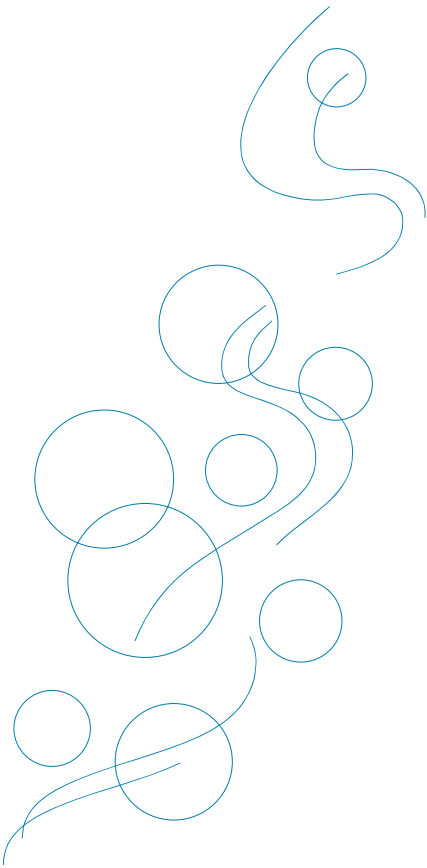




# Queensland Urban Drainage Manual

Volume 1

Second Edition 2007



## **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.

## **Acknowledgments**

The preparation of the original Manual was commissioned jointly by the Queensland Department of Primary Industries (Water Resources) the Institute of Municipal Engineering Australia (Queensland Division) and the Brisbane City Council.

Edition 2 was commissioned in 2005 by the Queensland Department of Natural Resources and Mines (NR&M) on behalf of the Department, the Queensland Division of Institute of Public Works Engineering Australia (IPWEAQ), and Brisbane City Council (BCC).

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The Steering Committee would like to extend special thanks to MacDonnells Solicitors (Brisbane) for their assistance in drafting Chapter 3, Geoffrey O’Loughlin of Anstad Pty Ltd for his assistance in the development of Chapters 4, 6 and 10; and Neil Collins of Cardno Lawson Treloar for his assistance with Chapter 10.

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Finally, thanks to Mr. Peter Gouriev of the Brisbane City Council who designed the logo and coordinated the printing of the manual.

The following figures have been supplied courtesy of Catchments & Creeks Pty Ltd and remain the property of Catchments & Creeks Pty Ltd: 4.02, 4.03, 4.04, 7.05.4, 7.05.5, 7.05.6, 7.06.1, 7.06.2, 7.06.3, 7.06.4, 7.16.4(a), (b) & (c), 7.16.9(a) & (b), 7.16.10 (a) & (b), 7.16.11 (a) & (b), 7.16.12 (a), (b) & (d), 8.02, 8.04, 8.05, 8.06, 8.07, 8.08, 8.09, 8.10, 8.11, 8.12, 8.13, 8.14, 8.15, 8.16, 8.17, 8.18, 8.19, 8.20, 8.21, 8.22, 8.23, 9.09, 9.10, 9.11, 9.12, 9.13, 9.14, 9.15, 9.16, 9.17, 9.18, 9.19, 10.04, 10.05, 10.06, 10.07, 10.08, 10.09, 10.10, 10.11, 10.12, 12.01, 12.02, 12.03, 12.04, 12.05, 12.06, 12.07, 12.13, 12.15.

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Published by:  
Department of Natural Resources and Water  
GPO Box 2454  
Brisbane Qld 4001

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Published December 2007  
ISBN 9781741727715  
#28390

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Cover photographs (bottom left and right) courtesy of Grant Witheridge



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## Amendments to volume 2

1992/94 Edition	2006 Edition
<b>Charts 1 to 6</b>	
Symbols and abbreviations	Updated in Volume 1 (2006)
Table 5.04.1	Superseded by Table 4.05.1
Table 5.04.2	Superseded by Table 4.05.3
Table 5.04.3	Table 4.05.2 (unchanged)
Table 5.05.1	Table 4.06.1 (unchanged)
Table 5.05.2	Superseded by Table 4.06.3
Figure 5.05.2	Figure 4.07 (unchanged)
Table 5.05.5	Table 4.06.2 (unchanged)
Figure 5.05.5	Figure 4.06 (unchanged)
Figure 5.05.6	Figure 4.09 (unchanged)
Figure 5.05.7	Figure 4.10 (unchanged)
Figure 5.05.8	Figure 4.11 (unchanged)

1992/94 Edition	2006 Edition
<b>Charts 7 to 29</b>	
Table 5.06.2	Modified Table 7.02.2
Table 5.06.1	Modified Table 7.02.1
Table 5.08.1	Modified Table 7.03.1
Figure 5.08.1 (a)	Modified Figure 7.03.1(a)
Figure 5.08.1 (b)	Modified Figure 7.03.1(b)
Table 5.09.1	Modified Table 7.04.1
Table 5.10.1	Modified Table 7.05.1
Figure 5.10.1	Figure 7.05.1 (unchanged)
Figure 5.10.2	Figure 7.05.2 (unchanged)
Figure 5.10.3	Figure 7.05.3 (unchanged)
Table 5.11.1	Modified Table 7.06.1
Table 5.11.2	Table 7.06.2 (unchanged)
Table 5.13.1	Table 7.08.1 (unchanged)
Table 5.13.2	Table 7.08.2 (unchanged)
Table 5.15.1	Table 7.10.1 (unchanged)
Table 5.16.1	Table 7.11.1 (unchanged)
Table 5.18.1	Table 7.13.1 (unchanged)
Table 5.17.1	Table 7.12.1 (unchanged)
Chart No. 15	Unchanged (not available in Vol 1)

Chart No. 16	Unchanged (not available in Vol 1)
Figure 5.18.1 (a) to (e)	Figure 7.13.1 (unchanged)
Table 5.18.2	Modified Table 7.13.2
Table 5.18.3	Modified Table 7.13.3
Table 5.18.4	Modified Table 7.13.4
Table 5.18.5	Table 7.13.5 (unchanged)
Figure 5.18.2	Figure 7.13.2 (unchanged)
Table 5.18.6	Modified Table 7.13.6
Table 5.18.7	Table 7.13.7 (unchanged)
Table 5.18.8	Modified Table 7.13.8
Figure 5.20.2 (a)	Figures 7.15.2(a) & (c) (unchanged)
Figure 5.20.2 (b)	Figure 7.15.2(b) (unchanged)
Figure 5.21.1	Figure 7.16.1 (unchanged)
Figure 5.21.2	Figure 7.16.2 (unchanged)
Figure 5.21.3	Figure 7.16.3 (unchanged)
Table 5.21.1	Modified Table 7.16.1
Table 5.21.2	Modified Table 7.16.2
Equation 5.21.4	Equation 7.13 (unchanged)
Table 5.21.3	Modified Table 7.16.3
Figure 8.01	Deleted
Table 8.01	Table 9.03.5 (unchanged)
Equation 8.05	Equation 9.06 (unchanged)
Table 8.02	Table 9.03.1 (unchanged)
Figure 8.02	Modified Figure 9.08
Table 8.03	Table 9.05.3 (unchanged)
Table 8.04	Modified Table 9.08.1

1992/94 Edition	2006 Edition
<b>Charts 30 to 60</b>	
Figure 5.21.4	Modified Figure 7.16.5
Figure 5.21.5	Figure 7.16.6 (unchanged)
Charts 31 to 55	Unchanged
Table 5.21.6	Table 7.16.6 (unchanged)
Figure 5.21.7	Figure 7.16.13 (unchanged)
Figure 5.21.11	Superseded by Tables 7.16.7, 7.16.8
Figure 5.21.8	Figure 7.16.14 (unchanged)
Table 5.21.4	Table 7.16.4 (unchanged)
Figure 5.21.6	Figure 7.16.8 (unchanged)

Table 5.21.5	Table 7.16.5 (unchanged)
Figure 5.21.12	Figure 7.16.20 (unchanged)
Table 5.21.7	Table 7.16.10 (unchanged)

<b>1992/94 Edition</b>	<b>2006 Edition</b>
<b>Road flow</b>	
Chart A2-1 to A2-5	Unchanged
<b>Inlet capacity</b>	
All charts	Unchanged
<b>Pressure change</b>	
All text	Unchanged
<b>Calculation sheets</b>	
All charts	Unchanged
<b>Example drawings</b>	
All charts	Unchanged
<b>Standard drawings</b>	
Chart R-01	Unchanged

## Symbols and abbreviations

$A$	catchment area	$C_u$	total energy loss coefficient
$A_e$	equivalent area of pipe	$C_w$	weighted coefficient of runoff
$A_g$	clear opening area of gully inlet	$C_y$	coefficient of discharge for ARI of “y” years
$A_i$	impervious catchment area	$C_{weir}$	weir coefficient
$A_L$	area of lateral pipe at a junction	( $C.A$ )	equivalent impervious area
$A_o$	area of outflow pipe at a junction	CPM Act	<i>Coastal Protection and Management Act, 1995 (Qld)</i>
$A_p$	pervious catchment area	CHMP	<i>Cultural Heritage Management Plan</i> under the ACHA
AEP	annual exceedance probability (percent)		
ACHA	<i>Aboriginal Cultural Heritage Act, 2003 (Qld)</i>		
ARI	average recurrence interval (years)	$d$	channel flow depth or diameter of obstructing pipe
ARR	"Australian Rainfall & Runoff"	$d_{av}$	average flow distance in channel network
$b$	channel base width	$d_c$	depth of flow at crown of road, or critical depth in closed conduit flow
$B$	channel width, routing parameter RAFTS Model or junction pit width	$d_g$	depth of flow in gutter, or channel adjacent to a kerb
$C$	coefficient of discharge	$d_p$	depth of flow at pavement edge (lip)
$C_g$	interpolation coefficient for intermediate $Q_g/Q_o$ ratios in the Hare pressure change coefficient charts	$D$	pipe diameter, or duration of rainfall excess
$C_i$	coefficient of discharge – impervious area	$D_e$	equivalent pipe diameter
$C_p$	coefficient of discharge – pervious area	$D_f$	pipe diameter – far lateral

$D_L$	pipe diameter – lateral	$h$	depth of water
$D_{LL}$	pipe diameter – lateral left looking downstream	ha	hectares (area)
$D_{LR}$	pipe diameter – lateral right looking downstream	$h_a$	pressure change at a surcharge manhole
$D_n$	pipe diameter – near lateral	$h_b$	head loss (pressure change) at a channel bend
$D_o$	pipe diameter for outlet pipe	$h_c$	height (distance) to the centreline of an obstructing pipe from the most distant pipe wall
DOGIT	Deeds of Grant in Trust		
DOT	Department of Transport, Queensland	$h_f$	pipe friction head loss (pressure change) or pressure change at far lateral
$D_u$	pipe diameter for upstream pipe	$h_g$	gully head loss – grate inflow
d/s	downstream	$h_n$	head loss (pressure change) at near lateral
EIS	<i>Environmental Impact Statement</i>	$h_p$	head loss at penetration
EP Act	<i>Environmental Protection Act 1994(Qld)</i>	$h_s$	head loss or pressure change at a structure
$f$	Darcy-Weisbach friction factor	$h_{sup}$	superelevation (difference in level) of the water surface across an open channel at a bend
$f_i$	fraction impervious	$h_t$	head loss at a channel transition
$F$	kerb and channel flow correction factor in Izzard Equation, or factor of proportionality in Bransby-Williams' Equation	$h_u$	head loss (pressure change) for the main pipe at a structure
$F_y$	frequency factor	$h_w$	change in water surface elevation
FRC	fibre-reinforced cement (pipes)	H.G.L.	hydraulic grade line
$g$	gravitational acceleration, (9.79 m/s <sup>2</sup> in Queensland)	HAT	highest astronomical tide

Health Act <i>Health Act 1937 (Qld)</i>	$K_{HV}$	junction pit pressure change coefficient – higher velocity lateral, applied to downstream velocity head
$I$ average rainfall intensity (mm/hr)	$\bar{K}_L$	intermediate pressure change coefficient – lateral pipe
$I_y$ average rainfall intensity for ARI of “y” years	$K_L$	junction pit pressure change coefficient – lateral pipe, applied to downstream velocity head
${}^tI_y$ average rainfall intensity for duration of “t” hours and ARI of “y” years	$K_{LL}$	junction pit pressure change coefficient – left lateral pipe (looking d/s), applied to downstream velocity head
IDAS <i>Integrated Development Approval System</i> under IPA	$K_{LR}$	junction pit pressure change coefficient – right lateral pipe (looking d/s), applied to downstream velocity head
ILUA <i>Indigenous Land Use Agreement</i>	$K_{LV}$	junction pit pressure change coefficient – lower velocity lateral, applied to downstream velocity head
IPA <i>Integrated Planning Act 1997 (Qld)</i>	$K_p$	penetration loss coefficient
$k$ pipe boundary roughness (Colebrook-White)	$K_u$	junction pit pressure change coefficient – upstream pipe
$k_c$ empirical coefficient – RORB Model parameter	$K_u$	junction pit pressure change coefficient – upstream pipe, applied to downstream velocity head
$k_r$ dimensionless ratio called the relative delay time – RORB Model	$K_u$	intermediate pressure change coefficient – main pipe
$K$ conveyance = $(1/n)AR^{2/3}$ , or head loss or pressure change coefficient	$K_w'$	water surface elevation increment coefficient applied to upstream velocity head
$K_a$ 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		

$K_w$	water surface elevation change coefficient applied to downstream velocity head	$n$	Manning's roughness coefficient, or Horton's roughness value
$L$	stream flow length, or overland flow path length, or pipe length, or gutter flow length, or weir length	$n_g$	Manning's "n" – gutter or channel
$L_{eff}$	effective length of drainage path	$n_p$	Manning's "n" – pavement
Land Act		$n^*$	surface roughness/retardance coefficient
<i>Land Act 1994 (Qld)</i>		$N$	design ARI for minor system (years)
LAT	lowest astronomical tide	$N_R$	Reynold's Number = $V_o \cdot D_o / \nu$
LG Act		Native Title Act	
<i>Local Government Act 1993 (Qld)</i>		<i>Native Title Act 1993 (Commonwealth)</i>	
$m$	exponent – RORB Model parameter	NCA	<i>Nature Conservation Act, 1997 (Qld)</i>
MHWN	mean high water neap	NSB	Notes on the Science of Building (C.S.I.R.O.)
MHWS	mean high water spring	$P$	wetted perimeter, or depth of rainfall excess
MLWN	mean low water neap	$P^*$	effective wetted perimeter
MLWS	mean low water spring	P&D Act	
MSL	mean sea level	<i>Plumbing and Drainage Act 2002 (Qld)</i>	
MWL	mean water level	$Q$	flow rate ( $m^3/s$ or L/s)
$M$	design ARI for gap flow (years)	$Q_f$	flow rate – full area, or inflow rate – far lateral
$M_L$	pressure change coefficient multiplier – lateral pipe	$Q_g$	surface inflow to gully inlet
$M_u$	pressure change coefficient multiplier – main pipe	$Q_{gap}$	"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	$S$	channel slope, storage or submergence depth at a structure
$Q_{LR}$	lateral pipe flow right looking downstream	$S_c$	modified equal area slope (%)
$Q_m$	outflow rate from a surcharge manhole	$S_f$	friction slope
$Q_n$	inflow rate – near lateral	S & S	spigot and socket
$Q_o$	peak or design outflow rate, or outlet pipe flow	SBR	<i>Standard Building Regulation</i>
$Q_p$	discharge rate – part area	$T$	routing time step
$Q_{peak}$	peak flow rate	$t$	time
$Q_u$	upstream pipe flow	$t_c$	time of concentration or travel time from extremity of pervious area
$Q_y$	peak discharge rate for ARI of “y” years	$t_i$	travel time from extremity of impervious area or drop in pipe inverts at a drop manhole
QDC	<i>Queensland Development Code</i>		
RCBC	reinforced concrete box culvert	$U$	fraction of catchment urbanised
RCP	reinforced concrete pipe	u/s	upstream
$r$	centreline radius of a pipe bend or reduction ratio	UPVC	unplasticised polyvinyl chloride
$R$	hydraulic radius = A/P	$V^2/2g$	velocity head
$R_c$	centreline radius of open channel bend	$V$	velocity (m/s)
$R_i$	inner radius of open channel bend	$V_{ave}$	average velocity of channel flow
$R_o$	outer radius of open channel bend	$V_e$	equivalent velocity of flow
RRJ	rubber ring jointed	$V_g$	velocity through a grate
		$V_u$	velocity in junction pit inflow (upstream) pipe
		$V$	runoff volume (m <sup>3</sup> )

$V_i$	volume of inflow	$Z_p$	reciprocal of pavement cross-slope
$V_o$	volume of outflow, or velocity in junction pit outflow pipe = $Q_o/A_o$	$\alpha$	deflection angle, or velocity head coefficient
$V_s$	storage volume	$\beta$	triangular flow correction factor
$w$	width of flow spread from kerb (m)	$\Delta$	channel flow multiplier
Water Act <i>Water Act, 2000 (Qld)</i>		$\theta$	upstream-downstream pipe deviation angle at junction pit
W.S.E. water surface elevation		$\nu$	kinematic viscosity (water) = $1.14 \times 10^{-6} \text{ m}^2/\text{s}$ at $15^\circ\text{C}$
$y$	general ARI expression (years)	$\Delta h$	water surface superelevation at a bend in an open channel
$Z_g$	reciprocal of gutter or channel cross-slope		