AUS-SPEC #1
DEVELOPMENT SPECIFICATION SERIES
DESIGN

Specification No.	Specification Title
DQS	Quality Assurance Requirements for Design
D1	Geometric Road Design (Urban and Rural)
D2	Pavement Design
D3	Structures/Bridge Design
D4	Subsurface Drainage Design
D5	Stormwater Drainage Design
D6	Site Regrading
D7	Erosion Control and Stormwater Management
D8	Waterfront Development
D9	Cycleway and Pathway Design
D10	Bushfire Protection

GUIDELINES

FOR

DEVELOPMENT AND SUBDIVISION

OF LAND

GUIDELINES

FOR DEVELOPMENT AND SUBDIVISION OF LAND

This Booklet

This Guidelines Booklet is divided into five sections:

Each section has a plain English description of the processes and requirements necessary progressively taking the reader through the subdivision process. Keywords are provided in the right hand margin to enable readers to conveniently find passages relevant to key issues.

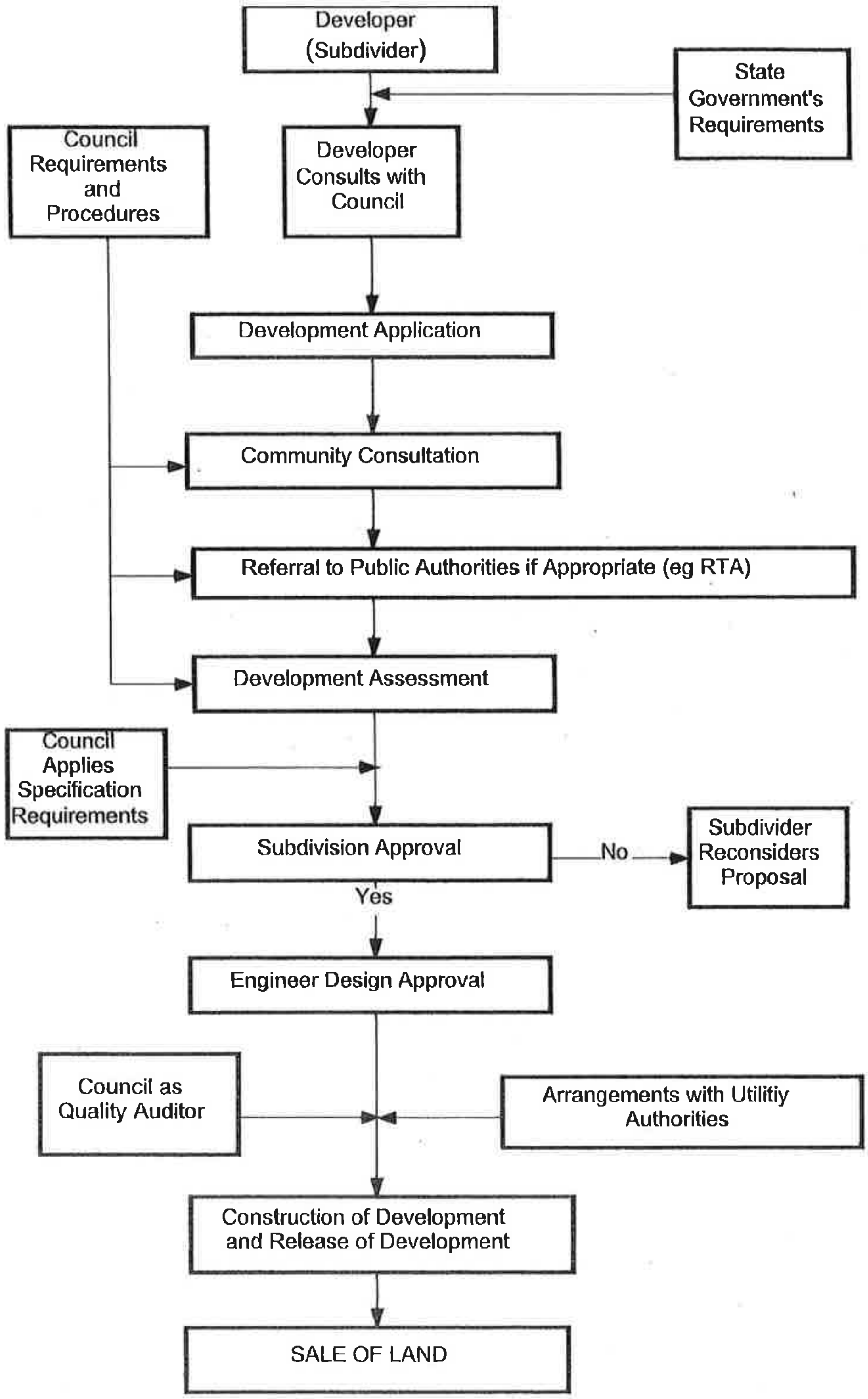
This Guidelines Booklet is an introduction to other documentation prepared by Council to manage Subdivision Development matters. Other documents include:

- Council's Local Environmental Plan 2000
- LEP 2000 Locality Statements
- Subdivision Design Specifications
- Subdivision Construction Specifications
- Council's Section 94 Contribution Plans
- Construction Certificate Application Form
- Development Application Form
- Subdivision Certificate Application Form
- State Environmental Planning Policies (SEPPS)
- Local Environmental Plans (LEPS)

SECTION I

INTRODUCTION

CONTENTS



FLOW DIAGRAM - OVERALL PROCESS

I1. COUNCIL'S OBJECTIVES

Council has the following objectives in providing for the development and subdivision of land:

Council Objectives

- To provide a functional, attractive and safe environment for residents that is consistent with community standards and needs.
- To minimise adverse effects on the natural environment.
- To provide for the needs of future users of the land in respect to building requirements, vehicular and pedestrian access, provision of services and an amenity appropriate to the zoning of the land.
- To assist developers by providing for the economic utilisation of the land resource of the area.
- To achieve a balance between the subdivision of residential land and the amenity of existing residents.
- To provide for an equitable and efficient distribution of public amenities and services.
- To minimise Council's future maintenance costs for roads, services and open spaces.

Additional Information

This Guidelines Booklet provides an outline of the procedures to be followed and refers to most standards and requirements. It is not intended to be comprehensive or totally definitive. Warringah Council's Local Environmental Plan 2000 (LEP 2000), Design Specifications and Construction Specifications provide necessary additional information.

I2. COUNCIL'S AUTHORITY

Council is the authority responsible for consent to development and approval of developments and subdivisions within the Warringah Council area.

Department of Planning

Council has declared Local Environmental Plan 2000 which includes "Locality Statements" which set out Council's necessary provisions for development and subdivision. In some circumstances Council is required to obtain the concurrence of the Department of Planning, and Council must also comply with particular legislative requirements. Compliance with the provisions of Council's LEP does not necessarily imply that Council is required to consent to, or approve, an application.

I3. RESTRICTIONS TO COUNCIL'S ACTIVITIES

LEPs
SEPPs

Restrictions to Council's powers to approve the subdivision of land are set out in the various planning instruments, Local Environmental Plans (LEPs), State Environmental Planning Policies (SEPPs), etc which are applicable throughout Council's Area. Advice as to which of these restrictions apply to a property should be initially obtained from Council's Local Approvals Customer Service Centre.

DEVELOPMENT AND SUBDIVISION PROCESSES

Development and Application Consent

It is important to understand that in a majority of cases Development Consent is required before land can be "subdivided" and sold. In due course a Construction Certificate is required before buildings are commenced. A Construction Certificate can be lodged at the same time as a Development Application.

The Development Application is a requirement of the Environment Planning and Assessment Amendment Regulation 1998 to allow consent to be provided to the concept of the development in relation to Council's controls and requirements eg. land use, community facilities, traffic generation, environmental considerations etc.

Subdivision Approval

After Development Consent is provided the more detailed requirements of the subdivision are investigated during the preparation of an Application for a Construction Certificate. Satisfactory completion will result in the granting of Subdivision Certificate as required by the Environmental Planning and Assessment Act.

I5 DEPARTMENT OF URBAN AFFAIRS AND PLANNING (DUAP) – AND PRIVATE CERTIFICATION

In 1998 the Environment Planning and Assessment Act, 1979 underwent a major overhaul to include building, demolition and subdivision control as well as private certification. In the guideline booklet "Guiding Development, better outcomes" DUAP, 1999, the process for approval and supervision by an accredited certifier is defined.

A summary of the process is explained as follows.

DEVELOPMENT APPLICATION Approved by Council ⇩	▪ Preliminary enquiries with the Council ▪ Lodge your development application with Council. ▪ Council considers the impacts of the proposal. ▪ If satisfactory, the Council will give you a development consent subject to conditions. ▪ You need to check with Council about options for the following stages of the process, including fees payable.
CONSTRUCTION CERTIFICATE Issued by Council or an accredited certifier ⇩	▪ Apply for your construction certificate either to Warringah Council or a qualified professional in the private sector – called an 'accredited certifier'. ▪ Council or the accredited certifier checks that the plans and specifications of your proposal will comply with the relevant conditions of the consent and detailed standards. ▪ If satisfactory, they will issue a construction certificate.

PLICANT APPOINTS RINCIPAL CERTIFYING AUTHORITY AND NOTIFIES COUNCIL	▪ Before any works start on the site, you must appoint a principal certifying authority (PCA) – this can be either the local Council or an accredited certifier. NB: for subdivision if Council is the PCA. ▪ Confirm what inspections will be done, the fee and any other requirements. ▪ Two days notice before work begins to the Council (if a private PCA).
BUILDING WORK BEGINS	▪ Work begins in accordance with the development consent, including any conditions, and the construction certificate. ▪ PCA to determine inspection stages. ▪ It is likely that your builder will advise the PCA of stages of work to allow the required inspections to be done.
SUBDIVISION CERTIFICATE Completion of works	▪ After the works are concluded satisfactorily, the PCA will issue the subdivision certificate.

The Development Approval Process

The Engineering Specifications included in this document can be used by Council or an accredited certifier. A Principal Certifying Authority (PCA) takes on the role of the Council consistent with the legislation (where an LEP permits private certification) and AUS-SPEC is used accordingly.

SECTION A

APPLICATION PROCESS

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Figures

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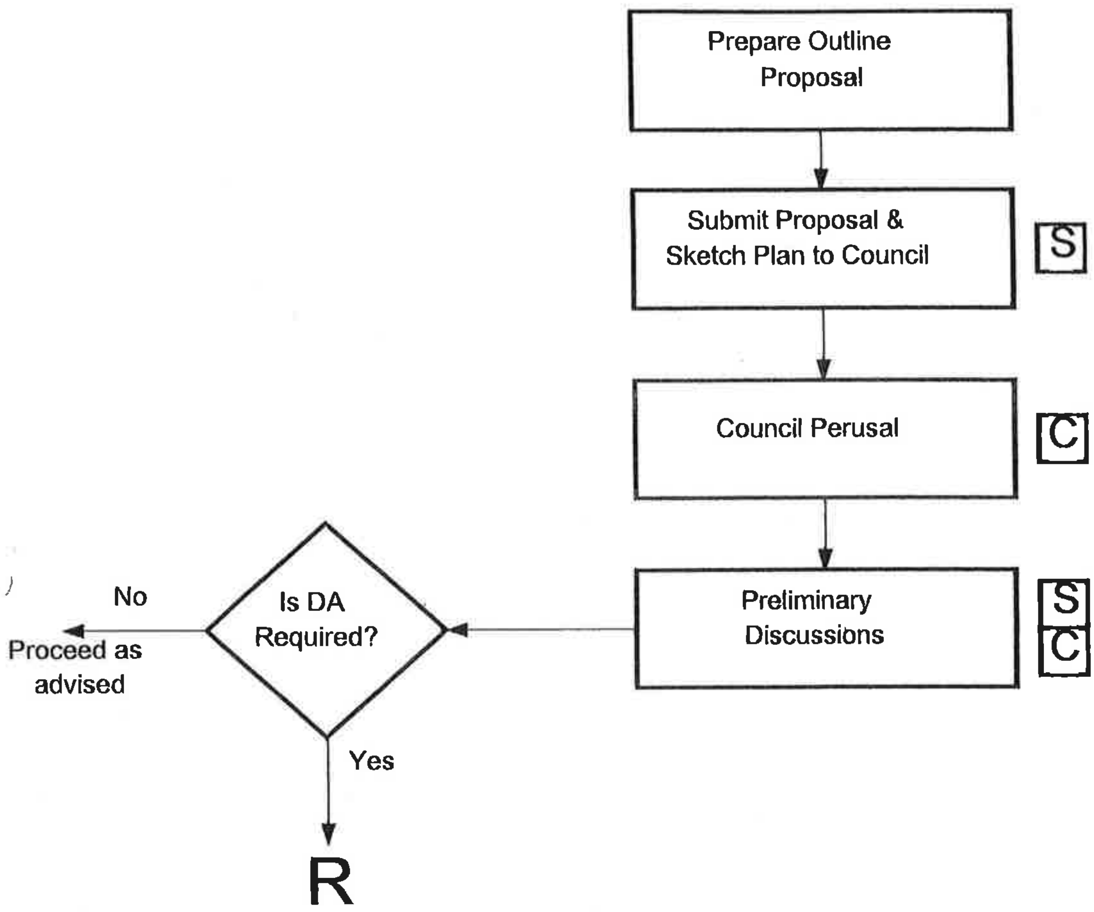

NOTE: $\boxed{S}$ denotes Applicant (Subdivider) responsibility

$\boxed{C}$ denotes Council responsibility

R denotes proceed to a flow diagram for consideration of Council Requirements (R)

FLOW DIAGRAM - APPLICATION PROCESS

A

A1 FORMULATING A DEVELOPMENT AND SUBDIVISION APPLICATION

Development Application Form

A person or company (The Applicant) making application to develop and/or subdivide an area of land within Warringah Council area will be required to lodge a Development Application on Council's standard application form, and accompany this form with supporting information which will be detailed later. (See Council's Standard Application for Development Form 1, Figure 1.)

Developer's Information

Before formally applying to Council to develop and/or subdivide, a considerable amount of information about the site needs to be sought. The Applicant should be aware of the nature of title of the land, easements, items of heritage significance, topography, slope and aspect, stormwater flows, surrounding development, vegetation, trees, road and traffic situations and other physical characteristics pertinent to the design of the development.

Early Consultation

It is recommended that a preliminary consultation with Council will enable the Applicant to determine what Council codes are applicable, what zone classification applies and which legislative requirements are applicable and most importantly whether professional assistance is required. A Pre-development Meeting with Council is available to the Applicant.

Preliminary Sketch Plan

It is advantageous to prepare a sketch plan at this early stage indicating the location, aspect and size of the various elements of the development including subdivision patterns surrounding this site. Figure 2 is an example of a preliminary sketch plan. The more information shown on the sketch plan, the more likely the consultations with Council and others will benefit both the Applicant and the Council.

Purpose of Consultation

The purpose of consultation about sketch plan proposals (which may be accompanied by explanatory reports or background material) is to:

- assess whether any modifications to the proposal are necessary prior to its being formally submitted;
- identify Council's requirements in regard to the particular Development Application;
- identify any problems which may necessitate the Applicant reviewing his/her approach;
- identify any issues related to prior site contamination, heritage issues, etc.
- indicate Council's likely subsequent requirements (eg financial contributions for services and amenities).

While consultation with Council at this early stage and the preparation of sketch plans is not mandatory, it is obviously in the Applicant's interest if it will reduce costs in preparing plans, increase the likelihood of Development Consent, and reduce the time the Council needs to consider the formal application. Similar early consultation with public authorities is also advantageous to ascertain their requirements, eg water, sewer, gas, telephone, electricity.

A2 MAKING APPLICATION FOR DEVELOPMENT AND SUBDIVISION

A Development Application is only required if the environmental planning instrument(s) applying to the land so require. Minor subdivisions such as boundary adjustments which meet standards may not require consent. All the necessary information should have been compiled in consultation with Council whilst formulating the application and developing the sketch plan.

Development Application Boundary Adjustments

The written approval of the owner is required if the application is not by the owner. Warringah Council's scale of fees for Development Applications can be obtained from the Local Approvals Customer Service Centre.

Owner's Scale of Fees

A Development Application is required for all types of subdivision. Development Applications are made on Council's Standard Development Application Form (1) (Figure 1.)

Development Appl'n Form

Development Applications are to be accompanied by nine (9) copies of subdivision sketch plans drawn on one of the following paper size sheets, A1, A2, A3 or A4.

Number of Plan Copies

The sketch plan shall show the following:

Plan Detail Required

a. Reduction ratio (preferably 1 : 500).

b. The location, boundary dimensions, site area and north point of the land.

c. The existing vegetation and trees on the land (attention is drawn to Council's Tree Preservation Order).

d. The location and uses of existing buildings on the land and adjoining properties. (Measured floor plans of existing buildings may also be necessary in order for Council to calculate floor space ratios.)

e. Contours based on existing levels of the site (preferably one metre interval drawn to Australian Height Datum).

f. Any natural features of the site, including rock formations or cliffs, watercourses, flood levels, wetlands, forest areas and slip areas.

g. Any existing drains, easements or rights-of-way affecting the site.

h. Title description of land.

i. Details of existing and proposed subdivision pattern (including the number of lots and location of roads).

j. Any Heritage items (buildings and sites), or relics defined by the Locality Statement or the Heritage Act.

k. Other details relevant to consideration of the application.

In addition the Applicant is to provide details of consultation with public authorities responsible for provision, alteration or amplification of utility services required by the proposed subdivision.

Details of Consultation with Public Authorities

ɔuncil may require additional information about the proposed development to be provided '/here that information is essential to the determination of the Development Application.

Additional information required may include:

Additional Information

- principles, assumptions and calculations behind stormwater drainage and on-site detention (OSD) proposals;
- rationale for the design of utilities, roads, open space, bicycle and pedestrian ways, bus routes etc;
- requirements of the Warringah Council Locality Statements under LEP 2000;
- a contamination assessment.

Figure 2 provides an example of a suitable subdivision sketch plan.

A3 COUNCIL'S CONSIDERATION OF APPLICATIONS FOR DEVELOPMENT AND SUBDIVISION

Council will deal with each application on its merits, however, a number of policies have been adopted on matters not specifically covered by planning legislation to ensure a uniformity of approach.

Design Standards

Council's LEP 2000 incorporates minimum design standards for different suburbs. These standards should not be interpreted as relieving the Applicant of the responsibility to properly assess all conditions and to use sound planning and engineering practices in the development of designs. Council is prepared to consider alternative approaches to subdivision design where the Applicant satisfies Council that its objectives have been achieved.

Determination within 40 days

Regulations normally require Council to determine applications within 40 days of receipt of the application. Upon determination of any application, a written notification will be sent to the Applicant stating that consent/approval has been granted subject to detailed conditions, or that consent/approval has been refused (with reasons).

Re-consideration

Where an Applicant is dissatisfied with the determination of an application, a request for ˀeview of the application or of particular conditions of consent may be lodged by the ˌpplicant for Council's determination. A reconsideration fee will be required and details of the reasons for reconsideration must be submitted with the request.

Appeal to Court

Alternatively, (and preferably as a last resort), the Applicant may lodge an appeal with the Land and Environment Court. Such an appeal is required to be lodged with the Court within twelve months of receipt of Council's determination of the application.

Revocation of Approvals

Council can revoke or modify approvals in circumstances where there is fraud or failure to comply with the Local Government Act (1993) or conditions of an approval. Once an application for development or subdivision receives consent and approval the Applicant becomes the Developer.

Once an application for development or subdivision receives consent and approval the Applicant becomes the Developer.

4 TIME REQUIREMENTS FOR SUBDIVISION WORKS

5 Year Limit on Roads and Drainage

A development application for subdivision given development consent requires road and drainage works to be commenced within five years of development consent approval and the subdivision development to be fully completed within a reasonable period.

Staged Development

In some cases a development may be of sufficient magnitude that it requires staging. Where staged development is proposed, the Applicant should prepare a sketch plan showing the complete concept so that Council can see the various stages in the overall context. Each stage should comply with the standard requirements.

Final Survey Plan
Linen Plan
Release Fees

When all conditions of development consent and Construction Certificate approval have been satisfied, the Developer will arrange for a Registered Surveyor to prepare the final survey plan. This plan, plus 9 copies, together with any Section 88B Instrument under the Conveyancing Act (detailing easements, restrictions etc) and an application for Subdivision Certificate form is submitted to Council with appropriate fees for the Council Authorised Officer's signature (see Council's standard Application for Subdivision Certificate Form (Figure 3)).

Section 88B Instrument

The original plan, plus one copy, together with any Section 88B Instrument, all personally signed by the Council Authorised Officer, are then released to the Developer.

Issue of New Titles

In order to effect registration and the issue of new titles for the proposed subdivision lots, the documents released should then be lodged promptly with the Registrar General's Department.

(To be provided by Council)

Figure 1. Council's Application for Development Form

A

(To be provided by Council)

Figure 2. Example of Preliminary Subdivision Sketch Plan

A

(To be provided by Council)

Figure 3. Council's Application for Subdivision Certificate Form

A

SECTION R

COUNCIL REQUIREMENTS

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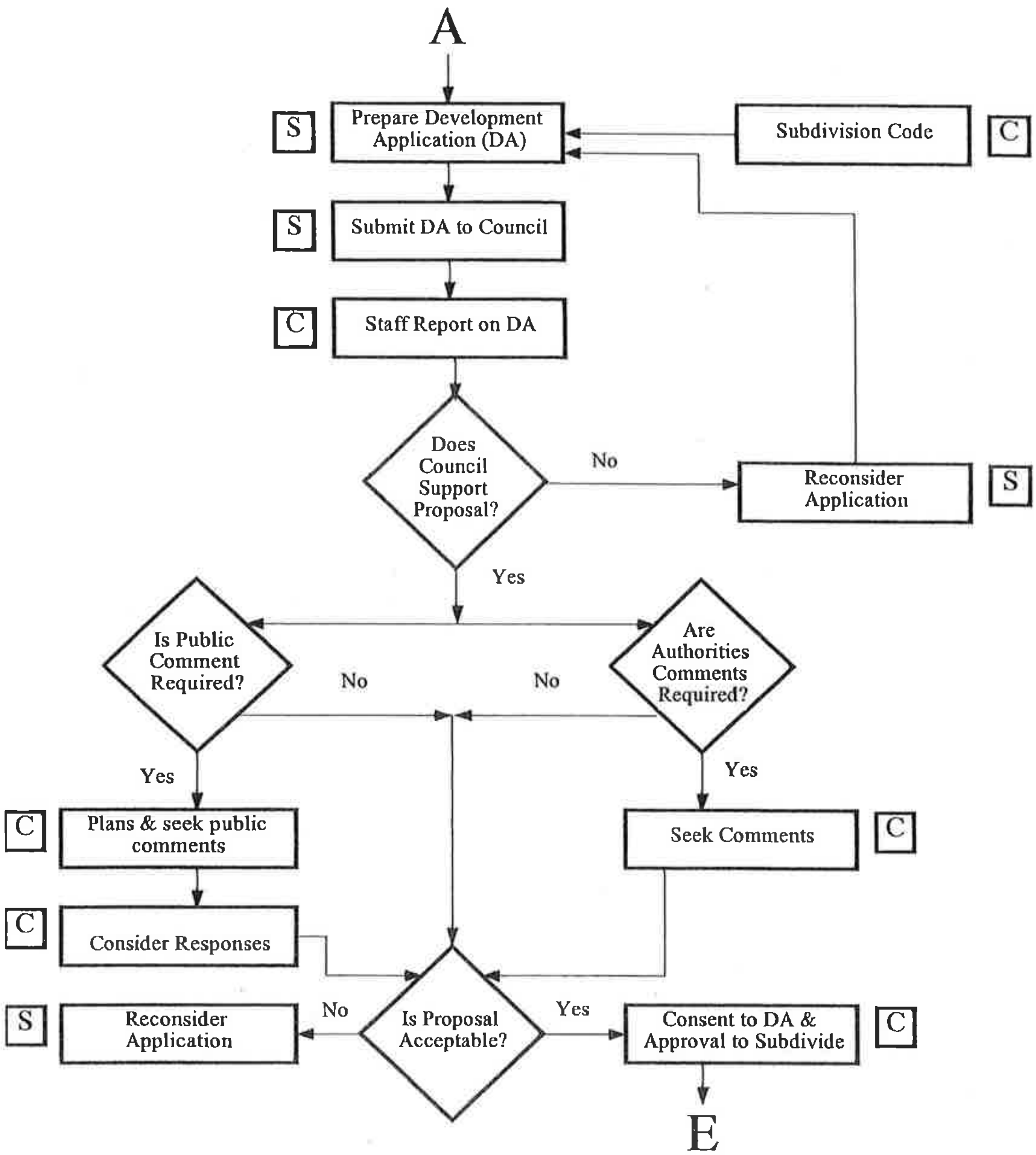
R



NOTE: E denotes proceed to a flow diagram for engineering requirements (E)

NOTE: * Council's Staff Report Considerations include.

- Environmental Assessment
  - is an Environmental Impact Statement (EIS) or Review of Environmental Factors (REF) required?
  - is a geotechnical or hydrological report required?
  - is a tree preservation or heritage preservation an issue?
- Zoning requirements.
- Infrastructure requirements (roads, water, sewer, drainage).
- Easements.
- LEP 2000 compliance

FLOW DIAGRAM - COUNCIL CONTROL AND REQUIREMENTS

R

?1 ENVIRONMENTAL CONSIDERATIONS

Statement of Environmental Effects

Information

A Statement of Environmental Effects is required for most development applications for subdivisions. This statement normally addresses such matters as:

- suitability of the land
- access
- traffic generation
- risk of flooding
- flora and fauna
- local amenity

Tree Preservation

ne proposed plan of subdivision shall identify vegetation that is significant to the overall ındscape of the area. Trees to be removed shall also be identified on the plan of subdivision.

Tree Preservation Officer

Trees are not to be pruned, damaged or removed without the prior consent of Council in accordance with Council's Tree Preservation Order and LEP 2000. Council's Tree Preservation Officer is to be contacted prior to any clearing or underscrubbing being carried out.

Lodging of Bond

Any significant tree/s identified by Council shall be protected at all times during excavation and/or construction, and Council may require the Developer to lodge a bond at the time of Construction Certificate approval, to be forfeited in the event that the trees are either damaged or removed. Any such bond is to remain in force for a period of six (6) months after the issue of the Subdivision Certificate or registration of the linen plan.

Heritage Items

Aboriginal and other Relics

Development shall comply with the Heritage requirements of Heritage Control defined in LEP 2000. In general any sites of Aboriginal carvings or relics or sites significant to heritage for other reasons shall be identified in the application. The National Parks and Vildlife Service should be contacted for details and verification.

All recognised heritage items, including natural features of the site and man-made buildings, works and sites are to be identified and retained, wherever possible. The Heritage Council should be contacted for details and verification. Adequate area is to be retained around any heritage item to protect its setting.

R2 SUBDIVISION DESIGN - Urban Residential Areas

Full Service

Kerb & Gutter

Urban residential land is defined as land within Locality Statements as detailed in LEP 2000 that permit development for the purpose of housing. Applicants will be required to provide fully serviced subdivisions including the provision of a sealed road system with drainage, and kerb and gutter to adequately and safely provide both vehicular and pedestrian access to each allotment. The Applicant will be required to meet the full cost of kerb and guttering across all road frontages of any subdivision in urban areas except where direct vehicular access is restricted. Roads adjoining a reserve are to be provided

ith kerb and gutter.

There are statutory requirements and Council requirements pertinent to housing density, lot dimensions, building line set backs etc, and the supply of services to allotments. Warringah Council's Schedule 7 of the Locality Statements of LEP 2000 sets out these requirements for each zone type. The designer of a subdivision is required to provide for the requirements of Council's LEP 2000 (or Interim Development Orders). Council will have requirements on access to subdivisions with the objectives of:-

Lot Dimensions/ Housing Density

Road Traffic

- providing for flow of through traffic with least disruption;
- establishing a hierarchy of roads in accordance with function and usage;
- providing a variation in alignment to allow for existing natural features and create interest in the streetscape;
- providing a network of safe pedestrian and cycle paths.

Pedestrians and Cyclists

egal easements of width as determined by the Council Codes are to be provided over stormwater drains and watercourses.

Water and Sewerage

Applicants will be required to extend and meet the full cost of water and sewerage reticulations, as arranged with Sydney Water, within subdivisions plus the cost of connecting to existing services.

Electricity

Electricity services are to be extended to the development and in accordance with the requirements of Energy Australia and at no cost to Energy Australia. Underground power will be required except where it can be shown that it is not appropriate. Underground telephone cables, where underground electricity is used, are to be provided by the Applicant.

Telephone

Applicants will be required to provide for telephone facilities within the development.

Stormwater Runoff

Urban stormwater runoff will need to be assessed in terms of satisfactory performance both within the development and external to the development.

R3 SUBDIVISION DESIGN - Industrial/Commercial Areas

LEP

LEP 2000 identifies permissable Commercial and Industrial development within localities. All proposed Commercial and Industrial subdivisions would be anticipated to be located in these localities. It is essential that early consultation with Council Officers is sought to determine that the proposed subdivision is in the locality and is in conformity with Council's planning principles for the area.

Lot Sizes

The Applicant should note the minimum lot sizes in the Locality Statement. Industrial subdivisions should generally comply to the standards suggested in the State Planning Authority Technical Bulletin No. 6 "Design and Standards for New Industrial Areas" (June 1974). Both commercial and industrial subdivisions will need to comply with the Locality Statement for the area and the general principles of LEP 2000..

Pavement for Heavy Traffic

Engineering Road Design and Pavement Design will need to cater for heavy traffic conditions as specified by Council.

Water and Sewerage

Applicants will be required to meet the full cost of water and sewerage reticulations within subdivisions plus the cost of connecting to existing supplies in accordance with Sydney

Water requirements. Electricity services are to be extended to the subdivision and in accordance with the requirements of Energy Australia at full cost to the Applicant. Underground power and telephone services will be required and are to be provided by the Applicant at full cost to the applicant. Determination of the maximum loading of the electricity service and whether the service is provided above ground or underground will be made by Energy Australia. Evidence of conformity with Energy Australia and telephone service requirements must be submitted prior to release of the final plan of survey (linen plan).

Electricity

Telephone

R4 SUBDIVISION DESIGN - Natural Hazard Areas

Flooding Coastal Erosion

Subdivisions of land susceptible to tidal inundation or coastal erosion are considered Designated Developments and require Environmental Impact Statements in accordance with the Director of Department of Planning requirements.

Policies

The subdivision of flood prone land is to comply with the requirements of Council's Flood Prone Land Policies and the New South Wales Government's Floodplain Development Manual, 1986.

Embankments

Council will only support subdivisions of rural properties, part of which are flood prone, if in Council's opinion there are adequate flood free homestead and stock-holding areas on each allotment as well as access to higher ground. Development will not be allowed to significantly alter flooding patterns, accordingly development of internal roads etc will not be permitted to form significant embankments. Each case to be treated on its merits.

The subdivision of urban land, other than boundary adjustments, will only be considered where it can be clearly demonstrated that flood free allotments can be provided and that the creation of these allotments will not adversely affect flood patterns or levels in the area.

Bushfire Protection

Applicants will be required to provide suitable protection zones and access for fire fighting vehicles and maintenance vehicles so as to minimise the risk of bushfire damage.

R5 PROVISION OF OPEN SPACE AND OTHER CONTRIBUTIONS

Public Reserve and Contributions

In residential subdivision (both rural and urban) Council requires the creation of an area of public reserve (open space) useable for recreation, or payment of a monetary contribution in lieu of land or a combination of both.

Applicants will also be required to contribute towards roadworks where upgrading requirements can be attributed to the development.

Section 94 Contributions

Council's authority to impose conditions of contribution is derived from the Environmental Planning and Assessment Act 1979, Section 94. Accordingly Council's contribution requirements will be in accordance with a "Section 94 Contributions Plan".

Public reserve will not normally be required in rural subdivision, unless the subdivision contains significant areas of special scenic or public recreational value.

Bushfire Protection

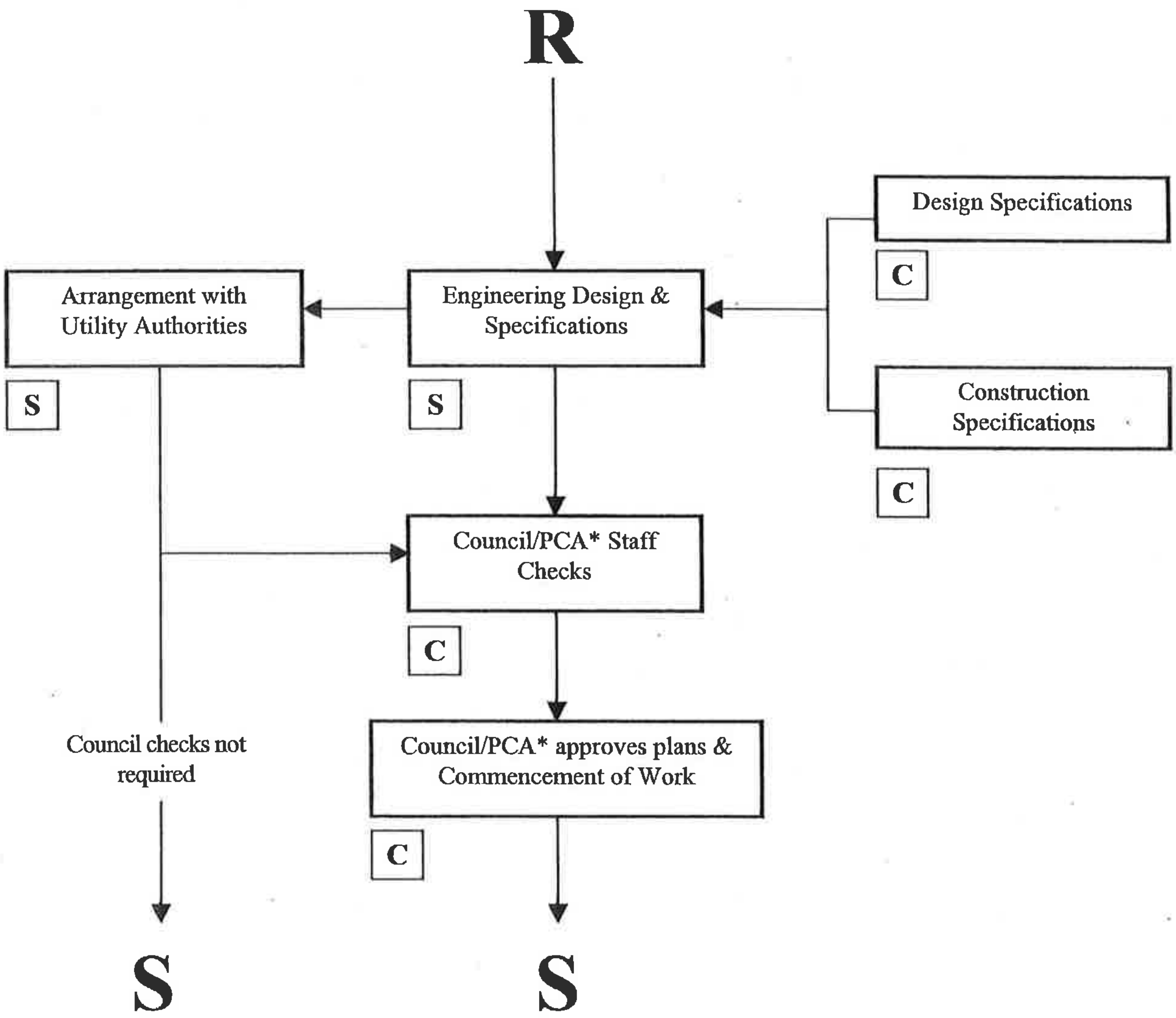
In rural subdivisions, and commercial or industrial subdivisions contributions of open space are less often required, however contributions towards upgrading roads, community facilities and bushfire protection will be required as determined by the appropriate "Section 94 Contributions Plan".

SECTION E

ENGINEERING REQUIREMENTS

CONTENTS

E



* Council or Private Certifying Authority

NOTE: **S** Denotes proceed to flow diagram for the Provision for Sale of Allotments (S).

FLOW DIAGRAM – ENGINEERING REQUIREMENTS

E

E1 ENGINEERING PLANS AND SPECIFICATIONS

Qualification of Designers

All plans for earthworks (site regrading), roadworks, drainage works, and foreshore works are to be certified by a Civil Engineer or Registered Surveyor. All plans for bridgeworks, retaining walls and other major structures are to be certified by a Civil Engineer.

Council's Specifications

Standard Drawings, Design Specifications and Construction Specifications have been prepared by Council and can be purchased for use in subdivisions. Specifications other than those supplied by Council are required to be prepared by a Civil Engineer and will need to be submitted to Council for approval with each set of engineering designs.

In summary the requirements for design plans are as follows:

a) Earthworks (site regrading)
b) Roadworks
c) Road Pavement
d) Road Furnishings
Stormwater Drainage
Foreshore Works
g) Landscaping Works
h) Erosion Control Works

E2 COMMENCEMENT OF WORKS

Necessary Conditions

Notwithstanding approval to the subdivision application, no engineering works are to be undertaken until the design plans and specifications are formally approved by the Council or the Principle Certifying Authority. The Contractor(s), and their quality testing organisation will be nominated and will also require approval by the Team Leader – Development Engineering.

Quality Assurance

Approval to the subdivision will stipulate whether the subdivision is to be constructed as a "Quality Assured Contract" in which case a Quality Plan will need to be submitted to cover all construction works in accordance with Council's Contract Quality System Requirements Specification. Acceptance of the submitted Quality Plan will be required prior to commencement of works.

Where a Quality Assurance contract is not a requirement and a Quality Plan is not therefore provided, it will be necessary as a minimum requirement that the Principal's Superintendent or Superintendent's Representative under the Contract be nominated and approved as suitably qualified and experienced.

E3 INSPECTIONS AND TESTING

Cost of Quality Testing

Whether the subdivision proceeds under Quality Assurance Contract or not, the full cost of all testing is to be met by the Applicant (Developer). Test results will be required to ensure that the material supplied and the work carried out conforms with the approved specification.

E

..ilarly joint inspections at key stages of construction will be required to be carried out ' representatives of both Council and the Developer. Key stages include:

Inspections

- Site regrading and clearing
- Installation of erosion control measures
- Preservation measures installed for trees, vegetation or heritage sites as determined
- Drainage line installation prior to backfilling
- Subgrade preparation
- Establishment of line and level for kerb and gutter placement
- Road Pavement construction
- Road Pavement surfacing
- Practical Completion

Council will insist on uninterrupted access at all times for the Team Leader – Development Engineering or his/her representative so as to enable audit inspections or testing. Records of all test results required by Council will be made available to Council promptly when requested and tests will be undertaken strictly to prescribed test procedures by testing organisations approved by Council prior to work commencement.

Records of Testing and Inspections

_4 INSURANCES

The Supervising Consultant shall take out professional indemnity insurance indemnifying themselves and Council. The Developer's Supervising Consultant will also provide Council with evidence that all contractors have obtained appropriate third party and public risk insurance satisfactory to Council's requirements.

Third Party Insurance Public Risk

E5 WORK-AS-EXECUTED PLANS

Following completion of the work, one full set of work-as-executed plans marked up in red showing any discrepancies from the design is to be submitted and retained by Council. All work-as-executed plans shall bear the Supervising Consultant's as defined or Accredited Certifiers Certification stating that all information shown on the plans is accurate.

Certification

E6 QUALITY ASSURANCE PRINCIPLES

ıe principles of Quality Assurance procedures will be applied by Council to all ubdivision works. In major or otherwise significant subdivisions the provisions of Australian Standard AS/NZS ISO 9000 series (1994) will be required to be fully applied to the construction project. This will involve the submission of a Quality Plan for all Works associated with the project. The requirement to comply with AS/NZS ISO 9000 series (1994) will be determined prior to the preparation of design plans. In all cases Council will require the Developer to organise and pay for inspection and testing services such that the Developer can validly certify the quality of all works and materials progressively during construction.

Quality Plan

·7 INTEGRATED DEVELOPMENT ASSESSMENT – ACCREDITED CERTIFICATION

If subdivision work is to be certified by an independently accredited certifier then reference to "Council" in regard to approval of design and approval of construction will be read in the Specifications as "Accredited Certifier".

All certificates (construction compliance etc) shall be provided to Council in accordance with the requirements of the Integrated Assessment Amendment to the Development Environmental Planning and Assessment Act 1997.

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SECTION S

ALLOTMENTS FOR SALE

CONTENTS

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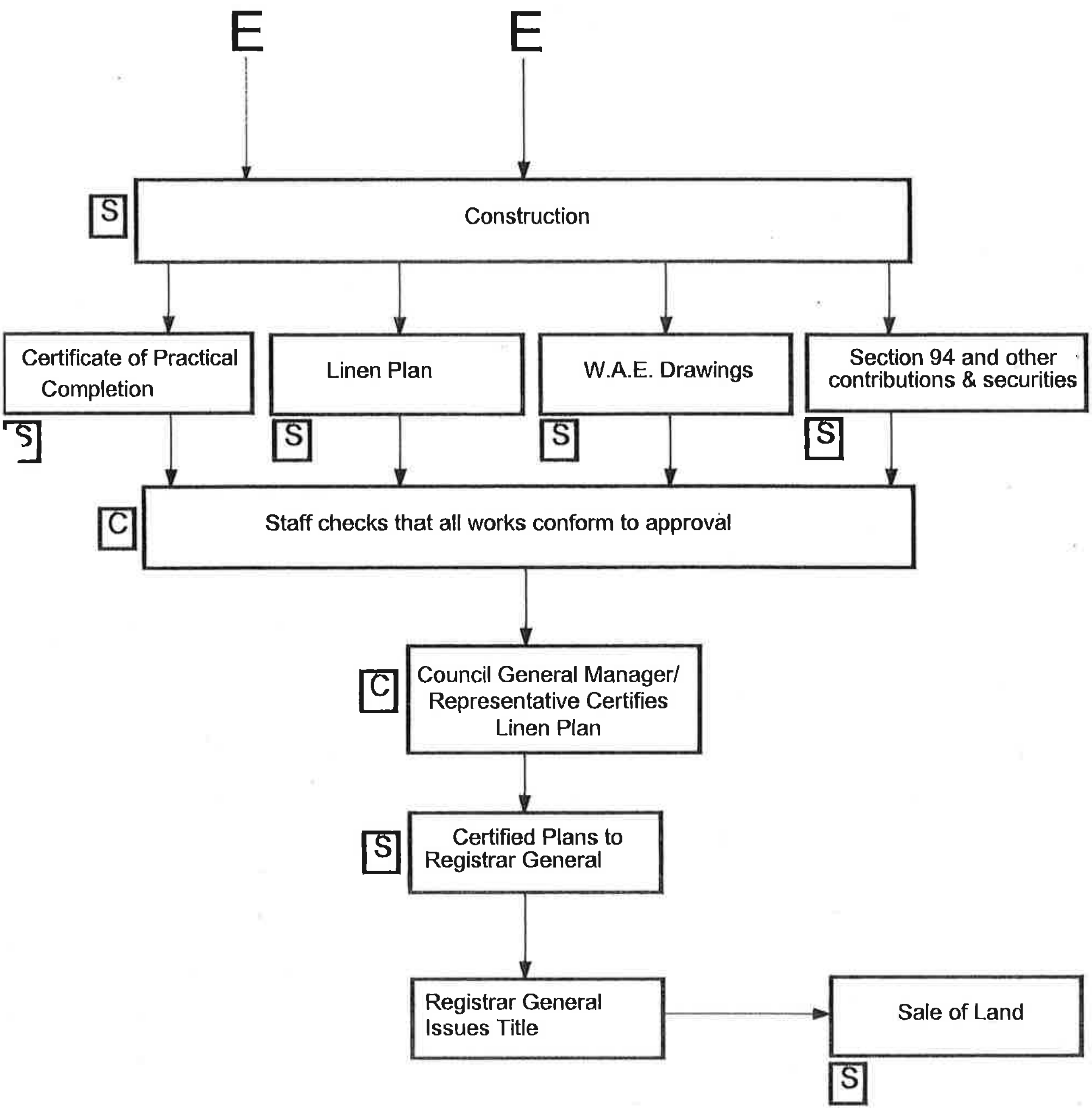


NOTE: W.A.E. denotes Works-as-Executed and describes plans and drawings showing as built details.

FLOW DIAGRAM - PROVISION OF ALLOTMENTS FOR SALE

S

.1 COMPLETION OF WORKS AND CERTIFICATION

On practical completion of development works the Developer is to advise the Team Leader – Development Engineering to that effect in writing and certify that the whole of the works have been carried out in accordance with the approved plans and specification. If the whole of the works are considered satisfactory the Senior Development Engineer will agree to a date (the date of practical completion) on which the whole of the works are considered to have entered into the maintenance period.

Maintenance Period

At this stage the Developer's Surveyor completes the final property survey and prepares the final plan of subdivision which is known as the "linen" plan. The final plan of subdivision shall be submitted for endorsement by Council as an original transparency and nine (9) copies. Requirements for these plans are set out in Council's Application for Subdivision Certificate forms (Figure 3). This plan will later be lodged by the Developer with the Land Titles Office who will prepare title deeds and advise Council of a deposited plan (DP) number so that sale of allotments of land may proceed.

Final Survey

ıe maintenance period will commence for all components at the date of practical ›mpletion and not beforehand.

Practical Completion

S2 EARLY RELEASE OF ALLOTMENTS BY APPLICATION OF ENGINEERING BONDS

Council may give consideration to the acceptance of a bond for the performance of engineering works to enable the early release of linen plans of subdivision. However, before Council will consider accepting a bond providing an irrevocable work guarantee for the construction of engineering works within the subdivision the following must apply:

Guarantee Bonds

- All sewer and water supply works required are complete and have been tested.
- All major engineering problems have been overcome to the satisfaction of the Senior Development Engineer.
- All works that involve the safety of the public (eg road junctions, flood control structures) are completed.
- Any geotechnical reports regarding the suitability of land for development as required by the Senior Development Engineer are to be submitted.
- Payment of all fees and contributions required as conditions of development consent are complete.

Bonds for engineering works required as a condition of Construction Certificate approval will be for a maximum period of one (1) year.

Period of Bonds

Bank guarantees and interest bearing deposits in the name of Council only will be accepted for works with a value in excess of $1,000.00.

A bond fee is payable where a bond has been lodged to guarantee the completion of engineering works.

Bond Fee

S

The bond amount may be progressively reduced as the work covered by the bond is carried out but at no time will the bond amount fall below 10% of the contract amount or the estimated total cost of the works. The Developer's Supervising Consultant will be required to lodge a schedule of quantities of all outstanding works to enable the bond amount to be determined.

Limits on Outstanding Bonds

S

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D10

BUSHFIRE PROTECTION

CONTENTS

DEVELOPMENT DESIGN SPECIFICATION D10
BUSHFIRE PROTECTION

GENERAL

D10.01 SCOPE

1. The work to be executed under this Specification consists of the design of bushfire protection facilities to protect life and property and bring a fire to a halt.

2. The Specification contains procedures for the design of fire protection facilities. Designs shall be carried out to satisfy requirements of the Rural Fires Act 1997, the Council and the guidelines published by the Department of Bushfire Services (now NSW Rural Fire Service), May 1991. Consultation with Council's Fire Control Officer may be required.

10.02 OBJECTIVES

1. This Specification aims to outline the requirements that will minimise bushfire hazard in developments. The requirements are particularly pertinent to rural developments but should be an integral part of urbanised development as well. The concepts proposed need to be incorporated at an early stage of development design.

Rural Development
Urban Development

D10.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

C501 - Bushfire Protection (Perimeter Tracks)

(b) NSW Government Legislation

Environment Planning and Assessment Act 1979 - Section 94
Rural Fires Act, 1997
Native Vegetation Conservation Act, 1997

) NSW Government Department Publications

Department of Bushfire Services (now NSW Rural Fire Service), May 1991
- Planning for Bushfire Protection. A Guide for Land Use Planners, Fire Authorities, Developers and Home Owners, May 1991

Department of Land and Water Conservation (formerly Land Management)
- Soil Conservation Service 1994. Guidelines for Planning, Construction and Maintenance of Tracks.

NSW Department of Urban Affairs (formerly Environment) and Planning
- Circular 74: Planning in Fire Prone Areas, 1984.

AS3959 - Australian Standard for construction of buildings in bushfire prone areas.

) Other

Board of Fire Commissioners
- Hazard Reduction for the Protection of Buildings in Bushland Areas, 1984.

Californian Department of Forestry
- Fire Safety Guides for Residential Development in California, 1980.

Insurance Council of Australia.
- Bushfire Safety in Urban Fringe Areas.

Luke, R.H. - Before the Fires Start.

DESIGN CRITERIA

D10.04 GENERAL

1. Where a subdivision will abut unimproved timber in a bushfire prone area (as classified by Council), perimeter tracks are to be located immediately between the created allotment and the bushland within a minimum cleared width of 6m, and have a minimum formed width of 4m. Such roads shall be adequately drained to provide all weather access for fire fighting vehicles. ***Perimeter Tracks/Fuel Protection Zone***

2. The perimeter track shall be contained within a 20m reservation or easement which borders those allotments abutting the bushfire prone area. Such a reserve shall serve as a basis for fire protection measures to be undertaken and will not be considered as part of the public reserve dedication applicable to the subdivision. ***20m Reservation***

3. Access is to be provided from the above described reservation from the local road system at regular intervals in a system of 'loops'. ***Access***

4. For those subdivisions receiving reticulated water, fire hydrants shall be situated at appropriate intervals or near where potential fire hazard areas exist as determined by Council. ***Fire Hydrants***

5. Fire protection zones access tracks and perimeter tracks shall be clearly indicated on the subdivision plan. Erosion control features and revegetation requirements shall also be indicated in the subdivision plan. Council's Fire Protection Officer shall be consulted for technical advice in relation to bushfire protection of subdivisions. Notwithstanding the above requirements, Council's Fire Protection Officer may vary conditions pertinent to site specific issues. ***Consultation***

D10.05 FIRE PROTECTION ZONES

1. The provision of Fire Protection Zones (FPZs) shall occur as part of the development of the subdivision pattern. Each individual allotment shall have adequate space for the main building (*usually a dwelling*), an area of open space (*front,.back or side yard*) and the FPZ (*which may include part of the yard area and/or neighbouring properties*). Figure D10.1 illustrates a typical FPZ. ***Part of Development***

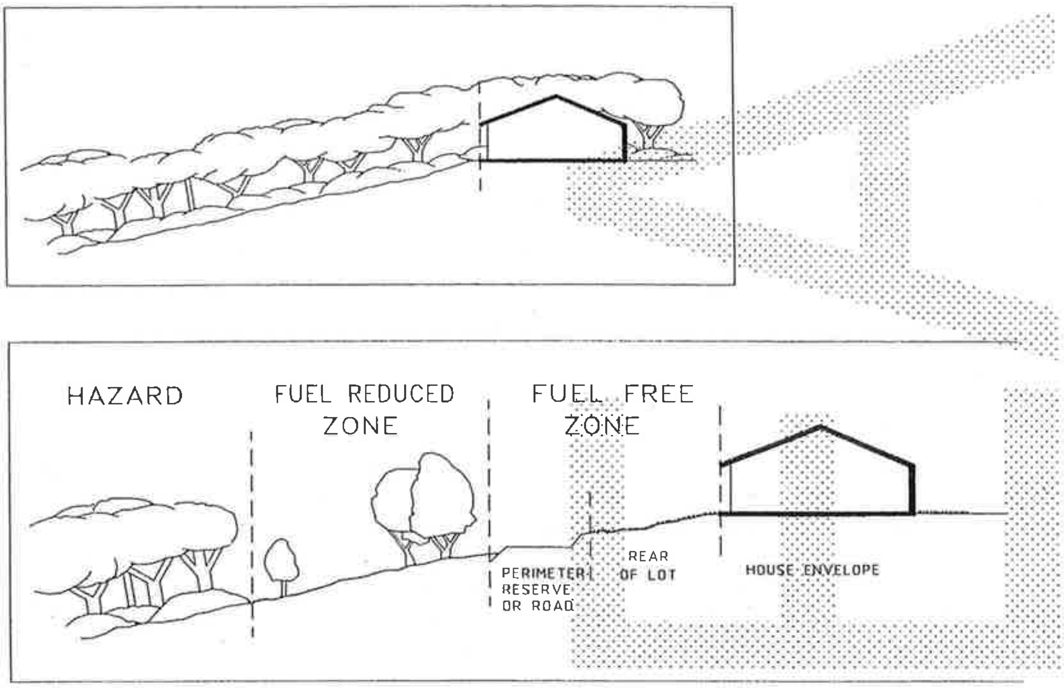


Figure D10.1
Fire Protection Zone

Buffer Zone

2. FPZs shall be required for any development fronting a bush fire hazard area, whether a single dwelling, a group of isolated dwellings or an urban subdivision. They act as a buffer zone between the development and the fuel.

Reduction of Fuel

3. The primary purpose of FPZs is to ensure that a progressive reduction of fuel occurs between the bush fire hazard and any combustible structures within the development.

Other Purposes

4. Apart from its primary purpose the FPZ serves a number of other important purposes, dependent upon local fire fighting policy. The FPZ shall be designed to:

(a) maximise the separation distance between high intensity fire and any structure, thereby reducing the radiation and direct flame contact;

(b) provide an area where embers can fall with minimal opportunity to create further fire outbreaks;

(c) provide a safe access to a structure for fire fighters by reducing the heat level from the main fire;

(d) provide a safe retreat for fire fighters; and

(e) provide a clear control line from which to begin back burning or hazard reduction operations.

Safety requirements sometimes dictate that fires are fought from the property itself rather than along the perimeter track.

Separate Components

5. The FPZ incorporates up to three separate components:

(a) Fuel Reduced Zone (FRZ); and

(b) Fuel Free Zone (FFZ) incorporating:

(i) a perimeter road or reserve (which incorporates an access track); and

(ii) a set-back (currently defined by minimum lot depths), which is usually part of the allotment.

D10.06 FUEL REDUCED ZONE

1. The FRZ is located adjacent to the hazard: *Location*

Reduced Fuel Loadings

Originally it would have been part of the bush fire hazard but has become an area where the fuel loadings are reduced through thinning of vegetation, mechanical clearing, hazard reduction burning or location of suitable developments such as playing fields or car parks (provided it is wide enough).

Minimum Fuel Loadings

2. Fuel loadings within the FRZ shall be kept to a level where the fire intensity expected will not impact on adjacent developments. In the absence of any policy to the contrary, 8 tonnes per hectare of total fuel is commonly used.

Part of the Development

3. The FRZ should always be part of the development so that dedication of land or monetary contribution through Section 94 of the EP and A Act ensures that the cost of fire protection is met by the Developer, not by the general community.

Clearing Steep Slopes

4. For slopes greater than 20 degrees, the environmental consequences of ground clearing (erosion) may not be acceptable. Developments abutting such slopes shall avoid both the ridge and the slope. Compliance is also required of Section 7 of the Native Vegetation Conservation Act, 1997 as related to slopes greater than 18°.

D10.07 FUEL FREE ZONE

1. The fuel free zone is located adjacent to, or is part of, the development and comprises a perimeter road and a set-back.

(a) Perimeter Road

Location

(i) The perimeter road or access trail lies between the FRZ and the boundary of the allotments.

Concept

(ii) The concept of a perimeter road requires that one side of the road has no fuel. Perimeter roads are not fire breaks in the same sense as used in fire fighting operations. Their main purpose relates to reduction of radiation and provision of access. Without a fuel source on the other side, perimeter roads can however prove very effective fire breaks.

Form

(iii) The form that the perimeter road or track takes will depend on local policy in regard to both road construction and fire fighting. In many instances, a perimeter reserve will be preferred due to cost. The reserve should be a minimum of 20m wide, with a 6m access track and passing bays about every 200m.

Design

(iv) In designing for a perimeter road or track, the distance required may not seem very great. Given that the probability of fire jumping a fire break increases as the width decreases, then areas where the highest intensity fires are likely should have fire breaks of greatest width.

Innovative Design

(v) Perimeter roads can be less economic than roads which service two frontages unless some innovative designs are incorporated into the subdivision. Figure D10.2 illustrates perimeter roads and perimeter tracks.

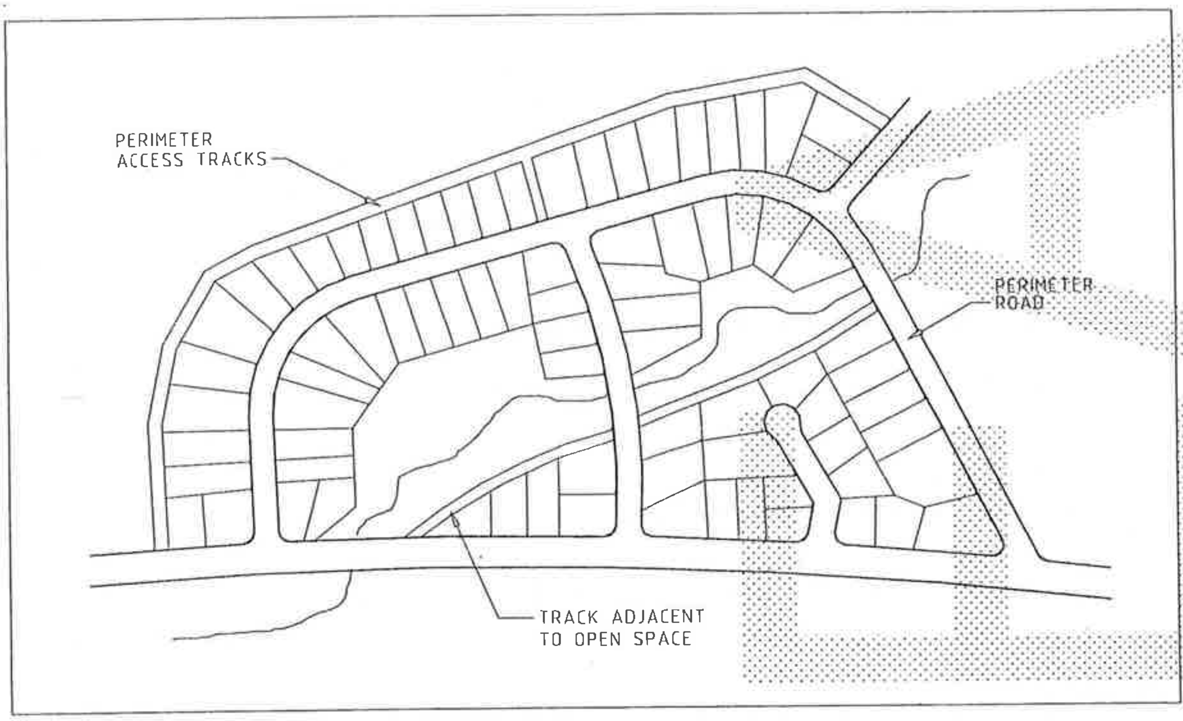


Figure D10.2 Perimeter Road Track

(vi) Perimeter roads that do not require clearing or maintenance (compared to tracks), can be cheapest in the long term. Ultimately the decision between a road or track depends on the local council's subdivision and bush fire fighting policies. ***No Clearance or Maintenance***

(vii) Tracks shall be constructed to Soil Conservation Service (1983) guidelines.

(b) Set-back

(i) Part of the allotment can be used as a section of the buffer by setting a minimum lot depth and rear setback. This can ensure that sufficient room (30-35m) is available to allow for erection of a dwelling that does not encroach upon the rear of the allotment. ***Minimum Lot Depth***

(ii) The policy previously required a minimum of 40m lot depth in order to be consistent with the average minimum lot depth in bushland residential developments. Based on the requirement to maximise the distance between hazard and structures on reasonable grounds (*as developed above*) and a 30m wide building envelope which includes the surrounding yard, there is no justification for a 40m minimum lot depth in some instances. ***Previous Policy***

D10.08 MODIFICATIONS TO FUEL REDUCED AND FUEL FREE ZONES

1. Modifications to the width of either the FRZ or the FFZ shall only be made with the written approval from Council's fire control authority and based on an examination of the particular cases rather than according to any formula. ***Approval of Fire Control Authority***

2. Modifications would need to take account of adjacent or proposed development. Some difficulties arise where new development abuts existing development that is a fire hazard because of the nature of its usage (eg forests, parks etc). The general principle is that fire protection should be shared by both users which may require a certain level of egotiation outside the planning system. ***Adjacent Development***

3. Even without an extensive area of fuel outside the FRZ, intense fires can develop if the FRZ has not been hazard-reduced and if the fire begins as a line ignition from spotting embers.

4. Under adverse conditions fires moving up a slope may not be slowed by the presence of rocky outcrops and ledges, even though the continuity of the fuel bed may be broken.

D10.09 INTERNAL ACCESS FROM SUBDIVISION ROADS

1. The provision of adequate internal access is also controlled by subdivision design. Subdivision roads shall incorporate the following features:

Incorporated in Subdivision Design

(a) width, vertical clearances and any dips and crests which allow the two way movement of firefighting appliances;

(b) construction standards of roads and any bridges which allow for the carrying of fully loaded fire appliances (28 tonnes or 8 tones per axle);

(c) curves which have a minimum inner radius of 12m and are minimal in number;

(d) maximum grades which do not exceed 15% (1:7) and preferably not more than 10% (1:10);

(e) clearly signposted roads;

(f) dead end roads which do not exceed 200 metres in length;

(g) dead ends which incorporate a minimum turning circle of 12.5m diameter; and

(h) a road network which connects regularly to any access tracks.

D10.10 STAGING WORKS

1. When considering the rate of development, planners shall provide for initial development to occur on the hazard perimeter of the development. A line of dwellings will tend to minimise the threat to the entire subdivision by limiting the hazard interface.

Initial Development on Hazard Perimeter

2. Scattered developments on the other hand, will allow a continuous network of fuel to threaten individual buildings until development is substantially underway.

Scattered Developments

3. For similar reasons, new developments should be 'tacked' onto old developments to minimise the hazard perimeter.

Minimise Hazard Perimeter

4. It is important that much of the bush fire protection is incorporated into the design of the development, rather than into individual allotments.

Incorporated in Subdivision Design

SPECIAL REQUIREMENTS

D10.11 RESERVED

D10.12 RESERVED

D10.13 RESERVED

APPENDIX A

DESIGN IFD RAINFALLS

CATCHMENT INDEX

MAIN DRAINAGE CATCHMENT INDEX

No.	CATCHMENT	RAINFALL AREA
1	BANTRY BAY	F
2	BARE CREEK	T
3	BROOKVALE CREEK	N
4	BURNT BRIDGE CREEK	N
5	CARROL CREEK	F
6	COLLAROY	C
7	COTTAGE POINT	T
8	DEEP CREEK	T
9	DEE WHY BEACH	C
10	DEE WHY LAGOON NORTH	C
11	DEE WHY LAGOON SOUTH	C
12	FRENCHS CREEK	F
13	FRESHWATER CREEK	N
14	GREENDALE CREEK	N
15	MANLY CREEK	N
16	McCARRS CREEK	T
17	MIDDLE CREEK	F,C
18	MIDDLE HARBOUR	F
19	NARRABEEN FORESHORES	C
20	NEVERFAIL CREEK	T
21	OXFORD CREEK	F
22	SMITHS CREEK	T
23	SOUTH CREEK	C

RAINFALL AREAS:

C - CROMER
F - FRENCHS FOREST
N - NORTH MANLY
T - TERRY HILLS

LOCATION 33.725 S 151.275 E * NEAR. CROMER DEPOT ISSUED 23RD FEBRUARY 1969 REF.-FN2910

LIST ØF CØEFFICIENTS TØ EQUATIØNS ØF THE FØRM

* ENSURE THE COORDINATES ARE THOSE REQUIRED SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME

$$\ln(I) = a + b^*(\ln(T)) + c^*(\ln(T))^{**}2 + d^*(\ln(T))^{**}3 + e^*(\ln(T))^{**}4 + f^*(\ln(T))^{**}5 + g^*(\ln(T))^{**}6$$

I = INTENSITY IN MILLIMETRES PER HØUR

T = TIME IN HØURS

RETURN PERIØD (YEARS)	a	b	c	d	e	f	g
1	3.4241	-0.5720	-0.0218	0.00908	-0.000899	-0.0004329	0.0000584
2	3.6859	-0.5697	-0.0253	0.00886	-0.000499	-0.0004178	0.0000452
5	3.9627	-0.5645	-0.0353	0.00843	0.000608	-0.0003701	0.0000084
10	4.0972	-0.5619	-0.0408	0.00832	0.001211	-0.0003690	-0.0000074
20	4.2480	-0.5593	-0.0453	0.00806	0.001743	-0.0003427	-0.0000263
50	4.4184	-0.5569	-0.0503	0.00790	0.002298	-0.0003325	-0.0000423
100	4.5320	-0.5553	-0.0535	0.00787	0.002650	-0.0003336	-0.0000514

RAINFALL INTENSITY IN MM/HR FØR VARIØUS DURATIØNS AND RETURN PERIØDS

DURATIØN (HØURS)	RETURN PERIØD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	98.7	127.	161.	180.	206.	240.	265.
0.100	92.4	118.	151.	169.	193.	225.	249.
0.167	75.7	97.4	125.	140.	161.	188.	209.
0.333	55.3	71.5	92.8	105.	122.	143.	159.
0.500	45.0	58.3	76.3	86.9	101.	119.	133.
1.000	30.7	39.9	52.6	60.2	70.0	83.0	92.9
2.000	20.5	26.6	35.1	40.1	46.6	55.2	61.8
3.000	16.1	20.9	27.4	31.3	36.3	42.9	48.0
6.000	10.7	13.8	17.9	20.3	23.5	27.7	30.9
12.000	7.00	9.04	11.7	13.3	15.3	18.0	20.1
24.000	4.51	5.84	7.64	8.70	10.1	11.9	13.3
48.000	2.80	3.64	4.86	5.58	6.53	7.79	8.75

DESIGN RAINFALL INTENSITY DIAGRAM

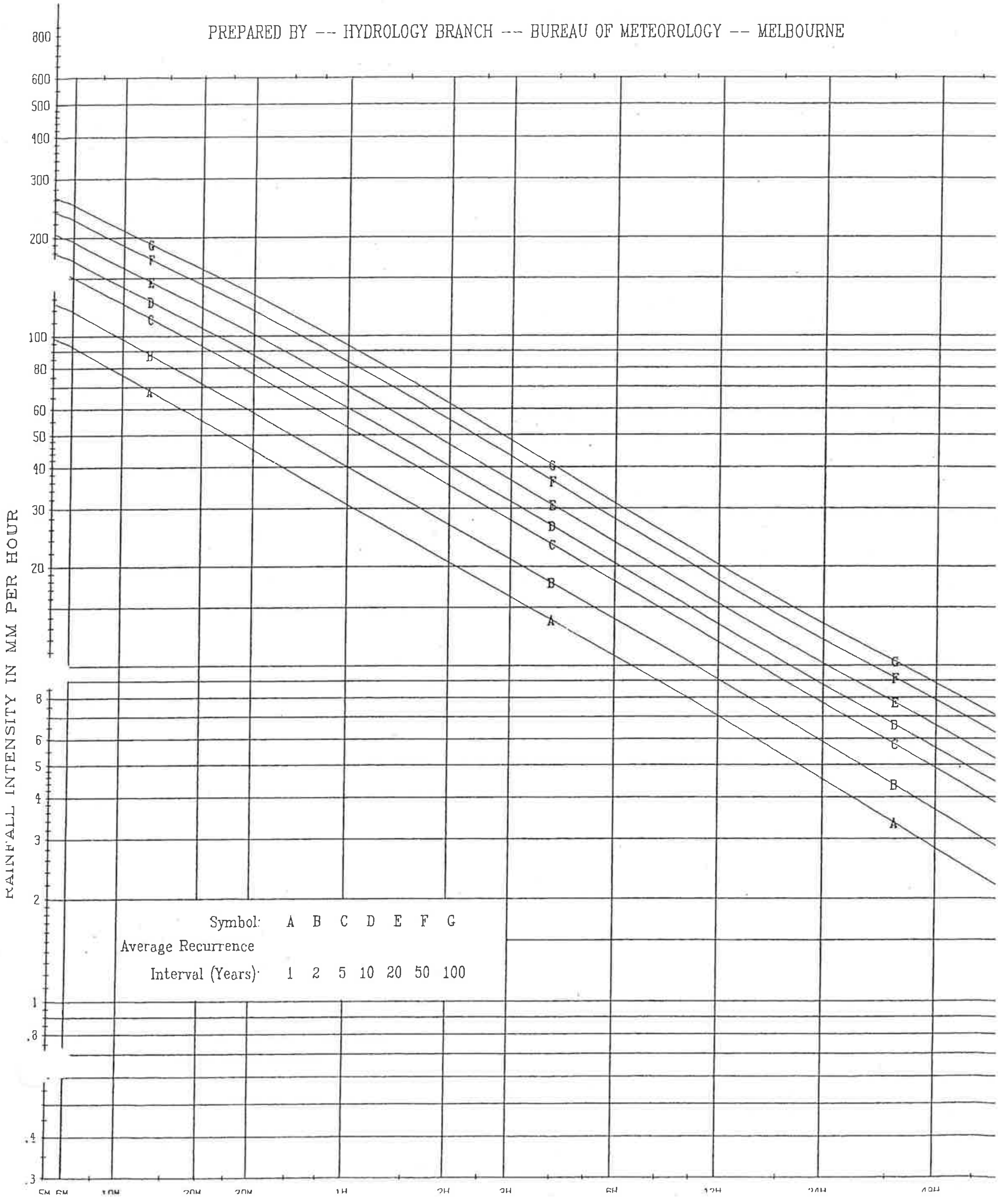
LOCATION 33.725 S 151.275 E * NEAR. CROMER DEPOT

* ENSURE THE COORDINATES ARE THOSE REQUIRED
SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME

ISSUED 23RD FEBRUARY 1989 REF.-FN2910

(RAW DATA 40.03, 9.08, 2.68, 84.05, 18.02, 5.83, 0.000, 1HG)

PREPARED BY -- HYDROLOGY BRANCH --- BUREAU OF METEOROLOGY -- MELBOURNE



LOCATION 33.750 S 151.200 E * NEAR. GLEN ST THEATRE ISSUED 23RD FEBRUARY 1989 REF. -FN2910

LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

* ENSURE THE COORDINATES ARE THOSE REQUIRED AS DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

$$\ln(I) = a + b*(\ln(T)) + c*(\ln(T))**2 + d*(\ln(T))**3 + e*(\ln(T))**4 + f*(\ln(T))**5 + g*(\ln(T))**6$$

I = INTENSITY IN MILLIMETRES PER HOUR

T = TIME IN HOURS

RETURN PERIOD (YEARS)	a	b	c	d	e	f	g
1	3.4599	-0.5778	-0.0306	0.00728	0.000585	-0.0001595	-0.0000244
2	3.7214	-0.5719	-0.0318	0.00733	0.000703	-0.0001771	-0.0000257
5	3.9955	-0.5558	-0.0335	0.00764	0.000744	-0.0002592	-0.0000121
10	4.1289	-0.5474	-0.0345	0.00766	0.000808	-0.0002798	-0.0000110
20	4.2785	-0.5407	-0.0353	0.00799	0.000800	-0.0003398	0.0000003
50	4.4474	-0.5326	-0.0362	0.00789	0.000880	-0.0003501	-0.0000003
100	4.5600	-0.5274	-0.0367	0.00792	0.000892	-0.0003659	0.0000025

RAINFALL INTENSITY IN MM/HR FOR VARIOUS DURATIONS AND RETURN PERIODS

DURATION (HOURS)	RETURN PERIOD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	102.	131.	164.	184.	209.	243.	268.
0.100	95.8	122.	155.	173.	197.	229.	253.
0.167	78.5	101.	128.	144.	164.	192.	212.
0.333	57.4	73.9	95.3	108.	124.	146.	162.
0.500	46.7	60.4	78.4	89.1	103.	121.	135.
1.000	31.8	41.3	54.4	62.1	72.1	85.4	95.6
2.000	21.1	27.4	36.5	41.9	48.9	58.2	65.3
3.000	16.4	21.4	28.7	33.0	38.6	46.1	51.8
6.000	10.7	14.0	18.9	21.8	25.6	30.7	34.7
12.000	7.02	9.21	12.5	14.5	17.1	20.5	23.2
24.000	4.62	6.09	8.29	9.65	11.4	13.7	15.5
48.000	3.00	3.95	5.40	6.29	7.43	8.96	10.2

DESIGN RAINFALL INTENSITY DIAGRAM

LOCATION 33.750 S 151.200 E * NEAR. GLEN ST THEATRE

* ENSURE THE COORDINATES ARE THOSE REQUIRED
SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

ISSUED 23RD FEBRUARY 1989 REF. -FN2910

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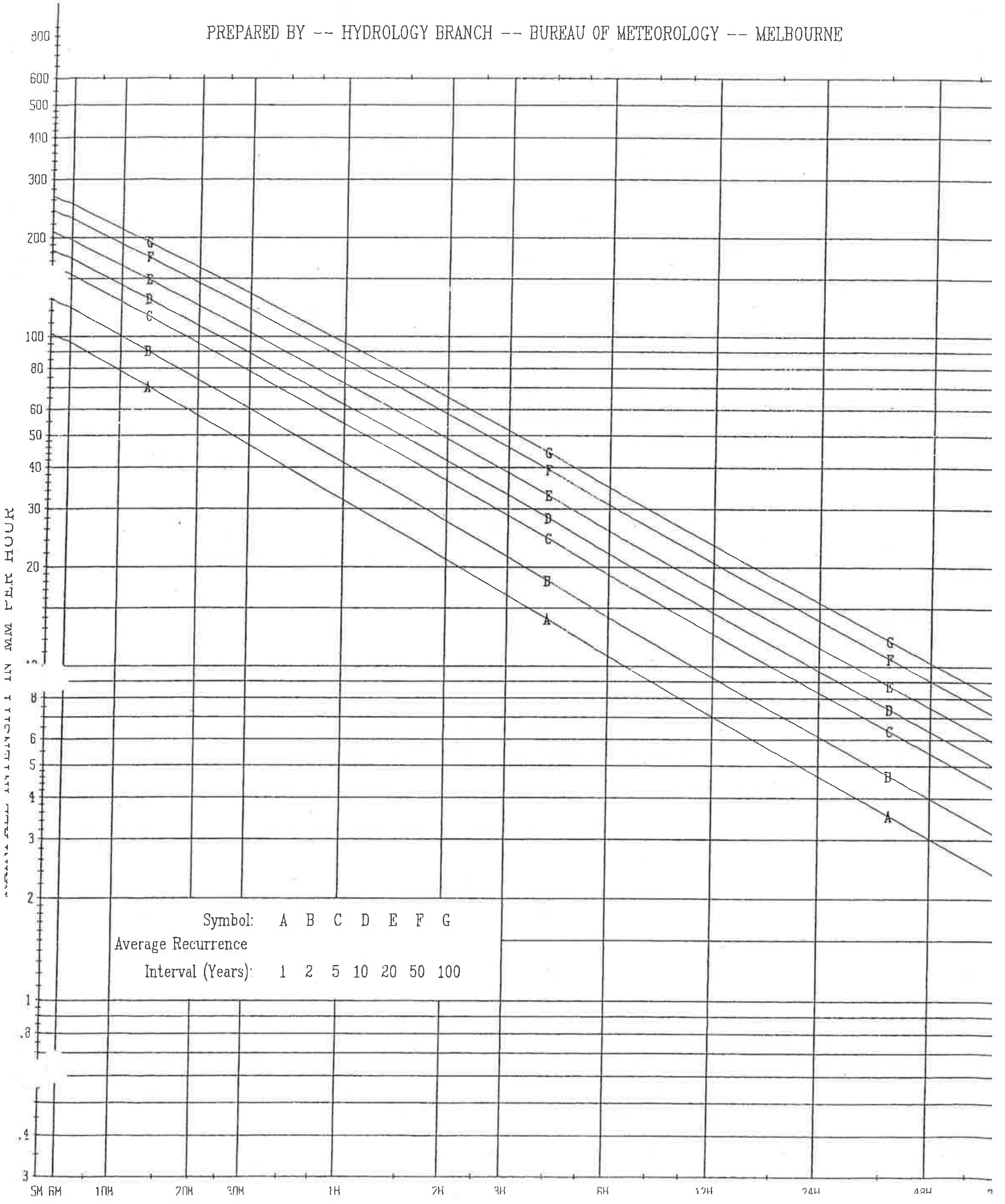

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LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

* ENSURE THE COORDINATES ARE THOSE REQUIRED SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

$$\ln(I) = a + b*(\ln(T)) + c*(\ln(T))**2 + d*(\ln(T))**3 + e*(\ln(T))**4 + f*(\ln(T))**5 + g*(\ln(T))**6$$

I = INTENSITY IN MILLIMETRES PER HOUR

T = TIME IN HOURS

RETURN PERIOD (YEARS)	a	b	c	d	e	f	g
1	3.4039	-0.5743	-0.0237	0.00859	-0.000579	-0.0003583	0.0000361
2	3.6675	-0.5727	-0.0273	0.00870	-0.000253	-0.0003855	0.0000339
5	3.9509	-0.5684	-0.0381	0.00839	0.000921	-0.0003617	-0.0000010
10	4.0890	-0.5656	-0.0440	0.00786	0.001621	-0.0003068	-0.0000291
20	4.2427	-0.5640	-0.0486	0.00790	0.002110	-0.0003167	-0.0000403
50	4.4165	-0.5619	-0.0538	0.00776	0.002680	-0.0003090	-0.0000566
100	4.5317	-0.5603	-0.0573	0.00762	0.003064	-0.0002962	-0.0000689

RAINFALL INTENSITY IN MM/HR FOR VARIOUS DURATIONS AND RETURN PERIODS

DURATION (HOURS)	RETURN PERIOD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	96.8	124.	159.	179.	205.	240.	266.
0.100	90.7	117.	149.	168.	193.	225.	250.
0.167	74.3	95.7	123.	139.	160.	188.	209.
0.333	54.3	70.3	91.8	105.	121.	143.	160.
0.500	44.1	57.3	75.5	86.3	100.	119.	133.
1.000	30.1	39.2	52.0	59.7	69.6	82.8	92.9
2.000	20.0	26.1	34.5	39.6	46.1	54.8	61.5
3.000	15.7	20.4	26.9	30.8	35.8	42.4	47.5
6.000	10.3	13.4	17.5	19.9	23.0	27.2	30.3
12.000	6.78	8.77	11.4	12.9	14.9	17.6	19.6
24.000	4.38	5.67	7.43	8.46	9.82	11.6	13.0
48.000	2.73	3.55	4.74	5.45	6.38	7.59	8.54

DESIGN RAINFALL INTENSITY DIAGRAM

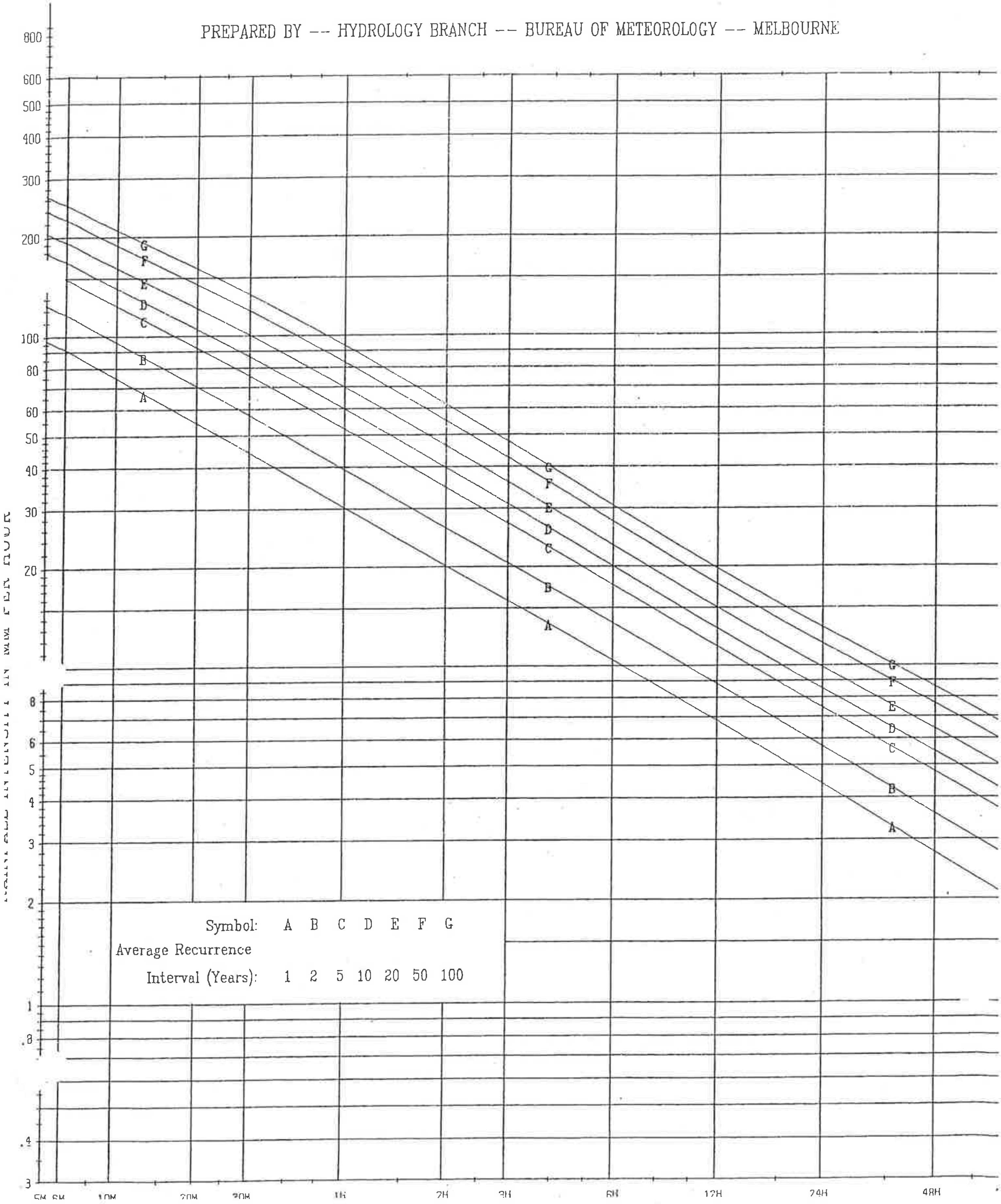
LOCATION 33.775 S 151.275 E * NEAR. NOLANS RESERVE

* ENSURE THE COORDINATES ARE THOSE REQUIRED.
SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

ISSUED 23RD FEBRUARY 1989 REF. -FN2910

(RAW DATA = 39.32, 8.80, 2.62, 83.36, 17.56, 5.69, 0.000, 2HG)

PREPARED BY -- HYDROLOGY BRANCH -- BUREAU OF METEOROLOGY -- MELBOURNE



LOCATION 33.675 S 151.225 E * NEAR. TERRY HILL BUSH F/B ISSUED 23RD FEBRUARY 1989 REF. -FN2910

LIST ØF CØEFFICIENTS TØ EQUATIØNS ØF THE FØRM

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ln(I) = a + b*(ln(T)) + c*(ln(T))**2 + d*(ln(T))**3 + e*(ln(T))**4 + f*(ln(T))**5 + g*(ln(T))**6

I = INTENSITY IN MILLIMETRES PER HØUR

T = TIME IN HØURS

RETURN PERIØD (YEARS)	a	b	c	d	e	f	g
1	3.4789	-0.5704	-0.0255	0.00727	0.000058	-0.0001611	-0.0000115
2	3.7388	-0.5659	-0.0277	0.00741	0.000239	-0.0002003	-0.0000090
5	4.0098	-0.5545	-0.0338	0.00743	0.000835	-0.0002335	-0.0000191
10	4.1408	-0.5481	-0.0367	0.00733	0.001104	-0.0002400	-0.0000243
20	4.2898	-0.5436	-0.0393	0.00761	0.001322	-0.0002845	-0.0000235
50	4.4572	-0.5375	-0.0423	0.00748	0.001618	-0.0002938	-0.0000290
100	4.5684	-0.5339	-0.0441	0.00743	0.001805	-0.0002903	-0.0000346

RAINFALL INTENSITY IN MM/HR FØR VARIØUS DURATIØNS AND RETURN PERIØDS

DURATIØN (HØURS)	RETURN PERIØD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	104.	132.	166.	185.	211.	245.	270.
0.100	97.4	124.	156.	174.	199.	230.	254.
0.167	79.9	102.	130.	145.	166.	193.	213.
0.333	58.3	75.0	96.5	109.	125.	147.	163.
0.500	47.4	61.3	79.5	90.1	104.	122.	136.
1.000	32.4	42.0	55.1	62.9	72.9	86.2	96.4
2.000	21.6	28.1	37.0	42.3	49.2	58.4	65.4
3.000	17.0	22.1	29.1	33.3	38.7	45.9	51.4
6.000	11.2	14.5	19.2	22.0	25.6	30.3	34.0
12.000	7.39	9.62	12.7	14.6	17.0	20.1	22.6
24.000	4.87	6.35	8.45	9.71	11.3	13.5	15.2
48.000	3.14	4.11	5.52	6.37	7.45	8.91	10.1

DESIGN RAINFALL INTENSITY DIAGRAM

LOCATION 33.675 S 151.225 E * NEAR. TERRY HILL BUSH F/B

* ENSURE THE COORDINATES ARE THOSE REQUIRED
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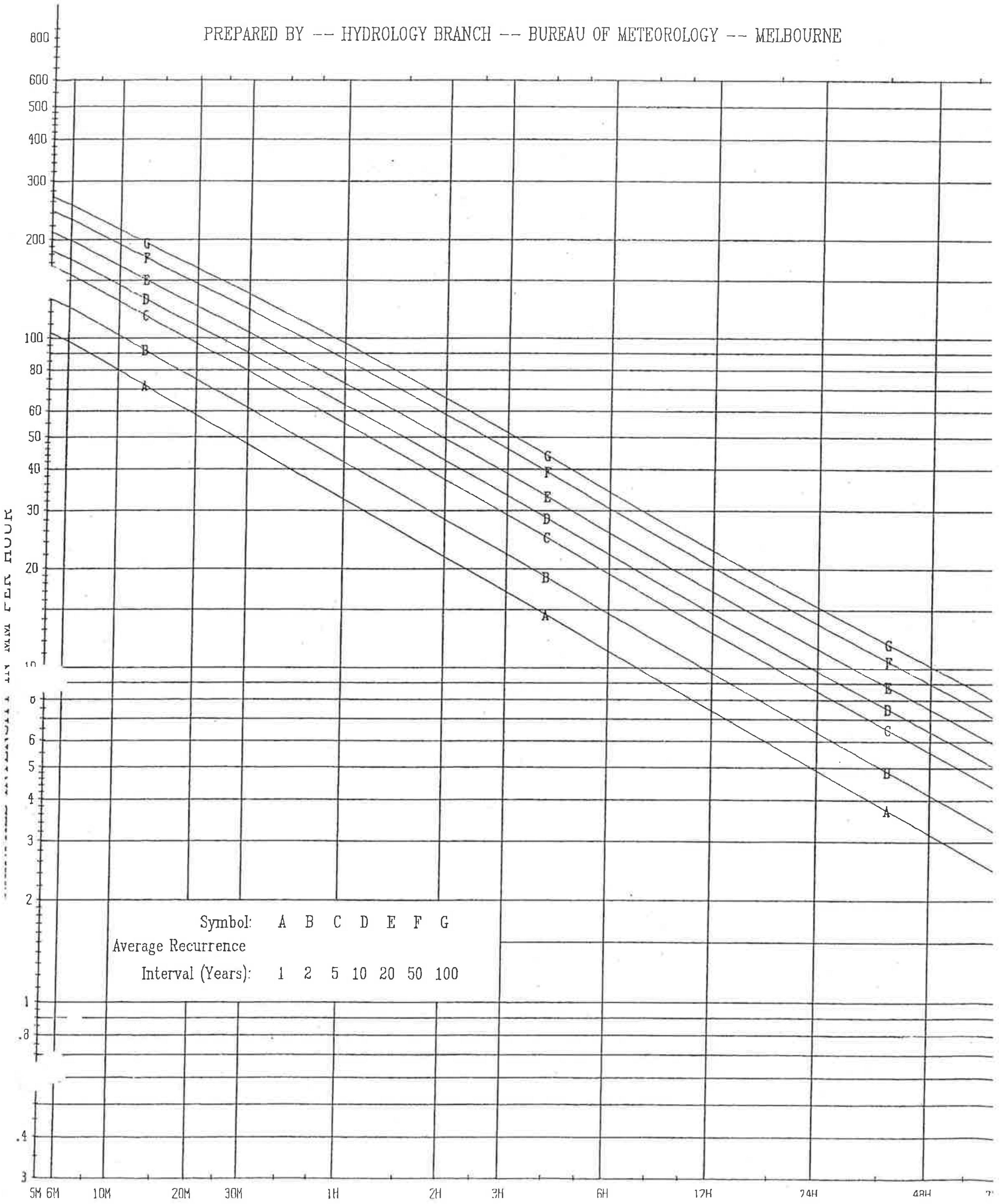
ISSUED 23RD FEBRUARY 1989 REF. -FN2910

(RAW DATA 42.15, 9.62, 3.08, 87.09, 20.19, 6.75, 0.000, (NC)

PREPARED BY -- HYDROLOGY BRANCH -- BUREAU OF METEOROLOGY -- MELBOURNE



APPENDIX B

PIT PRESSURE
CHANGE COEFFICIENTS

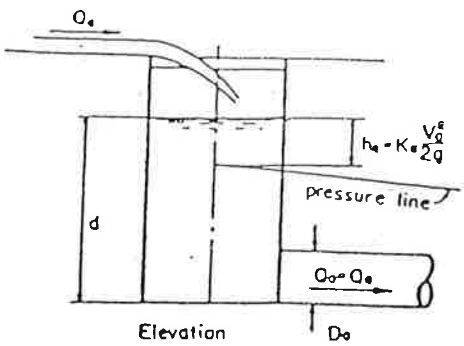


CHART 2

RECTANGULAR INLET WITH GRATE FLOW ONLY.

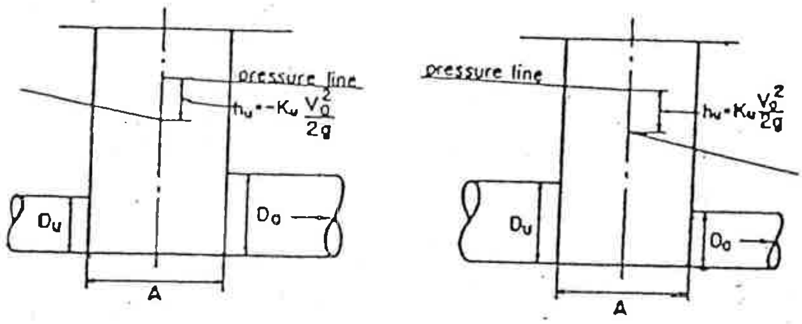


CHART 3

FLOW STRAIGHT THROUGH ANY JUNCTION.

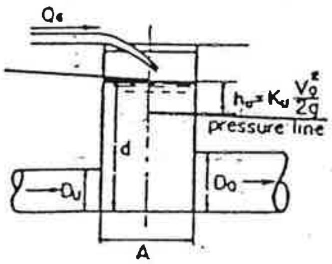


CHART 4

RECTANGULAR INLET WITH THROUGH PIPELINE AND GRATE FLOW.

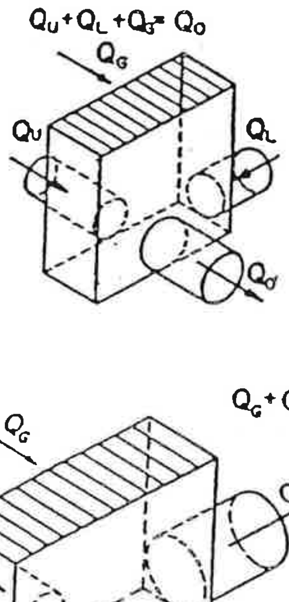


CHART 5

RECTANGULAR INLET WITH IN-LINE UPSTREAM MAIN AND 90° LATERAL PIPE (WITH OR WITHOUT GRATE FLOW.)

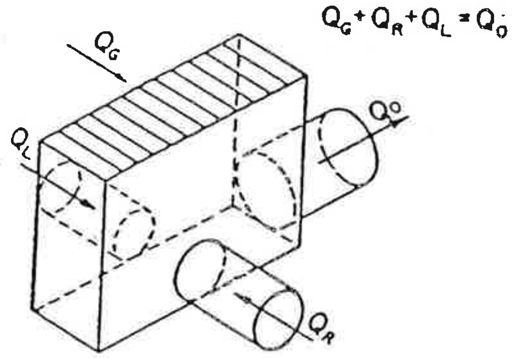


CHART 6

RECTANGULAR INLET WITH IN-LINE OPPOSED LATERAL PIPES EACH AT 90° TO OUTFALL (WITH OR WITHOUT GRATE FLOW.)

Basic types of pits covered by Missouri Charts.

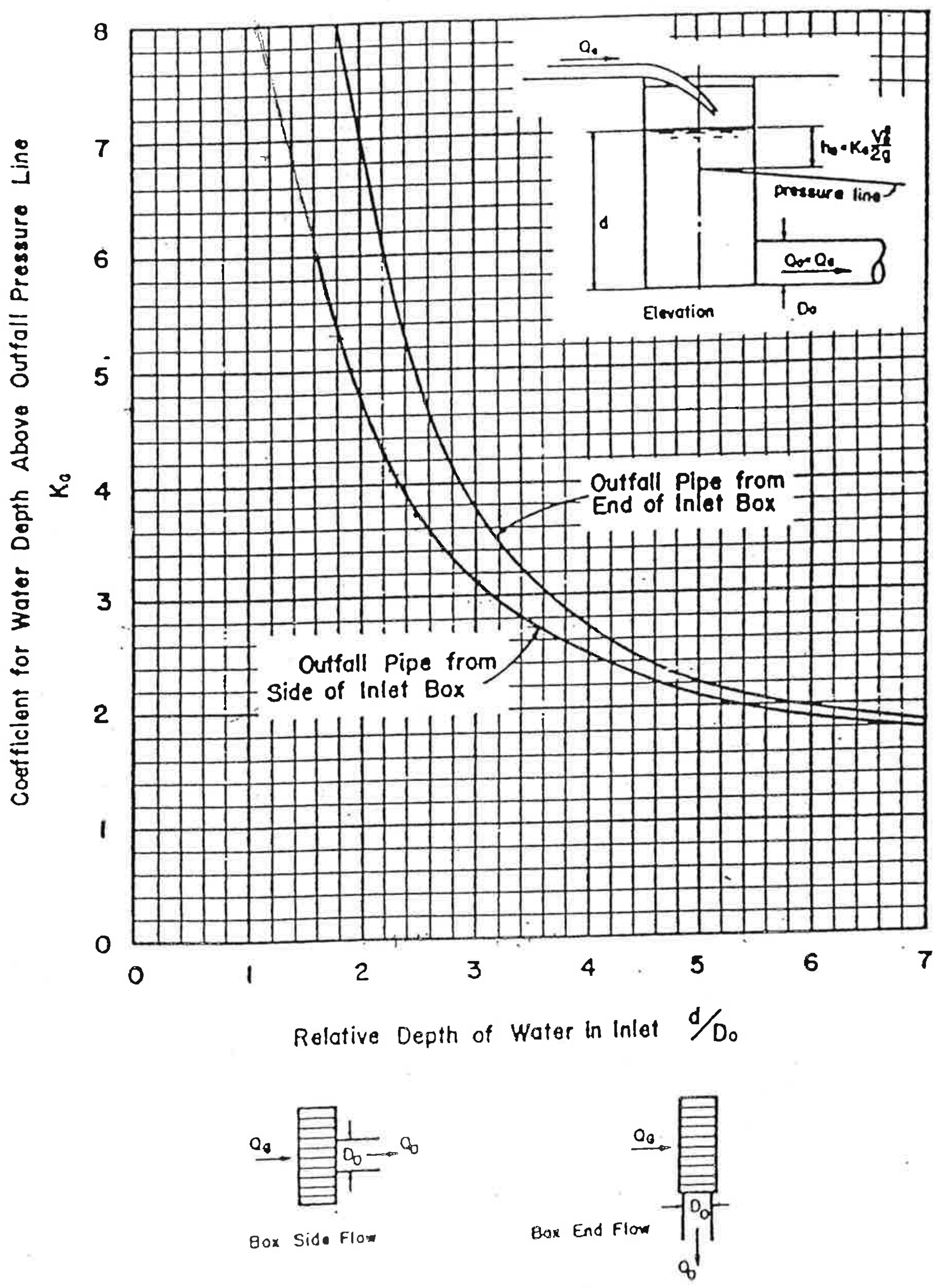


Chart 2. Rectangular inlet with grate flow only.

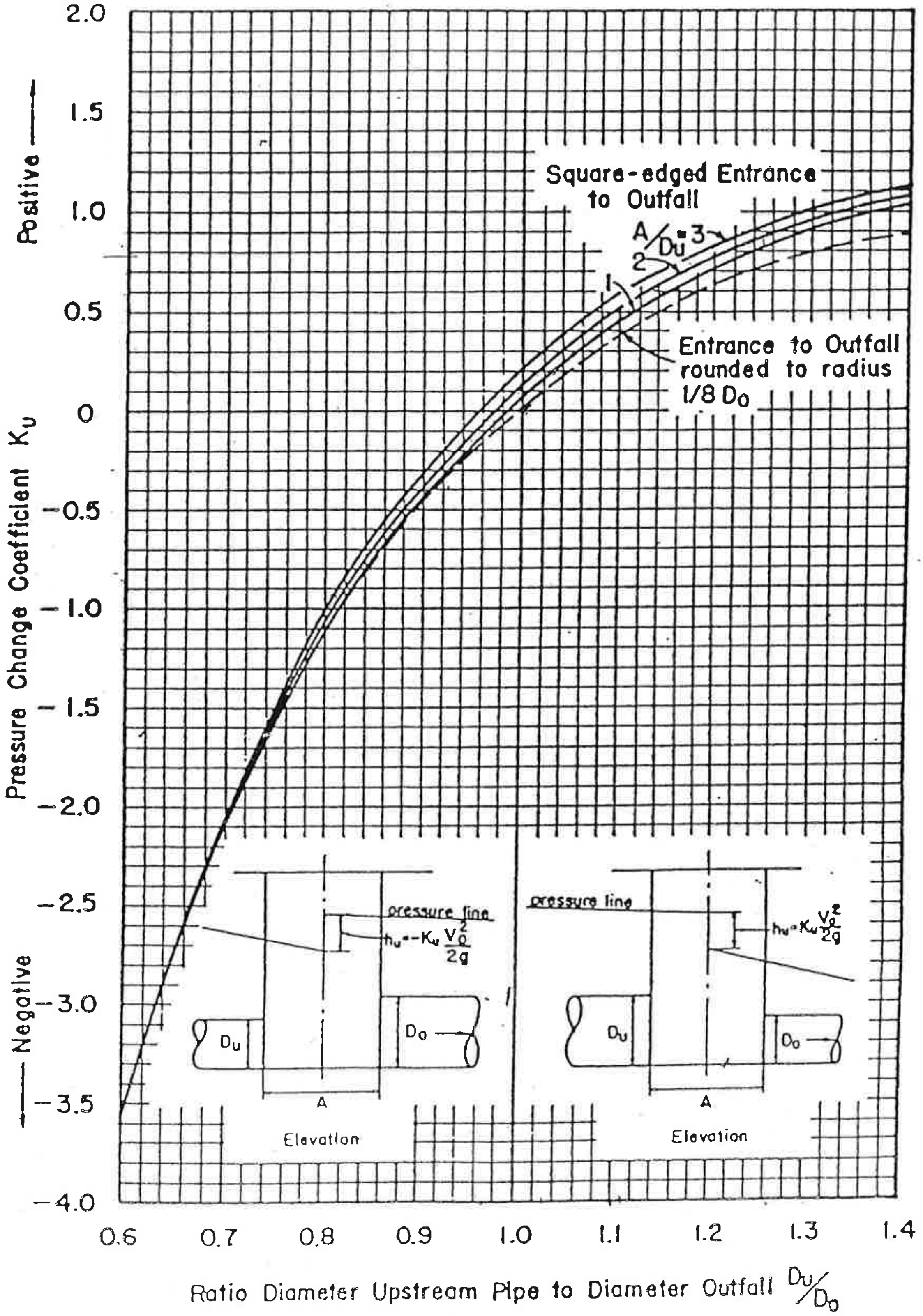


Chart 3. Flow straight through any junction.

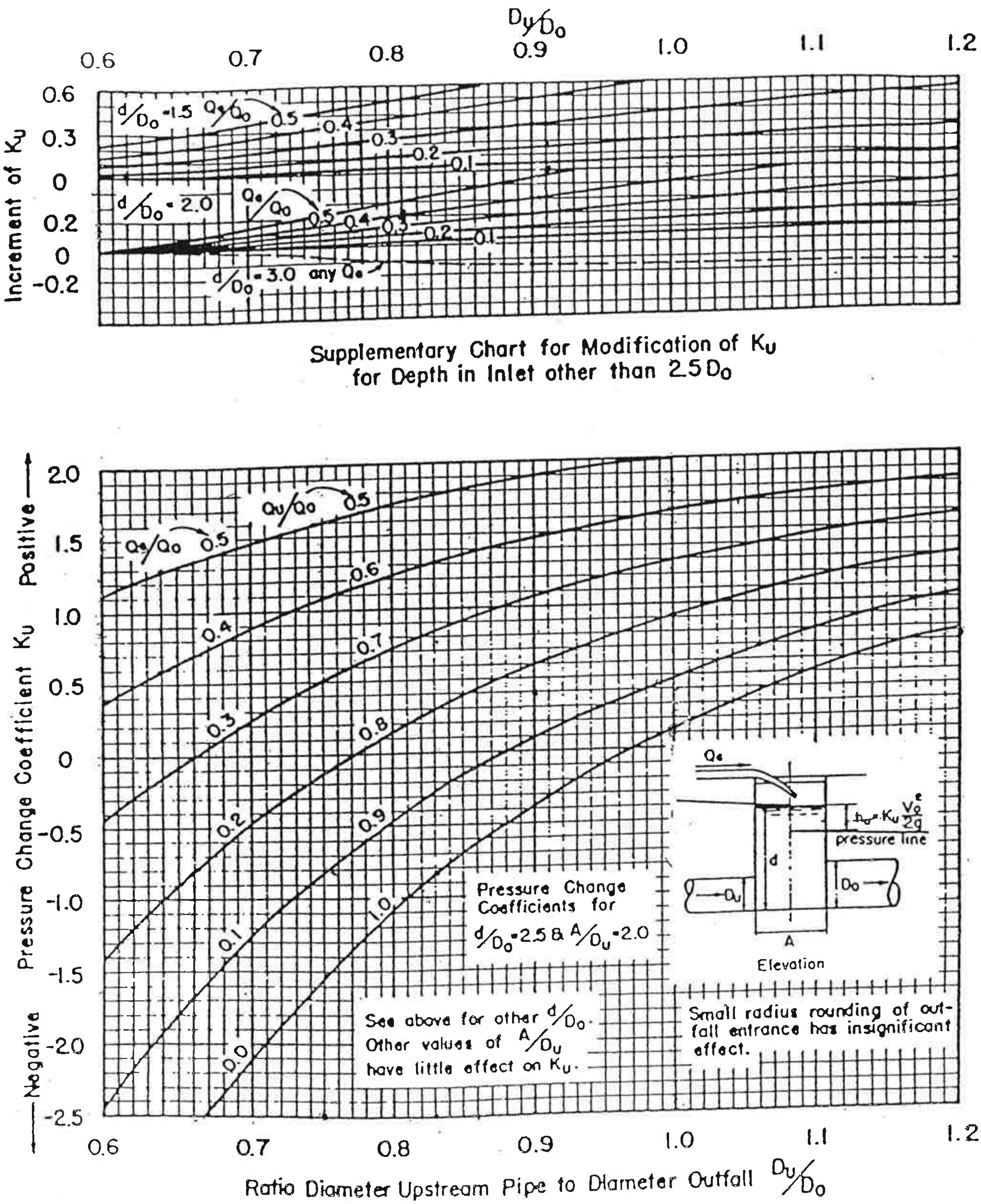


Chart 4. Rectangular inlet with through pipeline and grate flow.

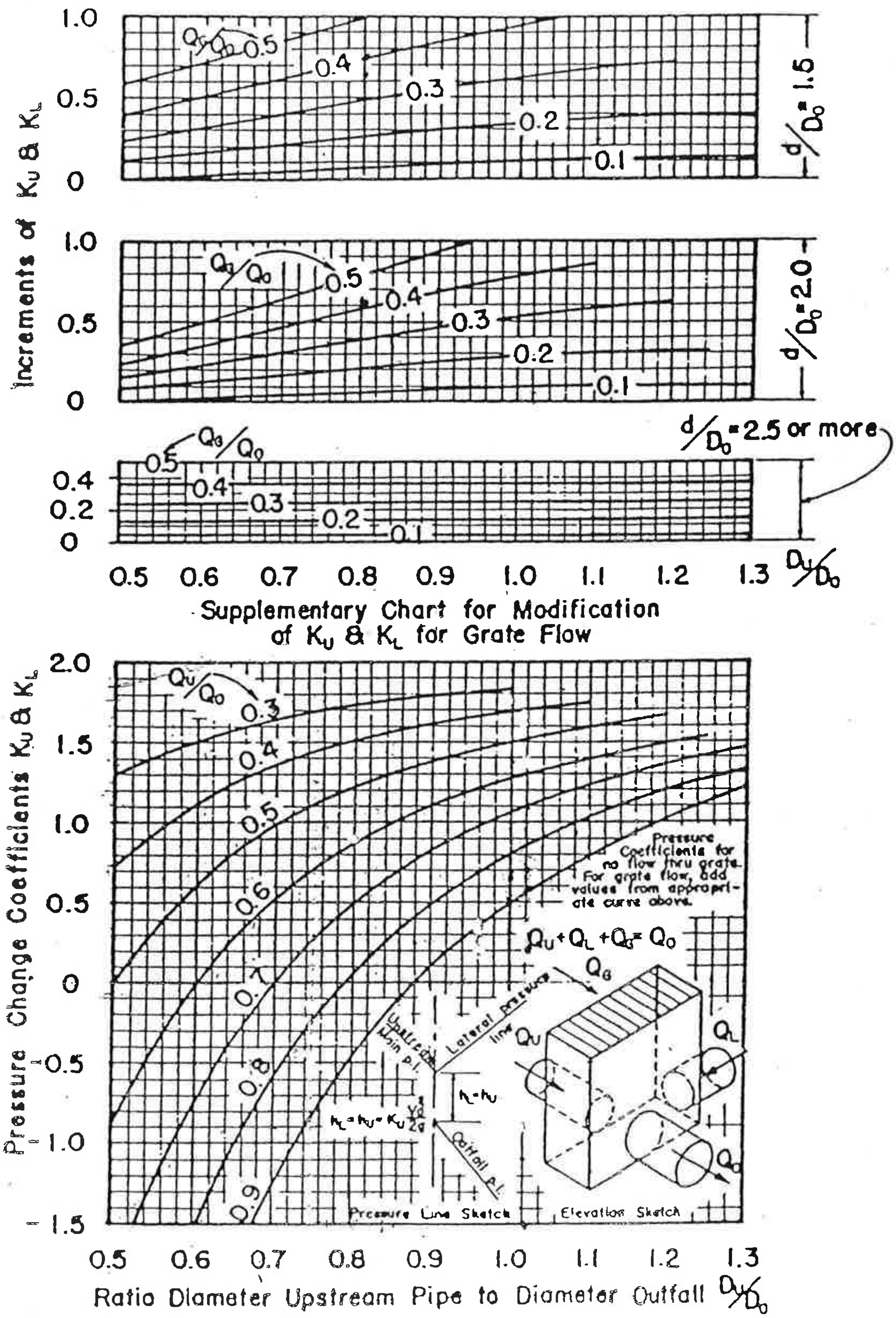
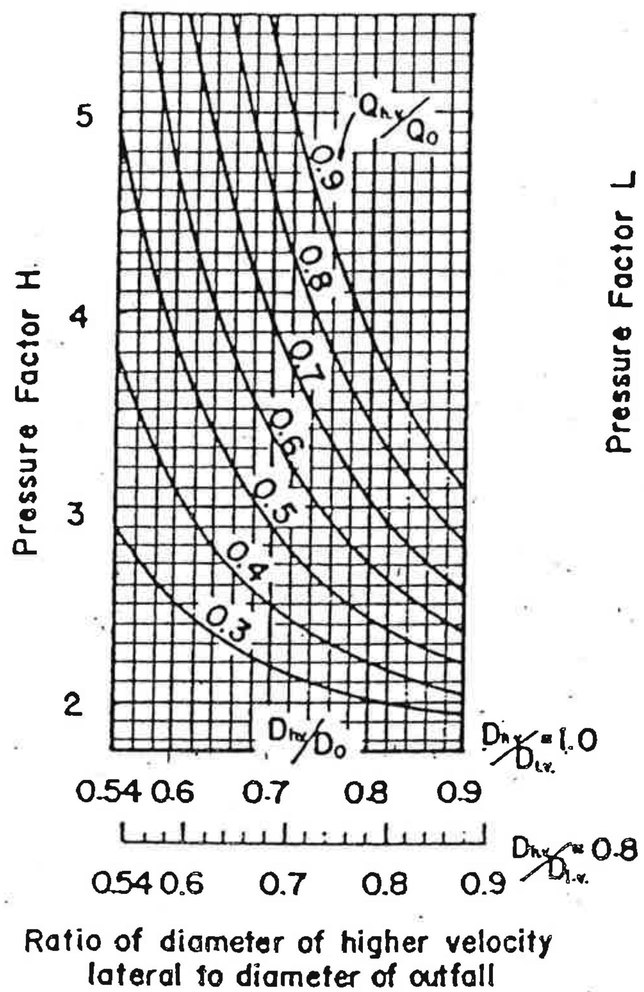
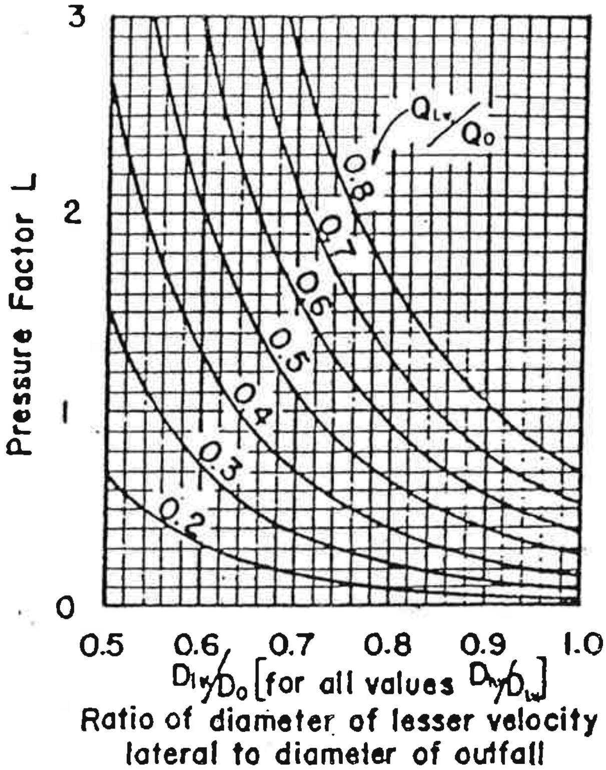


Chart 5. Rectangular inlet with in-line upstream main and 90° lateral pipe (with or without grate flow).



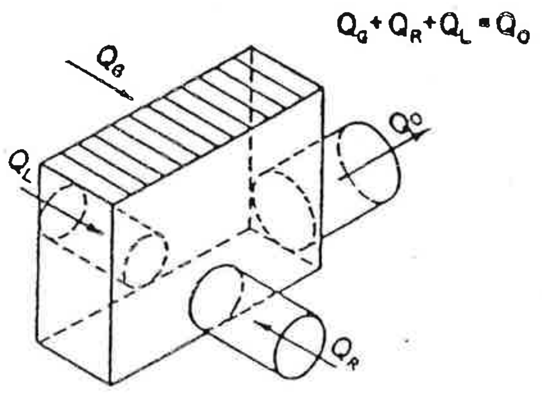


$D_{h.v.}$ = diameter of lateral with higher-velocity flow.

$Q_{h.v.}$ = rate of flow in lateral with higher-velocity flow.

$D_{l.v.}$ = diameter of lateral with lower-velocity flow.

$Q_{l.v.}$ = rate of flow in lateral with lower-velocity flow.



Elevation Sketch

To find K_R or K_L for the right or left lateral pipe with flow at a lesser velocity than the other lateral, read H for the higher velocity lateral D and Q, then read L for the lower velocity lateral D and Q; then: K_R (or K_L) = H − L

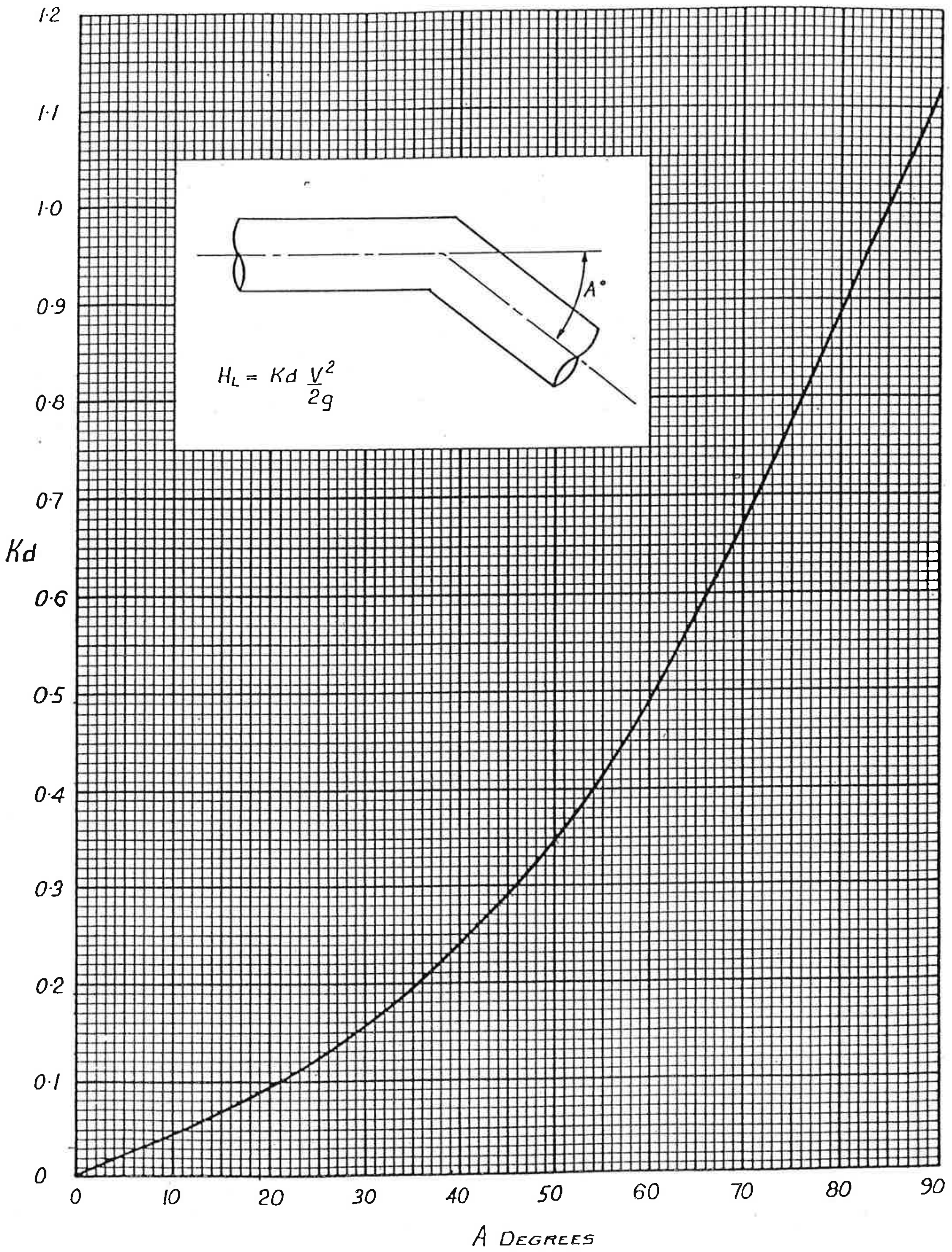
K_R or K_L for the lateral pipe with higher velocity flow is always 1.8

$$h_L = K_L \frac{V_0^2}{2g} \qquad h_R = K_R \frac{V_0^2}{2g}$$

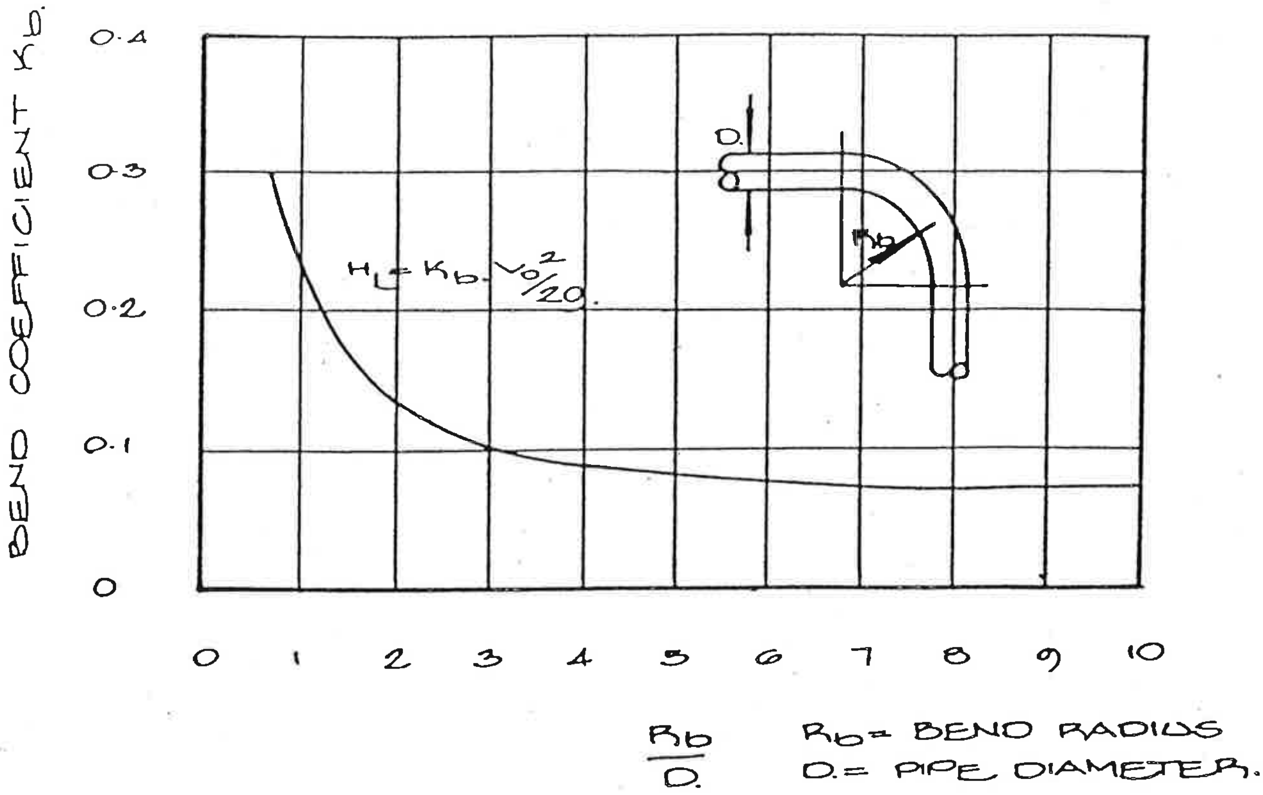
Chart 6. Rectangular inlet with in-line opposed lateral pipes each at 90° to outfall (with or without grate flow).

APPENDIX C

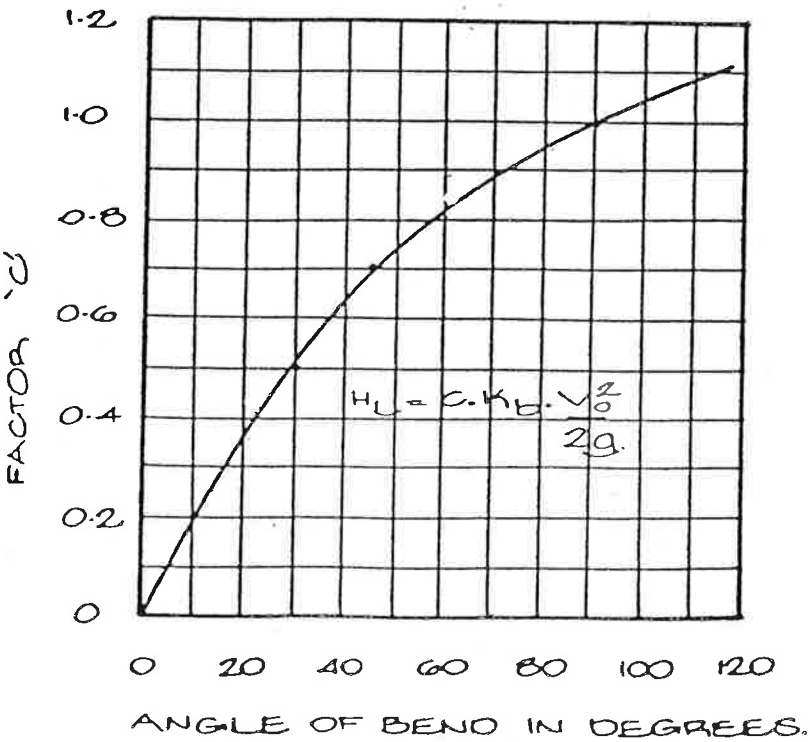
PIT PRESSURE CHANGE AT BENDS



Loss coefficients for Mitre bends.



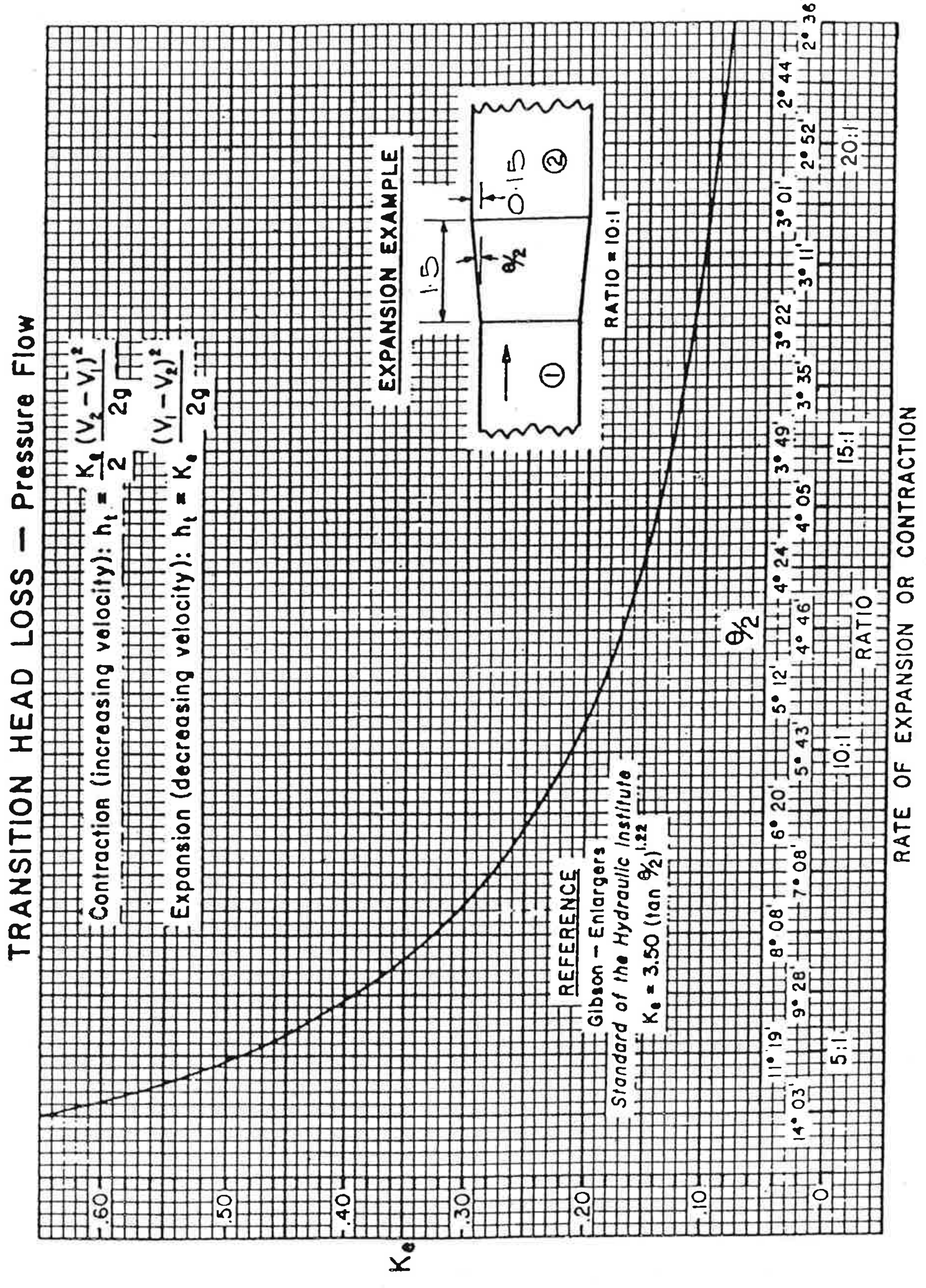
Variation of Bend coefficient with relative Radius for 90° bends of circular cross-section.



Factors for Bend loss coefficient for other than 90° bends.

APPENDIX D

LOSSES IN SUDDEN EXPANSIONS AND CONTRACTIONS



Transition Head loss coefficients.

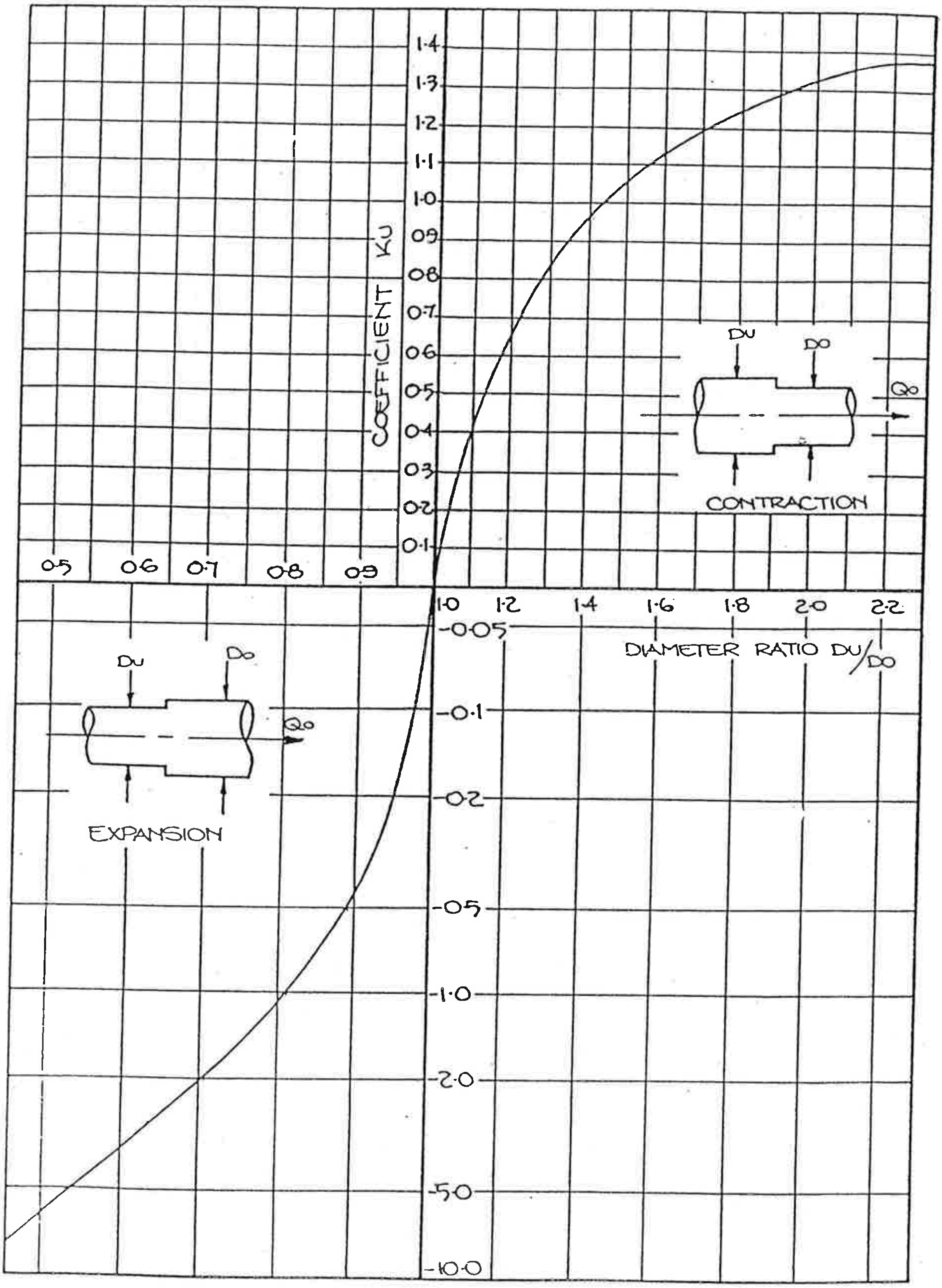
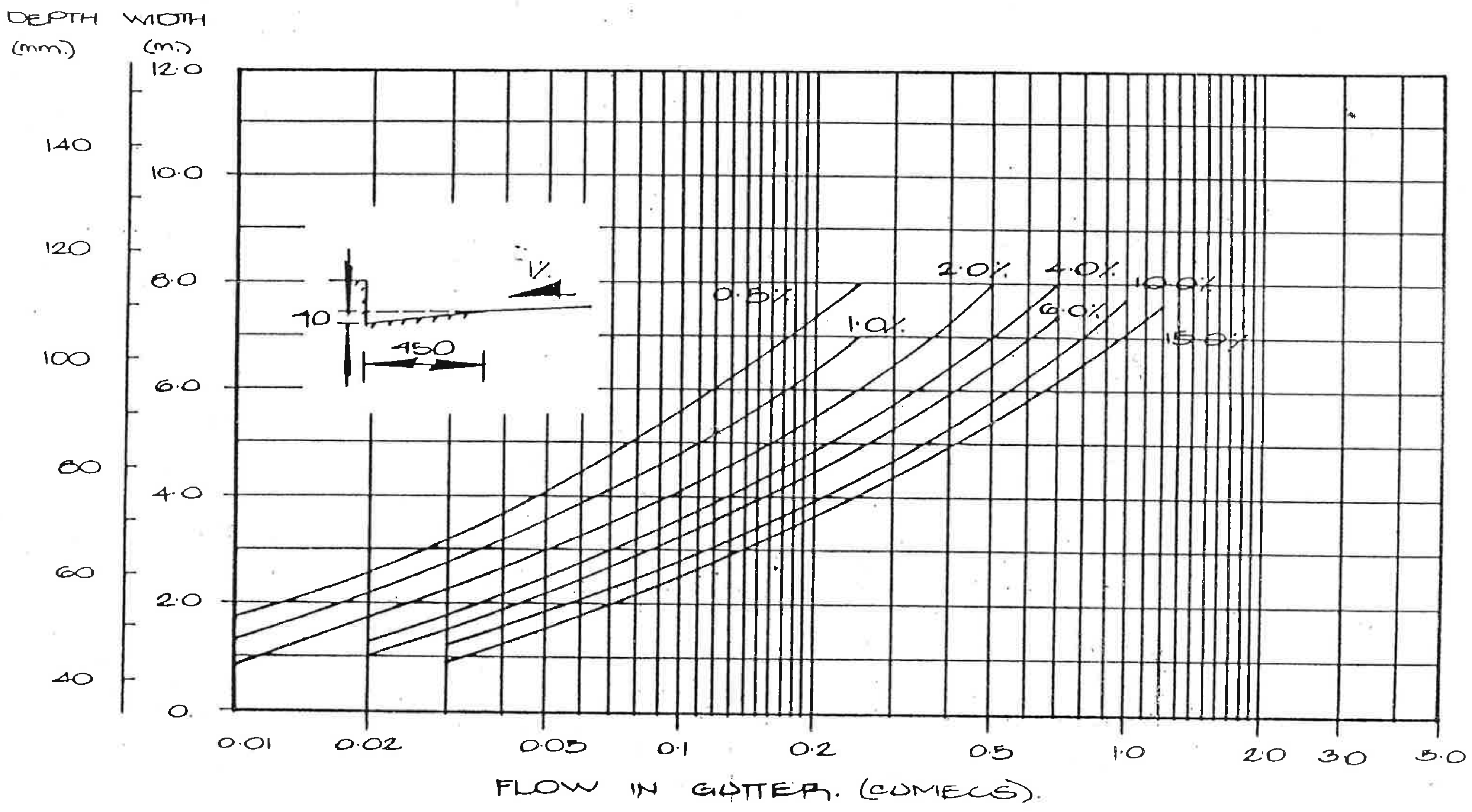


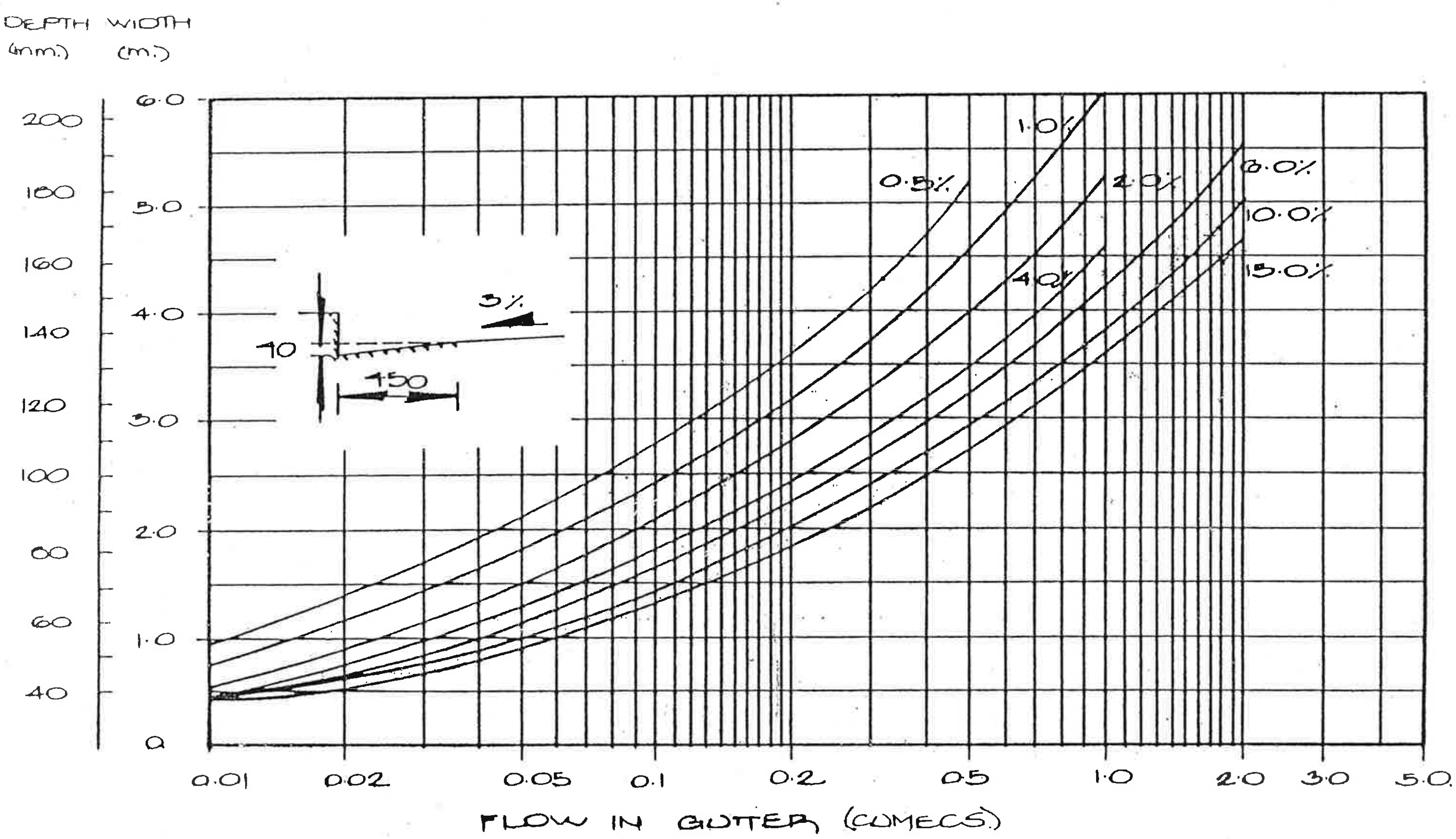
Figure 4.10 Loss coefficients for sudden Expansion or Contraction.

APPENDIX E

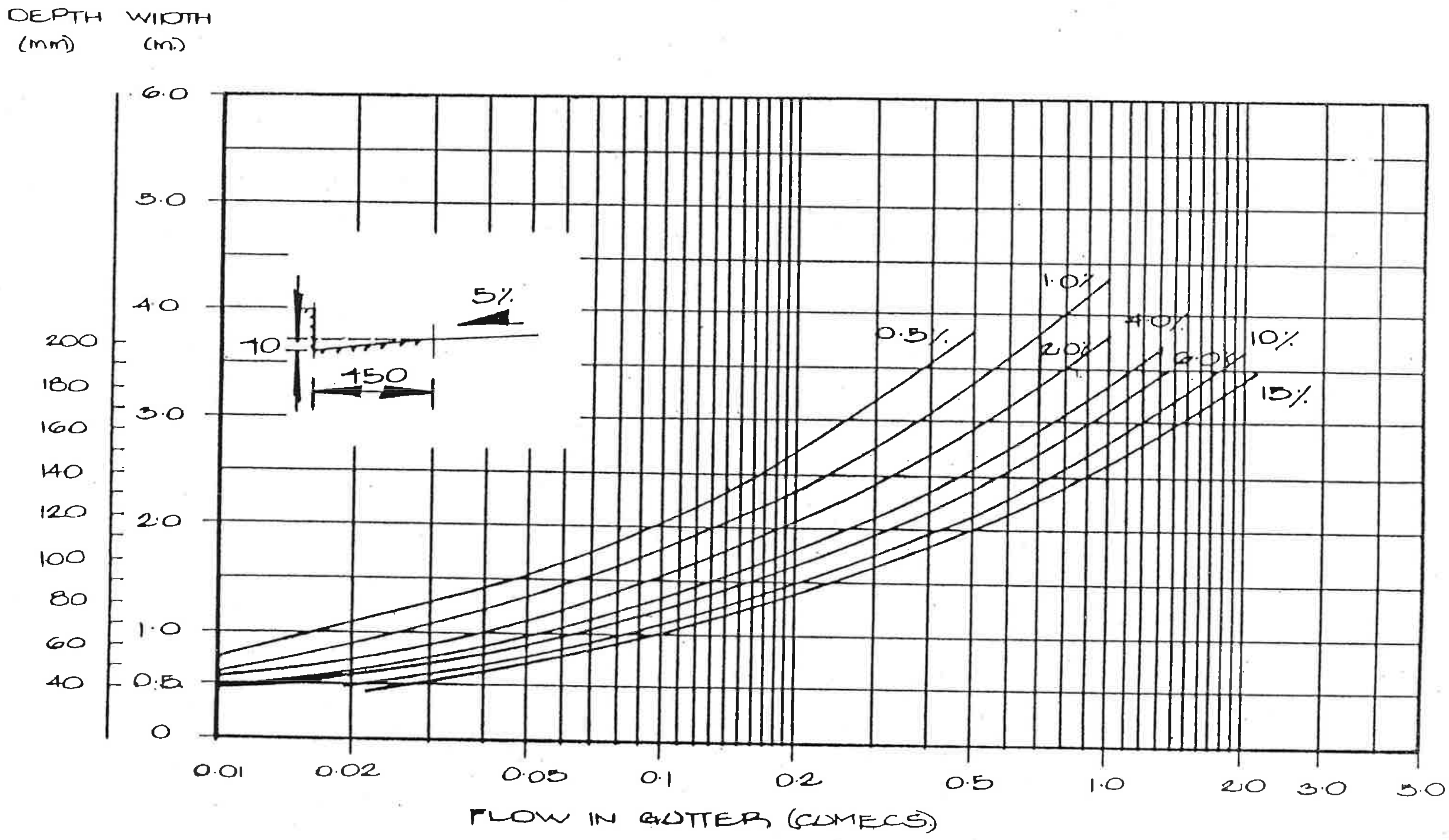
ROAD CAPACITY CHARTS



GUTTER FLOW PROFILE – 1% CROSSPALL.



GUTTER FLOW PROFILE – 3% CROSSFALL.



GUTTER FLOW PROFILE – 5% CROSSFALL.

The Froude Number (Fr) is given by the equation:

$$Fr = \frac{V_o}{\sqrt{gy}}$$

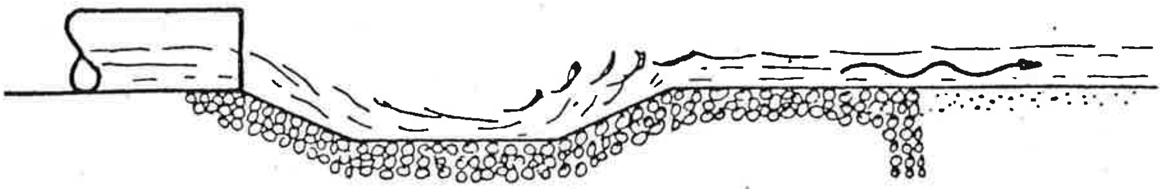
For pipes, use $Fr = \frac{0.38V_o}{\sqrt[4]{A_e}}$

For box culverts, use $Fr = \frac{0.32V_o}{\sqrt{d_e}}$

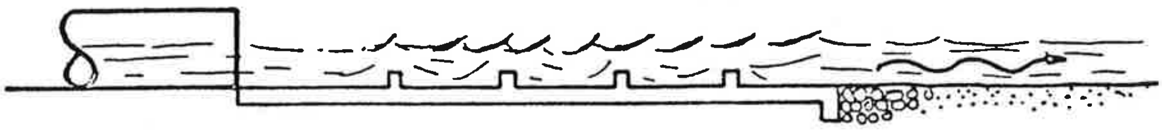
where V_o = outlet velocity (m/sec)
g = acceleration of gravity, 9.81 m/sec^2
y = depth of water (m)
A_e = effective outlet area (sq.m)
d_e = effective water depth at outlet

For $Fr < 1.7$ Channel lining should give adequate protection. Typical methods used are a concrete apron in conjunction with outlet wingwalls, hand-packed heavy stones, grouted stone pitching, sand bag revetment, "Reno mattress" and gabions (wire cages filled with smaller stones ordinarily moved by the flood flow).
The latter two methods are becoming increasingly economical by comparison with the cost of stone pitching. They provide flexible structures which can deform without fracture.

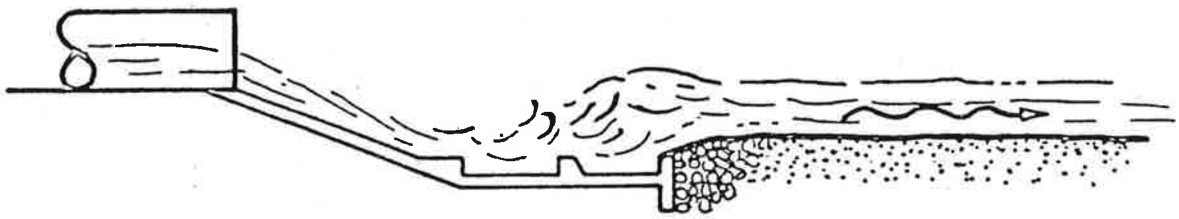
For $Fr > 1.7$ reduction of outlet velocity can be achieved by creating a hydraulic jump in the flow or by providing stilling basins.
A hydraulic jump is the abrupt rise (a standing wave) which frequently occurs in the water surface in open channel flow, when water at high velocity (super-critical) discharges into a zone of lower velocity (sub-critical). The hydraulic jump is accompanied by violent turbulence, eddying, air entrainment and surface undulations.
Some energy-dissipating structures to produce this hydraulic jump are are illustrated in Figure . A further alternative is to create a hydraulic jump within the culvert by breaking the slope of the culvert so that the first portion of the culvert will be on a steeper slope than the second portion. These solutions require detailed design and should be referred back to Head Office if their use cannot be avoided.



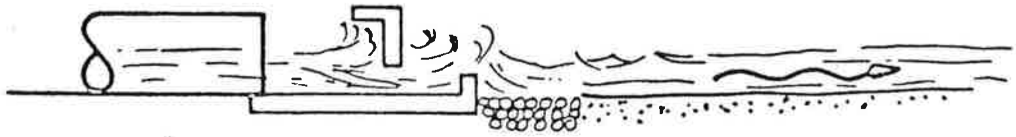
Riprap basin ($F_r < 3$)



Horizontal roughness element basin ($F_r < 3$)



Forced jump basin (F_r 2 to 17)



Impact energy dissipator ($F_r < 7$)

Illustrations Of Conditions Relating to Froude Numbers

Figure

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

DQS

QUALITY ASSURANCE REQUIREMENTS FOR DESIGN

CONTENTS

QUALITY ASSURANCE REQUIREMENTS FOR DESIGN

DQS.01 SCOPE

1. This Design Specification sets out the process for quality assurance of designs required by Council for development consents. The requirements are applicable to all design work whether undertaken by the Developer, the Developer's Project Manager, Consultant or a Sub-Consultant. ***Quality Assurance***

2. The Specification refers to engineering design processes. Requirements which refer to the concept design of developments are generally covered in Council's LEP 2000. The requirements of the Subdivision LEP are a prerequisite to the quality requirements for engineering design provided in this Specification (DQS). ***Prerequisite***

3. The Specification refers also to engineering design processes for developments that do not involve subdivision.

DQS.02 OBJECTIVES

1. This Specification aims to set standards and document requirements for the execution and recording of design processes in order that the infrastructure associated with any development is designed to be fit for service and of a standard reasonably maintainable when it is accepted by Council as a community asset. ***Maintenance***

2. It is also an objective that these qualities be readily demonstrable by clear records of key design processes and that data relevant to the upkeep of the assets is available to Council's management. ***Records***

DQS.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

All Specifications for Design and Construction
Council's Codes and Policies

(b) Australian Standards

AS/NZS 3905.2	Guide to quality system Standards AS/NZS 9001, AS/NZS 9002 and AS/NZS 9003 for construction.
AS/NZS 3913	Quality manuals - Guide to preparation.
AS/NZS ISO 8402	Quality management and quality assurance - Vocabulary.
AS/NZS ISO 9001	Quality systems - Model for quality assurance in design, development, production, installation and servicing.
AS/NZS ISO 9004.1	Quality management and quality system elements - Guidelines.

(c) Other

Section 90 (EP&A ACT)
Local Government Act (1919) Subdivisions Pt XII
Local Government Act (1993)
Technical Publications used as Engineering Standards (AR&R)
Interim Policies and Guidelines

DQS.04 CERTIFICATION

1. The Developer shall present all engineering drawings to Council's Senior Development Engineer for acceptance. Each set of drawings shall be accompanied by a Certification Report which will be signed by the Developer's Engineering Consultant or Registered Surveyor. The Certification Report will comprise the certificate and check lists set out in Annexure DQS-A. ***Certification Report***

2. Certification Reports shall be required with preliminary drawings and shall require resubmission with updates when final drawings are submitted. Certification is not required with sketch plans or concept plans. ***Certification of Preliminary Drawings***

3. The Certification Report shall indicate on check lists any aspects of design which do not meet requirements or tolerances set out in LEP 2000 and Council's Design and Construction Specifications. ***Design Non-conformance***

DQS.05 MINIMUM DRAFTING REQUIREMENTS

1. Design drawings shall be definitive and clearly set out so as to present the design concepts in such a way that the project can be understood, specified for construction and satisfactorily built. ***Criteria***

2. All design drawings should be clearly numbered by the designer with separate sheets numbered as part of a set. All drawing sheets shall have an allocated space in the bottom right hand corner for an assigned number provided by Council (10 characters). ***Sheet Numbers***

3. The information shown on the drawings shall be logically collected on discrete sheets to avoid illogical and onerous effort in cross referencing between sheets in order to find information. Drawings should not be overcrowded with information and should not rely on colour printing or colour wash to impart information. Drawings should be on A1 or A2 size sheets and be suitable for black and white copying and photo reduction to A3 paper size without loss of clarity. ***Logical Drawing Sheets***

4. Annexure DQS-B provides guidelines for grouping information in design drawings.

DQS.06 DESIGNER'S QUALIFICATIONS

1. A Practising Civil Engineer deemed to be suitably experienced by Council and qualified so as to be accepted as a Member of the Institution of Engineers, Australia (and registered under the Institute's Professional Engineers Register for Development of related works) or a Registered Professional Surveyor and qualified so as to be accepted as a Professional Member of the Institution of Surveyors, Australia who are deemed to be suitably experienced by Council shall be accepted as qualified to prepare plans for roadworks, drainage works, (excluding flood control structures and bridges). ***Engineer Surveyor***

2. A Civil or Structural Engineer qualified as detailed above shall be accepted as qualified to prepare plans for bridges, retaining walls, miscellaneous structures, buildings, and flood control structures. ***Structural Design by Engineer***

DQS.07 RECORDS

1. The Designer shall retain appropriate design records in a format such that they can be understood readily by design staff with no prior knowledge of the particular design.

Calculations which can readily be re-done need not be kept once the construction maintenance period of the project has expired. *Calculation Record Retention*

3. A design file shall be maintained by the Developer or the Developer's Consultant containing records of calculations, approvals and decisions, geotechnical data and other design data which could be relevant in reviewing aspects of the design or planning future maintenance responsibilities. *Design File to be kept*

4. Particular requirements apply to hydrological and hydraulic design data. (Refer to Council's Stormwater Drainage Design Specification). *Hydrologic, Hydraulic Design*

5. Copies of records will be made available to Council on request and without charge.

DQS.08 AUDIT

Council shall have the right of audit of all processes and documents related to the project design. The Developer and the Developer's Consultant shall provide Council's Officers all reasonable assistance in inspecting records of designs submitted to Council for acceptance. *Provide Assistance*

2. In order to provide for such audit, access to the premises of the Developer or the Developer's Consultant will be provided to Council on a 24 hour notice basis. *Notice of Access*

ANNEXURE DQS-A

WARRINGAH COUNCIL
DESIGN CERTIFICATION REPORT

Project Title: ____________________

DA/BA No: ____________________

Consultant's Drawing No: ____________________

Name of Consultant: ____________________

ˋame and Address of Developer: ____________________

____

I certify that the subject drawings represent a design for which the attached design check lists provide a valid record.

I certify that this Design has been carried out in accordance with current standards of good industry practice and in accordance with Warringah Council's Design Specifications, LEP 2000 and specific instructions received with the exception of departures cited in the attached design check lists for Council's advice.

I certify that this Design will not significantly impact on the environmental factors of the area as interpreted under Part V of the Environmental Planning and Assessment Act.

I certify that this Design is in strict compliance with the development consent conditions and where a variance to the consent is found, written confirmation has been received from Council approving of the variance prior to the lodgement of Design Drawings (this includes designs for staged construction).

I certify that all structural elements of the Design have been designed by a competent qualified practicing Civil or ˁtructural Engineer.

Contact Phone: ____________________

Contact Postal Address: ____________________

____

____

____

____

Design Engineer/Surveyor Date

____

Qualifications

Design Check List 1 BASE PLOT OF EXISTING FEATURES

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
1.1	Initial plot verified by site inspection for existing drainage.	______	/ /	☐
1.2	Initial plot verified by site inspection for existing property descriptions, boundaries and accesses.	______	/ /	☐
1.3	Initial plot of contours verified as representative of site terrain.	______	/ /	☐
1.4	Trees and significant environmental features affected by development are clearly indicated and annotated.	______	/ /	☐
1.5	Features significant to heritage considerations within the development boundaries are clearly indicated and annotated.	______	/ /	☐
1.6	Existing public and private property likely to be affected by these Designs are clearly indicated and annotated.	______	/ /	☐
1.7	Survey and bench-marks clearly indicated and annotated.	______	/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

____

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____

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____

____

esign Check List 2 HORIZONTAL ROAD ALIGNMENT

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
2.1	Alignment compatible with design speed.	______	/ /	☐
2.2	Alignment is adequate in relation to clearance of roadside hazards.	______	/ /	☐
2.3	Driver and pedestrian sight distance is adequate.	______	/ /	☐
.4	Conflict with existing services is minimised.	______	/ /	☐
2.5	Road widths and lanes meet Councils requirements and design traffic requirements.	______	/ /	☐
2.6	Alignment of bridges suits road alignment.	______	/ /	☐
2.7	Pedestrian, bicycle and parking requirements are met.	______	/ /	☐
2.8	Provision for large vehicles such as buses, garbage trucks and emergency vehicles is adequate.	______	/ /	☐
9	Intersection layouts meet turning requirements of design traffic including emergency vehicles.	______	/ /	☐
2.10	Pavement width tapers and merges are adequate.	______	/ /	☐
2.11	Pedestrians and prams are catered for.	______	/ /	☐
2.12	Conflict with existing public utility services has been identified and resolved.	______	/ /	☐
2.13	Horizontal road alignment has been provided in accordance with any conditions of development consent.	______	/ /	☐
14	Horizontal road alignment setout data is clearly defined and tabulated.	______	/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

›sign Check List 3 VERTICAL ROAD ALIGNMENT

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
3.1	Grades meet maximum and minimum requirements.	______	/ /	☐
3.2	Vertical clearances to bridges and services meet standards.	______	/ /	☐
3.3	Vertical sight distance is adequate for drivers and pedestrians.	______	/ /	☐
4	Cover to drainage structures or services is adequate.	______	/ /	☐
3.5	Vertical alignment is adequate for disposal of surface drainage from properties and from road.	______	/ /	☐
3.6	Grades are satisfactory for 1:100 year flood levels.	______	/ /	☐
3.7	Vertical alignment is compatible with property access.	______	/ /	☐
3.8	The gradient on an intersecting road is not significantly greater than the cross slope of the through pavement and no greater than 3% at give way and stop signs.	______	/ /	☐
.9	Sight distance is acceptable for all accesses to roundabouts.	______	/ /	☐
3.10	Alignment coordination with horizontal alignment is in accordance with the appropriate AUSTROADS design guides as referenced in the AUS-SPEC specifications.	______	/ /	☐
3.11	Conflict with existing public utility services has been identified and resolved.	______	/ /	☐
3.12	Vertical road alignment setout data is clearly defined on the longitudinal sections.	______	/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

Design Check List 4   ROAD CROSS SECTIONS

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
4.1	Typical cross sections have complete dimensions.	______	/ /	☐
4.2	Typical cross sections have kerb & gutter, road safety barrier and surface drainage indicated.	______	/ /	☐
4.3	Batter slopes are indicated and batter treatment is indicated where appropriate.	______	/ /	☐
4.4	Property boundaries, service allocations and location of known existing underground services and pathway treatments are indicated.	______	/ /	☐
4.5	Sufficient cross sections are shown to define all variations and width transitions.	______	/ /	☐
4.6	Cross sections are of sufficient width to fully assess impact of road level on adjoining property.	______	/ /	☐
4.7	Stability of embankment slopes, batters and retaining walls has been verified as satisfactory.	______	/ /	☐
4.8	Cross section reference level conforms with vertical road alignment.	______	/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

Design Check List 5 ROAD AND INTERALLOTMENT DRAINAGE

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
5.1	Drawings indicate existing surface drainage.	________	/ /	☐
5.2	Hydrological data is the most current available.	________	/ /	☐
5.3	Hydrologic and hydraulic design calculations are complete and fully recorded and available for audit.	________	/ /	☐
5.4	Underground drainage and structures do not conflict with services.	________	/ /	☐
5.5	The designed drainage lines are compatible with existing incoming lines and outgoing lines.	________	/ /	☐
5.6	The length of line, type of pipe, size, class and bedding requirements are indicated for each drainage line on the schedule of drainage elements.	________	/ /	☐
5.7	Height of fill over drainage lines is within allowable limits.	________	/ /	☐
5.8	Drainage is provided for local depressions eg median areas or areas adjacent to fills.	________	/ /	☐
5.9	The effect of headwater and back-up water on private property has been assessed.	________	/ /	☐
5.10	Subsurface drainage has been provided when required and clearly located by line and level, with details provided..	________	/ /	☐
5.11	The need for batter drains has been considered for fills and cuttings.	________	/ /	☐
5.12	The height and energy level of downstream drainage has been considered.	________	/ /	☐
5.13	Drainage structures and flowpaths are located so as to ensure safe vehicular and pedestrian transit.	________	/ /	☐

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
5.14	Drainage structure number, setout, type and pipe details indicated on the drainage plans and schedule of drainage elements.		/ /	☐
5.15	Emergency flowpaths are located so as to minimise impact on private property.		/ /	☐
5.16	Road drainage has been provided in accordance with any conditions of development consent.		/ /	☐
5.17	Interallotment drains have been designed in accordance with Council's Specification and Australian Rainfall and Runoff (Edition 1987).		/ /	☐
5.18	Appropriate land stabilisation and velocity controls have been implemented to pipe systems, open channels and embankments.		/ /	☐
5.19	For allotments affected by flood controls, the floor height controls are to be compatible with road and drainage levels.		/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

Design Check List 6 SIGNS AND MARKINGS

		Check Completed By (initials)	Date	Not Applicable (tick)
6.1	Sign types, sizes, locations and support structure details are shown on the drawings in accordance with AS 1742 (All parts).	______	/ /	☐
6.2	Pavement linemarking and pavement marking type and setout is indicated on the drawings to meet the requirements of AS 1742.2.	______	/ /	☐
6.3	Signs and linemarking have been designed in accordance with any conditions of development consent.	______	/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

Design Check List 7 PAVEMENT DESIGN

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
7.1	The pavement design and surface treatment is shown clearly on the drawings and any variations are indicated on appropriate cross sections.	______	/ /	☐
7.2	The pavement design complies with Council's Pavement Design Specification.	______	/ /	☐
7.3	Pavement design is in accordance with any conditions of development consent.	______	/ /	☐
7.4	Geotechnical data is assessed as adequate and is held on the design file.	______	/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

Design Check List 8 BRIDGE/MAJOR CULVERT DESIGN

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
8.1	The design has been performed by a competent practicing Civil or Structural Engineer.		/ /	☐
8.2	Geotechnical data is assessed as adequate and is held on the design file.		/ /	☐
8.3	The type and functional dimensions of the bridges meet AUSTROADS Bridge Design Codes 1992, AS 3600, AS 1684, AS 1170, AS 4100.		/ /	☐
8.4	The type and class of all materials are indicated on the drawings.		/ /	☐
8.5	Records of all significant design calculations are available for audit.		/ /	☐
8.6	The design complies with any conditions of development consent.		/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

Design Check List 9 EROSION/AND SEDIMENTATION CONTROL PLANS

		Check Completed By *(initials)*	Date	Not Applicable *(tick)*
9.1	Both short term and long term erosion control plans have been prepared using the guidelines within Council's Design Specification D7 and Construction Specification C211.	______	/ /	☐
9.2	Erosion and sedimentation control has been designed in accordance with any conditions of development consent.	______	/ /	☐

DEPARTURES FROM COUNCIL OR STATE ROAD AUTHORITY NORMAL REQUIREMENTS OR SPECIAL FEATURES TO BE NOTED:

ANNEXURE DQS-B

EXAMPLE COMPILATION OF DRAWINGS

A. ROADWORKS PLANS

An example of the sequence of drawing sheets acceptable to Council in the compilation of a full set of Roadworks Drawings is set out as follows.

Sheet Nº	TOPIC
1	Development Consent Number Locality Sketch and Index of Sheets.
2	General Subdivision Plan with contour details and a clear indication of the extent of work.
3	Typical Road Cross Sections showing road widths, pavement (design) configuration, batter slopes, kerb and gutter types.
4.	Plan and Longitudinal Section of each road showing setout data and services.
5.	Drainage Plan and Schedule of Drainage Elements including on-site detention design as required (Pipe lines and structures).
6.	Drainage Profiles.
7.	Drainage Structure Details.
8.	Road Cross Sections.
9.	Intersection Layout Details.
10.	Pavement Marking and Signposting.
11.	Erosion and Sedimentation Control Plans (short term and long term treatment).
12.	Structure Details – Bridges, Retaining Walls, etc.
13.	Utility Services affecting the development.

NOTE

1. Any one set of Roadworks Plans may require more than 1 sheet for each of the topics listed and may also require supplementary sheets for site specific details.
2. Scales are required to be nominated on all drawings and north points shown on all plan views.

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D1

GEOMETRIC ROAD DESIGN

Amendment Record for this Specification Part

This Specification is 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
EXAMPLE 1	*Provision for acceptance of nonconformance with deduction in Payment*	*XYZ.00*	*AP*	*KP*	*2/6/97*

CONTENTS

DEVELOPMENT DESIGN SPECIFICATION D1
GEOMETRIC ROAD DESIGN

GENERAL

D1.01 SCOPE

Subdivision Roadworks

1. This section sets out the specifications developed specifically for the design of subdivision roadworks using principles of street design to ensure safety and improved amenity and to reduce pedestrian/vehicular conflicts.

Acceptable Vehicle Speed

2. A fundamental requirement of the design process is for designers to determine the vehicle speed which is deemed acceptable for a particular subdivision or section of road. The concept of designing to regulatory street speeds is contrary to the current principles of subdivision road design.

Integrated Design Principles

3. All relevant design principles must be integrated in the development of the road network. A careful balance is required between maximising amenity, safety and convenience considerations and those related to the drivers' perception of driving practice.

4. The words "street" and "road" are interchangeable throughout all parts of this Specification.

Road Reserve Component Definitions

5. For the purpose of this Specification the definition of terms used to define the components of the road reserve shall be in accordance with AS 1348.1 and AMCORD.

AS 1348.1 terms:

Carriageway	-	That portion of the road or bridge devoted particularly to the use of vehicles, inclusive of shoulders and auxiliary lanes.
Footpath	-	The paved section of a pathway (verge).
Pathway	-	A public way reserved for the movement of pedestrians and of manually propelled vehicles (AMCORD verge).
Pavement	-	That portion of a carriageway placed above the subgrade for the support of, and to form a running surface for, vehicular traffic.
Shoulder	-	The portion of the carriageway beyond the traffic lanes and contiguous and flush with the surface of the pavement.

AMCORD term:

Verge:	-	That part of the road reserve between the carriageway and the road reserve boundary. It may accommodate public utilities, footpaths, stormwater flows, street lighting poles and plantings.

D1.02 AIMS

1. The provision of a road system within a subdivision is to be designed so as to achieve the following aims:

- Provide convenient and safe access to all allotments for pedestrians, vehicles and cyclists.

- Provide safe, logical and hierarchical transport linkages with existing street system.
- Provide appropriate access for buses, emergency and service vehicles.
- Provide for a quality product that minimises maintenance costs and overall life cycle costs.
- Provide a convenient way for public utilities.
- Provide an opportunity for street landscaping.
- Provide convenient parking for visitors.
- Have appropriate regard for the climate, geology, hydrology and topography of the area.

D1.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

All Specifications for Design and Construction.

(b) Australian Standards

AS 1348.1	-	Road and traffic engineering – Glossary of terms, Road design and construction.
AS 2890.1	-	Parking facilities: Off-street car parking.
SAA HB69.14	-	Guide to traffic engineering practice - Bicycles.
AS/NZS 3845	-	Road safety barrier systems.

(c) State Authorities

Roads and Traffic Authority NSW - Road Design Guide.
Department of Housing - Road Manual, 1987.
Department of Urban Affairs (formerly Environment) and Planning - Technical Bulletin 12 (1981), Residential Road Widths.

(d) Other

AUSTROADS

RURAL ROAD DESIGN, Guide to the Geometric Design of Rural Roads.
Guide Policy for the Geometric Design of Major Urban Roads.
Guide to Traffic Engineering Practice:

PART 5,	Intersections at Grade
PART 6,	Roundabouts
PART 10,	Local Area Traffic Management
PART 13,	Pedestrians
PART 14,	Bicycles

The Institute of Municipal Engineering Australia, Qld Division - 1993: Design Guidelines for Subdivisional Streetworks.

ARRB Special Report No. 33, L E Comerford: A Review of Subdivision Road Design Criteria.

Commonwealth Department of Housing and Regional Development – 1995: Australian Model Code for Residential Development. (AMCORD). A National Resource Document

for Residential Development.

Stapleton, C 1984: Streets Where We Live – A Manual for the Design of Safer Residential Estates.

Stapleton, C 1988, Dept of Transport South Australia: Planning & Road Design for New Residential Subdivisions.

Brindle, R 1988, ARRB: Planning & Design of the Local Distributor.

Colman, J 1978, ARRB: Streets for Living.

Pak-Poy Kneebone – 1989: Research Study into Road Characteristics for Residential Development.

D1.04 CONSULTATION

1. Designers are encouraged to consult with the Council and other relevant authorities prior to or during the preparation of design. Designers should in addition to requirements of this Specification ascertain specific requirements of these authorities as they relate to the designs in hand. ***Council, Other Authorities***

2. Public consultation on designs shall be provided where such action is required by Council's current policy. ***Public Consultation***

3. The Designer shall obtain service plans from all relevant public utility authorities and organisations whose services may exist within the area of the proposed development. These services are to be plotted on the relevant drawings including the plan and cross-sectional views. ***Public Utilities***

D1.05 PLANNING CONCEPTS

1. In new areas (as distinct from established areas with a pre-existing road pattern) each class of route should reflect its role in the road hierarchy by its visual appearance and related physical design standards. Routes should differ in alignment and design standard according to the volume of traffic they are intended to carry, the desirable traffic speed, and other factors. ***Road Hierarchy***

2. The road pattern and width must be in conformity with that shown in LEP2000. ***Conformance with LEP2000***

3. The road network for residential developments should have clear legibility. ***Legibility***

4. The road network should reinforce legibility by providing sufficient differentiation between the road functions. ***Differentiation***

5. Distinct landmark features such as watercourses, mature vegetation or ridge lines should be emphasised within the structural layout so as to enhance the legibility. ***Landmark Features***

6. Whilst legibility can be enhanced by introduced physical features such as pavement and lighting details, the road network should by its inherent design and functional distinction provide the necessary legibility. ***Introduced Features***

7. The maximum number of turning movements at intersections or junctions that a driver should be required to undertake to reach a particular address within the development should be minimised. ***Intersection Turning Movements***

D1.06 DRAWING REQUIREMENTS

(a) Reduction Ratios

1. All plans for urban design are to be reduced to 1:500.

Longitudinal Sections	1:500 H 1:100 V
Cross Sections	1:100 Natural

(b) Drawing Sheets

1. Separate sheets should be provided for

   a. Cover sheets
   b. Plan views
   c. Longitudinal sections
   d. Cross sections
   e. Structural details
   f. Standard drawings

(c) Drawing Presentation

Clear and Legible, Permanent Record, Legal Document

1. Drawings are to be presented on A1 sheets unless otherwise authorised. They are to be clear and legible with consistent lettering and style. Council has the authority to refuse drawings that do not meet these drafting requirements. Drawings copied from other works will not be accepted. All drawings shall be clearly referenced with notations and tables as appropriate. The Designer should always be mindful that apart from being a permanent record and legal document, drawings should be easily read and understood by the Contractor, and others involved in the construction of the Works. Terminology should be kept in 'plain English' where possible. All public Utility Authority Services shall be shown on the Drawings as they relate to the development work and to assist with the assessment of the Design.

Compliance

2. The scope and sequence of drawing sheets shall comply with the example provided in Annexure DQS-B of the Specification for QUALITY ASSURANCE REQUIREMENTS FOR DESIGN.

(d) Certification

Design Consultant

1. Drawings shall bear the signature of the Design Engineer/Surveyor and shall, where required by the Council, be certified as complying with the appropriate design specifications (D1 to D12). The certificate shall be in the format detailed in Annexure DQS-A of the Specification for QUALITY ASSURANCE REQUIREMENTS FOR DESIGN.

URBAN DESIGN CRITERIA

D1.07 ROAD HIERARCHY

Functionality

1. A hierarchical road network is essential to maximise road safety, residential amenity and legibility. Each class of road in the network serves a distinct set of functions and is designed accordingly. The design should convey to motorists the predominant function of the road. A typical hierarchy is shown on Figure D1.1.

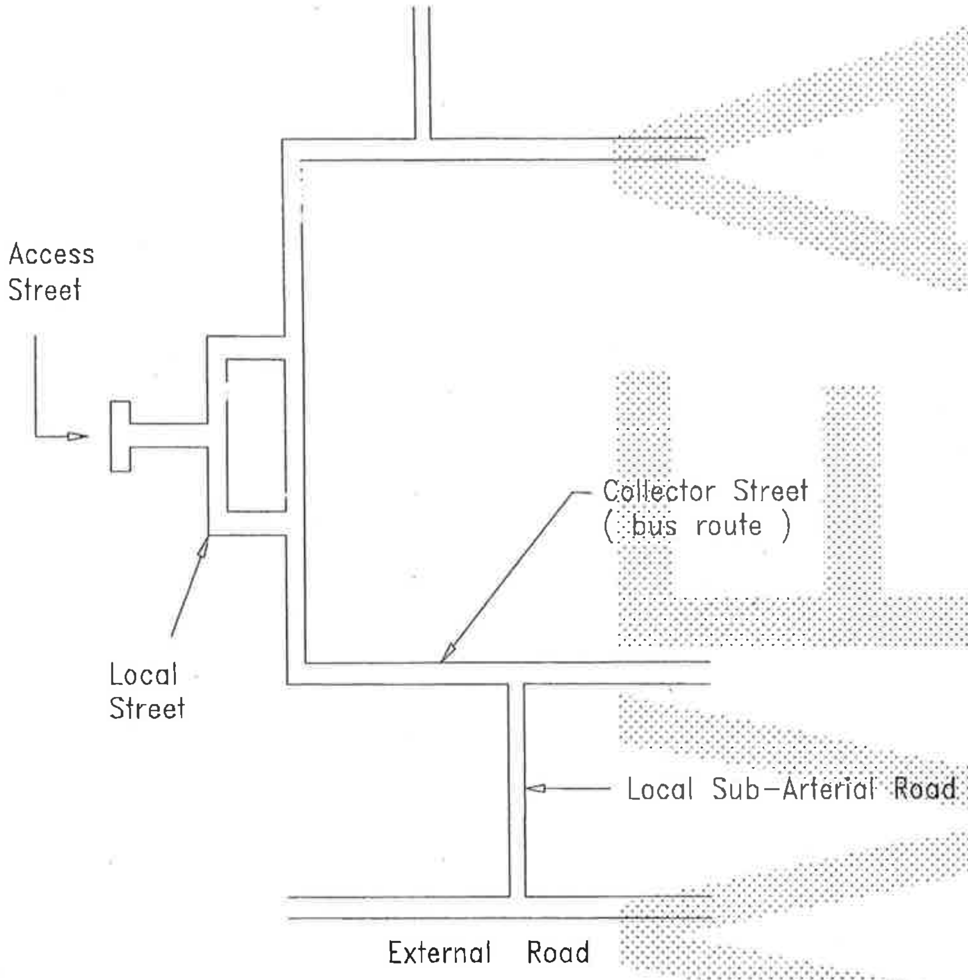


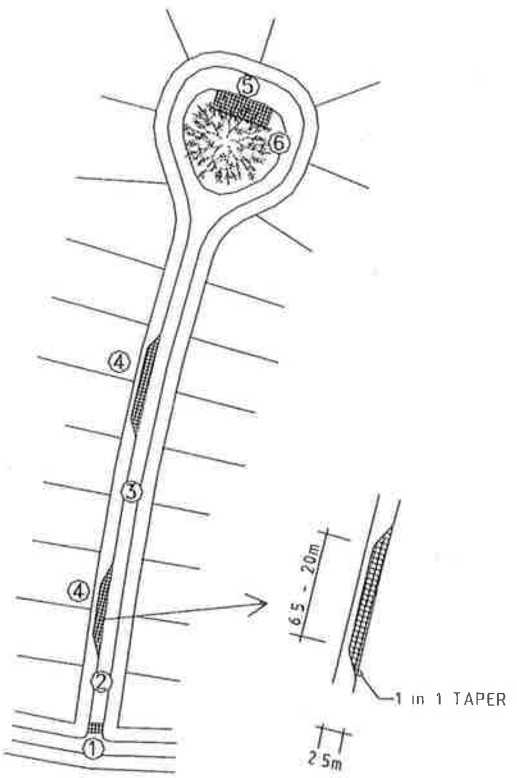
Figure D1.1 - Typical Road Hierarchy

2. Four distinct levels of roads are:

   Access Street
   Local Street
   Collector Street
   Sub-Arterial Road.

Access Street

3. The lowest order road (access street) having as its primary function, residential space - amenity features which facilitate pedestrian and cycle movements, and where vehicular traffic is subservient in terms of speed and volume, to those elements of space, amenity, pedestrians and cyclists. The features of a typical access street are shown in Figure D1.2.

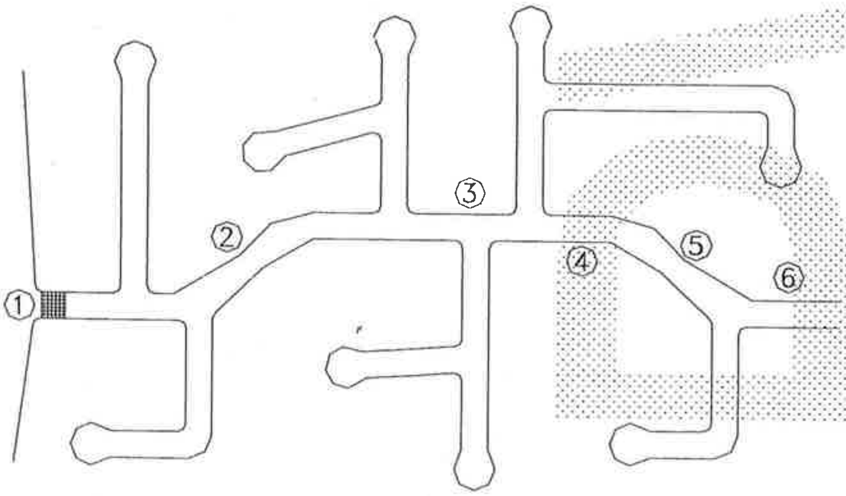


1. Entry threshold to indicate lower speed environment.
2. Brick paving or coloured surface to indicate shared way.
3. 5m – 6m two way traffic carriageway width.
4. Visitor parking areas which can also be used as passing bays for streets longer than 100m (1 space per 3 dwellings).
5. Right angled visitor parking.
6. Landscaped open space.

Figure D1.2 - Access Street

Local Street

4. The next level road (local street) as a local residential street should provide a balance between the status of that street in terms of its access and residential amenity functions. Resident safety and amenity are dominant but to a lesser degree than access streets. A typical local street is illustrated in Figure D1.3.



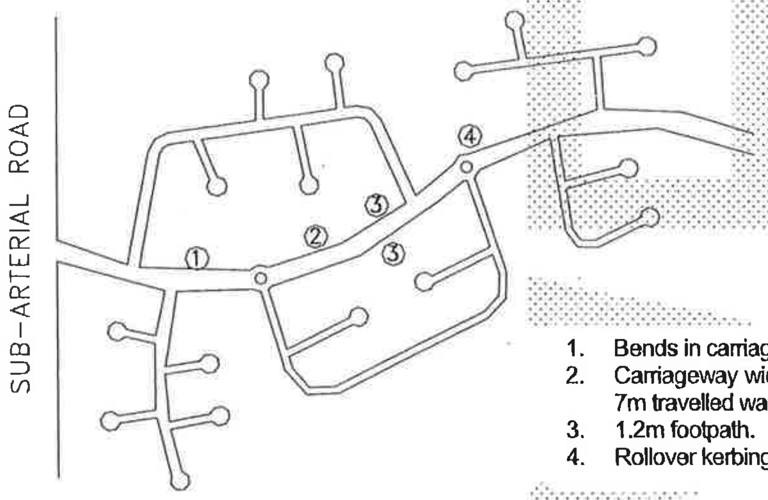
1. Brick-paved entry threshold signifies entry to lower speed environment.
2. Bends in carriageway control speed.
3. Short sections of straight carriageway, street furniture, landscaping – trees etc, control speed.
4. Carriageway width 7m.
5. 12m footpath on one side.

Figure D1.3 - Local Street

Collector Street

The second highest order road (collector street) has a residential function but .lso carries higher volumes of traffic collected from lower order streets. A reasonable level of residential amenity and safety is maintained by restricting traffic volumes and speeds, however, amenity and resident safety do not have the same priority as access or local streets. A typical collector street is shown in Figure D1.4. In certain circumstances a street network should include strategic connectivity to reduce traffic travelling long distances unnecessarily.

- Maximum volume 3000 VPD.
- Maximum speed 50km/h.
- Carriageway shared by vehicles and cyclists.
- As a cul-de-sac arrangement services approximately 16 Ha.



1. Bends in carriageway control speed.
2. Carriageway width 11-13m or on bus routes 7m travelled way with indented parking.
3. 1.2m footpath.
4. Rollover kerbing.

Figure D1.4 - Collector Street

Sub-Arterial Road

6. The highest order road (sub-arterial road) within a residential development should have as its main function the convenient and safe distribution of traffic generated by the development. Direct access should be provided for single dwelling allotments. Access can also be provided to multi-unit developments and non-residential land uses. The sub-arterial should serve only the development and may attract through traffic. Figure D1.5 shows the layout of a sub-arterial road.

Appropriate network design and number of access points can limit sub-arterial to short lengths.

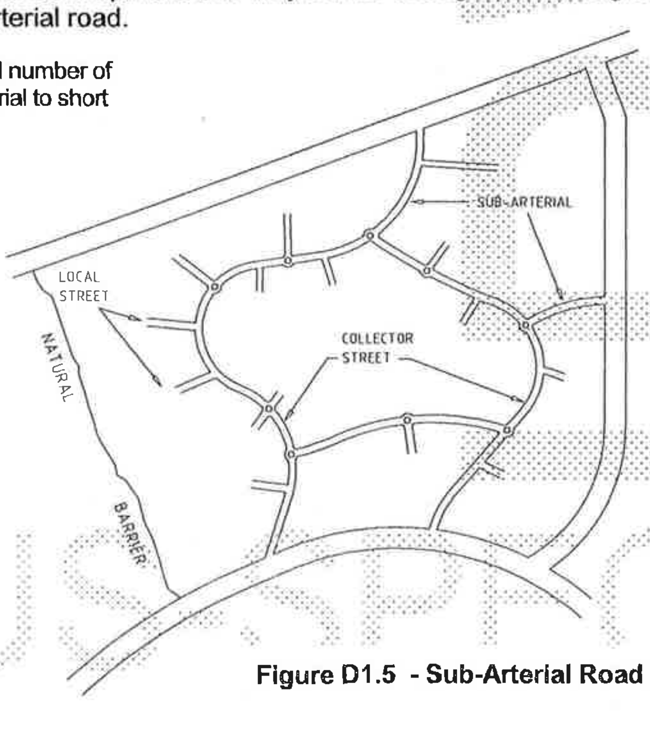


Figure D1.5 - Sub-Arterial Road

D1.08 ROAD NETWORK

1. The design features of each type of road convey to the driver its primary functions and encourage appropriate driver behaviour (refer Figure D1.2 to D1.5).

2. Traffic volumes and speeds on any road should be compatible with the residential functions of that road. ***Compatibility***

3. The maximum length of an access street should ensure its status as a residential place is retained, where the traffic, in terms of speed and volume will enable the integration of pedestrian, bicycle and vehicular movements. This length will also ensure that residential convenience is not unduly impaired as a result of speed restraints. ***Access Street***

4. The length of sub-arterial within a development should be minimised. ***Local Sub-Arterial***

5. The time required for drivers to travel on all streets within the development should be minimised, but not at the expense of safety or amenity. Motorists wishing to travel longer distances at a greater speed should be encouraged to use major roads around the development site. ***Travel Time***

6. Where access streets form part of a pedestrian or bicycle network, access links should provide suitable connectivity with adjoining access streets or open space systems so as to ensure such pedestrian and bicycle network are functionally efficient. ***Pedestrian or Bicycle Network***

7. The road network should ensure that no road links with another road which is more than two levels higher or lower in the hierarchy. In exceptional circumstances roads may link with others that are more than two levels apart, however, no access street or local street should have access to an access-controlled arterial road. ***Road Links***

8. Connections between internal roads should be T-junctions or controlled by roundabouts. ***Internal Road Connections***

9. The road layout should conform to the requirements of the external road network and satisfy the transport provisions of an outline development plan. ***Transport Provisions***

10. The external road network should be designed and located to provide routes which are more convenient for potential through traffic within the network. Major roads should be provided at intervals of no more than 1.5 km and should be complete and of adequate capacity to accommodate through network movements. The internal road system should not provide through routes that are more convenient than the external road network. ***External Road Network***

D1.09 DESIGN SPEED

1. Design speed is generally used as the basic parameter in the specification of design standards, determining the minimum design value for other elements. The NSW Roads and Traffic Authority bases its current design standards on a travel speed rather than a design speed. Travel speed identifies a speed/horizontal radius relationship. This approach is intended for roads of a minimum travel speed of 60 km/h. The maximum speed limit in NSW for built-up areas is 60 km/h and this should be used in calculating design values which depend on speed, (eg collector and sub-arterial roads) however, in difficult topography, the design speed may be reduced. Vehicular speeds are also limited by road intersections as well as changes in horizontal and vertical alignment. ***RTA Guidelines***

2. Adoption of a low design speed discourages speeding, however, where vertical or horizontal curves of low design speed are located in otherwise high speed sections (tangents) the result is a potentially dangerous section of road. It should be recognised that in low standard roads, operating speeds will tend to be in excess of arbitrary speed ***Low Speeds*** ***Hazardous***

standards. Attention should be given to ensuring that potentially hazardous features are visible to the driver and adopting traffic engineering measures which will help a driver avoid errors of judgement. ***Features***

3. Generally the following design speeds should be adopted:

Access Street	25 km/h
Local Street	40 km/h
Collector Street	60 km/h
Sub-Arterial Road	60/80 km/h

4. The need for road safety barriers shall be assessed and designed in accordance with AS/NZS 3845. ***Road Safety Barriers***

D1.10 LONGITUDINAL GRADIENT

1. A general minimum gradient of 0.5 per cent should be adopted. In very flat conditions it may be reduced to 0.3 per cent. Where underground drainage with gully pits or other special works are used it is preferable to allow near level grades rather than reverting to the unsatisfactory device of introducing artificial undulations. Variable crossfall may be necessary to produce the required grade in the gutter. Maximum recommended grades are shown in Table D1.1. ***Flat Terrain***

Table D1.1

	Local Access	Collector	Sub-Arterial	Rural
Desirable maximum percentage*	12	10	8	10
Absolute maximum percentage*	16	12	10	12

* maximum length 150 m on straight alignment.

2. Longitudinal grade of the minor street on the approach to an intersection should not exceed 4 per cent, the actual gradient being dependent on the type of terrain. Design of the road alignment and the grades used are interrelated. A steep grade on a minor side street is undesirable if vehicles have to stand waiting for traffic in the major road. ***Intersections***

3. Turning circles in cul-de-sacs on steep grades should have grades less than 5 per cent. ***Cul-de-Sacs***

D1.11 HORIZONTAL CURVES AND TANGENT LENGTHS

1. The horizontal alignment of a road is normally in a series of tangents (straights) and curves which may be connected by transition curves. The choice of the horizontal alignment is normally determined from the design speeds for a particular street within the road hierarchy as described in Clause D1.09. Designers should ensure that, for a given design speed, the minimum radius of curvature utilised is such that drivers can safely negotiate the curve. Curves which progressively tighten produce an uncomfortable sense of disorientation and alarm. Sudden reverse curves which drivers cannot anticipate also have a potential to cause similar conditions. ***Speed/Radius Relation***

2. Where speed restriction is provided by curves in the street alignment the relationship between the radius of the curve and the desired vehicle speed is given in Table D1.2(a). ***Speed Restriction***

3. To determine appropriate lengths for tangents between speed restrictions, which may be curves, narrow sections or other obstructions, Table D1.2(b) is recommended. *Tangent Length*

4. Sight distance on curves is determined by formula, values of which are tabulated in RTA Road Design Guide.

Table D1.2(a)
Speed/Radius Relationship

Desired Vehicle Speed (km/h)	Curve Radii (m) on Road Centreline	
	Curvilinear Alignment (no tangents)	Isolated Curve Alignment (with tangent sections)
20	15	10
25	20	15
30	30	20
35	50	30
40	90	40
45	105	50
50	120	60
55	140	70
60	160	80

Table D1.2(b)
Speed/Tangent Length Relationship

Desired Vehicle Speed in Curve (km/h)	Maximum Advisable Tangent Length (m) between Curves or Restrictions Appropriate to a Selected Design Speed. DESIGN SPEED						
	25	30	35	40	45	50	60
20 or less	40	75	100	120	140	155	180
25	-	45	75	100	120	140	165
30	-	-	45	80	100	120	150
35	-	-	-	50	80	100	135
40	-	-	-	-	55	80	120
45	-	-	-	-	-	60	105

NOTE:
Tables D1.2(a) and D1.2(b) are derived from AMCORD.

D1.12 VERTICAL CURVES

1. Vertical curves will be simple parabolas and should be used on all changes of grade exceeding 1 per cent. The desirable minimum design speed is 60 km/h. The length of the crest vertical curve for stopping sight distance should conform with RTA Road Design Guide. These standards are based on 1.5 second's reaction time which provides a reasonable safety margin for urban conditions, where drivers' reaction time is usually considered to be lower than in rural conditions. *Criteria*

2. For adequate riding comfort, lengths of sag vertical curves should conform with the RTA Road Design Guide. As residential roads are usually lit at night, the criterion for *Riding Comfort*

designing sag vertical curves is a vertical acceleration of 0.05g for desirable riding comfort, and 0.10g for minimum riding comfort. The minimum length for sag vertical curves are shown in Table D1.3.

Table D1.3 Minimum Length of Sag Vertical Curves

	Local access (m)	Collector (m)	Local Sub-Arterial (m)
Minimum vertical curve	25	35	50
Absolute minimum vertical curve (to be applied at road junctions only)	6	12	20

3. Junctions of roads should be located at a safe distance from a crest, determined by visibility from the side road. Location of a side road at a crest should only occur if there is no suitable alternative. ***Side Road Junctions***

4. Drainage poses a practical limit to the length of sag curves and a maximum length (in metres) of 15 times the algebraic sum of the intersecting vertical grades (expressed as a percentage) has been suggested. This is to avoid water ponding in excessively flat sections of kerb and gutter. A minimum grade of 0.5 per cent should be maintained in the kerb and gutter. This may require some warping of road cross sections at sag points. ***Sag Curves***

5. The three dimensional coordination of the horizontal and vertical alignment of a road should be aimed at improved traffic safety and aesthetics. Economic considerations often require a compromise with aesthetic considerations. The following principles should be applied: ***Horizontal and Vertical Alignment Coordination***

- The design speed of the road in both horizontal and vertical planes should be of the same order.
- Combined horizontal and vertical stopping sight distance and minimum sight distance should be considered three dimensionally.
- Sharp horizontal curves should not be introduced at or near the crest of a vertical curve. A horizontal curve should leave the vertical curve and be longer than the vertical curve.
- A short vertical curve on a long horizontal curve or a short tangent in the gradeline between sag curves may adversely affect the road's symmetry and appearance.

D1.13 SUPERELEVATION

1. The use of superelevation in association with horizontal curves is an essential aspect of geometric design of roads with design speeds in excess of 60 km/h. Local access roads which are designed for speeds of 40 km/h or less and with curves of 60m radius or less generally have the pavement crowned on a curve instead of superelevation. Design standards for such curves have little meaning as drivers usually cut the corners and rely on friction to hold them on a curved path. As the radius of the curve falls, friction becomes more important than superelevation. ***Low Design Speed, Crowned Pavement***

2. The maximum superelevation for urban roads of higher design speeds should be 6 per cent. Any increase in the longitudinal grade leading to excessive crossfall at intersections should be considered with caution. While it is desirable to superelevate all curves, negative crossfall should be limited to 3 per cent. ***High Design Speed***

3. In general, curve radii larger than the minimum and superelevation rates less than the maximum should be used where possible. The minimum radius of curves is determined by the design speed, the minimum superelevation (or maximum adverse crossfall) at any point on the circular portion of the curve, and the maximum coefficient of side friction which allows safe lane changing. This is 0.15 where there is positive superelevation and 0.12 where there is adverse crossfall. The coefficient of side friction depends upon the type and condition of tyres, the pavement, and on speed. ***Criteria***

4. Recommendations for minimum curve radii (in metres) on major urban roads under varying superelevation/crossfall are shown in Table D1.4.

Table D1.4 Minimum Radius of Curvature

	Design Speed km/h	60	70	80
Minimum Superelevation (%)	5	145	195	255
	4	150	205	265
	3	160	215	280
	2	170	230	300
	1	180	245	315
Maximum Crossfall (%)	0	190	260	340
	1	260	355	460
	2	285	390	505
	3	315	430	560

(Source: NAASRA (Now AUSTROADS), Guide policy for the geometric design of major urban roads.)

5. Plan transitions are desirable on superelevated curves for appearance and to provide a convenient length in which to apply the superelevation. On urban roads, superelevation may be conveniently applied to the road cross section by shifting the crown to 2m from the outer kerb. The axis of rotation of the cross section for urban roads will normally be the kerb grading on either side which best enables access to adjacent properties and intersections. On the outside of superelevation, or where the longitudinal grade of the gutter is less than 0.5 per cent, a crossfall of 63mm in a 450mm wide gutter may be adopted. ***Transitions, Offset Crowns***

D1.14 ROAD RESERVE CHARACTERISTICS

1. The cross section of the road reserve must provide for all functions that the road is expected to fulfil, including the safe and efficient movement of all users, provision for parked vehicles, acting as a buffer from traffic nuisance for residents, the provision of public utilities and streetscaping. Table D1.5 details characteristics of the road reserve. ***Cross Section Provisions***

Table D.1.5 Characteristics of Roads in Residential Subdivision Road Networks

Road Type	Maximum Traffic Volume (vpd) [(1)]	Maximum Speed [(2)] (km/h)	Carriageway Width (m)[(3)]		Parking Provisions Within Road Reserve	Kerbing [(4)]	Footpath Requirement	Bicycle path Requirement	Verge Width (each side)
			Minimum	Maximum					
Access Street	300	25	Single Lane: [(5)] 3.5	3.7	1 verge space per 2 allotments[(5)]	Barrier	No	No	See Note[(6)]
			Two Lane:5.0	6.0	Carriageway	As Above	No	No	See Note [(6)]
Local Street	2,000	40	78.0 (up to 1,000 vpd)	7.5	Carriageway	As Above	1. 82m wide [(7)] footpath(s)	No	Minimum 4.0m
			8.0	9.0	Carriageway	As Above	As Above	No	Minimum 4.0m
Collector Street	3,000 (with access to residential allotments)	50 [(8)]	7.0 On bus routes 11-13m [(10)].	9.0	Carriageway or Indented parking.	Barrier [(9)]	1.2m wide footpath both sides.	No 1.0m gap in pro-tuberances required for cyclists [(10)]	Minimum 4.0m[(14)]
Sub-Arterial Road	6,000 (no access to single dwelling residential allotments	60 [(11)]	7.0 On bus routes 11-13m [(10)].	9.0	Parking not permitted on carriageway [(12)]	Barrier	If required 1.2m wide footpath, and/or 2.0m bicycle path one side only[(13)]	If required 2.0m bicycle path one side only in the verge or two 1.5m wide bicycle lanes marked on carriageway [(13)].	Minimum 4.5m.

Derived from AMCORD

NOTES:

1. For single dwelling allotments apply traffic generation rate of 10 vehicles per day (vpd)/allotment (equivalent to approximately 0.85 vehicle per hour (vph) in the peak hour) unless a lower rate can be demonstrated. Lower rates can be applied to multi-unit dwellings based on locally derived rates.

2. See Clauses D1.09 and D1.11 on designing for specific operating speeds.

3. Widening required at bends to allow for wider vehicle paths (using AUSTROADS Turning Templates).

4. Where kerbing is not required a flush pavement edge treatment can be used. Maximum carriageway widths required if barrier kerbing used.

5. Requires:
   (i) Provision for widening to 5.0m if necessary in the future.
   (ii) Verge parking as noted with scope for additional spaces.

6. Minimum width required to provide for pedestrians, services, drainage, landscape and preservation of existing trees. Add additional width on one side for future widening of carriageway to 5.0m if required. For two lane carriageway design, no provision for widening required.

7. A minimum of one footpath on one side of the street to be constructed initially with provision to construct a second footpath if required by residents in the future.

8. Reduced speeds are required at designated pedestrian/bicycle crossing. A speed of 20 km/h is desirable, achieved by the road design principles outlined in this Specification.

9. Barrier kerbing may be used if required for drainage purposes without reducing the carriageway width.

10. On bus routes, 7.0m travelled way with 2.0m wide indented parking and bus bays defined by kerbed protuberances. Where bicycle way can be anticipated, a bicycle lane is required along the kerb.

11. Speed on local sub-arterial road not to exceed legal limit.

12. If required, to be provided in parking areas which can be exited in a forward direction.

13. Required only if part of a pedestrian/bicycle network.

14. Provide adequate road reserve width for widening of carriageway for future bus route if required.

* Many elements are inter-related. Therefore variations from any particular recommended characteristic may require changes to others.

Operational Aspects

2. The carriageway width must allow vehicles to proceed safely at the operating speed intended for that level of road in the network and with only minor delays in the peak period. This must take into consideration the restrictions caused by parked vehicles where it is intended or likely that this will occur on the carriageway. Vehicles include trucks, emergency vehicles and, on some roads, buses. (Refer to Clause D1.21 for bus routes.)

The safety of pedestrians and cyclists where it is intended they use the carriageway must also be assured by providing sufficient width. ***Pedestrians, Cyclists***

4. The carriageway width should also provide for unobstructed access to individual allotments. Drivers should be able to comfortably enter or reverse from an allotment in a single movement, taking into consideration the possibility of a vehicle being parked on the carriageway opposite the driveway. ***Access to Allotments***

5. The design of the carriageway should discourage drivers from travelling above the intended speed by reflecting the functions of the road in the network. In particular the width and horizontal and vertical alignment should not be conducive to excessive speeds. ***Discourage Speeding***

6. Appropriate verge width should be provided to enable the safe location, construction and maintenance of required footpaths and public utility services (above or below ground) and to accommodate the desired level of streetscaping. Wherever possible services should be located in common trenches. ***Verge Width***

7. The verge when considered in conjunction with the horizontal alignment and permitted fence and property frontage treatments should provide appropriate sight distances, taking into account expected speeds and pedestrian and cyclist movements. ***Sight Distance Across Verge***

8. Stopping sight distances and junction or intersection sight distances, provided by the verge, should be based on the intended speeds for each road type.

D1.15 CROSSFALL

1. Desirably, roads should be crowned in the centre. Typical pavement crossfalls on straight roads are:

Pavement Type	*Crossfall*
Bituminous seal coat	3 per cent
Bituminous concrete pavement	2.5 per cent
Cement concrete pavement	2 per cent

(Source: NAASRA (Now AUSTROADS), Guide policy for geometric design of major urban roads.)

2. There are many factors affecting levels in urban areas which force departures from these crossfalls. Differences in level between road alignments can be taken up by offsetting crown lines or adopting one way crossfalls. Sustained crossfalls should not exceed 4 per cent, although up to 6 per cent may be used where unavoidable. The rate of change of crossfall should not exceed: 6 per cent per 30m for through traffic; 8 per cent per 30m for free flowing turning movements; or 12 per cent per 30m for turning movements for which all vehicles are required to stop. ***Offset Crown Lines*** ***Rate of Change***

3. The crossfall on a collector or sub-arterial road should take precedence over the grade in minor side streets. Standard practice is to maintain the crossfall on the major road and adjust the minor side street levels to suit. The crossfall in side streets should be warped quickly either to a crown or a uniform crossfall depending on the configuration of the side street. A rate of change of grade of two per cent in the kerb line of the side street relative to the centre line grading is a reasonable level. ***Precedence***

D1.16 VERGES AND PROPERTY ACCESS

1. A suitable design for the verge will depend on utility services, the width of footpath, access to adjoining properties, likely pedestrian usage and preservation of trees. Low level footpaths are undesirable but may be used if normal crossfalls are impracticable. Crossfalls in footpath paving should not exceed 2.5 per cent, in accordance with AUSTROADS Guide to Traffic Engineering Practice, Part 13, Pedestrians. Longitudinal grade usually parallels that of the road and this may be steeper than 5 per cent. ***Criteria***

2. Differences in level across the road between road reserve boundaries may be accommodated by: ***Options***

- Cutting at the boundary on the high side and providing the verge at normal level and crossfall.
- Battering at the boundary over half the verge width with the half against the kerb constructed at standard crossfall.
- A uniform crossfall across the carriageway.
- The lower verge being depressed below the gutter level.

3. The above measures can be used singularly or combined. The verge formation should extend with a 0.5m berm beyond the road reserve boundary.

4. The Designer shall design a vehicular driveway centreline profile for the property access and check this design using critical car templates, available from Council, to ensure that vehicles can use the driveway satisfactorily. ***Driveway Profile***

D1.17 INTERSECTIONS

1. The design of intersections or junctions should allow all movements to occur safely without undue delay. Projected traffic volumes should be used in designing all intersections or junctions on sub-arterial roads. ***Traffic Volumes***

2. Intersection design for the junction of subdivision roads with existing state urban roads and national highways should generally be in accordance with the publication AUSTROADS Guide to Traffic Engineering Practice, PART 5, Intersections at Grade. ***State Roads, National Highways***

3. Intersections with state roads or national highways are to be designed, approved and constructed in accordance with the requirements of the State Road Authority and Council. ***Approval of State Road Authority***

4. Where major intersections are required to serve a development complete reconstruction of the existing road pavements will be necessary where the speed environment and irregularity of the existing road pavement may endanger the safety of traffic in the locality. ***Existing Road Pavement***

5. Intersections should be generally located in such a way that: ***Criteria***

- The streets intersect preferably at right-angles and not less than 70°.
- The landform allows clear sight distance on each of the approach legs of the intersection.
- The minor street intersects the convex side of the major street.
- The vertical grade lines at the intersection do not impose undue driving

difficulties.

- The vertical grade lines at the intersection will allow for any direct surface drainage.
- Two minor side streets intersecting a major street in a staggered pattern should have a minimum centreline spacing of 40m where a left turn.
- Right turn manoeuvre between the staggered streets is likely to occur frequently.

6. Adequate stopping and sight distances are to be provided for horizontal and vertical curves at all intersections. ***Sight Distance***

7. Where required, appropriate provision should be made for vehicles to park safely. ***Parking***

8. The drainage function of the carriageway and/or road reserve must be satisfied by the road reserve cross-section profile. ***Drainage***

9. All vehicle turning movements are accommodated utilising AUSTROADS Design Vehicles and Turning Templates, as follows: ***Turning Movements***

- For intersection turning movements involving sub-arterial roads, the "design semi-trailer" with turning path radius 15.0m.
- For intersection turning movements involving local streets or collector streets, but not sub-arterial roads, the "design single unit" bus with turning path radius 13m.
- For intersection turning movements on access streets but not involving sub-arterial roads, collector streets or local streets, the garbage collection vehicle used by the local authority.
- For turning movements at the head of cul-de-sac access streets sufficient area is provided for the "design single unit" truck to make a three-point turn or, where the length of the cul-de-sac is less than 60m for the "design car" to make a three-point turn. Where driveway entrances are to be used for turning movements, the required area is to be designed and constructed to withstand the relevant loads.

10. Turning radii at intersections or driveways on sub-arterial road accommodate the intended movements without allowing desired speeds to be exceeded. ***Turning Radii***

11. On bus routes 3-centred curves with radii 7.0m, 10.0m, 7.0m are used at junctions and intersections. ***Bus Routes***

D1.18 ROUNDABOUTS

1. Roundabouts are to be approved by the Council and the Roads Traffic Authority. ***Approval***

2. Roundabouts should generally be designed in accordance with the requirements of the publication AUSTROADS Guide to Traffic Engineering Practice - PART 6 Roundabouts. Designs adopting alternative criteria will be considered on their merits. Roundabout design should generally comply with the following: ***Criteria***

- entry width to provide adequate capacity
- adequate circulation width, compatible with the entry widths and design vehicles eg. buses, trucks, cars.

- central islands of diameter sufficient only to give drivers guidance on the manoeuvres expected
- deflection of the traffic to the left on entry to promote gyratory movement
- adequate deflection of crossing movements to ensure low traffic speeds
- a simple, clear and conspicuous layout
- design to ensure that the speed of all vehicles approaching the intersection will be less than 50 km/h.

D1.19 TRAFFIC CALMING

1. Traffic calming devices are to be approved by the Council. ***Approval***

2. Calming devices such as thresholds, slowpoints, speed humps, chicanes and splitter islands should be designed in accordance with the requirements of the publication AUSTROADS Guide to Traffic Engineering Practice - PART 10, Local Area Traffic Management, (LATM). Devices designs should generally comply with the following: ***Criteria***

(a) Streetscape

- reduce the linearity of the street by segmentation
- avoid continuous long straight lines (eg. kerb lines)
- enhance existing landscape character
- maximise continuity between existing and new landscape areas

(b) Location of Devices/Changes

- devices other than at intersections should be located to be consistent with streetscape requirements
- existing street lighting, drainage pits, driveways, and services may decide the exact location of devices
- slowing devices are optimally located at spacings of 100-150m.

(c) Design Vehicles

- emergency vehicles must be able to reach all residences and properties
- local streets with a 'feeding' function between arterial roads and minor local streets might be designed for a AUSTROADS Design Single Unit Truck/Bus
- where bus routes are involved, buses should be able to pass without mounting kerbs and with minimised discomfort to passengers
- in newly developing areas where street systems are being developed in line with LATM principles, building construction traffic must be provided for

(d) Control of Vehicle Speeds

- maximum vehicle speeds can only be reduced by deviation of the travelled path. Pavement narrowings have only minor effects on average speeds, and usually little or no effect on maximum speeds

- speed reduction can be achieved using devices which shift vehicle paths laterally (slow points, roundabouts, corners) or vertically (humps, platform intersections, platform pedestrian/school/bicycle crossings)

- speed reduction can be helped by creating a visual environment conducive to lower speeds. This can be achieved by 'segmenting' streets into relatively short lengths (less than 300m), using appropriate devices, streetscapes, or street alignment to create short sight lines

(e) Visibility Requirements (sight distance)

- adequate critical sight distances should be provided such that evasive action may be taken by either party in a potential conflict situation. Sight distances should relate to likely operating speeds

- sight distance to be considered include those of and for pedestrians and cyclists, as well as for drivers

- night time visibility of street features must be adequate. Speed control devices particularly should be located near existing street lighting if practicable, and all street features/furniture should be delineated for night time operation. Additional street lighting shall be provided by the Developer at proposed new speed control devices located away from existing street lighting.

(f) Critical Dimensions

Many devices will be designed for their normal use by cars, but with provision (such as mountable kerbs) for larger vehicles. Some typical dimensions include:

- pavement narrowings
  - single lane 3.50m between kerbs
  - 3.75m between obstructions
  - two lane 5.50m minimum between kerbs

- bicycle lanes (including adjacent to pavement narrowings) - 1.2m absolute minimum (1.0m in special circumstances in accordance with AUSTROADS Guide to Traffic Engineering Practice – PART 14, Bicycles.)

- plateau or platform areas
  - 75 mm to 150 mm height maximum, with 1 in 15 ramp slope

- width of clear sight path through slowing devices

  - 1.0m maximum

  (ie. the width of the portion of carriageway which does not have its line of sight through the device blocked by streetscape materials, usually vegetation)

- dimensions of mountable areas required for the passage of large vehicles to be determined by appropriate turning templates.

D1.20 PARKING

1. The parking requirements for normal levels of activity associated with any land se should be accommodated on-site. ***On-Site***

2. All on-site parking should be located and of dimensions that allow convenient and safe access and usage.

Road Reserve Parking

3. Adequate parking should be provided within the road reserve for visitors, service vehicles and any excess resident parking since a particular dwelling may generate a high demand for parking. Such parking is to be convenient to dwellings.

Obstruction

4. The availability of parking should be adequate to minimise the possibility of driveway access being obstructed by cars parked on the opposite side of the street.

Joint Use

5. For non-residential land uses the opportunity for joint use of parking should be maximised by being shared by a number of complementing uses.

Road Reserve Space Dimensions

6. A single (car) space is 6.5m by 2.5m and combined spaces are 13.0m by 2.5m (for two cars) and 20m by 2.5m (for truck parking) with adequate tapers at both ends to allow the necessary parking manoeuvres determined by using AUSTROADS Turning Templates.

Verge Spaces, Indented Parking

7. All verge spaces and indented parking areas are constructed of concrete, interlocking pavers, lawn pavers, bitumen with crushed rock or other suitable base material and are designed to withstand the loads and manoeuvring stresses of vehicles expected to use those spaces.

Right-angled Parking

8. Right-angled parking is provided only on access streets and local streets where speeds do not exceed 40 km/h.

9. The number of on-site parking spaces for non-residential land uses conforms to parking standards as determined by the relevant authority.

10. The layout and access arrangements for parking areas for non-residential land uses should conform to Australian Standard 2890.1.

D1.21 BUS ROUTES

Criteria

1. Bus routes will normally be identified by Council. It is important that the road hierarchy adequately caters for buses. The main criteria in determining the location of bus routes is that *no more than 5% of residents should have to walk in excess of 400 metres* to catch a bus. Normally roads above the local street in the hierarchy are designed as bus routes. Table D1.2 details minimum criteria for bus route design.

Table D1.6 Bus Route Criteria

Road	Carriageway Width (min)	Stops (Spacing)	Bays
Collector*	9m	400 metre **	Single
Local Sub-Arterial	11m	400 metre	Shelters***

* Collector roads not identified as bus routes may have 7m carriageways (see Table D1.5)

** Loop roads with single entry/exit only require stops and bays on one side road.

*** Shelters are subject to Council's requirements.

D1.22 RESERVED

D1.23 RESERVED

D1.24 RESERVED

D1.25 RESERVED

D1.26 RESERVED

D1.27 RESERVED

D1.28 RESERVED

D1.29 RESERVED

SPECIAL REQUIREMENTS

D1.30 RESERVED

D1.31 RESERVED

D1.32 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D2

PAVEMENT DESIGN

CONTENTS

PAVEMENT DESIGN

GENERAL

D2.01 SCOPE

Design Criteria

1. The work to be executed under this Specification consists of the design of the road pavement to meet the required design life, based on the subgrade strength, traffic loading and environmental factors, and including the selection of appropriate materials for select subgrade, subbase, base and wearing surface.

Surfaced Pavement Types

2. The Specification contains procedures for the design of the following forms of surfaced road pavement construction:

(a) flexible pavements consisting of unbound granular materials;

(b) flexible pavements that contain one or more bound layers, including pavements containing asphalt layers other than thin asphalt wearing surfaces;

(c) rigid pavements (ie. cement concrete pavements);

(d) concrete or clay segmental pavements.

D2.02 OBJECTIVES

Pavement Performance

1. The objective in the design of the road pavement is to select appropriate pavement and surfacing materials, types, layer thicknesses and configurations to ensure that the pavement performs adequately and requires minimal maintenance under the anticipated traffic loading for the design life adopted.

D2.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

D1	-	Geometric Road Design
D4	-	Subsurface Drainage Design
C242	-	Flexible Pavements
C245	-	Asphaltic Concrete
C247	-	Mass Concrete Subbase
C248	-	Plain or Reinforced Concrete Base
C254	-	Segmental Paving

(b) Other

AUSTROADS - Pavement Design, A Guide to the Structural Design of Road Pavements, 1992.

AUSTROADS - Guide to Control of Moisture in Roads.

ARRB-SR41 - Australian Road Research Board, Special Report No. 41 - A Structural Design Guide for Flexible Residential Street Pavements, 1989.

Cement and Concrete Association of Australia.
CACA - T51 - Concrete Pavement Design for Residential Streets, 1997.

Concrete Masonry Association of Australia.
CMAA - T44 - Concrete Segmental Pavements - Guide to Specifying, 1997
CMAA - T45 - Concrete Segmental Pavements - Design Guide for Residential Access Ways and Roads, 1997.
CMAA - T46 - Concrete Segmental Pavements - Detailing Guide, 1997.

Clay Brick and Paver Institute
- Design Manual 1 - Clay Segmental Pavements, A Design and Construction Guide for Sites Subjected to Vehicular and Pedestrian Traffic, 1989.

PAVEMENT DESIGN CRITERIA

D2.04 DESIGN VARIABLES

1. Regardless of the type of road pavement proposed, the design of the pavement shall involve consideration of the following five input variables:

(a) Design Traffic
(b) Subgrade Evaluation
(c) Environment
(d) Pavement and Surfacing Materials
(e) Construction and Maintenance Considerations

D2.05 DESIGN TRAFFIC

1. The design traffic shall be calculated based on the following minimum design lives of pavement:- ***Minimum Pavement Design Life***

(a) Flexible, Unbound Granular - 25 years
(b) Flexible, Containing one or more bound layers - 25 years
(c) Rigid (Concrete) - 40 years
(d) Segmental Block - 25 years

Equivalent Standard Axles

Design traffic shall be calculated in equivalent standard axles (ESAs) for the applicable design life of the pavement, taking into account present and predicted commercial traffic volumes, axle loadings and configurations, commercial traffic growth and street capacity. For new subdivisions, the design traffic shall take account of both the construction traffic associated with the subdivision development and the in-service traffic for the subdivision and any future developments linked to that subdivision. For interlocking concrete segmental pavements, the simplification of replacing ESA's with the number of commercial vehicles exceeding 3 tonne gross contained in CMAA - T45 is acceptable up to a design traffic of 10^6. Beyond this, ESAs should be calculated.

Traffic Data

3. The pavement design shall include all traffic data and/or assumptions made in the calculation of the design traffic.

Design Traffic Volumes

4. In general, reference should be made to ARRB-SR41 for the calculation of design traffic volumes up to 10^6 ESAs and AUSTROADS Pavement Design for design traffic volumes approaching or exceeding 10^6 ESAs.

Guide to Design ESAs

5. In the absence of other traffic data, the following traffic values (in ESAs) may be taken as a guide to the design traffic, but shall be subject to variation depending on the circumstances for the particular development.

Street Type:		**Design ESA's - 25 year design life**
Urban Residential	- Access Street	6×10^4
	- Local Street	3×10^5
	- Collector Street	1×10^6
	- Sub-Arterial	2×10^6
Rural Residential	-	3×10^5
Commercial and Industrial		5×10^6

D2.06 SUBGRADE EVALUATION

California Bearing Ratio

1. Except where a mechanistic design approach is employed using AUSTROADS Pavement Design, the measure of subgrade support shall be the California Bearing Ratio (CBR). Where a mechanistic design approach using linear elastic theory is employed for flexible pavements, the measure of subgrade support shall be in terms of the elastic parameters (modulus, Poisson's ratio).

Design Considerations

2. The following factors must be considered in determining the design strength/stiffness of the subgrade:

(a) Sequence of earthworks construction

(b) The compaction moisture content and field density specified for construction

(c) Moisture changes during service life

(d) Subgrade variability

(e) The presence or otherwise of weak layers below the design subgrade level.

3. The subgrade Design CBR adopted for the pavement design must consider the effect of moisture changes in the pavement and subgrade during the service life, and hence consideration must be given to the provision of subsurface drainage in the estimation of equilibrium in-situ CBRs, and hence in the design of the pavement structure. Warrants for the provision of subsurface drainage are given in Specification for SUBSURFACE DRAINAGE DESIGN. If subsurface drainage is not provided, then the Design CBR adopted must allow for a greater variability in subgrade moisture content during the service life of the pavement, and hence a Design Moisture Content above the Optimum Moisture Content. ***Design CBR Considerations***

4. The calculation of the Design CBR shall be based on a minimum of three 4 day soaked CBR laboratory samples for each subgrade area, compacted to the relative density specified for construction, and corrected to allow for the effects of subsurface drainage (or lack of), climatic zone, and soil type if appropriate (as per the guidelines in ARRB SR41) to give an estimated equilibrium in-situ CBR. The Design CBR for each subgrade area is computed by using the appropriate formulae as follows: ***Calculation of Design CBR***

Design CBR = Least of estimated CBRs, for less than five results

Design CBR = 10th percentile of all estimated CBRs, for five or more results

= $C - 1.3S$

Where C is the mean of all estimated CBRs, and
S is the standard deviation of all values.

5. Where practicable, the Design CBR obtained from laboratory testing should be confirmed by testing performed on existing road pavements near to the job site under equivalent conditions and displaying similar subgrades. ***Field Confirmation***

6. The pavement design shall include a summary of all laboratory and field test results and assumptions and/or calculations made in the assessment of Design CBR. ***Summary of Results***

D2.07 ENVIRONMENT

1. The environmental factors which significantly affect pavement performance are moisture and temperature. Both of these factors must be considered at the design stage of the pavement. Reference should be made to AUSTROADS Pavement Design, ARRB-SR41, and to NAASRA (Now AUSTROADS) - Guide to Control of Moisture in Roads. ***Moisture and Temperature***

2. The following factors relating to moisture environment must be considered in determining the design subgrade strength/stiffness and in the choice of pavement and surfacing materials: ***Moisture Considerations***

(a) Rainfall/evaporation pattern

(b) Permeability of wearing surface

(c) Depth of water table

(d) Relative permeability of pavement layers

(e) Whether shoulders are sealed or not

(f) Pavement type (boxed or full width)

3. The effect of changes in moisture content on the strength/stiffness of the subgrade shall be taken into account by evaluating the design subgrade strength parameters (ie. CBR or modulus) at the highest moisture content likely to occur during the design life, ie the Design Moisture Content. The provision of subsurface drainage may, under certain circumstances, allow a lower Design Moisture Content, and hence generally higher Design CBR. ***Evaluate Design CBR***

The effect of changes in temperature environment must be considered in the design of pavements with asphalt wearing surfaces, particularly if traffic loading occurs at night when temperatures are low, thus causing a potential reduction in the fatigue life of thin asphalt surfacing. The effect of changes in temperature environment should also be considered for bound or concrete layers. ***Temperature Change***

5. The pavement design shall include all considerations for environmental factors, and any assumptions made that would reduce or increase design subgrade strength, or affect the choice of pavement and surfacing materials.

D2.08 PAVEMENT AND SURFACING MATERIALS

1. Pavement materials can be classified into essentially four categories according to their fundamental behaviour under the effects of applied loadings: ***Pavement Classification***

(a) Unbound granular materials, including modified granular materials
(b) Bound (cemented) granular materials
(c) Asphaltic Concrete
(d) Cement Concrete

2. Surfacing materials can also be classified into essentially four categories or types:- ***Surfacing Classification***

(a) Asphaltic concrete and bituminous microsurfacing (cold overlay)
(b) Cement Concrete
(c) Concrete Segmental Pavers
(d) Clay Segmental Pavers

3. Unbound granular materials, including modified granular materials, shall satisfy the requirements of the Construction Specification for FLEXIBLE PAVEMENTS.

4. Bound (cemented) granular materials shall satisfy the requirements of the Construction Specification for FLEXIBLE PAVEMENTS.

5. Asphaltic concrete shall satisfy the requirements of the Construction Specification for ASPHALTIC CONCRETE.

6. Cement concrete shall satisfy the requirements of the Construction Specifications for MASS CONCRETE SUBBASE, PLAIN OR REINFORCED CONCRETE BASE, or FIBRE REINFORCED CONCRETE, as appropriate.

7. Concrete and clay segmental pavers shall satisfy the requirements of the Construction Specification for SEGMENTAL PAVING.

D2.09 CONSTRUCTION AND MAINTENANCE CONSIDERATIONS

1. The type of pavement, choice of base and subbase materials, and the type of surfacing adopted should involve consideration of various construction and maintenance factors as follows:

(a) Extent and type of drainage
(b) Use of boxed or full width construction

(c) Available equipment of the Contractor

(d) Use of stabilisation

(e) Aesthetic, environmental and safety requirements

(f) Social considerations

(g) Construction under traffic

(h) Use of staged construction

(i) Ongoing and long-term maintenance costs

These factors are further discussed in AUSTROADS Pavement Design.

PAVEMENT THICKNESS DESIGN

D2.10 PAVEMENT STRUCTURE - GENERAL

1. The pavement thickness, including the thickness of surfacings, shall not be less than 250mm for roads in which kerb and guttering is to be constructed, 200mm for unkerbed roads and 150mm for carparks. ***Minimum Pavement Thickness***

5. Notwithstanding subgrade testing and subsequent pavement thickness design, the thickness of subbase and base layers shall not be less than the following:-

(a) Flexible pavement: Subbase 100mm, Base 100mm
(b) Rigid pavement: Subbase 100mm, Base 150mm

3. The subbase layer shall extend a minimum of 150mm behind the rear face of any kerbing and/or guttering. ***Subbase Extent***

4. The base and surfacing shall extend to the face of any kerbing and/or guttering. Where the top surface of the subbase layer is below the level of the underside of the kerbing and/or guttering, the base layer shall also extend a minimum of 150mm behind the rear face of the kerbing and/or guttering. ***Base Extent***

5. For unkerbed roads, the subbase and base layers shall extend at least to the nominated width of shoulder. ***Unkerbed Roads***

6. The pavement designer shall make specific allowance for traffic load concentrations within carpark areas (eg entrances/exits). ***Carparks***

7. The pavement designer shall make provision for pavement layer drainage on the assumption that during the service life of the pavement ingress of water will occur. ***Drainage***

D2.11 UNBOUND GRANULAR FLEXIBLE PAVEMENTS (BITUMINOUS SURFACED)

1. Unbound granular flexible pavements with thin bituminous surfacings, including those with cement or lime modified granular materials, with design traffic up to 10^6 ESAs shall be designed in accordance with ARRB-SR41, using Figure 7 (95% confidence limit curves).

2. For design traffic above 10^6 ESAs, the design shall be in accordance with AUSTROADS Pavement Design.

D2.12 FLEXIBLE PAVEMENTS CONTAINING BOUND LAYERS (BITUMINOUS SURFACED)

1. Flexible pavements containing one or more bound layers, including cement stabilised layers or asphaltic concrete layers other than thin asphalt surfacings, shall be designed in accordance with AUSTROADS Pavement Design.

2. As an alternative to AUSTROADS Pavement Design for design traffic up to 10^6 ESAs, bound layers may be assumed to be equivalent to unbound layers of the same thickness, and the pavement designed in accordance with ARRB-SR41, using Figure 7 (95% confidence limit curves).

D2.13 RIGID PAVEMENTS

1. Rigid (concrete) pavements, with design traffic up to 10^6 ESAs shall be designed in accordance with either CACA -T51 or AUSTROADS Pavement Design.

2. Rigid (concrete) pavements for design traffic above 10^6 ESAs, the design shall be in accordance with AUSTROADS Pavement Design.

D2.14 CONCRETE SEGMENTAL PAVEMENTS

1. Concrete segmental pavements with design traffic up to 10^6 estimated commercial vehicles exceeding 3T gross shall be designed in accordance with CMAA-T45.

2. For design traffic above 10^6 estimated commercial vehicles exceeding 3T gross the design shall be in accordance with AUSTROADS Pavement Design, with the calculation of design traffic in terms of ESAs.

D2.15 CLAY SEGMENTAL PAVEMENTS

1. Clay segmental pavements with design traffic up to 10^6 ESAs shall be designed in accordance with Design Manual 1 - Clay Segmental Pavements.

2. For design traffic above 10^6 ESAs and up to 10^7 ESAs the design shall involve consideration of both Design Manual 1 - Clay Segmental Pavements and AUSTROADS Pavement Design, with the thicker and more conservative design of each of the two methods adopted.

3. For design traffic above 10^7 ESAs, the pavement shall be designed in accordance with AUSTROADS Pavement Design.

SURFACING DESIGN

D2.16 CHOICE OF SURFACE TYPE

Bitumen Wearing Surface

1. Except where the pavement is designed for concrete or segmental block surfacing, the wearing surface shall be a bituminous wearing surface as follows:-

(a) Urban Residential streets - Access Street and Local Street

- primer seal, plus asphalt.

(b) Urban Residential streets - Collector and Sub-Arterial:

- primer seal, plus asphalt

(c) Commercial and Industrial streets:

- primer seal, plus asphalt

2. At intersection approaches and cul-de-sac turning circles on residential streets with flush seals, asphalt surfacing shall be provided within the vehicle braking and turning zones. ***Braking and Turning Zones***

3. Variations to these requirements may be approved by Council in special circumstances. ***Approval***

D2.17 RESERVED

D2.18 RESERVED

D2.19 ASPHALTIC CONCRETE

1. In urban residential access and local streets, rural or light trafficked commercial streets (design traffic up to approximately 3 x 10^5 ESAs), the asphalt mix design shall be either a 'high-bitumen content' mix or the ARRB Gap-graded mix in accordance with ARRB-SR41 and the Construction Specification for ASPHALTIC CONCRETE. ***Light to Medium Traffic***

2. In urban residential collector and sub-arterial roads, medium to heavily trafficked commercial streets and in all industrial roads, the asphalt mix design shall be a dense graded mix in accordance with the Construction Specification for ASPHALTIC CONCRETE. ***Medium to Heavy Traffic***

3. Asphaltic concrete surfacings shall be designed to provide a nominal compacted layer thickness of not less than 25mm on light to medium trafficked residential, rural and commercial streets, and 40mm on medium to heavily trafficked residential, rural or commercial roads and on all industrial and classified roads. ***Minimum Thickness***

4. As a minimum, a 7mm or 10mm primer seal shall be indicated on the Drawings below the asphalt surfacing. ***Primer Seal***

D2.20 SEGMENTAL PAVERS

1. Concrete segmental pavers shall be 80mm thick, shape Type A, and designed to be paved in a herringbone pattern. ***Size and Shape***

2. Clay segmental pavers shall be 65mm thick, Class 4, and designed to be paved in a herringbone pattern.

3. The edges of all paving shall be designed to be constrained by either kerbing and/or guttering, or by concrete edge strips. ***Edge Constraint***

DOCUMENTATION

D2.21 DESIGN CRITERIA AND CALCULATIONS

1. All considerations, assumptions, subgrade test results, and calculations shall be submitted with the pavement design for approval by Council. ***Submission Details***

2. The Drawings shall clearly indicate the structure, material types and layer ***Drawings***

thicknesses of the proposed pavement and surfacing.

SPECIAL REQUIREMENTS

D2.22 RESERVED

D2.23 RESERVED

D2.24 RESERVED

D2.25 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D3

STRUCTURES BRIDGE DESIGN

CONTENTS

DEVELOPMENT DESIGN SPECIFICATION D3
STRUCTURES/BRIDGE DESIGN

GENERAL

D3.01 SCOPE

1. This Specification sets out design considerations to be adopted in the design of structural engineering elements for land subdivisions. Such activities will include:

- Road traffic bridges
- Pedestrian bridges
- Structures other than bridges, but associated with roads (eg major culverts, retaining walls, major sign support structures)
- Small earth dams, detention basins
- Structures used for public safety (road safety barriers, pedestrian safety rails, street lighting)
- Temporary works

Such structures may be of concrete, timber or steel constructions, but with emphasis placed on low maintenance.

D3.02 OBJECTIVE

Design Life

1. The aim of design shall be the achievement of acceptable probabilities that the structure being designed will not become unfit for use during its design life, having regard to economic, physical, aesthetic and other relevant constraints.

D3.03 BASIS OF DESIGN

Safety Quality Qualifications

1. The design shall be based on scientific theories, experimental data and experience, interpreted statistically as far as possible. The safety and service performance of a structure depends also on the quality control exercised in fabrication, supervision on site, the control of unavoidable imperfections and the qualifications, experience and skill of all personnel involved. Adequate attention shall therefore be given to these factors. In addition, adequate management control and supervision by experienced engineers shall be required at all stages of design and construction to prevent the occurrence of gross errors.

2. Specifications shall be notated on the Drawings with sufficient detail to ensure that the above described strategies are able to be effectively implemented at the construction stage.

D3.04 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

D1	-	Geometric Road Design
D5	-	Stormwater Drainage Design
D7	-	Erosion Control and Stormwater Management

(b) Australian Standards

AS1158	-	The lighting of urban roads and other public thoroughfares (SAA Public Lighting Code)
AS1170	-	Minimum design loads on structures (SAA Loading Code)
AS1684	-	National Timber Framing Code
AS3600	-	Concrete structures
AS3700	-	Masonry in buildings (SAA Masonry Code)
AS/NZS 3845	-	Road safety barrier systems
AS4100	-	Steel structures

Other relevant codes and guidelines with the above.

(c) Other

AUSTROADS	-	Bridge Design Code
Inst. of Eng.	-	Australian Rainfall and Runoff
KD Nelson	-	Design and Construction of Small Earth Dams

D3.05 ROAD TRAFFIC AND PEDESTRIAN BRIDGES

1. Bridge design shall only be carried out by properly qualified persons whose Association of Consulting Engineers Australia (ACEA) listing includes structural design of bridges in its claimed area of competency. Such designers shall submit evidence of these qualifications to Council prior to approval of any bridge design. ***A.C.E.A. Listing***

2. However, this does not preclude submissions by other qualified persons in which cases Council reserves the right to call for evidence of the qualifications and experience of the responsible designer; or to seek referral of the design calculations to an appropriate A.C.E.A. firm for checking. The latter requirement will be at the Developer's cost, if directed. ***Design Checking***

3. The AUSTROADS Bridge Design Code shall be used for all bridge design.

4. Bridges shall have low maintenance finishes. Adequate precautions shall be taken for protection of the materials used in the bridge design; for example, timber and steel require special consideration. Heavy debris and bed loads may be characteristic of some streams so that large spans with slender piers are encouraged. If overtopping is permitted, pedestrian safety rails and road safety barriers are usually omitted. Flood depth indicators and appropriate signposting will be provided in such cases. ***Finishes*** ***Debris, Overtopping***

5. Preventative maintenance is a key issue affecting the design life of the structure. The Drawings shall specify the design life of the structure together with the relevant maintenance programs to be adopted upon which the design life is based. Parameters used in the design shall also be shown on the Drawings. ***Design Life Maintenance***

6. Hydraulic design of bridges shall be in accordance with the requirements for major structures in the Specification for STORMWATER DRAINAGE DESIGN. ***Hydraulic Design***

7. Where structures are designed to be inundated, the effect of the backwater gradient on upstream property shall be identified on the Drawings. ***Inundation***

8. Where no inundation is permitted, appropriate afflux shall be adopted together with a 500mm freeboard to the underside of the bridge deck. ***Freeboard***

9. Designers should enquire regarding current or likely provision for public utilities in bridges. These should be concealed for aesthetic reasons. ***Public Utilities***

3.06 PROVISION FOR PEDESTRIANS ON ROAD BRIDGES

1. Provision for pedestrians on bridges is required in rural residential as well as urban areas. The minimum provision is a 1.5m footpath with kerb at the road traffic edge and pedestrian safety rails at the external edge. ***Minimum Provision***

2. Council may require the provision of separate pedestrian footpaths in other situations should the anticipated traffic warrant it. ***Separate Footpaths***

3. Disabled access shall be considered in the design. ***Disabled Access***

4. Urban bridge approaches should be lit in accordance with AS1158. ***Lighting***

D3.07 STRUCTURES OTHER THAN BRIDGES, ASSOCIATED WITH ROADS

1. Public utility structures, major culverts, major sign support structures, retaining walls, and the like will be designed by a competent, practicing engineer, accredited in the design of such structures. The design shall be in accordance with the AUSTROADS Code, all relevant Australian Standards, and the requirements of any utility owners that may be relevant.

D3.08 SMALL EARTH DAMS/DETENTION BASINS

1. Small earth dams shall be designed following the guidelines in "Design and Construction of Small Earth Dams" by K D Nelson together with relevant geotechnical recommendations. The structural design of weir outlets to resist failure shall be considered in design. Refer also to the Retarding Basin and Stormwater Detention sections in the Specification for STORMWATER DRAINAGE DESIGN.

2. Childproof fencing shall be nominated where it is a requirement of relevant statutory regulations, Australian Standards or Council Specifications and where unacceptable risk exists due to the location of the dam/basin in relation to the urban nature of the area. ***Fencing***

3. The Designer shall carry out the design with recognition of the potential risk on existing and planned infrastructure downstream, assuming the probability of dam/basin failure. ***Risk of Failure***

4. The Designer shall be a qualified civil or structural engineer having accreditation in the design of such structures. ***Qualification***

5. The Designer shall be required to certify the design and ultimately certify the work-as-executed Drawings for compliance with the design. All relevant details shall be shown on the Drawings. ***Certification***

D3.09 STRUCTURES USED FOR PUBLIC SAFETY

1. Since the requirement of road safety barriers and pedestrian safety rails on bridges are different, the design engineer shall consider whether separate traffic and pedestrian barriers can be detailed to satisfy the major functional requirements. ***Barriers and Rails***

2. The AUSTROADS Bridge Design Code and AS/NZS 3845 are recommended references in this regard.

3. It is essential that all safety barriers and rails have been fully tested and accredited for the intended use under quality assurance provisions.

Lighting

4. Bridge crossings in urban and rural residential areas shall be provided with streetlighting in accordance with AS 1158. Such requirements will be noted accordingly on the Drawings.

D3.10 TEMPORARY WORKS

Programme of Temporary Provisions

1. Structures which are proposed for the temporary support of roads, services and the like shall be designed by a qualified Engineer experienced and accredited in the design of such structures and designed in accordance with the AUSTROADS Bridge Design Code. A construction programme, indicating the sequence of events leading to the implementation and removal of the temporary structures shall be specified on the Drawings.

SPECIAL REQUIREMENTS

D3.11 RESERVED

D3.12 RESERVED

D3.13 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D4

SUBSURFACE DRAINAGE DESIGN

CONTENTS

DEVELOPMENT DESIGN SPECIFICATION D4
SUBSURFACE DRAINAGE DESIGN

GENERAL

D4.01 SCOPE

1. The work to be executed under this Specification consists of the design of the subsurface drainage system for the road pavement and/or subgrade.

2. This Specification contains procedures for the design of subsurface drainage, including:

   (a) Subsoil and Foundation Drains

   (b) Sub-Pavement Drains

   (c) Drainage Mats, including Type A and Type B Mats.

3. Reference guidelines for the application and design of subsurface drainage include ARRB Special Reports 35 and 41, and the AUSTROADS publication - Guide to the Control of Moisture in Roads. The full titles of these guidelines are given below.

D4.02 OBJECTIVES

Control Moisture Content

1. The objective in the design of the subsurface drainage system is to control moisture content fluctuations in the pavement and/or subgrade to within the limits assumed in the pavement design.

D4.03 TERMINOLOGY

Subsoil Drains

1. Subsoil drains are intended for the drainage of ground water or seepage from the subgrade and/or the subbase in cuttings and fill areas.

Foundation Drains

2. Foundation drains are intended for the drainage of seepage, springs and wet areas within and adjacent to the foundations of the road formation.

Sub-pavement Drains

3. Sub-pavement drains are intended for the drainage of the base and subbase pavement layers in flexible pavements. They may also function to drain seepage or groundwater from the subgrade.

Type A Drainage Mats

4. Type A drainage mats are intended to ensure continuity of a sheet flow of water under fills, to collect seepage from a wet seepage area, or for protection of vegetation or habitat downstream of the road reserve where a fill would otherwise cut the flow of water.

Type B Drainage Mats

5. Type B drainage mats are constructed to intercept water which would otherwise enter pavements by capillary action or by other means on fills and to intercept and control seepage water and springs in the floors of cuttings.

D4.04 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specification

C230	-	Subsurface Drainage - General
C231	-	Subsoil and Foundation Drains
C232	-	Pavement Drains
C233	-	Drainage Mats

(b) Australian Standards

AS2439.1	-	Perforated drainage pipe and associated fittings.
AS/NZS 1477	-	Unplasticised PVC (UPVC) pipes and fittings for pressure applications.

(c) Other

AUSTROADS	-	Guide to the Control of Moisture in Roads, 1983
ARRB-SR35	-	Australian Road Research Board, Special Report No. 35 - Subsurface Drainage of Road Structures, Gerke R.J., 1987.
ARRB-SR41	-	Australian Road Research Board, Special Report No. 41 - A Structural Design Guide for Flexible Residential Street Pavements, Mulholland P.J., 1989.

SUBSOIL AND SUB-PAVEMENT DRAINS

D4.05 WARRANTS FOR USE

1. Subsoil drains are designed to drain groundwater or seepage from the subgrade and/or subbase in cuttings and fill areas. *Subsoil Drains*

2. Sub-pavement drains are designed to drain water from base and subbase pavement layers in flexible pavements, and to drain seepage or groundwater from the subgrade. *Sub-pavement Drains*

3. Subsoil or sub-pavement drains shall be provided on both sides of the formation in the following locations, unless the geotechnical report indicates the absence of subsurface moisture at the time of investigation and the likelihood that changes in the subsurface moisture environment will not occur within the design life of the pavement and/or the pavement has been specifically designed to allow for likely variations in subgrade and pavement moisture contents: *Geotechnical Survey*

(a) Cut formations where the depth to finished subgrade level is equal to or greater than 400mm below the natural surface level. *Locations*

(b) Locations of known hillside seepage, high water table (close to underside of subbase) or isolated springs.

(c) Irrigated, flood-prone or other poorly drained areas.

(d) Highly moisture susceptible subgrades, ie. commonly displaying high plasticity or low soaked CBRs.

(e) Use of moisture susceptible pavement materials.

(f) Existing pavements with similar subgrade conditions displaying distress due to excess subsurface moisture.

(g) At cut to fill transitions.

Where only one side of the formation is in cut, and the other side in fill, it may be sufficient to provide subsoil or sub-pavement drains only along the edge of the formation in cut.

During Construction

4. The need for subsoil and sub-pavement drains may otherwise become apparent during the construction process, due to changes in site moisture conditions or to areas of poorer subgrade being uncovered that were not identified in the geotechnical investigation. The Design Drawings shall be suitably annotated to the potential need for subsoil or sub-pavement drains in addition to those originally specified and shown on the Drawings.

D4.06 LAYOUT, ALIGNMENT AND GRADE

Typical Cross Sections

1. Typical cross sections of subsoil and sub-pavement drains are shown below in Figures D4.1 and D4.2. As indicated in these figures, subsoil drain trenches are excavated to below subgrade level, while sub-pavement drains extend into or adjacent to the pavement layers to facilitate drainage of the pavement layers in addition to the subgrade.

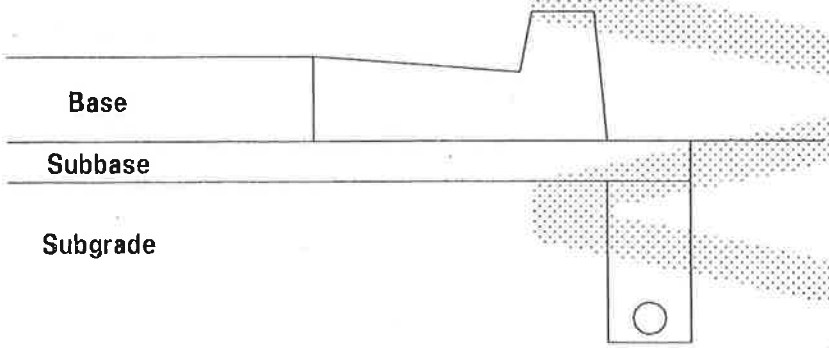


Figure D4.1 - Typical Subsoil Drain

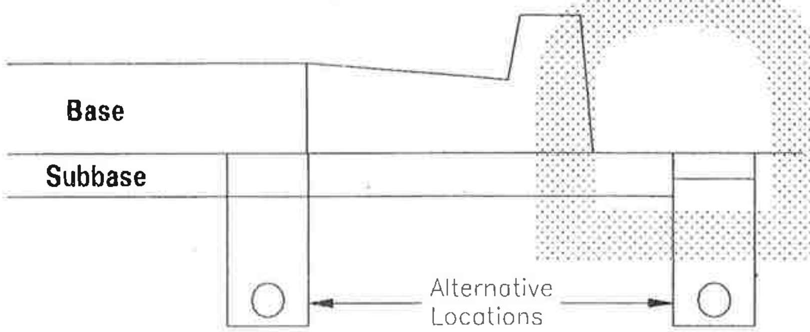


Figure D4.2 - Typical Subpavement Drain

2. In kerbed roads, the two acceptable alternative locations for the line of the trench are directly behind the kerbline. Pavement layers must extend to at least the line of the rear of the trench. *Kerbed Roads*

3. In unkerbed roads, subsoil and sub-pavement drains shall be located within the shoulder, preferably at the edge of the pavement layers as shown in Figure D4.2. *Unkerbed Roads*

4. The minimum desirable longitudinal design grade shall be 1.0%. For non corrugated pipes, an absolute minimum grade of 0.5% is acceptable. *Grade*

5. Trench widths shall be a minimum of 300mm, with a minimum depth below finished subgrade level of 600mm in earth and 450mm in rock, and below the invert level of any service crossings. *Trench Dimensions*

6. Outlets shall be spaced at maximum intervals of 150 metres. Where possible, subsoil and sub-pavement drainage pipes shall discharge into drainage pits or other stormwater drainage structures. Where not possible, outlets shall be provided through fill batters. Unless otherwise authorised, where subsurface drains outlet through fill batters, a small precast concrete headwall shall be installed at the drain outlet with a marker post to assist maintenance and protect the end of the pipe. *Outlets*

7. Cleanouts are to be provided at the commencement of each run of drain, and at intervals not exceeding 80 metres. Cleanouts shall generally be located directly at the rear of kerb or at the edge of shoulder, as applicable. *Cleanouts*

8. Care shall be taken when positioning subsoil and subpavement drains to avoid interfering with or damaging Public Utility services.

FOUNDATION DRAINS

D4.07 WARRANTS FOR USE

1. Foundation drains are designed to drain excessive ground water areas within the foundation of an embankment or the base of cutting, or to intercept water from entering these areas. *Foundation Drains*

2. The need to provide foundation drains may be apparent from the results of the geotechnical survey along the proposed road formation alignment, and in this case the location shall be shown on the Drawings. However, more commonly, the need to provide foundation drains is determined during construction, and hence in this situation requirements and locations cannot be ascertained at the design stage. *Geotechnical Survey During Construction*

3. Where the road formation traverses known swampy, flood-prone, or watercharged strata, the Drawings shall be suitable annotated to the potential need for foundation drains at various locations, in addition to those originally specified and shown on the Drawings. *Need for Additional Drains*

D4.08 LAYOUT, ALIGNMENT AND GRADE

1. A typical cross-section showing foundation drains is shown below in Figure D4.3. *Typical Cross Section*

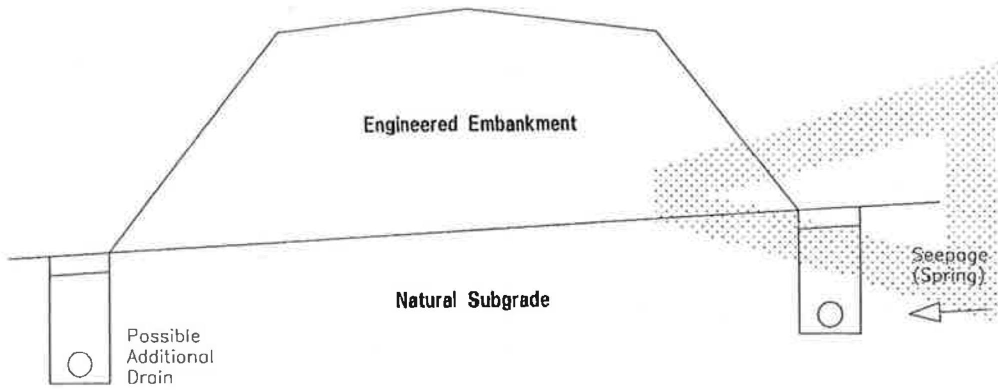


Figure D4.3 - Foundation Drains

Grade

2. The minimum desirable design grade shall be 1.0%. For non corrugated pipes an absolute minimum grade of 0.5% is acceptable.

Trench Dimensions

3. Foundation drains shall be a minimum trench width of 300mm, with a variable trench depth to suit the application and ground conditions on site.

Outlets

4. Outlets shall be spaced at maximum intervals of 150 metres. Where possible foundation drains shall discharge into drainage pits or other stormwater drainage structures, where not possible, outlets shall be provided through fill batters.

Cleanouts

5. Where practicable, cleanouts are to be provided at the commencement of each run of foundation drain and at intervals not exceeding 80 metres. Where not practicable to provide intermediate cleanouts, outlets shall be spaced at maximum intervals of 100 metres.

6. Care shall be taken when positioning foundation drains to avoid interfering with or damaging Public Utility services.

DRAINAGE MATS (BLANKETS)

D4.09 WARRANTS FOR USE

Type A Mats

1. Type A drainage mats are designed where there is a need to ensure continuity of a sheet flow of water under fills, to collect surface seepage from a wet seepage area, or for protection of vegetation or habitat downstream of the road reserve where a fill would otherwise cut the flow of water. Type A drainage mats are constructed after the site has been cleared and grubbed and before commencement of embankment construction.

Type B Mats

2. Type B drainage mats are designed where there is a need to intercept water which would otherwise enter pavements by capillary action or by other means on fills and to intercept and control seepage water and springs in the floors of cuttings. Type B drainage mats shall be constructed after completion of the subgrade construction and before construction of the pavement.

Geotechnical Survey

3. The need to design for the provision of drainage mats should be apparent from the result of the geotechnical survey along the proposed road formation alignment.

MATERIALS

D4.10 SUBSOIL AND SUB-PAVEMENT DRAIN PIPE

1. Pipes designated for subsoil, foundation and sub-pavement drains shall be 100mm dia. slotted pipe.

2. Corrugated plastic pipe shall conform with the requirements of AS2439.1. The appropriate class of pipe shall be selected on the basis of expected live loading at the surface. Joints, couplings, elbows, tees and caps shall also comply with AS2439.1.

3. Slotted rigid UPVC pipe shall be of a type and class approved by Council.

4. All pipe shall be slotted, and fitted with a suitable geotextile filter tube, except for cleanouts and outlets through fill batters which shall be unslotted pipe.

D4.11 INTRA PAVEMENT DRAIN PIPE

1. Pipes designated for intra pavement drains with crushed rock subbases having layer thicknesses neither less than 150mm nor more than 200mm shall be slotted thick walled UPVC pressure pipe complying with AS/NZS 1477.

2. Pipes designated for intra pavement drains with crushed rock subbases having layer thicknesses exceeding 200mm shall be slotted pipe of a type and class approved by Council.

3. Pipes for use in Type B drainage mats shall be slotted thick walled UPVC pressure pipe complying with AS/NZS 1477.

D4.12 FILTER MATERIAL

1. The types of filter material covered by this Specification shall include:

   (a) Type A filter material for use in subsoil, foundation, and sub-pavement (trench) drains and for Type B drainage mats.

   (b) Type B filter material for use in subsoil, foundation and sub-pavement (trench) drains.

   (c) Type C filter material comprising crushed rock for use in Type A drainage mats.

   (d) Type D filter material comprising uncrushed river gravel for use in Type A drainage mats.

2. Material requirements and gradings for each type of filter material are included in the Construction Specification, SUBSURFACE DRAINAGE GENERAL.

The type of filter material specified to backfill the sub-surface drainage trenches (subsoil, foundation and sub-pavement drains) shall depend on the permeability of the pavement layers and/or subgrade and the expected flow rate. Generally, Type A filter material is used for the drainage of highly permeable subgrade or pavement layers such as crushed rock or coarse sands, while Type B filter material is used for the drainage of subgrade and pavement layers of lower permeability such as clays, silts or dense graded gravels. Further guidance to the selection of appropriate filter material is contained in ARRB Special Report 35.

D4.13 GEOTEXTILE

1. To provide separation (ie. prevent infiltration of fines) between the filter material in the trench and the subgrade or pavement material, geotextile shall be designated to encapsulate the filter material. The geotextile shall comply with the requirements included in the Construction Specification, SUBSURFACE DRAINAGE GENERAL.

2. Geotextile shall also be designated for both Type A and Type B Drainage Mats.

DOCUMENTATION

D4.14 DRAWINGS AND CALCULATIONS

1. The proposed location of all subsurface drains shall be clearly indicated on the Drawings, including the nominal depth and width of the trench, and the location with respect to the line of the kerb/gutter or edge of pavement. The location of outlets and cleanouts shall also be indicated on the Drawings. The locality of Public Utility services shall also be indicated on the Drawings.

2. Assumptions and/or calculations made in the determination of the need or otherwise for subsurface drainage in special circumstances or as a variation to the requirements of this Specification shall be submitted to Council for approval with the Drawings.

SPECIAL REQUIREMENTS

D4.15 RESERVED

D4.16 RESERVED

D4.17 RESERVED

D4.18 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D5

STORMWATER DRAINAGE DESIGN

CONTENTS

DEVELOPMENT DESIGN SPECIFICATION D5
STORMWATER DRAINAGE DESIGN

GENERAL

D5.01 SCOPE

1. The work to be executed under this Specification consists of the design of stormwater drainage systems for urban and rural areas.

2. This Specification supports and compliments the requirements of Council's Stormwater Drainage Policy.

3. Variations to the requirements of this Specification will only be considered on merit following submission of documentation to allow assessment.

D5.02 OBJECTIVES

1. The objectives of stormwater drainage design are as follows;

(b) To ensure that inundation of private and public buildings located in flood-prone areas occurs only on rare occasions and that, in such events, surface flow routes convey floodwaters below the prescribed velocity/depth limits.

(b) To provide convenience and safety for pedestrians and traffic in frequent stormwater flows by controlling those flows within prescribed limits.

(c) Retain within each catchment as much incident rainfall and runoff as is possible and appropriate for the planned use and the characteristics of the catchment.

2. In pursuit of these objectives, the following principles shall apply; ***Design Principles***

(a) New Developments are to provide a stormwater drainage system in accordance with the "major/minor" system concept set out in Chapter 14 of Australian Rainfall & Runoff, 1987 (AR&R); that is, the "major" system shall provide safe, well-defined overland flow paths for rare and extreme storm runoff events while the "minor" system shall be capable of carrying and controlling flows from frequent runoff events.

(b) Redevelopment – Where the proposed development replaces an existing development, the on-site drainage system is to be designed in such a way that the estimated peak flow rate from the site for the design average recurrence interval (ARI) of the receiving minor system is no greater than that which would be expected from the existing development, or better.

(c) On-site stormwater detention will be applied to achieve the objectives set out above and as required in Council's Stormwater Drainage Policy.

3. Stormwater drainage for all properties shall be by gravity means. Mechanical means (e.g. pump-out systems) for disposal of stormwater runoff, other than for sub-surface flows from under-ground areas in commercial and multiple occupancy buildings, **will not be permitted**. Charged drainage systems (part of the system is below the outlet level and permanently hold water) are not acceptable. All stormwater drainage lines must be free draining.

4. Diverting flows from one catchment (or sub-catchment) to another catchment (or sub-catchment) will not be permitted. Properties must be drained in their natural direction. Where necessary, drainage easements must be obtained through downstream properties for piping flows to the downstream drainage system. The site's existing discharge point into the public drainage system, cannot be altered.

5. Inability to provide a gravity stormwater drainage system and drainage easement(s) may result in a Development Consent not being granted.

D5.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

C220 - Stormwater Drainage - General
C221 - Pipe Drainage
C222 - Precast Box Culverts
C223 - Drainage Structures
C224 - Open Drains including Kerb & Gutter
Council On-site Stormwater Detention – Technical Specification.

(b) Council's Policies

Drainage Easements and Buildings Over Constructed Public Drainage Systems.

(c) Australian Standards

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/NZS 2566.1 - Buried flexible pipelines, structural design.
AS 3725 - Loads on buried concrete pipes.
AS 4058 - Precast concrete pipes.
AS 4139 - Fibre reinforced concrete pipes and fittings.

(d) State Authorities

RTA, NSW - Model Analysis to determine Hydraulic Capacities of Kerb Inlets and Gully Pit Gratings, 1979.

(e) Other

AUSTROADS - Bridge Design Code.

Inst. of Eng. - Australian Rainfall and Runoff (AR&R) - A guide to flood estimation. Aug 1987.

Queensland Urban Drainage Manual, Volumes 1 & 2, 1993.

Sangster, WM., Wood, HW., Smerdon, ET., and Bossy, HG.
- Pressure Changes at Storm Drain Junction, Engineering Series, Bulletin No. 41, Eng. Experiment Station, Univ. of Missouri 1958.

Hare CM. - Magnitude of Hydraulic Losses at Junctions in Piped Drainage Systems. Transactions, Inst. of Eng. Aust., Feb. 1983.

Concrete Pipe Association of Australia
- Concrete Pipe Guide, charts for the selection of concrete pipes to suit varying conditions.

Henderson, FM.Open Channel Flow, 1966.

Chow, Ven Te - Open Channel Hydraulics, 1959.

John Argue - Australian Road Research Board Special Report 34
- Stormwater drainage design in small urban catchments: a handbook for Australian practice.

Australian National Conference On Large Dams, Leederville WA.
- ANCOLD 1986, Guidelines on Design Floods for Dams.

HYDROLOGY

D5.04 DESIGN RAINFALL DATA

1. Design Intensity-Frequency-Duration (IFD) Rainfall - IFD relationships shall be derived in accordance with Volume 1 Chapter 2, of AR&R, for the particular catchment under consideration. ***I-F-D Relationships***

2. The nine basic parameters read from Maps 1-9 in Volume 2 of AR&R shall be shown in the calculations submitted to Council, except where the Bureau of Meteorology provides a polynomial relationship for the catchment.

3. Where design IFD rainfalls are provided for specific locations these are provided in Appendix A.

4. Design Average Recurrence Interval (ARI) - For design under the "major/minor" concept, the design ARIs to be used are given below. ***Average Recurrence Intervals***

5. Recurrence intervals for minor events depends on the road class and zoning of the land being serviced by the drainage system. The minor system design ARIs are detailed below:-

Public piped drainage and channel systems shall be designed for the following recurrence intervals:

Location	ARI (yr)
Local roads	10
Collector roads	10
Sub-arterial roads	10
Arterial roads	20
State roads	50
Access to emergency facilities	100

Piped drainage systems for urban developments, shall be designed for the following recurrence intervals:

Location	ARI (yr)

Residential - low density	20
Residential - medium/high density	20
Commercial	20
Industrial	50
Hospitals and emergency facilities	100

Easements in Private Property

6. In addition, where a development is designed in such a way that the major system flows involve surcharge across private property, then the underground system (both pipes and inlets) shall be designed to permit flows into and contain flows having an ARI of 100 years from the upstream catchment which would otherwise flow across the property. A surcharge path shall be defined for systems even where 100 year ARI flows can be maintained within the system. Easements are to be provided in private property over pipe systems and surcharge paths.

D5.05 CATCHMENT AREA

Catchment Definition

1. 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 this point. Consideration shall be given to likely changes to individual catchment areas due to the full development of the catchment.

2. Where no detailed survey of the catchment is available, 1:2000 contour maps can be obtained from Council showing the existing drainage system or, 1:4000 orthophoto maps are to be used to determine the catchments and to measure areas.

3. Catchment area land use shall be based on current available zoning information or proposed future zonings, where applicable.

4. Stormwater from the upstream catchment(s) must be considered in the design.

D5.06 RATIONAL METHOD

1. Rational Method calculations to determine peak flows shall be carried out in accordance with Volume 1, Chapter 14, of AR&R and the requirements of this Specification. Rational Method calculations can be used for small catchments of areas less than 600m^2. For larger catchments, suitable hydrologic computer models are to be used.

Qualified Person

2. All calculations shall be carried out by a qualified person experienced in hydrologic and hydraulic design.

Runoff Co-efficients

3. Co-efficients of Run-off shall be calculated as per Volume 1, Chapter 14.5 of AR&R and full details of co-efficients utilised shall be provided.

Impervious Areas

4. Details of percentage impervious areas for interallotment drainage in subdivisions and developments are to be designed for the greater of the following:

- minimum 35% impervious area, or
- proposed impervious area of the site.

Eventual public stormwater drainage systems or trunk lines shall be designed for the following minimum impervious percentages:

- 40% all residential areas.
- 100% industrial/commercial areas.

- 70% road carriageway.

5. The time of concentration of a catchment is defined as the time required for storm runoff to flow from the most remote point on the catchment to the outlet of the catchment. *Times of Concentration*

6. Where the flow path is through areas having different flow characteristics or includes property and roadway, then the flow time of each portion of the flow path shall be calculated separately. *Different Flow Characteristics*

7. The maximum time of concentration in an urban area shall be 20 minutes unless sufficient evidence is provided to justify a greater time.

8. 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. *Flow Paths to Pits*

9. Surface roughness co-efficients "n" shall generally be derived from information in Volume 1, Chapter 14 of AR&R. Values applicable to specific zoning types and overland flow path types are given below: *Overland Flow Retardance*

Flow across Parks	0.35
Flow across Rural Residential land	0.30
Flow across Residential (2a)	0.21
Flow across Residential (2b)	0.11
Flow across Industrial	0.06
Flow across Commercial	0.04
Flow across Paved Areas	0.01
Flow across Asphalt Roads	0.02
Flow across Gravel Areas	0.02

D5.07 OTHER HYDROLOGICAL MODELS

1. The preferred model for analysis is ILSAX. Council has chosen this model because it is public domain and requires minimum data entry, and is consistent with Council's drainage database. Other models that may be used are THSM, RORB, RAFTS, EXTRAN, WBNM94 and MOUSE, as long as the requirements of AR&R are met, summaries of calculations are provided and details are given of all program input and output. The use of these models will delay the processing of the Application since Council does not have all of these models readily available for checking.

2. Where computer analysis programs are used, copies of the final data files shall be provided on submission of the design to Council and with the final drawings after approval by Council.

HYDRAULICS

D5.08 HYDRAULIC GRADE LINE

1. Hydraulic calculations shall generally be carried out in accordance with AR&R and shall be undertaken by a qualified person experienced in hydrologic and hydraulic design. The calculations shall substantiate the hydraulic grade line adopted for design of the system and shown on the drawings. Summaries of calculations are added to the plan and detailed engineering long section. Details of all calculations are given including listings of all programme input and output. *Qualified Person*

2. **Full hydraulic calculations** will be required for all public and major piped systems (375mm dia and larger), or where it is necessary to determine the feasibility of the proposal. Stormwater drainage systems shall include piped drainage, box culverts,

open drains, drainage structures and the like. Hydraulic calculations shall include the determination of water surface profiles using hydraulic grade line analysis and/or backwater calculations. It is preferable that the hydrologic information, to be used in the analysis, be determined from the ILSAX program, although for smaller drainage systems, covering areas less than 600sqm, the Rational Method design would be acceptable.

3. The "major" system shall provide safe, well-defined overland flow paths for rare and extreme storm runoff events while the "minor" system shall be capable of carrying and controlling flows from frequent runoff events.

4. Downstream water surface level requirements are given below:-

Downstream Control

(a) Known hydraulic grade line level from downstream calculations including pit losses at the starting pit in the design event.

(b) Where the downstream starting point is a pit and the hydraulic grade line is unknown, a level of 0.15m below the surface inlet level of the downstream pit is to be adopted.

(c) 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.

(d) Where the outlet is an open channel, the design storm is the major event and downstream flood levels are not known, the top of the outlet pipe shall be the downstream control.

(e) Where the outlet is an open channel, the design storm is the major event and downstream flood levels are known, the downstream control shall be the 1% probability flood level.

5. The water surface in drainage pits shall be limited to the level of the surface inlet level for inlet pits and to the top of the lid for junction pits.

Water Surface Limits

D5.09 MINOR SYSTEM CRITERIA

1. The acceptable gutter flow widths in the 20% probability event is 2.5 metres maximum. Wider flow widths may be approved on roads with flat grades.

Gutter Flow Widths

2. Minimum conduit sizes shall be as follows:

Conduit Sizes

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

3. Minimum and maximum velocity of flow in stormwater pipelines shall be 0.6m/sec and 6m/sec respectively.

Velocity Limits

4. Pipes are to be rubber ring jointed reinforced concrete. Other types may be used at the discretion of Council. Pipes to be laid in the public road carriageway are to be laid under or in front of the kerb and gutter. Laying pipes behind the kerb or within the nature strip will not be permitted unless there is no other alternative. In which case, written approval from all service utility authorities must be provided to Council.

D5.10 PITS

1. Inlet Pits shall be spaced so that the gutter flow width is limited in accordance with this Specification and so that the inlet efficiency is not affected by adjacent inlet openings. Preference shall be given to the location of drainage pits at the upstream side of allotments.

Spacing

2. Other pits shall be provided:

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

3. The maximum recommended spacing of pits where flow widths are not critical are given in Table D5.1 below:

	Pipe Size (mm)	Spacing (m)
Generally	less than 1200	100
	1200 or larger	150
In tidal influence	all	100

Table D5.1 Pit Spacing

Inlet Capacity

4. Kerb inlet lengths to side entry pits are to be a preferred maximum of 3.0m, with an absolute maximum of 5.0m where the grade is 10% or more, and an absolute maximum of 4.0m where the grade is less than 10%.

5. Information on pit capacities is available in the following sources:-

- Roads and Traffic Authority's "Model analysis to determine Hydraulic Capacities of Kerb Inlets and Gully Pit Gratings", with due allowance to inlet bypass due to grade, for grade inlet pits, and recognised orifice or weir formulae for sag inlet pits.

- Pit relationships given in Volume 1, Chapter 14 of AR&R.

Allowance for Inlet Blockage

6. None of these pit charts include any blockage factors. The percentage of theoretical capacity allowed in relation to type of pit is given in Table D5.2 below:-

Condition	Inlet Type	Percentage of Theoretical Capacity Allowed
Sag	Side entry	80%
Sag	Grated	50%
Sag	Combination	Side inlet capacity only Grate assumed completely blocked
Sag	"Letterbox"	50%
Continuous Grade	Side entry	80%
Continuous Grade	Grated	50%
Continuous Grade	Combination	90%

Table D5.2 Allowable Pit Capacities

7. Surface inlet pits are generally to be 450 x 450 and are to be grated. Grates are to be galvanised and hinged to frame. Medium duty covers are to be used in landscaped and light trafficked areas whilst heavy duty covers are to be used in vehicular access-ways and carparks and driveways and where heavy traffic loads are expected. Smaller pit dimensions, 300 x 300 can be used where there is only minor runoff. Smaller pit dimensions may be used. However grates should not exceed 600 x 600 where possible, to allow for easier removal during maintenance.

Where pits are not designed to collect stormwater, solid concrete covers can be used. These need to be liftable for inspections and maintenance. Junction pits are not to be designed for pressurised systems.

9. Pre-cast pits and proprietary items may be used. However these must be watertight and structurally adequate for the intended loads. A manufacturer's specification may need to be provided to Council to support the use of a product.

10. Where pits are to be constructed in public areas such as on the naturestrip or kerb, these are to be standard double grated pits minimum 450 x 900 with 1.2m long (minimum) extended kerb inlets or lintels. Grates are to be weldloc type or equivalent, galvanised medium duty (for light traffic) or heavy duty (heavy traffic), hinged to frame.

D5.11 HYDRAULIC LOSSES

1. Bends may be permissible in certain circumstances and discussions with Council regarding their use is required prior to detailed design. Appropriate values of pit pressure change co-efficient at bends are given in Appendix C. ***Bend Losses***

2. Where possible design should try to avoid clashes between services. However, where unavoidable clashes occur with existing sewer mains then the pressure change co-efficient Kp shall be determined from the chart given in Council's current Handbook of Drainage Design Criteria. ***Service Entry Losses***

3. Requirements for private pipes entering Council's system are given below:-

(a) All pipe inlets, including roof and subsoil pipes, shall where possible, enter the main pipe system at junction pits. These shall be finished off flush with and be grouted into the pit wall.

(b) If a junction has to be added which is larger than 225mm then a junction pit shall be built at this location in accordance with this Specification.

(c) For smaller inlets, the drainage pipes may be broken into to allow interconnection with the main line. In this case the sideline shall be finished flush with and be grouted into the main line.

4. Construction of a junction without a structure should be avoided where possible. Permission to do this is required by Council prior to detailed design. Where this is unavoidable the pressure change co-efficients Ku, for the upstream pipe and Kl, for the lateral pipe, shall be determined from the chart given in Appendix B. ***Pipe Junction Losses***

5. Going from larger upstream to smaller downstream conduits is not permitted without approval of Council prior to detailed design. In going from smaller to larger pipes benching shall be provided in pits to enable a smooth flow transition. Losses in sudden expansions and contractions are given in Appendix D. ***Contraction/ Expansion Losses***

6. Drainage pipe systems shall be designed as an overall system, with due regard to the upstream and downstream system and not as individual pipe lengths. Drainage pipeline systems shall generally be designed as gravity systems flowing full at design discharge. Pipe friction losses and pipe sizes in relation to discharge shall be determined using the Colebrook-White formula with the acceptable roughness co-efficients being 0.6mm for concrete pipes and 0.06mm for FRC pipes. ***Pipe Friction Losses***

D5.12 MAJOR SYSTEM CRITERIA

1. Surcharging of drainage systems which would provide for water depth above the top of kerb will not be permitted except: ***Surcharging***

(a) Surcharging of drainage system for storm frequencies greater than 5% probability may be permitted across the road centreline where the road pavement is below the natural surface of the adjoining private property.

(b) Flow across footpaths will only be permitted in situations specifically approved by Council, where this will not cause flooding of private property or danger to pedestrians.

2. The velocity x depth product of flow across the footpath and within the road reserve shall be such that safety of children and vehicles is considered. The maximum allowable depth of water is 0.2 metres and the maximum velocity x depth product of $0.4m^2/s$ is permitted. Where the safety of only vehicles can be affected, a maximum velocity x depth product of $0.6m^2/s$ is permitted. In open channels the above velocity x depth product criteria will be followed where possible or the design shall address the requirements for safety in relation to children by providing safe egress points from the channel or other appropriate methods. ***Velocity/ Depth Criteria***

3. Freeboard requirements for floor levels and levee bank levels from flood levels in roadways, stormwater surcharge paths and open channels are given below: ***Freeboard***

In Roadways:-

(a) A minimum freeboard of 0.3m shall be provided between the 100 year flood level and floor levels on structures and entrances to underground car parks. A higher freeboard may be required in certain circumstances.

(b) Where the road is in fill or overtopping of kerbs and flow through properties may occur a 150mm freeboard shall be provided between the ponding level of water in the road and the high point in the footpath. Driveway construction in these instances needs to consider this requirement.

In Stormwater Surcharge Paths:-

(c) A minimum freeboard of 0.3 shall be provided between the 100 year flood level and floor levels on structures and entrances to underground car parks.

In Open Channels:-

(d) A minimum freeboard of 0.5m shall be provided between the 100 year flood level and floor levels on structures and entrances to underground car parks.

4. Road capacity charts are provided in Appendix E for some standard road designs. For other road designs, flow capacities of roads should be calculated using Technical Note 4 in Volume 1, Chapter 14 of AR&R with appropriate flow adjustment factors. ***Roadway Capacities***

D5.13 OPEN CHANNELS

1. Generally, 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. Where Council permits the use of an open channel to convey flows from a development site to the receiving water body, such a channel shall comply with the requirements of this Specification. ***Safety***

2. Design of open channels shall be in accordance with Volume 1, Chapter 14, of AR&R. Open channels will be designed to contain the major system flow less any flow that is contained in the minor system, with an appropriate allowance for blockage of the minor system.

3. Friction losses in open channels shall be determined using Mannings "n" values given below:- ***Channel Roughness***

Mannings "n" Roughness Co-efficients for open channels shall generally be derived from information in Chapter 14 of AR&R. Mannings "n" values applicable to specific channel types are given below:-

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

4. Where the product of average Velocity and average flow Depth for the design flow rate is greater than $0.4m^2/s$, the design will be required to specifically provide for the safety of persons who may enter the channel in accordance with Volume 1, Chapter 14, of AR&R..

5. Maximum side slopes on grassed lined open channels shall be 1 in 4, with a preference given to 1 in 6 side slopes, channel inverts shall generally have minimum cross slopes of 1 in 20. ***Side Slopes***

6. Low flow provisions in open channels (man-made or altered channels) will require low flows to be contained within a pipe system or concrete lined channel section at the invert of the main channel. Subsurface drainage shall be provided in grass lined channels to prevent waterlogging of the channel bed. The width of the concrete lined channel section shall be the width of the drain invert or at least sufficiently wide enough to accommodate the full width of a tractor. ***Low Flows***

7. Transition in channel slopes to be designed to avoid or accommodate any hydraulic jumps due to the nature of the transition. ***Hydraulic Jumps***

D5.14 MAJOR STRUCTURES

1. All major structures in urban areas, including bridges and culverts, shall be designed for the 100 year ARI storm event without afflux. Some afflux and upstream inundation may be permitted in certain rural and urban areas provided the increased upstream flooding is minimal and does not inundate private property. ***Afflux***

2. A minimum clearance of 0.3m between the 100 year ARI flood level and the underside of any major structure superstructure is required to allow for passage of debris without blockage. ***Freeboard***

3. Certified structural design shall be required on bridges and other major culvert structures and may be required on some specialised structures. Structural design shall

carried out in accordance with the Specification for STRUCTURES BRIDGE DESIGN.

Culverts (either pipe or box section) shall be designed in accordance with charts provided in the Appendices, with due regard being given to inlet and exit losses, inlet and outlet control and scour protection. ***Culverts***

D5.15 RETARDING BASINS

1. For each ARI a range of storm events shall be run to determine the peak flood level and discharge from the retarding basin. Storm patterns shall be those given in Volume 1, Chapter 11 of AR&R. Stacked rainfall patterns for use in hydrological computer models, such as ILSAX, are given in Council's On-site Stormwater Detention Technical Specification. Sensitivity to storm pattern should be checked by reversing these storm patterns. ***Critical Storm Duration***

2. The critical storm duration with the retarding basin is likely to be longer than without the basin. A graph showing the range of peak flood levels in the basin and peak discharges from the basin shall be provided for the storms examined.

3. Flood Routing should be modelled by methods outlined in AR&R. ***Routing***

4. The high level outlet to any retarding basin shall have capacity to contain a minimum of the 100 year ARI flood event. Additional spillway capacity may be required due to the hazard category of the structure. The hazard category should be determined by reference to ANCOLD. ***High Level Outlet***

5. The spillway design shall generally be in accordance with the requirements for Open Channel Design in this Specification.

6. Pipe systems shall contain the minor flow through the Retarding Basin wall. Outlet pipes shall be rubber ring jointed with lifting holes securely sealed. Pipe and culvert bedding shall be specified to minimise its permeability, and cut off walls and anti-seepage collars installed where appropriate. ***Low Flow Provision***

7. The low flow pipe intake shall be protected to prevent blockages.

8. Freeboard - Minimum floor levels of dwelling shall be 0.5m above the 100 year ARI flood level in the basin. ***Freeboard at Dwellings***

Public Safety Issues - Basin design is to consider the following aspects relating to public safety. ***Safety Issues***

- Side slopes are to be a maximum of 1 in 6 to allow easy egress. Side slopes of greater than 1 in 4 may require handrails to assist in egress.
- Water depths shall be, where possible, less than 1.2m in the 20 year ARI storm event. Where neither practical or economic greater depths may be acceptable. In that case the provision of safety refuge mounds should be considered.
- The depth indicators should be provided indicating maximum depth in the basin.
- Protection of the low flow intake pipe shall be undertaken to reduce hazards for people trapped in the basin.
- Signage of the spillway is necessary to indicate the additional hazard.
- Basins shall be designed so that no ponding of water occurs on to private property or roads.

- No planting of trees in basin walls is allowed.
- No basin spillway is to be located directly upstream of urban areas.
- Submission of design Drawings to the Dam Safety Committee is required where any of these guidelines are not met or Council specifically requires such submission.

STORMWATER DETENTION

D5.16 STORMWATER DETENTION

1. Installation of Stormwater Detention is required on redevelopment sites within the Council area where under capacity drainage systems exist. A redevelopment site is defined as a site which used to have or was originally zoned to have a lower density development than is proposed. ***Re-development***

2. The requirements for Stormwater Detention Design are outlined in the Council's current On-site Stormwater Detention Technical Specification.

INTERALLOTMENT DRAINAGE

D5.17 INTERALLOTMENT DRAINAGE

1. Interallotment Drainage shall be provided for every allotment which does not drain directly to its frontage street or a natural watercourse.

2. Interallotment drainage shall be contained within an easement not less than 1.0m wide , and the easement shall be in favour of the upstream allotments.

3. Pipe Capacity - The interallotment drain shall be designed to accept concentrated drainage from buildings and paved areas on each allotment for flow rates having a design ARI the same as the "minor" street drainage system.

4. In lieu of more detailed analysis, the following areas of impervious surface are assumed to be contributing runoff to the interallotment drain:- ***Impervious Area***

Development Type	% of Lot Area
• Residential Housing	40
• Medium Density	70
• Industrial	100
• Commercial	100
• Road Carriageway	70

5. Pipes shall be designed to flow full at the design discharge without surcharging of inspection pits.

6. Interallotment drainage pits shall be located at all changes of direction. Pits shall be constructed of concrete, with 100mm thick walls and floor and have a minimum 600 x 600 internal dimensions. Pits shall be with a 100mm concrete lid finished flush with the surface of works. Depressed grated inlets are acceptable. ***Pits***

7. Pipes - Minimum Grade - The interallotment drainage shall have a minimum longitudinal gradient of 1.0%. ***Grade***

8. Interallotment Drainage Pipe Standards - The interallotment drainage shall be ***Pipe Type***

constructed from rubber ring jointed pipes of either fibre reinforced concrete drainage pipe, reinforced concrete pipe, or UPVC pipe which shall conform respectively to the requirements of AS 4139, AS 4058 and AS 1254. In public road and recreation reserves where vehicle loads may be encountered, reinforced concrete pipe only, shall be used.

9. Interallotment Drainage Pipe – Relationship to Sewer Mains - Where interallotment drainage and sewer mains are laid adjacent to each other they are to be spaced 1.5 metres between pipe centrelines (where the pipe inverts are approximately equal). ***Sewer***

10. Where there is a disparity in level between inverts the spacing is to be submitted for approval.

11. Where sewer mains are in close proximity to interallotment drainage lines they are to be shown on the interallotment drainage plan.

DETAILED DESIGN

D5.18 CONDUITS

1. Conduits and materials shall be in accordance with the standards detailed in Council's Pipe Drainage Specification - C221. ***Materials***

2. Pipe bedding and cover requirements for reinforced and fibre reinforced concrete pipes shall be determined from the Concrete Pipe Association "Concrete Pipe Guide" or AS 3725 and Council's Pipe Drainage Specification – C221. For uPVC pipes, the requirements shall be to AS 2032. The minimum cover requirements for stormwater pipes in public areas are as follows: ***Bedding and Cover***

- Landscaped, turfed, naturestrip areas 450mm
- Carparks, roads and accessways 600mm

Cover over interallotment (internal) drainage systems within site boundaries may be reduced to 300mm or less where it is unlikely that there will be any loading over the pipes. Where less cover is required, approval may be given at the discretion of Council's Senior Development Engineer.

3. Pipes are to be rubber ring jointed reinforced concrete. Other types may be used at the discretion of Council. Full details are to be provided to Council if alternatives are to be considered. ***Jointing***

4. Drainage lines in road reserves shall generally be located behind the kerb line and parallel to the kerb. Drainage lines will not be permitted behind the kerb or in the pathway unless there is no other alternative, in which case, written approval from all service utility authorities must be provided to Council. Drainage lines in easements shall generally be centrally located within easements. ***Location***

5. Bulkheads shall be designed on drainage lines where the pipe gradient exceeds 5 per cent. The design details shall address the size, and position in the trench as well as spacing along the line. Bulkheads shall be installed at every third pipe joint. ***Bulkheads***

ADVICE TO THE DEVELOPER'S DESIGNER
BURIED FLEXIBLE DRAINAGE PIPES

Particular situations may be identified during the design of a development for the use of buried flexible pipes instead of the pipes specified in Council's Handbook or the AUS-SPEC Specification C221 for PIPE DRAINAGE.

In such cases, the Developer's Designer will be required to select the flexible pipe type appropriate for the particular application and prepare the relevant technical specification clauses for supply and construction with reference to AS/NZS 2566.1, Buried flexible pipelines Part 1: Structural design. The proposed additional clauses would then be submitted by the Developer, as a variation to the development consent, for approval by Council. If use is approved, then the supply and construction specification clauses shall be inserted in the Special Requirements section of the AUS-SPEC Specification C221 for PIPE DRAINAGE.

D5.19 PIT DESIGN

1. Pits shall be designed with benching to improve hydraulic efficiency and reduce water ponding. Safety and safe access are important considerations in pit design. Step irons shall be detailed where required when depth exceeds 1200mm and grates shall be of "bicycle safe" design.

D5.20 STORMWATER DISCHARGE AND CONNECTION TO PUBLIC DRAINAGE SYSTEM

Scour Protection

1. Scour protection at culvert or pipe system outlets shall be provided unless the velocity is significant and unless outlet conditions dictate the use of more substantial energy dissipation arrangements.

Kerb & Gutter Termination

2. Kerb and gutter shall be extended to drainage pit or natural point of outlet. Where outlet velocity is greater than 2.5m per second or where the kerb and gutter discharge causes scour, then protection shall be provided to prevent scour and dissipate the flow.

Easements, Adjoining Owners

3. At points of discharge of gutters or stormwater drainage lines or at any concentration of stormwater from one or on to adjoining properties, either upstream or downstream, Council will require the Developer to enter into a Deed of Agreement with the adjoining owner(s) granting permission to the discharge of stormwater drainage and the creation of any necessary easements with the cost of the easement being met by the Developer.

Other Authorities' Requirements

4. Where the drainage is to discharge to an area under the control of another statutory authority eg, Public Works, the design requirements of that Statutory Authority are also to be met.

Council Easement

5. The minimum drainage easement width shall be 3.0m for drainage systems to be taken over by Council. The overall width of the 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. Easement widths are to be in accordance with Council's "Drainage Easements and Building over Constructed Public Drainage Systems Policy":

- The minimum width of any drainage easement shall be 3 metres.

- For pipes/channels having a width greater than 1.0 metre, the drainage easement shall have a minimum width equal to external width of the pipe plus 2m, rounded to the nearest 0.1 metre.

Recreation Reserves

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

Connection to Kerb & Gutter

7. Where possible, all stormwater shall be piped or channelled to the nearest downstream formed or natural public drainage system. Internal piped discharge systems such as interallotment drains from the site may be connected to the kerb and gutter, provided that the total concentrated discharge does not exceed 20 litres per second per

outlet per 15m run of kerb and gutter for storms up to and including the 100 year ARI.

The outlet pipe leaving the site, must exit at an **acute angle of less than 45 degrees** from the boundary.

9. Council will require all concentrated stormwater runoff to be piped to the nearest public drain, or natural watercourse, with a minimum 375 mm diameter pipe, and to Council's specifications, if: ***Connection to Public Drainage System***

(i) concentrated discharge from the site to the street gutter cannot be restricted to 20 l/s at 15 m apart, and

(ii) a direct connection to the public drainage system is not available.

10. Pipe junctions are to be orientated to minimise hydraulic losses. Pits are to be located at changes of direction, at property boundaries, and connection to the public drainage system. Where pits cannot be used, suitable transition structures may be accepted at Council's discretion. ***Pipe Junctions***

11. Where an outlet pipe is to be connected to a standard 150 mm high kerb and gutter, and is greater than 100 mm in diameter (or there is less than 50 mm cover over the pipe), the following structures will be required: ***Structures***

(i) minimum 450 x 450 grated converter pit to be constructed inside the boundary of the property, and

(ii) between the converter pit and the kerb and gutter, laying galvanised steel rolled hollow rectangular sections to the following requirement:

- 100 dia outlet pipe - use 1 x 100 mm x 100 mm x 6 mm thick RHS
- 150 dia outlet pipe - use 1 x 200 mm x 100 mm x 6 mm thick RHS
- 225 dia outlet pipe - use 2 x 200 mm x 100 mm x 6 mm thick RHS.

12. The use of two 100 mm diameter pipes with a minimum cover of 50 mm set 150 mm apart, may be used instead of the 150 mm diameter pipe provided that the twin 100 mm diameter pipes can carry the design flows and have no hydraulic impact on the discharge from the detention system. Full hydraulic calculations will be required to be submitted.

NOTE: No other allowance will be considered, especially for twin 150 mm pipes into a 200 mm high kerb and gutter, or multiple outlets of more than two pipes.

13. The absolute minimum grades are: ***Minimum Grades***

- 3.0 % for pipes less than 225 mm diameter, or
- % for pipes greater than 225 mm, or
- 0.5% for concrete lined box culverts formed insitu

D5.21 TRENCH SUBSOIL DRAINAGE

1. Subsoil Drainage shall be provided in pipe trenches as follows:

In cases where pipe trenches are backfilled with sand or other pervious material, a 3m length of subsoil drain shall be constructed in the bottom of the trench immediately upstream from each pit or headwall. The subsoil drain shall consist of 100mm diameter agricultural pipes, butt jointed with joints wrapped with hessian, or slotted PVC pipe. The upstream end of the subsoil drain shall be sealed with cement mortar, and the downstream end shall discharge through the wall of the pit or headwall.

DOCUMENTATION

D5.22 DRAWINGS & DETAILS TO ACCOMPANY CONSTRUCTION CERTIFICATE

1. Catchment Area Plans shall be drawn to scales of 1:500, 1:4000 or 1:25000, unless alternative scales are specifically approved by Council and shall show contours, proposed and existing floor levels to Australian Height Datum (AHD), direction of grading of kerb and gutter, general layout of the drainage system with pit locations, dimensions and areas of the site including existing and proposed roof and paved areas, catchment limits and any other information necessary for the design of the drainage system. ***Catchment Areas***

2. The Drainage System Layout Plan shall be drawn to a scale of 1:500 and shall show any existing and proposed drainage pipeline diameter and location, drainage pit location, overland flow paths, points of discharge(s), and number and road centreline chainage, size of opening and any other information necessary for the design and construction of the drainage system. ***Drainage System Layout***

3. The plan shall also show all drainage easements and details of pipeline connections to downstream easements, reserves and natural water courses. The plan may be combined with the road layout plan.

4. The Drainage System Longitudinal Section shall be drawn to a scale of 1:500 horizontally and 1:50 vertically and shall show pipe size, class and type, pipe support type in accordance with AS 3725 or AS 2032 as appropriate, pipeline and surface levels and road chainages, pipeline grade velocities, hydraulic grade line and any other information necessary for the design and construction of the drainage system. All services are to be checked and shown on drawings. All services are to be checked and confirmed on site prior to any excavation work. Prior contact is to be made with the "Dial 1100 before you dig" service to determine utility service requirements and locations. For internal or minor drainage systems, invert levels, design surface levels, flows, pipe sizes, class and grades shall be shown. ***Longitudinal Section***

5. Open Channel Cross Sections shall be drawn to a scale of 1:100 natural and shall show the direction in which the cross sections should be viewed. Reduced levels are to be to Australian Height Datum (AHD), unless otherwise approved by Council where AHD is not available. Cross sections may alternatively be provided on 3.5 inch dia floppy disk in HEC2 format as a data input file for the design flow rates. ***Open Channels***

6. Details including standard and non-standard pits and structures, pit benching, open channel designs and transitions shall be provided on the Drawings to scales appropriate to the type and complexity of the detail being shown. ***Details***

7. Final drawings to be submitted showing all the relevant details of the OSD system and associated works and to be signed and certified by a suitably qualified and experienced Engineer, who has membership to the Australian Institution of Engineers or a Registered Surveyor or designer approved by Council. ***Work-as-Executed Drawings***

D5.23 EASEMENTS AND AGREEMENTS

1. Evidence of any Deed of Agreement necessary to be entered into as part of the drainage system will need to be submitted prior to any approval of the engineering Drawings. Easements will need to be created prior to the issue of the subdivision certificate in accordance with Council's "Drainage Easements and Building over Constructed Public Drainage Systems Policy".

2. Where an agreement is reached with adjacent landowners to increase flood levels on their property or otherwise adversely affect their property, a letter signed by all the landowners outlining what they have agreed to and witnessed by an independent person shall be submitted prior to any approval of the engineering Drawings.

D5.24 SUMMARY SHEETS

1. A copy of a Hydrological Summary Sheet providing the minimum information is required. ***Hydrology***

2. A copy of a Hydraulic Summary Sheet providing the minimum information is required. ***Hydraulics***

D5.25 COMPUTER PROGRAM FILES AND PROGRAM OUTPUT

1. Computer program output may be provided as long as summary sheets for Hydrological and Hydraulic calculations in accordance with this Specification are provided with plans submitted for checking and with final Drawings.

2. Copies of final computer data files, for both hydrological and hydraulic models shall be provided for Council's data base of flooding and drainage information in formats previously agreed with Council on 3.5 inch dia floppy disks..

SPECIAL REQUIREMENTS

D5.26 CONSTRUCTED WORKS

1. On completion of the Works, the system must be certified by a **suitably qualified and experienced Engineer, who has membership to the Australian Institution of Engineers or Registered Surveyor**, with Works-as-Executed drawings supplied to Council in respect of:

(i) Compliance with the Development Application (DA).

(ii) Intended purpose of the stormwater system and storage structure, and that the structure has been designed to comply with all relevant Australian Standards and Codes.

(iii) The Works have been constructed in accordance with the approved drawings. Where 'approved drawings' are those that bear Council's or the PCA's approval stamp. The Certification shall read "I have carried out all inspections necessary to declare that the work nominated in drawing No.-----, have been carried out in accordance with the approved plans and specifications, and the conditions of development consent and that the system functions hydrologically and hydraulically as intended for the purpose of the design and in accordance with the Specification". Such certification shall be signed and dated.

(iv) The Works-as-Executed drawings submitted to Council are also to include all relevant levels, reduced to Australian Height Datum and locations including:

- invert levels,
- surface or pavement levels,
- floor levels including adjacent property floor levels, if required,
- maximum water surface level for 100 year ARI storm,
- hydraulic grade line (where applicable)
- dimensions of basin(s), tank(s), pit(s), etc. (where applicable),
- location of basins and distances from building and boundaries (where applicable),
- pipe sizes, grades, design flow rates,
- set-out of pits and drainage structures.

2. If the Applicant chooses to have an Accredited Certifier prepare the Construction Certificate, then certification of the Works must be provided by the Accredited Certifier including submission of Works-as-Executed drawings in respect of the above points 1 to 4. A copy of the Works-as-Executed drawings must be lodged for Council's records.

D5.27 RESERVED

D5.28 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D6

SITE REGRADING

CONTENTS

DEVELOPMENT DESIGN SPECIFICATION D6 - SITE REGRADING

GENERAL

D6.01 SCOPE

1. This Design Specification sets out requirements for the site regrading involved in land development and subdivision. Conceptual requirements are presented as necessary considerations when preparing designs for site regrading.

Familiarity with other Specifications Required

2. The scope of this Specification assumes that the Designer is familiar with requirements cited in the various construction specifications, specifically those related to earthworks, clearing and grubbing, erosion and sedimentation. Additionally the Designer needs to make reference to the associated design specifications related to stormwater drainage design, geometric road design and erosion control and stormwater management.

D6.02 OBJECTIVES

1. This Specification aims to assist the Designer in achieving:

- efficient and economical design
- enhancement of the environmental character of the site whilst maintaining the natural features of the site *Environmentally Sound*
- provision of safe conditions for construction commensurate with the proposed purpose of the development *Safe for Construction*
- equality of building conditions for residential development
- a minimal impact on adjoining properties and developments. *Impact on Adjoining Properties*

D6.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

Construction Specifications

C211	-	Control of Erosion and Sedimentation
C212	-	Clearing and Grubbing
C213	-	Earthworks
C273	-	Landscaping

Design Specifications

D1	-	Geometric Road Design
D5	-	Stormwater Drainage Design
D7	-	Erosion Control and Stormwater Management

(b) Australian Standards

AS 3798	-	Guidelines on earthworks for commercial and residential developments
AS 2870.1	-	Residential slabs and footings - Construction

D6.04 SITE REGRADING CONCEPT

1. Areas of a site proposed for building or recreational purposes may not be suitable in their natural state for their intended function without improvement works to:

(a) Alleviate flooding of low-lying ground

(b) Fill gullies or create emergency flowpaths after underground stormwater piping has been installed

(c) Allow improved runoff from flat ground

(d) Regrade excessively steep slopes that would preclude economical construction of dwelling foundations

(e) Allow effective recreational use or give reasonable access

The Designer shall review the natural surface contours and where necessary shall design finished surface levels that ensure the land is suitably prepared

2. Where practical, areas should be regraded to minimise the necessity for underground drainage systems with surface inlet pits, and allow surface water to flow naturally to roads or drainage reserves without excessive concentration. ***Drainage***

3. The Designer shall consider the implications of site regrading in relation to the existing natural environment. Generally site regrading shall be minimised in heavily treed areas. ***Natural Environment***

4. Care shall be taken to provide depressions for overland flow from low points and over major drainage lines, to direct stormwater for storms up to a 100 year average recurrence interval (ARI). ***Overland Flow***

5. The design of site regrading areas in conjunction with the design of roadworks shall be considered with the objective of balancing cut to fill and achieving both an economical development and minimising haulage of imported fill or spoil to and from the development site. Bulk haulage should always be considered an adverse effect on adjacent development, and infrastructure. ***Minimal Road Haulage***

D6.05 SPECIAL TREATMENT OF PARTICULAR AREAS

1. In the event that an area is known to be affected by or inundated by local stormwater flows, the Designer shall investigate the existing conditions as they relate to the proposed development and advise the Developer in the preliminary design report on all data obtained in the investigation and recommend appropriate contour adjustments. The report should normally be accompanied by sketch plans to clarify recommendations. ***Inundation Areas***

2. Site constraints either natural or otherwise may be required to be identified as a burden on developed property. It is recommended that the Designer take this into account when preparing the design. The property may ultimately be affected by a "restriction as to user", which may be controlled by a legal 88B Instrument placed on title to the land and/or by a Section 149 message advising prospective purchasers of any restrictions affecting the land. ***Restrictions on Land Use***

3. The finished surface of filled areas shall be designed to levels allowing an ***Piped Gullies***

adequate cover depth over the pipeline (if piped) and permitting surface stormwater flow to be guided to inlet pits if depressions are retained in the finished surface contouring. *or Depressions*

4. The location of such features shall be clearly defined on the site regrading plans and defined by distance to corner boundaries, monuments, etc for purposes of relocation at the geotechnical testing stage for work as executed Drawings. A geotechnical report specifying the site specific preparation and compaction requirements will be required to be incorporated with the site regrading plan. A description of the minimum acceptable quality of the fill shall also be specified on the plans, supported by geotechnical recommendations. All documentation necessary from various authorities to support the filling of dams and watercourses shall be supplied with the Drawings. *Dams and Water Courses*

5. The finished level of any building area shall be designed to ensure a desirable surface grading of 1.5% (1% minimum) oriented in the direction of the nearest street drainage system designed to cater for its catchment. *Flat Ground*

6. Building areas containing natural ground slopes of an excessively steep nature, ie greater than 15% shall be brought to the attention of a Geotechnical Engineer for investigation of compatibility with dwelling types proposed. Specific requirements shall be noted on the Drawings. Please note: there are steep slope stability hazard areas within Council's area. Consultation with Council is recommended in regard to works within these areas. *Steep Slopes*

D6.06 GENERAL STANDARD OF LOT PREPARATION

1. Special requirements will apply where necessary but generally lots are to be cleared of low scrub, fallen timber, debris, stumps, large rocks, concrete, steel and any trees which in the opinion of Council are approaching the end of their functional life or are dangerous or will be hazardous to normal use of the development. Prior consultation with Council's Tree Preservation Officer is necessary. Such requirements shall be shown on the Drawings. *Clearing*

2. All timber and other materials cleared from lots shall be removed from the site. All roots, loose timber, etc which may contribute to drain blockage shall be removed. Such requirements shall be shown on the Drawings. *Disposal*

3. Selected trees shall be preserved by approved means to prevent destruction normally caused by placement of conventional filling or other action within the tree drip zone. The Tree Preservation Officer shall be consulted for advice and all specific requirements noted on the Drawings. *Preservation of Trees*

D6.07 STANDARD OF FILL FOR LOTS

1. The following notations are to be incorporated in the Construction Specifications: "Filling is to be of sound clean material, reasonable standard and free from large rock, stumps, organic matter and other debris." "Placing of filling on the prepared areas shall not commence until the authority to do so has been obtained from the Council". *Drawing Notations*

2. All work shall be in accordance with AS 3798. Fill is to be placed in layers not exceeding 150mm compacted thickness. All fill is to be compacted to 95% standard maximum dry density. Maximum particle size shall be 2/3 of the layer thickness. *Fill Quality*

3. Fill comprising natural sands or industrial wastes or by-products may only be used after the material type and location for its use is approved by Council and will be subject to specific requirements determined by prevailing conditions. *Restricted Fill*

4. It is essential that prior advice be given of intended use of such materials. It should be noted that failure to obtain Council's approval may lead to an order for removal of any material considered by Council or other relevant authorities as unsuitable or in any way unfit for filling. *Prior Approval*

5. All areas where filling has been placed are to be dressed with clean arable topsoil, fertilised and sown with suitable grasses. This work shall be carried out in accordance with the Construction Specification for LANDSCAPING. ***Top Dressing***

D6.08 TEMPORARY DIVERSION DRAINS

1. Where temporary drains are required to divert surface flows away from the site regrading area, the location and silt/erosion control treatment shall be clearly identified on the Drawings. The scale of such works shall reflect the volume of water to be diverted. ***Silt/Erosion Control***

The objective will be to ensure minimal soil disturbances and material loss off the site.

Control measures will include, but not be limited to:

(a) Provision of trench stops every 30m along a trench, with provision for overtopping to be directed to the kerb.

(b) Placement of "blue metal" bags along kerb and gutter at maximum 30m spacings.

(c) Placement of "blue metal" bags around downstream drainage pits.

The requirements identified in the Design Specification for EROSION CONTROL AND STORMWATER MANAGEMENT should be addressed for any additional requirements.

D6.09 CONCURRENCE WITH THE ENVIRONMENTAL PROTECTION AUTHORITY (EPA)

1. The Designer is recommended to refer to the EPA with regard to any items requiring specific consideration when preparing a site regrading plan. Such plans may need to incorporate sediment/siltation/erosion control devices with specific reference to the stage at which these are to be provided. The responsibility shall rest with the Designer/ Developer to make enquiries with EPA and subsequently obtain Council approval to proposed measures. ***Specific Considerations***

D6.10 WORK AS EXECUTED DRAWINGS

1. The Designer shall annotate on the site regrading plan, the site specific detail to be shown on the Work-as-Executed Drawings. Such detail shall include geotechnical report certifying the works to be suitable for the intended purpose and any other certifications, testing and survey data, as required in this Specification. ***Site Specific Details***

D6.11 CARTAGE OF SOIL

1. The Designer shall refer to Council for acceptable haul roads with applicable load limits. This detail shall be required to be shown on the site regrading plan. The payment of a Bond may be required by the Developer/Contractor where Council has some concern about the ability of a haul road to sustain the loads without undue damage or maintenance requirements. ***Possible Bond Requirement***

2. Unless specific application is made to Council and approval obtained, the plans will be annotated as follows: ***Topsoil***

"All topsoil shall be retained on the development site and utilised effectively to encourage appropriate revegetation."

ʲ.12 EFFECT ON ADJOINING PROPERTIES

1. Where it is proposed to divert or direct piped stormwater into adjoining properties, drainage easement rights are to be created over the adjoining lots in accordance with the Specification for STORMWATER DRAINAGE DESIGN. *Stormwater Easement*

2. A written agreement shall also be sought to carry out construction work on adjoining properties and all such agreements are to be submitted to Council. *Construction Agreement*

SPECIAL REQUIREMENTS

D6.13 RESERVED

D6.14 RESERVED

D6.15 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D7

EROSION CONTROL AND STORMWATER MANAGEMENT

CLAUSE CONTENTS PAGE

EROSION CONTROL AND STORMWATER MANAGEMENT

GENERAL

D7.01 SCOPE

1. Virtually all construction activity which requires the disturbance of the soil surface and the existing vegetation, naturally predisposes the construction site to erosion. This in turn leads to sediment loss in the resultant run-off water. ***Erosion***

2. Since such soil disturbance is a necessary part of development, it is essential therefore to develop measures which reduce the erosion hazard of any particular construction activity. Having done that, it is necessary to control run-off water, which carries the sediment, in such a way as to reduce the amount of that sediment leaving the site to an acceptable level. ***Reduce Sedimentation***

3. After construction is complete and the site fully rehabilitated, permanent water quality control structures and features commence their role. These include trash racks, gross pollutant traps, wet retention basins and the creation of, or increase in size of wetlands. ***Water Quality***

D7.02 AIMS

1. Limit/minimise the amount of site disturbance. ***Site Disturbance***

2. Isolate the site by diverting clean upstream "run-on" water around or through the development where possible. ***Diversion Works***

3. Control runoff and sediment movement as its point source rather than at one final point. ***Point Source***

4. Stage earthworks and **progressively revegetate** the site where possible to reduce the area contributing sediment. This in turn increases the efficiency and effectiveness of the entire sediment control system while decreasing the number and size of controls required. ***Progressive Revegetation***

5. Provide an effective major stormwater system economical in terms of capital, operational and maintenance costs, incorporating water quality controls. ***Major Stormwater***

6. Retain topsoil for effective revegetation works. ***Topsoil***

7. Locate sediment control structures where they are most effective and efficient. ***Sediment Structures***

D7.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Documents and Specifications

DQS - Quality Assurance Requirements for Design
D5 - Stormwater Drainage Design
C211 - Control of Erosion and Sedimentation
C273 - Landscaping
Guidelines for Sediment and Erosion Control, May 1994.
Northern Beaches Stormwater Management Plan, July 1999.

(b) NSW State Legislation

Protection of the Environment Operations Act, 1997
Dams Safety Act, 1978
Soil Conservation Act, 1938
Water Act, 1912

(c) ACT Government Publications

Design Manual for Urban Erosion and Sediment Control - July 1988
"Protecting the Murrumbidgee from the Effects of Land Development"
"Guidelines for Erosion and Sediment Control on Building Sites"
Implications for Building Construction
Pollution Control on Residential Building Sites (Brochures)
Field Guide - Erosion and Sediment Control
Australian Journal of Soil and Water Conservation - Vol 3, Number 1

(d) State Authorities

NSW Department of Housing
- Managing Urban Stormwater, Soils and Construction, 3rd Ed. Aug. 1998.

Roads and Traffic Authority
- Erosion and Sedimentation Design Considerations.

Soil Conservation Service
- Erosion and Sediment Control - Model Policy and Code of Practice (Discussion Paper).

NSW Department of Land and Water Conservation (DLWC)
- Urban Erosion and Sediment Control.

State Environmental Planning Policy No.14 - Coastal Wetlands.

D7.04 PLANNING AND CONCEPT DESIGN

Site Characteristics

1. Assess the physical characteristics and limitations of soils, landform and drainage of the site and plan the subdivision accordingly.

Concept Design Submission

2. A concept design for soil and stormwater control shall be submitted with the development application to Council for all developments. This will assist in assessing the impact of the development on the site.

D7.05 DETAILED DESIGN

Site Specific

1. After development consent is given, an erosion and sediment control/water management plan shall be submitted to Council as part of the detailed engineering design. This plan shall give all details for erosion, sediment and pollution controls and shall be site specific and not a generalisation of erosion control philosophy. It may also form part of the contract specifications for a contractor to comply with during construction.

2. Detailed engineering designs shall include scaled drawings (no larger than 1:1000) and detailed specifications/diagrams which can be readily understood and applied on site by supervisory staff. All Drawings shall be in accordance with the minimum drafting requirements in the Specification for QUALITY ASSURANCE REQUIREMENTS FOR DESIGN.

ems to be included, but not limited to, shall be:

- existing and final contours
- the location of all earthworks including roads, areas of cut and fill and re-grading
- location of access haulage tracks and borrow pits
- location and design criteria of erosion and sediment control structures
- location and description of existing vegetation
- proposed vegetated buffer strips and "no access" areas
- location of critical areas (vegetated buffer strips, drainage lines and structures, water bodies, unstable slopes, flood plains and seasonally wet areas)
- type and location of diversion works to direct uncontaminated run-on around areas to be disturbed
- revegetation program
- procedures for maintenance of erosion and sediment control
- details for staging of works

3. No site works shall commence prior to approval of the detailed engineering design. All works are to be carried out in accordance with the approved erosion and sedimentation control/water management plan. Its implementation must be supervised by personnel with appropriate qualifications and/or experience in soil conservation on construction sites. ***Approval***

4. The erosion and sedimentation control/water management plan and its associated control measures shall be constantly monitored, reviewed and modified as required, by the Developer, to correct any deficiencies. Council has the right to request changes if, in its opinion, the measures that have been put in place are inadequate. ***Additional Works***

5. If required, examples of proposed subdivisions detailing locations of water quality structures, sediment and erosion control devices may be obtained from Council and used as a guide when preparing an erosion and sedimentation control/water management plan. ***Example Design***

EROSION CONTROL

D7.06 BUFFER ZONES

1. Buffer zones are corridors of vegetation adjacent to waterways or disturbed areas. The vegetation filters suspended solids and reduces the nutrient levels in run-off. Wetlands, stream and rivers adjacent to construction sites shall be protected by buffer zones. ***Filters***

2. Buffer zone performance increases as catchment area and slope gradient decreases. Thirty-metre-wide buffer zones generally provide adequate protection. ***Performance***

Slope %	Buffer Width in Metres
2	15
4	20
6	30
8	40
10	50
12	60
14	70

3. Buffer zones can reduce the need for other erosion and sediment control measures. However, contaminated water in a concentrated form will require treatment both at its sources point and final disposal. ***Contaminated Water***

4. A fence shall be used to exclude traffic from buffer zones to prevent damage to the vegetation, particularly during any construction phase. ***Fencing***

D7.07 "NO ACCESS" AREAS

1. It is Council's Policy to conserve as much existing vegetation in new developments as possible. ***Conserve Vegetation***

2. The landscape plan shall incorporate as much existing native vegetation as possible.

3. The "no access" fence locations shall be shown on the detailed engineering design. These locations will be approximate only as machinery type, topography etc will determine actual on site location. ***No Access***

4. Fenced areas shall be clearly signposted "No Access Area".

D7.08 DIVERSION WORKS

1. Diversion works may be in the form of earth drains and banks, haybales, sand bags or even pipelines and may be permanent or temporary. ***Diversion Types***

2. Such techniques are used to divert the upstream run-on water around the site. Such flows shall discharge to a formal drainage point or open areas where level spreader banks should ensure a broad water spread. ***Discharge Point***

3. Pipelines may also be used to convey such run-on through the development site, and discharge the flow to a formal drainage point/dissipater if necessary. Such pipelines may also form part of the overall final drainage system. ***Pipelines***

4. Design of the diversion system should suit the following:-

   (a) The drain should preferably be dish shaped with batter grades of less than 2:1 ***Drain Shape***

   (b) If a piped system is selected its design capacity shall be a minimum of the capacity nominated in the Specification for STORMWATER DRAINAGE DESIGN. ***Pipe Capacity***

5. Diversion works are designed to carry peak flows at non-erosive velocities in bare soil, vegetated or lined drains/banks. ***Peak Flows***

6. Generally, the channel should be lined with turf. However, where velocities are designed in excess of 2m per second, non erosive linings such as concrete, geotextiles, grouted rock etc or velocity reducers (check dams etc) are required. ***Non-Erosiv Linings***

Typical arrangements of diversion drains and banks are shown in Figure D7-1.

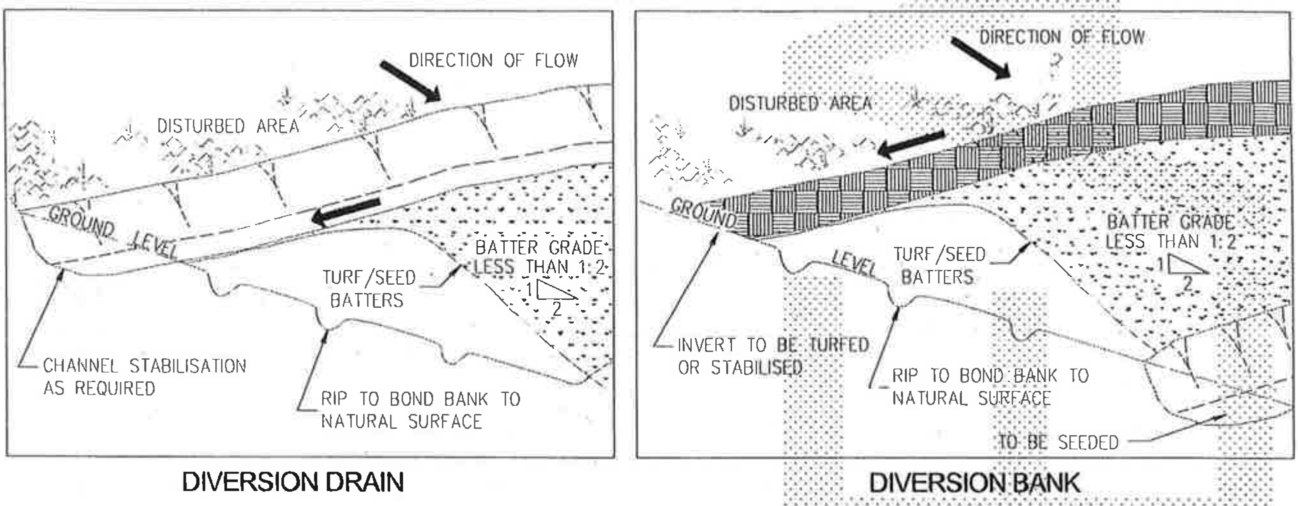


Figure D7-1 - Diversion Drains/Banks

D7.09 DROP DOWN DRAINS

1. These are temporary or permanent drains which divert concentrated run-off down slopes such as road batters without causing erosion. They usually consist of a dished earth drain smoothly shaped, consolidated and lined with a variety of materials or they may be a flexible/rigid pipe or half pipe. ***Lined Drains***

2. Drop down drains consisting or rigid, or flexible, pipes are very effective as a temporary measure during road construction used in association with an earth windrow (or bund wall) along the top edge of the batter. Run-off flowing along the windrow is directed to the pipe by which water is conveyed down the batter. It is a simple matter to extend the pipe as the batter rises. ***Piped Drains***

3. Drop down drains shall have sufficient capacity for a minimum 1 in 5 year peak flow without eroding. Energy dissipators may be required to reduce the flow velocity at the outlet of the drop down drain. ***Capacity***

D7.10 STOCKPILES

1. Location of stockpiles shall be indicated on the approved engineering Drawings.

2. Stockpile sites shall be located within the development site: ***Location***

   (a) Clear of existing or proposed drainage lines.
   (b) Clear of areas likely to be disturbed during construction.
   (c) Clear of the drip zone of trees.
   (d) Preferably on reasonably flat areas.
   (e) So that there will be no spill over to Council's footway or roadway or reserve land or drainage system.

3. Stockpiles must be protected from erosion and sediment loss by: ***Erosion Protection***

   (a) The installation of diversion works.

   (b) The use of silt fences, haybales etc or other approved controls on the downstream side.

   (c) Compaction.

   (d) Revegetation if left exposed for longer than 30 days (refer to the Construction Specification for LANDSCAPING for seed mix).

4. Site topsoil shall be isolated from subsoil material in separate stockpiles. ***Separate Stockpiles***

D7.11 SEDIMENT BASINS/TRAPS/DAMS

1. Sediment traps are either permanent or temporary sediment control devices that intercept sediment and run-off usually at the final discharge point of the site. ***Sediment Control***

2. They are formed by excavation and/or by constructing embankments. ***Construction***

3. There are two types, wet and dry basins. ***Types***

4. Preferably sediment traps shall not be located directly upstream of residential areas. ***Location***

5. Basin design must meet the following: ***Design Criteria***

   (a) Volume/capacity of the trap shall be $250m^3$/ha of disturbed site including the building areas.

   (b) An allowance of $50m^3$/ha is required if diversion controls are not used to direct clean upstream water from outside the site away from construction areas.

   (c) The capacity shall be measured below the invert of the lowest incoming flow. Otherwise pipelines and associated works will be affected.

   (d) A secondary or emergency stabilised spillway must be provided to prevent overtopping of the structure. This shall be directed to a safe overland flow path.

   (e) The basin shall have a minimum of 0.5 metres freeboard above the level of the spillway.

   (f) The basin shall be surrounded by a manproof fence with lockable gates.

   (g) An all weather access must be provided to the basin for maintenance.

   (h) The basin shall have an arbitrary length to width ratio of between 2 and 3:1. This encourages soil particle settlement. The entry and exit points should be located at the opposite ends of the basin.

   (i) If this is not possible some form of approved baffles shall be installed to minimise short circuiting of the flow.

   (j) Discharge of the basin shall be via a perforated riser encapsulated by a filter device for a dry basin. Wet basins shall be flocculated by dosing with gypsum and pumped.

(k) Internal basin batters shall be a maximum of 3:1 and external batters a maximum of 2:1.

(l) All disturbed areas including batters shall be topsoiled and seeded.

6. Permanent wet basin designs slightly vary from the above. Refer to the Stormwater Management Section of this Specification. ***Permanent Wet Basins***

D7.12 SEDIMENT TRAPS/ BARRIERS FOR MINOR CATCHMENTS

1. These are silt retention/filtering structures of a temporary nature used in situations where the catchment does not exceed 0.5ha. ***Filtering Structures***

2. Such sediment traps/barriers generally consist of: ***Barrier Types***

(a) silt fences

(b) hay bales

(c) “blue metal” groynes/sausages

(d) filter fabric located beneath stormwater grates

(e) gabions

(f) or a combination of the above.

3. The choice of material and type of treatment will depend on the size of the catchment the location and the structure being treated such as: ***Location of Structure***

(a) surface inlet pits

(b) kerb inlet pits

(c) catch drain disposal areas

(d) culvert inlets and outlets

(e) minor construction/earthwork sites

(f) check dams/velocity reducers etc.

D7.13 LEVEL SPREADERS

1. Level spreaders are outlets or "sills" having a level cross section. They convert erosive channelised flows into non-erosive sheet flow. ***Convert Flows***

2. Level spreaders can only be used to dissipate flows from small catchments. The area below the outlet should be stable and of even cross section so that the water will not re-concentrate into channels. ***Location***

3. To reduce flow velocity before the spreader, the channel grade shall not exceed 1 per cent for a minimum of 8 metres. The outlet or "sill" width depends on contributing catchment, slope and ground conditions. The minimum width should be four metres, and the maximum width 25 metres. Final discharge should be over a level surface, which may require stabilising by turfing or seeding and fertilising or perhaps lining with a geotextile fabric or something similar. ***Design Criteria***

D7.14 THE LOCATION OF SHAKEDOWN AREAS AND ACCESS STABILISATION

1. Access to construction sites shall be limited to a maximum of two locations. ***Number of Accesses***

2. Such access locations shall require Council approval. ***Location Approval***

3. Shakedown areas or access stabilisation shall comprise a bed of aggregate on filter cloth or a metal bar cattle grid located at any point where traffic enters or leaves a construction site. Stabilised accesses reduce or eliminate tracking of sediments onto public rights of way or streets. Should such tracking occur the contaminants must be swept off the road way each day or before rain. Clean off draw bars etc after dumping and before starting journey. ***Types***

4. If a shaker grid is used, this should be so placed as to ensure the vehicles when crossing the grid have sufficient speed to "shake the mud" or other contaminants such as gravel from the vehicle. It must not be placed where the vehicle is slowing to enter a roadway. Cattle grids shall be a minimum length of 7 metres. ***Cattle Grid***

5. A stabilised access comprises a vehicular pathway suitably constructed to facilitate the collection of any site debris in order to prevent such material leaving the site. Stabilised accesses are generally used on small sites. The entrance shall be at least 15 metres long with a minimum width of 3 metres for a one way entrance and 6 metres for a two way entrance. ***Stabilised Access***

6. Surface water within the site shall not flow to the street as sheet flow. The water must be collected in a sediment trap and piped under thefootpath to the street gutter, or a berm constructed to direct surface flow away from the exit. ***Flow Control***

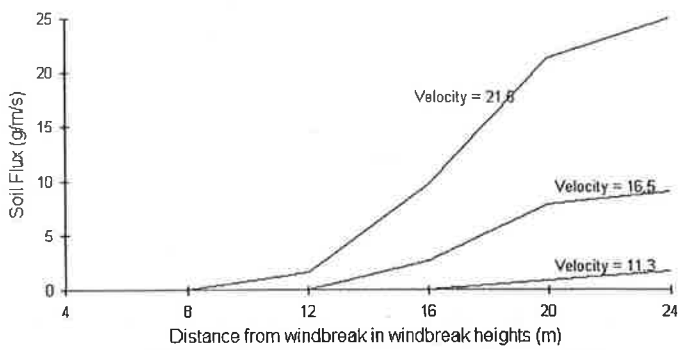
D7.15 WIND EROSION/DUST CONTROL

1. Research has demonstrated average dust emission rates of over 2½ tonnes per hectare per month at urban construction sites. This erosion rate is unacceptable. ***Erosion Rate***

2. Various measures are available to minimise such emissions, including:- ***Treatments***

   (a) limiting the area of lands exposed to erosive forces through phasing works/progressive revegetation and/or provision of a protective ground cover and/or keeping the ground surface damp (not wet); and/or

   (b) on building sites, installing a barrier fence on the windward side - effective to a distance of 15 times its height, assuming an acceptable soil flux of 5 grams per metre per second. See Figure D7-2.



Effect of distance from windbreak on soil loss, wind blowing at less than 90 to the windbreak.

Figure D7-2 - Pollution Control

7.16 REQUIREMENTS FOR BUILDING SITES

1. The clearing of vegetation and preparation of building pads is to be undertaken in the last stages of the development when the majority of the site has been effectively revegetated. ***Site Clearing***

2. When the development calls for the construction of a number of buildings, the sediment trap/s and other appropriate sediment controls shall remain operational. ***Development Control***

3. Cross/catch drains shall be installed on long or steep unpaved driveways, disposing run-off to stable areas. ***Driveway Control***

4. Where a majority of the lot is disturbed the following controls or measures shall be undertaken: ***Lot Control***

   (a) Silt fences, located around the downstream sides of the lot.

   (b) Sediment traps/barriers to be provided to all on-site and adjacent stormwater inlets.

   (c) Only one site access to be provided. This may require treatment to prevent soil being tracked from the site.

   (d) All subsurface drainage for roofing must be in place prior to the installation of the roof and gutter so downpipes can be immediately connected.

D7.17 EXTERNAL SITE REQUIREMENTS

1. Sediment control devices or stabilising works shall be provided outside construction sites where necessary or as directed by the Superintendent. ***Necessary Controls***

2. Where increased stormwater run-off is likely to accelerate erosion of any downstream watercourse, the necessary remedial work shall be provided concurrently with other sediment and erosion requirements. ***Accelerate Erosion***

3. Where sediment is likely to be transported from the site, all immediate downstream drainage inlets shall have appropriate controls installed. ***Downstream Controls***

4. If such works require entry onto private property, written permission shall be obtained prior to the entry and commencement of such works. ***Written Permission***

5. All disturbed areas on private property to be reinstated to original condition and to the satisfaction of the owner. ***Reinstated***

STORMWATER MANAGEMENT

D7.18 GENERAL

1. Most developments mean a change in land use and is usually accompanied by a decline in stormwater quality. This applies to the long term as well as during the short term construction phase. The main components required to enhance stormwater quality are as follows:- ***Main Components***

(a) Buffer Zones and Filter Strips, being grassed, or similarly treated areas to facilitate the natural assimilation of water pollutants and reduce run-off.

(b) Gross Pollutant Traps (GPT) designed to intercept litter and debris to maintain visual quality in downstream waterways, and to reduce the coarse sediment load on downstream water management structures.

(c) Wet Retention Ponds are permanent sediment ponds designed to allow particulate matter to settle out. They operate under both sedimentation and macrophyte regimes. Note that a large proportion of nutrients adhere to the sediments, and therefore settle out. Other nutrients are removed by macrophytic vegetation as part of the food chain.

(d) Wetland (Nutrient) Filter to enhance the removal of fine sediment and nutrients from stormwater run-off, and are largely dependent on biochemical removal mechanisms (ie, nutrients taken up as part of the plant food chain).

2. Excess nutrients (N,P) lead to eutrophication of waterways. This can cause uncontrolled growth of algae, water weeds etc, which can deplete oxygen levels, kill resident flora and fauna, and reduce recreational appeal. However waterways do have a natural capacity to assimilate nutrients in small to moderate amounts as initial flows have. ***Excess Nutrients***

3. It is essential to treat the "first flush" of stormwater as these initial flows from urban areas have relatively high pollutant loads. Such heavy pollution results from significant areas of impervious surfaces which do not assimilate pollutants such as dust, fertilisers, pesticides, detergents, etc to the same extent as occurs in more rural environments. ***First Flush***

D7.19 WET RETENTION BASINS/PONDS

1. Basins designed for water quality control should maximise the extent of settling. In general quiescent conditions and infiltration should be maximised. ***Maximise Infiltration***

2. A wet retention basin can be located either on-line or off-line as shown in Figure D7-3. Its capacity however needs to be considerably greater if it is located on-line. The wet retention basin usually has some form of energy dissipation at the inlet or a sufficient length-to-width ratio (greater than 2:1) to prevent short circuiting of flow across the pond, although its shape may vary considerably. The pond may vary in size, but it usually has a minimum surface area of about 1 per cent of the total catchment area. At a depth of 2.5 metres, this provides a storage volume approximately equal to the maximum total run-off from a 1 in 1 year storm. Basins may be installed as smaller multiple units (in series) or as large single units. ***Location and Size***

Basin Efficiency

Other design guides that will make the basin efficient in removing particles and provide for public safety, include the following.

(a) The minimum depth should be not less than 1.5 metres with an average depth of 2.5 metres. This discourages macrophyte growth in the deeper portions of the pond and also the breeding of mosquitos.

(b) The basins should have side slopes of approximately 1 in 8. This provides for safety and encourages microphyte growth around edges facilitating nutrient uptake.

(c) The maximum velocity through the pond based on a 1 in 1 year storm should not exceed 0.3 metres per second (at 2.5 metres depth, this is the maximum practical flow velocity at which optimum sediment removal can be achieved).

(d) A minimum freeboard of 0.3 metres should be provided between a restricted discharge outlet for the pond and a storm overflow weir. This discharge outlet should be designed so that the weir overtops on average three times per year.

(e) Inlet and outlet structures should be located at extreme ends of the basin, with short circuiting of flow further minimised by the use of baffles.

Construction and Maintenance

4. Basins should be constructed prior to the commencement of any site clearing or construction works, and should be de-silted when the level of sediment reduces the average water depth to less than 1.5 metres.

Outlet Design

5. (a) It may be desirable for the designer of an urban retention basin to incorporate an outlet device that enables dewatering of the basin. This simplifies de-silting, enabling earthmoving equipment to be used for de-silting operations.

Access Track

(b) An all weather access track shall be provided to the basin for maintenance works.

Trash Racks

6. It is generally necessary to incorporate a gross solids trap and trash rack facility on major discharges into the retention basin. This prolongs the life of the basin and prevents the accumulation of litter.

Buffer Zones

7. Basins should be surrounded by buffer zones, typically comprising grassed foreshores of not less than 20 metres between the nearest development and the basin. This allows for some infiltration of drainage from developments, permits the drainage authority scope to develop aesthetic surrounds and reduces the likelihood of over the fence dumping of rubbish.

Particle Settling

8. The settling velocity of particles should service as the basis for design. This, of course, can only be found by conducting standard settling tests or from a knowledge of local soil characteristics. The surface area of the required basin can then be determined from design settling velocities (Randall et al 1982).

Basin Classification

9. Wet retention basins are regarded as impoundments and normal dam safety requirements should be met. A dam may be prescribed under the Dams Safety Act, 1978, depending on the recommendations of the NSW Dams Safety Committee. A dam is normally prescribed if it is:

(a) metres or more in height and has a storage capacity of more than 20 megalitres; or

(b) metres or more in height and has a storage capacity of 50 megalitres or more.

Dam Safety Committee

10. If the wet retention basin is a prescribed dam, the Dams Safety Committee will maintain an interest in the dam, will seek information from its owner and will require that reports be prepared on the dam and submitted to the Committee.

D7.20 TRASH RACKS

1. Trash racks are usually permanent structures which intercept trash and other debris to protect the aesthetic and environmental quality of water. Where appropriate, construct them upstream of all permanent retarding basins and/or wetlands which have a capacity greater than 5,000 cubic metres, and elsewhere as required by Council. ***Environmental Quality***

2. Generally, their design criteria should ensure:- ***Design Criteria***

   (a) vertical bar screens with bar spacing of 65mm clear;

   (b) the length of the rack is consistent with the channel dimension and cause minimal damage when overtopped;

   (c) they are as large as practicable while considering all other design criteria - a maximum height of 1.2 metres is suggested;

   (d) a structure which remains stable in at least the 20 year ARI event, and is unlikely to cause flooding on adjacent lands as a result of the rack becoming completely blocked in the 100 year ARI event (analysis should include investigation of backwater effects and any consequent flooding);

   (e) the structure drains by gravity to a dry condition; and

   (f) adequate access for maintenance and which permits the use of mechanical equipment.

3. Where associated with outlet structures for small sediment basins or constructed wetlands, they can be relatively simple in design. ***Associated Structures***

4. Trash racks may be incorporated in the design of gross pollutant traps. ***Gross Pollutant Trap***

5. Trash racks shall be checked periodically and all debris and silt removed. ***Maintenance***

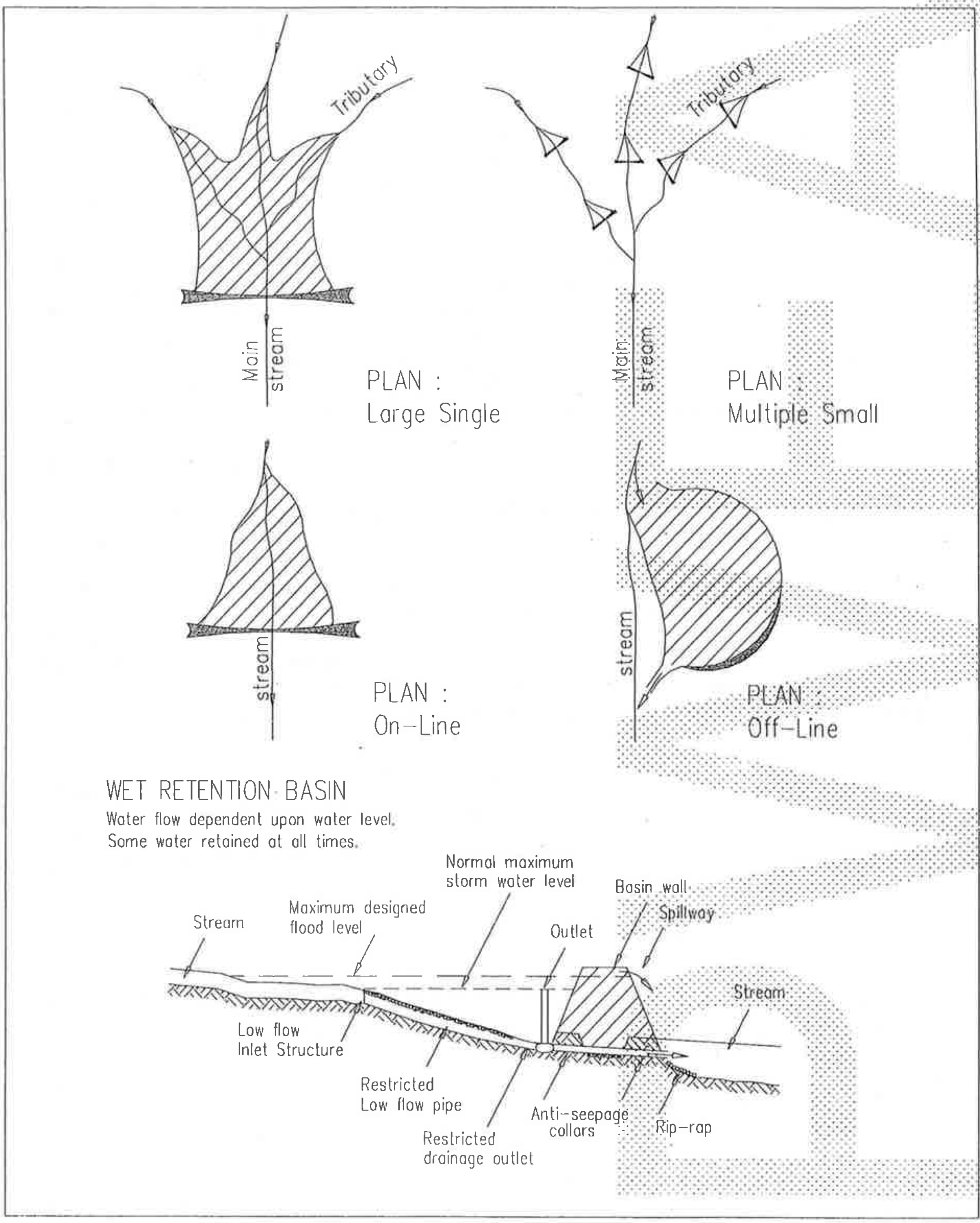


Figure D7-3 - Configuration and Design of Wet Retention Basins

D7.21 GROSS POLLUTANT TRAPS

Description

1. Gross pollutant traps (GPTs) are permanent structures used to trap coarse sediments, trash, litter, and other floating materials. Usually, they are located upstream of constructed wetlands and receiving waters. They consist of an energy dissipater at the upper end, concrete sediment trap and trash rack at the lower end. Sometimes a "mini" wetland is incorporated at the downstream end.

Applications

2. These traps have restricted application and each should be justified on individual merits. They have high construction costs and are generally unable to trap silt and clay sized particles other than in relatively small storm events (eg, one year ARI, critical duration storm event). Nevertheless, in some specialised situations their use might be justified, especially where a significant proportion of the bed load consists of particles coarser than 0.04mm (sandy soils) and/or where their construction/maintenance cost can be justified when compared with more conventional sediment retention basins.

Definition

3. GPTs can be defined as major or minor:

(a) major gross pollutant traps can be located on major floodways and waterways to intercept medium to high flows; and

(b) minor, enclosed gross pollutant traps can be located at heads of major floodways and/or where stormwater discharges into floodways or water bodies.

Sediment Interception

4. Design traps to intercept at least 75 per cent of sediment with a grain size of 0.04mm or greater under average annual runoff conditions. Further, ensure peak flow velocities are less than 0.3 metres per second in the 1 year ARI storm event, and taking into account any likely backwater effect from a blocked trash rack.

Capacity

5. The structure should have sufficient capacity and stability to discharge the inlet flow with the trash rack fully blocked without flooding adjacent properties.

Maintenance Requirement

6. Ensure GPTs are capable of gravity drainage to a dry condition for periodic cleaning and maintenance if at all possible.

D7.22 WETLANDS

Depth and Batters

1. Wetlands used for improvement of urban run-off quality can be either natural or artificial. They necessarily have to be shallow. Growth of emergent aquatic plants (reeds, etc) should be encouraged by using sideslopes of very low gradient (1 in 8 or less). A large percentage (greater than 25 per cent) of any permanent water should be less than 1 metre deep. The remainder of any open water should have a depth of not greater than 2 metres which will allow submerged plant growth. Figure D7.4 shows a typical wetland arrangement.

SEPP No 14

2. Where wetlands are natural, the provisions of State Environmental Planning Policy No 14 - Coastal Wetlands, should be consulted. This policy protects wetlands from clearing, construction of levees, draining and filing, but does not prevent wetlands being used for run-off control, provided safeguards and operation control ensures their continued viability.

Efficiency

3. Wetlands, like retention basins, operate more effectively when higher contact time between the pollutants and the biota of the wetland is provided. Thus, like retention basins, wetlands will be more efficient when used in conjunction with upstream flow retardation basins that will maintain run-off closer to pre-development levels.

Water Levels

4. A structure should be included to allow manipulation of water levels in the wetland. This will enable control of microphyte, insect populations and facilitate dredging.

Where possible, small islands or shoals should be constructed in the upstream areas of the wetland to reduce water velocities, prevent short circuiting and promote aquatic plant growth. ***Short Circuiting***

6. The performance and life of wetlands, like wet retention basins, will suffer if they are not protected from trash and large particles. It is therefore recommended that trash racks/gross sediment/pollution traps be installed upstream of the wetland. ***Wetland Protection***

7. Wetlands need to be surrounded by a buffer at least 20 metres wide in order to:- ***Buffer Zones***

(a) Restrict access to maintenance vehicles by the installation of an all weather track with a lockable device.

(b) Acts as an infiltration area for surface run-off.

(c) Provide flood protection and secondary assimilation of pollutants.

8. These areas are best planted with vegetation native to the area, but they can be used as grassed areas and an aesthetic feature. ***Native Vegetation***

9. Work in the ACT indicates rates of removal of phosphorous and particles in wetlands are higher than for wet retention basins. ***Results***

10. In designing wetlands, it is recommended that, as an interim guide, the surface area of the wetlands be a minimum of 0.5 per cent of the catchment which it serves. If wetlands are used in conjunction with wet retention basins, this percentage can be proportionately lowered by allowing for the surface area of the installed wet retention basin. ***Surface Area***

11. In open water zones, rooted emergent macrophytes appear to be more efficient than substrate microphytes (plants that are attached to the bottom of the water but which do not emerge). This is because the emergent aquatic plants act as an oxygen pump, taking oxygen from the atmosphere into their roots and eventually into the water and so making it available for bacteria and attached algae which grow on the roots on the emergent plants. In the crushed rock zones, emergent aquatic plants are the only types of macrophytes that will grow. These plants will also act as oxygen pumps, and facilitate biological uptake of nutrients and the breakdown of organic matter by bacteria which grow on their roots. ***Microphyte Types***

12. A variety of plant species should be planted in artificial wetlands to achieve efficient colonisation and maximise pollutant removal. Establishment of plants should be through transplantation of seedlings during spring and early summer. ***Revegetation***

13. Wetlands will serve other purposes than just improving a quality of urban run-off. They will serve to attract a large range of biota and bird habitat. In areas where they have been installed, they have become an aesthetic feature. Indeed, this may present problems as surrounding communities may resist efforts by the controlling authority to de-silt the wetland. ***Aesthetic Feature***

14. To minimise mosquito problems, limit expanses of water with more than 50 per cent shading and ensure no sections of water become isolated from the main body. ***Insect Problems***

15. Islands are highly beneficial as wildlife refuges, especially for birds. Their design should consider the effects on changes in water tables. ***Wildlife Refuge***

16. Stock ponds with selected native fish to improve the water quality (not for sport), especially species which will control mosquito larvae and select zooplankton in preference to phytoplankton. Avoid use of fish which are bottom feeders. ***Native Fish***

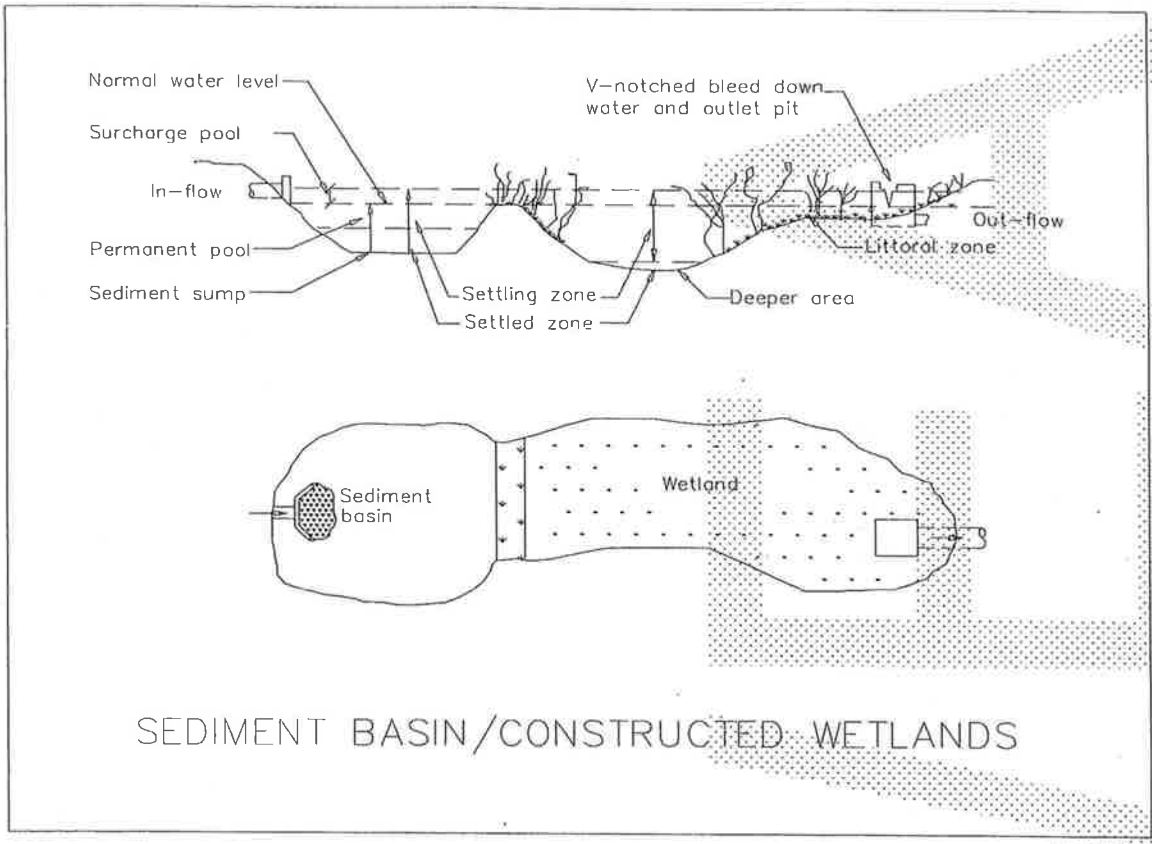


Figure D7-4 - Sediment Trap/Constructed Wetland

SPECIAL REQUIREMENTS

D7.23 WETLANDS MAINTENANCE MANUAL

1. For wetland that will be dedicated to Council for care, control and management, a comprehensive maintenance manual shall be prepared by a suitably qualified person and lodged with Council prior to issue of a final compliance certificate.

D7.24 RESERVED

D7.25 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D8

WATERFRONT DEVELOPMENT

DESIGN SPECIFICATION D8
WATERFRONT DEVELOPMENT

CLAUSE CONTENTS PAGE

DEVELOPMENT DESIGN SPECIFICATION D8
WATERFRONT DEVELOPMENT

GENERAL

D8.01 SCOPE

1. The work to be executed under this Specification consists of the design of waterway facilities and structures for canal type subdivisions to meet the requirements of Council and the Department of Public Works and Services.

2. This Specification provides specific requirements related to developments that include water frontages to natural waterways or include the development of artificial waterways. The requirements set out for design in this Specification are to be considered supplementary to the requirements of Council's other design specifications.

D8.02 OBJECTIVE

1. This Specification aims to provide both guidelines and requirements for Designers of developments that include water frontage. The requirements and guidelines seek to ensure waterfront development that is environmentally sound and avoids major commitments to future maintenance and restoration.

D8.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

D1 - Geometric Road Design
D3 - Structures and Bridge Design

(b) Australian Standards

AS 2870.1 - Residential slabs and footings - Construction
AS 3798 - Guidelines on earthworks for commercial and residential developments.

(c) NSW State Legislation

Rivers and Foreshores Improvement Act No.20, 1948-1965

(d) State Authorities

PUBLIC WORKS DEPARTMENT, NSW.
- Canal Subdivisions: General Conditions and Guidelines: Reference Document (1989).
- Floodplain Development Manual. Report PWD86010 (1986).
- Design Guidelines for Wharves and Jetties. Report No. 88062 (1990).
- Boat Launching Ramp Guidelines. Report No. PWD78024 (1985).
- Marina Guidelines. Report No. 87054 (1985).

DEPARTMENT OF PLANNING, NSW.
- Canal Estate Development: Planning guidelines Discussion

Paper (1989).
- Canal Estate Developments: Design Guidelines (1991).

NSW FISHERIES, NSW
- Guidelines for Canal Estate Developments. Advisory Note 3.84.

SOIL CONVSERVATION SERVICE, NSW
- Urban Erosion and Sediment Control. Technical Handbook No.2 (1978).

NSW GOVERNMENT
- A Greenhouse Strategy for New South Wales: Discussion Paper (1990).

AUSTRALIAN WATER AND COASTAL STUDIES
- Greenhouse Seminar Notes (1990).

D8.04 CONSULTATION

1. Consultation with public authorities is necessarily more comprehensive in the case of waterfront developments. Design proposals shall not be considered by Council until all relevant approvals from public authorities have been obtained. Relevant public authorities include: ***Public Authority Approval***

- The Department of Public Works and Services, NSW (DPWS)
- NSW Fisheries
- Waterways Authority
- National Parks and Wildlife Services (NPWS)
- The Department of Land and Water Conservation.

D8.05 GENERAL REQUIREMENTS

1. There are general requirements pertinent to waterfront development which are applied by Council or other public authorities. These requirements include: ***Flood Levels***

- No adverse effect to flood levels in the area.
- No adverse effect to erosion or deposition conditions within the existing environment. ***Erosion***
- Revetment walling is to be located with the property boundary. ***Siltation***
- Rivers and Foreshores Improvement Act No. 20 1948-1965.

D8.06 LAND RECLAMATION

1. A detailed foundation investigation shall be carried out by a qualified practising geotechnical engineer to determine the long term bearing capacity of the site. The investigation shall include the bearing capacity of the in-situ and fill components of the foundation. It shall predict the settlement of the finished surface through time (without structural loading). The foundation investigation shall specify any procedures or provisions to ensure that the foundation performance of the site will be suitable for the proposed types of site development in accordance with AS3798. ***Fill Bearing Capacity***

2. Before any allotments can be sold to the public, a certificate shall be issued by a ***Geotechnical***

qualified practising geotechnical engineer, attesting that the site has achieved the desired standard of performance and each site is to be classified in accordance with AS 2870.1.

Certification for Allotments

Foundation Design

3. The design of structural foundations should be carried out by a qualified practising structural engineer to ensure compatibility with the inherent foundation properties of the proposed site.

CANALS

D8.07 PLANNING CONCEPTS

Appearance

1. Consideration should be given to design of artificial waterways which are more natural in appearance than conventional rectilinear key type canal developments, exhibit superior mixing and tidal exchange performance and which permit straightforward maintenance. See Figure D8.1 for typical layout.

Positioning Parks

2. The location of parks and reserves within the development should be judiciously selected. Location of parks and reserves at the head of canals is desirable.

Canal Depth

3. Depths shall be kept as shallow as possible, consistent with navigation and other requirements, in order to maximise tidal flushing and mixing by wind action.

Moorings

4. The factors involved in selection of water depth for navigation and mooring areas are as follows:

- draught of boat
- underkeel clearance (UKC)
- allowance for sedimentation.

5. Water quality within canals must be such that the following are not adversely affected:

- occasional swimming and wading
- boating
- passive recreation
- visual aesthetic acceptability
- freedom from excessive plant and algal growth
- the maintenance of a complete aquatic faunal community.

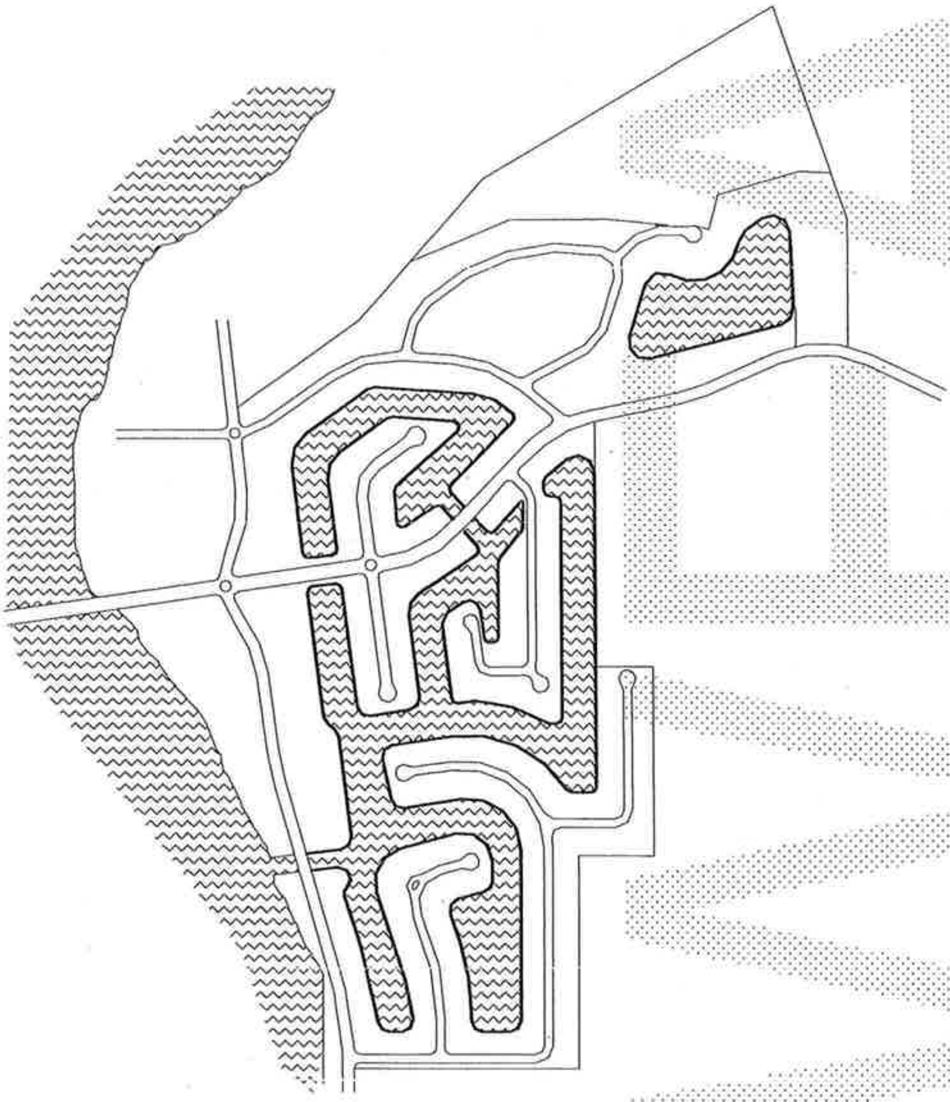


Figure D8.1 Typical Layout

Source: Planning Workshop 1994 (Consultants)

D8.08 PLAN GEOMETRY

Waterway Mixing and Exchange

1. Wherever possible, the design of the canal development should incorporate the following factors to promote optimal mixing and exchange:

- provision of bends and meandering canals, and elimination of poorly flushed pockets and coves;
- provision of additional tidal prism at the head of canals by creation of a lake or basin;
- provision of multiple entrances to produce flow-through currents;
- inclusion of artificial islands and roughness elements to enhance local circulation.

D8.09 WATERWAY DEPTHS

Entrance Depth

1. Canal centre depths shall not exceed the depth available in the host waterbody at the canal entrance(s).

2. Canal centre depths throughout the canal system shall be uniform or graded towards the canal entrance(s).

Navigable Depths

3. Depths should be sufficient for safe navigation by craft likely to use the waterway, except in non navigable areas which may be set aside for creation of wetland habitats.

Preferred Maximum Depth

4. A maximum canal depth of 2 metres is preferred. Depths in excess of 3 metres below Indian Spring Low Water will not be accepted unless detailed studies are undertaken to satisfy DPWS that water quality problems will not arise.

Allowance

5. Suitable allowance shall be made for sedimentation and bank stability in establishing the design canal depth.

D8.10 WATERWAY (CANAL) WIDTHS

Width Definition

1. Two measurements for canal width can be distinguished:

- navigation width: width of canal at the navigation depth
- overall canal width: width of canal between the top of the revetment walls.

These two canal widths are shown in Figure D8-2 for a typical "Dry Beach" canal cross-section.

Navigable Widths

2. The navigation widths for Main Canals and Side Canals shall be sufficient for safe navigation by two-way and one-way boat traffic respectively, taking into account the size of craft likely to use the waterway. Minimum navigation widths shall be as follows:

Main Canal	5 x B_{max} or 20m whichever is the greater
Side Canal	3 x B_{max} or 15m whichever is the greater

Where B_{max} is the maximum beam of the craft likely to use the waterway.

Where any structures or moored craft encroach into the navigation width, a clear distance of 5 x B_{max} and 3 x B_{max} shall be provided in Main Canals and Side Canals respectively, measured between structures or craft moored on opposite sides of the canals.

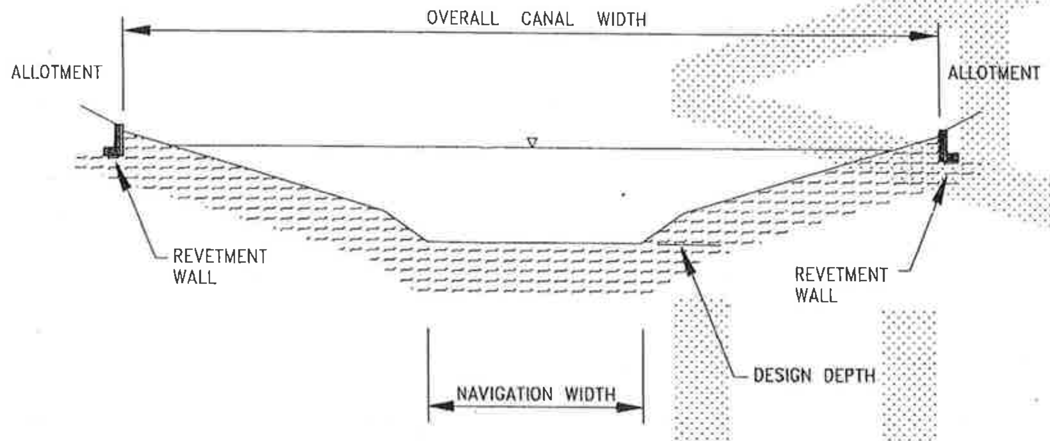


Figure D8.2 Typical Beach Cross Section

3. The navigation width of the entrance channel shall be sufficient for safe navigation by craft likely to use the waterway taking into account the degree of exposure of the entrance, but shall not be less than 25m.

4. The overall width of any canal shall not be less than 50m. ***Minimum Overall Width***

5. The DPWS may require that the overall width of canals be increased above the minimum value where it is considered that such widening is necessary to improve mixing and flushing characteristics.

6. Determination of the navigation and overall canal widths shall take into account bank and bed stability considerations.

D8.11 WATERWAY LENGTH

1. Determination of the design canal length(s) shall take into account the following main factors:

- flushing and water quality considerations
- bank and bed stability
- boat travel times.

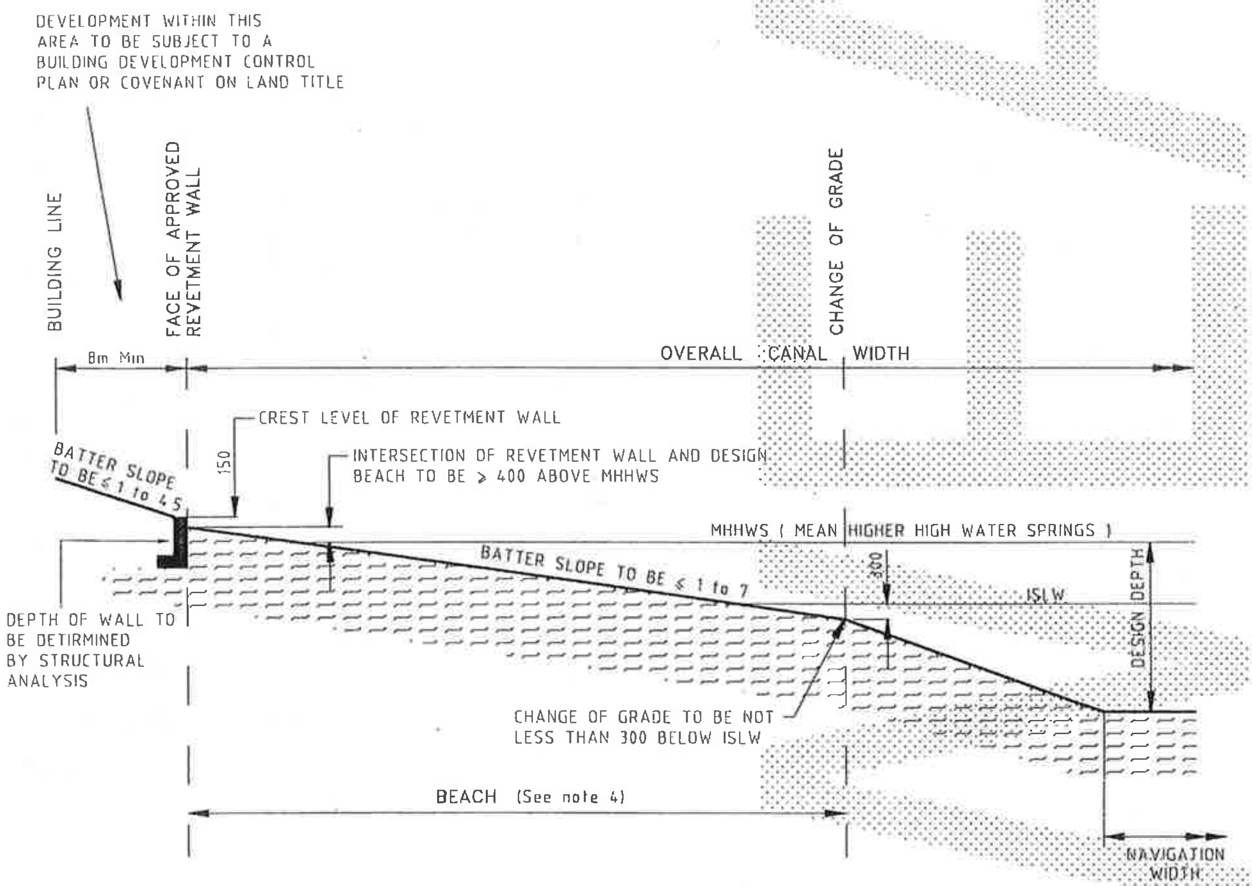
2. The maximum distance from the host waterbody to the end of the canal(s) shall not exceed 1 kilometre unless studies are undertaken which establish that water quality will be satisfactory. ***Maximum Canal Length***

D8.12 WATERWAY CROSS SECTIONS

1. The canal cross-section and edge treatment shall be designed in accordance with sound engineering practice by a qualified civil engineer, taking into account the type of soil conditions, the likely range of water levels including long term variations, and the applied forces. Engineering studies demonstrating the adequacy of the canal cross-sections and edge treatment shall be made available to the PWD. ***Engineering Studies***

2. The canal cross-section design should conform in principle with the design cross- ***Alternatives***

...ections shown in Figure D8.3 however, alternative designs will be considered.



NOTES:

1. Revetment wall to incorporate kerb and gutter detail to prevent runoff over wall onto beach
2. Design of revetment wall to allow for a minimum of 300 erosion in front of wall
3. Revetment wall shown schematically only
4. Beach to comprise a minimum 600 thickness of clean sand approved grain size and to a minimum width of 7.5m
5. All underwater batter slopes subject to engineering investigation
6. Building line to be specified by Council
7. Diagram not to scale

Figure D8.3
No Beach Submerged Cross Section

Source: Public Works Department 1992

D8.13 UNDERWATER BATTERS AT CANALS AND SHORELINES

1. The typical ranges of stable underwater batters for different types of material are designated in Table D8-1.

Table D8-1
Effect Of Material Type On Underwater Batter

MATERIAL	STABLE UNDERWATER BATTER		
Stiff Clay		1 : 1.5	
Firm Clay	1 : 2	to	1 : 4.5
Sandy Clay	1 : 4	to	1 : 7
Coarse Sand	1 : 3	to	1 : 6
Fine Sand	1 : 5	to	1 : 10
Mud	1 : 8	to	1 : 50

Stormwater Outlets

2. Stormwater outlets into beach type canals are to be submerged in the canal waters.

Beach Material

3. Use of coarse granular materials for beach formation, eg. gravels and cobbles, may cause problems in the form of oyster and barnacle growth.

D8.14 ENTRANCES

Engineering Studies

1. The DPWS requires that the proponent adequately demonstrate, by engineering studies, the impact of the physical processes within the host waterbody on the entrance design, and conversely the impact of the entrance design on these processes. These impacts should be considered in the context of establishing:

- entrance location
- number of entrances proposed
- entrance alignment
- entrance dimensions
- the need for flow control structures (eg, weirs or one-way flow devices) if there is more than one entrance.

Navigation

2. For navigable entrances, the width and depth of the entrance shall be sufficient for safe navigation by craft likely to use the waterway.

Width

3. The entrance navigation width shall not be less than 25m.

Depth

4. The entrance depth shall not exceed the depth available in the host waterbody.

Bed Stability

5. Determination of entrance dimensions shall take into account bank and bed stability considerations.

The entrance dimensions shall be kept to the minimum practical, consistent with navigation and other requirements, in order to maximise tidal flushing performance and potential for ebb tide scour of any sediments deposited at the entrance. *Tidal Flushing*

7. In selecting the entrance location(s) for the canal system, the following factors should be taken into account: *Entrance Locations*

- areas of naturally occurring sedimentation should be avoided;
- areas which would require construction of long access channels, subject to infilling, should be avoided, except where infilling rates can be accurately quantified and be shown to be manageable. Such channels can also act as a sediment "sink" in terms of the sediment budget of the host waterbody and lead to erosion problems;
- the entrance should be sheltered from excessive wave action and strong currents.

8. Significant flushing and water quality benefits can be derived from construction of more than one entrance to a canal development. The additional entrance may be navigable or non-navigable. *Second Entrance*

The alignment of the entrance influences the trajectory of the flood tide currents itering the development, which in turn affects the extent of flood tide penetration and pattern of internal circulations. These factors are important in establishing the degree of flushing under tidal action and hence water quality.

10. Consideration of the alignment of the entrance relative to the host waterbody is also important for several reasons: *Alignment*

- possibility of flow diversion
- safe navigability
- introduction of debris into the canal development.

11. The factors involved in selection of water depth for the entrance channel are as follows: *Depth Selection*

- draft of boat
- underkeel clearance (UKC)
- allowance for sedimentation.

HYDRAULICS

D8.15 STORMWATER MANAGEMENT

1. The DPWS requires that the Developer adequately demonstrate that the proposed method of stormwater management will not adversely affect water quality within the canal development and host waterbody, or lead to problems associated with siltation and erosion. Figure D8.4 is a typical solution for stormwater management. *Water Quality*

2. The canal allotment shall be graded to ensure as much runoff as possible is directed to the street where it may be collected and then directed into the canals through properly designed stormwater outlets. The preferred system of stormwater discharge is by means of a "drowned outlet" constructed below beach level, incorporating suitable scour protection.

3. Wherever practical, stormwater outlets shall be located at points of maximal flushing, or directly within the host waterbody. *Flushing*

Stormwater outlets shall not be located at the heads of dead-end canals. *Outlets*

5. Runoff towards the canals from the slope behind the revetment wall shall be intercepted prior to flowing over the revetment wall onto the beach, and otherwise directed into the canal waters without causing beach erosion. The preferred method of collection is by means of a kerb and gutter arrangement incorporated into the revetment wall, with flows then directed via pipework into the canal to discharge below anticipated lowest low water level. ***Runoff***

6. Suitable allowance for sedimentation near stormwater outlets shall be made in the design of the canal cross-section and/or access made available for future maintenance dredging.

7. Suitable temporary sediment control devices shall be installed during the construction phase to ensure that sedimentation within the canal system is minimised and sedimentation does not occur within the host waterbody. ***Sediment Control***

D8.16 FLOOD CONTROL STRUCTURES

1. Flood control structures usually include a system of canals and weirs which are to be approved by the DPWS. Usually detailed designs for flood control structures are commenced only after the overall canals and flood structures have been mathematically and physically modelled and approved by the DPWS and Council. Preliminary plans are usually prepared as part of a "flood study" which involves modelling procedures. ***Modelling*** ***Flood Study***

2. Designs must ensure that the proposed works and any raising of the land will not result in any significant increase in flood levels in the area.

D8.17 TIDAL INFLUENCES

1. The level of study of tidal hydraulics necessary to adequately demonstrate the impact of the proposed development on tidal hydraulics, and the effects of the tidal hydraulics on the development, is dependent on a number of factors. It is important that the proponent seek early consultation with the DPWS.

2. It is likely that detailed studies, involving mathematical and/or physical modelling, will be necessary where it is proposed that the canal subdivision development have more than one entrance, where an understanding of internal tidal circulations is important, or where the development is located within the entrance reach of the host estuary and would involve significant changes to the frictional and shallow water controls on tidal propagation. ***Modelling***

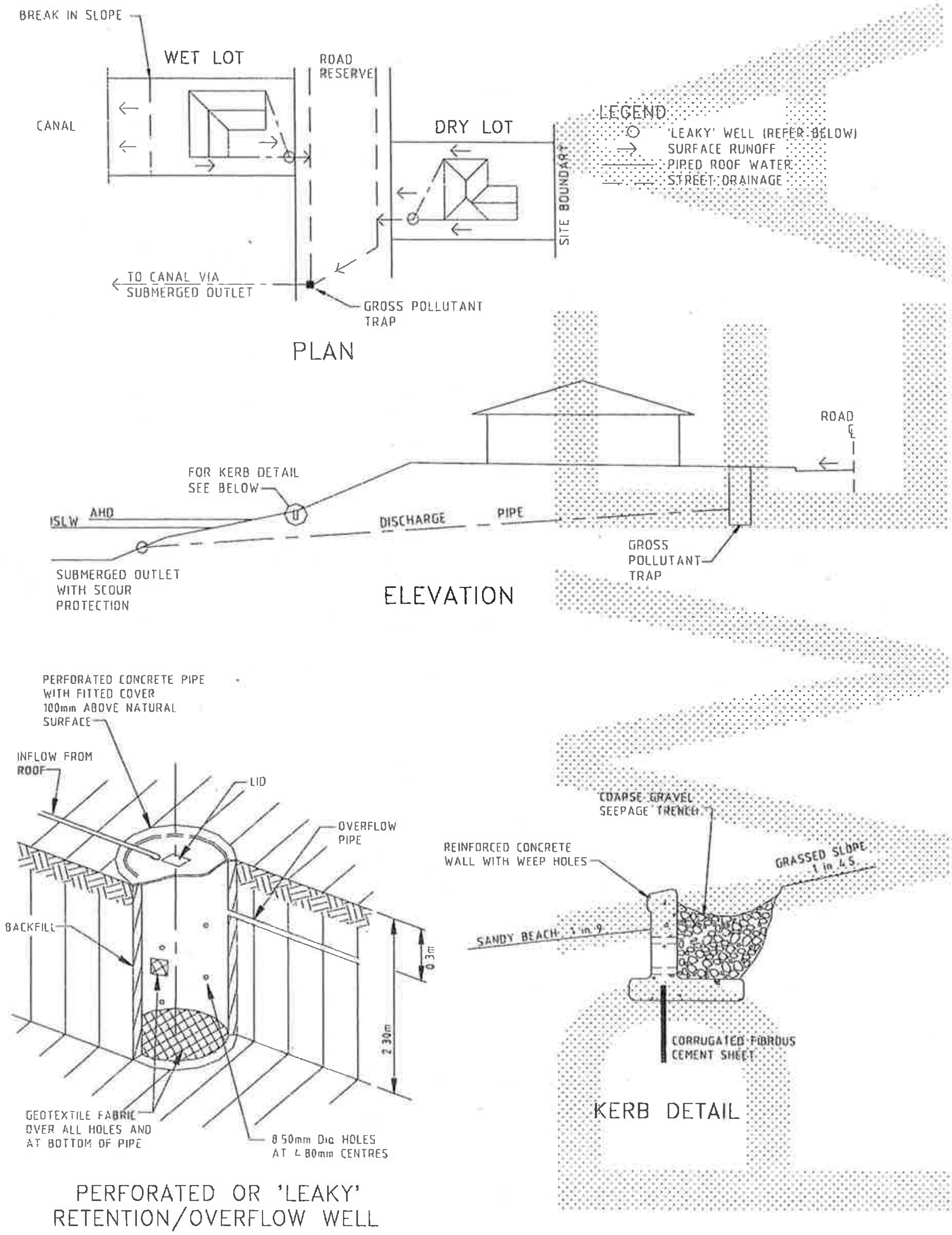


Figure D8.4
Typical Stormwater Management

Source: Planning Workshop 1994
(Consultants)

3. The Developer shall assess variations in the tidal characteristics of the host estuary at the development site taking into account cyclic and long term changes in: estuary shoaling and scour, entrance stability, hydrologic input, mean sea level, and any engineering works (such as large scale estuary dredging, entrance works, or other canal subdivisions) proposed or approved by the various government authorities. The implications of these changes to the design and functionality of the canal subdivision shall be established and accommodated. ***Tidal Characteristics***

4. The Developer shall establish the tidal levels at the proposed development site. These levels may be based on existing information supplied by the DPWS, where available, or measurements undertaken on behalf of the Developer by a suitably qualified surveyor or civil engineer. ***Tidal Levels***

5. There is no minimum acceptable tidal range below which canal developments would not be considered. The degree of tidal flushing will however reduce as tidal range decreases, and this effect must be considered in the water exchange and mixing studies required by the DPWS and outlined elsewhere in the guidelines. ***Tidal Range***

D8.18 WATER QUALITY INFLUENCES

1. Consideration should be given, where practical, to enhancement of water circulation and/or exchange by the following additional means: ***Water Circulation***

- provision of an additional entrance(s), not necessarily navigable
- provision of additional tidal prism by creation, for example, of a lake or basin at the head of the canal(s)
- provision of bends, curves and island features
- elimination of poorly flushed dead-end canals, pockets and covers
- alignment of the canals in the direction of prevailing winds
- mechanical assistance.

2. There would appear to be benefit in aligning canals in the direction of prevailing winds if this is possible, providing the canals are not too long, in order to maximise mixing and exchange processes. ***Winds***

3. Fetch lengths in the direction of strong winds should be minimised to mitigate the potential adverse impacts of wind-generated waves. ***Waves***

4. The effectiveness of the wind in developing vertical secondary mixing circulation is increased by increasing the width of the water surface in the canals. It follows that broad canals, and lake-type developments, will exhibit enhanced vertical secondary mixing. ***Vertical Mixing***

D8.19 EROSION AND SEDIMENTATION INFLUENCES

1. Sandy beaches within canal developments require maintenance (nourishment) at regular intervals. Where recovery of the eroded sand from the bad of the canal is unlikely to be feasible, it is necessary to make allowance for ongoing sedimentation on the canal bed from this source. ***Sand Beach Maintenance***

2. Long canals with sandy shorelines, and aligned with prevailing winds, are likely to experience littoral drift. Generally speaking, the length and alignment of canals should be carefully considered and the potential for littoral drift balanced against the advantages of wind action for promotion of mixing of canal waters.

Shoreline structures which extend across the littoral drift zone, eg. some stormwater outlet designs, should be avoided where relatively high littoral drift rates are anticipated, except where special provision has been made to mitigate beach erosion. ***Drift***

4. In assessing the sediment load carried by stormwater outlets from a given catchment area, it is reasonable to adopt the following sediment quantities per hectare of catchment area per year: ***Sediment Load***

- partially developed urban catchment 5.5 tonnes/ha/yr
- fully developed urban catchment 1.5 tonnes/ha/yr
- rural areas 0.3 tonnes/ha/yr

5. Stormwater outlets should be arranged so as not to directly or indirectly cause beach erosion or local scour. Consideration should be given to construction of the stormwater outlets below the beach level.

STRUCTURES

D8.20 REVETMENT WALLS

1. There will be some locations in the canal development where it will not be possible to "hold" a sandy beach due to the level and type of wave and current exposure, eg. at so called "external corners". In such locations it will be necessary to adopt an alternative canal edge treatment, most probably a rock revetment. ***Wall Requirement***

2. Revetment walls are to be designed as retaining walls certified by a practicing Structural Engineer and submitted to Council for approval.

3. Filling is to be composed of material not injurious to the health of the neighbourhood and shall comply with Council's requirements for filling in subdivisions. ***Filling Behind Walls***

4. The crest of the revetment wall above the design canal profile, for the particular type of canal cross-section adopted, shall conform with the requirements set out in Table D8-2. ***Wall Height***

5. There is no maximum height for revetment walls as such. However, consistent with the requirements in Table D8-2 the crest level of revetment walls should be kept as low as possible to enable easy access from the allotments onto the waterway, to optimise mixing wind action, and to reduce visual impact. ***Maximum Height***

6. Determination of the full construction height, structural adequacy and stability of the wall shall take into account an erosion allowance in front of the wall. In the absence of detailed hydraulic tests the allowances for erosion shall not be less than the values specified in Table D8-3. ***Erosion Allowance***

Table D8-2
Factors For Determining Height Of Revetment Walls

CANAL CROSS-SECTION	HEIGHT OF REVETMENT WALL ABOVE DESIGN CANAL PROFILE
Dry Beach	Minimum of 150mm
Inter-Tidal Beach	Sufficiently high to accommodate MHHWS* plus wind setup, wave runup, long term changes in mean sea level and local tide levels, without overtopping.
No Beach - Submerged Slope	Sufficiently high to accommodate MHHWS plus wind setup, wave runup, long term changes in mean sea level and local tide levels, without overtopping.
No Beach - Vertical Wall	Sufficiently high to accommodate design water depth, MHHWS, wind setup, wave runup, long term changes in mean sea level and local tide levels, without overtopping.

(* MHHWS = Mean Higher High Water Springs)

Table D8-3
Minimum Erosion Allowances For Revetment Walls

CANAL CROSS-SECTION	MINIMUM EROSION ALLOWANCE IN FRONT OF REVETMENT WALL (MM)
Dry Beach	300
Inter-Tidal Beach	450
No Beach - Submerged Slope	300
No Beach - Vertical Wall	300

7. To mitigate against beach erosion, runoff from the slope behind the revetment wall should be interrupted prior to flowing over the revetment wall onto the beach. The preferred method for collection and discharge of the runoff is by means of a kerb and gutter arrangement incorporated into the revetment wall, with flows then directed via pipework into the canal to discharge below ISLW. ***Beach Erosion***

D8.21 JETTIES, PONTOONS AND BOAT RAMPS

1. Where jetties and pontoons are proposed for canals which serve as floodways, the effect of these structures on the hydraulic performance of the canals shall be taken into account in the hydraulic design of the canals. ***Pontoons Jetties***

2. Jetties, pontoons and boat ramps shall be designed in accordance with sound engineering practice by a qualified Civil Engineer to satisfactorily resist all dead loads and applied live loads. Particular consideration shall be given to the effect of flood currents and debris loading on structures proposed to be located within canals which will serve as floodways.

3. Special design requirements due to the height of water levels during flooding shall also be considered, eg. electrical connections and cut-off levels for mooring piles. ***Electrical Connections***

4. Account shall be taken of jetty pontoon, ramp, etc design in assessing the required width of the canals.

5. Where a hinged access ramp leads to a pontoon the slope of the hinged access ***Ramp***

Geometry

ramp should not exceed 1 in 6 at the lowest anticipated water level. Where pontoons are to be provided, fixed-jetties can be used to reduce the length of hinged access ramps but should not extend past the revetment wall by a distance greater than 7m. The level of the jetty deck should be not greater than 300mm above the top of the revetment wall, and the deck should not rest on the wall. The overall length from the revetment wall to the outer edge of the mooring structure should not exceed 17m and must not extend into the navigation channel.

Boat Ramps

6. Boat ramps for individual allotments are acceptable only in the Dry Beach and Inter-Tidal Beach cross-sections. They should be constructed of concrete and be not less than 150mm thick on the canal side of the revetment wall and have a width not less than 3m. Isolation joints are to be provided so that the concrete slabs forming the ramp are not supported by the revetment wall and can move independently of the wall.

End of Ramp

7. The ramp should not extend below the position of the change in grade at ISLW-0.3m (Canal Cross-Section/Edge Treatment; Figure D8.3).

Ramp Level

8. A boat ramp can be constructed with its surface either flush with beach surface or the top of the revetment wall at the point of intersection. There are advantages and disadvantages with each approach which should be evaluated during the determination of standard design. The following issues should be considered:-

- Boat ramps flush with canal beach:
  - ramp will be recessed into the revetment wall and allotment
  - structural design of the revetment wall will need to allow for recessing
  - allotment surface drainage control could be disrupted.
- Boat ramps flush with top of revetment wall:
  - ramp will be proud of beach profile which could lead to beach scour through groyne action and local wave reflections
  - ramp will constitute an impediment to access for maintenance vehicles (if required).

Visual Impact

9. Boat ramps should be designed to minimise their visual impact. Boat ramps having their surfaces level with the canal beach surface are less visually prominent and are therefore preferable, in terms of visual impact, to ramps which project above the beach surface.

10. Adequate provision should be made to ensure that scour does not occur under any part of the ramp, eg. by founding the ramp on stable, non-erodible, material and/or incorporating deeper edge beams.

11. Reference should also be made to the "Boat Launching Ramp Guidelines" (Public Works Department, 1985) and "Design Guidelines for Wharves and Jetties" (Public Works Department, 1990).

Standard Designs

12. A standard design could be considered for jetties, pontoons and boat ramps (including the means of shore connection) that are proposed as part of the development or that may be constructed by owners at a later date.

Aesthetics

13. Special consideration should be given to the appearance of the structures in the waterway, and guidance can be found in the Department of Planning's "Canal Estate Developments: Design Guidelines" (1991).

14. Public boat launching facilities and marina facilities are generally regarded as unsuitable to a residential canal development because of the difficulty of ensuring adequate privacy for residents. Such facilities should only be considered where adequate and comprehensive environmental safeguards can be incorporated in the design of the development. ***Marinas***

15. Public boat launching facilities and marina facilities shall be developed in accordance with the Public Works Department's "Boat Launching Ramp Guidelines" and "Marina Guidelines" respectively. ***Public Facilities***

16. Where it is proposed to construct public boat launching facilities within a canal development, consideration shall be given to siting of the launching facilities so as to minimise any adverse noise impacts on adjacent development due to the particular hours of use of the facilities. ***Noise***

17. Where it is proposed to construct marina facilities within a canal development, consideration shall be given to siting of the marina and design of the marina so as to maximise tidal exchange between the marina basin and the host waterbody. ***Marina Basin***

18. Ideally, marina basins should be located separately from residential canals and close to the entrance of the overall development.

19. Rectangular marina basins with a ratio of length to breadth greater than 3 should be avoided since internal tidal circulation cells tend to develop which reduce tidal flushing.

20. Marina basins having poorly flushed pockets and coves should be avoided.

21. Rounding of corners within the marina basin will produce greater uniformity in local exchange through the basin, eliminating areas of poor local exchange.

22. For rectangular basins, a single centrally-located entrance produces better flushing behaviour than a single corner-located asymmetric entrance.

23. At public boat launching ramps, consideration should be given to providing holding beaches and boarding jetties or pontoons to facilitate rigging and efficient boarding of craft. ***Holding Beaches at Ramps***

D8.22 BRIDGES AND STRUCTURES

1. Bridges and structures shall be designed in accordance with the Specification for Structures and Bridge Design. The design life shall be 100 years and the serviceability design flood shall be 1:20 years. The ultimate limit state, that is the capability of the bridge to withstand a flood without collapse, shall be 1:2000 years.

2. Where canals are narrowed at bridge locations, it is likely that complete rock protection of the banks and bed of the canal will be required. Lowering of the canal bed to reduce velocities may also be required. ***Narrowing***

3. The vertical clearance of any proposed bridge should be checked with the Waterways Authority. ***Clearance***

4. Where a canal entrance cuts pedestrian access along a public foreshore (eg. by removing the intertidal area) then a footbridge should be provided to ensure continuance of public access and amenity.

SPECIAL REQUIREMENTS

D8.23 RESERVED

D8.24 RESERVED

D8.25 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D9

CYCLEWAY AND PATHWAY DESIGN

DESIGN SPECIFICATION D9
CYCLEWAY AND PATHWAY DESIGN

CLAUSE CONTENTS PAGE

DEVELOPMENT DESIGN SPECIFICATION D9
CYCLEWAY AND PATHWAY DESIGN

GENERAL

D9.01 SCOPE

1. This Specification sets out requirements to be used in the design of various types of cycleways and pathways.

2. All relevant design principles contained in the Warringah Bicycle Plan (July 1998) and the AUSTROADS Guide referenced below must be integrated in the design of cycleways and associated infrastructure. This Specification serves as a companion document to the Bicycle Plan and the AUSTROADS Guide extended to incorporate basic requirements for pathways. ***AUSTROADS***

D9.02 OBJECTIVES

1. This Specification aims to set standards and document requirements related to the provision of cycleways and pathways which encourage pedestrian activities and cycling for transportation and recreational purposes. Cycleways and pathways are to be safe and convenient and shall maintain a satisfactory level of service for all pathway users including users with disabilities and limited mobility. ***Safety*** ***Level of Service***

D9.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

D1 - Geometric Road Design

(b) Australian Standards

AS 1742 - Manual of uniform traffic control devices.
AS 2890.3 - Bicycle parking facilities
SAA HB69.14 - Guide to traffic engineering practice – Bicycles
AS Collection 005 Access and mobility – People with disabilities

(c) Other

Warringah Bicycle Plan – Geoplan & Arup, July 1998.

AUSTROADS - Guide to Traffic Engineering Practice - PART 13 Pedestrians, PART 14 Bicycles.

- Planning and Designing for Bicycles - NAASRA (now AUSTROADS) Technical Report June 1988.

Ministry of Transport, Victoria - State Bicycle Committee
- Planning and Design of Bicycle Facilities.

D9.04 CONSULTATION

1. The Designer must consult with Council, the Developer's Landscape Architects/Designers and relevant authorities prior to and during the preparation of cycleway and pathway design. ***Landscape Designers Public Authorities***

D9.05 PLANNING CONCEPTS

1. Council will provide specific requirements for cycleways and pathways in LEP 2000 as well as in the Warringah Bicycle Plan. The Designer will need to enquire about such documents and comply with requirements defined. ***Subdivision Code and Bicycle Plan***

- The Designer should be familiar with cycleway geometric design requirements in terms of: ***Geometric Design***
  - width
  - grade
  - stopping sight distance
  - change in grade
  - horizontal curvature
  - crossfall and drainage
  - superelevation
  - sight distance on horizontal curves

These requirements are discussed in the AUSTROADS Guide. ***AUSTROADS Guide***

3. The Designer shall incorporate all the requirements for disabled access as appropriate for pathway design in accordance with any Council Policy or LEP 2000 on Access and Mobility and AS Collection 005. ***Disabled Access***

D9.06 CYCLEWAY AND PATHWAY TYPES

1. Cycleways can be provided on road and off road. The Warringah Bicycle Plan and the AUSTROADS Guide provides detailed descriptions, warrants, widths, pavement marking etc for the majority of these cycleways. ***On Road Off Road***

2. Common alternative cycleway types include:

On Road

Shared Parking/Bicycle Lanes
Wide Kerbside Lanes
Shared Traffic Lanes
Exclusive Bicycle Lane
Sealed Shoulder

Off Road

Shared Use Bicycle/Pedestrian Pathway
Separated Pathway
Exclusive Cycleway

The AUSTROADS Guide provides advice on the suitability of pavement conditions, drainage pit grates etc for on road cycleways. ***AUSTROADS Guide***

Common pathway types include:

Exclusive Pedestrian Pathways
Shared Use Bicycle/Pedestrian Pathways

By definition pedestrian pathways are "off road" in that pedestrian facilities routinely designed adjacent to roadways are termed footpaths and are designed to meet criteria outlined in Council's Geometric Road Design Specification – D1 and typically related to road cross section detailing. *Footpaths*

4. Pathways by comparison diverge from the road alignment either within the road reserve or across land reserves. Pathways can be provided in conjunction with overland floodways or retention basins. *Land Reserves*

D9.07 PROVISIONS FOR CYCLEWAYS AND PATHWAYS AT STRUCTURES

1. Designers shall consider the best way to provide for the uninterrupted movement of cyclists and pedestrians at proposed and existing structures wherever possible. Structures include bridges and underpasses over rivers, roads or railways. The reference and source documents provide information on: *Bridges Underpasses*

- acceptable widths and clearances
- types of cycleways and pathways
- handrails
- bicycle bridges
- approach ramps

etc.

D9.08 SIGNAGE AND PAVEMENT MARKING

1. The Designer shall provide adequate signposting design for cycleways and pathways.

2. Signs and pavement marking will provide for the safe and convenient use of the facility. The signs and pavement marking will comply with AS 1742. *Compliance*

D9.09 END OF JOURNEY FACILITIES

1. Consideration must be given to the design of adequate facilities at common destinations of cyclists and pedestrians so as to encourage cycleway and pathway usage.

2. Such facilities could include: *Facilities*

- seats
- standby areas
- secure bicycle parking
- picnic facilities

3. The Warringah Bicycle Plan and the bicycle parking installation design should meet appropriate criteria discussed in the AUSTROADS Guide and be fabricated to meet AS 2890.3. *Parking*

D9.10 MINIMUM DESIGN STANDARDS

1. Notwithstanding the guidelines provided in this Specification and referenced

documents the following minimum standards have been determined as shown in Table D9.1.

Table D9.1 Minimum Design Standards

	Cycleway	Pathway	Shared Use Pathway
Path Width	2.0m	1.2m	2.0m
Formation Width	3.0m	2.0m	3.0m
Crossfall min. max.	1:40 1:20	1:40 1:20	1:40 1:20
Grade max.	2% for 450m 5% for 90m 10% for 30m	NA	2% for 140m 3% for 70m 4% for 40m 5% for 30m

D9.11 DOCUMENTATION

1. The following listing outlines Council's minimum requirements for presentation of cycleway and/or pathway designs.

- All plans for cycleways/pathways are to be presented at the reduction ratio 1:500. ***Plans***
- The cycleway plan sheet may be incorporated into the road plan where clarity permits. Specific details are to be provided at reduction ratio 1:200.
- Longitudinal Sections will be required for all off-road cycleways where grades exceed 4%. ***Long Sections***
- Longitudinal Sections will have reduction ratios of 1:500 horizontal and 1:100 vertical.
- Cross Sections will be presented at 1:100 reduction ratio (natural) and transition tables will be required where cross falls vary or superelevation is provided. ***Cross Sections***
- A typical cross section will be detailed to indicate pavement materials and layer depths.

2. All Drawings shall be in accordance with the minimum drafting requirements in the Specification for QUALITY ASSURANCE REQUIREMENTS FOR DESIGN.

SPECIAL REQUIREMENTS

D9.12 RESERVED

D9.13 RESERVED

D9.14 RESERVED

NEW SOUTH WALES

DEVELOPMENT DESIGN SPECIFICATION

D10

BUSHFIRE PROTECTION

CONTENTS

DEVELOPMENT DESIGN SPECIFICATION D10
BUSHFIRE PROTECTION

GENERAL

D10.01 SCOPE

1. The work to be executed under this Specification consists of the design of bushfire protection facilities to protect life and property and bring a fire to a halt.

2. The Specification contains procedures for the design of fire protection facilities. Designs shall be carried out to satisfy requirements of the Rural Fires Act 1997, the Council and the guidelines published by the Department of Bushfire Services (now NSW Rural Fire Service), May 1991. Consultation with Council's Fire Control Officer may be required.

D10.02 OBJECTIVES

1. This Specification aims to outline the requirements that will minimise bushfire hazard in developments. The requirements are particularly pertinent to rural developments but should be an integral part of urbanised development as well. The concepts proposed need to be incorporated at an early stage of development design.

Rural Development
Urban Development

D10.03 REFERENCE AND SOURCE DOCUMENTS

(a) Council Specifications

C501 - Bushfire Protection (Perimeter Tracks)

(b) NSW Government Legislation

Environment Planning and Assessment Act 1979 - Section 94
Rural Fires Act, 1997
Native Vegetation Conservation Act, 1997

(c) NSW Government Department Publications

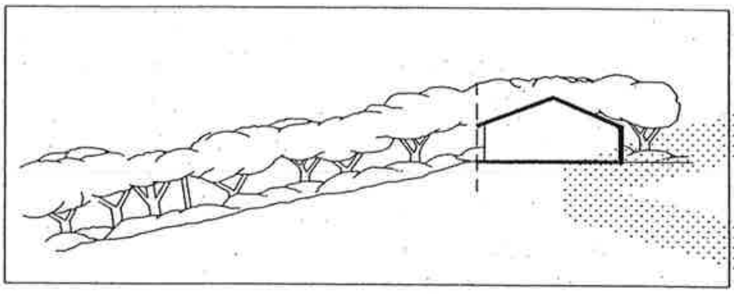
Department of Bushfire Services (now NSW Rural Fire Service), May 1991
- Planning for Bushfire Protection. A Guide for Land Use Planners, Fire Authorities, Developers and Home Owners, May 1991

Department of Land and Water Conservation (formerly Land Management)
- Soil Conservation Service 1994. Guidelines for Planning, Construction and Maintenance of Tracks.

NSW Department of Urban Affairs (formerly Environment) and Planning
- Circular 74: Planning in Fire Prone Areas, 1984.

AS3959 - Australian Standard for construction of buildings in bushfire prone areas.

(d) Other



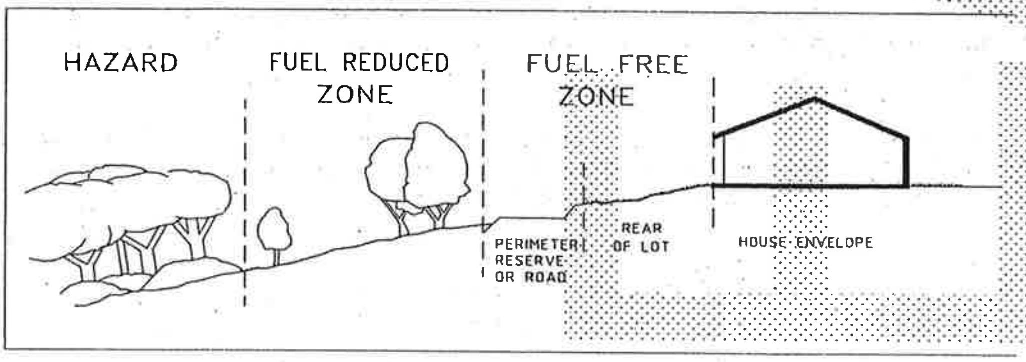


Figure D10.1
Fire Protection Zone

2. FPZs shall be required for any development fronting a bush fire hazard area, whether a single dwelling, a group of isolated dwellings or an urban subdivision. They act as a buffer zone between the development and the fuel. ***Buffer Zone***

3. The primary purpose of FPZs is to ensure that a progressive reduction of fuel occurs between the bush fire hazard and any combustible structures within the development. ***Reduction of Fuel***

4. Apart from its primary purpose the FPZ serves a number of other important purposes, dependent upon local fire fighting policy. The FPZ shall be designed to: ***Other Purposes***

(a) maximise the separation distance between high intensity fire and any structure, thereby reducing the radiation and direct flame contact;

(b) provide an area where embers can fall with minimal opportunity to create further fire outbreaks;

(c) provide a safe access to a structure for fire fighters by reducing the heat level from the main fire;

(d) provide a safe retreat for fire fighters; and

(e) provide a clear control line from which to begin back burning or hazard reduction operations.

Safety requirements sometimes dictate that fires are fought from the property itself rather than along the perimeter track.

5. The FPZ incorporates up to three separate components: ***Separate Components***

(a) Fuel Reduced Zone (FRZ); and

(b) Fuel Free Zone (FFZ) incorporating:

(i) a perimeter road or reserve (which incorporates an access

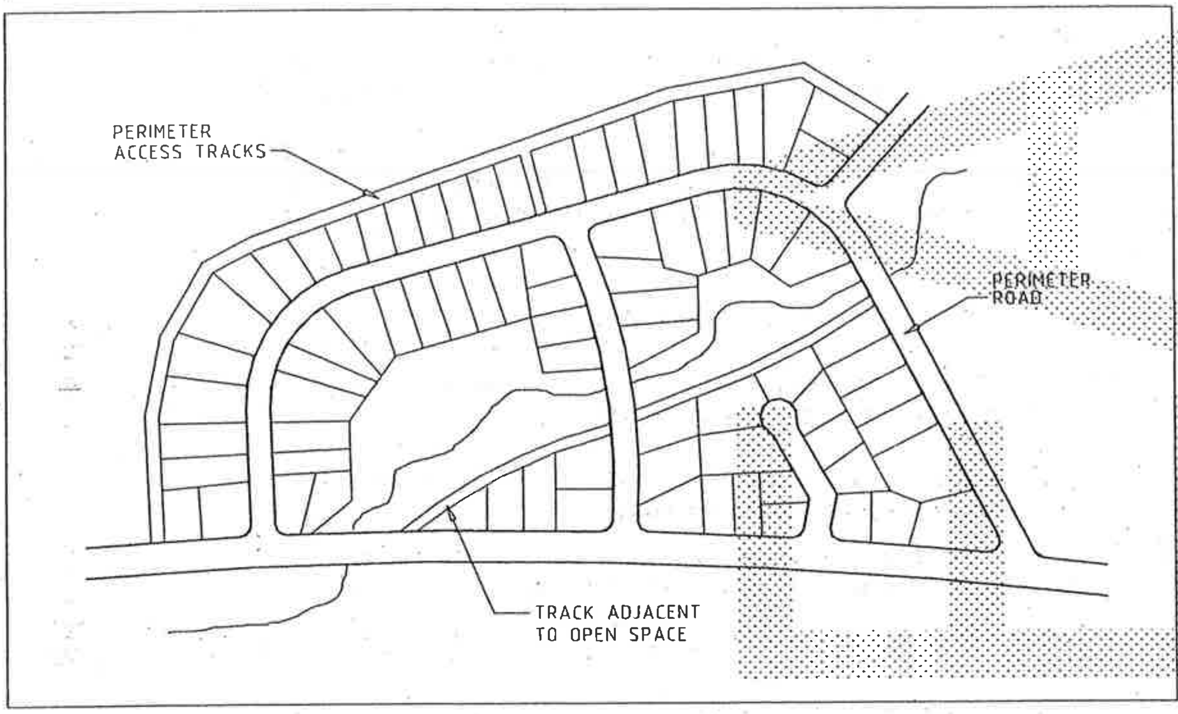


Figure D10.2 Perimeter Road Track

(vi) Perimeter roads that do not require clearing or maintenance (compared to tracks), can be cheapest in the long term. Ultimately the decision between a road or track depends on the local council's subdivision and bush fire fighting policies. ***No Clearance or Maintenance***

(vii) Tracks shall be constructed to Soil Conservation Service (1983) guidelines.

(b) Set-back

(i) Part of the allotment can be used as a section of the buffer by setting a minimum lot depth and rear setback. This can ensure that sufficient room (30-35m) is available to allow for erection of a dwelling that does not encroach upon the rear of the allotment. ***Minimum Lot Depth***

(ii) The policy previously required a minimum of 40m lot depth in order to be consistent with the average minimum lot depth in bushland residential developments. Based on the requirement to maximise the distance between hazard and structures on reasonable grounds (*as developed above*) and a 30m wide building envelope which includes the surrounding yard, there is no justification for a 40m minimum lot depth in some instances. ***Previous Policy***

D10.08 MODIFICATIONS TO FUEL REDUCED AND FUEL FREE ZONES

1. Modifications to the width of either the FRZ or the FFZ shall only be made with the written approval from Council's fire control authority and based on an examination of the particular cases rather than according to any formula. ***Approval of Fire Control Authority***

2. Modifications would need to take account of adjacent or proposed development. Some difficulties arise where new development abuts existing development that is a fire hazard because of the nature of its usage (eg forests, parks etc). The general principle is that fire protection should be shared by both users which may require a certain level of negotiation outside the planning system. ***Adjacent Development***

APPENDIX A

DESIGN IFD RAINFALLS

CATCHMENT INDEX

MAIN DRAINAGE CATCHMENT INDEX

No.	CATCHMENT	RAINFALL AREA
1	BANTRY BAY	F
2	BARE CREEK	T
3	BROOKVALE CREEK	N
4	BURNT BRIDGE CREEK	N
5	CARROL CREEK	F
6	COLLAROY	C
7	COTTAGE POINT	T
8	DEEP CREEK	T
9	DEE WHY BEACH	C
10	DEE WHY LAGOON NORTH	C
11	DEE WHY LAGOON SOUTH	C
12	FRENCHS CREEK	F
13	FRESHWATER CREEK	N
14	GREENDALE CREEK	N
15	MANLY CREEK	N
16	McCARRS CREEK	T
17	MIDDLE CREEK	F,C
18	MIDDLE HARBOUR	F
19	NARRABEEN FORESHORES	C
20	NEVERFAIL CREEK	T
21	OXFORD CREEK	F
22	SMITHS CREEK	T
23	SOUTH CREEK	C

RAINFALL AREAS:

C - CROMER
F - FRENCHS FOREST
N - NORTH MANLY
T - TERRY HILLS

LOCATION 33.725 S 151.275 E * NEAR. CROMER DEPOT ISSUED 23RD FEBRUARY 1989 REF.-FN2910

LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

* ENSURE THE COORDINATES ARE THOSE REQUIRED SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME

$$\ln(I) = a + b*(\ln(T)) + c*(\ln(T))**2 + d*(\ln(T))**3 + e*(\ln(T))**4 + f*(\ln(T))**5 + g*(\ln(T))**6$$

I = INTENSITY IN MILLIMETRES PER HOUR

T = TIME IN HOURS

RETURN PERIOD (YEARS)	a	b	c	d	e	f	g
1	3.4241	-0.5720	-0.0218	0.00908	-0.000899	-0.0004329	0.0000584
2	3.6859	-0.5697	-0.0253	0.00886	-0.000499	-0.0004178	0.0000452
5	3.9627	-0.5645	-0.0353	0.00843	0.000608	-0.0003701	0.0000084
10	4.0972	-0.5619	-0.0408	0.00832	0.001211	-0.0003690	-0.0000074
20	4.2480	-0.5593	-0.0453	0.00806	0.001743	-0.0003427	-0.0000263
50	4.4184	-0.5569	-0.0503	0.00790	0.002298	-0.0003325	-0.0000423
100	4.5320	-0.5553	-0.0535	0.00787	0.002650	-0.0003336	-0.0000514

RAINFALL INTENSITY IN MM/HR FOR VARIOUS DURATIONS AND RETURN PERIODS

DURATION (HOURS)	RETURN PERIOD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	98.7	127.	161.	180.	206.	240.	265.
0.100	92.4	118.	151.	169.	193.	225.	249.
0.167	75.7	97.4	125.	140.	161.	188.	209.
0.333	55.3	71.5	92.8	105.	122.	143.	159.
0.500	45.0	58.3	76.3	86.9	101.	119.	133.
1.000	30.7	39.9	52.6	60.2	70.0	83.0	92.9
2.000	20.5	26.6	35.1	40.1	46.6	55.2	61.8
3.000	16.1	20.9	27.4	31.3	36.3	42.9	48.0
6.000	10.7	13.8	17.9	20.3	23.5	27.7	30.9
12.000	7.00	9.04	11.7	13.3	15.3	18.0	20.1
24.000	4.51	5.84	7.64	8.70	10.1	11.9	13.3
48.000	2.80	3.64	4.86	5.58	6.53	7.79	8.75

DESIGN RAINFALL INTENSITY DIAGRAM

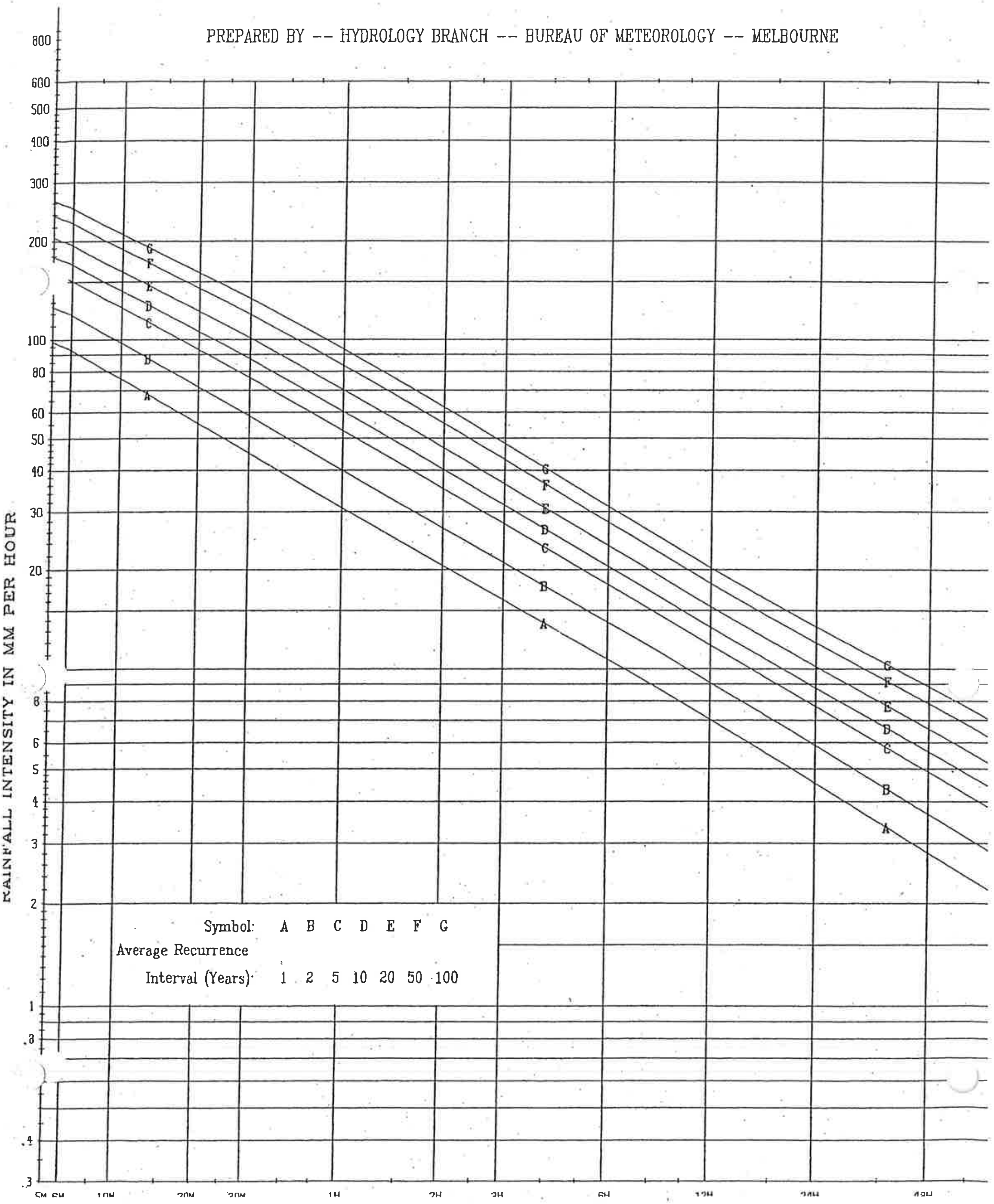
LOCATION 33.725 S 151.275 E * NEAR. CROMER DEPOT

* ENSURE THE COORDINATES ARE THOSE REQUIRED
SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

ISSUED 23RD FEBRUARY 1989 REF.--FN2910

(RAW DATA 40.03, 9.08, 2.68, 84.06, 18.02, 5.83, 0.000, 1HG)

PREPARED BY -- HYDROLOGY BRANCH -- BUREAU OF METEOROLOGY -- MELBOURNE



LOCATION 33.750 S 151.200 E * NEAR. GLEN ST THEATRE ISSUED 23RD FEBRUARY 1989 REF. -FN2910

LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

* ENSURE THE COORDINATES ARE THOSE REQUIRED SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

$$\ln(I) = a + b*(\ln(T)) + c*(\ln(T))**2 + d*(\ln(T))**3 + e*(\ln(T))**4 + f*(\ln(T))**5 + g*(\ln(T))**6$$

I = INTENSITY IN MILLIMETRES PER HOUR

T = TIME IN HOURS

RETURN PERIOD (YEARS)	a	b	c	d	e	f	g
1	3.4599	-0.5778	-0.0306	0.00728	0.000585	-0.0001595	-0.0000244
2	3.7214	-0.5719	-0.0318	0.00733	0.000703	-0.0001771	-0.0000257
5	3.9955	-0.5558	-0.0335	0.00764	0.000744	-0.0002592	-0.0000121
10	4.1289	-0.5474	-0.0345	0.00766	0.000808	-0.0002798	-0.0000110
20	4.2765	-0.5407	-0.0353	0.00799	0.000800	-0.0003398	0.0000003
50	4.4474	-0.5326	-0.0362	0.00789	0.000880	-0.0003501	-0.0000003
100	4.5600	-0.5274	-0.0367	0.00792	0.000892	-0.0003659	0.0000025

RAINFALL INTENSITY IN MM/HR FOR VARIOUS DURATIONS AND RETURN PERIODS

DURATION (HOURS)	RETURN PERIOD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	102.	131.	164.	184.	209.	243.	268.
0.100	95.8	122.	155.	173.	197.	229.	253.
0.167	78.5	101.	128.	144.	164.	192.	212.
0.333	57.4	73.9	95.3	108.	124.	146.	162.
0.500	46.7	60.4	78.4	89.1	103.	121.	135.
1.000	31.8	41.3	54.4	62.1	72.1	85.4	95.6
2.000	21.1	27.4	36.5	41.9	48.9	58.2	65.3
3.000	16.4	21.4	28.7	33.0	38.6	46.1	51.8
6.000	10.7	14.0	18.9	21.8	25.6	30.7	34.7
12.000	7.02	9.21	12.5	14.5	17.1	20.5	23.2
24.000	4.62	6.09	8.29	9.65	11.4	13.7	15.5
48.000	3.00	3.95	5.40	6.29	7.43	8.96	10.2

DESIGN RAINFALL INTENSITY DIAGRAM

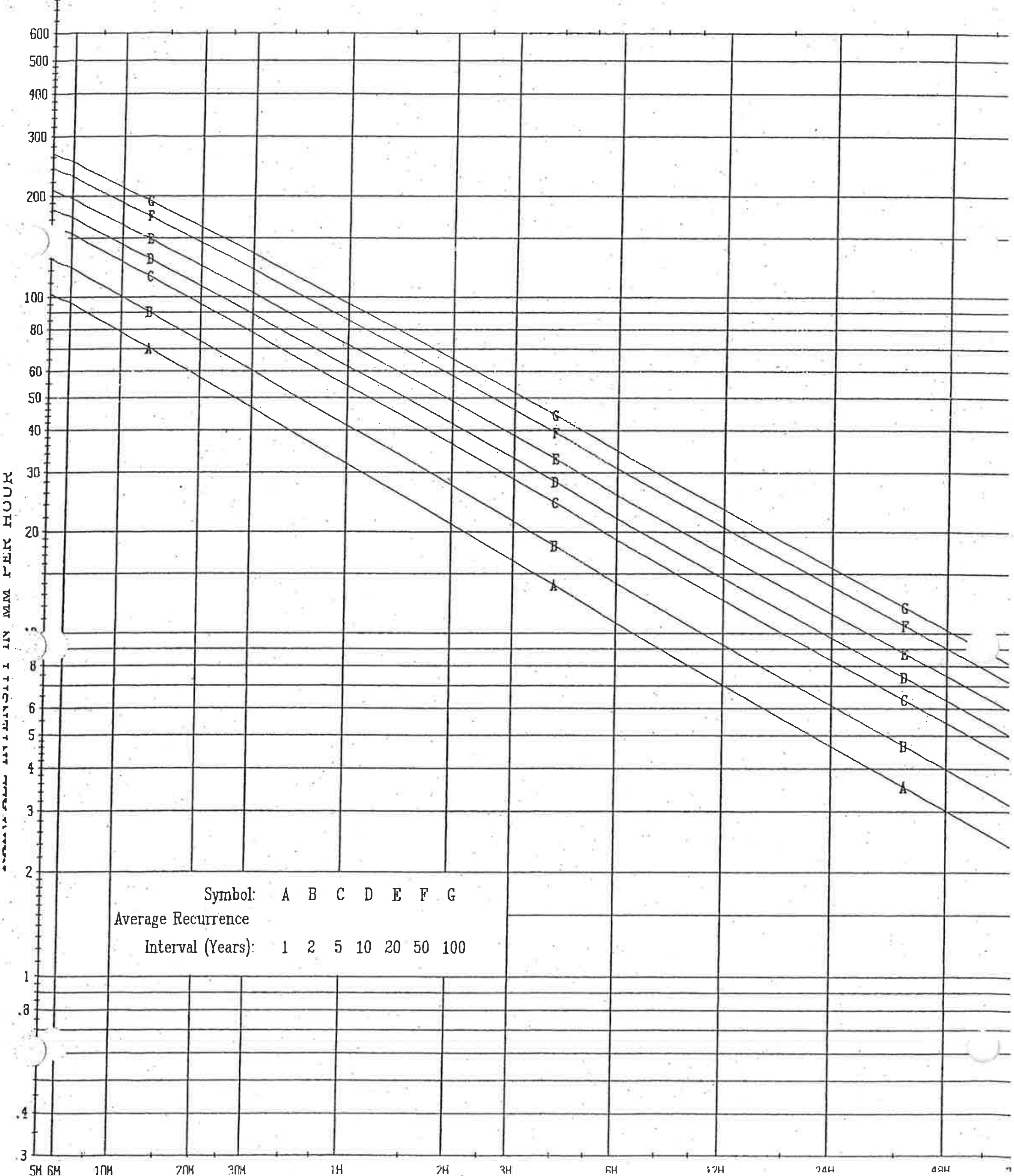
LOCATION 33.750 S 151.200 E * NEAR. GLEN ST THEATRE

* ENSURE THE COORDINATES ARE THOSE REQUIRED
SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

ISSUED 23RD FEBRUARY 1989 REF. -FN2910

(RAW DATA 41.46, 9.21, 2.96, 86.10, 20.58, 6.76, 0.000, 1HC)

PREPARED BY -- HYDROLOGY BRANCH -- BUREAU OF METEOROLOGY -- MELBOURNE



LOCATION 33.775 S 151.275 E * NEAR. NOLANS RESERVE ISSUED 23RD FEBRUARY 1989 REF. -FN2910

LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

* ENSURE THE COORDINATES ARE THOSE REQUIRED SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

$$\ln(I) = a + b*(\ln(T)) + c*(\ln(T))**2 + d*(\ln(T))**3 + e*(\ln(T))**4 + f*(\ln(T))**5 + g*(\ln(T))**6$$

I = INTENSITY IN MILLIMETRES PER HOUR

T = TIME IN HOURS

RETURN PERIOD (YEARS)	a	b	c	d	e	f	g
1	3.4034	-0.5743	-0.0237	0.00859	-0.000579	-0.0003583	0.0000361
2	3.6675	-0.5727	-0.0273	0.00870	-0.000253	-0.0003855	0.0000339
5	3.9509	-0.5684	-0.0381	0.00839	0.000921	-0.0003617	-0.0000010
10	4.0890	-0.5656	-0.0440	0.00786	0.001621	-0.0003068	-0.0000291
20	4.2427	-0.5640	-0.0486	0.00790	0.002110	-0.0003167	-0.0000403
50	4.4165	-0.5619	-0.0538	0.00776	0.002680	-0.0003090	-0.0000566
100	4.5317	-0.5603	-0.0573	0.00762	0.003064	-0.0002962	-0.0000689

RAINFALL INTENSITY IN MM/HR FOR VARIOUS DURATIONS AND RETURN PERIODS

DURATION (HOURS)	RETURN PERIOD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	96.8	124.	159.	179.	205.	240.	266.
0.100	90.7	117.	149.	168.	193.	225.	250.
0.167	74.3	95.7	123.	139.	160.	188.	209.
0.333	54.3	70.3	91.8	105.	121.	143.	160.
0.500	44.1	57.3	75.5	86.3	100.	119.	133.
1.000	30.1	39.2	52.0	59.7	69.6	82.8	92.9
2.000	20.0	26.1	34.5	39.6	46.1	54.8	61.5
3.000	15.7	20.4	26.9	30.8	35.8	42.4	47.5
6.000	10.3	13.4	17.5	19.9	23.0	27.2	30.3
12.000	6.78	8.77	11.4	12.9	14.9	17.6	19.6
24.000	4.38	5.67	7.43	8.46	9.82	11.6	13.0
48.000	2.73	3.55	4.74	5.45	6.38	7.59	8.54

DESIGN RAINFALL INTENSITY DIAGRAM

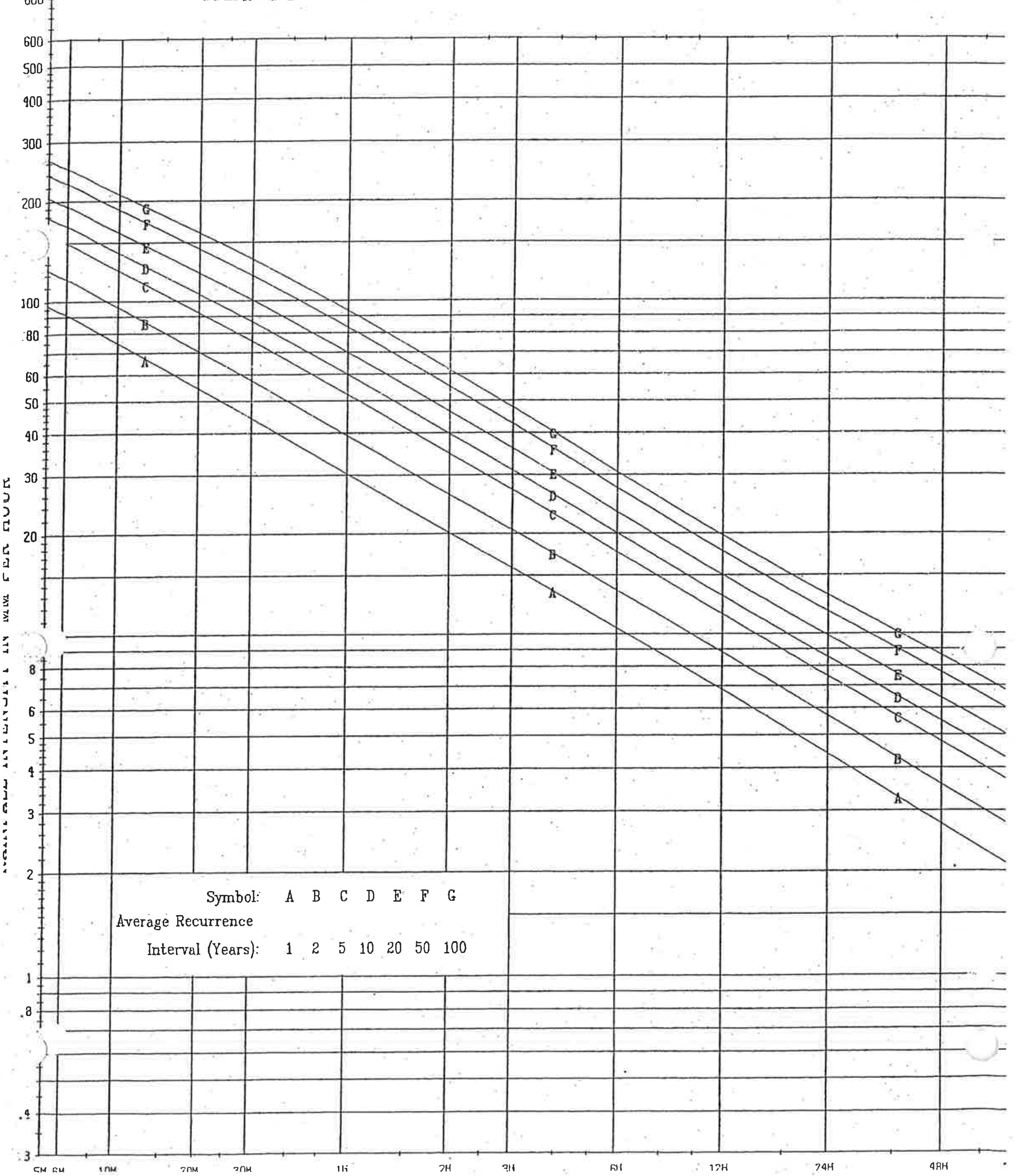
LOCATION 33.775 S 151.275 E * NEAR. NOLANS RESERVE

* ENSURE THE COORDINATES ARE THOSE REQUIRED, SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

ISSUED 23RD FEBRUARY 1989 REF. -FN2910

(RAW DATA : 39.32, 8.80, 2.62, 83.96, 17.56, 5.69, 0.000, 2HG)

PREPARED BY -- HYDROLOGY BRANCH -- BUREAU OF METEOROLOGY -- MELBOURNE



LOCATION 33.675 S 151.225 E * NEAR. TERRY HILL BUSH F/B ISSUED 23RD FEBRUARY 1989 REF. -FN2910

LIST OF COEFFICIENTS TO EQUATIONS OF THE FORM

* ENSURE THE COORDINATES ARE THOSE REQUIRED, SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

$$\ln(I) = a + b*(\ln(T)) + c*(\ln(T))**2 + d*(\ln(T))**3 + e*(\ln(T))**4 + f*(\ln(T))**5 + g*(\ln(T))**6$$

I = INTENSITY IN MILLIMETRES PER HOUR

T = TIME IN HOURS

RETURN PERIOD (YEARS)	a	b	c	d	e	f	g
1	3.4789	-0.5704	-0.0255	0.00727	0.000058	-0.0001611	-0.0000115
2	3.7388	-0.5659	-0.0277	0.00741	0.000239	-0.0002003	-0.0000090
5	4.0098	-0.5545	-0.0338	0.00743	0.000835	-0.0002335	-0.0000191
10	4.1408	-0.5481	-0.0367	0.00733	0.001104	-0.0002400	-0.0000243
20	4.2898	-0.5436	-0.0393	0.00761	0.001322	-0.0002845	-0.0000235
50	4.4572	-0.5375	-0.0423	0.00748	0.001618	-0.0002938	-0.0000290
100	4.5684	-0.5339	-0.0441	0.00743	0.001805	-0.0002903	-0.0000346

RAINFALL INTENSITY IN MM/HR FOR VARIOUS DURATIONS AND RETURN PERIODS

DURATION (HOURS)	RETURN PERIOD 1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
0.083	104.	132.	166.	185.	211.	245.	270.
0.100	97.4	124.	156.	174.	199.	230.	254.
0.167	79.9	102.	130.	145.	166.	193.	213.
0.333	58.3	75.0	96.5	109.	125.	147.	163.
0.500	47.4	61.3	79.5	90.1	104.	122.	136.
1.000	32.4	42.0	55.1	62.9	72.9	86.2	96.4
2.000	21.6	28.1	37.0	42.3	49.2	58.4	65.4
3.000	17.0	22.1	29.1	33.3	38.7	45.9	51.4
6.000	11.2	14.5	19.2	22.0	25.6	30.3	34.0
12.000	7.39	9.62	12.7	14.6	17.0	20.1	22.6
24.000	4.87	6.35	8.45	9.71	11.3	13.5	15.2
48.000	3.14	4.11	5.52	6.37	7.45	8.91	10.1

DESIGN RAINFALL INTENSITY DIAGRAM

LOCATION 33.675 S 151.225 E * NEAR. TERRY HILL BUSH F/B

* ENSURE THE COORDINATES ARE THOSE REQUIRED
SINCE DATA IS BASED ON THESE AND NOT THE LOCATION NAME.

ISSUED 23RD FEBRUARY 1989 REF.-FN2910

(RAW DATA 42.15, 9.62, 3.08, 87.09, 20.19, 6.75, 0.900, ING)

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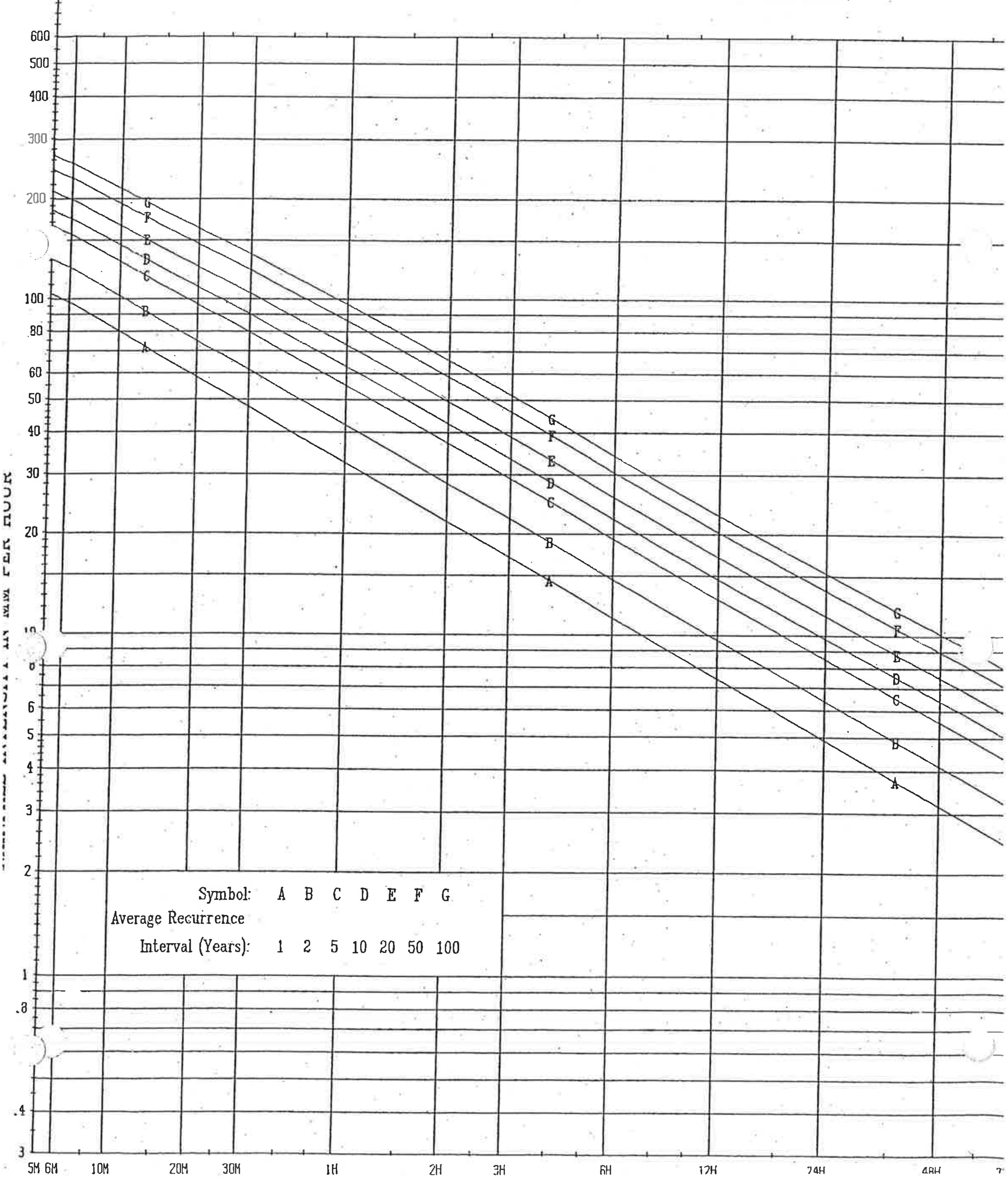


APPENDIX B

PIT PRESSURE CHANGE COEFFICIENTS

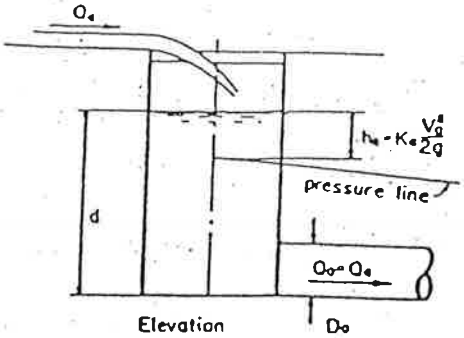


CHART 2

RECTANGULAR INLET WITH GRATE FLOW ONLY.

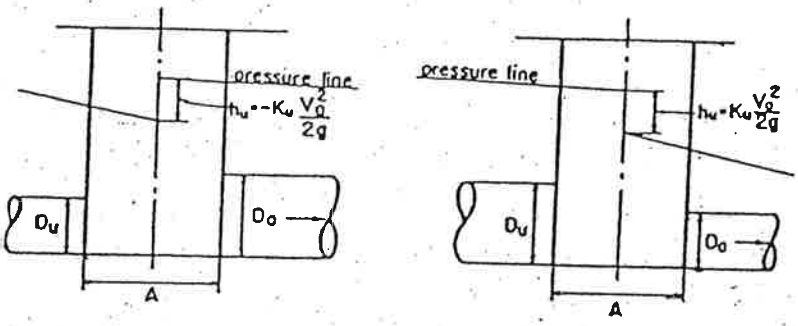


CHART 3

FLOW STRAIGHT THROUGH ANY JUNCTION.

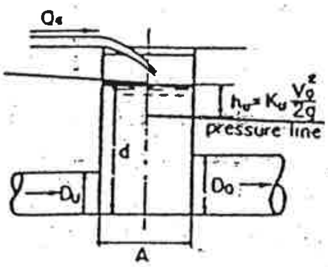


CHART 4

RECTANGULAR INLET WITH THROUGH PIPELINE AND GRATE FLOW.

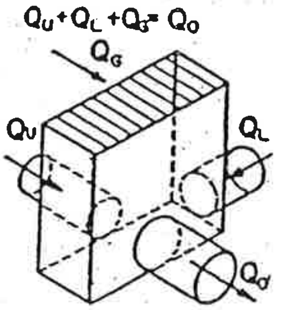


CHART 5

RECTANGULAR INLET WITH IN-LINE UPSTREAM MAIN AND 90° LATERAL PIPE (WITH OR WITHOUT GRATE FLOW)

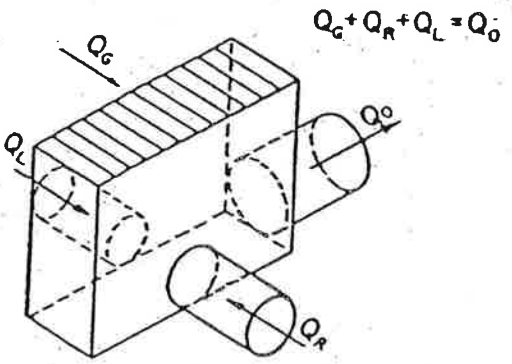


CHART 6

RECTANGULAR INLET WITH IN-LINE OPPOSED LATERAL PIPES EACH AT 90° TO OUTFALL (WITH OR WITHOUT GRATE FLOW)

Basic types of pits covered by Missouri Charts.

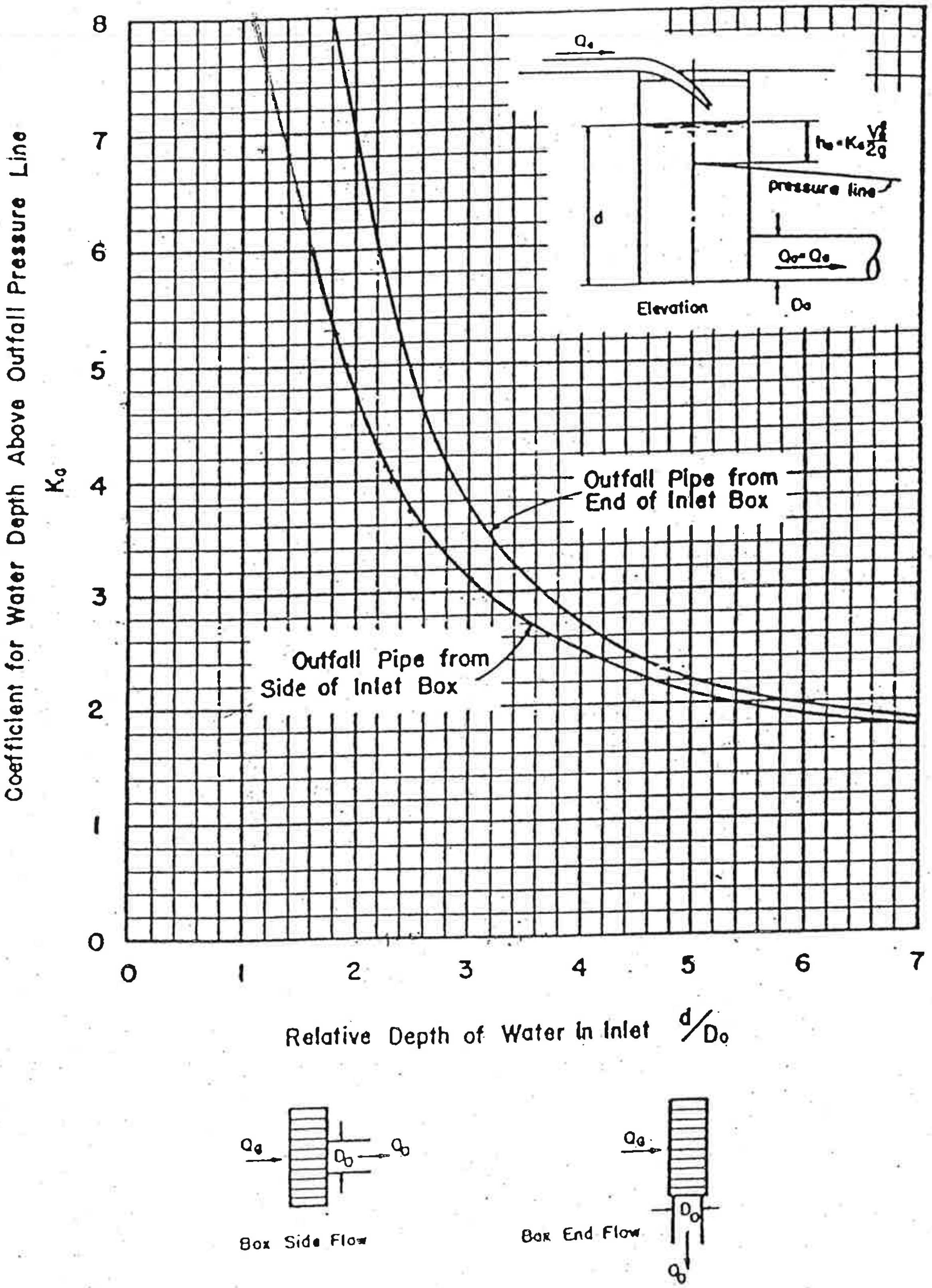


Chart 2. Rectangular inlet with grate flow only.

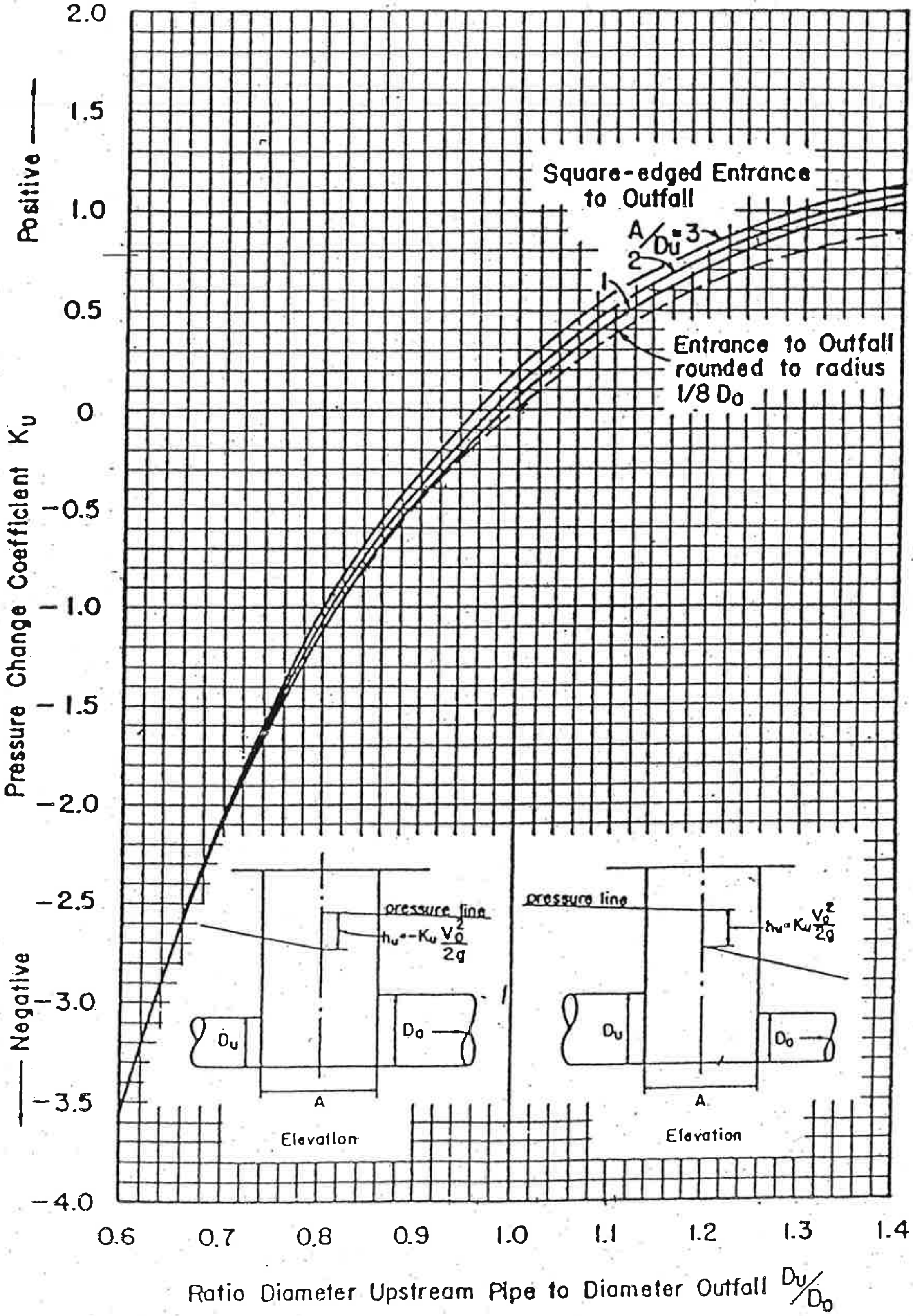


Chart 3. Flow straight through any junction.

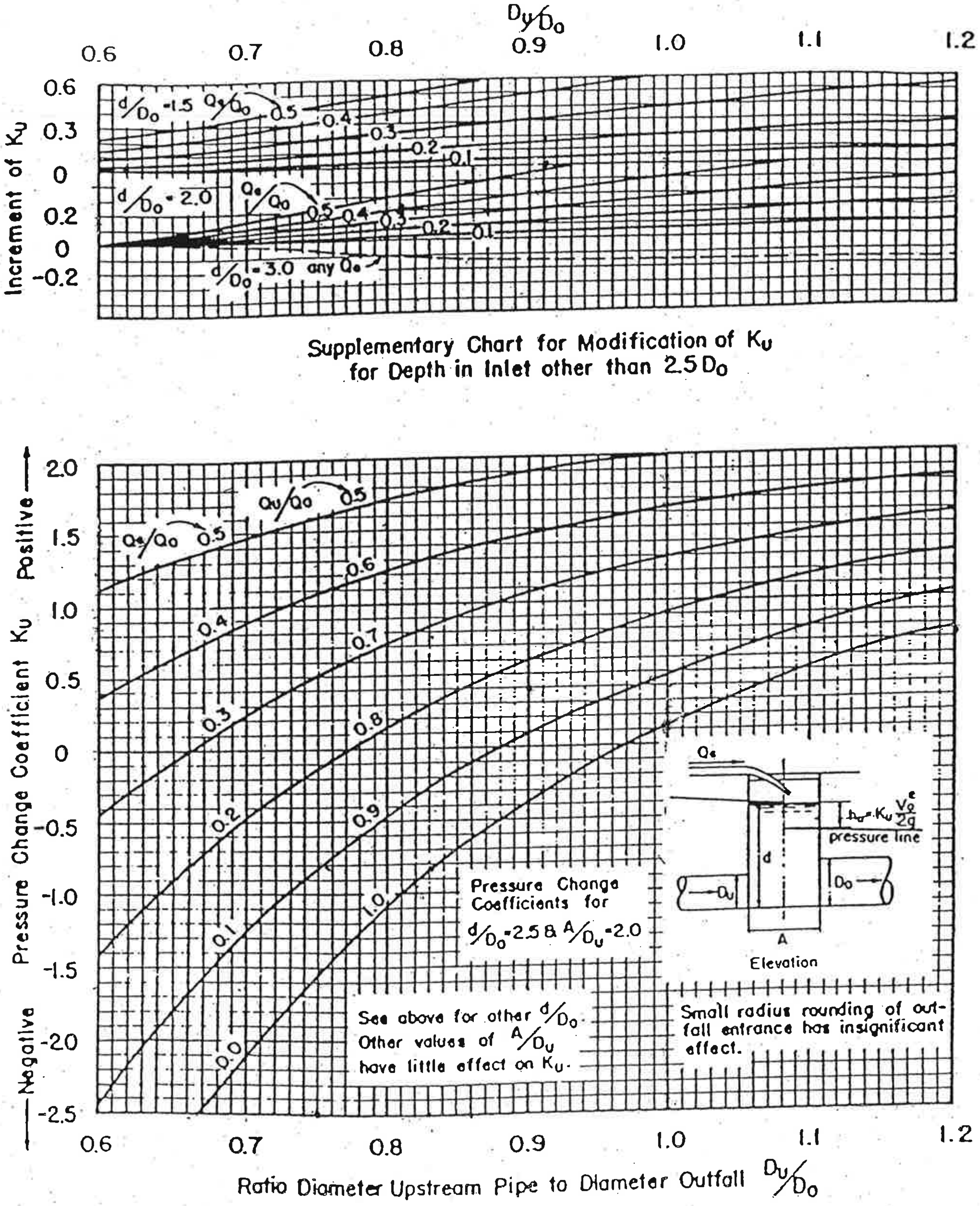


Chart 4. Rectangular inlet with through pipeline and grate flow.

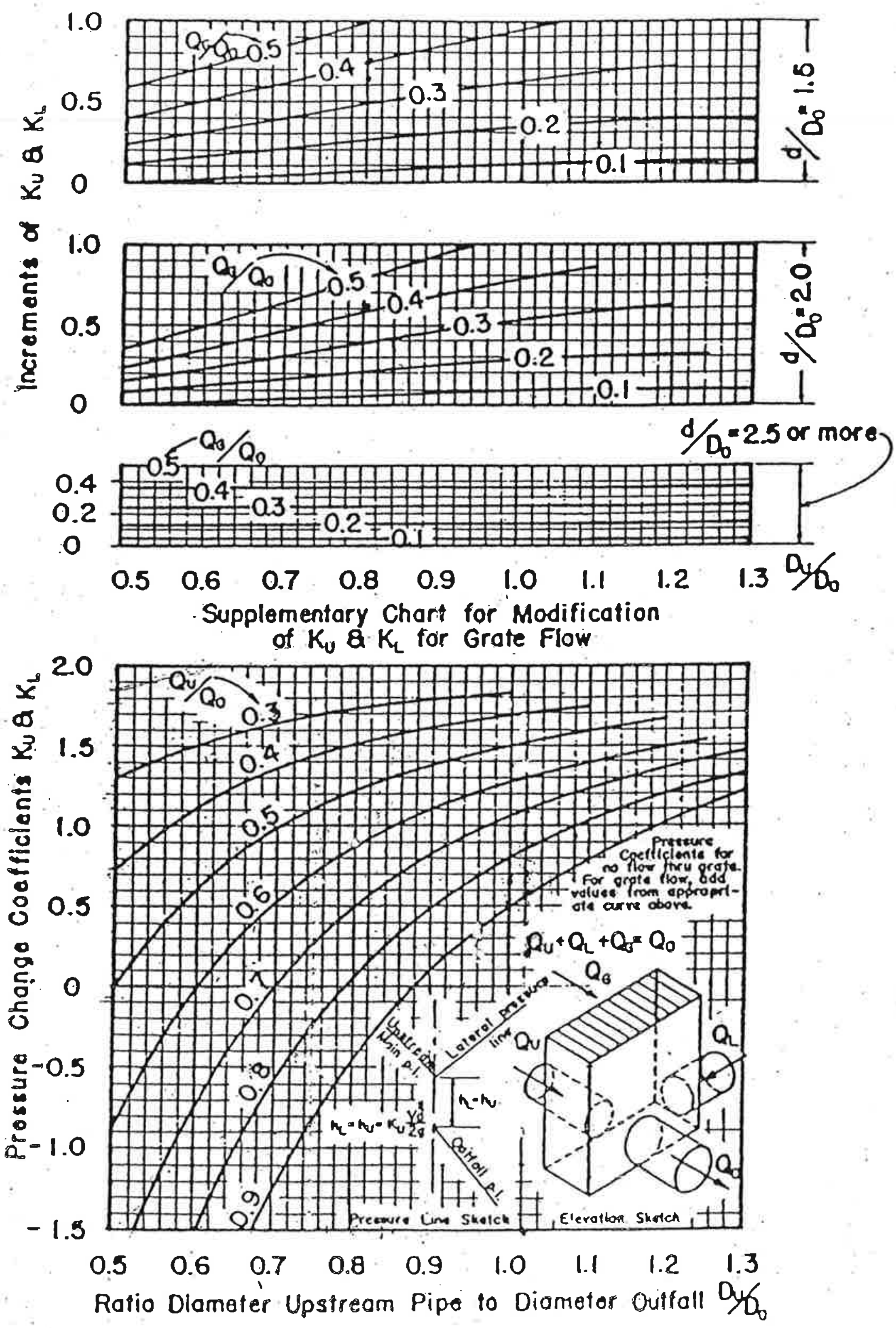
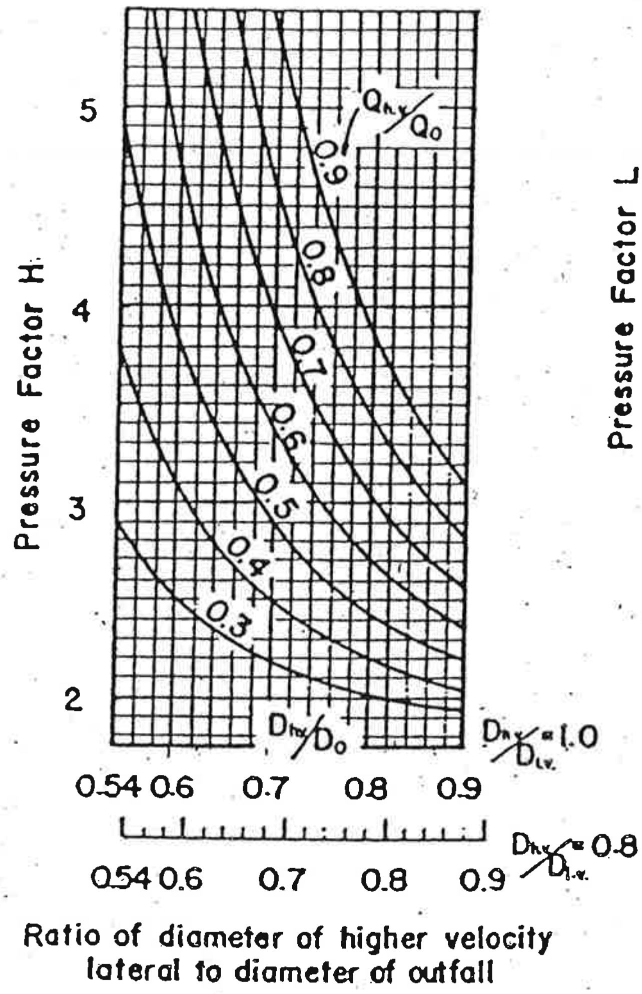
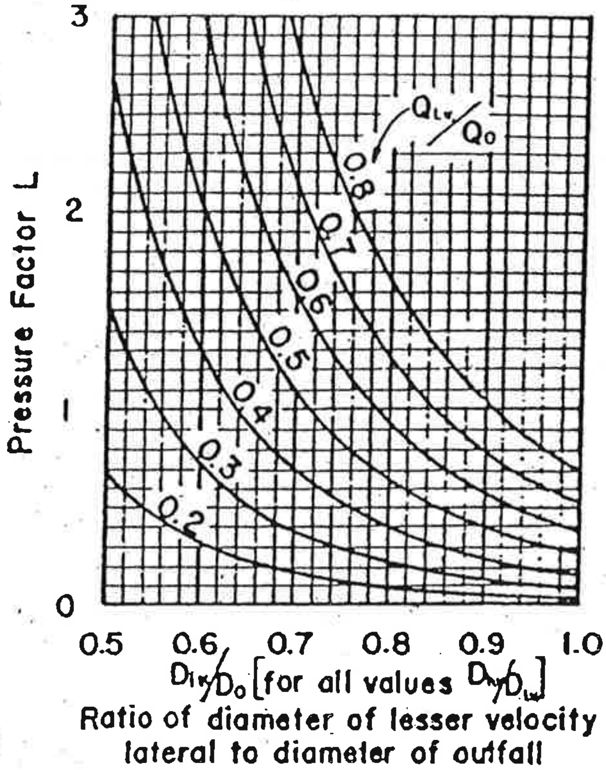


Chart 5. Rectangular inlet with in-line upstream main and 90° lateral pipe (with or without grate flow).



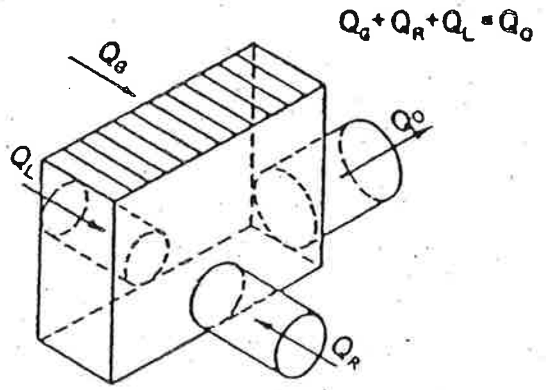


$D_{h.v.}$ = diameter of lateral with higher-velocity flow.

$Q_{h.v.}$ = rate of flow in lateral with higher-velocity flow.

$D_{l.v.}$ = diameter of lateral with lower-velocity flow.

$Q_{l.v.}$ = rate of flow in lateral with lower-velocity flow.



Elevation Sketch

To find K_R or K_L for the right or left lateral pipe with flow at a lesser velocity than the other lateral, read H for the higher velocity lateral D and Q, then read L for the lower velocity lateral D and Q, then: K_R (or K_L) = H − L

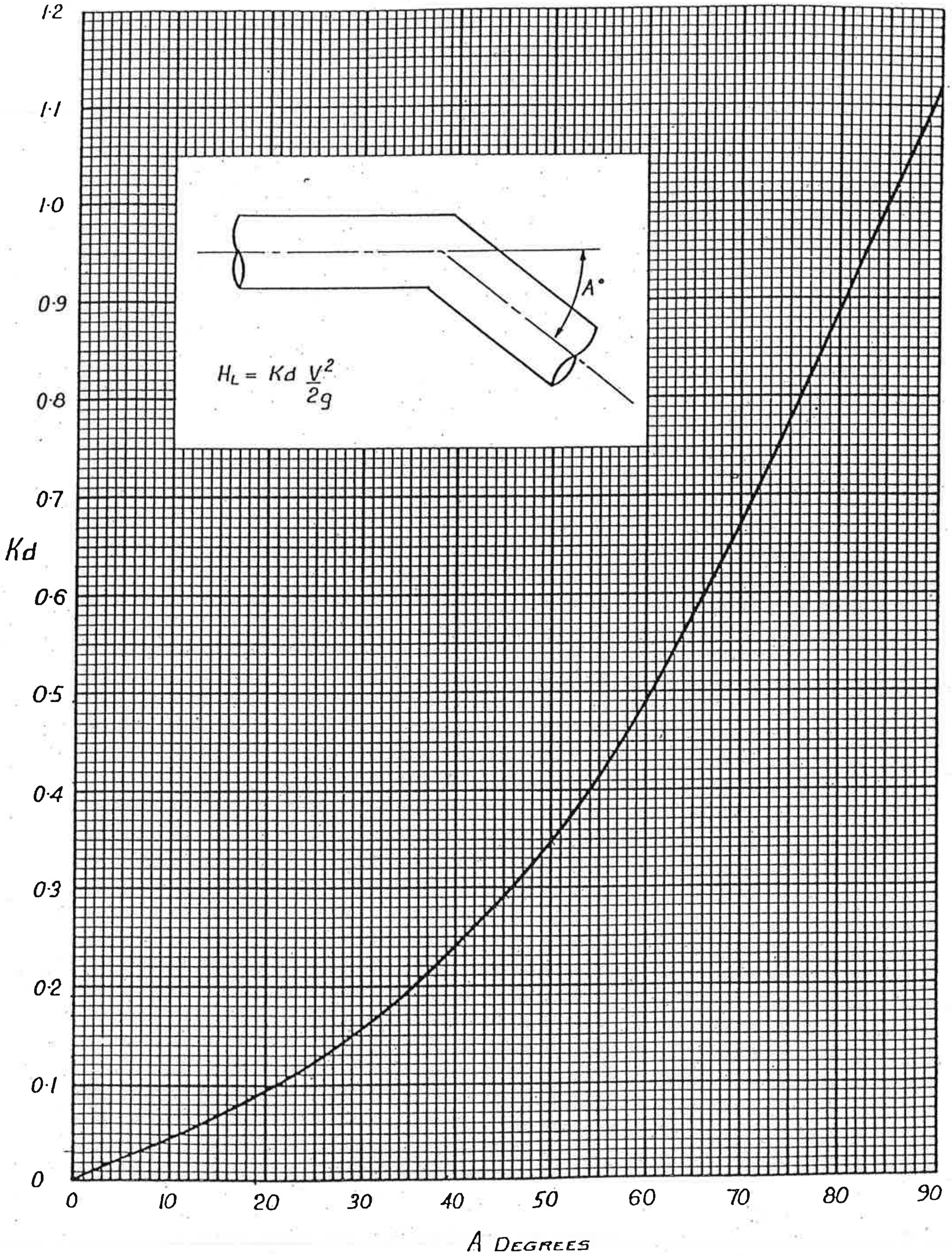
K_R or K_L for the lateral pipe with higher velocity flow is always 1.8

$$h_L = K_L \frac{V_o^2}{2g} \qquad h_R = K_R \frac{V_o^2}{2g}$$

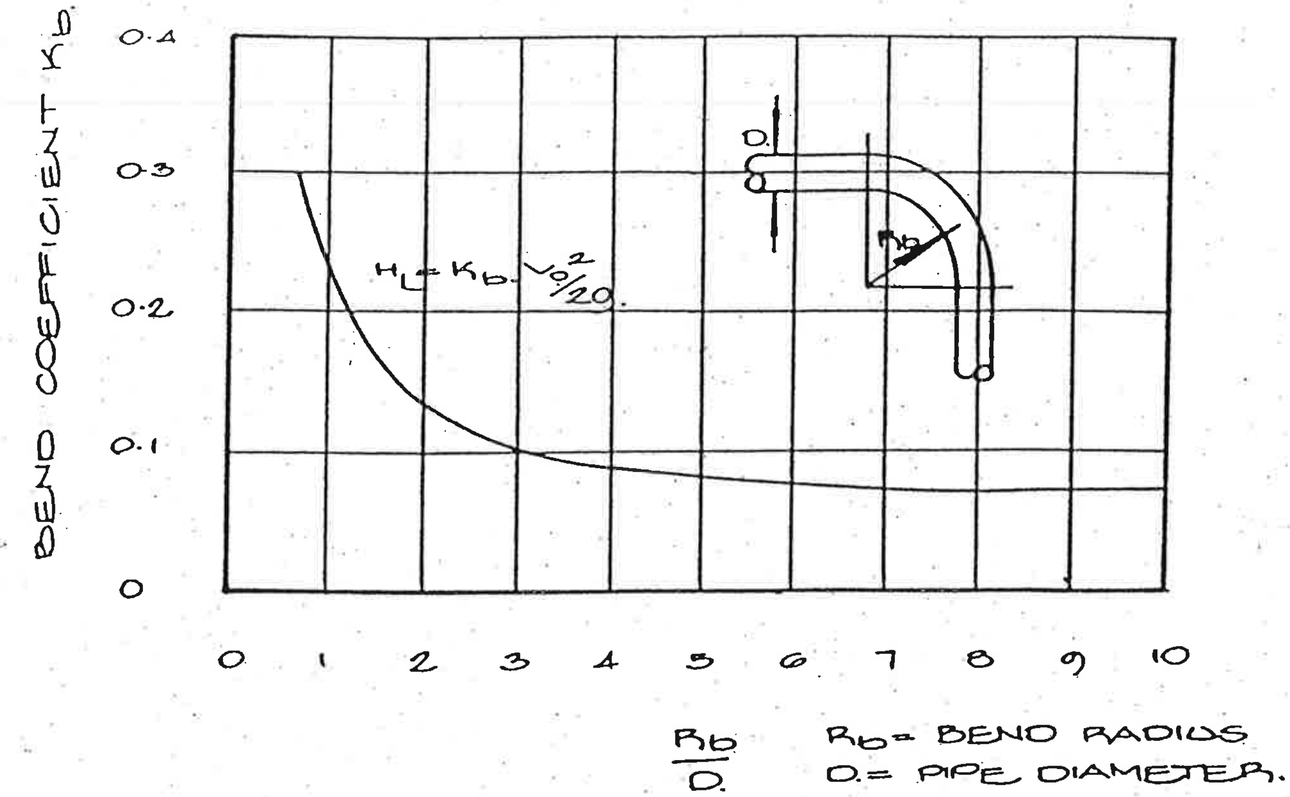
Chart 6. Rectangular inlet with in-line opposed lateral pipes each at 90° to outfall (with or without grate flow).

APPENDIX C

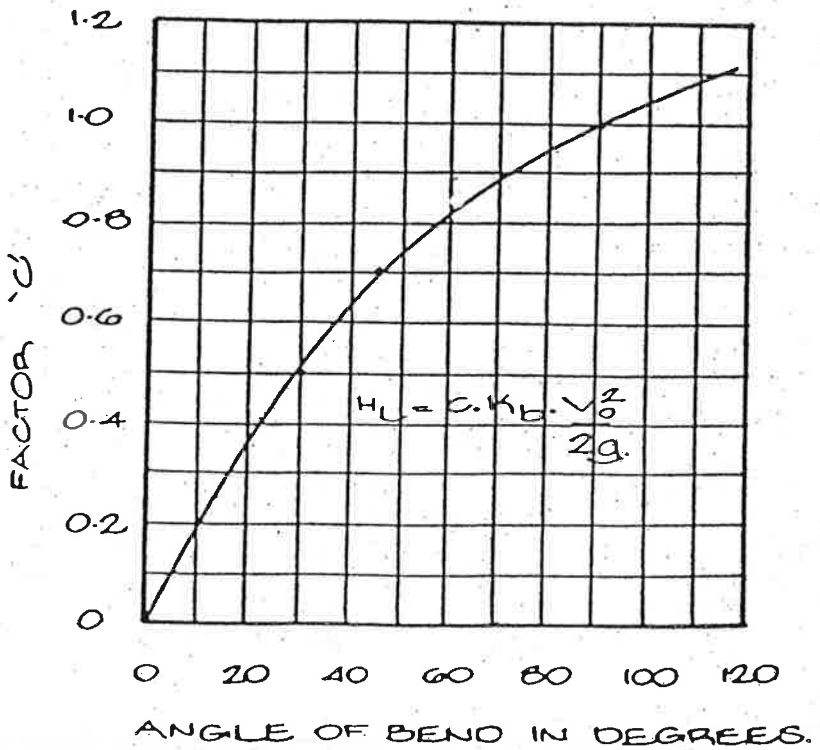
PIT PRESSURE CHANGE AT BENDS



Loss coefficients for Mitre bends.



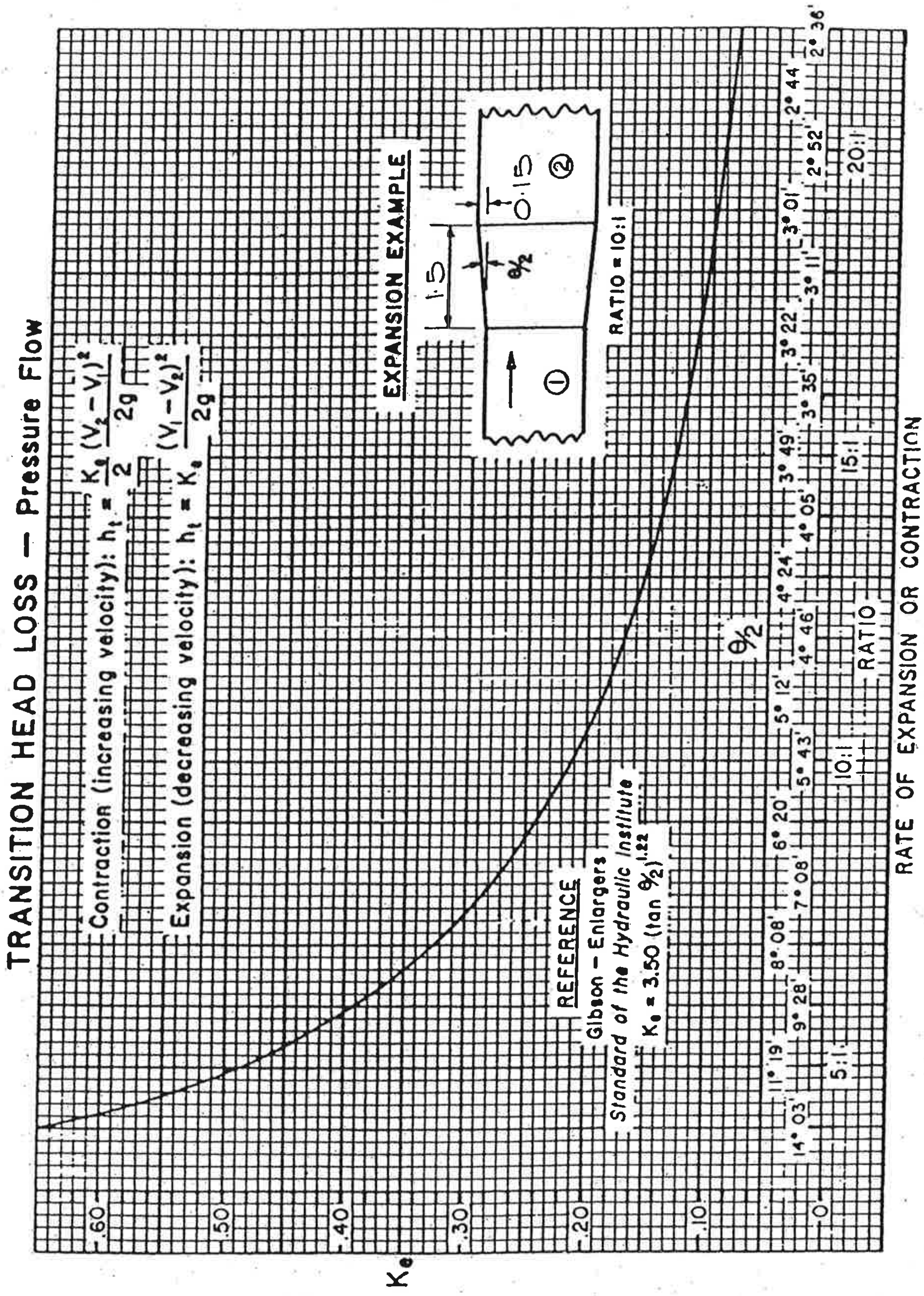
Variation of Bend coefficient with relative Radius for 90^0 bends of circular cross-section.



Factors for Bend loss coefficient for other than 90^0 bends.

APPENDIX D

LOSSES IN SUDDEN EXPANSIONS AND CONTRACTIONS



Transition Head loss coefficients.

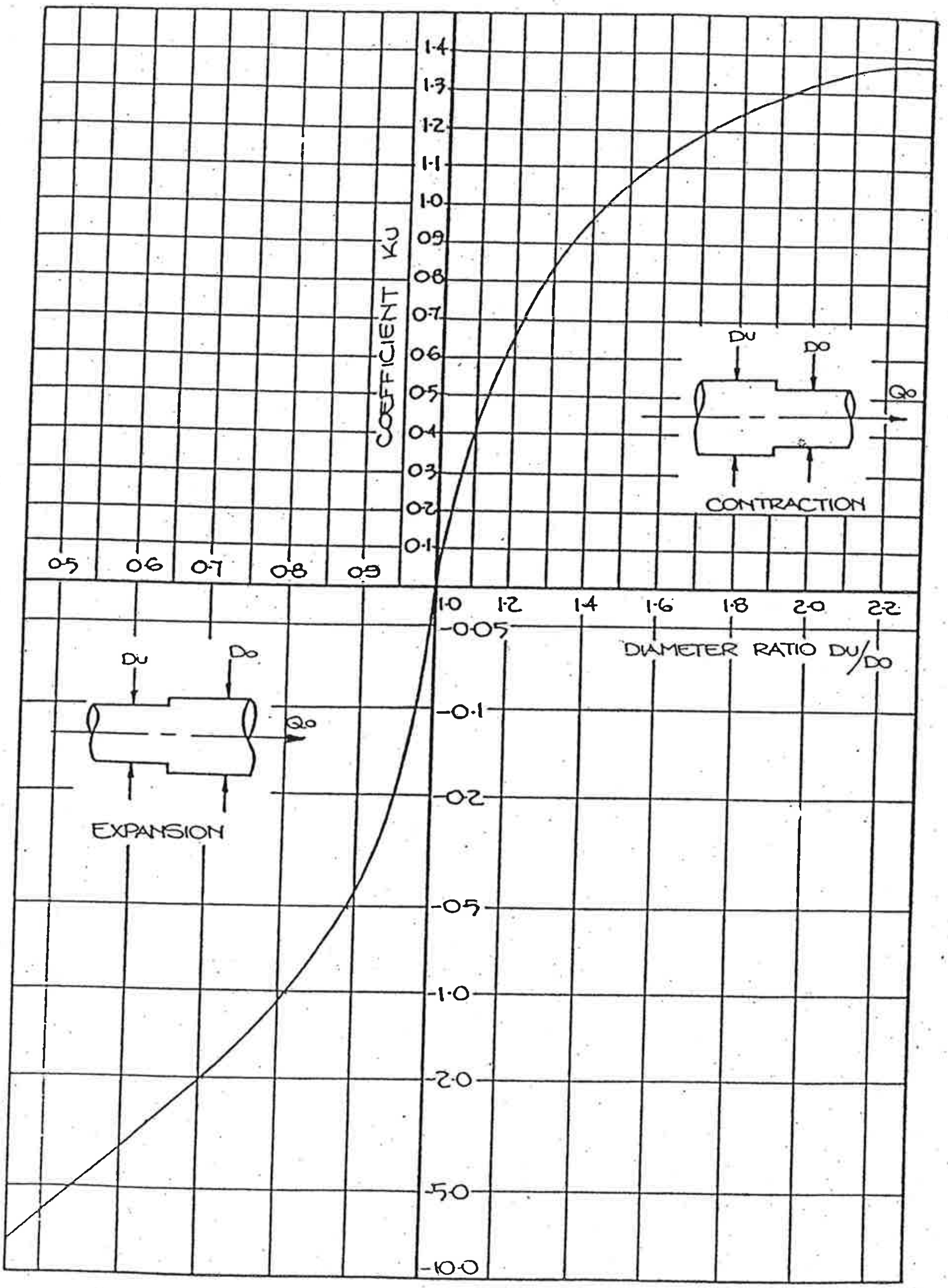
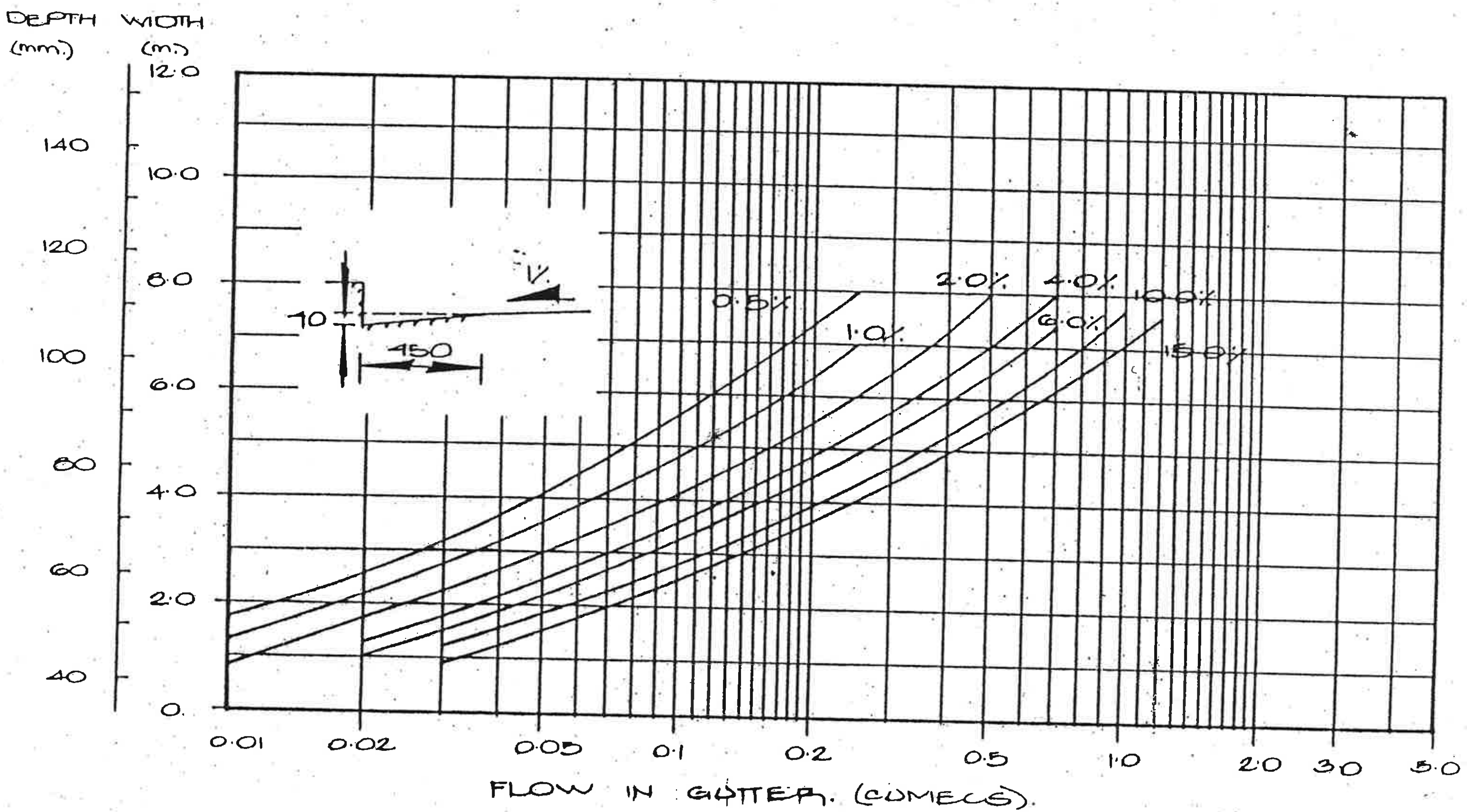


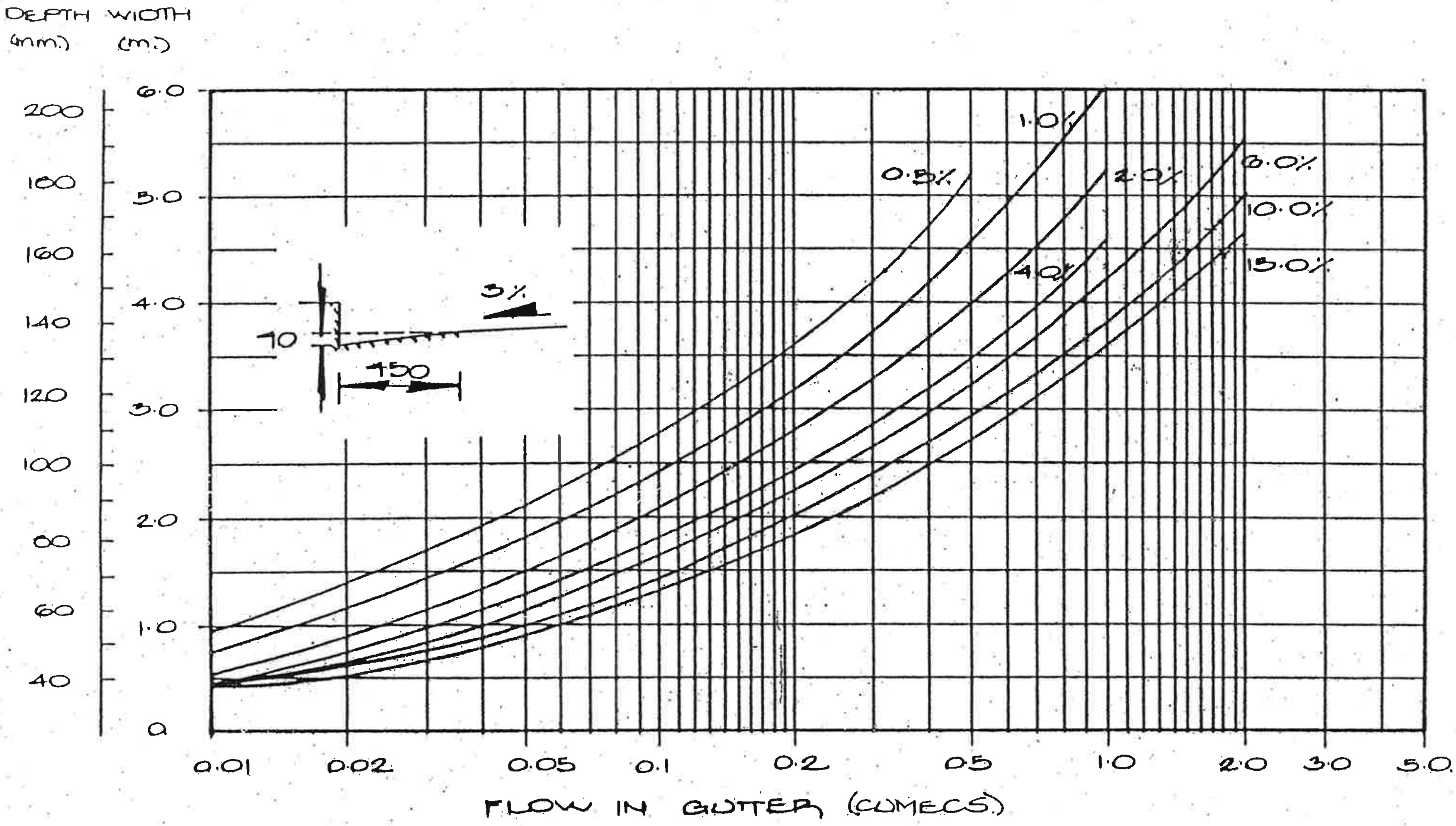
Figure 4.10 Loss coefficients for sudden Expansion or Contraction.

APPENDIX E

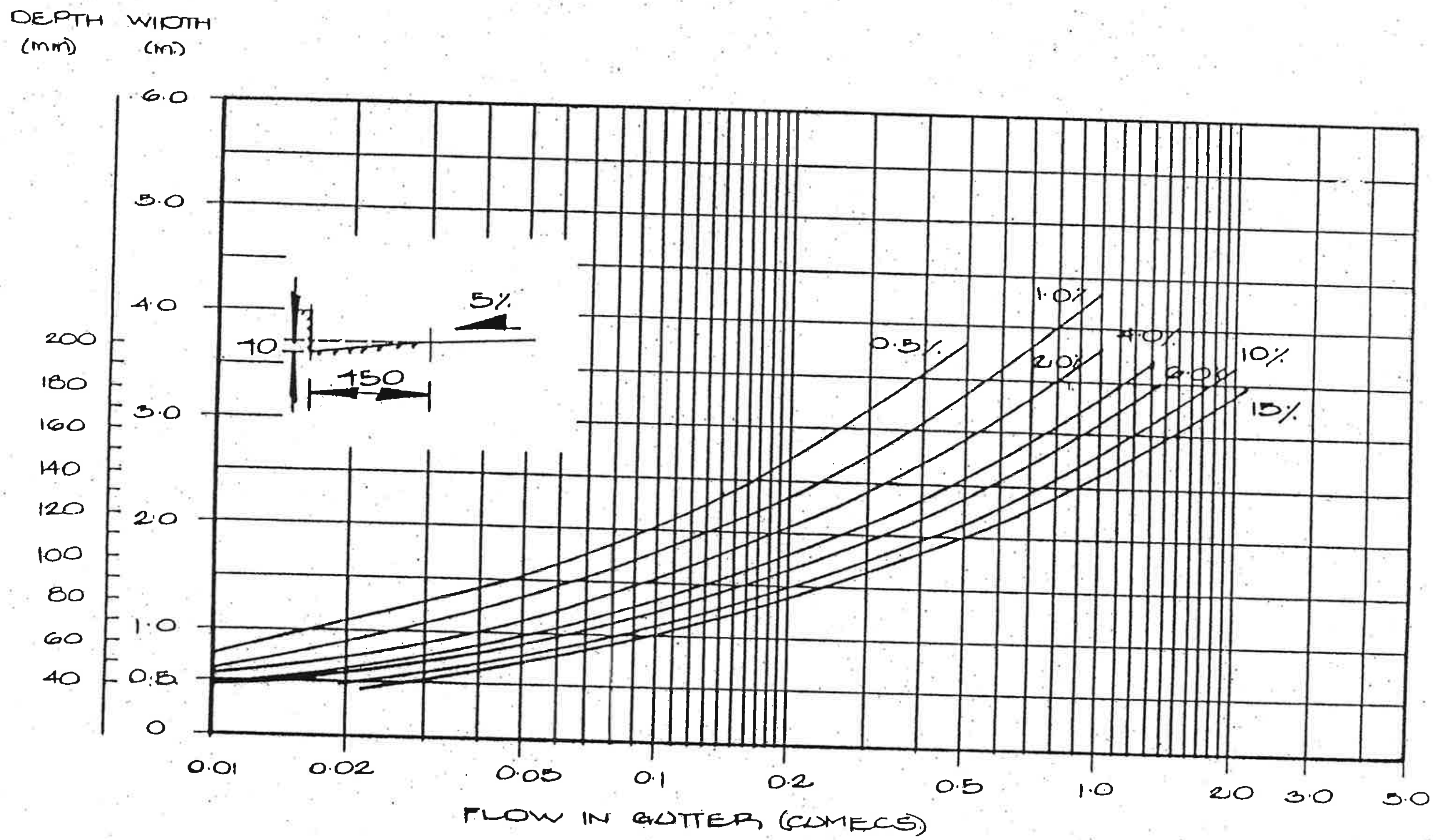
ROAD CAPACITY CHARTS



GUTTER FLOW PROFILE – 1% CROSSFALL.



GUTTER FLOW PROFILE – 3% CROSSFALL.



GUTTER FLOW PROFILE – 5% CROSSFALL.

The Froude Number (Fr) is given by the equation:

$$Fr = \frac{V_o}{\sqrt{gy}}$$

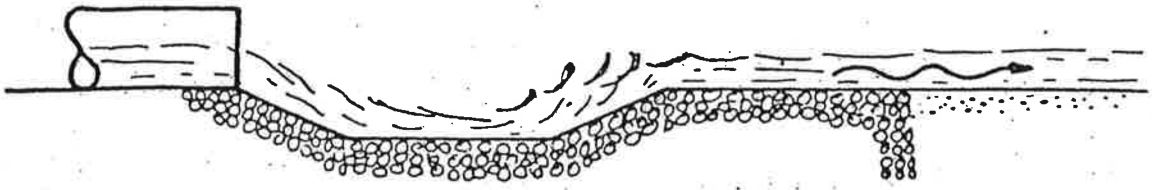
For pipes, use $Fr = \frac{0.38V_o}{\sqrt[4]{A_e}}$

For box culverts, use $Fr = \frac{0.32V_o}{\sqrt{d_e}}$

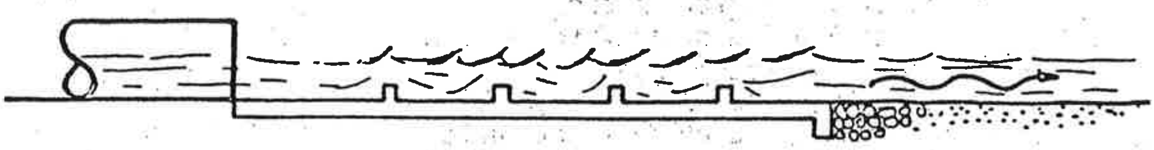
where V_o = outlet velocity (m/sec)
g = acceleration of gravity, 9.81 m/sec^2
y = depth of water (m)
A_e = effective outlet area (sq.m)
d_e = effective water depth at outlet

For Fr < 1.7 Channel lining should give adequate protection. Typical methods used are a concrete apron in conjunction with outlet wingwalls, hand-packed heavy stones, grouted stone pitching, sand bag revetment, "Reno mattress" and gabions (wire cages filled with smaller stones ordinarily moved by the flood flow).
The latter two methods are becoming increasingly economical by comparison with the cost of stone pitching. They provide flexible structures which can deform without fracture.

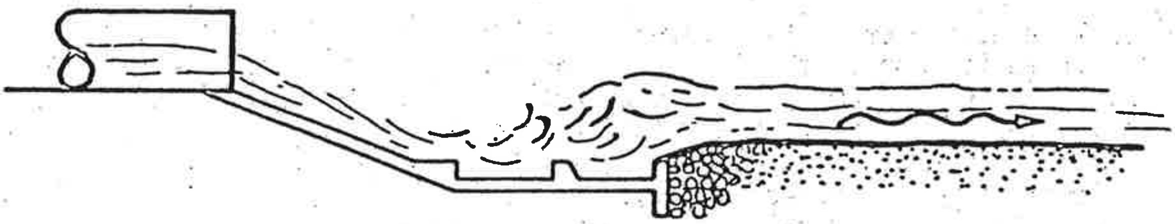
For Fr > 1.7 reduction of outlet velocity can be achieved by creating a hydraulic jump in the flow or by providing stilling basins.
A hydraulic jump is the abrupt rise (a standing wave) which frequently occurs in the water surface in open channel flow, when water at high velocity (super-critical) discharges into a zone of lower velocity (sub-critical). The hydraulic jump is accompanied by violent turbulence, eddying, air entrainment and surface undulations.
Some energy-dissipating structures to produce this hydraulic jump are are illustrated in Figure . A further alternative is to create a hydraulic jump within the culvert by breaking the slope of the culvert so that the first portion of the culvert will be on a steeper slope than the second portion. These solutions require detailed design and should be referred back to Head Office if their use cannot be avoided.



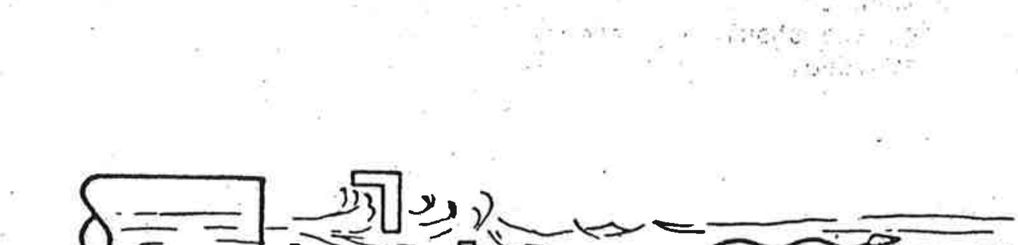
Riprap basin $(F_r < 3)$



Horizontal roughness element basin $(F_r < 3)$



Forced jump basin (F_r 2 to 17)



Impact energy dissipator $(F_r < 7)$

Illustrations Of Conditions Relating to Froude Numbers

Figure