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An Australian Handbook of Stream Roughness Coefficients

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Disclaimer

An Australian Handbook of Stream Roughness Coefficients

What is Stream Roughness?

If you have ever tried to work out discharge, flow depth or channel dimensions to carry a particular flow, you have probably needed to estimate a roughness coefficient, the most common being Manning's n. Using Manning's n is a simple and widely adopted approach to characterising energy losses as water flows down a stream. Manning's n is used in the Manning equation.

Where:

- Q is discharge
- A cross-sectional area
- S is slope
- R is hydraulic radius (area divided by wetted perimeter) and n is Manning's n.

Although there has been criticism of this formula and other methods have been suggested, the use of Manning's n for simple hydraulic calculations remains the preferred approach of Australian engineers and other practitioners working in the field of 'open channel' flow. Manning's n is a key parameter in a range of activities associated with hydrology and water resources including floodplain management, stream restoration, and the design of hydraulic structures.

Manning's n typically ranges from 0.01 in smooth concrete channels with no obstructions to 0.10 in streams with large amounts of large woody debris and vegetation that impedes flow. Rarely, values as high as 0.2 have been used.

Roughness values come from a variety of sources and we have varying levels of confidence in the coefficients. The sources, in order of quality, are:

- Sites where there are direct measurements of discharge, water surface slope, flow depth and cross-sections. Manning's n-values can be calculated directly from these measured parameters.
- Reaches where Manning's n-values are estimated by calibration as part of hydraulic modelling undertaken for a flood study.
- Field assessments where n-values have been estimated based on pictorial guides or documented procedures. Although, we have less confidence in these values, they are likely to be more reliable that office based assessments.

The procedure used to estimate the roughness coefficient are explained in the entry for that particular location.

In 1982 a conference was held to discuss roughness coefficients where it was concluded that: "the most promising method for estimation of energy loss parameters in natural streams, and in particular n-values, would be based on a comprehensive data bank of descriptive and photographic information for typical stream reaches in Victoria or Australia". More than 20 years later, this handbook is that start of that project.

Expanding the Database

Although these case studies and the links to other guides are a good start in developing the Australian Handbook, the project could be improved if there were further contributions.

A particularly important source of data could be from stream gauges where there are regular measurements of discharge. If additional water level measurements could be made at cross sections upstream and downstream of the main gauging site then roughness could be calculated routinely. This would be a major advance in the understanding of stream roughness in Australia. A similar approach was undertaken in New Zealand to produce, probably, the best data on stream roughness available from anywhere in the world (see Hicks and Mason, 1998).

Acknowledgements

I would like to acknowledge the assistance of my colleagues: Brett Anderson, Ian Rutherfurd and Simon Lang and members of the steering committee Bob Keller, Erwin Weinmann, John Fenton and Rex Candy. Siwan Lovett and Phil Price from Land & Water Australia have had the vision and perseverance to see this task through. Brenda Moon and Kim Lynch of The Reef Multimedia are responsible for the website development.

Information on the Acheron River at Taggerty was obtained from Thiess Services Pty Ltd and we gratefully acknowledge their assistance. In particular, the help of Michael Briggs and Barbara Dworakowski is greatly appreciated.

1 Estimation of Floodplain Resistance

For overbank flows the determination of resistance involves is a problem with two parts: firstly, the estimation of resistance to flow across the floodplain; and secondly accounting for the interaction between the floodplain and main channel flows, known as the compound channel problem. The simulation of floodplain flows is now routinely conducted using two dimensional (2D) fluid dynamic models, with full three dimensional (3D) models becoming more common. However, increased model sophistication does not reduce the need for the users to provide resistance estimates, in fact input data requirements are more demanding to drive these higher dimensional schemes.

For a listing of current research and other relevant resources that provide some insight into each of the three issues see the links below.

1.1 Floodplain Resistance

- Arcement, G.J. and Schneider, V.R., 1989. Guide for selecting Manning 's roughness coefficients for natural channels and flood plains. Water-Supply Paper 2339, US Geological Survey.

See Guide for Selecting Manning's Roughness Coefficients for Natural channels and Flood Plains PDF

- Chow, V.T., 1959. Open channel hydraulics. McGraw Hill, New York.
- Poole, G.C., Stanford, J.A., Frissell, C.A. and Running, S.W., 2002. Three-dimensional mapping of geomorphic controls on flood-plain hydrology and connectivity from aerial photos. Geomorphology, 48(4): 329-347.
- Righetti, M. and Armanini, A., 2002. Flow resistance in open channel flows with sparsely distributed bushes. Journal of Hydrology, 269(1-2): 55-64.
- Kouwen, N. and Fathi-Moghadam, M., 2000. Friction factors for coniferous trees along rivers. Journal of Hydraulic Engineering: 732-740.
- Graeme, D. and Dunkerley, D.L., 1993. Hydraulic resistance by the River Red Gum Eucalyptus camaldulensis in ephemeral desert streams. Australian Geographical Studies, 31(2): 141-54.
- Nuding, A., 1994. Hydraulic resistance of river banks covered with trees and brushwood. In: W.R. White and J. Watts (Editors), 2nd International Conference on River Flood Hydraulics. John Wiley & Sons Ltd, York, England, pp. 427-437.
- Tamai, N., 1993. Discharge prediction for flow in a compound channel: A new approach to overbank flow. Part 1: Evaluation of flood plain resistance. Australian Civil Engineering Transactions, 4(December): 285-302.

1.2 The Compound Channel Problem

- Review by Sturm, pp126-129
- Sturm, T.W., 2001. Open channel hydraulics. McGraw-Hill, Boston, USA.
  Myers, W.R.C., Lyness, J.F., Cassells, J.B. and O'Sullivan, J.J., 2000. Geometrical and roughness effects on compound channel resistance. Proceedings of the Institution of Civil Engineers-Water Maritime & Energy, 142(3): 157-166.
- Sellin, R.H.J. and Willetts, B.B., 1996. Three-Dimensional Structures, Memory and Energy Dissipation in Meandering Compound Channel Flow. In: M.G. Anderson, Walling, D.E. and Bates, P.D. (Editor), Floodplain Processes. Wiley, Chichester; New York, pp. 255 - 297.
- Keller, R.J. and Rodi, W., 1988. Prediction of flow characteristics in main channel/flood plain flows. Journal of Hydraulic Research, 26(No. 4): 425-441.

1.3 Numerical Simulation Methods

- Lane, S.N., Bradbrook, K.F., Richards, K.S., Biron, P.A. and Roy, A.G., 1999. The application of computational fluid dynamics to natural river channels: three-dimensional versus two-dimensional approaches. Geomorphology, 29(1-2): 1-20.
- Lane, S.N., 1998. Hydraulic modelling in hydrology and geomorphology: A review of high resolution approaches. Hydrol. Process., 12(8): 1131-1150.
- Hervouet, J.M. and Haren, L.V., 1996. Recent Advances in Numerical Methods for Fluid Flows. In: M.G. Anderson, Walling, D.E. and Bates, P.D. (Editor), Floodplain Processes. Wiley, Chichester; New York, pp. 183 - 214.
- Bates, P.D., Anderson, M.F., Price, D.A., Hardy, R.J. and Smith, C.N., 1996. Analysis and Development of Hydraulic Models for Floodplain Flows. In: M.G. Anderson, Walling, D.E. and Bates, P.D. (Editor), Floodplain Processes. Wiley, Chichester; New York, pp. 215 - 254.
- Horritt, M.S. and Bates, P.D., 2002. Evaluation of 1D and 2D numerical models for predicting river flood inundation. Journal of Hydrology, 268(1-4): 87-99.
- El-Hames, A.S. and Richards, K.S., 1998. An integrated, physically based model for arid region flash flood prediction capable of simulating dynamic transmission loss. Hydrological Processes, 12(8): 1219-1232.
- Bates, P.D., Horritt, M. and Hervouet, J.M., 1998. Investigating two-dimensional, finite element predictions of floodplain inundation using fractal generated topography. Hydrological Processes, 12(8): 1257-1277.
- Nicholas, A.P. and Mitchell, C.A., 2002. Numerical simulation of overbank processes in topographically complex floodplain environments. Hydrological Processes.

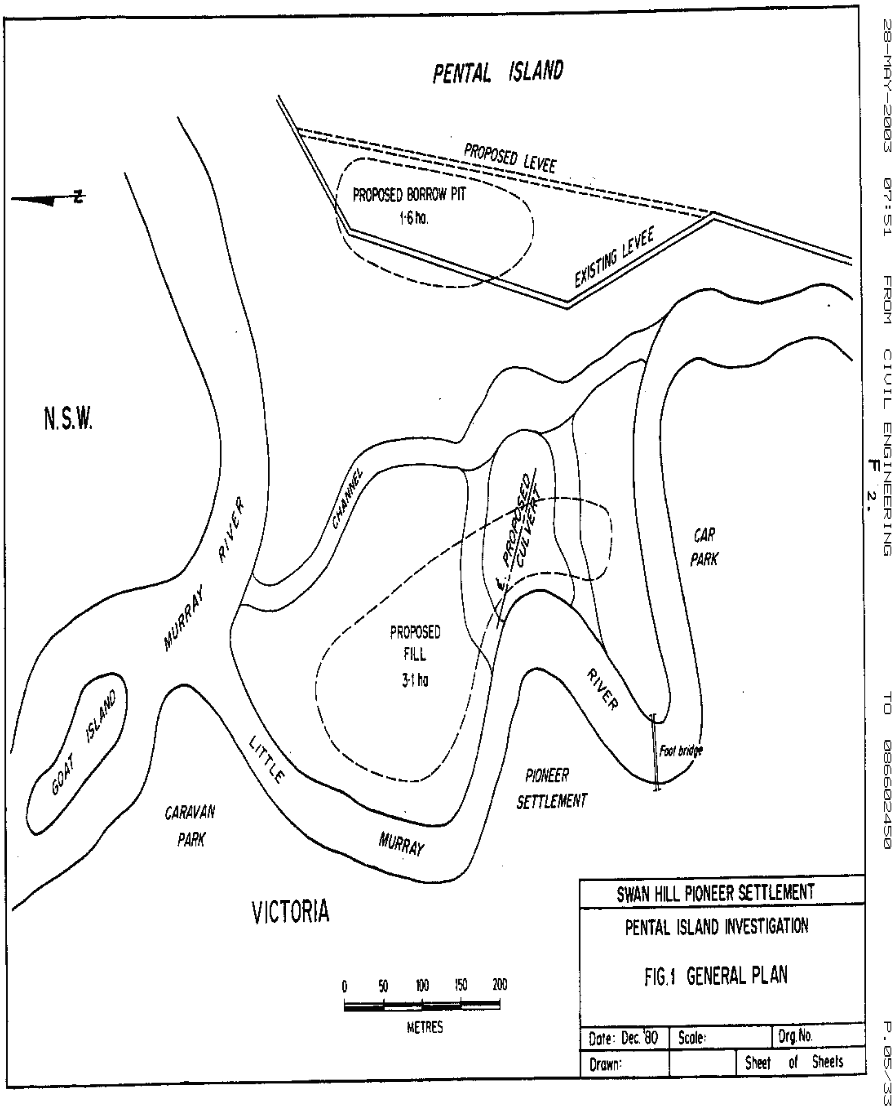
2 New South Wales

2.1 Murray River at Swan Hill

Range of Manning's n value	
Channel	0.034
Floodplain	0.100
Estimated by	Using HEC2* to fit November 1975 flood
Drainage Division	4
Basin	409
River	Murray River
Nearest Stream Gauge	409204
Catchment Area	70200 km2
Latitude	35.33°
Longitude	143.56°
Elevation	67.40 m
Average Daily Flow	9113 ML
Channel Type	Natural, fine sediment on bed with cohesive banks

* Hydrologic Engineering Center

2.2 Reach map



2.3 References

Keller, R. J. (1982) Case study: Confluence of Little Murray and Murray Rivers at Swan Hill. The Association for Computer Aided Design, Ltd (ACADS) Forum/Workshop on energy loss parameters for flow profile computation programs. October 6, 1982. Melbourne, ACADS

See Confluence of Little Murray and Murray Rivers at Swan Hill PDF

2.4 Key information

Manning's n-values are based on a case study where HEC-2 was used to model the area near the junction of the Murray and Little Murray Rivers near Swan Hill.

Manning' n-values for the Murray River and Little Murray Rivers near Swan Hill, calibrated to the November 1975 flood. Flow is 380 cumec in the Murray River downstream of the Little Murray confluence (source: Keller, 1982 (see above)

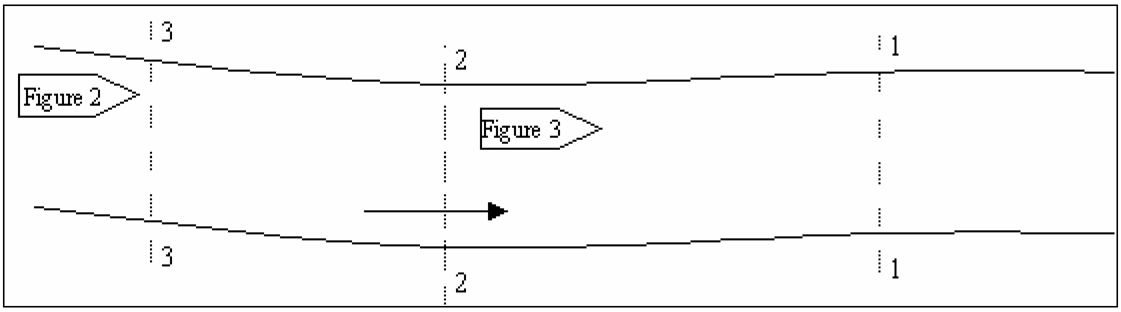
Stream	n-value
Murray River	0.034
Little Murray River	0.038
Flood Channel	0.048
Overbank Areas	0.100

3 Victoria

3.1 Acheron River at Taggerty

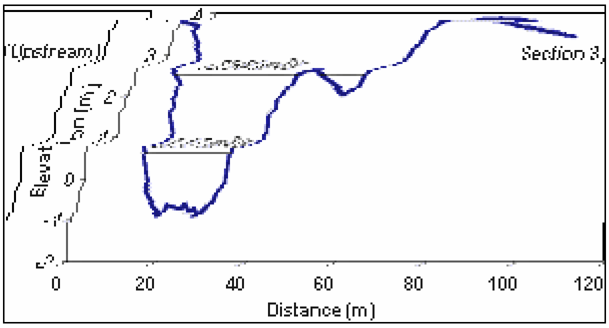
Range of Manning's n value	
Channel	0.034 - 0.047
Estimated by	Direct measurement of hydraulic properties
Drainage Division	4
Basin	405
River	Acheron River
Nearest Stream Gauge	405209
Catchment Area	619 km2
Latitude	37.317°
Longitude	145.717°
Elevation	198.177 m
Average Daily Flow	800 ML
Channel Type	Gravel bed stream

3.2 Acheron River at Taggerty - Reach Map

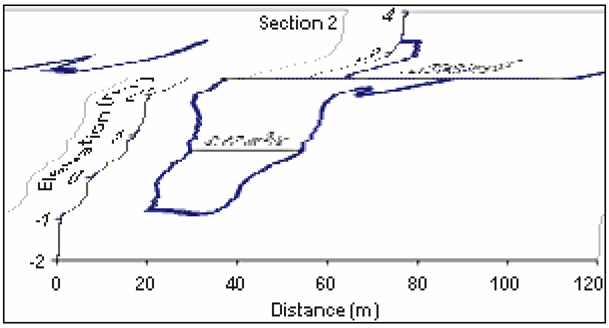


Plan view (not to scale) - Acheron River at Taggerty.

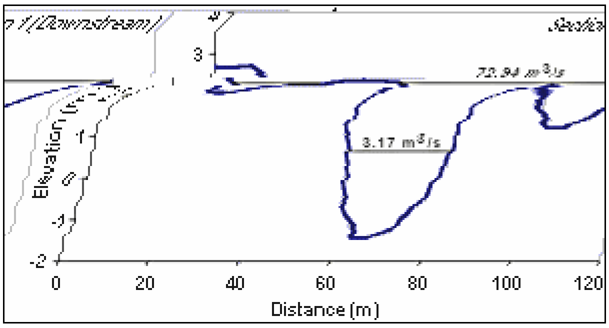
3.3 Acheron River at Taggerty - Cross Sections



Cross-Section 3 - Gauging Station



Cross-Section 2 - 191.5 metres downstream of gauging station



Cross-Section 1 - 283.0 metres downstream of gauging station

3.4 Acheron River at Taggerty – Photographs

Figure 2. View downstream from top of reach (1st August 2002, discharge 5.16 m3/s)
Acheron River at Taggerty

Figure 3. View downstream from middle of reach (1st August 2002, discharge 5.16 m3/s)
Acheron River at Taggerty

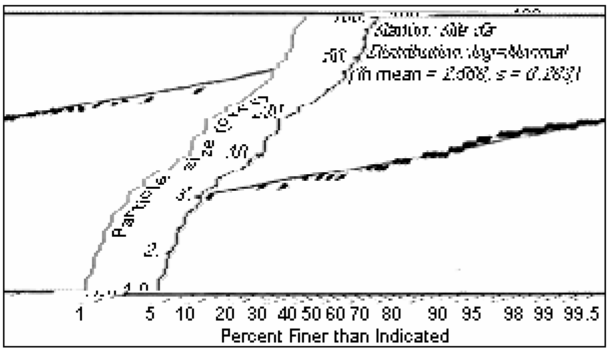
3.5 References

Lang,S., Ladson, A., Anderson, B. and Rutherford, I. (2004) Stream roughness. Four case studies from Victoria. Australian Journal of Water Resources. In press.

See Case studies from Victoria PDF

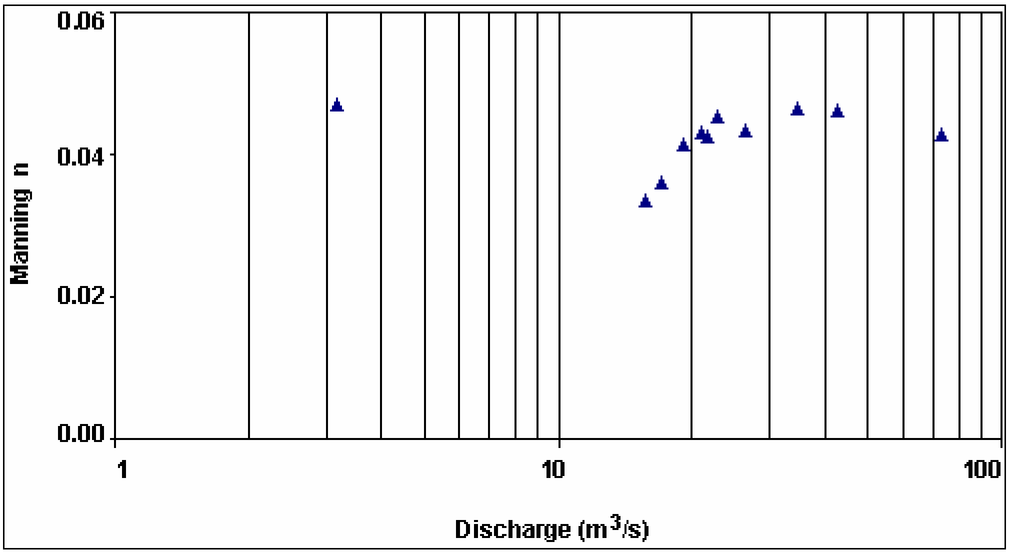
3.6 Key Information

Particle Distribution Curve



Measurements

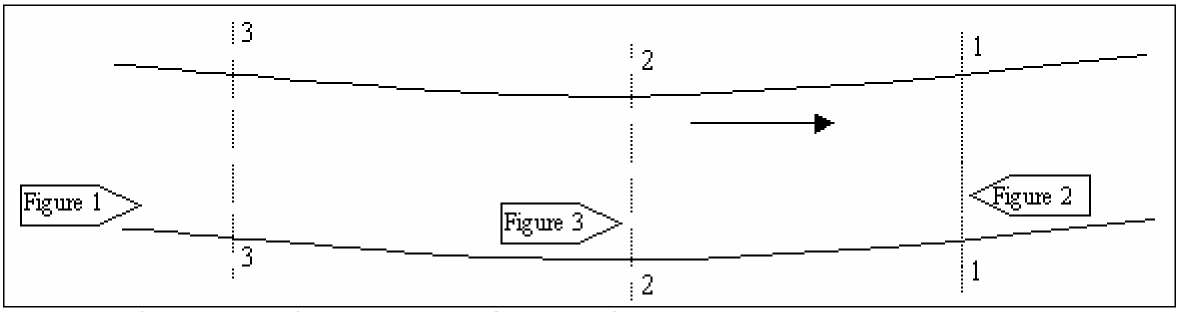
Discharge	ARI	Flow	Water Surface Slope	Friction Slope	Area	Expansion	Hydraulic Radius	Mean Velocity	Manning	Chezy	Darcy and Wiesbach
(m3/s)	(yr)	Percentile			(m2)	(%)	(m)	(m/s)	*n*	C	*f*
3.17	0.1	26.8%	0.00002	0.00003	28.21	51%	1.23	0.12	0.047	22.0	0.162
15.74	0.2	80.5%	0.00011	0.00012	38.68	39%	1.56	0.41	0.034	32.1	0.076
17.04	0.2	82.7%	0.00013	0.00015	39.60	38%	1.59	0.44	0.036	30.0	0.087
19.10	0.2	85.1%	0.00021	0.00023	40.56	36%	1.62	0.48	0.042	26.1	0.115
21.06	0.2	87.1%	0.00025	0.00026	42.16	34%	1.67	0.51	0.043	25.2	0.124
21.64	0.2	87.8%	0.00025	0.00026	42.65	34%	1.63	0.52	0.043	25.5	0.121
22.82	0.2	88.9%	0.00030	0.00032	43.53	33%	1.61	0.53	0.045	23.9	0.138
26.50	0.3	91.5%	0.00030	0.00032	46.70	34%	1.66	0.58	0.043	25.1	0.124
34.55	0.4	95.2%	0.00042	0.00045	52.66	33%	1.75	0.67	0.046	23.7	0.140
42.55	0.5	97.2%	0.00046	0.00049	59.84	37%	1.84	0.72	0.046	23.9	0.137
72.94	1.7	99.7%	0.00085	0.00090	81.94	43%	1.45	0.91	0.043	24.9	0.126



3.7 Merimans Creek at Stradbroke West

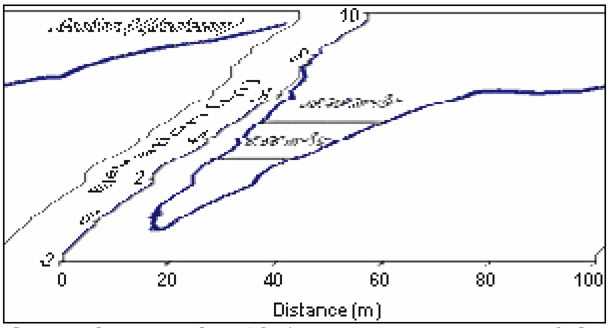
Range of Manning's n value	
Channel	0.076 - 0.080
Estimated by	Direct measurement of hydraulic properties
Drainage Division	2
Basin	227
River	Merimans Creek
Nearest Stream Gauge	227239
Catchment Area	256 km2
Latitude	38.270°
Longitude	146.910°
Elevation	78.02 m
Average Daily Flow	267 ML
Channel Type	Small rural stream

3.8 Merimans Creek at Stradbroke West - Reach Map

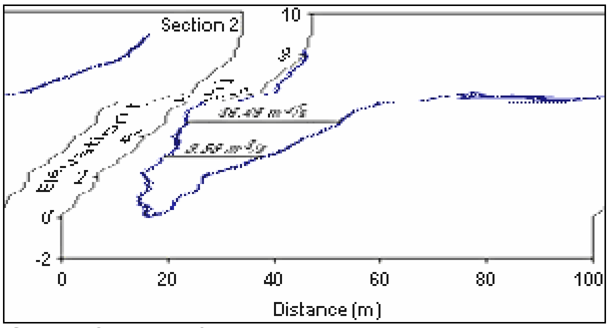


Plan view (not to scale) - Merrimans Creek at Stradbroke West.

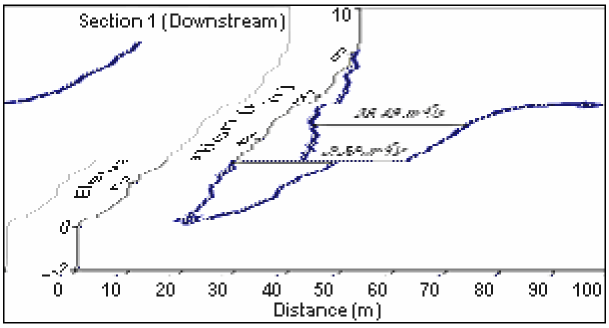
3.9 Merimans Creek at Stradbroke West - Cross Sections



Cross-Section 3 - 68.4 metres upstream of Cross-Section 2



Cross-Section 2



Cross-Section 1 - 59.7 metres downstream of Cross-Section 2

3.10 Merimans Creek at Stradbroke West - Photographs

Figure 1. View downstream from top of reach (1st April 2003, discharge (recorded downstream at Seaspray) 0.047m3/s) - Merrimans Creek at Stradbroke West.

Figure 2. View upstream from bottom of reach (1st April 2003, discharge (recorded downstream at Seaspray) 0.047 m3/s) - Merrimans Creek at Stradbroke West.

Figure 3. View downstream from middle of reach (1st April 2003, discharge (recorded downstream at Seaspray) 0.047 m3/s) - Merrimans Creek at Stradbroke West.

3.11 References

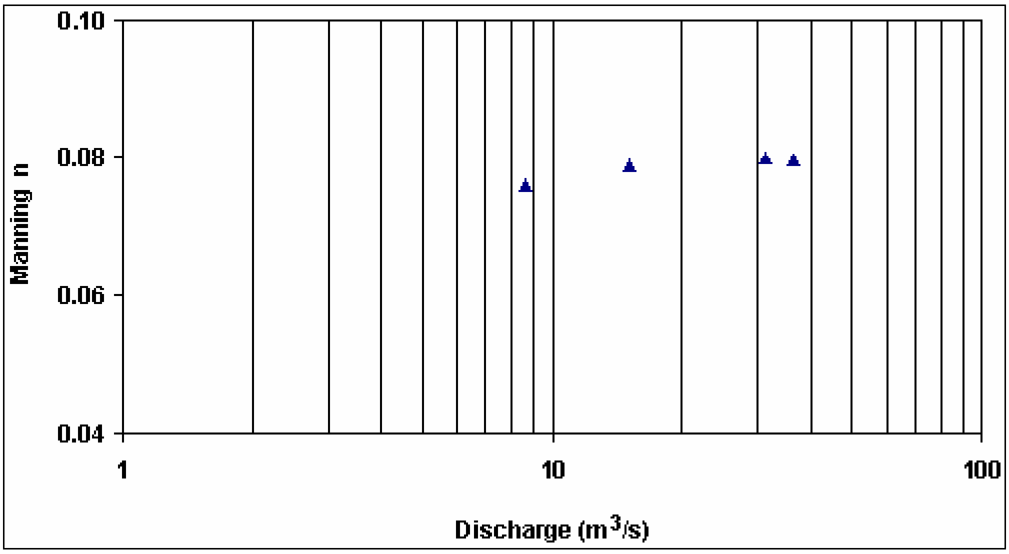
Lang,S., Ladson, A., Anderson, B. and Rutherford, I. (2004) Stream roughness. Four case studies from Victoria. Australian Journal of Water Resources. In press.

See the four case studies from Victoria PDF

3.12 Key Information

Measurements

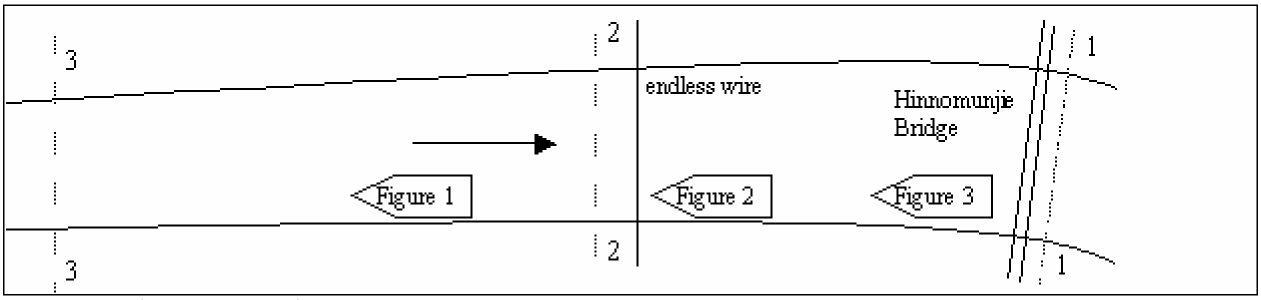
Discharge	ARI	Water Surface Slope	Friction Slope	Area	Expansion	Hydraulic Radius	Mean Velocity	Manning	Chezy	Darcy and Wiesbach
(m3/s)	(yr)			(m2)	(%)	(m)	(m/s)	*n*	C	*f*
8.56	1.1	0.00027	0.00027	30.38	3%	1.60	0.28	0.076	14.2	0.387
15.12	1.2	0.00035	0.00035	42.82	9%	1.90	0.35	0.079	14.1	0.395
31.31	1.6	0.00055	0.00056	63.24	13%	2.22	0.50	0.080	14.3	0.385
36.49	1.8	0.00059	0.00060	68.77	13%	2.31	0.53	0.080	14.4	0.378



3.13 Mitta Mitta River at Hinnomunjie Bridge

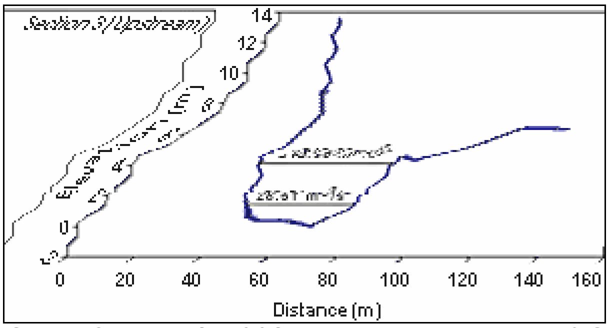
Range of Manning's n value	
Channel	0.039 - 0.049
Estimated by	Direct measurement of hydraulic properties
Drainage Division	4
Basin	401
River	Mitta Mitta River
Nearest Stream Gauge	401203
Catchment Area	1533 km2
Latitude	39.950°
Longitude	147.600°
Elevation	542.10 m
Average Daily Flow	1307 ML
Channel Type	Gravel bed stream

3.14 Mitta Mitta River at Hinnomunjie Bridge - Reach Map

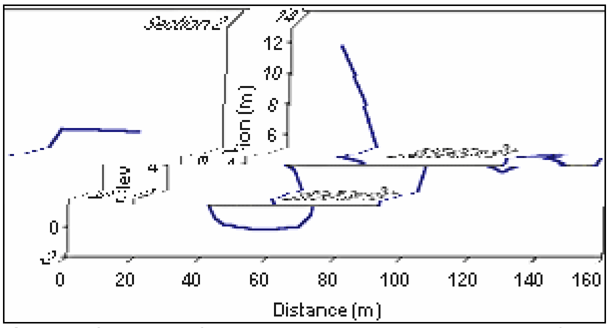


Plan view (not to scale) - Mitta Mitta River at Hinnomunjie Bridge

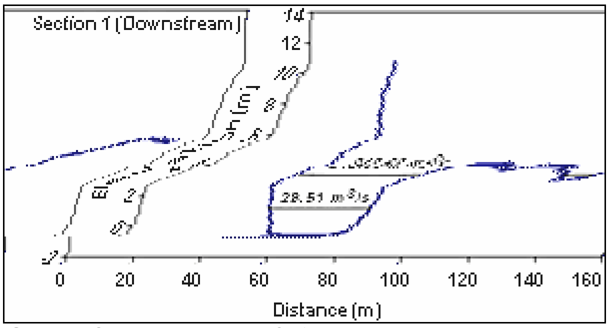
3.15 Mitta Mitta River at Hinnomunjie Bridge - Cross Sections



Cross-Section 3 - 223.1 metres upstream of Cross-Section 2



Cross-Section 2 - Immediately upstream of endless wire



Cross-Section 1 - 179.6 metres downstream of Cross-Section 2

3.16 Mitta Mitta River at Hinnomunjie Bridge - Photographs

Figure 1. View upstream from middle of reach (1st April 2003, discharge 1.68 m3/s)
Mitta Mitta River at Hinnomunjie Bridge

Figure 2. View upstream from bottom of reach (1st April 2003, discharge, 1.68 m3/s)
Mitta Mitta River at Hinnomunjie Bridge.

Figure 3. View upstream to endless wire (1st April 2003, discharge 1.68 m3/s)
Mitta Mitta River at Hinnomunjie Bridge.

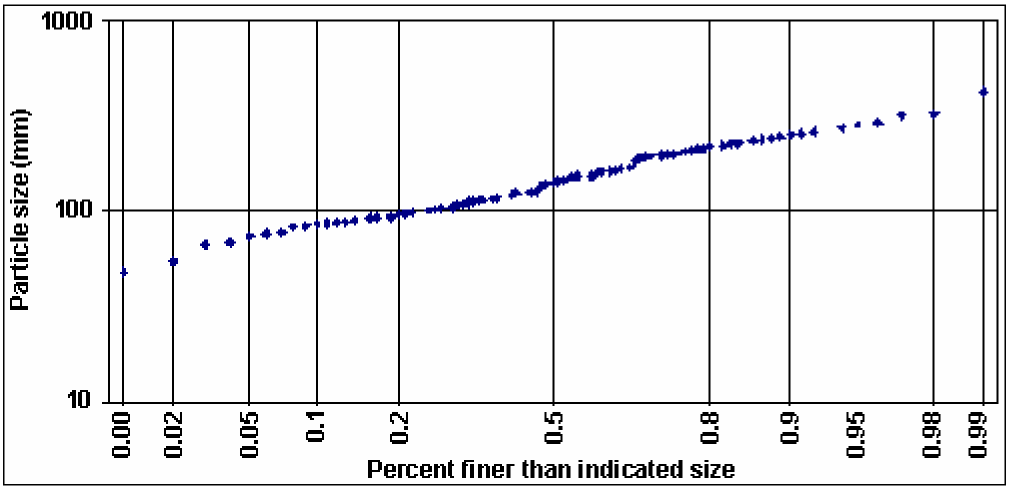
3.17 References

Lang,S., Ladson, A., Anderson, B. and Rutherford, I. (2004) Stream roughness. Four case studies from Victoria. Australian Journal of Water Resources. In press.

See Case studies from Victoria PDF

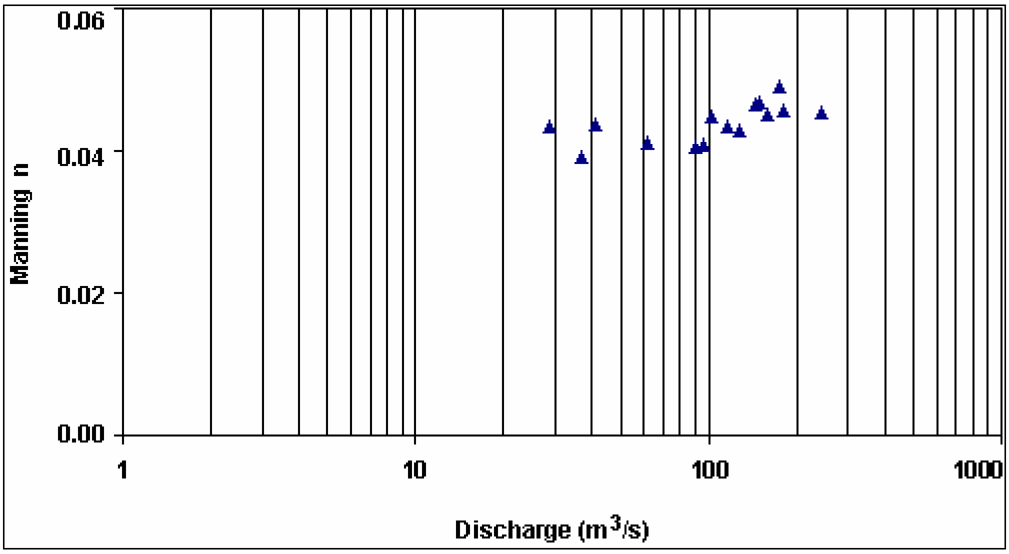
3.18 Key Information

Particle Distribution Curve



Measurements

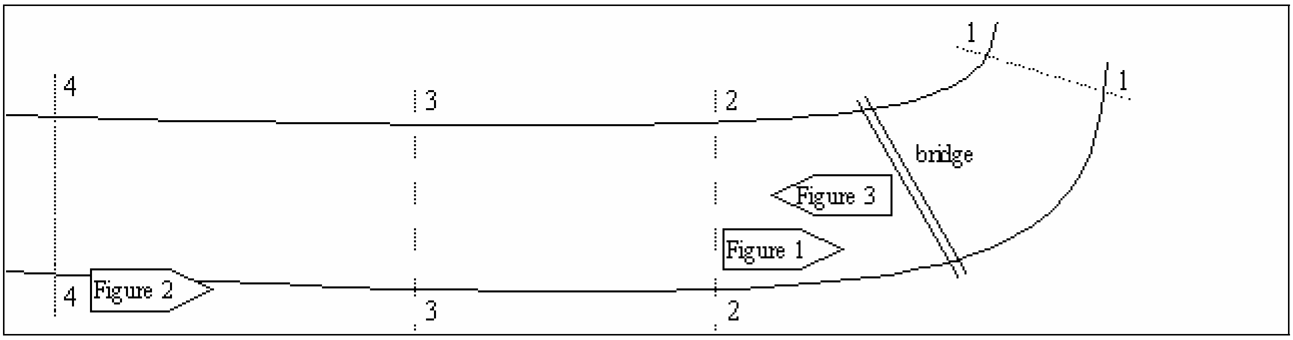
Discharge	ARI	Flow	Water Surface Slope	Friction Slope	Area	Expansion	Hydraulic Radius	Mean Velocity	Manning	Chezy	Darcy and Wiesbach
(m^3/s)	(yr)	Percentile			(m^2)	(%)	(m)	(m/s)	*n*	*C*	*f*
28.51	0.2	85.0%	0.00074	0.00077	40.10	38%	1.27	0.72	0.043	24.0	0.136
36.88	0.2	90.1%	0.00073	0.00076	44.65	32%	1.39	0.84	0.039	26.9	0.109
41.09	0.2	91.8%	0.00089	0.00091	47.49	24%	1.46	0.87	0.044	24.5	0.131
61.94	0.3	96.4%	0.00094	0.00096	58.42	16%	1.73	1.06	0.041	26.6	0.111
89.53	0.4	98.3%	0.00107	0.00108	69.81	10%	2.00	1.28	0.041	27.7	0.102
95.50	0.5	98.5%	0.00109	0.00111	72.75	8%	2.07	1.31	0.041	27.5	0.103
102.73	0.5	98.8%	0.00124	0.00125	78.00	4%	2.19	1.32	0.045	25.4	0.122
115.79	0.6	99.1%	0.00121	0.00122	82.61	4%	2.28	1.40	0.043	26.5	0.112
127.29	0.7	99.2%	0.00134	0.00134	84.61	2%	2.32	1.50	0.043	26.9	0.108
144.73	0.9	99.5%	0.00139	0.00138	96.14	0%	2.56	1.51	0.046	25.2	0.124
149.94	1.0	99.5%	0.00144	0.00143	97.95	-1%	2.59	1.53	0.047	25.0	0.125
157.94	1.1	99.6%	0.00139	0.00138	100.23	0%	2.63	1.58	0.045	26.0	0.116
174.63	1.4	99.7%	0.00158	0.00156	108.84	-4%	2.78	1.61	0.049	24.2	0.134
178.95	1.5	99.7%	0.00161	0.00158	104.35	-4%	2.71	1.72	0.046	25.9	0.117
242.63	3.5	99.9%	0.00202	0.00194	127.97	-8%	2.71	1.90	0.045	26.1	0.115


0.06
0.04
0.02
0.00
Manning n
1
10
100
1000
Discharge (m3/s)

3.19 Tambo River downstream of Ramrod Creek

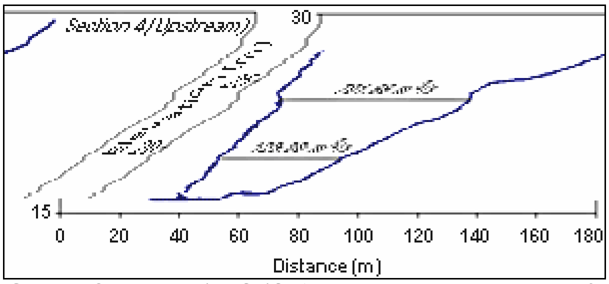
Range of Manning's n value	
Channel	0.041 - 0.045
Estimated by	Direct measurement of hydraulic properties
Drainage Division	2
Basin	223
River	Tambo River
Nearest Stream Gauge	223205
Catchment Area	2681 km2
Latitude	37.670°
Longitude	147.870°
Elevation	24.615 m
Average Daily Flow	733 ML
Channel Type	Gravel bed stream

3.20 Tambo River downstream of Ramrod Creek - Reach Map

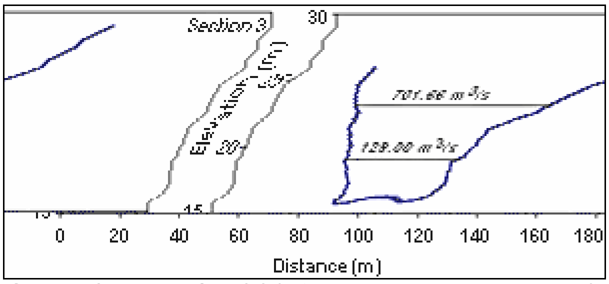


Plan view (not to scale) - Tambo River downstream of Ramrod Creek.

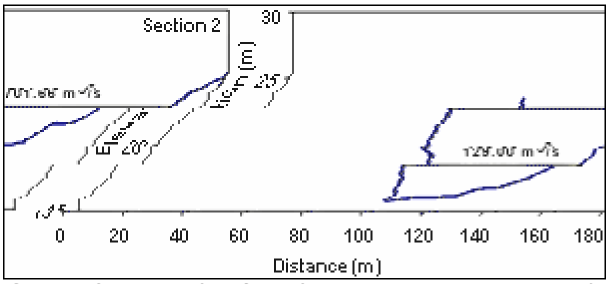
3.21 Tambo River downstream of Ramrod Creek - Cross Sections



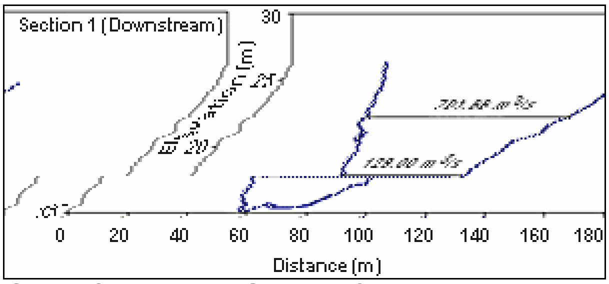
Cross-Section 4 - 343.65 metres upstream of Cross-Section 3



Cross-Section 3 - 290.65 metres upstream of Cross-Section 2



Cross-Section 2 - 315.85 metres upstream of Cross-Section 1



Cross-Section 1 - Gauging Station

3.22 Tambo River downstream of Ramrod Creek - Photographs

Figure 1. View downstream from cross-section 2 to cross-section 1 (1st April 2003, discharge (recorded on 30th March 2003) 0.54 m3/s) - Tambo River downstream of Ramrod Creek.

Figure 2. View downstream from top of reach (1st April 2003, discharge (recorded on 30th March 2003) 0.54 m3/s) - Tambo River downstream of Ramrod Creek.

Figure 3. View upstream from bottom of reach (1st April 2003, discharge (recorded on 30th March) 0.54 m3/s) - Tambo River downstream of Ramrod Creek.

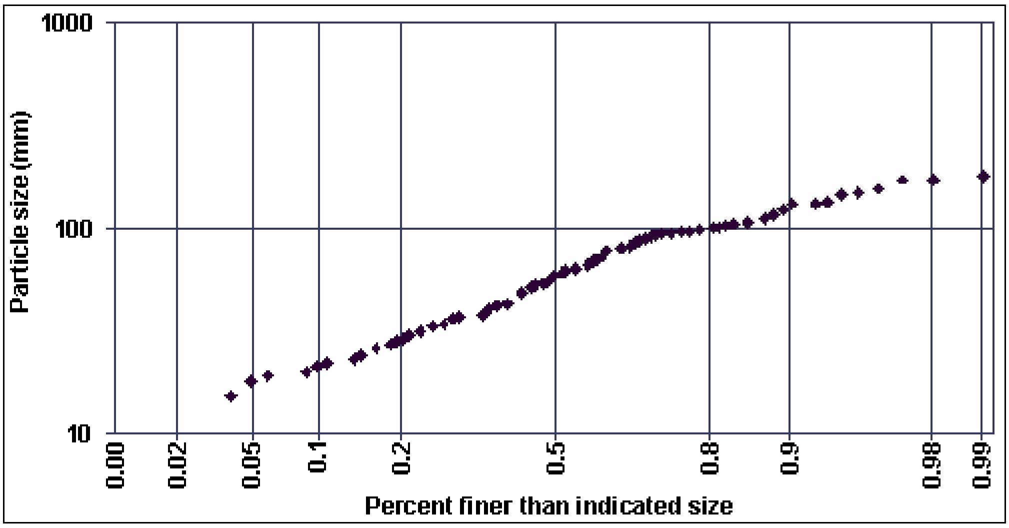
3.23 References

Lang,S., Ladson, A., Anderson, B. and Rutherford, I. (2004) Stream roughness. Four case studies from Victoria. Australian Journal of Water Resources. In press.

See Case studies from Victoria PDF

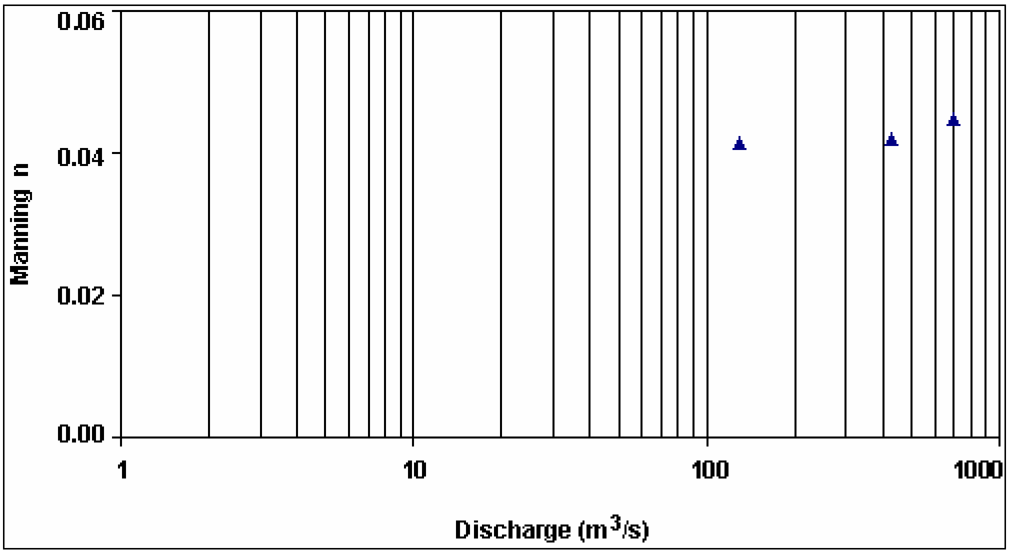
3.24 Key Information

Particle Distribution Curve



Measurements

Discharge	ARI	Water Surface Slope	Friction Slope	Area	Expansion	Hydraulic Radius	Mean Velocity	Manning	Chezy	Darcy and Wiesbach
(m3/s)	(yr)			(m2)	(%)	(m)	(m/s)	*n*	C	*f*
129.00	07	0.00125	0.00121	93.24	-17%	2.15	1.39	0.041	27.3	0.104
428.43	2.8	0.00127	0.00124	218.90	-8%	3.70	1.97	0.042	29.5	0.090
701.66	8.0	0.00134	0.00131	328.99	-5%	4.49	2.15	0.045	28.7	0.095



4 Guides and References for the Selection of Roughness Parameters

These guides provide information on stream roughness characteristics in Canada, New Zealand, Switzerland, and the US.

Only recent US guides are presented here. Most of the older guides have been incorporated into a USGS web-based database of stream roughness coefficients.

Reference	Summary	For more information
Hicks & Mason (1998) Roughness characteristics of New Zealand Rivers. Water Resource Publications	Physical and hydraulic characteristics are presented for 78 New Zealand river and canal reaches	Water Resource Publications
Coon, W. R. (1998) Estimation of roughness coefficients for natural stream channels with vegetated banks. US Geological Survey Water-Supply Paper 2441	Water-surface profiles were recorded, and Manning's roughness coefficients were computed for a wide range of discharges on 21 sites on unregulated streams in New York State.	US Geological Survey, Information Services Box 25286, Federal Center, Denver, CO 80225 www.usgs.gov.au
Spreafico, M. Hodel, H.P. & Kaspar (2001) Rauheiten in ausgesuchten schweizerischen Fliessgewässern.	Guide to stream roughness characteristics in Switzerland	Publication and purchase information
Annable, W.K. (1996) Database of morphologic characteristics of watercourses in Southern Ontario. Ontario Ministry of Natural Resources Annable, W. K. (1996) Morphologic relationships of rural watercourses in Southern Ontario and selected field methods in fluvial geomorphology. Ontario Ministry of Natural Resources	Roughness characteristics of 47 streams in Southern Ontario Canada	Lands and Natural Heritage Branch, Ontario Ministry of Natural Resources, 300 Water St, P.O. Box 7000, Peterborough ON, K9J 8M5
Phillips, J. V. and Ingersoll, T. L. Verification of roughness coefficients for selected natural and constructed stream channels in Arizona. USGS Professional Paper 1584	Physical and hydraulic characteristics are presented for 14 river and canal reaches in Arizona for which 37 roughness coefficients have been determined	US Geological Survey, Information Services Box 25286, Federal Center, Denver, CO 80225 www.usgs.gov.au
Engman, E.T., 1986. Roughness Coefficients for Routing Surface Runoff. Journal of Irrigation & Drainage Division. American Society of Civil Engineers, 112(1), 39-53.	Manning's n values for shallow flow	
Shields, F. D. & Gippel, C. J. (1995) Prediction of the effects of woody debris removal on flow resistance. Journal of Hydraulic Engineering 121(4) 341-354	Estimation of flow resistance parameters before and after the removal of large woody debris	