Natural Resources and Water
Managing Queensland's natural resources
... for today and tomorrow

Queensland Urban Drainage Manual

Volume 1

Second Edition 2007

Queensland the Smart State

Queensland Government
Natural Resources and Water

Minister’s foreword

It gives me a great deal of pleasure to present the second edition of the Queensland Urban Drainage Manual (QUDM). Since first being published in 1992 over 900 copies of QUDM have been distributed and it has become one of the primary reference documents for stormwater practitioners within Queensland and interstate.

Since the first edition was produced, there have been major developments in both the recognition and understanding of the potential impacts of stormwater runoff on our environment, as well as greater recognition of the resource value of stormwater and promotion of its use in supplementing tradition urban supplies.

The manual’s traditional focus on safety, urban amenity and flood management remains a fundamental aspect of the document; however, the objectives of environmental protection and sustainable resource management have been important additions to the list of stormwater management considerations.

These changes which require stormwater to be recognized as an important component of a sustainable total urban water cycle have made contemporary stormwater management a much more complex and demanding field—a trend that is likely to only increase as we strive to meet the challenges of our expanding urban populations.

The expanding objectives of stormwater management have meant that QUDM can no longer be used as the sole planning and design guideline for stormwater management, but must be supplemented with other design manuals on topics such as water sensitive urban design, natural channel design, and erosion and sediment control. The latest version of QUDM does not attempt to supersede such guidelines, but complements their use within the stormwater industry.

I believe this updated version of QUDM provides stormwater managers with an extensive guideline on current best practices for the planning and design or urban stormwater management systems.

The Hon. Craig Wallace MP
Minister for Natural Resources and Water
and Minister Assisting the Premier in North Queensland

Preface

The QUDM partners recognise that the Manual is not a stand-alone planning and design guideline for stormwater management. It must be used in coordination with other recognised manuals covering topics such as:

- Water Sensitive Urban Design
- Water Sensitive Road Design
- Natural Channel Design
- Waterway management including fauna passage
- Erosion & Sediment Control
- Bridge and culvert design manuals
- Australian Rainfall and Runoff (ARR)
- Australian Runoff Quality (ARQ)
- various Australian Standards on product manufacture and installation

The information presented within this edition of QUDM on stormwater quality treatment and the management of environmental impacts is not comprehensive and should not be used to supersede other more comprehensive and locally relevant manuals and guidelines.

This edition of QUDM has been prepared with the specific aim of:

(i) outlining the objectives of urban stormwater management;
(ii) highlighting the planning tasks local governments should undertake to develop a stormwater strategy for their area;
(iii) listing the latest legislative requirements and legal issues applicable to stormwater management;
(iv) expanding the discussion on planning considerations for stormwater projects;
(v) updating its traditional hydrologic and hydraulic content;
(vi) supplementing the information provided on the design of piped drainage systems;
(vii) expanding the discussion on environmental considerations;
(viii) providing greater recognition and guidance on “soft” engineering approaches including the use and design of vegetated drainage channels;
(ix) providing broad guidance on the application of stormwater quality measures on small projects where it is impractical to conduct detailed water quality modelling;
(x) expanding the discussion on the hydraulic and environmental considerations of waterway crossings;
(xi) providing a rational approach to the management of the public safety risk associated with stormwater systems.

The contents of this edition of QUDM have been prepared using the experiences and knowledge of a range of stormwater management practitioners across government, academia and the private sector. The QUDM partners would like to thank all who have provided input into this review and trust that this edition of QUDM will maintain the manual's standing as a lead stormwater management guideline.

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Symbols and abbreviations

A catchment area

A_e equivalent area of pipe

A_g clear opening area of gully inlet

A_i impervious catchment area

A_L area of lateral pipe at a junction

A_o area of outflow pipe at a junction

A_p pervious catchment area

AEP annual exceedance probability (percent)

ACHA *Aboriginal Cultural Heritage Act, 2003* (Qld)

ARI average recurrence interval (years)

ARR "Australian Rainfall & Runoff"

b channel base width

B channel width, routing parameter RAFTS Model or junction pit width

C coefficient of discharge

C_g interpolation coefficient for intermediate Q_g/Q_o ratios in the Hare pressure change coefficient charts

C_i coefficient of discharge – impervious area

C_p coefficient of discharge – pervious area

C_u total energy loss coefficient

C_w weighted coefficient of runoff

C_y coefficient of discharge for ARI of "y" years

C_{weir} weir coefficient

(C.A) equivalent impervious area

CPM Act *Coastal Protection and Management Act, 1995 (Qld)*

CHMP *Cultural Heritage Management Plan* under the ACHA

d channel flow depth or diameter of obstructing pipe

d_{av} average flow distance in channel network

d_c depth of flow at crown of road, or critical depth in closed conduit flow

d_g depth of flow in gutter, or channel adjacent to a kerb

d_p depth of flow at pavement edge (lip)

D pipe diameter, or duration of rainfall excess

D_e equivalent pipe diameter

D_f pipe diameter – far lateral

D_L pipe diameter – lateral

D_{LL} pipe diameter – lateral left looking downstream

D_{LR} pipe diameter – lateral right looking downstream

D_n pipe diameter – near lateral

D_o pipe diameter for outlet pipe

DOGIT Deeds of Grant in Trust

DOT Department of Transport, Queensland

D_u pipe diameter for upstream pipe

d/s downstream

EIS *Environmental Impact Statement*

EP Act *Environmental Protection Act 1994(Qld)*

f Darcy-Weisbach friction factor

f_i fraction impervious

F kerb and channel flow correction factor in Izzard Equation, or factor of proportionality in Bransby-Williams' Equation

F_y frequency factor

FRC fibre-reinforced cement (pipes)

g gravitational acceleration, (9.79 m/s^2 in Queensland)

h depth of water

ha hectares (area)

h_a pressure change at a surcharge manhole

h_b head loss (pressure change) at a channel bend

h_c height (distance) to the centreline of an obstructing pipe from the most distant pipe wall

h_f pipe friction head loss (pressure change) or pressure change at far lateral

h_g gully head loss – grate inflow

h_n head loss (pressure change) at near lateral

h_p head loss at penetration

h_s head loss or pressure change at a structure

h_{sup} superelevation (difference in level) of the water surface across an open channel at a bend

h_t head loss at a channel transition

h_u head loss (pressure change) for the main pipe at a structure

h_w change in water surface elevation

H.G.L. hydraulic grade line

HAT highest astronomical tide

Health Act
Health Act 1937 (Qld)

I average rainfall intensity (mm/hr)

I_y average rainfall intensity for ARI of "y" years

${}^tI_y$ average rainfall intensity for duration of "t" hours and ARI of "y" years

IDAS *Integrated Development Approval System* under IPA

ILUA *Indigenous Land Use Agreement*

IPA *Integrated Planning Act 1997 (Qld)*

k pipe boundary roughness (Colebrook-White)

k_c empirical coefficient – RORB Model parameter

k_r dimensionless ratio called the relative delay time – RORB Model

K conveyance = (1/n)AR$^{2/3}$, or head loss or pressure change coefficient

K_a pressure change coefficient at a surcharge manhole

K_b bend loss coefficient

K_e entry loss coefficient

K_g end gully pressure change coefficient or pressure change coefficient through a grate

K_{HV} junction pit pressure change coefficient – higher velocity lateral, applied to downstream velocity head

$\overline{K}_L$ intermediate pressure change coefficient – lateral pipe

K_L junction pit pressure change coefficient – lateral pipe, applied to downstream velocity head

K_{LL} junction pit pressure change coefficient – left lateral pipe (looking d/s), applied to downstream velocity head

K_{LR} junction pit pressure change coefficient – right lateral pipe (looking d/s), applied to downstream velocity head

K_{LV} junction pit pressure change coefficient – lower velocity lateral, applied to downstream velocity head

K_p penetration loss coefficient

K_u junction pit pressure change coefficient – upstream pipe

K_u junction pit pressure change coefficient – upstream pipe, applied to downstream velocity head

K_u intermediate pressure change coefficient – main pipe

K_w' water surface elevation increment coefficient applied to upstream velocity head

K_w water surface elevation change coefficient applied to downstream velocity head

L stream flow length, or overland flow path length, or pipe length, or gutter flow length, or weir length

L_{eff} effective length of drainage path

Land Act *Land Act 1994 (Qld)*

LAT lowest astronomical tide

LG Act *Local Government Act 1993 (Qld)*

m exponent – RORB Model parameter

MHWN mean high water neap

MHWS mean high water spring

MLWN mean low water neap

MLWS mean low water spring

MSL mean sea level

MWL mean water level

M design ARI for gap flow (years)

M_L pressure change coefficient multiplier – lateral pipe

M_u pressure change coefficient multiplier – main pipe

n Manning's roughness coefficient, or Horton's roughness value

n_g Manning's "n" – gutter or channel

n_p Manning's "n" – pavement

n* surface roughness/ retardance coefficient

N design ARI for minor system (years)

N_R Reynold's Number = $V_o.D_o/\nu$

Native Title Act *Native Title Act 1993 (Commonwealth)*

NCA *Nature Conservation Act, 1997 (Qld)*

NSB Notes on the Science of Building (C.S.I.R.O.)

P wetted perimeter, or depth of rainfall excess

*P** effective wetted perimeter

P&D Act *Plumbing and Drainage Act 2002 (Qld)*

Q flow rate (m^3/s or L/s)

Q_f flow rate – full area, or inflow rate – far lateral

Q_g surface inflow to gully inlet

Q_{gap} "gap" flow

Q_i peak or design inflow rate

Q_L lateral pipe flow to junction pit

Q_{LL} lateral pipe flow left looking downstream

Q_{LR} lateral pipe flow right looking downstream

Q_m outflow rate from a surcharge manhole

Q_n inflow rate – near lateral

Q_o peak or design outflow rate, or outlet pipe flow

Q_p discharge rate – part area

Q_{peak} peak flow rate

Q_u upstream pipe flow

Q_y peak discharge rate for ARI of "y" years

QDC *Queensland Development Code*

RCBC reinforced concrete box culvert

RCP reinforced concrete pipe

r centreline radius of a pipe bend or reduction ratio

R hydraulic radius = A/P

R_c centreline radius of open channel bend

R_i inner radius of open channel bend

R_o outer radius of open channel bend

RRJ rubber ring jointed

S channel slope, storage or submergence depth at a structure

S_c modified equal area slope (%)

S_f friction slope

S & S spigot and socket

SBR *Standard Building Regulation*

T routing time step

t time

t_c time of concentration or travel time from extremity of pervious area

t_i travel time from extremity of impervious area or drop in pipe inverts at a drop manhole

U fraction of catchment urbanised

u/s upstream

UPVC unplasticised polyvinyl chloride

$V^2/2g$ velocity head

V velocity (m/s)

V_{ave} average velocity of channel flow

V_e equivalent velocity of flow

V_g velocity through a grate

V_u velocity in junction pit inflow (upstream) pipe

$\mathbf{V}$ runoff volume (m^3)

$\boldsymbol{V_i}$ volume of inflow

$\boldsymbol{V_o}$ volume of outflow, or velocity in junction pit outflow pipe = Q_o/A_o

$\boldsymbol{V_s}$ storage volume

w width of flow spread from kerb (m)

Water Act *Water Act, 2000 (Qld)*

W.S.E. water surface elevation

y general ARI expression (years)

Z_g reciprocal of gutter or channel cross-slope

Z_p reciprocal of pavement cross-slope

α deflection angle, or velocity head coefficient

β triangular flow correction factor

Δ channel flow multiplier

θ upstream-downstream pipe deviation angle at junction pit

ν kinematic viscosity (water) = 1.14×10^{-6} m^2/s at 15°C

Δh water surface superelevation at a bend in an open channel