Urban Drainage Modelling and The Future of the Urban Rational Method
Part 1

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Australian Rainfall and Runoff
A guide to runoff estimation

ENGINEERS AUSTRALIA

Urban Rational Method (URM)

- Current URM was established in 1987 as part of ARR87.
- Recognised as a pragmatic approach which was not based on substantial data.
- "*Simplistic deterministic model at best useful for quick and rough estimates*"

Urban Rational Method (URM)

- Authors of ARR87
  - assumed a deterministic interpretation;
  - did not use empirical relationships to ensure AEP neutrality in predictions; and
  - Did not ensure that predictions from the current URM were probabilistic and consistent.

Urban Rational Method (URM)

- Pragmatic approach justified in ARR87 since computational capacity was not widely available
- Previous justification is not reasonable today
- Only methods justified by data and a sound technical basis will be recommended in next edition of ARR.

$$Q_Y = \frac{1}{3.6} C_Y I_{t,Y} A$$

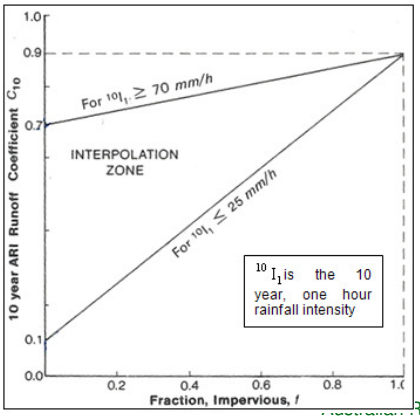
where :

Q_Y = peak flowrate (m^3/s) of average recurrence interval

C_Y = runoff coefficient for ARI of Y years

A = area of catchment (km^2)

$I_{t,Y}$ = average rainfall intensity (mm/h) for design duration of tc hours and ARI off Y years



$$t_c = \frac{6.94(L \cdot n^*)^{0.6}}{I_{t_c}^{0.4} S^{0.3}}$$

where :

t = overland flow time (mins)

L = overland flow path length (m)

n * = surface roughness

I = rainfall intensity (mm/hr)

S = slope (m/m)

URM limitations

- Uses Total Impervious Area (TIA) instead of Directly Connected Impervious Area (DCI)
  - Overestimates can occur if TIA is used instead of DCI (Alley 1983)
  - DCI is not a static figure (Ball and Powell 1998)
- URM does not scale flow correctly
  - Constant FF's scale flow based on C_{10} assumptions
  - Influence of DCI reduces with less frequent storms
- Accuracy is unknown

Summary of URM

- Developed with very limited data inadequate for task
- No reason to maintain “AEP Neutrality”
- Unverified (accuracy is not known)
- TIA instead of DCI

URM still used?

- 1997 Survey of Engineers in stormwater drainage showed 86% of respondents do (Ladson 2008)

Improvements to the URM

- Since ARR87, improved statistical techniques have been presented which are ideal for producing relationships for flow quantile prediction from catchment characteristics.
  - GLS, OLS, Quantile Regression, Bayesian Methods
  - Region of Influence (ROI)

Development of Revised Method

A database of gauged urban catchments was compiled to determine if suitable data exits to develop a revised method for urban flow estimation.

Database of Gauged Urban Catchments

- Criteria
  - Area less 20km^2
  - Record greater 10yrs*
  - Catchment significantly (>50%) urbanised
  - Acceptable gauging ratio*
  - Level of urbanisation is stationary*

* Some criterion were not strictly adhered to otherwise no suitable stations would be found

STATE	#	station	river	Area (km2)	Max stage (m)	Max Gauged Stage (m)	Years
ACT	410746	Phillip	Long Gully Ck	4.8	1.28	1.13	39.1
ACT	410753	Mawson	Yarralumla Ck	4.4	1.67	0.82	38.1
ACT	410763	Giralang	Stormwater Drain	0.9	1.3	0.21	36.1
ACT	410764	Gungahlin Catchment	Ginninderra Trib	1.1	0.95	0.69	18.0
ACT	410763	Giralang West	Stormwater Drain	0.1	1.68	0.06	33.1
NSW	23	Strathfield	Powells Creek	2.3			47.0
NSW	213006	Bradbury Park	Fishers Ghost Ck	2.5	1.62	0.62	29.1
QLD			Highland Park - Gold Coast	2.0			10.63
QLD	143022A	Interstate Railway	Stable Swamp Ck	19	6.96	3.71	11.0
QLD	143028A	Jason St	Ithaca Ck	10	4.31	1.98	37.1
TAS	353	Gore St	Hobart Rivulet	16.3	1.06		49.1
TAS	353	Argyle St	Hobart Rivulet	19	1.8		46.1
VIC			Stony Ck at Spotswood		1.124	2.5	10.79
VIC	228229A	Tecoma	Monbulk Ck	19	1.57	0.88	21.1
VIC	407257A	Bendigo- Quarry Hill	Back Ck	14	2.62	2.02	12.0
SA	AW504546	Paddocks Inlet	Para Hills Drain	0.6	1.7	1.55	19.1
SA	AW504561	Glenelg	Frederick St Drain	0.6	63.4		17.1
SA	AW504579	Forsyth Grove	Third Ck	17	2.04	2.3	13.1
SA	AW504589	Lake	Urrbrae Wetlands	3.8	76		10.1
SA	AW504582	D/S West St	Adelaide Tce Pipe		2.94	2.52	13.1
NT	G8150231		Moil Catchment U	0.4	2.35	1.34	25.1
NT	G8150233	McArthur Park	Palmerston Catch	1.4	2.98	2.32	26.1
WA	602006	Duck Lake	Albany Urban Drain	0.1	10.39		10.4
WA	616087	Abernethy Rd	South Belmont Main Drain	11.3	11.52	10.61	21.6

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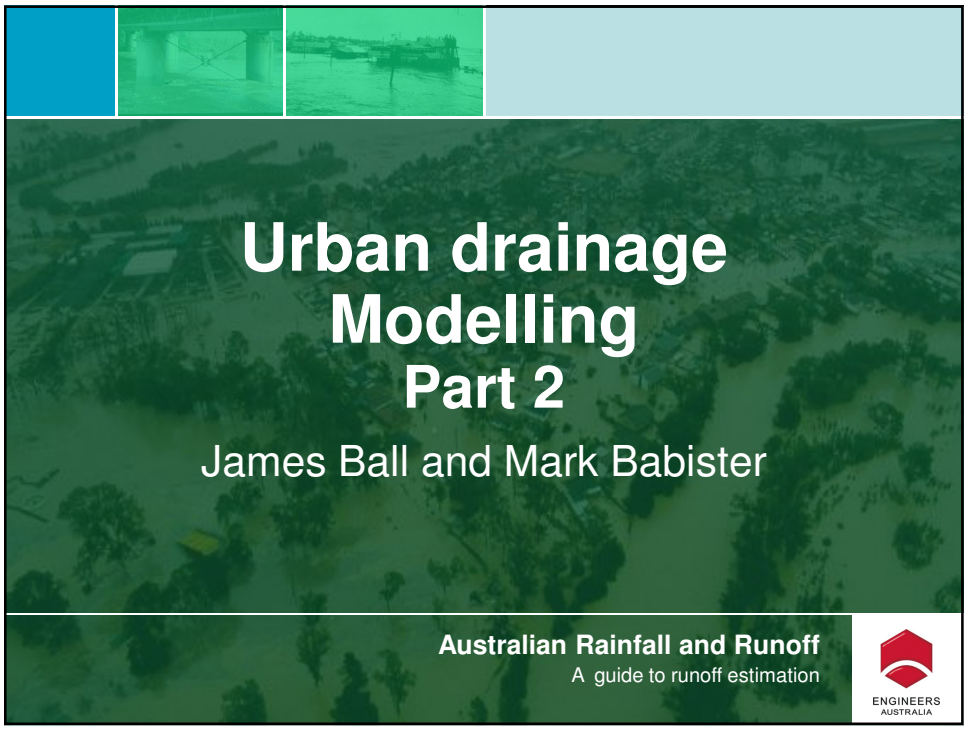
Do we have enough data for revised method?

- This database is **Draft** only
- Actual number of suitable catchments will be far less and likely unsuitable for any robust method development.
- A renewed focus on gauging urban streams is needed
- Data resources are barely better than 1987 when limitations were first observed

URM – Current Thoughts

- Restrict to lot scale unless adequate data can be found
- Need data collection and the continuation of long term gauges
- Add and improve the database by improving rating of some stations
- Impose a loading penalty on the use of the URM to encourage use of other methods
- Note method has been abandoned in other countries with similar rainfall



Urban Drainage Modelling – Advantages over the URM

- Models can be calibrated to observed events
- Attempting to model an important process
- Have a history of fitting observed events with reasonable consistent parameters
- More realistic method for the transformation of design rainfall into design flow
- Validation of model does not require a long term gauge record

Limitations Compared to URM

- Question about how performance changes with catchment size as most calibration is to observations on larger systems
- Generally processes modelled at fixed resolution
- Different models include different processes and conceptualisations
- Still necessary to ignore some processes eg. Gutters, very small pipes

Differences between actual behaviour and model assumptions

- Often a poor understanding of differences between design and analysis methods/modes
- Design models make many unrealistic assumptions (eg. system all subcritical - HGL analysis)
- Design methods have served the profession well but probably includes a variable level of conservatism

- Urban drainage behaviour is hydraulically very complex
- Complex mixture of sub and super critical flow regimes
- Local features have strong influence on local behaviour (eg. debris, blockage, gate, fences, cars, construction faults)
- Many of these features are transitory (eg. bin night, local newspaper delivery day)

Modelling approaches

- Types of models :
  - Rainfall Runoff models
  - Rainfall Runoff models with simple pipe work hydraulics (steady or unsteady)
  - RR models linked to 2D Hydrodynamic surface models with hydrodynamic pipe networks
  - Direct rainfall on 2D models

Future Directions ARR

- Restrict use of Urban Rational Method
- Encourage the use of urban modelling tools
- Confirm how well different models perform at different scales
- Identification of urban test catchments
- Powell's creek example
- Discourage rainfall on the grid method until further research has been done