.

5.14.8 Gutter flow width

The acceptable gutter flow widths for the minor design storm is 2.5 metres maximum.

Gutter flow around kerb returns shall be limited to 20 l/s but not exceed gutter capacity.

5.14.9 Pit inlet capacity

The kerb inlet opening lengths for side entry pits shall be:

- A desirable length of 3.0m,
- A maximum length of 5.0m where the grade is 10% or more,
- A maximum length of 4.0m where the grade is less than 10%.
- Minimum length of lintel is 1.2 metres.

Information on pit capacities is available in publication: *Model Analysis To Determine Hydraulic Capacities Of Kerb Inlets And Gully Pit Gratings, Department of Main Roads, NSW (1979).*

5.14.10 Pit selection

Pit uses shall be in accordance with the following standards.

Kerb Inlet Pit (KIP)

Kerb inlet pits have good entry conditions with little chance of blocking. To obtain maximum efficiency of kerb inlet pits the throat opening must be depressed below the line of the channel invert and the channel in front of and adjacent to the pit steepened so that water is drawn into the pit.

The bypass flow must be added to the design flow for the next downstream pit. To design spacing for 100% capture is not economical, however when evaluating alternative pit spacing, the aim is to achieve economical design by minimising the total number of pits in the system.

Grated Pits (GP)

Grated pits are generally located clear of carriageways, such as medians, table drains, or catch drains. The pit top is depressed below the drain invert by at least 75mm to increase inlet capacity.

Transverse steel bars must be used where pits are likely to be traversed by bicycle traffic. However, transverse bars reduce hydraulic efficiency. As grates are prone to blockage by debris, their use in trapped low points on carriageways is not advisable. KIPs are more suitable in this case.

Grated Kerb Inlet Pit (GKIP)

Grated kerb inlet pits may be used where the main pipe is located under and parallel to the road. Transverse bars are used for reasons given in (b) above. On grades above 3 per cent, the GKIP with transverse bars may have less capacity than the side entry pit, due to diversion of water from the partially blocked grate, or water overshooting the transverse bars.

Side Inlet Pit (SIP)

Side inlet pits commonly known as letter-box or mail box pits are generally located clear of carriageways, such as medians, table drains, or catch drains where blockage is an issue. The pit top is raised above the drain invert by at least 100mm to increase inlet capacity.

Lids can be solid or grated as required.

These pits are not suitable where pedestrian traffic is involved due to the trip hazard.

Junction pits (JP)

Junction pits are required at changes in both horizontal and vertical alignment of a pipeline where there is no need to admit surface water to the pipe system.

Pit construction shall be in accordance with Council's Standard Drawings.

5.14.11 Minimum drops at pits

Minimum drops at pits are required to provide sufficient slope along the pit inverts to clear debris, and to provide tolerance in setting pipe invert levels.

Generally the minimum drop through pits shall be 50mm.

However, losses shall be considered and provided for in all the following circumstances where changes in direction occur, a number of pipes enter the one pit, and/or large inlet and outlet velocity differences occur.

5.14.12 Maximum drops at pits

Significant changes in level through pits may be necessary in order to avoid existing public utility services, or to convey water down a batter, or as a deliberate means of reducing the energy of flow.

Where drop pits are proposed with a level difference greater than 2 metres between any incoming pipe and the pit outlet, the pit floor should be protected by a wearing course of concrete or rock and the outlet should be placed about 300 mm above the floor to leave a permanent water cushion.

Where pipes of 1200 mm or larger are used, changes in elevation should be made by providing steeper lengths of pipes between close successive pits.

The length of a drop pit should be increased to prevent unnecessary thrust on the pit walls. The minimum length of pit is set out below.

MINIMUM LENGTH OF DRAINAGE PITS

Drop	Inlet Type Du < 600mm L min.	Du > 600mm L min.
Less than 0.5 Du	Std size	1.5 Du
0.5 Du to 1.5 Du	1.5 Du	2.0 Du
1.5 Du to 2.5 Du	2.0 Du	2.0 Du
More than 2.5 Du	2.0 Du	2 - 3 Du

Du = diameter of upstream pipe

L = length of pit in the direction of flow

5.14.13 Pit blockages

Pit inlet capture rates shall include the following blockage allowances.

PIT BLOCKAGE FACTORS

Condition	Inlet Type	Blockage factor
Sag	Side entry	20%
Sag	Grated	50%
Condition	**Inlet Type**	**Blockage factor**
Sag	Combination	Side inlet capacity only. Grate assumed completely blocked
Sag	"Letterbox"	50%
Continuous Grade	Side entry	20%
Continuous Grade	Grated	50%
Continuous Grade	Combination	10%
Sag or on Grade	Headwall inlet	30% of pipe full capacity

5.15 MAIN (Trunk) DRAINS

Trunk Drainage is those drainage systems having catchment areas greater than 15 Hectares or runoff in excess of 3m³/s during a 20% ARI event.

Main drain pipes are to be designed so that large directional changes (> 90 deg.) through standard pits shall not be permitted. Consideration shall be given to use of special pits and additional pits at all changes of direction.

5.16 PIPE CONSTRUCTION

5.16.1 Pipe size and joints

The minimum pipe sizes are given below:

- The minimum pipe size shall be 375mm.
- The minimum box culvert size shall be 600mm wide x 300mm high.

The minimum pipe size in all easements is 375 mm diameter.

Note: Refer to section **5.21 INTER-ALLOTMENT DRAINS** for separate inter-allotment easements requirements.

All pipes are to have spigot-socket rubber ring joints.

5.16.2 Pipe class

In all instances the pipe class shall be determined using Australian Standards. Construction techniques should be considered when selecting the class of pipe, and restrictions to plant and compaction techniques may need to be specified to suit class of pipe.

The minimum pipe class shall be class 2 RCP.

5.16.3 Pipe type

Reinforced concrete pipes shall conform to *AS 4058 - Precast concrete pipes*.

Fibre reinforced concrete pipes shall conform to *AS 4139 - Fibre reinforced concrete pipes and fittings*.

uPVC pipes shall conform to *AS 1254 – Unplasticised PVC (uPVC) pipes and fittings for stormwater or surface water applications*. The use of uPVC pipes shall be restricted to inter-allotment drainage.

5.17 PIT CONSTRUCTION

Typical pit designs and other pit requirements are included in the Port Macquarie-Hastings Council Standard Drawings.

All pits shall provide safe access.

Pits not compliant with Port Macquarie-Hastings Council Standard Drawings shall be fully detailed and acceptance from council obtained.

5.17.1 Precast pits

Precast pits shall not be used in trafficable areas unless written acceptance by Council is obtained.

For construction detail refer to Port Macquarie-Hastings Council Standard Drawings No 320.

5.17.2 Pit covers

Pit covers shall have a clear opening of sufficient dimension and orientation to comply with OH&S and confined space entry requirements.

Hinged or lock-down lids are required in high-risk areas such as public open spaces, recreation reserves, school areas etc.

Heavy-duty covers (including grates) are to be provided on all pits located in exposed kerb areas. Elsewhere, covers are to be installed with class rating in accordance with potential traffic loadings.

Trafficable covers with load bearing covers are to be provided on all pits in industrial developments.

5.18 STORMWATER DISCHARGE

All outlet structures at receiving waters shall be designed in accordance with the requirements of the responsible authorities for the relevant land and receiving waters.

The concentration of stormwater onto adjoining properties shall not be permitted, unless this is defined as a legal point of discharge. However, where a concentration of stormwater cannot be avoided, Council will require evidence of a written agreement from the adjoining owners to allow discharge via a registered easement(s). The cost of all the easement shall met by the developer.

Where the drainage is to discharge to an area under the control of another authority eg, Department of Lands, the design requirements of that Authority are also to be met.

Stormwater drainage discharging to recreation reserves is to be taken to a natural watercourse and discharged in an approved outlet structure or alternatively taken to the nearest trunk stormwater line.

5.18.1 Energy dissipaters

Scour protection at all outlets shall include energy dissipation measures including geotextile lining of the embankment and open drain.

5.19 SUBSOIL DRAINAGE

The minimum subsoil drainage requirements are given below:

- Typically, circular 100 mm rigid wall or flexible uPVC Class 1000 slotted pipe including geotextile sock is to be installed to a minimum depth of 100 mm below the sub-base level.
- Sub soil drainage shall be located a minimum of 300 mm behind the back of kerb line unless otherwise approved.
- All subsoil drainage pipes shall discharge to a pit or an outlet structure.
- The Developer's Consultant shall include and submit to the Council, full details of all sub-surface drainage proposed to be used in the Development.

- Flushing points shall be provided at the commencement of each run of drain and at intervals not exceeding 50m.

Refer to **D4 - Subsurface Drainage Design** for further details.

5.20 PROPERTY DRAINS

All allotments in green-field developments shall provide a property drainage point connected to the council drainage system.

No property drainage shall discharge to kerb and gutter in a green-field development without the written acceptance of Council.

Direct connections to pits are preferred over pipe-to-pipe connections. Where property drains discharge directly to underground drains, connection works shall be in accordance with Council's Standard Drawings number ASD 324**.**

For in-fill development any allotment that has underground stormwater drains within 80m to the site, connection shall be made to the underground drainage system at the time of development.

In in-fill urban residential and commercial developments where connection to underground drains is impractical, two (2) kerb adaptors per lot are to be provided at the time of development. Kerb adaptors shall be located clear of all driveway crossings and a minimum distance of 1 metre from kerb crossings. Works shall be in accordance with Council's Standard Drawings numbers ASD 322 and 323.

Pipe connections are mandatory for the following:

- Two (2) unit minimum residential development,
- New Commercial and Industrial development,
- Alterations and additions to Commercial and Industrial developments that are greater than 40m^2

5.21 INTER-ALLOTMENT DRAINS

Inter-allotment drains shall be provided to all allotments that fall to the rear and shall be deep enough to serve the entire allotment. A property inlet, as per Council's Standard Drawings ASD 321 shall be constructed at the low corner of each allotment.

The following criteria shall apply:

- A maximum of **six (6) allotments** shall be served by an inter-allotment drainage system. Council reserves the right to restrict the maximum number of allotments served based on catchment characteristics and potential for runoff concentration onto downstream properties.
- Inter-allotment drainage shall be contained within an easement in favour of all upstream lots. Refer to **5.23 EASEMENTS** for further details.
- The inter-allotment drain shall be designed to cater for a 1 in 20 Yr ARI event for whole area of the allotments serviced.
- Pipe sizes shall be a minimum of 225mm.
- Pipes shall be designed to flow full at the design discharge without surcharging.
- Inter-allotment drainage pits shall be located at all changes of direction and at distances no greater than 60m. Pits shall be constructed of concrete, with a minimum 600mm x 600mm

internal dimension. Pits shall be fitted with a fixed concrete lid finished flush with the finished surface of works.

- The inter-allotment drainage shall have a minimum longitudinal gradient of 1:200 (0.5%).
- The inter-allotment drainage shall be constructed from the following pipe types and joints shall be of rubber rings.
    - Fibre reinforced concrete pipe (AS 4139),
    - Reinforced concrete pipe (AS 4058), or
    - uPVC pipe (AS 1254).
- Where inter-allotment drainage and sewer mains are laid adjacent to each other they are shall have a minimum clearance of 500 mm between pipes measured horizontally and vertically.
- Where sewer mains are in close proximity to inter-allotment drainage lines they shall be shown on the inter-allotment drainage plan.
- Located clear of any on-site detention systems.

5.22 DRAINAGE RESERVES

Where drainage reserves are incorporated into developments the minimum reserve width shall be 6.0 metres.

Reserve widths shall accommodate a drain with sufficient capacity to cater for a 100 year ARI storm event including the necessary freeboards shown in **5.24.3 Freeboard**. All-weather access tracks will be required on one side of the drain.

Water-quality treatment infrastructure shall be sited with sufficient room for construction and maintenance vehicle turning at an appropriate location. Consideration should be given to increasing reserve width for conservation and landscaping purposes.

Where drainage infrastructure within the drainage reserve does not comply with standards for public access, the reserve shall be fenced to prohibit public access. Fencing shall be at the full cost of the Developer.

5.23 EASEMENTS

Easements shall be provided in private property over all pipe systems and surcharge paths. Where a development is designed in such a way that the major system flows involve surcharge across private property or a road reserve then the drainage system shall be designed to conform to the following criteria:

- A combined pipe and surcharge path system shall meet the depth x velocity ratio of 0.4m²/s maximum. The surcharge path shall be maintained clear of obstructions (eg. Fence lines) and a restriction shall be placed on the title to secure the surcharge path shall be maintained clear of obstructions.

If the above criteria can not be achieved the following is required;

- An underground system, including pipes and inlet structures, will be designed to cater up to and including the 1 in 100 ARI flow.

The overall width of an easement in Council's favour will be such as to contain the full width of overland flow or open channel flow in the major system design event as indicated below.

EASEMENT WIDTHS

System Type	Easement Width

	(Rounded up to nearest 0.5m)
Single pipe	3.0m (minimum)
Multiple pipes	Overall outside width of pipe group plus 2.0m
Box culverts	Overall width of box plus 2.0m
Open channels	Total channel width plus 2.0m (generally restricted to drainage reserves)
Surcharge paths	Total flow path width plus 2.0m
Inter-allotments drainage	1.5m (minimum)

5.24 MAJOR DRAINAGE SYSTEM

The major drainage system shall collect major storm runoff from a catchment, in excess of the capacity of the minor drainage system, and convey this runoff to the receiving waters with minimal nuisance, danger or damage. The major drainage system shall be designed and constructed such that its function ensures a reasonable level of pedestrian and vehicular traffic safety and accessibility, limits flooding of private and public property and minimises pollutants inflows to receiving waters.

Minimum requirements of the major drainage system are as follows:

- Design of major drainage systems shall be based on the critical 100 year ARI storm with some consideration given to the impact of a rarer storm event. The critical storm shall be determined by routing storms of varying duration until peak flows (Q100) are identified. Two recognised flow estimation methods (runoff routing computer models) in addition to the Rational Method shall used for comparative purposes for urban catchments or sub-catchments greater than 50 Ha.
- Hydraulic/Energy Grade Line analysis shall be used for design of floodways, low flow pipes and detention basins. The width of major floodways shall be governed by the greater of the hydraulic requirements or the width for suitable maintenance (including mowing of grassed trapezoidal drains).
- Street drainage in urban areas should not be directed through private property via easements. Generally street drainage will be part of overland flow paths (ie Drainage Reserves, laneways or roads).
- Depth of overland flows in urban areas shall be controlled by freeboard to properties as shown in **5.24.3 Freeboard** or upper limits of surface flow depth/velocity criteria shown in **5.24.2 Velocity x depth product**.

5.24.1 Surcharge/overland flows

Flow across footpaths shall not be permitted unless in situations specifically approved in writing by Council, where this will not cause flooding of private property or create unsafe areas.

Where a development can not meet councils design standards (appropriate overflow route or 1 in 100 year detention system) and the runoff generated during the major storm event will cause surcharge across private property, the underground system (both pipes and inlets) shall be designed to convey the 100 year flows from the upstream catchment through the property. This surcharge path shall be defined within an easement.

A surcharge path shall be defined for all systems even where the 1 in 100 year ARI flows can be maintained within the system.

Where a surcharge flow path is required to carry flows from an upstream catchment with a contributing area greater than 4 allotments or 2,500m² (which ever is the lesser) a Drainage Reserve shall be created in favour of Council.

Where overland flow is anticipated from upstream property (eg downstream of parks or undrained lots) appropriate drainage reserves and easements shall be provided.

5.24.2 Velocity x depth product

The velocity x depth product shall be such that safety of children and vehicles is considered. The following criteria shall apply.

- The maximum allowable depth of water is 200 mm, and
- The maximum velocity x depth product of $0.4m^2/s$ is permitted.

Where the safety of vehicles only can be affected,

- A maximum velocity x depth product of $0.6m^2/s$ is permitted.

5.24.3 Freeboard

- Surcharge and overland flow routes shall have 300 mm freeboard between the 100 year level and habitable floor level and entrances to underground carparks.
- Major channels shall have 500 mm freeboard between the 100 year level and habitable floor level and entrances to underground carparks.
- For flood liable areas the freeboard to floor levels of dwellings and structures shall be in accordance with councils flood policy.

5.24.4 Major structures

All major structures shall be designed for the 100-year ARI storm event with a maximum afflux in urban areas of 300 mm unless otherwise approved by Council. Some afflux and upstream inundation may be permitted in certain rural and urban areas provided the increased upstream flooding does not inundate adjoining property.

A minimum clearance of 300 mm between the 1 in 100 year ARI flood level and the underside of all bridge structures is required to allow for passage of debris without blockage.

All bridges shall be designed for the 1 in 100 year ARI flood with a maximum afflux in urban areas of 300 mm in urban areas.

Certified structural designs shall be required on bridges and other major culvert structures and may be required on some specialised structures. Structural design shall be carried out in accordance with *AS 5100-2004 Bridge Design.*

All major culverts in urban areas shall be designed to ensure that the traffic lanes are not inundated in the 1 in 100 year ARI flood flow. Major culverts shall be designed with a blockage factor of 50%.

All culverts (either pipe or box section) shall be designed using established design techniques in the latest edition of *Australian Rainfall and Runoff*.

5.25 MAJOR OPEN CHANNELS

The design of all open channels shall be in accordance with *Australian Rainfall and Runoff*.

Open channels will only be permitted where they form part of the trunk drainage system and shall be designed to have smooth transitions with adequate access provisions for maintenance and cleaning.

Friction losses in open channels shall be determined using Mannings "n" values. Mannings "n" Roughness Co-efficients for open channels shall be derived from the latest edition of *Australian Rainfall and Runoff*.

Indicative values are shown below.

MANNINGS 'N'

Channel type	Mannings "n"
Concrete Pipes or Box Sections	0.011
Concrete (trowel finish)	0.014
Concrete (formed without finishing)	0.016
Sprayed Concrete (gunite)	0.018
Bitumen Seal	0.018
Bricks or pavers	0.015
Pitchers or dressed stone on mortar	0.016
Rubble Masonry or Random stone in mortar	0.028
Rock Lining or Rip-Rap	0.028
Corrugated Metal	0.027
Earth (clear)	0.022
Earth (with weeds and gravel)	0.028
Rock Cut	0.038
Short Grass	0.033
Long Grass	0.043

The following criteria shall apply:

- The desirable side slopes on grassed lined open channels shall be 1 in 6 or flatter.
- Council may consider an absolute maximum side slopes on grassed lined open channels of 1 in 4.
- Channel inverts shall generally have minimum cross slopes of 1 in 20,
- Floodways utilising a low flow pipe shall be sized for the entire ARI design flow (Q100) based on the assumption that the low flow pipeline is fully blocked during major storms.
- Low flow pipes shall be designed in accordance with the following:
    - The surface of low flow structures shall be designed to reduce scour and erosion in the base of the channel.
    - The width of the channel section shall be sufficiently wide enough to accommodate maintenance operations and equipment.
    - Desirable minimum cover for low flow pipes shall be 450 mm and absolute minimum cover shall be 300 mm. Appropriate pipe classes shall be adopted accordingly for the design circumstance, and with due consideration to plant used for drain maintenance.
    - The design flow for low flow pipes shall be in accordance with the relevant design criteria shown in **5.10 AVERAGE RECURRENCE INTERVAL (ARI)** for a three (3) month ARI flow as an absolute minimum.
    - Minimum grade of low flow pipes shall be sufficient to generate self-cleansing velocities.
    - Minimum size of low flow pipes shall be 375 mm.
    - Maximum spacing of pits on straight sections of low flow pipes shall be 60 metres.

  - Low flow infrastructure (pipes/pits etc) shall generally be designed to minimise hydraulic losses. In some cases however, pits/structures may be specifically designed to dissipate energy, eg. drop chamber energy dissipaters (with large diameter/minimum grade outlets.
  - Subsurface drainage shall be provided in grass-lined channels to prevent waterlogging of the channel bed. Refer to **D7 Stormwater Management** for details of techniques to incorporate WSUD in open channels.
- Transitions in channel longitudinal and side slopes shall avoid hydraulic jumps.
- All designs shall address the requirements for safety by providing safe egress points from the channel or other appropriate methods approved by Council.
- Permissible scour velocities and minimum permissible velocities for public safety shall govern maximum longitudinal grades for major floodways.

5.25.1 Floodways

Major floodways are generally located within drainage reserves or public open space. Council will not accept major floodways through easements on private land in urban situations and the 100 year event shall be contained entirely within reserves for urban areas.

Where the development is located in a high hazard, floodway or flood-storage an assessment in accordance with the councils current flood policy and the NSW *Floodplain Development Manual (April 2005)* shall be undertaken.

5.26 STORMWATER DETENTION - SUBDIVISIONS AND MAJOR DEVELOPMENTS

This section applies to all developments other than individual dwellings, multi-unit development, commercial and industrial developments where the detention system is to become part of councils assets.

5.26.1 Objectives

- To protect property and infrastructure from flooding during a nominated rainfall event by the provision of detention basins.
- To limit, as much as possible, the number of detention basins servicing an area to reduce Council's future maintenance liability.
- Detention basins, if designed as stand alone basins, shall be designed to drain completely and be constructed so that the area can be used for passive or active recreation or other uses such as carparks as determined by Council.
- To improve the quality of stormwater runoff being discharged from a particular development using Water Sensitive Urban Design principles. Refer to **D7 Stormwater Management.**
- To protect Council's existing stormwater drainage assets from overloading as a result of new developments which increase the amount of stormwater runoff being generated from a particular property.
- To protect the public from risk of injury or death.
- Detention basins shall be designed and constructed so as to be aesthetically pleasing and having regard to the area that they will be located in. They will not have an adverse amenity impact on the surrounding areas.
- To provide safe and unobstructed access for all maintenance operations and equipment.

5.26.2 General

Detailed design and documentation of drainage basins and/or similar detention facilities are to be prepared by an **Appropriately Qualified and Practicing Consultant**.

A Stormwater Management Plan shall be prepared in accordance with **5.2 STORMWATER MANAGEMENT PLANS** and consider the requirements for a suitable stormwater detention system and demonstrate that the system can be integrated in the proposed development. The detention basin location shall be in accordance with an approved Stormwater Management Plan.

Land that has been identified for stormwater detention basins to be maintained by Council, whether existing or proposed, must be shown on a Deposited Plan as a Council Reserve for drainage purposes and is vested in the Council.

When a detention basin is required for any development, the basin and any overland flow paths shall be constructed as part of stage one works. Where it can be demonstrated to Council that a detention basin is not required as part of the first stage works, plans, computations, and relevant acceptances must be provided to confirm the alternate method of outfall and/or storage capacity provisions.

Note: Rainwater tanks shall not be included in detention calculations.

5.26.3 Location and siting

Detention basins shall be sited outside of areas zoned Environmental Conservation (E2), or land affected by Floodway. Detention basins siting may be considered within an area affected by Environmental Management Zone (E3).

Siting of detention basins shall have regard to:

- The physical dimensions required for storage volume including the flattest possible batters, access to the basin bed, and maintenance of batters and edges.
- Pre-development catchments.
- Existing developed catchments.
- Existing drainage including piped, swale drains, or flow paths.
- Existing and proposed drainage easements.
- Ground water depth and seasonal fluctuations.
- Subsoil characteristics.
- Location and point of discharge.
- Soil type and seepage rate.
- Land uses and zoning.
- Effect of overland flows external to the catchment.
- Potential risk or affect on people, fauna and flora.
- Amenity of the area.
- Benefiting landholder issues.
- Maintenance issues and all weather access.
- Water quality.
- Whether or not the retarding basin is proposed to be used, or included in the calculation for Public Open Space.
- The location of overland flows into the basin and the treatment(s) to minimise erosion.
- Inlet velocity and the need to install energy dissipation structures.

- 1% flood level or highest recorded flood level information.
- Not placed within riparian zones or over natural water courses.

5.26.4 Design criteria

Detention basins shall be designed to maintain the existing undeveloped discharges for all storm durations and frequencies up to and including the 1 in 100 year events.

Designers shall ensure that discharges from new urban developments do not exceed the capacity of the downstream stormwater systems nor result in additional scour and instability of natural creek and river systems and artificial channels.

Detention basins shall have safe overland flow paths defined.

Freeboard shall be as follows for all structures.

- Desirable minimum – 500 mm.
- Absolute minimum – 300 mm.

Detention systems are not to be placed over natural water bodies and should be free draining.

Detention areas should be dual purpose where possible making use of existing open space and storage opportunities.

Grated pit covers at the base level of the basin floor shall not be permitted in detention basins. Council may consider grated pit covers if the cover is raised above the basin invert level. Acceptance in writing by Council is needed.

Standard grates and covers for pits will be sufficient in non-trafficable areas, however where the pit is located in the wheel path of vehicles a heavy-duty grate or cover shall be provided.

5.26.5 Inlet Structures

Any inlet pipe to a basin must be fitted with a headwall and an approved structure that will minimise blockages and restrict the entry of children.

All inlet headwalls will be fitted with an approved post and rail barrier to prevent falls and to identify the location of headwalls and wingwalls.

5.26.6 Low flow pipes

Detention basins shall incorporate a low flow system that may includes pipes or open drains. The low flow system shall be designed to match the outflow capacity where this is less than a 1 in 5 year storm event.

Any pipe system shall have a minimum pipe size 375mm dia. The designer shall check the need for orifice plates to control outflows if the minimum pipe size is excessive.

5.26.7 Overflow systems

A suitable overflow system must be provided to cater for rarer storm events than what the system has been designed for and to provide for a blockage in the system. All overflows are to be directed away from buildings, adjoining properties and associated infrastructure. Overflows shall be directed down a appropriate spillway and not directed down the face of the basin or embankment.

The depth of overland flow shall be designed so that it is no higher than 300 mm below the lowest floor level of any dwelling impacted by the overflow.

5.26.8 Depth of detention basins

Detention basins may require an impervious lining or other treatment to the acceptance of Council to prevent the ingress of groundwater.

The depth of all other detention basins for which the public have access to will be determined having regard to the safety of persons who may fall into or enter into the basin during times of operation. To allow for this contingency, basins shall be designed with inside batters having a desirable slope of 1 in 6. This slope will determine the maximum depth of many detention basins.

5.26.9 Batter slopes in earthen basins

Desirable batters for detention basins shall be 1 in 6 for both cut and fill situations. The absolute maximum batters shall not exceed 1 in 4 for both cut and fill situations. The use of the absolute maximum batter slopes shall only be permitted after acceptance in writing has been obtained from the Council.

A minimum cross-fall for the floor is to be 1 in 200 graded to the outlet point of the basin to eliminate water ponding.

5.26.10 Access requirements

An all weather access is to be provided to the detention basin and any associated structures to enable maintenance to be carried out. The access must be provided so that maintenance of any portion of the basin and its associated works can be safely carried out. Access into the basin shall be protected from scour. A 4.0 metre wide reserve shall be required around the perimeter of any detention basin, unless written acceptance is given otherwise. The access around the perimeter should be provided in such a manner that there is no need to reverse at any time.

5.26.11 Fencing

When required by Council, all detention basins shall be fenced off and made safe against casual entrance.

Refer to **5.28 FENCING AND SECURITY** for more details.

5.26.12 Landscaping

A fully detailed landscape plan for all detention basins shall be submitted to Council for acceptance.

Plants with major root systems shall not be permitted on embankment walls. Shallow rooted shrubs and grasses are acceptable.

5.26.13 Maintenance

Any large pipe inlets into the basin shall be grated in a satisfactory manner to prevent entry to the stormwater drain. The inlet shall be designed so that they can be easily maintained and so that they will minimise blockages during storm events.

Pits, pipes, screens etc that require regular cleaning and maintenance shall be readily accessible with all openings of suitable geometry to allow for cleaning and removal of debris and silt accumulations.

5.27 STORMWATER DETENTION - SMALL DETENTION SYSTEMS

This section applies to individual dwellings, multi-unit developments, commercial and industrial developments where works remain in the control of the property owner.

Note: Where AS 3500 does not apply this document shall be used.

5.27.1 Objectives

The objectives of small on site detention systems are as follows:

- The capacity of existing drainage infrastructure shall not be exceeded as a result of developments, which increase the volume and rate of stormwater runoff beyond the capacities originally designed for.
- The likely cumulative impact of similar developments shall not adversely impact on the capacity of the existing drainage system.
- That on-site detention (OSD) systems are able to be effectively maintained by landowners and provide a cost effective method of meeting the other objectives of this section.
- Provide a simplified method for designers, builders and owners to determine Council's requirements for on-site detention in relation to volume of detention and permissible rate of discharge to Council's drainage system.
- That on-site detention (OSD) systems meet necessary OH&S guidelines.

5.27.2 General

The following types of development typically require on-site detention:

- Multi-unit development in new residential areas where this has not been incorporated into the design of the drainage system for these areas.
- Multi-unit development in older residential estates where the design recurrence interval is less than the current 1 in 5 year recurrence interval.
- Industrial development where the pipes have been designed for less than the current design recurrence interval of 1 in 20 years.
- Commercial development where the pipes have been designed for less than the current design recurrence interval of 1 in 20 years.
- Any other development that could adversely impact on private property irrespective of the capacity of Council's infrastructure.
- Any other urban areas identified by Council as drainage problem areas.
- Alterations and additions to Commercial and Industrial developments that are greater than $40m^2$.

Note: Rainwater tanks shall not be included in detention calculations.

5.27.3 Requirements

Where on-site detention is required in order to discharge into Council's existing drainage system the developer shall provide computations to Council's satisfaction to demonstrate the volume of detention required and the permissible rate of discharge to ensure that Council's existing drainage system is not adversely impacted by the development.

Design methodology to determine these parameters is in accordance with the latest edition of *Australian Rainfall and Runoff*.

The development shall assume a 'green field' development scenario. That is a co-efficient equal to an undeveloped site shall be used for the existing conditions.

5.27.4 Specific Design Requirements

A suitable overflow system must be provided to cater for greater storm events than what the system has been designed for and to provide for a blockage in the system. All overflows are to be directed

away from buildings, adjoining properties and associated infrastructure. The overflow system shall be designed to cater for all storms up to and including a 1 in 100 year storm event.

The depth of overland flow shall be designed so that it is no higher than 300 mm below the lowest floor level of any dwelling impacted by the overflow.

Where the tables above are not used to determine on-site detention requirements, the system shall be designed using the following:

- Recurrence interval in accordance with **5.10 AVERAGE RECURRENCE INTERVAL (ARI)**
- Coefficients of runoff (C) in accordance with. The consultant shall calculate the specific 'equivalent' coefficient for the area.

The following minimum information is to be supplied to Council for acceptance:

- Plan showing invert levels of all pipes 100mm or over.
- Plan showing the designed finished surface level of all driveways, car parking areas, landscaping areas and lawns.
- Plan showing floor levels of all buildings whether existing or proposed. **Note:** All floor levels must be at least 300 mm above the top water level of the detention device when it is full to its design capacity.
- Cross section of the detention facility.
- Existing surface levels at intervals not exceeding 1.0 metre. **Note:** This is also required for adjoining properties.
- Plan showing location of detention device, position of all pipes and pits, pervious and impervious areas, buildings, driveways, overflow routes etc.
- Driveways, where these are used for on site detention, shall be bounded by kerbs of not less than 150 mm in height and 100 mm in width, and shall be cast integrally with the main slab unless otherwise approved.
- Drainage computations.

5.27.5 Discharge point

Orifice plates (if required) shall be corrosion resistant 3 mm stainless steel. Where the orifice plate exceeds 150 mm dia. the material is to be 5 mm thick.

The outlet is to be designed to avoid blockage.

5.27.6 Signage Requirements

Each on-site detention system is to be marked by a plate in a prominent position, which identifies the on-site detention system and that it is an offence to reduce the volume of the tank or basin or interfere with the orifice plate that controls the outflow.

5.27.7 Underground On-Site Detention (OSD) and Access Requirements:

All underground storage tanks shall have suitable access for maintenance and comply with *Occupational Health and Safety Act 2000* and Confined Space requirements.

All underground storage tanks shall comply with the *Public Health Act 1991*.

Access to underground storage tanks must be secured with a grate or cover and fastened to prevent unauthorised access. Access points are not to be concreted, paved, built over or otherwise obstructed.

Access openings must be a minimum:

- 600 mm by 600 mm for storages up to 600 mm deep
- 900 mm by 900 mm for storages greater then 600 mm deep.

The floor of underground storages must be graded so that the storage empties and water does not pool with the tank.

Underground storage tanks may face corrosion and acidic attack. The storage tank type must be resistant to the environment in which it is placed. This applies to both above and below ground installation.

Underground storage tanks must not be installed over or within 1.0m of a water main, sewer main, on-site wastewater system or on-site wastewater disposal field.

Underground storage tanks shall not be installed within 1.0m of the drip line of trees. A root barrier shall be installed if underground storage tanks are located adjacent to trees.

Where OSD facilities are located under driveways and parking areas, consideration must be given to the finished surface levels and vehicular access requirements.

OSD storage shall not be installed into the groundwater zone unless detailed computations are provided and approved by council.

5.27.8 Above Ground On-Site Detention OSD:

Paved Surfaces

- Water ponding depth is to be limited to a depth of 150 mm in areas where vehicles are parked and 180 mm in areas where vehicles are not parked.
- The storage area shall be totally impermeable.
- In trafficable or pedestrian areas no less that 15% of the total storage volume shall be provided underground.

Landscaped areas

- OSD systems shall not extend across lot boundaries.
- OSD shall meet the following requirements:
    - Water depth shall be no deeper than 1200 mm.
    - Water depth greater than 500 mm shall be fenced with child-proof fencing.
    - A maximum batter slope of 1 in 6 or alternatively a terraced slope system so that the maximum terraced depth is no greater than 300 mm.
    - Council may consider alternative designs to the above requirements, however public safety shall be addressed and child-proof fencing may be required.
- The floor of the OSD area is to be permeable to allow infiltration and should not pond water.
- The bunded wall of the OSD area must be impervious.
- Where vegetated the storage capacity shall be increased by 20% to allow for vegetation growth.

5.27.8 Approved Types of On-Site Detention Systems

The following systems that have been approved include:

- Driveways and carpark areas to store the stormwater.
- Multi-cell units,
- Underground tanks of various configurations,

- Excavated earthen storages,
- Above ground grassed or landscaped area.

5.27.9 Maintenance of On-Site Detention Systems

Where on-site detention system is required the landowner will be required to maintain these to the satisfaction of Council.

5.27.10 Development by the Crown

A building application is not required by the Crown and as such the OSD requirements are implemented differently for development applications made by or on behalf of the Crown (eg. Department of Housing etc).

The approval of an OSD system shall be in the following stages:

- The development application shall submit detailed design calculations and drawings for approval by council of all OSD systems.
- Before the release of the Subdivision Certificate or Occupancy Certificate or final acceptance by council the Crown must submit Work-as-Executed drawings, design certifications and all necessary legal titles or agreements protecting the OSD system.

5.28 FENCING AND SECURITY

5.28.1 Public safety considerations

Public safety is an important consideration near stormwater management devices. The following points need to be considered when designing a stormwater treatment &/or detention facility:

- Above and below water batter slopes need to be gentle (1V:6H to 1V:8H).
- Dense planting of vegetation and/or fencing should be provided where access is to be restricted. Wherever possible the extent of pedestrian barrier fence should be limited to control the risk at a particular location rather than the whole site.
- Densely planted vegetation can be used in a number of situations to discourage public access to parts of a site. Species with particularly spikey leaves that could cause serious eye damage should not be used where there is easy access to a wet area.
- Where dense vegetation is to be used as part of the risk minimisation strategy several factors need to be considered.
    - Advanced plants should be used adjacent to *Accidental Entry Fencing* and along the planting/ public interface to provide a quick barrier whilst the remainder of the planting establishes. Accidental Entry Fencing provides a nominal level of protection and controls illegal vehicle access.
    - Temporary fencing in the form of paraweb fencing (or similar) may be required until plantings are well established.
- Slopes of 1V:6H (above water) are considered as a maximum where machinery is used for maintenance. Appropriate barriers such as fencing or dense vegetation may be required to discourage public access on steeper batters.
- The *Institution of Engineers Australia (Rainfall & Runoff 1998)* outlines some criteria for detention basins that includes:

- Rails or fences should be provided at the most dangerous sections of drainage systems especially near schools, or upstream of culverts or closed conduits.
- Preferred slopes should not be steeper than 1V:6H and areas steeper than 1V:4H may require fencing or rails. These requirements are more important where water areas are deeper than 1.2m.
- Fences should be 1.0 to 1.2m in height and should not impede potential rescuers.
- Where signs are used, signs should inform the public of the function of the facility as well as giving a warning. In some situations gauge boards could be used in channels or ponds to give tacit warnings as well as for recording flood information. Warning picturegram signs, noting it as a water treatment and/or floodway area, and swimming not permitted, placed prominently upon the area.

5.28.2 Signage

Appropriate signage shall be installed to indicate the purpose of the facility and other warnings that are applicable to the general safety of all persons directly or indirectly exposed to the area.

Standard signage must be used.

Other information signage should promote positive public relations and convey the message of protecting the waterways of Port Macquarie-Hastings Council. For example: " This is a Water Quality Device maintained by Port Macquarie-Hastings Council to protect our waterways."

5.28.3 Maintenance considerations

Safe, practical and efficient maintenance is a primary consideration in the selection and layout of fencing.

Considerations include:

- Access and manoeuvring areas for vehicles and equipment.
- Material handling and de-watering areas.
- Mowing operations. The layout should facilitate tractor mowing.
- Use of standard products and module lengths. Limit the number of products used at any given site.

5.28.4 Major storm events

Consideration should be given to the major stormwater event flows. Depth, velocity and debris loadings can impart significant forces that can destroy fencing. If resisted, flows can also be diverted from their intended path and may have potentially serious effects, for example, causing the main wall to overtop rather than an overflow weir.

5.28.5 Proposed Fencing Styles

- **Accidental Entry Fence styles**

  Council has two options available and these are shown on ASD 818.

  Option 1 - Timber bollard and chain fence
  Option 2 - Timber bollard and pipe (top rail) fence.

- **Pedestrian Barrier Fence**

  The preferred style is Council's standard Pedestrian Barrier Fence (ASD 807) or an approved equivalent (to AS 1926.1-1993) in a powder coated colour (preferably black or dark green).

5.28.6 Gates

Gateways should preferably be located away from high pedestrian use areas. Gates should be lockable and 4.0m wide.

5.28.7 Industrial areas

Fencing shall be 1.8m high chainmesh fence installed for the entire perimeter. Suitable access via lockable gates shall be provided for maintenance purposes.

5.28.8 Factors for determining batter slope and fence treatments

Factors such as; batter slope angle, vertical drop height, water depth, and site context, are to be used to determine the internal batter slope treatments and fencing requirements around water quality and detention basins in the Port Macquarie-Hastings Council area. As a general principle the designer should aim to minimise the use of pedestrian barrier fence by selecting design elements with lower risk factors.

Where a site requires special considerations Council may approve alternative treatments based on their merits.

Refer to the table below for further details on fencing warrants. The designer must select the most appropriate condition/factor for items A-D. The total will determine the treatmrent needed for the sand filter, pond, wetland, basin etc.

FACTOR	RISK FACTOR
A) Batter slopes - above permanent water level Select the steepest batter slope in the section of the sand filter, pond, wetland, basin etc that is being considered.	
1:6 or shallower (1:8 ideal)	1
1:4 up to 1:6	2
Steeper than 1:4	6
Vertical Wall above permanent water level. 0.1m<wall height ≤0.5m	8
Vertical Wall above permanent water level. Wall height>0.5m	16

B) Vertical drop at water edge - below permanent water level	
0.0<vert. drop ≤0.3m (vertical drop at the permanent water edge) or continuously graded slopes	0
0.3<vert. drop ≤0.5m (vertical drop at the permanent water edge)	8
>0.5m (vertical drop at the permanent water edge)	16

C) Max water depth between water edge and 4m from the water edge - below permanent water level **NOTE**: For detention basins, the 1:20 yr water level shall be considered as the permanent water level if ponding time exceeds 2 hours or total water depth is greater than 1.2m.	
≤0.67m (max water depth up to 4.0m from the permanent water edge)	4
0.67<water depth ≤1.0m (max water depth up to 4.0m from the permanent water edge)	8

>1.0m (max water depth up to 4.0m from the permanent water edge)	16

D) Site context Select the site context that best fits the site being assessed.	
Reserve designed to incorporate a constructed wetland/pond or other feature that holds water as a landscape feature integral to the open space. Adjacent areas may already contain other water bodies or watercourses. Residences within 100m of site and there is good surveillance from overlooking houses. Infant/primary schools are >250m from the site.	4
Reserve, with potential high use including likely high pedestrian and cyclist numbers, playground, picnic/BBQ facilities and possible larger public events. Infant/primary school >250m from the site. Residential areas ≤150m of the site. Moderate/good public surveillance.	6
D) Site context (cont.) Select the site context that best fits the site being assessed.	
Reserve including parkland/natural areas, generally with low use. Infant/primary school ≤250m from site and/or on a direct route to/from the school. Residential areas >150m from the site. Limited public surveillance.	8

BATTER TREATMENT AND/OR FENCING REQUIREMENT (Add selected risk factors from items A-D)	**TOTAL SCORE**
Mown grass and/or planting for aesthetic and shade purposes.	≤11
Dense planting (2.5m width minimum, 4.0m width ideal. Plants to be preferably clumping, to approximately 0.75m high and at 0.5m spacing maximum).	12-16
Dense planting and Accidental Entry Fencing.	17-21
Pedestrian Barrier Fencing.	> 21

5.29 BASEMENT DRAINAGE AND GROUNDWATER

5.29.1 Objectives

Basements must be of fully 'tanked' construction such that pump-out systems are not required to drain the subsurface drainage system. The subsurface drainage system must be designed such that the existing subsurface flow regime in the vicinity of the development will not be significantly altered as a result of the development and there will be no adverse impact on surrounding properties.

Where the basement is associated with car parking facilities, a pump out system is permitted for minor surface areas that drain to the basement, such as from the access driveway. All other forms of access to the basement, including fire access stairs, must be protected from the weather, such that the entry of stormwater runoff to the basement is minimised.

Consideration may be given to the provision of a pump-out system where it can be demonstrated that groundwater flows are minimal/ intermittent and subject to direct connection of the site discharge to Council's piped stormwater drainage system. This option may only be considered when supported by detailed geotechnical investigation.

For basements other than car parking facilities, the above consideration will only be contemplated where the sump and pump facilities can be housed and accessed for maintenance externally to the development.

5.29.2 Design

The Stormwater Management Plan submitted with any Development Application incorporating a basement must include detail of how the proposed basement will be drained. Where minor surface areas drain to the basement, such as from the access driveway, a pump out system is permitted with discharge directed to the OSD storage tank(s) (where installed as part of the development).

Where subsurface waters are permitted to be pumped from the basement, discharge must be connected directly to Councils piped drainage system.

An integrated Structural and Geotechnical Engineering report addressing the design of the proposed basement must be submitted with the Development Application. The design must address the following issues at a minimum:

- The basement must be of fully ‘tanked’ construction and be entirely waterproofed.
- The existing subsurface flow regime in the vicinity of the development must not be significantly altered as a result of the development.
- No adverse impact on surrounding properties.
- Recommendations regarding method of excavation and construction, vibration emissions and identifying risks to existing structures or those on adjoining or nearby property.

A pump-out system for stormwater disposal must be designed in accordance with the following criteria:

- The proposed pump system must consist of two (2) pumps, connected in parallel, with each pump being capable of emptying the holding tank at a rate equal to the rate of inflow for the one hour duration, 100 year Average Recurrence Interval (ARI) storm event. The holding tank must be capable of holding one hour's runoff from a one-hour duration 20 year ARI storm event.
- An overflow, flashing light and audible alarm is to be provided to warn of pump failure.
- Where OSD facilities are required, the pump system must discharge to the OSD storage tank.
- A maintenance regime for the pump system must be provided, including provision for regular maintenance and servicing at least every 6 months.

5.30 RETAINING WALL DRAINAGE

5.30.1 Objectives

Retaining walls must be designed having regard for any required subsoil drainage required. The subsurface drainage system must be designed such that the existing subsurface flow regime in the vicinity of the development will not be significantly altered as a result of the development and there will be no adverse impact on surrounding properties.

Where a retaining wall is proposed along / adjacent to a property boundary, the wall must be set back sufficiently such that all subsoil drainage required is located wholly within the boundaries of the subject allotment.

5.30.2 Design

The Stormwater Management Plan submitted with any Development Application incorporating retaining walls adjacent to the property boundary to a public road must include a full structural design of the proposed retaining structures. Where the retaining structures are proposed at other locations within the allotment, the stormwater management plan must show the location of all subsurface drainage infrastructure, collection pits and points of discharge from the site.

The structural design of any retaining wall supporting a road reserve must address the following at a minimum:

- Retaining walls must be entirely self supporting in the event that excavation is undertaken within the road reserve adjacent to the property boundary to the depth of the proposed structure.
- All components of the structure, including subsoil drainage, must be located entirely within the property boundary.
- Any retaining walls must be adequate to withstand the loadings that could be reasonably expected from within the constructed road and footpath area, including normal traffic and heavy construction and earth moving equipment.
- Relevant geotechnical/subsurface conditions of the site, as determined by full geotechnical investigation.

5.31 ABSORPTION / DISPERSION TRENCHES

Where absorption disposal is approved, the following requirements will apply to the proposed development:

- The absorption facility must be accessible for future maintenance.
- A pollution trap is to be provided upstream of the absorption facility to screen debris and remove fine silts to minimise the likelihood of future blockage.
- The absorption facility is to be designed and certified by a suitably qualified Geotechnical Engineer. The geotechnical report must address the following at a minimum:
    - Depth to rock,
    - Depth to the water table,
    - Measured infiltration rate (in litres/square metres/second),
    - Infiltration rate that can be maintained in the long term over the life of the system,
    - Minimum distance any infiltration system should be located clear of property boundaries,
    - Whether the use of infiltration is likely to cause seepage problems to the proposed structure or to any adjoining properties,
    - The use of any waterproofing to protect underground areas,
    - Any special requirements for the design of walls or footings on the site.

The absorption pit is to be designed for an Average Recurrence Interval (ARI) storm of 50 years using Mass Curve techniques. An overflow mechanism in the form of a level spreader must be provided for all storms greater than the 50 year ARI storm, up to and including the 100 year ARI storm. The overflow mechanism must minimise overland flow disturbance to the lower property.

Where a high water table is encountered and gravel filled trench design is proposed, the base of the trench should be at least 500mm above the water table to accommodate fluctuations of the groundwater.

The absorption pit should not be located within three (3) metres of the side or rear boundary, or three metres from any onsite building or neighbouring buildings.

5.32 RURAL DRAINAGE

5.32.1 Objectives

The general objectives of rural drainage are as follows:

- To collect and control all stormwater generated within the development or subdivision to ensure that it is discharged from the site in a way that does not detrimentally impact on any upstream or downstream property.
- To ensure that developments or subdivisions that increase the rate and quantity of stormwater, runoff shall be detained to predevelopment runoff rates.
- To provide an effective outlet to an approved outfall.
- To ensure that culverts and waterways are designed so that any overtopping of any roadways will be such that it allows for the safe passage of vehicles.
- That stormwater flows are generally restricted to natural drainage lines and drainage catchment boundaries are not crossed.
- To achieve these objectives without detrimentally affecting the environment generally, surface and subsurface water quality, groundwater infiltration characteristics, the adjoining landowners and other landowners about the drainage outlet and watercourses either upstream or downstream of the development or subdivision.

5.32.2 General

Drainage design shall be in accordance with the provisions of the latest edition of *Australian Rainfall and Runoff*.

Drainage design shall give consideration to the entire drainage catchment, not just the area included in any development or subdivision.

Designers are to take into account upstream developments, overland flow paths, natural drainage lines, possible removal of unnatural drainage obstructions, depth of flooding that may occur on roads and private property and other factors which may impact on or be impacted by the design of any rural drainage system.

5.32.3 Requirements

Stormwater runoff estimation for rural catchments (undeveloped areas) shall be based upon hydrological methods and data contained within the latest edition of *Australian Rainfall and Runoff*, unless otherwise specified within this manual.

A recognised flow estimation method (runoff routing computer models) in addition to the latest edition of *Australian Rainfall and Runoff* shall be used for comparative purposes for rural farming catchments or sub-catchments greater than 50 Ha.

The minimum pipe size for any driveway crossing shall be no less than 375 mm diameter.

5.33 VEGETATION PLANTING OVER DRAINAGE PIPES

Trees, shrubs and other vegetation if planted in close proximity to pipelines will likely cause damage to drainage pipes. In addition, vegetation including garden beds can cause considerable accessibility problems if a pipe is to be repaired.

No vegetation of any type other than lawn shall be planted over any drainage pipes or in drainage easements where pipes exist.

5.34 INTENSITY / FREQUENCY / DURATION TABLES

Council has developed Intensity/Frequency/Duration (IFD) tables that apply to similar regional rainfall areas within the Port Macquarie-Hastings Council LGA. The regions are described as follows:

- **Coastal Region** – the area bounded by the eastern coastline, the northern & southern boundaries of the Council LGA and the area east of the Pacific Highway.
- **Lower Inland Region** – the area bounded by the northern and southern boundaries of the Council LGA, all areas west of the Pacific Highway with an elevation below 150m AHD.
- **Upper Inland Region** – the area as specified for the Lower Inland Region with an elevation above 150m AHD.

Intensity/Frequency/Duration (IFD) tables for the above regions are shown in **APPENDIX B – INTENSITY/FREQUENCY/DURATION TABLES**

5.35 REFERENCE DOCUMENTS

The following documents are reference in this document, however no guarantee is given that all reference documents are listed below. The designer shall ensure the current version of all necessary documents are used and source any other documents as necessary.

5.35.1 Council Specifications

Reference	Title
D4	Subsurface drainage design
D7	Stormwater Management.
D14	D14 - Work As Executed Plans
D15	CAD Specification
DQS	Quality assurance requirements for design
--	Port Macquarie-Hastings Council - Standard Drawings

5.35.2 Australian Standards

Reference	Title

AS 1254	Unplasticised PVC (uPVC) pipes and fittings for stormwater or surface water applications.
AS 2032	Code of practice for installation of uPVC pipe systems.
AS 3725	Loads on buried concrete pipes.
AS 4058	Precast concrete pipes.
AS 4139	Fibre reinforced concrete pipes and fittings.
AS 3500	Stormwater drainage

5.35.3 Other

Title
Australian Rainfall and Runoff (2001)
Queensland Urban Drainage Manual, Volumes 1 & 2 (1993)

APPENDIX A – INFORMATION TO BE SHOWN ON PLANS

This section applies to all developments.

Drainage layout Plans

Drainage layout Plans shall as a minimum show the following:

- Limit of Works to be constructed including all connections to existing work;
- All proposed allotments (numbered), reserves and easements within the development;
- All streets to be constructed;
- Existing and proposed survey marks;
- All drains to be constructed, including stormwater treatment structures and outfall drains;
- Existing surface levels of all allotments and all significant changes of grade within the allotment, or alternatively contour information of sufficient detail to show same;
- Flood levels shall be shown where applicable;
- Drainage Pipe diameters and offsets from property boundaries to pipe centreline;
- Drainage Pit numbers;
- Subsurface drains, house drains and property inlets;
- All existing fences, buildings, trees, etc on the street alignment or land through which drains or flow paths shall pass;
- Existing or proposed open earth drains, dams, watercourses, bore holes, sink holes, wells and springs within the area;
- Plans shall be drawn in accordance with Port Macquarie-Hastings Council drafting specifications – **D15 CAD Specifications**.
- The plan shall also show all drainage easements, reserves and natural watercourses.

Drainage Longitudinal Sections

A drainage longitudinal section for each leg of drainage shall be plotted regardless of the length of the leg including inter-allotment drains. Drainage longitudinal sections shall as a minimum show the following:

- Centreline chainage;
- Existing and finished surface levels at all pits and grade changes;
- Invert level of pipe at the inlet and outlet to pits;
- Datum level;
- Pit description;
- Depth to invert of pits from finished surface;
- Pipe size, grade, class and material;
- Actual velocities, actual discharge and pipe capacity;
- Plot of design pipe grade;
- Plot of hydraulic grade lines and levels;

- Pit numbers;
- All existing services shall be shown on the section where the designed pipe crosses;
- A pit schedule detailing:
  - ~ Pit number
  - ~ Pit type
  - ~ Internal dimension of pits
  - ~ Inlet and outlet levels
  - ~ Pipe sizes
  - ~ Finished top of pit level
  - ~ Depth of pit
  - ~ Pit lid details
  - ~ Origin/destination pits for inlets and outlets
  - ~ Comments specific to pit.
- The location of the pipe (ie. Street name, reserve, lot number) on the longitudinal section; and
- The location and type of special backfill in trenches.

Drainage Detention and Water Quality Treatment Drawings

Drawings for small on-site detention and large drainage detention systems shall as a minimum show the following:

- Limit of Works to be constructed including all connections to existing and proposed work;
- Property boundaries and easements within the limit of works;
- Existing and proposed survey marks;
- Flood levels shall be shown where applicable;
- Drainage Pipe diameters and grades;
- Drainage Pit numbers;
- All existing or proposed fences, buildings, trees, public open space features in the vicinity of the works;
- Invert levels of all inlet and outfall structures including pipes and open drains;
- Surface levels and freeboard;
- Batter slopes and grades of basin floor;
- Orifice plate details or similar for on-site detention systems;
- Top Water Levels during both the minor storm event and 100 ARI storm event;
- The hydraulic grade line in the inlet pipe/drain for both the minor storm event and 100 ARI storm event;
- Invert levels and cover levels of associated pits and litter traps;
- Design catchment and storage volume requirements shall be stated on the plans; and
- Planting schedules for landscaping including quantity and species of all plantings.

Detail Drawings

Detail drawings shall as a minimum show the following:

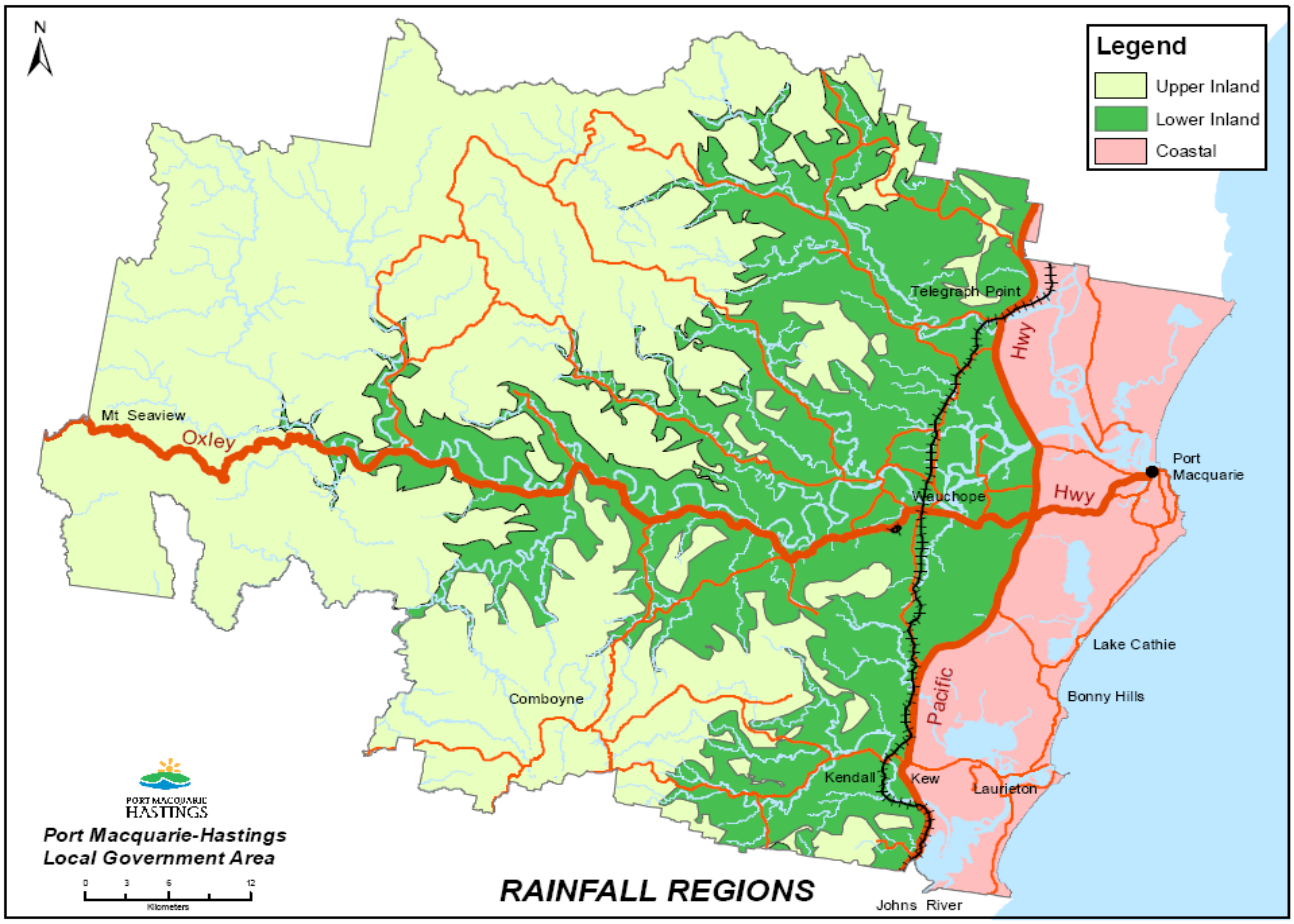
- All special drainage structures;
- Method of downstream erosion control at endwalls;
- Method of erosion control for batters in areas susceptible to erosion; and
- Structural details of retaining walls (if applicable).

Work-as-Executed Drawings

Work-as Executed plans shall detail all design information but shall highlight any deviation from the approved design plans. The details shown shall be prepared in accordance with Port Macquarie-Hastings Council – **D14 Works As Executed (WAE) specification**.

APPENDIX B – INTENSITY/FREQUENCY/DURATION TABLES

Plan of IFD Regions



Coastal Region IFD table

Duration (mins)	1 Yr ARI (mm/hour)	2 Yr ARI (mm/hour)	5 Yr ARI (mm/hour)	10 Yr ARI (mm/hour)	20 Yr ARI (mm/hour)	50 Yr ARI (mm/hour)	100 Yr ARI (mm/hour)
5	103	133	171	193	222	260	289
6	97	125	160	181	209	245	273
7	91	118	152	172	198	233	260
8	87	112	145	164	189	223	248
9	83	107	138	157	181	213	238
10	79	102	133	151	174	205	229
11	76	98	128	145	168	198	221
12	73	95	123	140	162	191	214
13	71	91	119	136	157	186	207
14	68	88	115	131	152	180	201
15	66	86	112	128	148	175	196
16	64	83	109	124	144	170	191
17	62	81	106	121	140	166	186
18	61	79	103	118	137	162	182
19	59	77	101	115	134	158	178
20	57	75	98	112	131	155	174
21	56	73	96	110	128	152	170
22	55	71	94	107	125	149	167
23	54	70	92	105	123	146	163
24	52	68	90	103	120	143	160
25	51	67	88	101	118	140	157
30	46.7	61	81	93	108	129	145
34	43.6	57	76	87	102	121	137
40	39.9	52	70	80	94	112	127
45	37.4	48.9	65	76	89	106	119
50	35.2	46.1	62	72	84	101	113
55	33.4	43.7	59	68	80	96	108
1hr	31.7	41.6	56	65	76	92	104
1.5	25	32.7	43.8	51	59	71	80
2	21	27.4	36.7	42.3	49.5	59	67
2.5	18.3	23.9	31.9	36.7	42.9	51	58
3	16.4	21.4	28.4	32.7	38.2	45.6	51
4	13.7	17.9	23.7	27.2	31.8	37.8	42.5
5	12	15.6	20.6	23.6	27.5	32.7	36.8
6	10.7	13.9	18.4	21	24.5	29.1	32.6
8	8.96	11.6	15.3	17.5	20.4	24.2	27.1
9	8.34	10.8	14.2	16.2	18.9	22.4	25.1
10	7.82	10.2	13.3	15.2	17.7	20.9	23.4
12	7	9.07	11.9	13.5	15.7	18.6	20.8
14	6.32	8.2	10.8	12.3	14.3	17	19
16	5.78	7.52	9.91	11.3	13.2	15.7	17.6
18	5.34	6.95	9.2	10.6	12.3	14.6	16.4
20	4.98	6.49	8.61	9.89	11.5	13.8	15.5
22	4.67	6.09	8.1	9.32	10.9	13	14.6
24	4.4	5.74	7.66	8.82	10.3	12.3	13.9
30	3.77	4.94	6.63	7.66	8.98	10.8	12.1
36	3.32	4.35	5.87	6.8	8	9.61	10.9
48	2.69	3.54	4.82	5.61	6.62	7.99	9.05
60	2.27	3	4.1	4.79	5.68	6.87	7.8
72	1.96	2.59	3.58	4.19	4.97	6.04	6.87

Lower Inland Region IFD table

Duration (mins)	1 Yr ARI (mm/hour)	2 Yr ARI (mm/hour)	5 Yr ARI (mm/hour)	10 Yr ARI (mm/hour)	20 Yr ARI (mm/hour)	50 Yr ARI (mm/hour)	100 Yr ARI (mm/hour)
5	99	128	164	186	214	253	283
6	93	120	154	175	202	238	267
7	87	113	146	165	191	226	253
8	83	107	139	157	182	216	242
9	79	102	132	151	175	207	232
10	76	98	127	144	168	199	223
11	73	94	122	139	161	191	215
12	70	91	118	134	156	185	208
13	67	87	114	130	151	179	201
14	65	85	110	126	146	174	195
15	63	82	107	122	142	169	190
16	61	80	104	119	138	164	185
17	60	77	101	115	134	160	180
18	58	75	98	113	131	156	175
19	56	73	96	110	128	152	171
20	55	71	94	107	125	149	168
21	54	70	92	105	122	146	164
22	52	68	90	103	120	143	161
23	51	67	88	100	117	140	157
24	50	65	86	98	115	137	154
25	49.1	64	84	96	113	134	151
30	44.6	58	77	88	103	123	139
34	41.7	54	72	83	97	116	131
40	38.2	49.8	66	76	89	107	121
45	35.7	46.7	62	72	84	101	114
50	33.7	44	59	68	80	96	108
55	31.9	41.7	56	64	76	91	103
1hr	30.3	39.7	53	61	72	87	99
1.25	26.9	35.2	47.1	54	64	77	87
1.5	24.3	31.9	42.6	49.2	58	70	79
2	20.8	27.2	36.3	41.9	49.3	59	67
2.5	18.3	24	32	37	43.5	52	59
3	16.5	21.6	28.9	33.4	39.2	47.1	53
4	14.1	18.4	24.5	28.3	33.3	40	45.3
5	12.4	16.2	21.6	25	29.3	35.2	39.9
6	11.2	14.6	19.5	22.5	26.5	31.8	36
8	9.53	12.5	16.6	19.1	22.5	27	30.6
9	8.92	11.7	15.5	17.9	21	25.3	28.6
10	8.41	11	14.6	16.9	19.8	23.8	26.9
12	7.6	9.93	13.2	15.2	17.9	21.5	24.3
14	6.94	9.07	12.1	13.9	16.3	19.6	22.2
16	6.41	8.38	11.2	12.9	15.1	18.1	20.5
18	5.98	7.82	10.4	12	14.1	16.9	19.1
20	5.62	7.35	9.77	11.3	13.2	15.9	17.9
22	5.31	6.94	9.23	10.6	12.5	15	17
24	5.04	6.59	8.76	10.1	11.9	14.2	16.1
30	4.4	5.75	7.64	8.81	10.3	12.4	14
36	3.93	5.13	6.82	7.87	9.23	11.1	12.5
48	3.27	4.27	5.67	6.54	7.67	9.2	10.4
60	2.81	3.67	4.88	5.62	6.6	7.91	8.95
72	2.47	3.23	4.29	4.94	5.8	6.95	7.86

Upper Inland Region IFD table

Duration (mins)	1 Yr ARI (mm/hour)	2 Yr ARI (mm/hour)	5 Yr ARI (mm/hour)	10 Yr ARI (mm/hour)	20 Yr ARI (mm/hour)	50 Yr ARI (mm/hour)	100 Yr ARI (mm/hour)
5	92	118	151	170	197	232	260
6	86	111	141	160	185	218	244
7	81	104	134	151	175	206	231
8	77	99	127	144	166	196	220
9	73	95	121	137	159	187	210
10	70	91	116	131	152	180	201
11	67	87	111	126	146	173	194
12	65	84	107	122	141	167	187
13	63	81	104	118	136	161	180
14	61	78	100	114	132	156	175
15	59	76	97	110	128	151	169
16	57	74	94	107	124	147	165
17	55	71	92	104	121	143	160
18	54	70	89	101	117	139	156
19	52	68	87	99	114	136	152
20	51	66	85	96	112	132	148
21	49.9	64	83	94	109	129	145
22	48.7	63	81	92	107	126	142
23	47.7	62	79	90	104	124	139
24	46.6	60	78	88	102	121	136
25	45.7	59	76	86	100	119	133
30	41.5	54	69	79	91	108	122
34	38.8	50	65	74	86	102	114
40	35.6	46	59	68	79	93	105
45	33.3	43.1	56	63	74	88	98
50	31.4	40.6	53	60	70	83	93
55	29.7	38.5	49.9	57	66	78	88
1hr	28.3	36.6	47.5	54	63	75	84
1.5	23.6	30.6	39.8	45.5	53	63	71
2	20.7	26.9	35.1	40.1	46.8	56	63
2.5	18.7	24.3	31.8	36.4	42.5	51	57
3	17.2	22.4	29.3	33.6	39.3	46.9	53
4	15	19.6	25.8	29.6	34.6	41.5	46.9
5	13.6	17.7	23.3	26.8	31.4	37.7	42.6
6	12.5	16.3	21.5	24.7	29	34.8	39.4
8	10.9	14.3	18.9	21.8	25.6	30.8	34.8
9	10.4	13.5	17.9	20.7	24.3	29.2	33.1
10	9.87	12.9	17.1	19.8	23.2	27.9	31.7
12	9.08	11.9	15.8	18.2	21.4	25.8	29.3
14	8.3	10.9	14.5	16.8	19.7	23.8	27
16	7.68	10.1	13.4	15.6	18.4	22.2	25.2
18	7.17	9.4	12.6	14.6	17.2	20.8	23.7
20	6.74	8.84	11.9	13.8	16.2	19.7	22.4
22	6.37	8.36	11.2	13	15.4	18.7	21.3
24	6.05	7.95	10.7	12.4	14.7	17.8	20.3
30	5.29	6.96	9.39	10.9	13	15.8	18
36	4.73	6.23	8.44	9.84	11.7	14.2	16.2
48	3.94	5.2	7.08	8.28	9.85	12	13.8
60	3.39	4.49	6.13	7.2	8.58	10.5	12
72	2.99	3.95	5.43	6.38	7.62	9.33	10.7