APPLICATION OF ARR

Mark Babister
WMAwater Pty Ltd

HOSTED BY:

ARR Australian Rainfall & Runoff

TGM Engineering | Surveying | Planning

Outline

- Background on ARR 2016
- Key outputs
- Key changes
- Examples

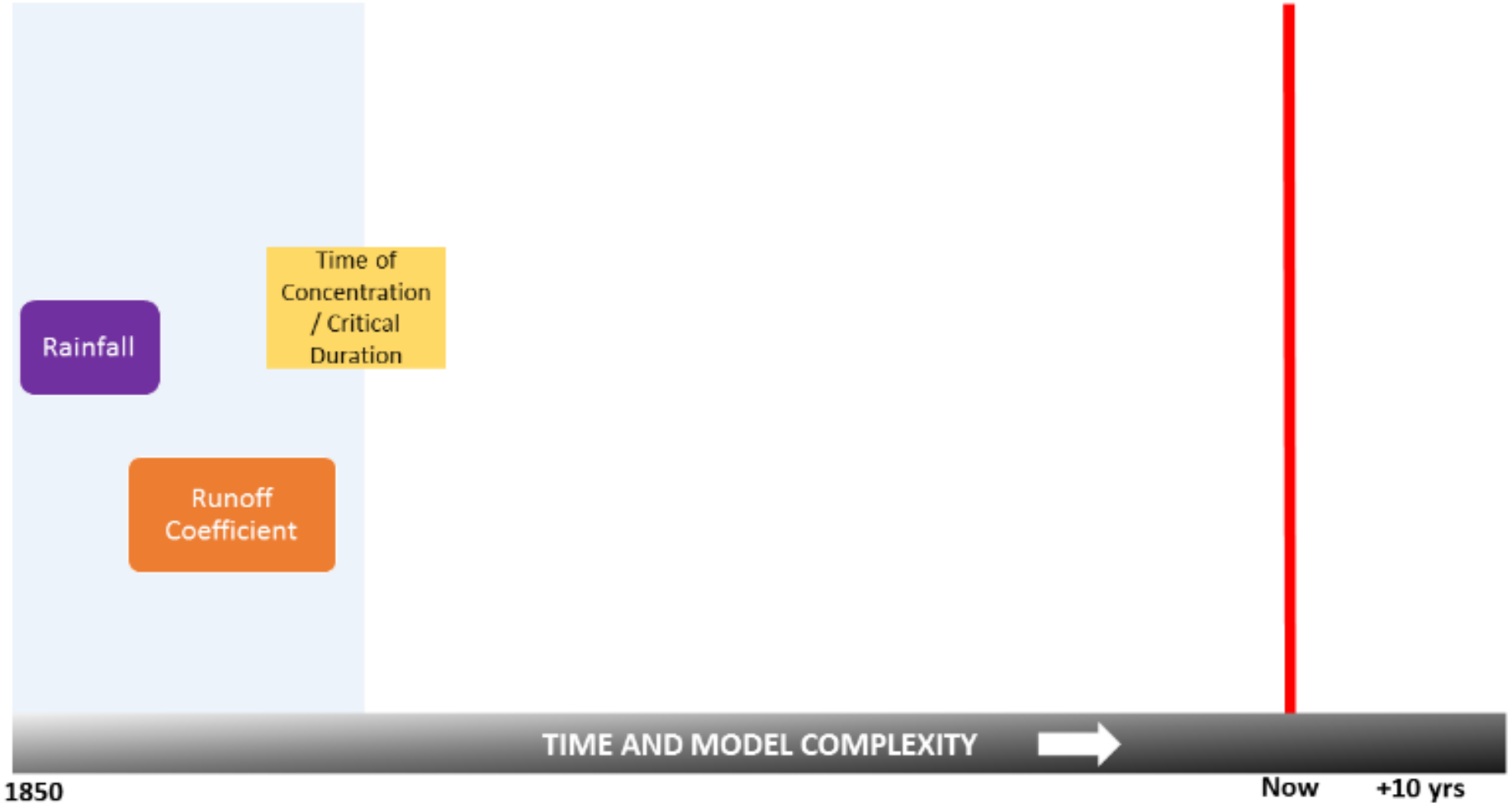
Background

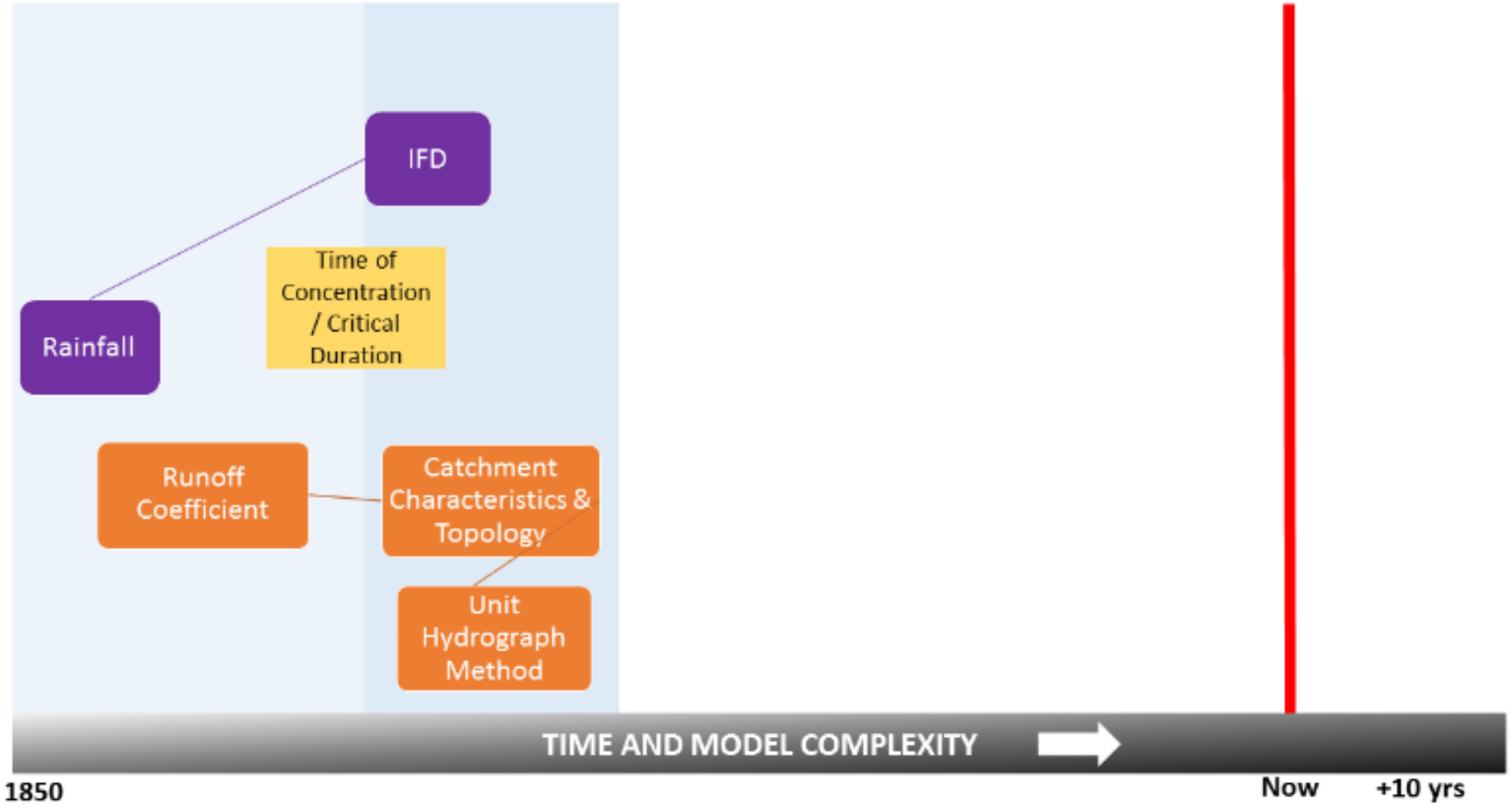
- Guideline not a standard as Australia is too diverse
- ARR is a 8 year project that commenced in 2008 with $9.15 Mill of government funding
- Project has involved:
  - BoM, Geoscience Australia, CSIRO, state agencies
  - UTS, UWS, UNSW, Uni of Newcastle, Uni of Adelaide, Melbourne Uni
  - Most consulting firms

WHAT IS ARR?

- Guideline for the calculation of flows and flood behaviour
- ARR is not prescriptive
- ARR is a guideline document as the nature of hydrologic problems vary

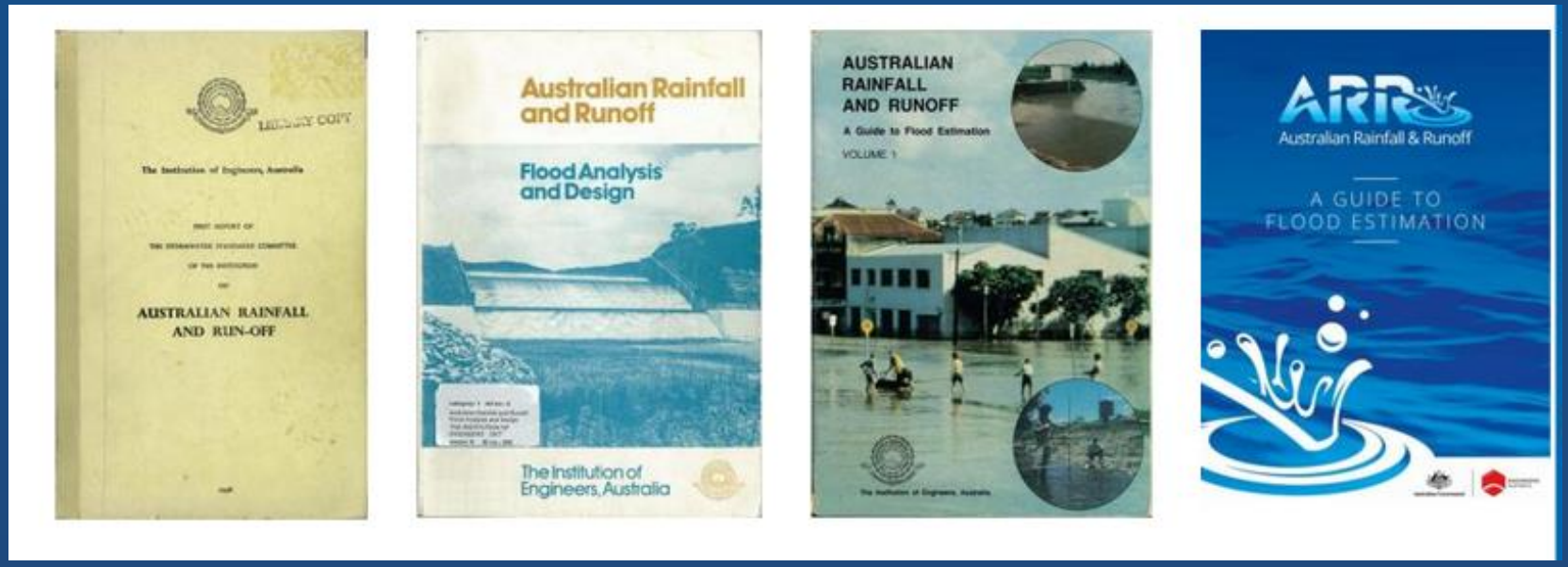

Rainfall
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs


Rainfall
Time of Concentration / Critical Duration
Runoff Coefficient
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs


IFD
Time of Concentration / Critical Duration
Rainfall
Runoff Coefficient
Catchment Characteristics & Topology
Unit Hydrograph Method
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs

History

- 1958 (version 1)
- 1977 (version 2)
- 1987 (version 3)
- 1999 (version 3.1 update for extreme floods)
- 2016 (version 4)



Development Objectives

- Use Australian data
- Practitioners are the primary audience
- To better represent real systems
- Scientific evidence based approaches
- Fit with and complement the broader set of tools used to manage the water cycle
- Where possible provide the uncertainty of methods and inputs

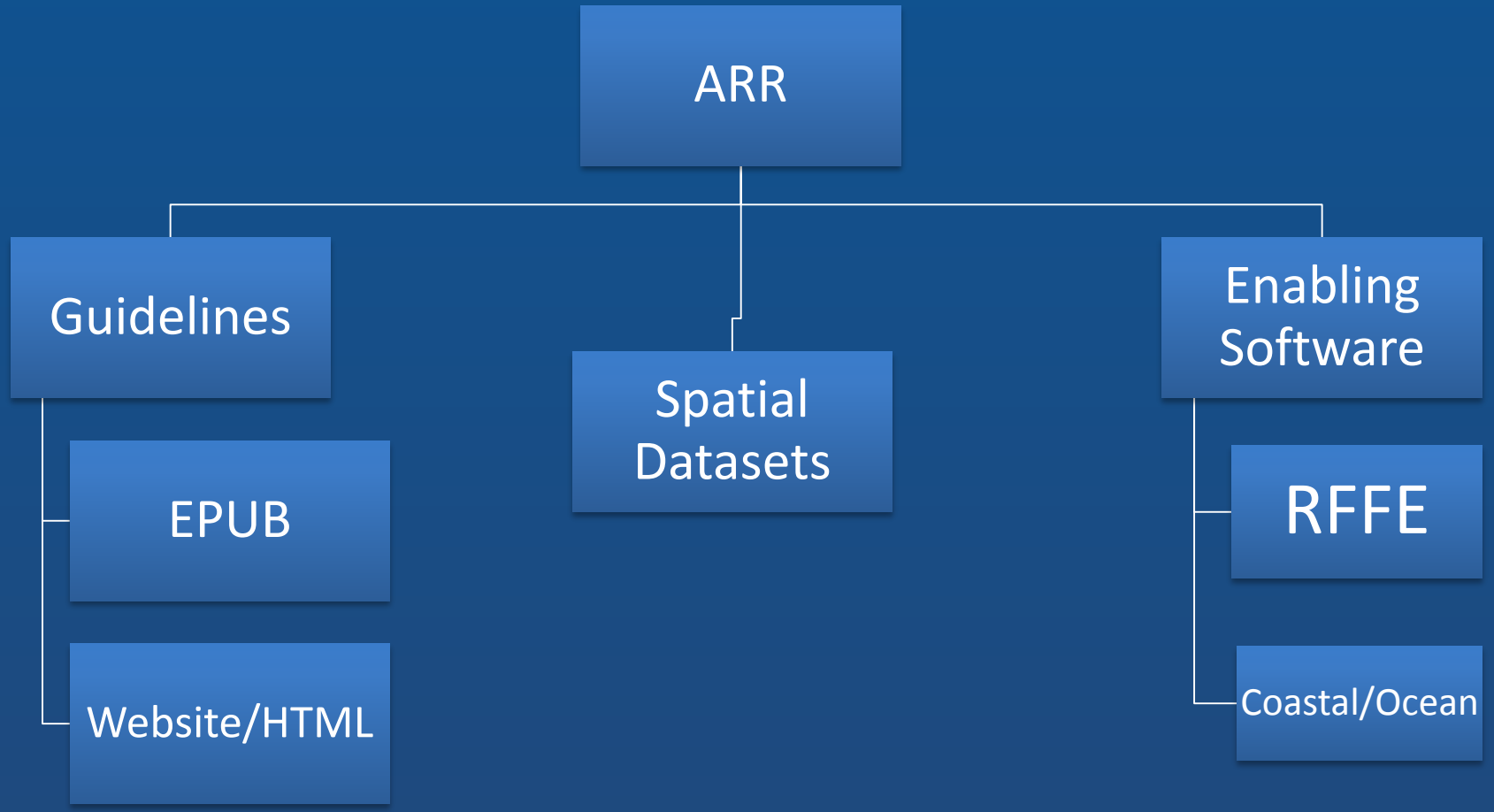
Application Objectives

- Computerise simple tasks
- Design inputs should be easy to use
- Minimise human errors in map/figure/table reading
- Reproducible
- Easily updated

Big Changes in Practice

- Ensemble and Monte Carlo approaches to better capture variability
- Move away from simple burst approaches
- Less reliance on the rational method

What does the new ARR look like?



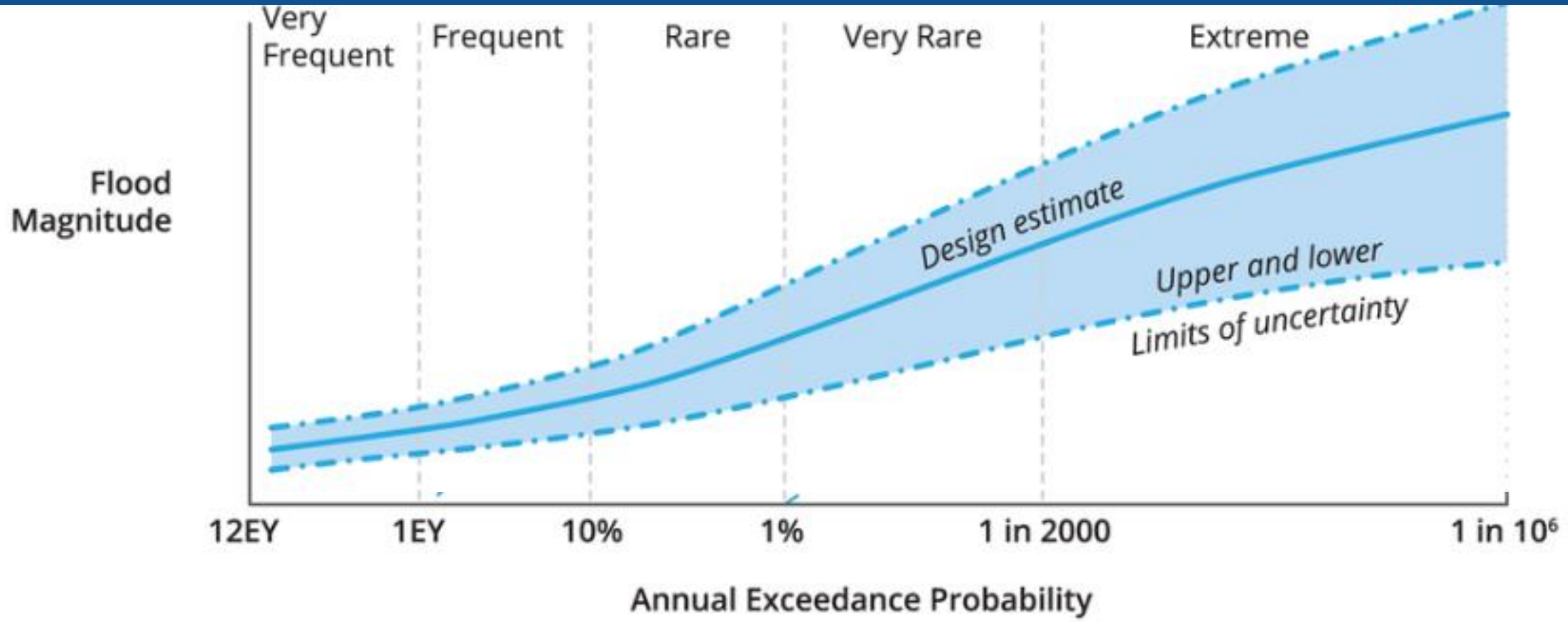
Australian Rainfall & Runoff

Terminology

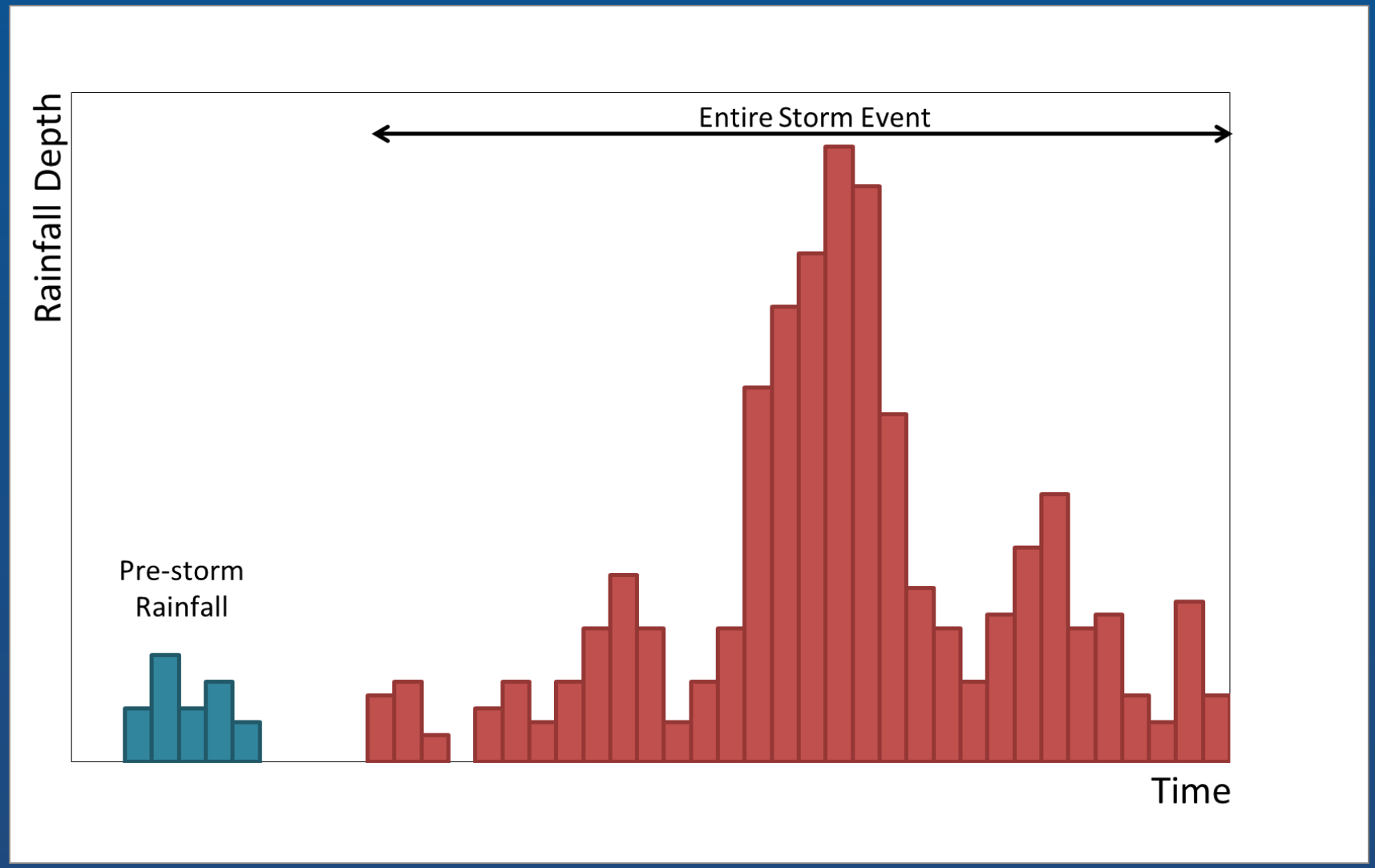
- ARI no longer recommended
- EY for frequent events to deal with seasonality

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
Rare	0.11	10	10	9.49
	0.05	5	20	20
	0.02	2	50	50
Very Rare	0.01	1	100	100
	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
Extreme	0.0005	0.05	2000	2000
	0.0002	0.02	5000	5000
			↓	
			PMP/ PMPDF	

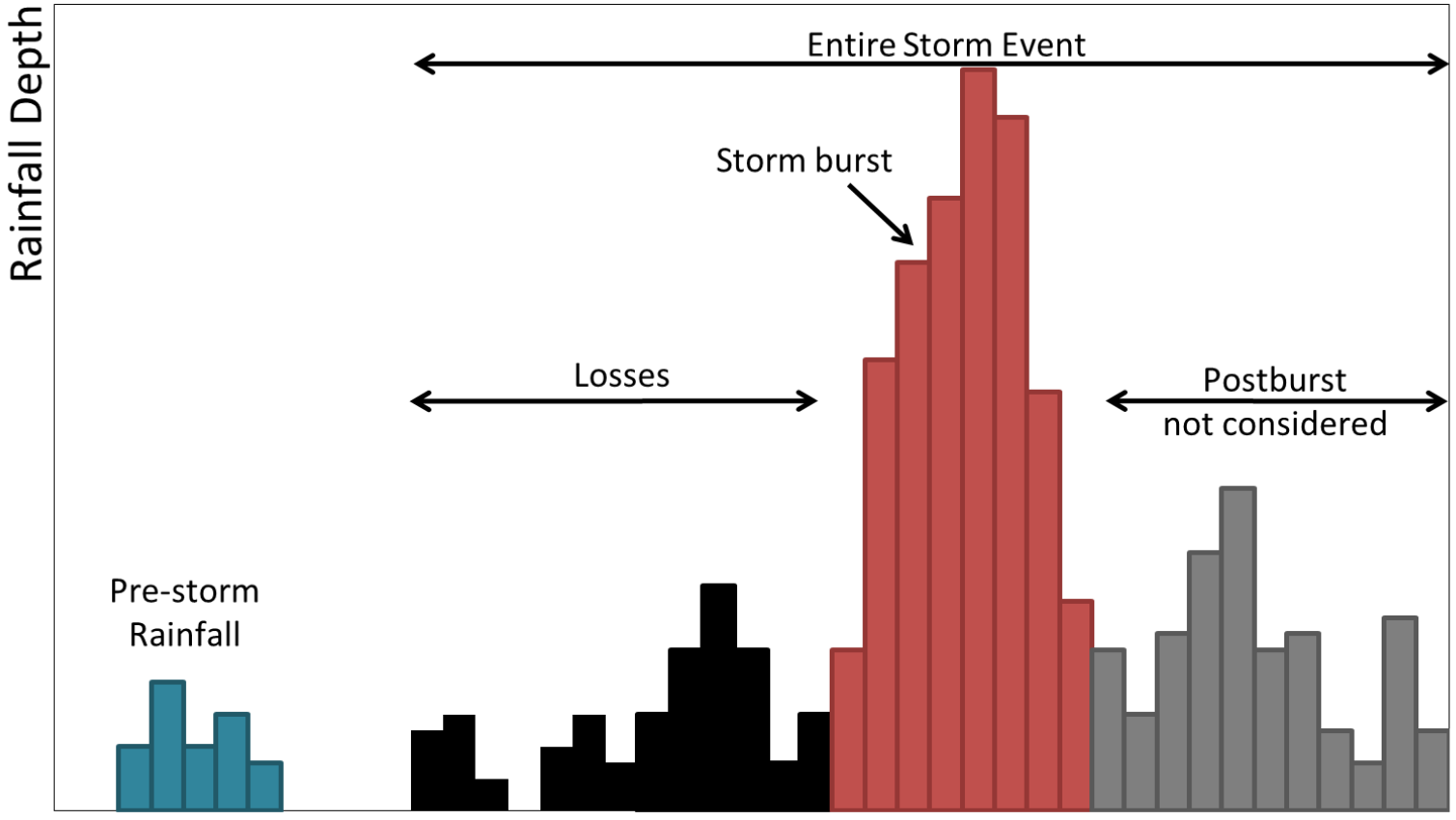
Frequency Descriptors



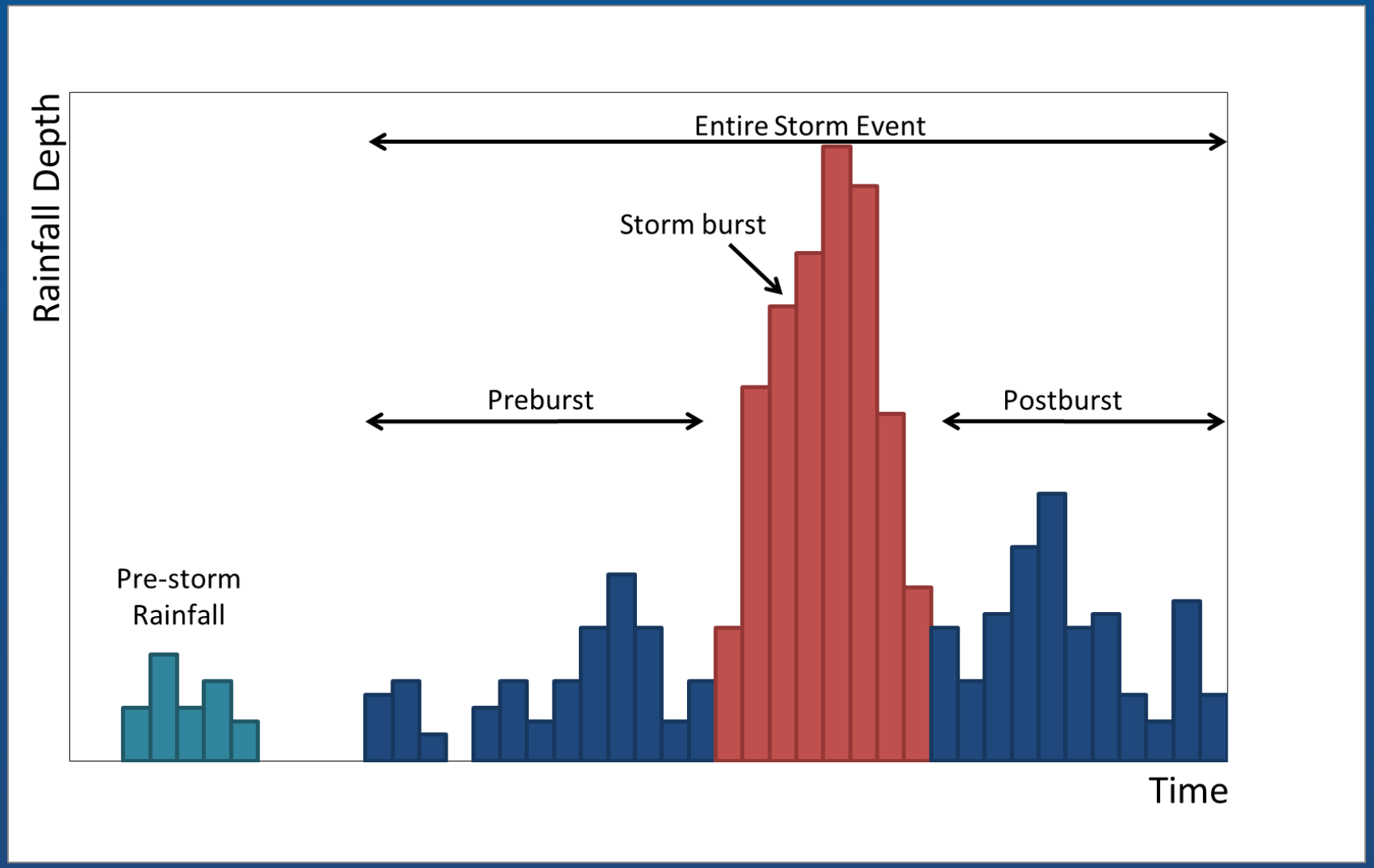
Storm definition



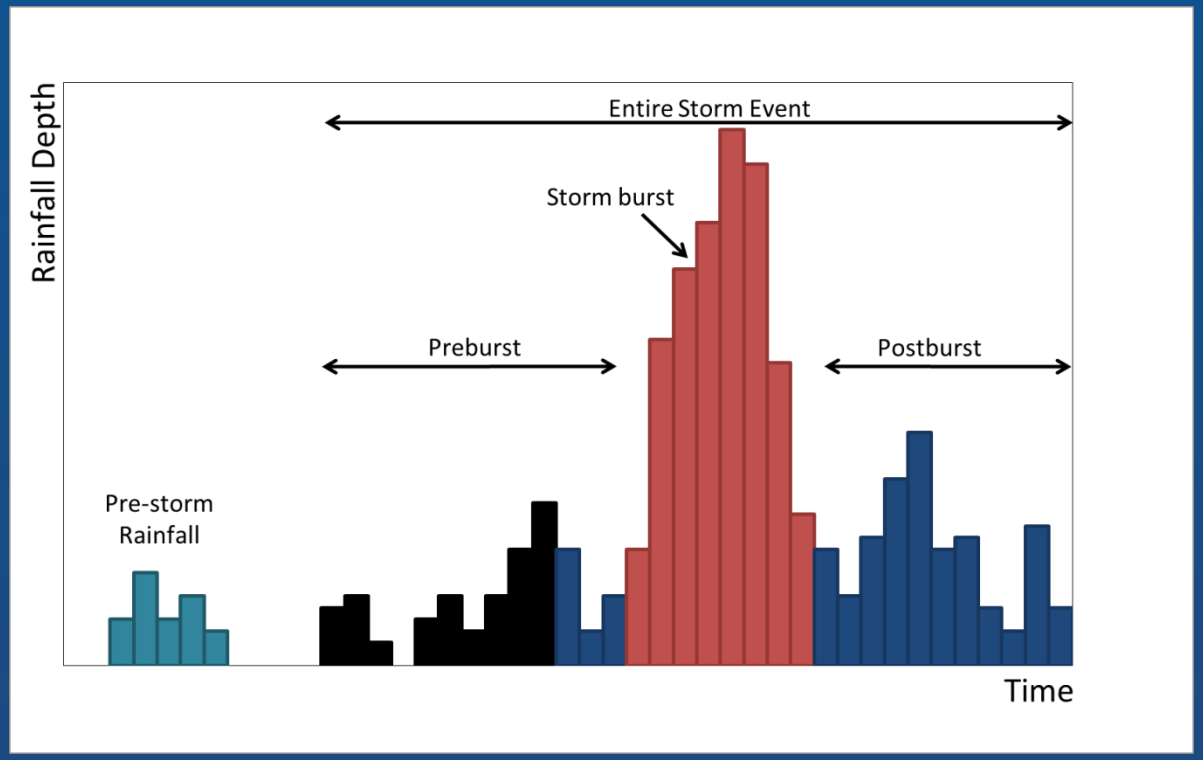
Storm definition – ARR87

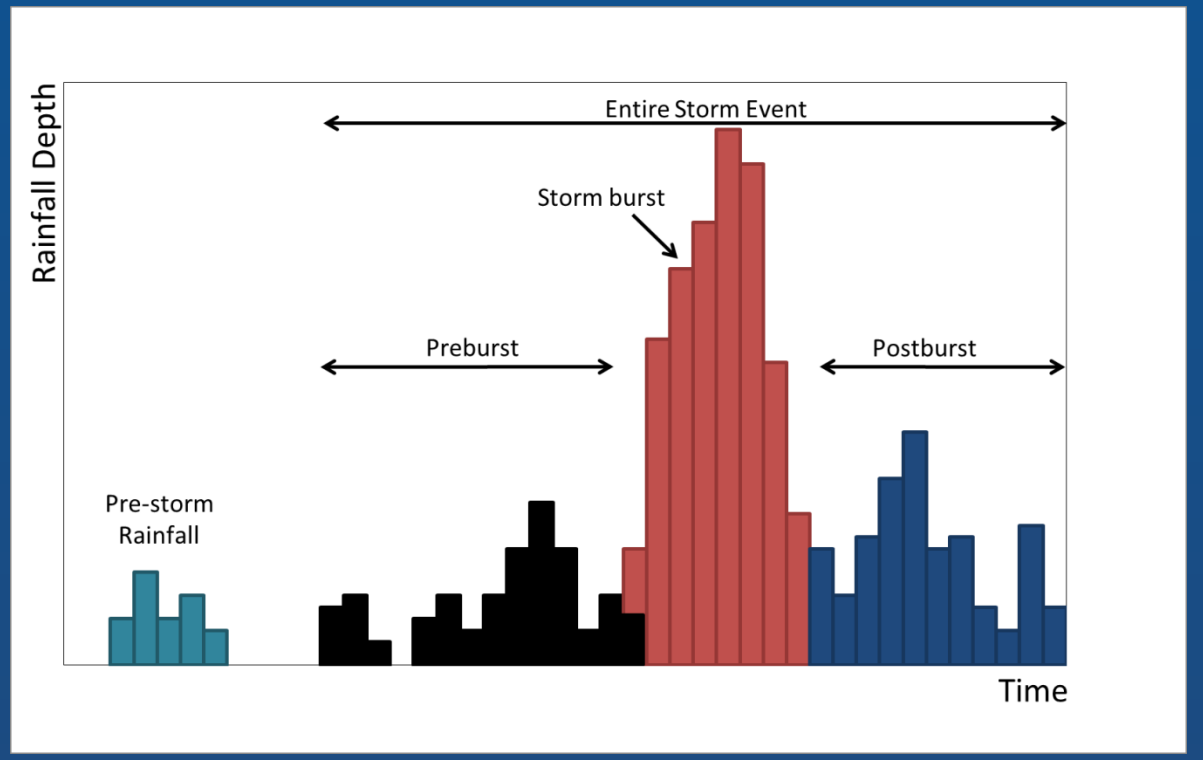


Storm definition – ARR16

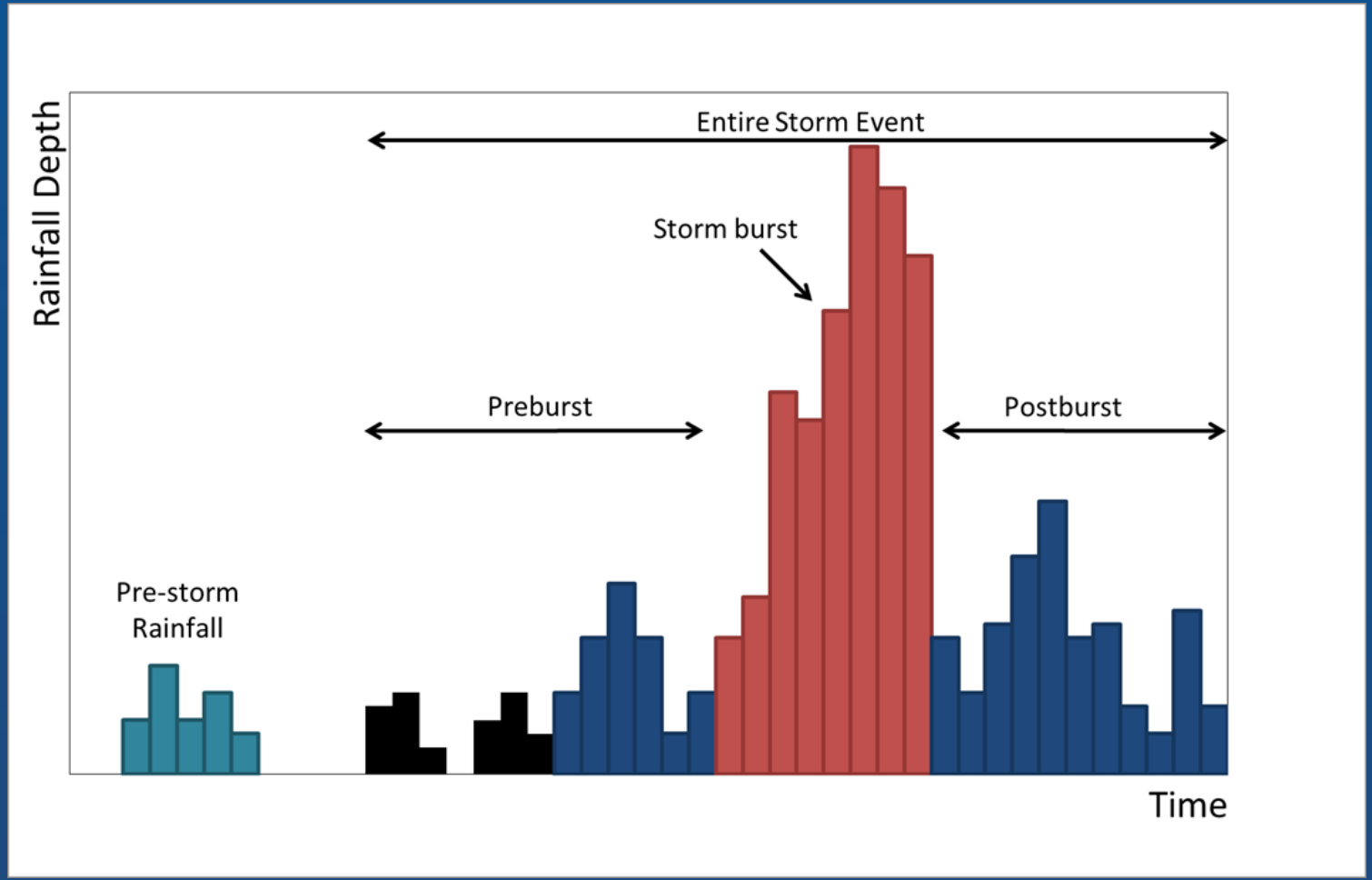


Storm definition – ARR16 Losses

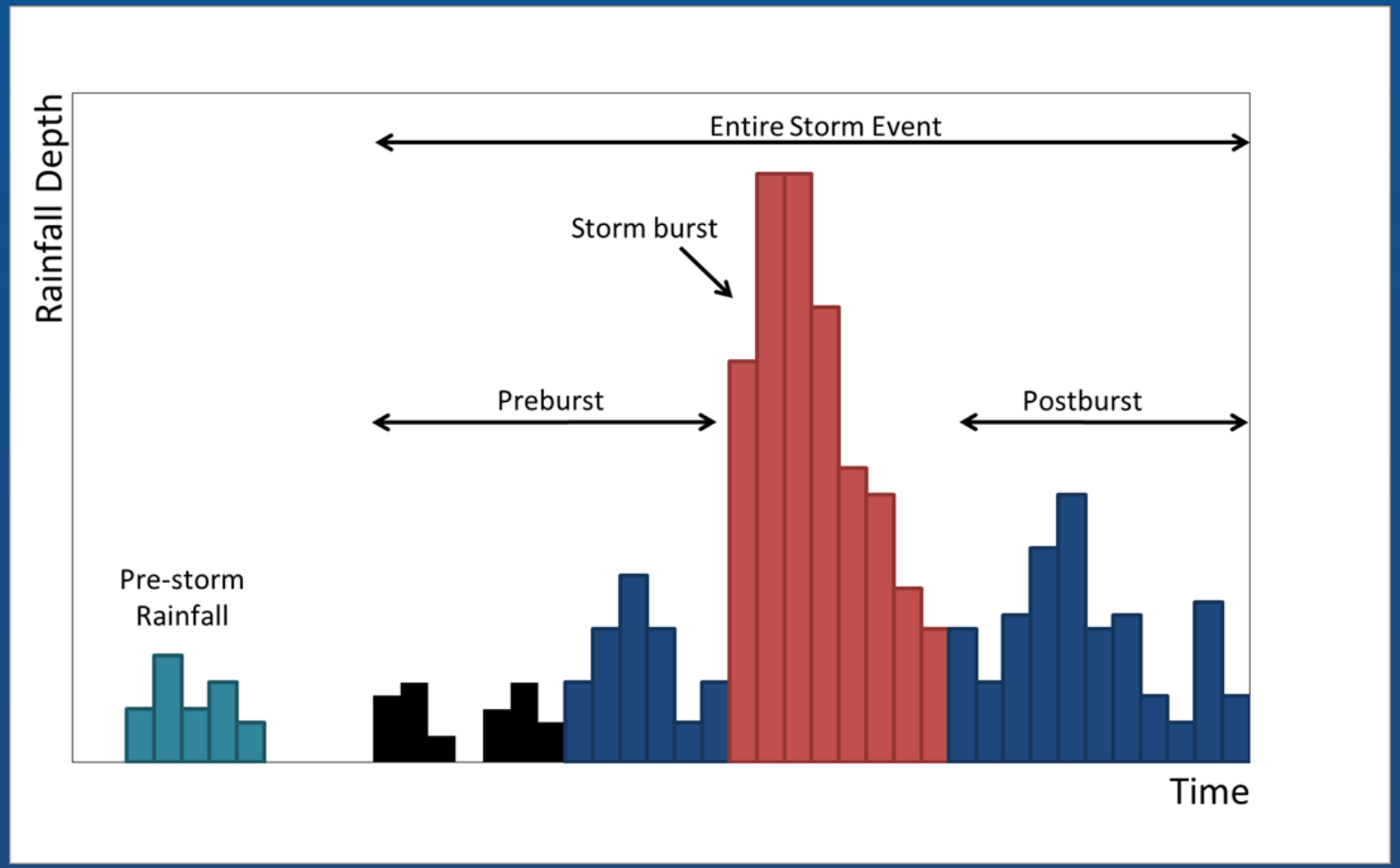


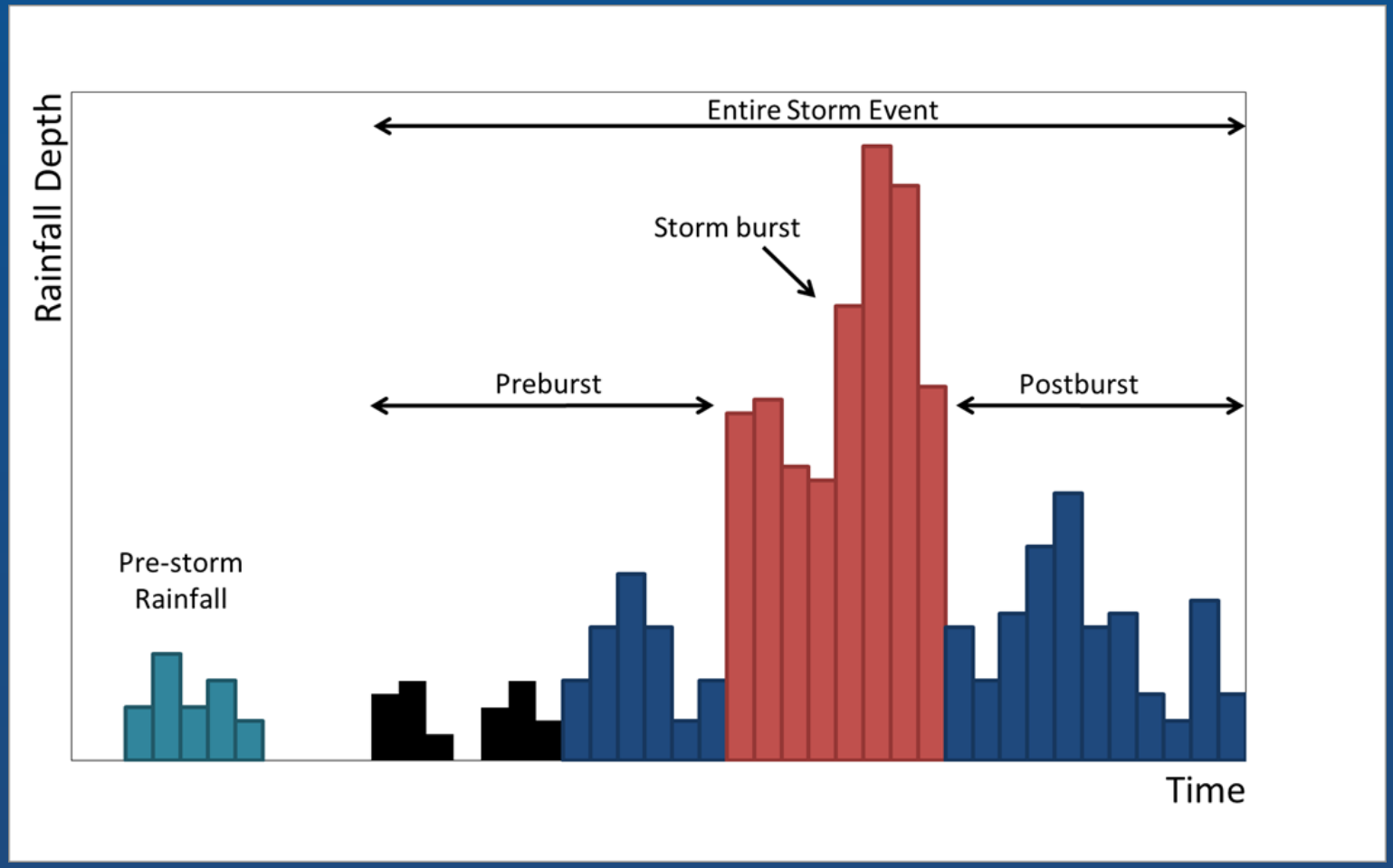


Storm definition – No one burst



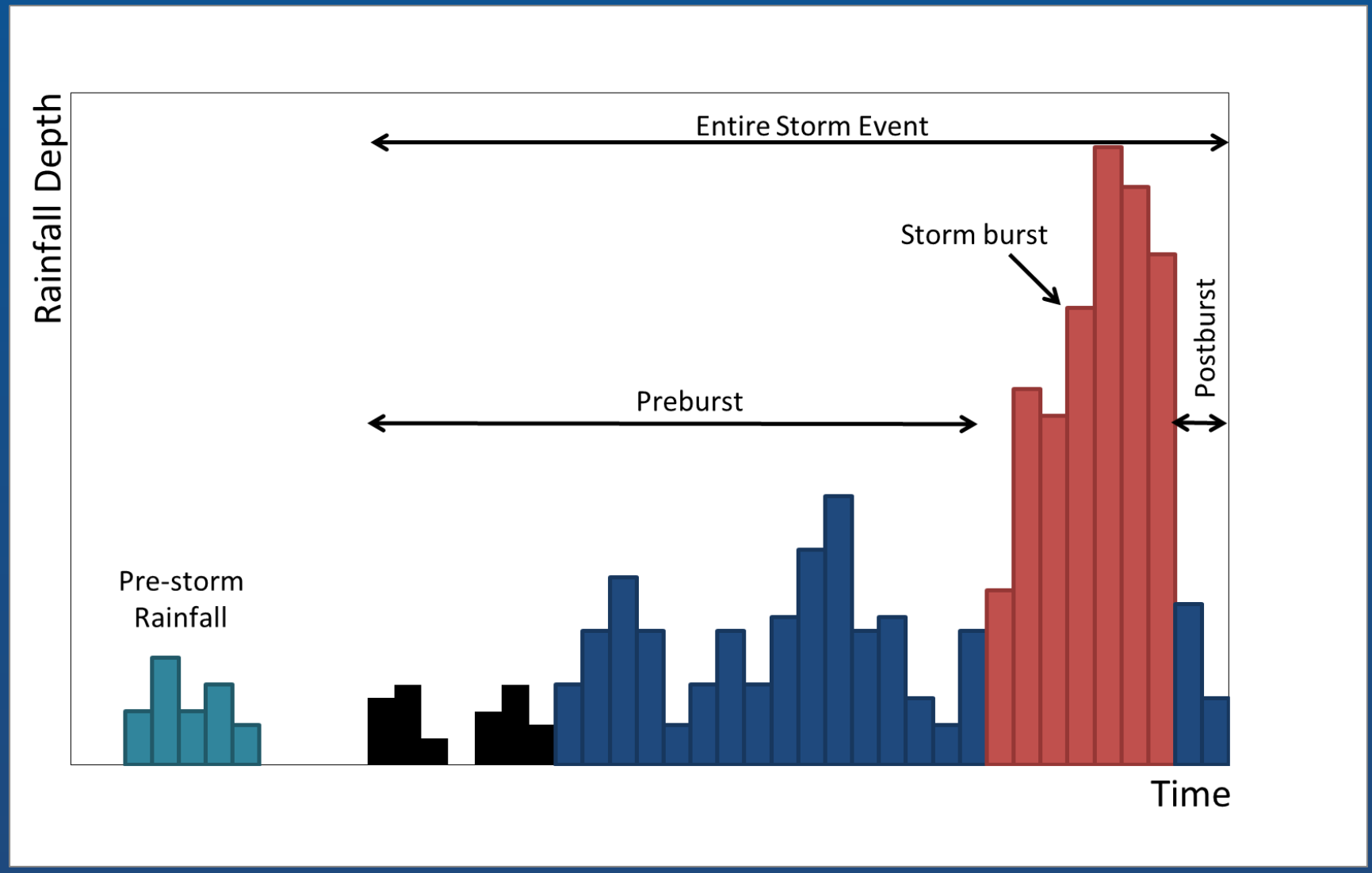
Storm definition – No one burst





Australian Rainfall & Runoff

Storm definition – varied burst ratios



What does the document look like – Comparison of Methods

Input	ARR 1987	Pre Update	ARR 2016
IFD	Paper maps	BoM web page	Updated BoM web page. Book 2 Chapter 2 Design Rainfall.
ARF	Figure 2.7 from US data	FORGE work (except NSW)	New equations derived using Australian data. Book 2 Chapter 4: Areal Reduction Factors.
Temporal patterns	AVM	AVM, filtered for embedded burst	Ensemble of real storms. Book 2 Chapter 5: Temporal Patterns.
Spatial pattern	Centroid	Spatially distributed IFD	Spatially distributed IFD
Losses	State based advice, sometimes based on data	Calibrated in the hydrologic Model.	Calibrated losses. Uncalibrated models use losses available from the datahub. Book 5 Chapter 3: Losses.
Pre burst	Allegedly incorporated into advice	mixed	Estimates provided on datahub

ARR
Australian Rainfall & Runoff

Changes in design modelling techniques

ARR 1987

Single design event using AVM

ARR 2016

Simple Design Method (1 pattern)

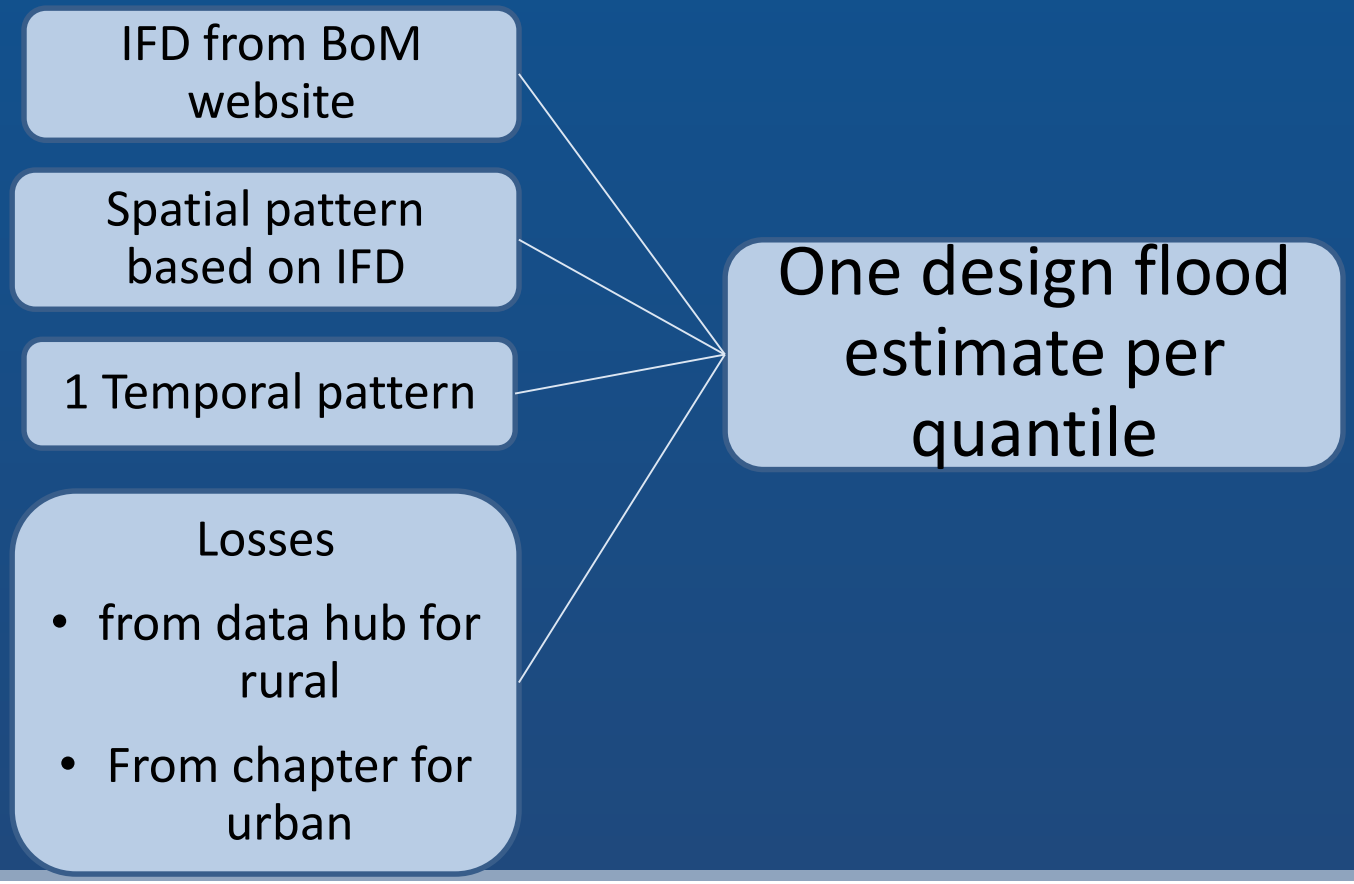
Ensemble in hydrology, pattern closest to mean in hydraulics

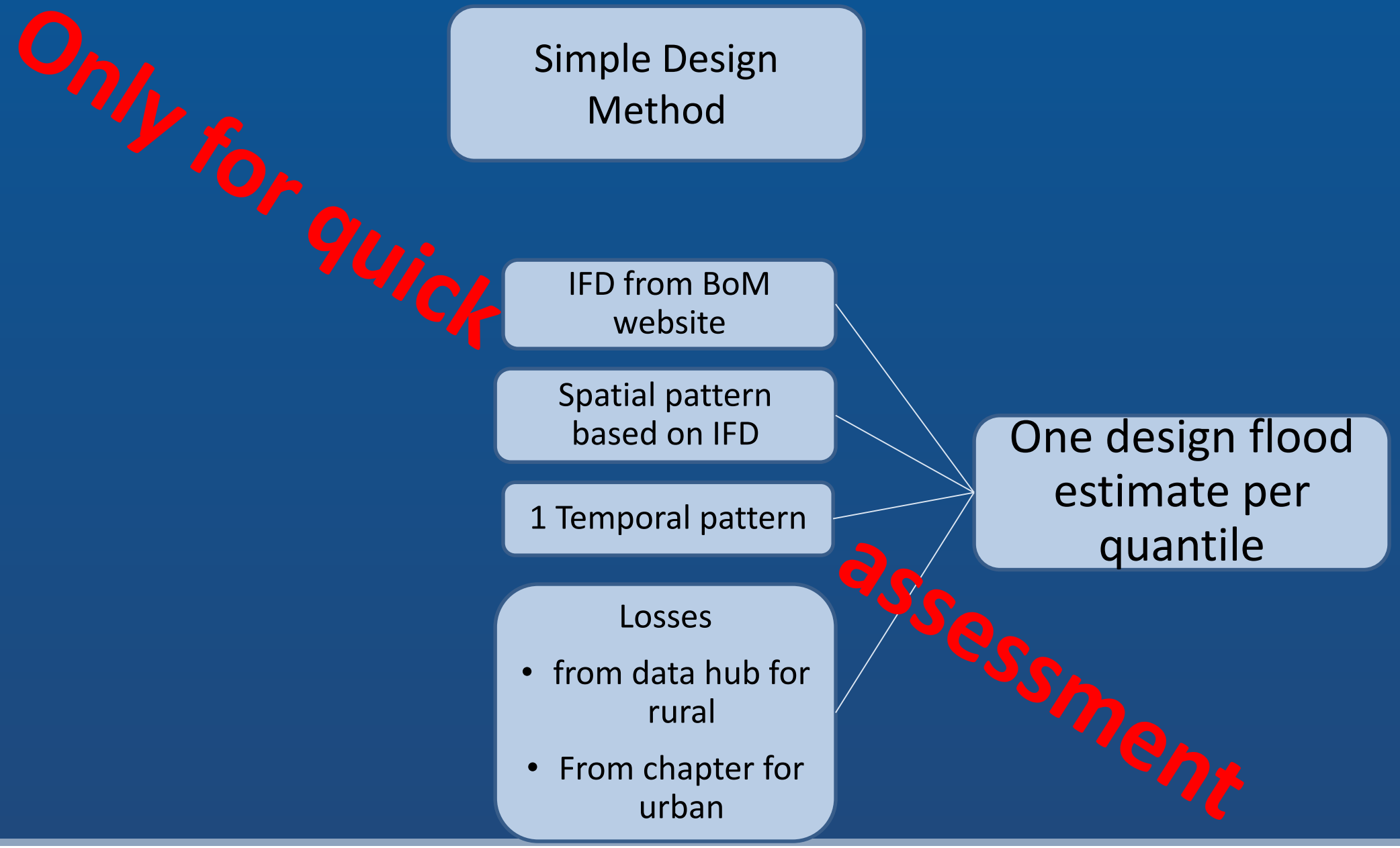
Ensemble in hydrology and hydraulics

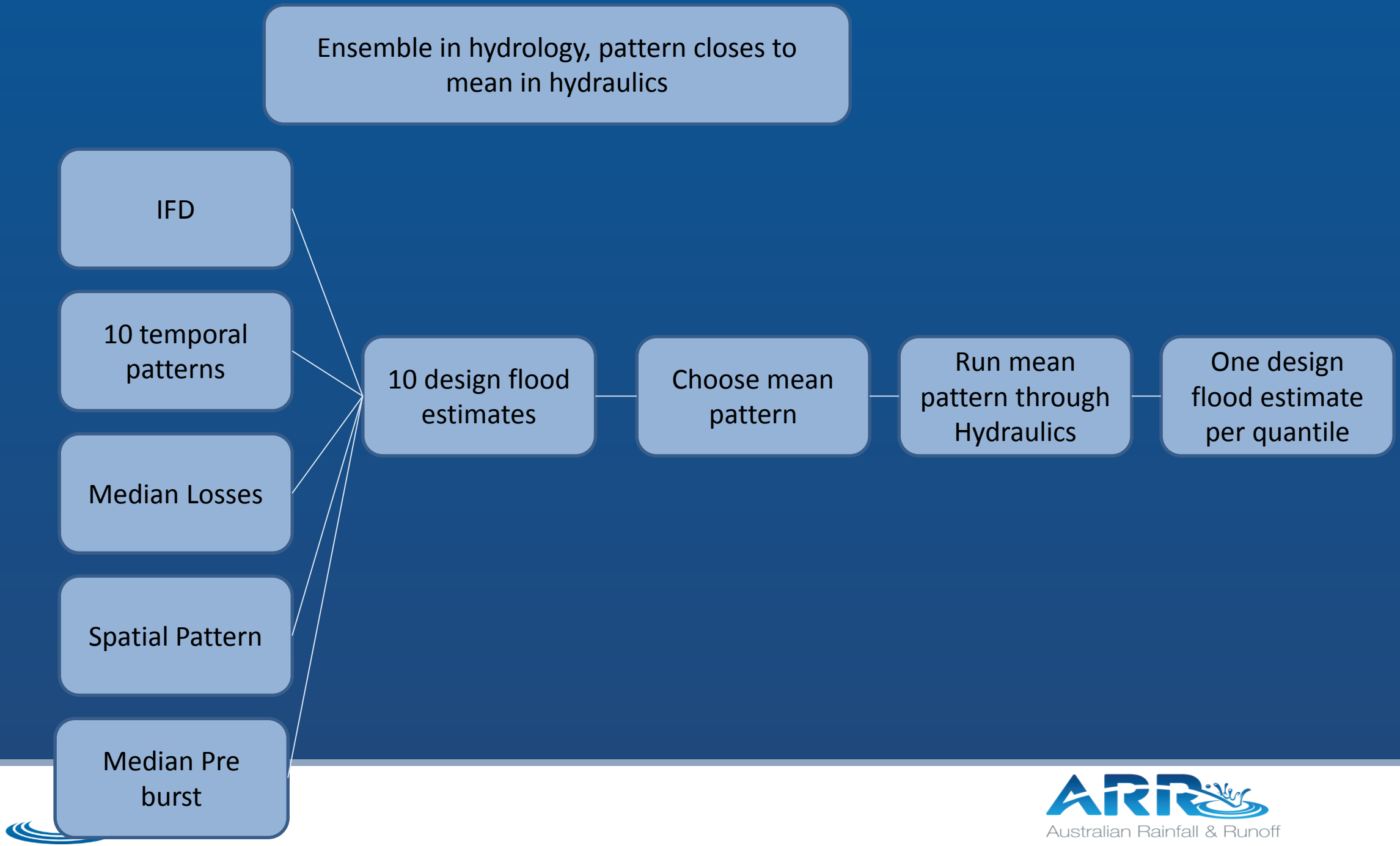
Full Monte Carlo

Rapid Assessment → Most common → Occasional → Special Cases

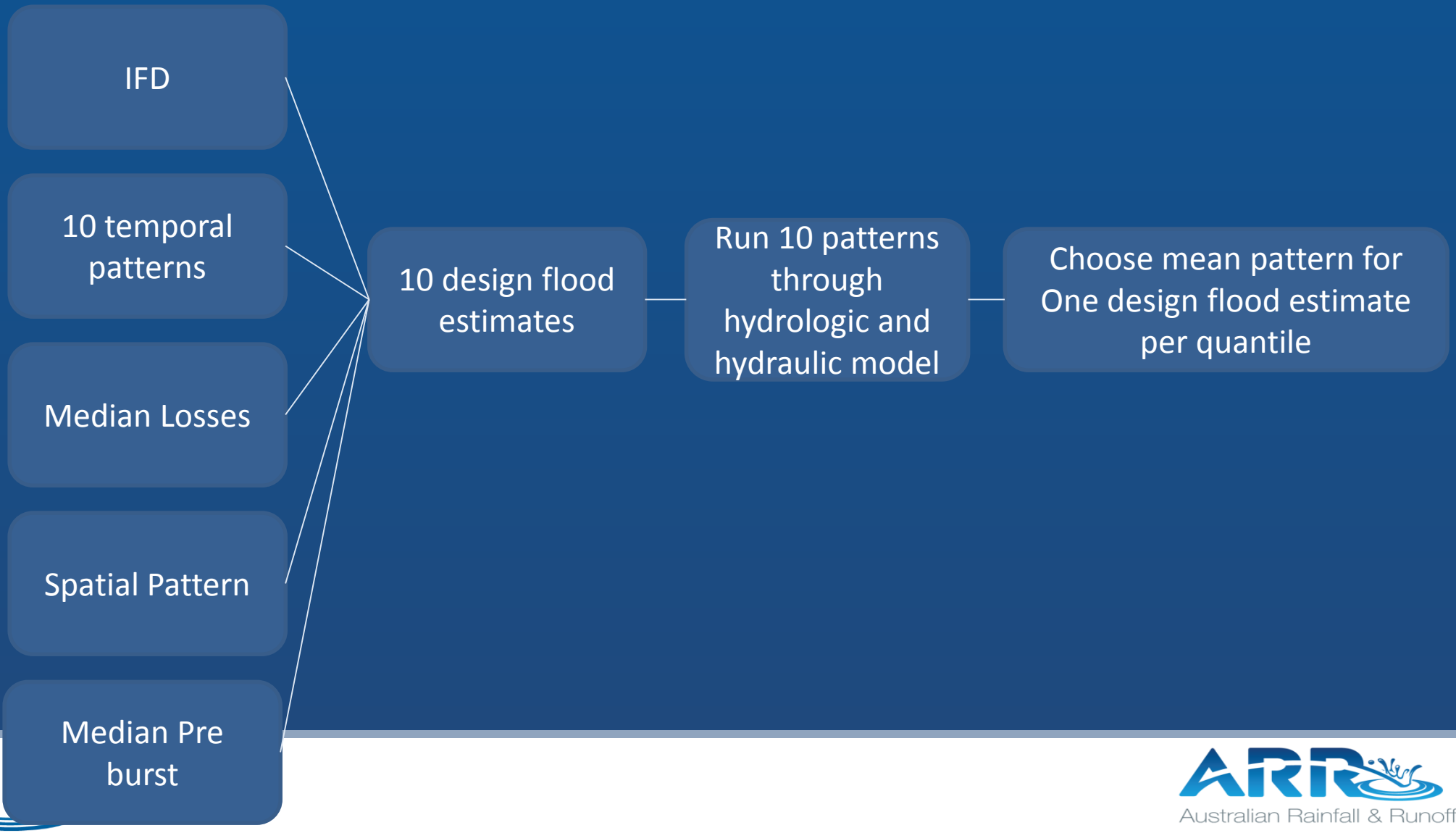
Simple Design Method



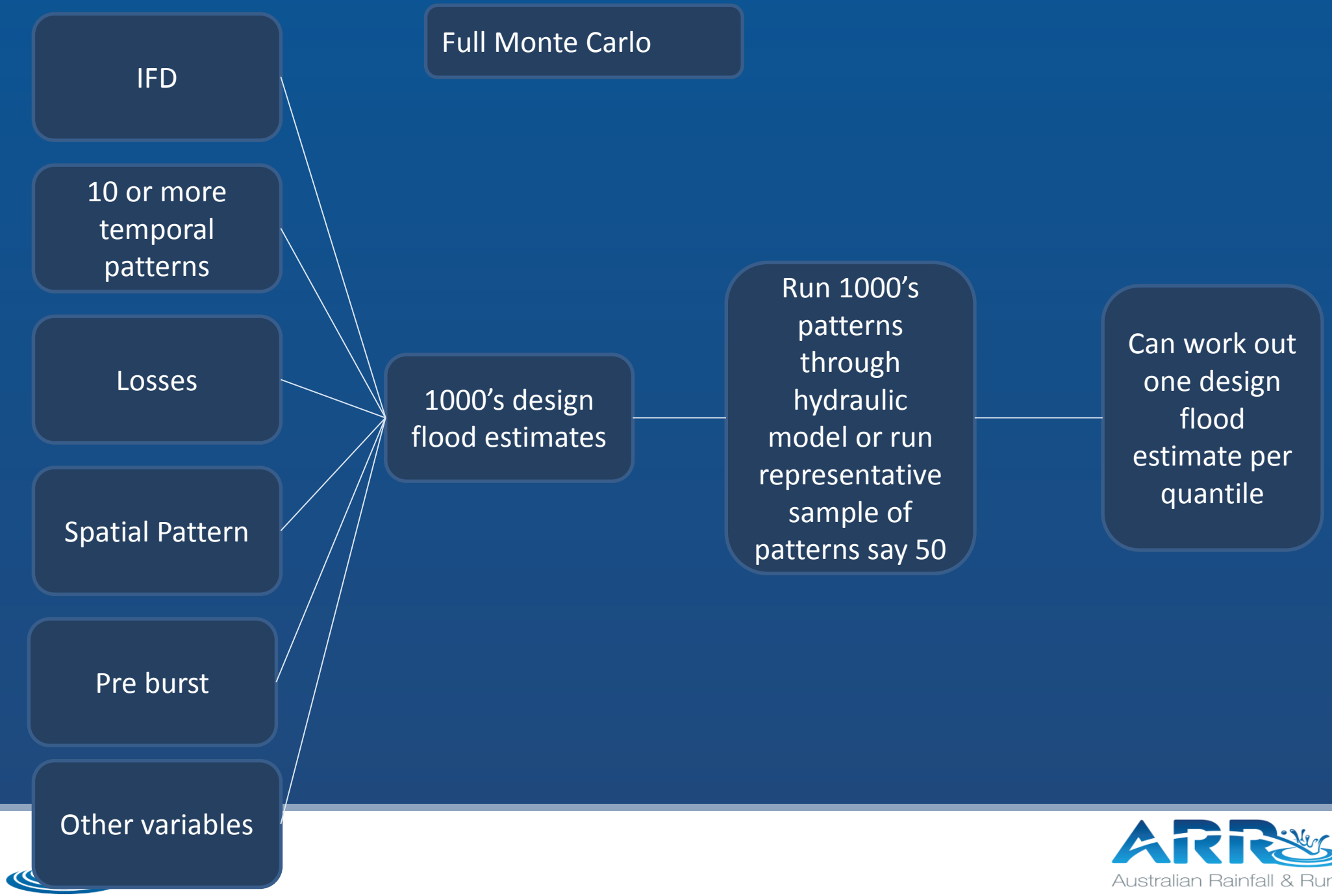

Only for quick
Simple Design Method
IFD from BoM website
Spatial pattern based on IFD
1 Temporal pattern
Losses
• from data hub for rural
• From chapter for urban
One design flood estimate per quantile
assessment


Ensemble in hydrology, pattern closes to mean in hydraulics
IFD
10 temporal patterns
Median Losses
Spatial Pattern
Median Pre burst
10 design flood estimates
Choose mean pattern
Run mean pattern through Hydraulics
One design flood estimate per quantile

Ensemble in hydrology and hydraulics



Australian Rainfall & Runoff



Australian Rainfall & Runoff

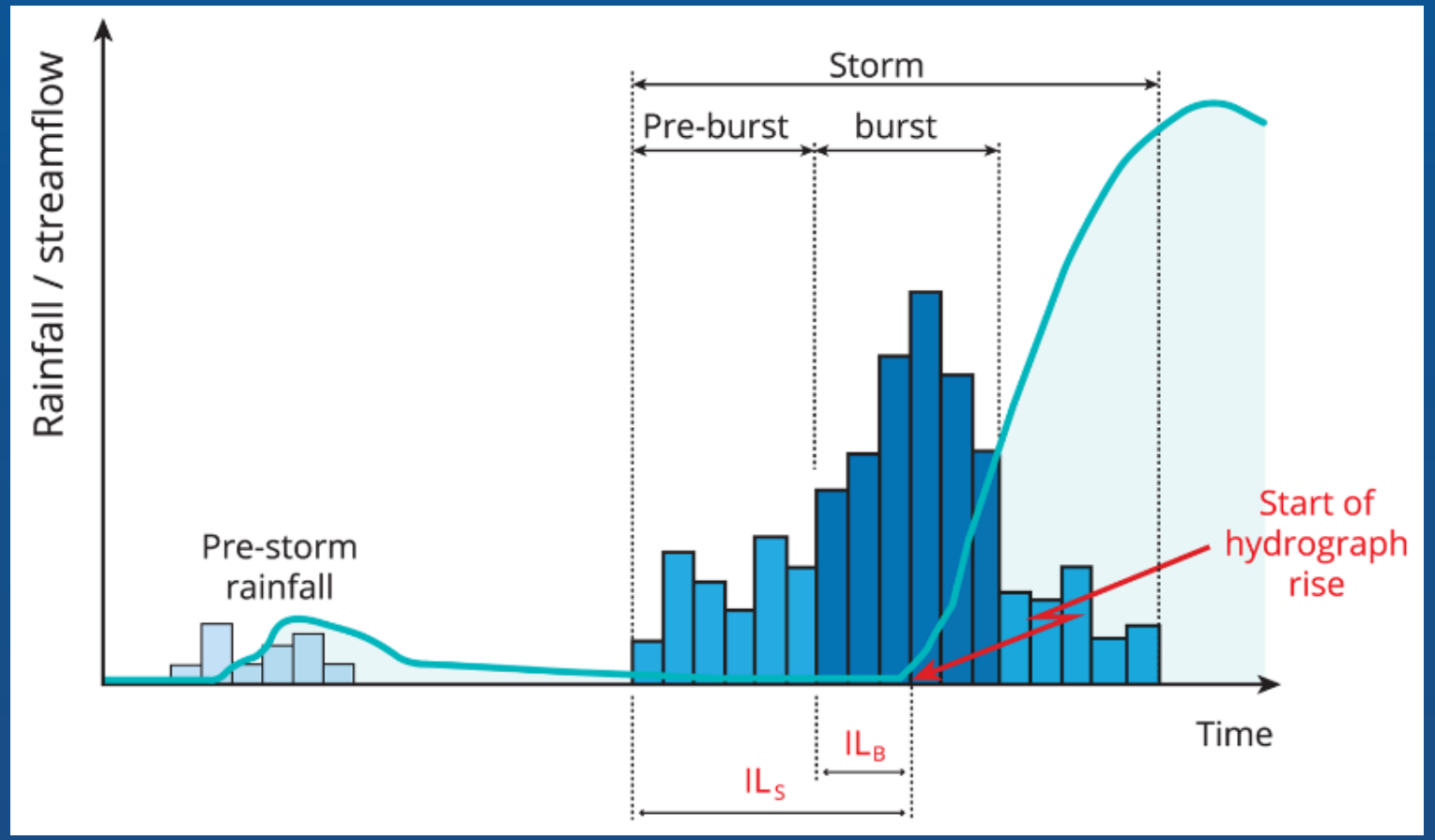
Losses

- Provide guidance on Application of new methods

- Difference between burst and Complete Storms

- Data hub is only RURAL losses

Loss Burst = Loss Storm – Preburst



In most cases

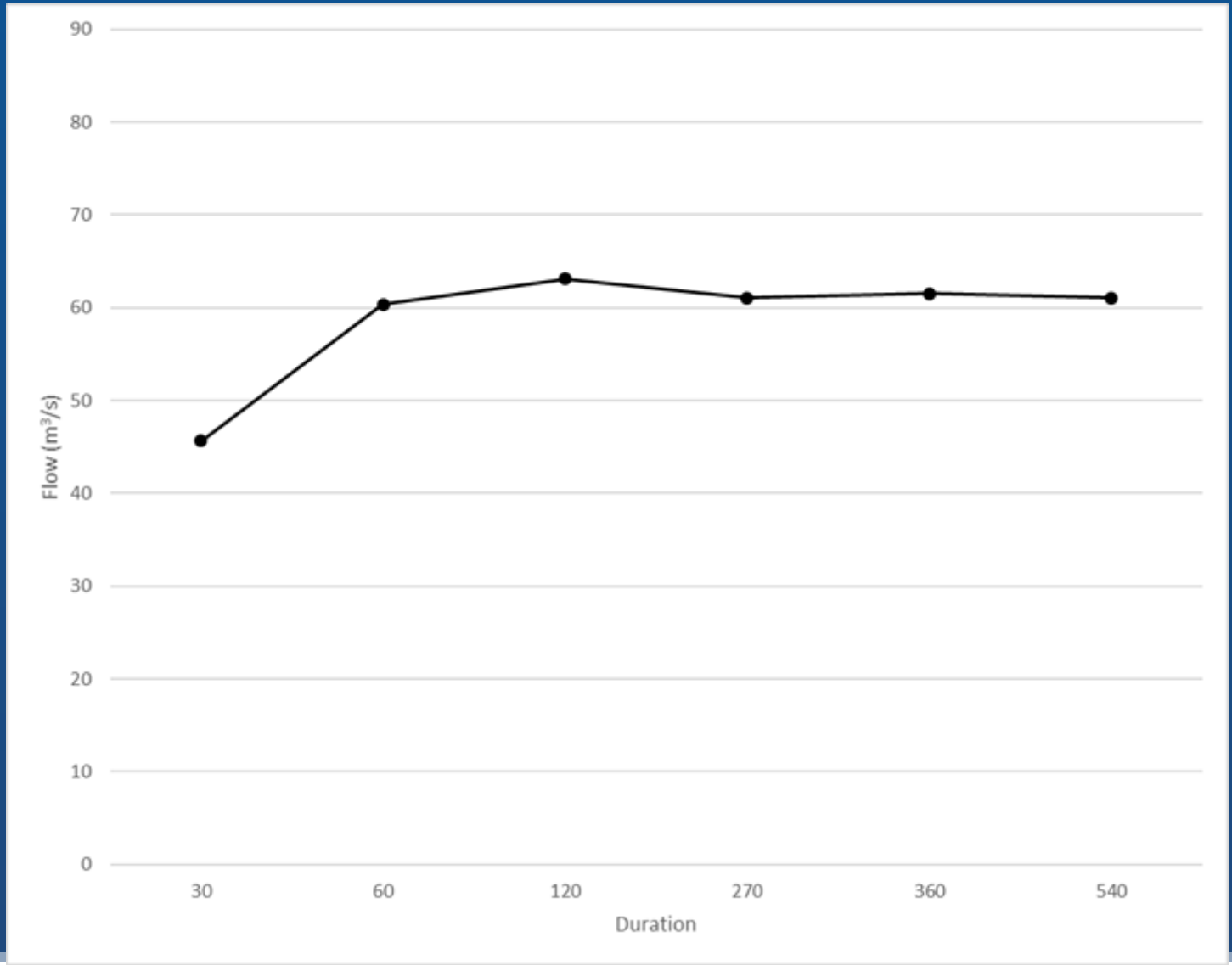
Loss Burst = Loss Storm (median) – Preburst (Median)

- Use medium of calibrated losses if available

Changes in outputs

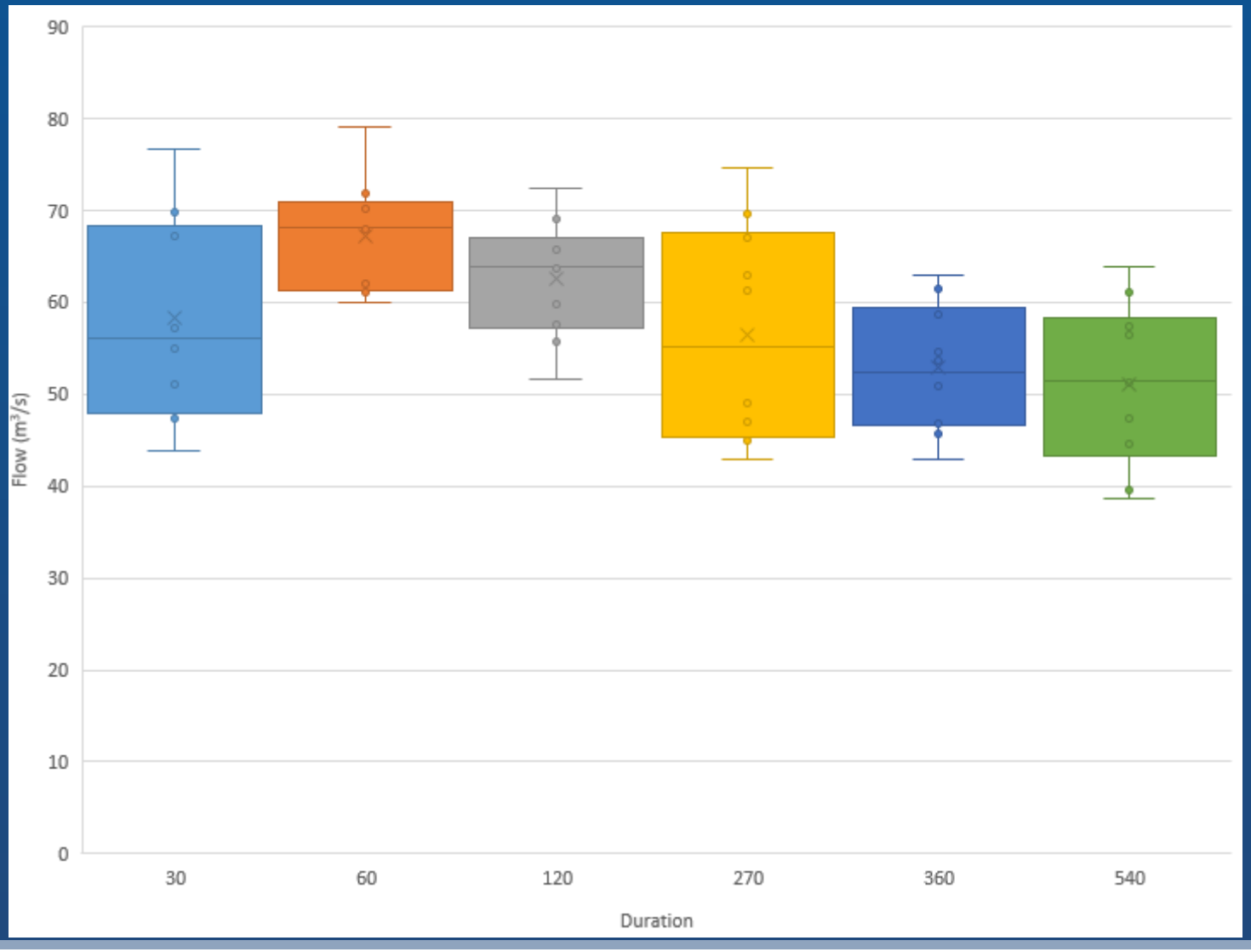
Critical duration plots

ARR 1987 Method



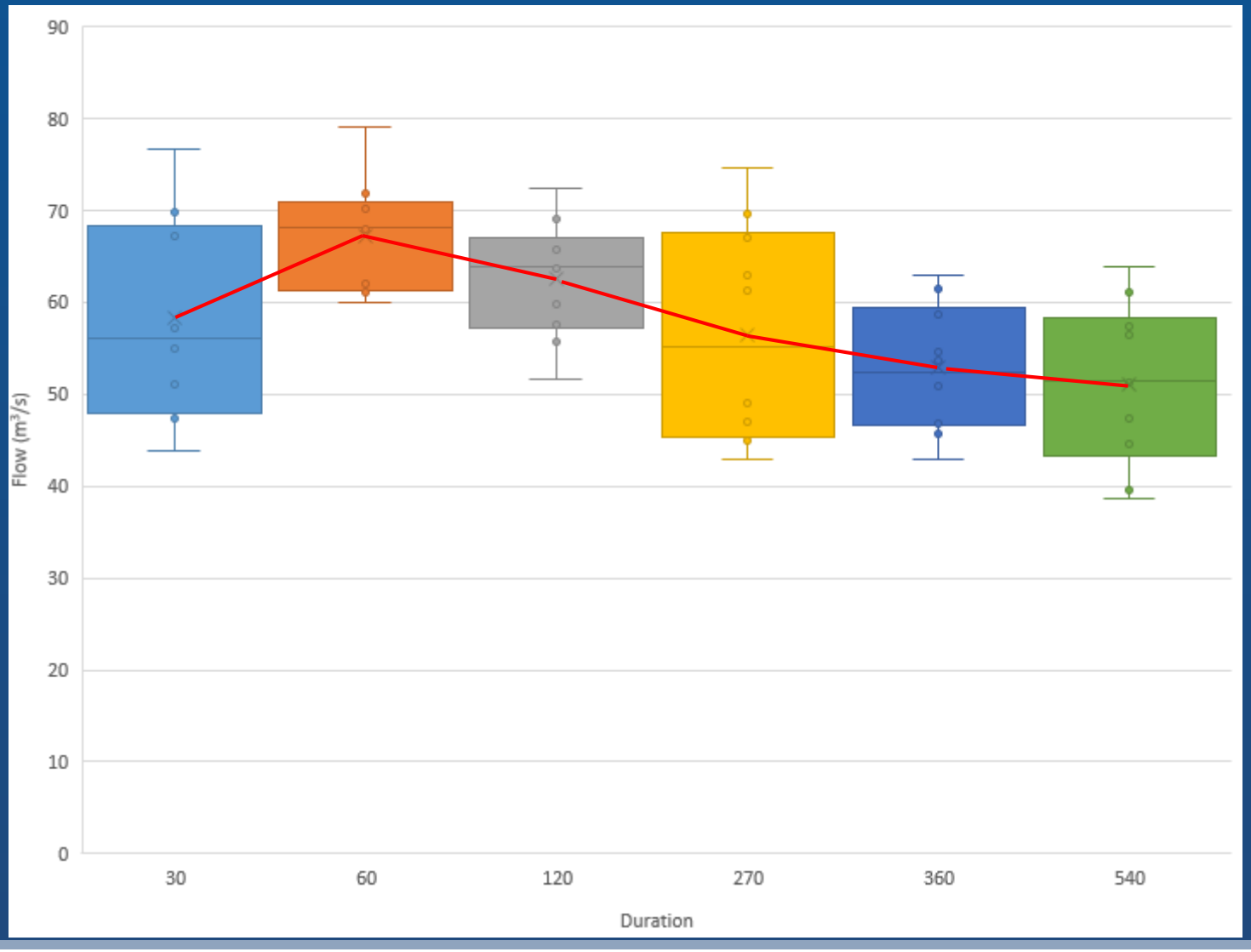
Australian Rainfall & Runoff

ARR 2016 Method



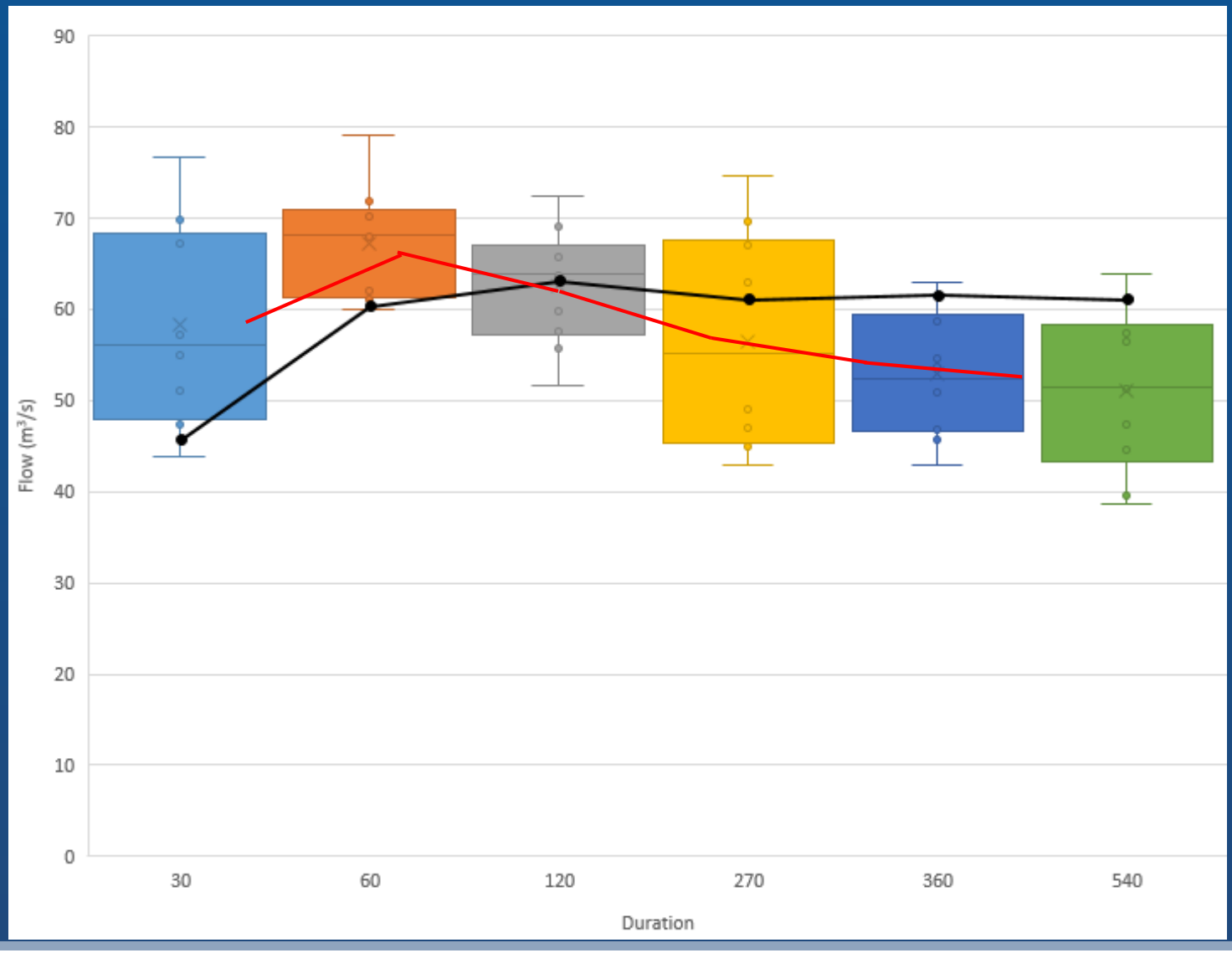
Australian Rainfall & Runoff

ARR 2016 Method



Australian Rainfall & Runoff

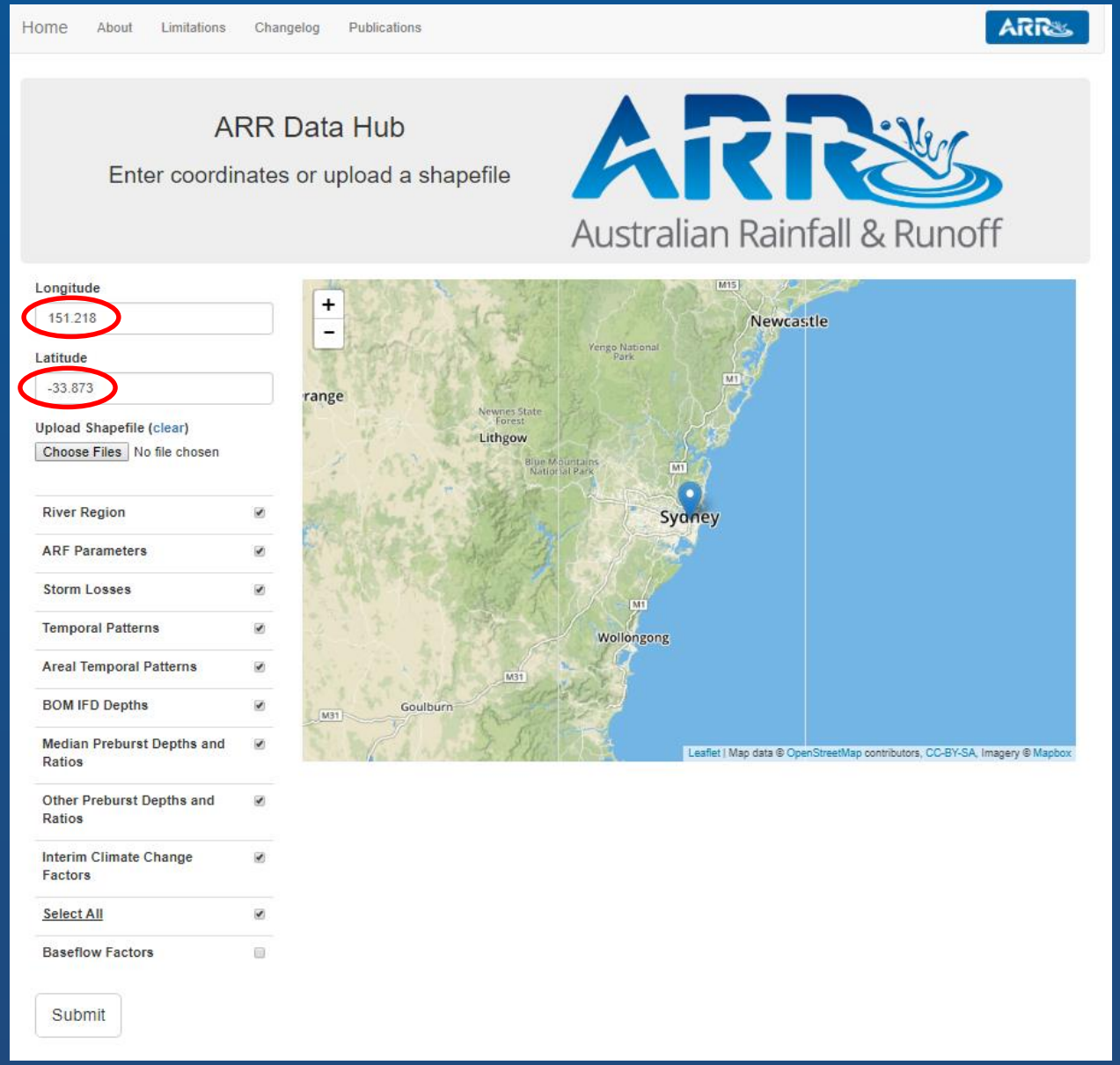
ARR 2016 Method Comparison



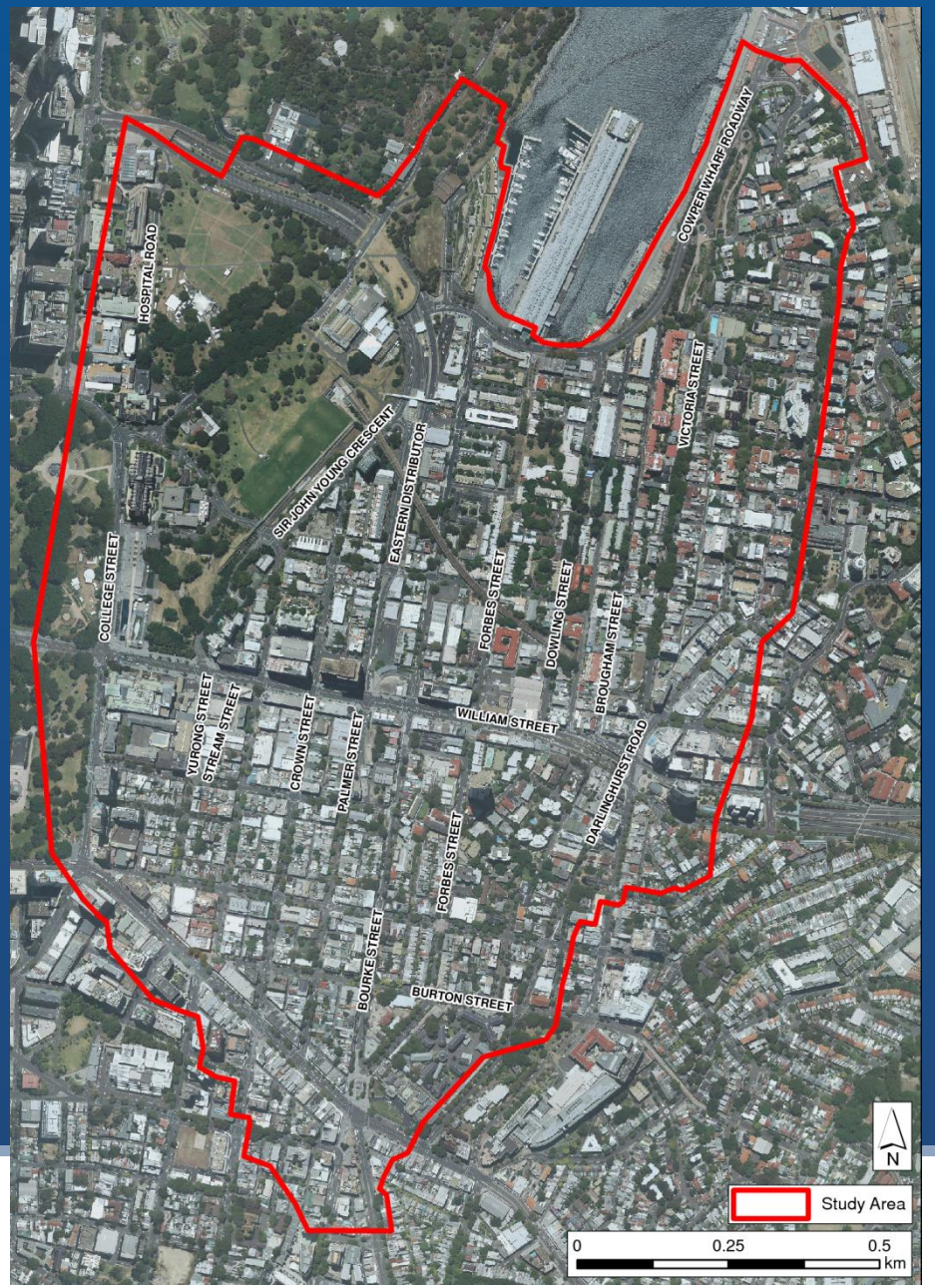
Australian Rainfall & Runoff

Data online

http://data.arr-software.org/



Woolloomooloo Example Drains And TUFLOW



Woolloomooloo Catchment

- Adopted Rainfall Loss Parameters from Woolloomooloo Flood Study using ARR 87

RAINFALL LOSSES	
Paved Area Depression Storage (Initial Loss)	1.0 mm
Grassed Area Depression Storage (Initial Loss)	5.0 mm
SOIL TYPE	3
Slow infiltration rates. This parameter, in conjunction with the AMC, determines the continuing loss	
ANTECENDENT MOISTURE CONDITIONS	3
Description	Rather wet
Total Rainfall in 5 Days Preceding the Storm	12.5 to 25mm

Woolloomooloo Catchment

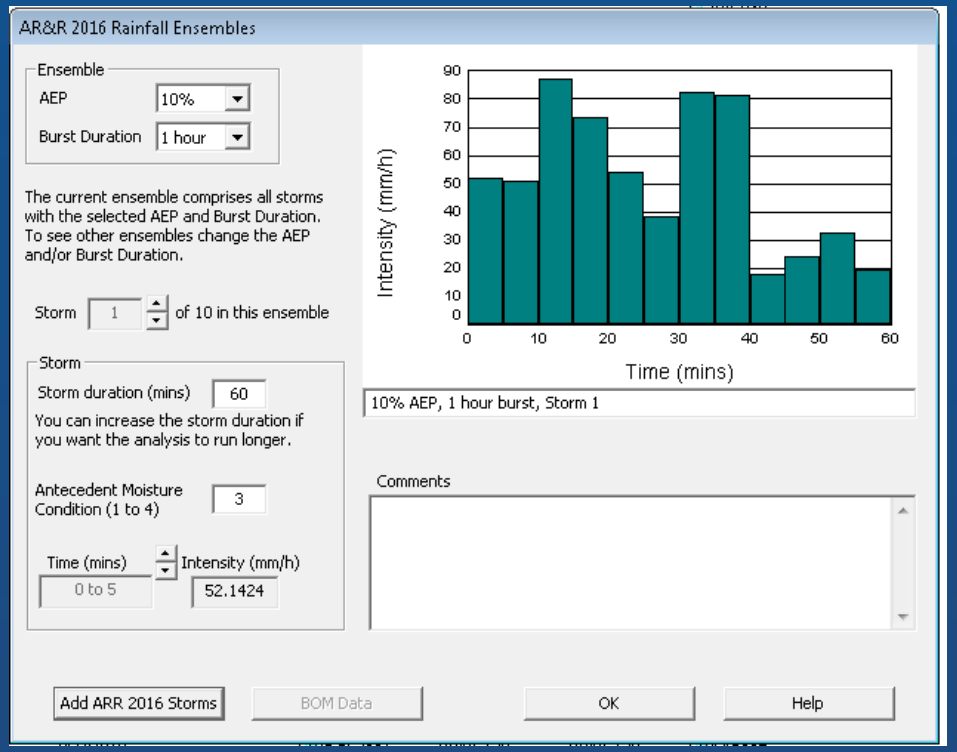
ARR 2016 provides recommendations for loss values in urban catchments (Book 5 Chapter 3 Section 3.5.3).

Urban Area	Burst Initial Loss (mm)	Continuous Loss (mm/hr)
Effective Impervious Area	1 – 2 mm	0
Indirectly Connected Area	60 to 80% of rural catchment losses	For southeastern Australia, a typical value of 2.5mm/h, with a range of 1 to 3 mm/h, would be appropriate. The value should be adjusted based on engineering judgement and reviewing the catchment characteristics such as soil types, interaction of indirectly connected impervious areas with pervious areas etc. For other areas, adopt a range of 1 to 4 mm/h.
Urban Pervious Area	Traditionally, practitioners have adopted similar loss values for these areas as for those they would adopt in rural areas.	

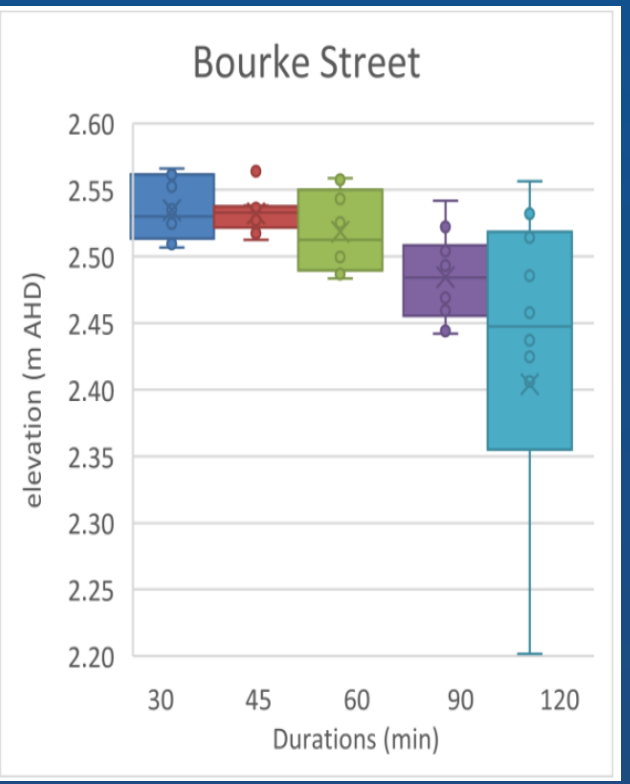
Woolloomooloo Catchment

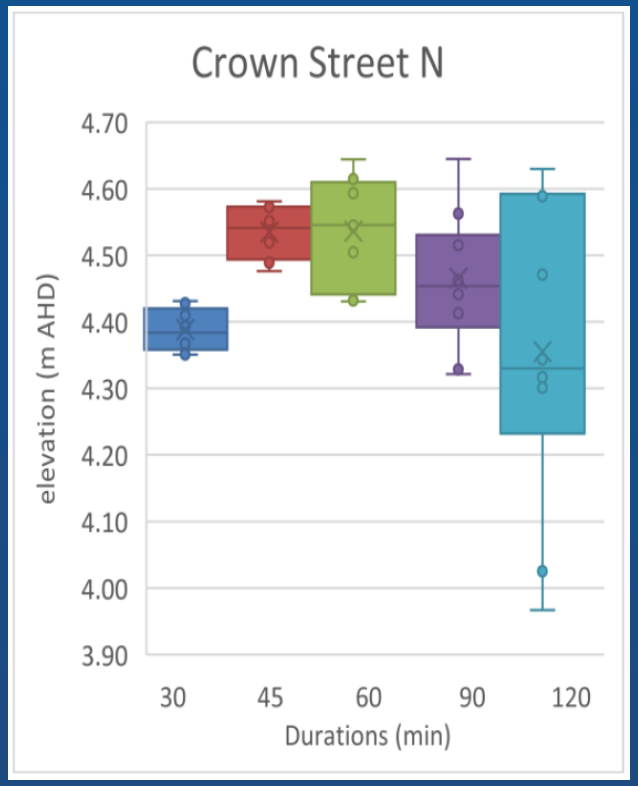
DRAINS Screenshot – ARR 2016 Rainfall Ensembles

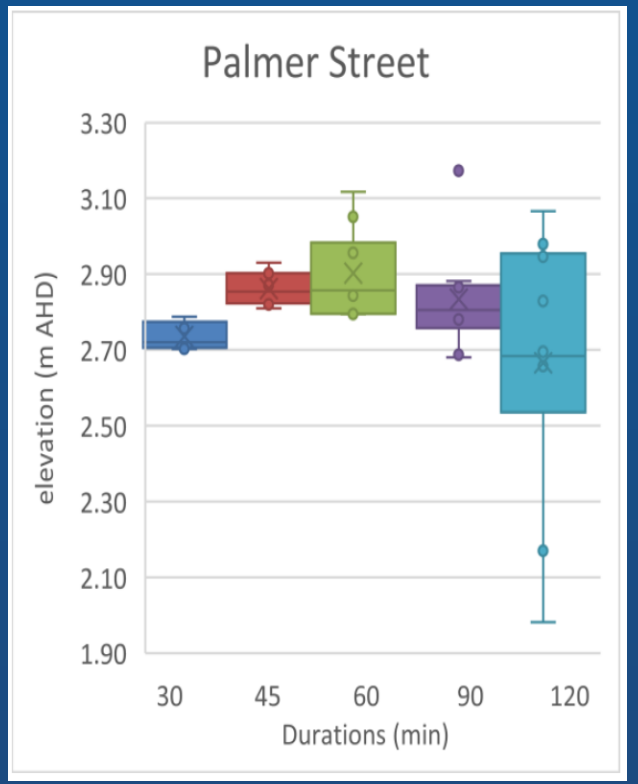
Drains will prompt to select the temporal pattern file (downloaded from the data hub) and select the AEPs and durations required.

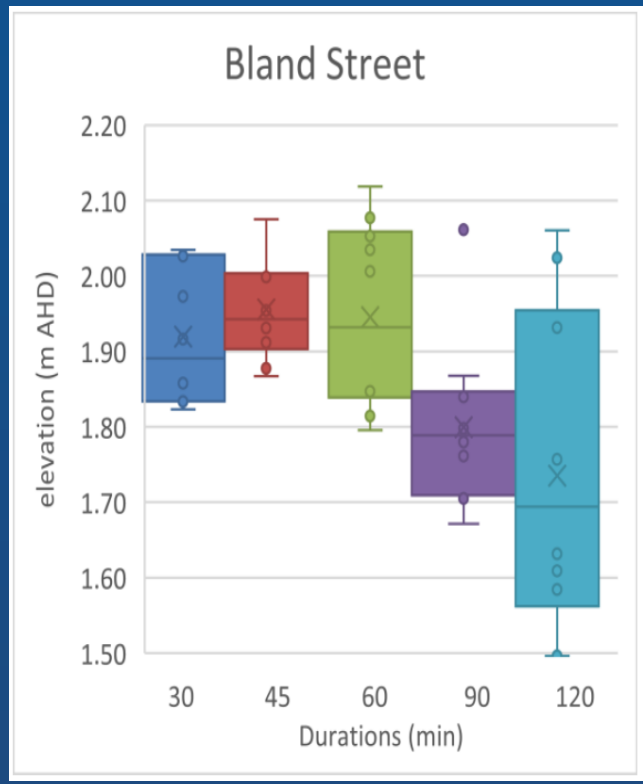


Woolloomooloo – tUFLOW results





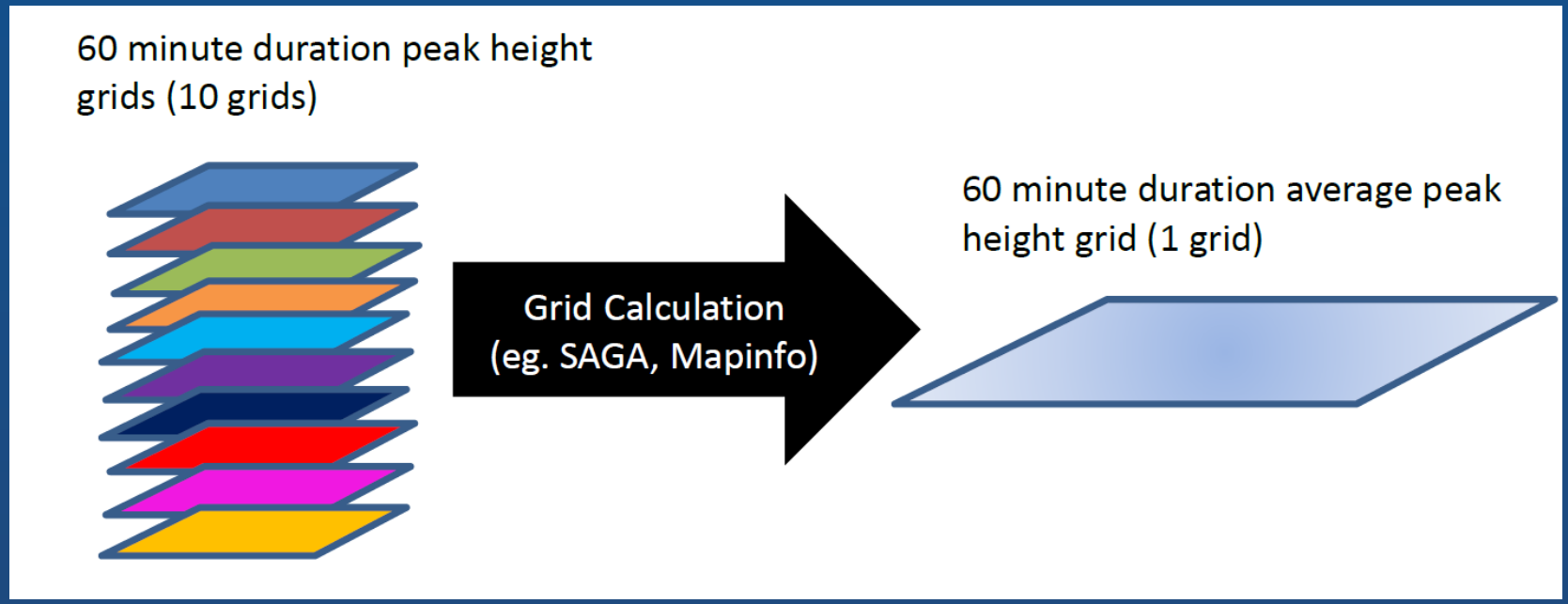




Woolloomooloo Catchment

Average (mean) Grid Calculation

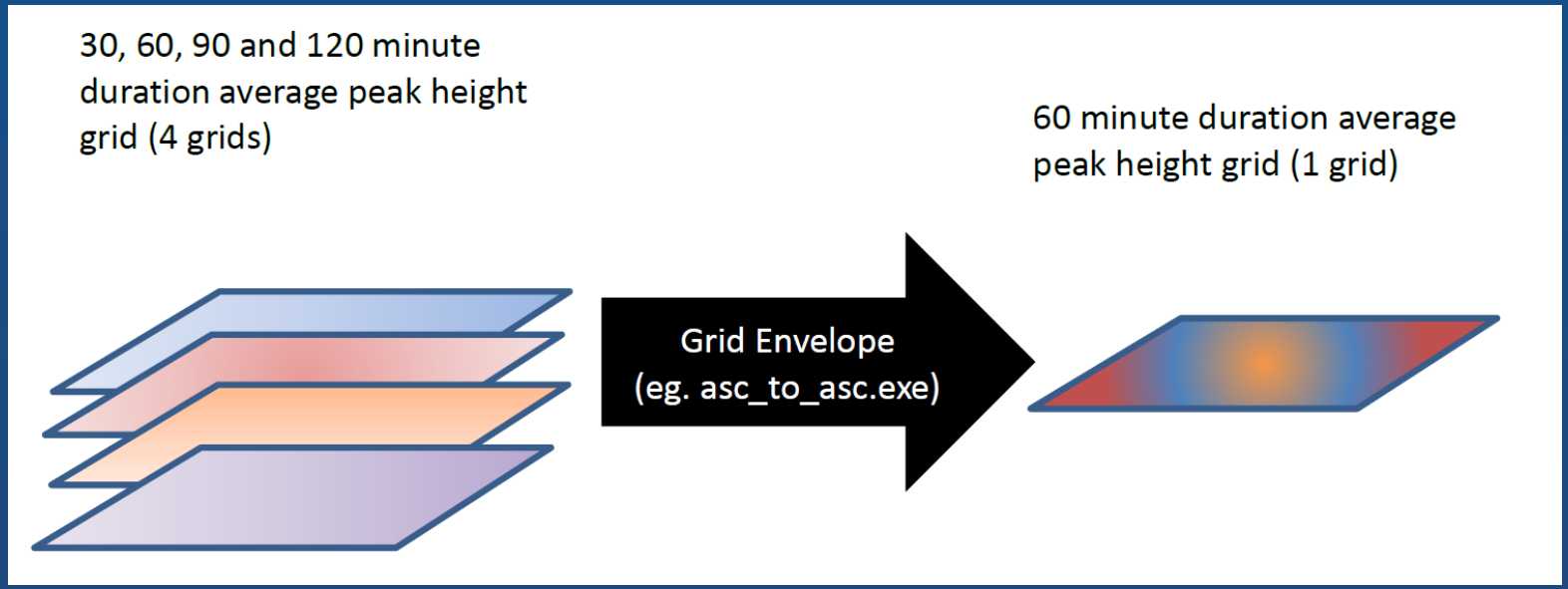
Create an average grid for each duration using a grid calculation tool (this can be done in several GIS programs such as SAGA, QGIS and Mapinfo).



Woolloomooloo Catchment

Grid Envelope

Envelope the average duration grids to create a grid of all the areas were the different durations are critical based. This grid calculation can be done using a standard TUFLOW utility called asc_to_asc.exe.

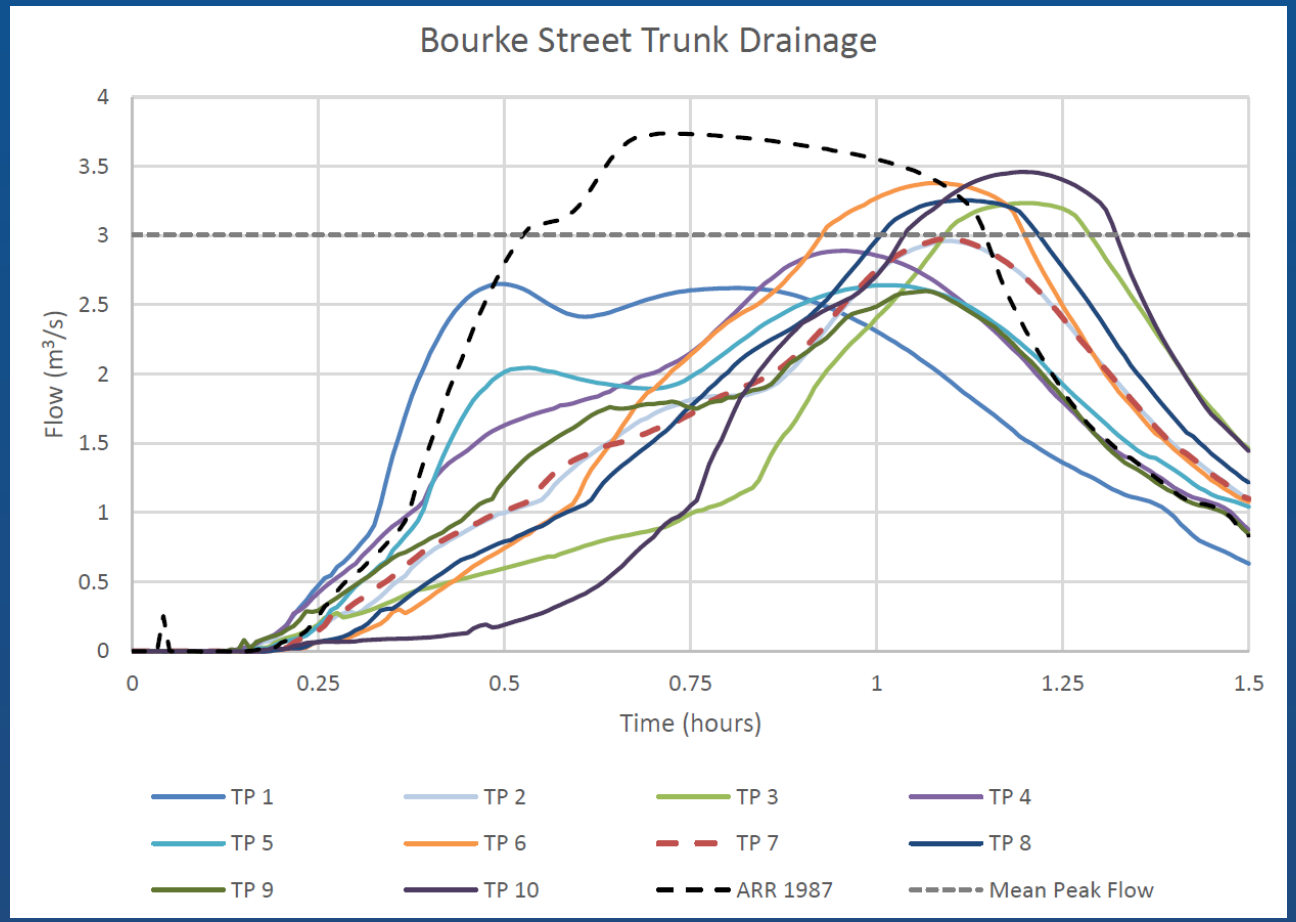


Woolloomooloo Catchment

Bourke St Trunk Drainage

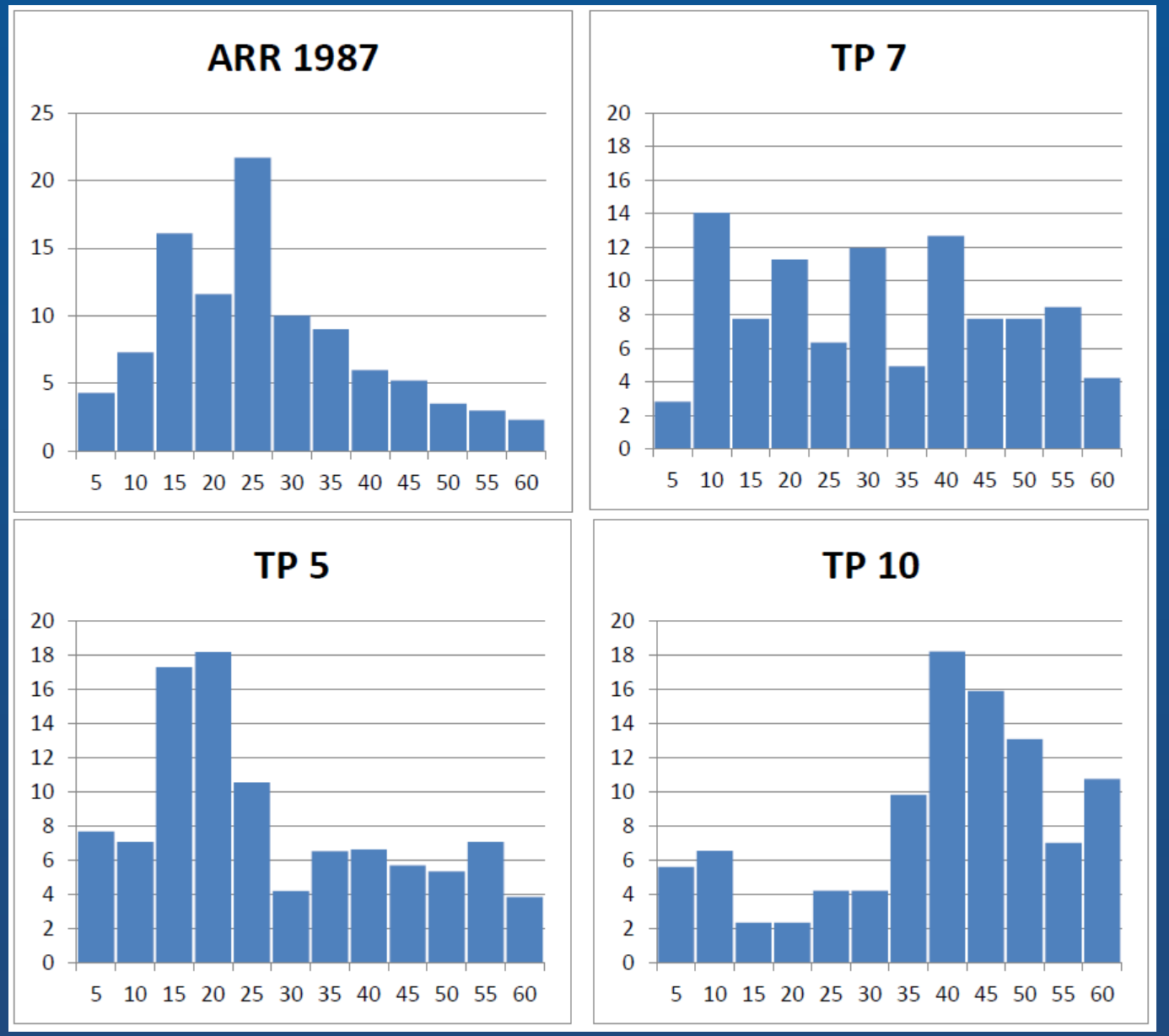
This graph presents ten hydrographs of the 1% AEP in the trunk drainage system at Bourke Street confluence.

TP 7 is the mean temporal pattern based on the levels across the catchment.



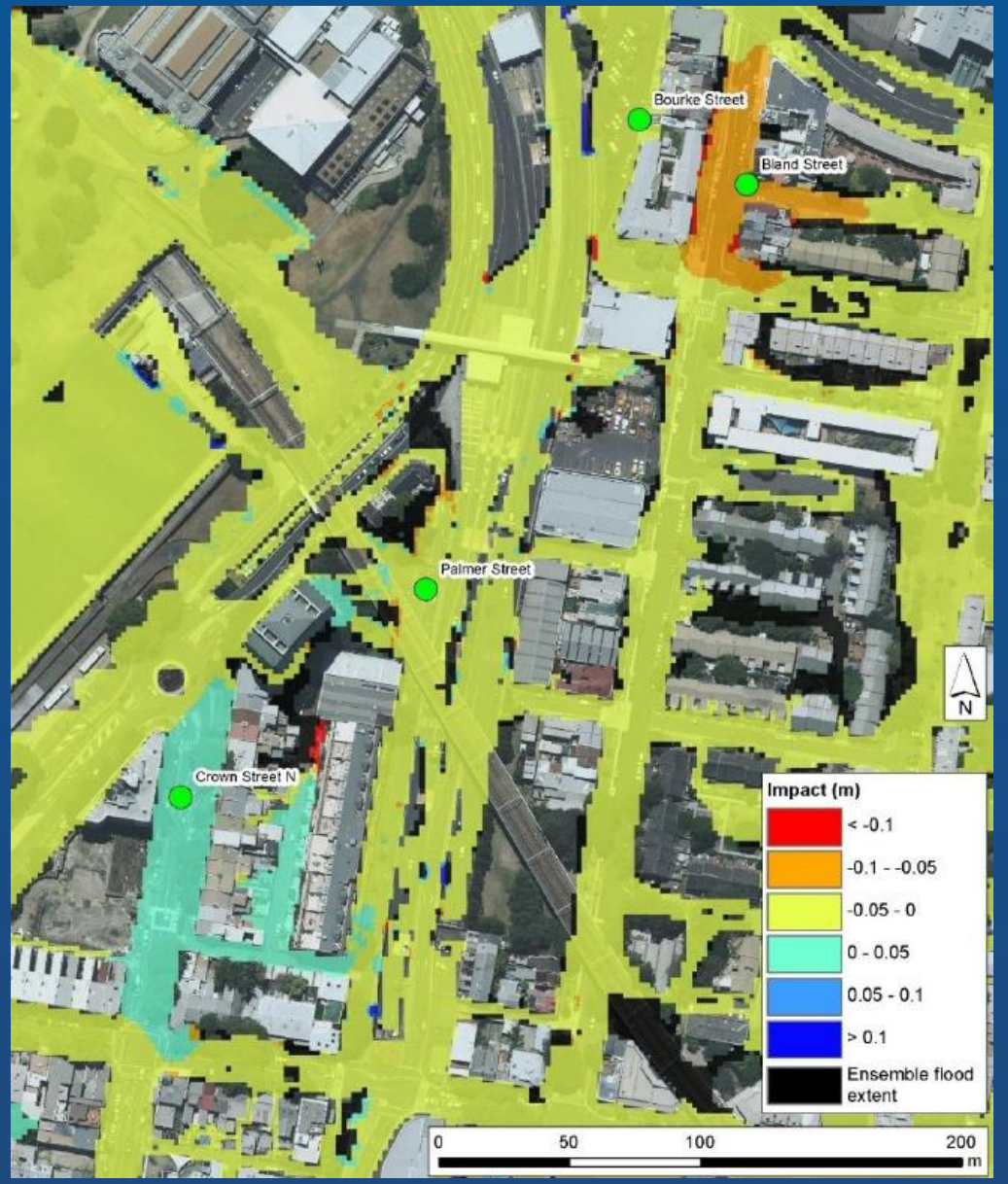
Woolloomooloo Catchment

Temporal Pattern comparison



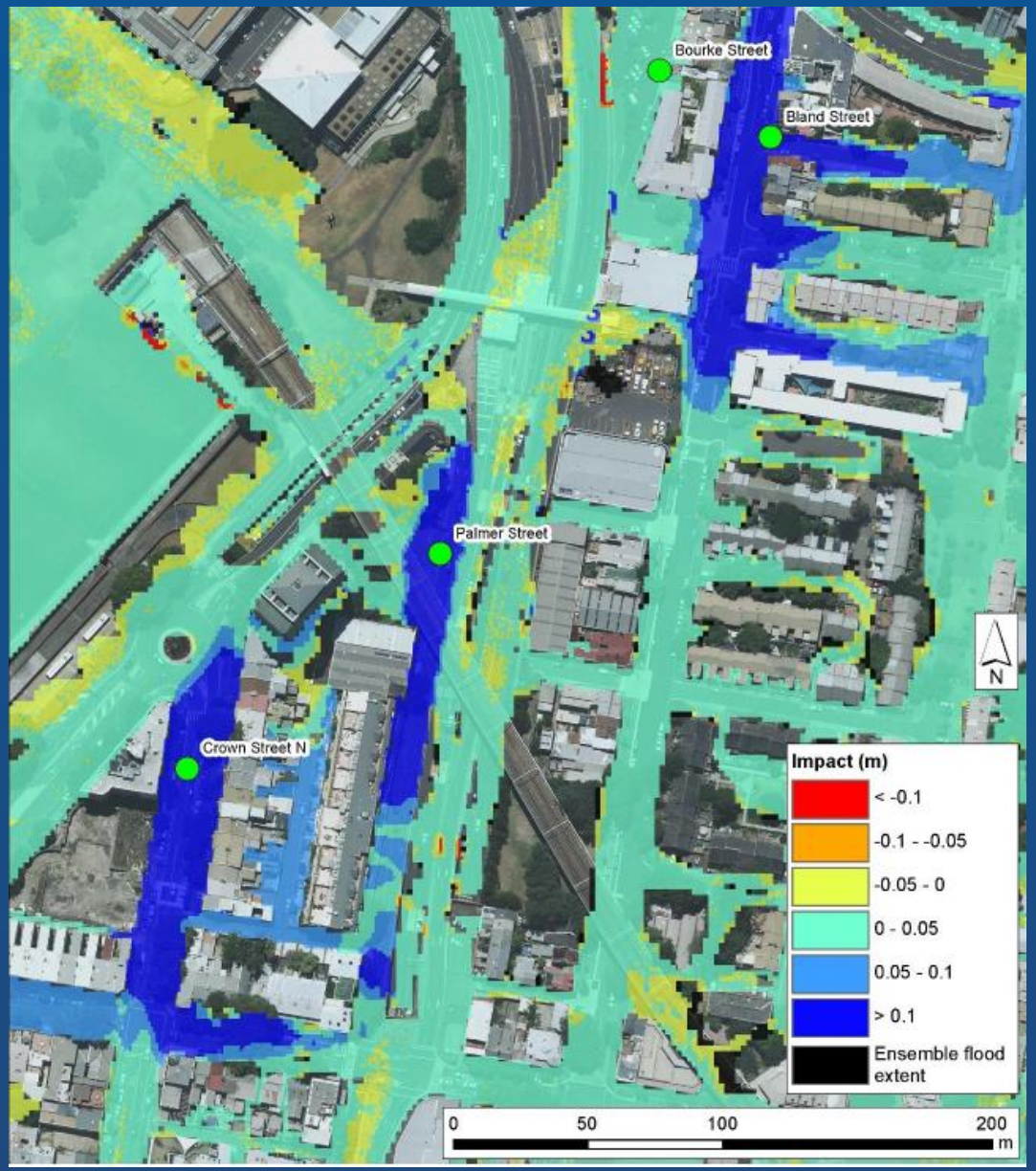
Woolloomooloo Catchment

Difference in level between the *chosen* temporal pattern and the average grid.



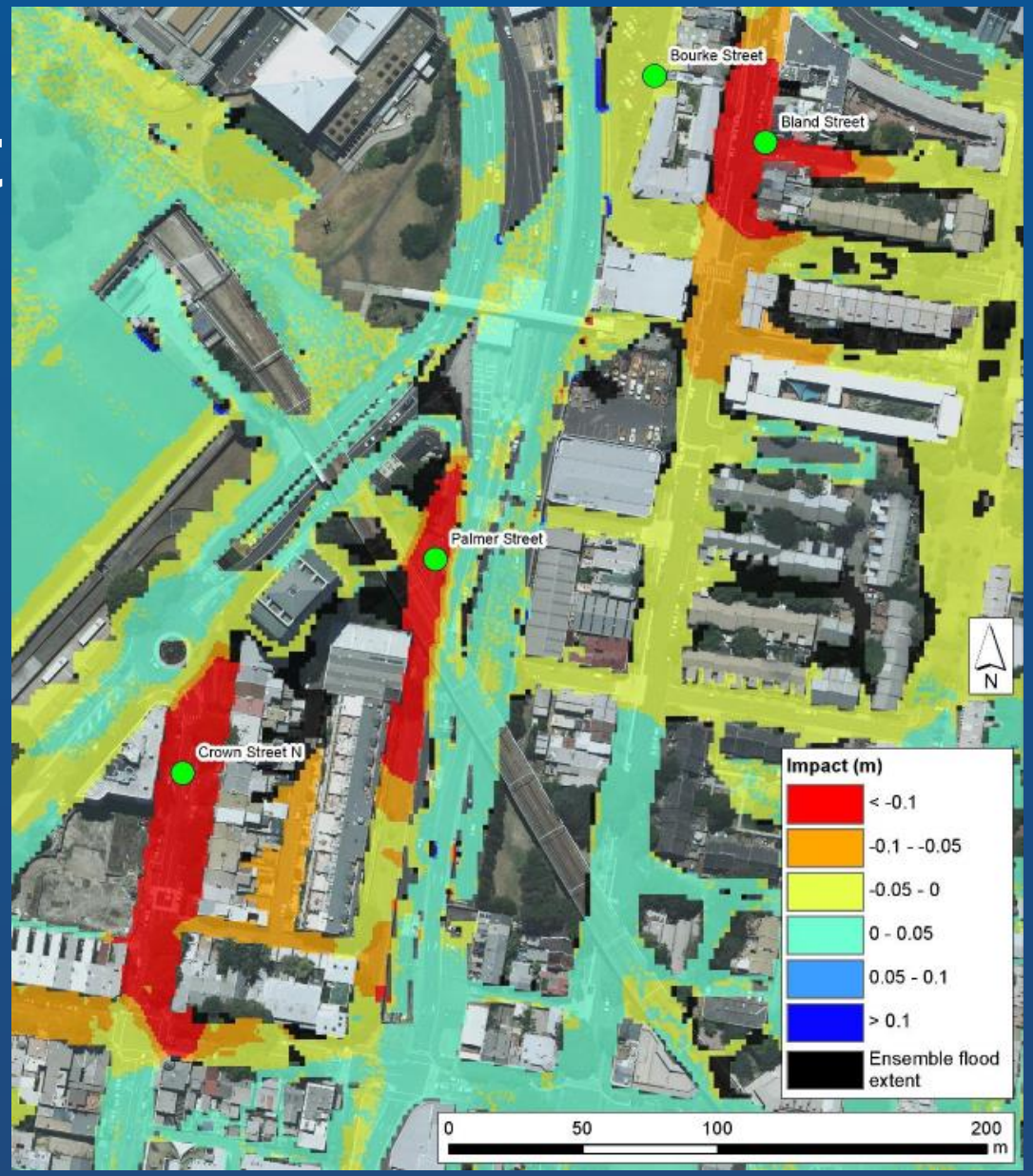
Woolloomooloo Catchment

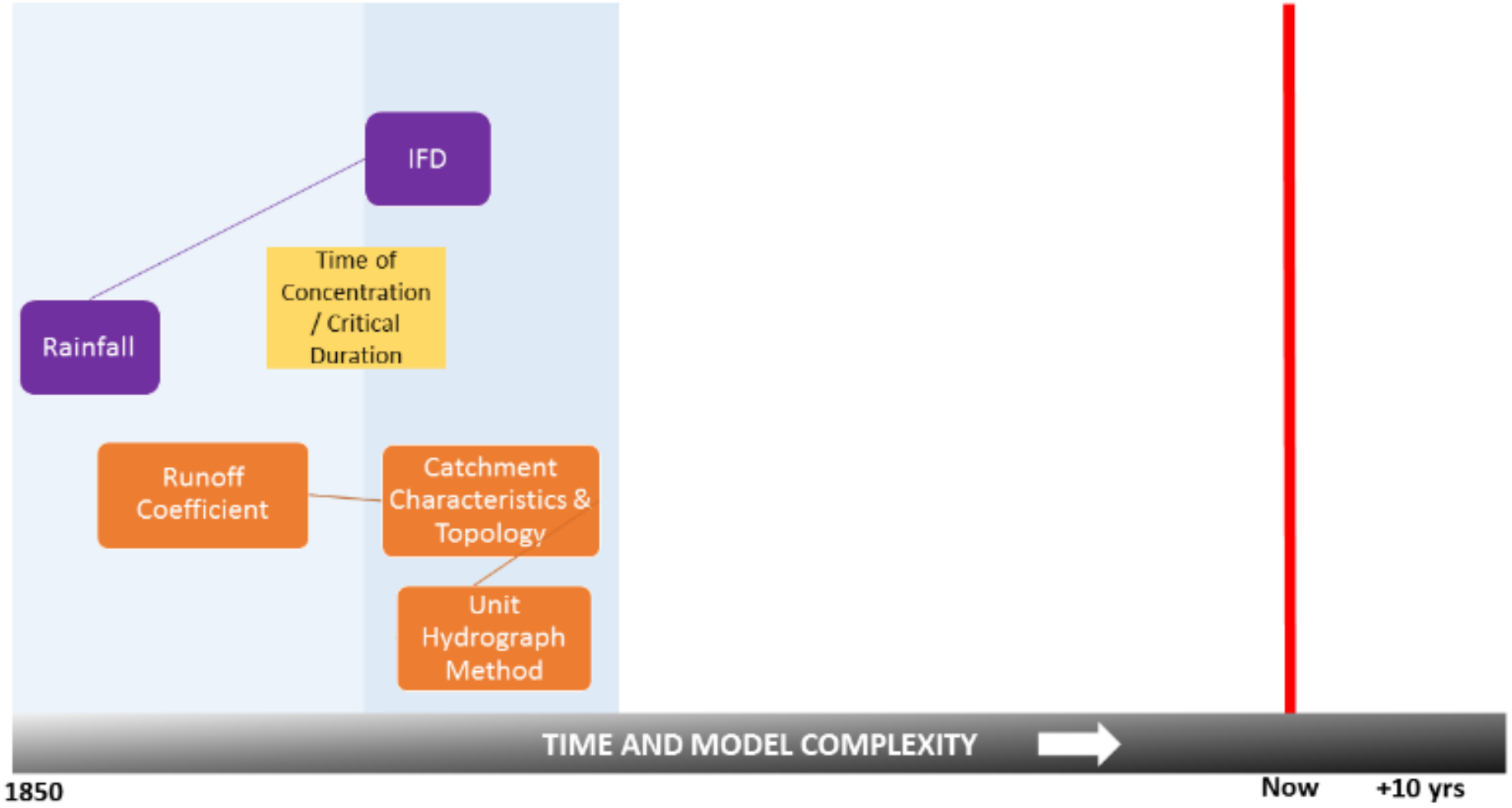
Difference in level between the *maximum* temporal pattern and the average grid.

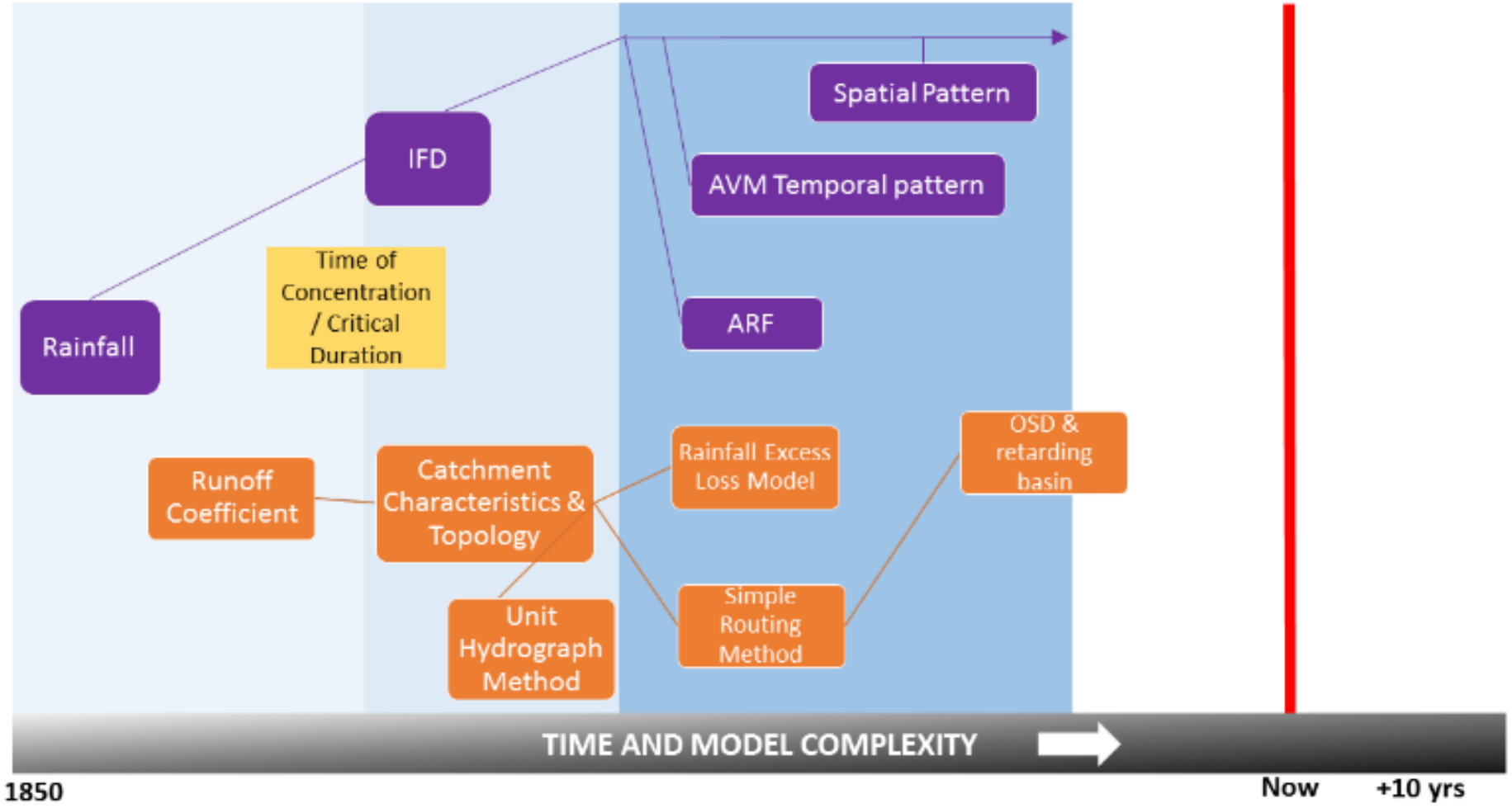


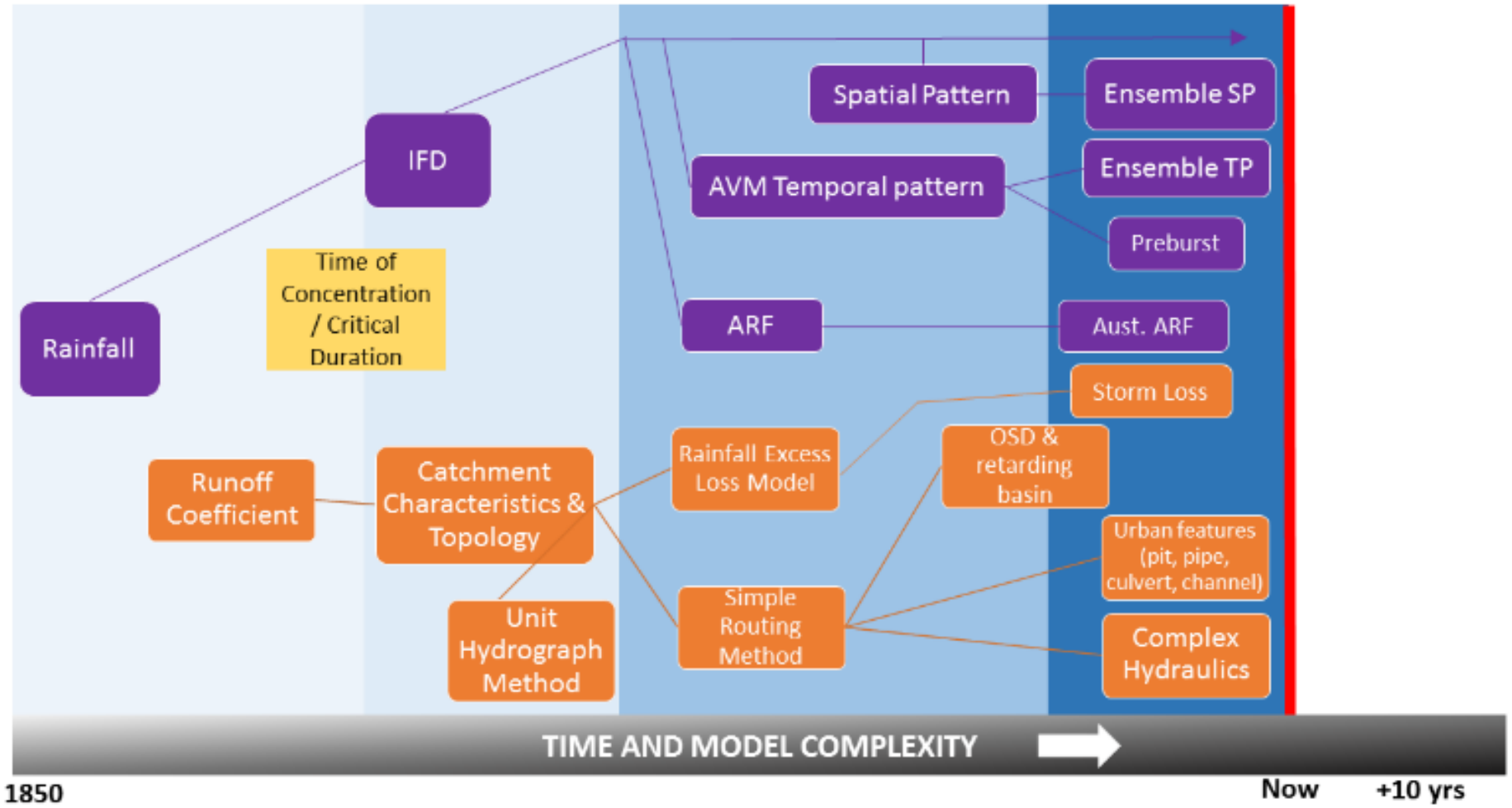
Woolloomooloo Catchment

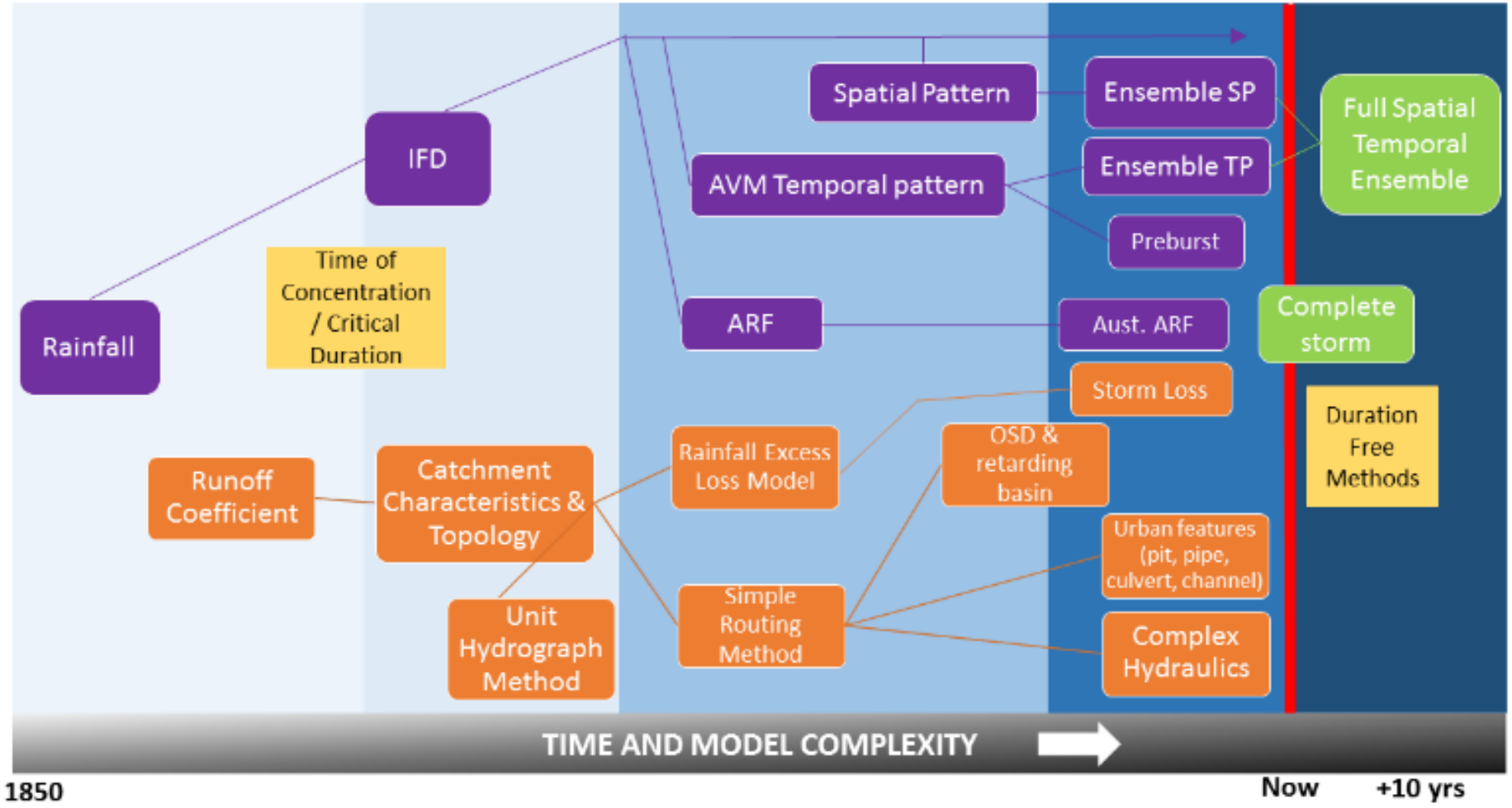
Difference in level between the *minimum* temporal pattern and the average grid.

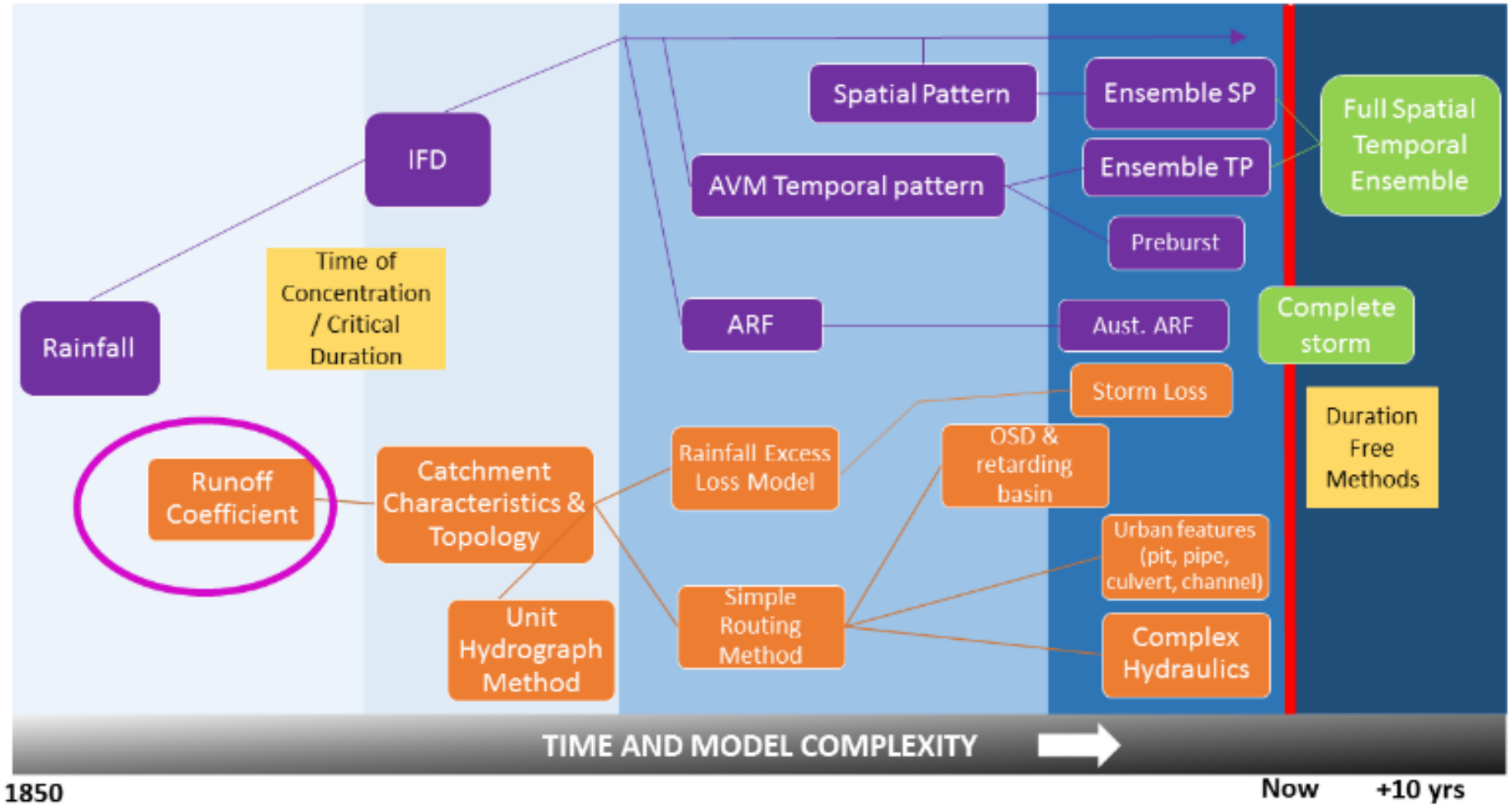


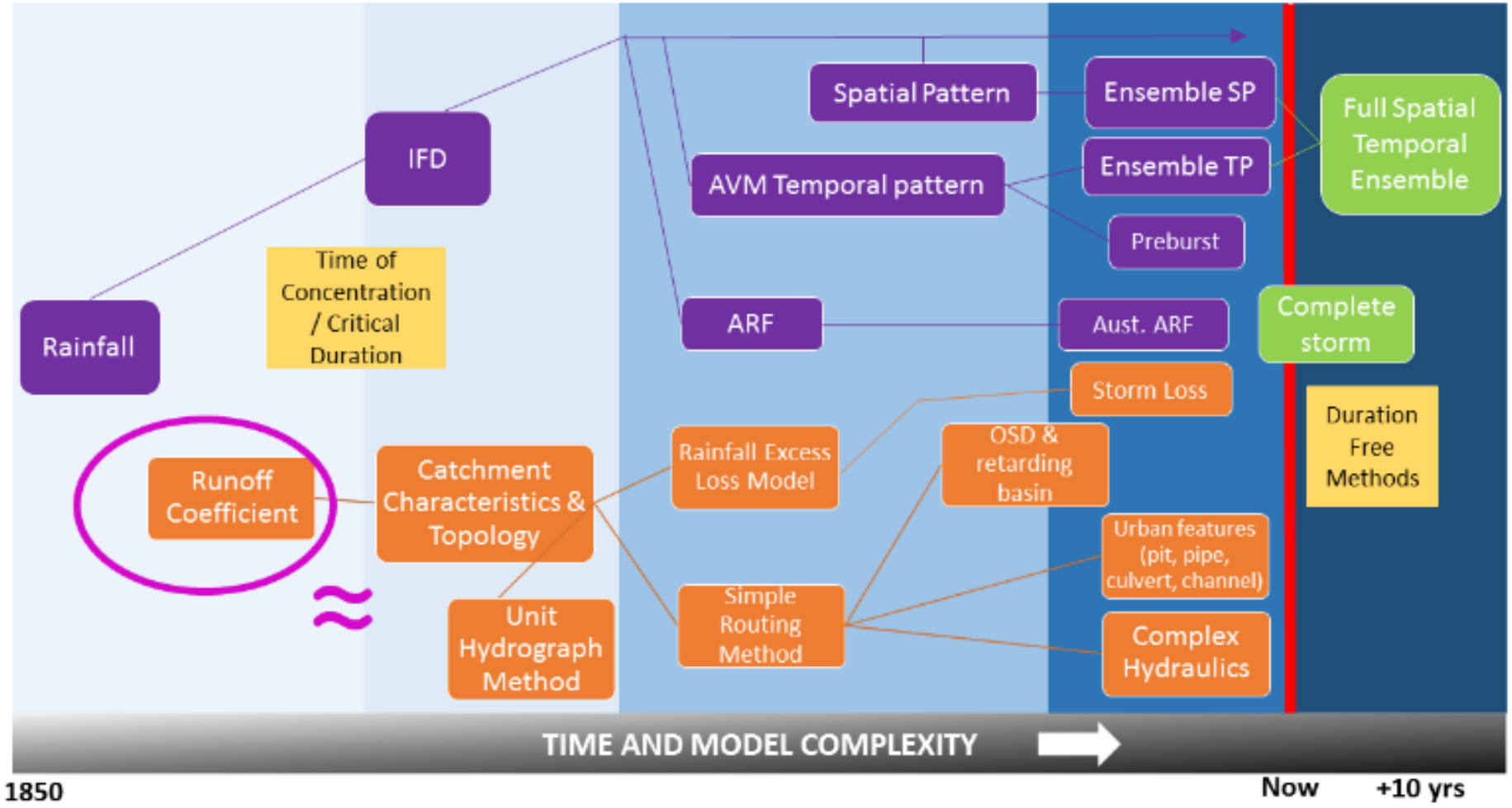

IFD
Time of Concentration / Critical Duration
Rainfall
Runoff Coefficient
Catchment Characteristics & Topology
Unit Hydrograph Method
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs

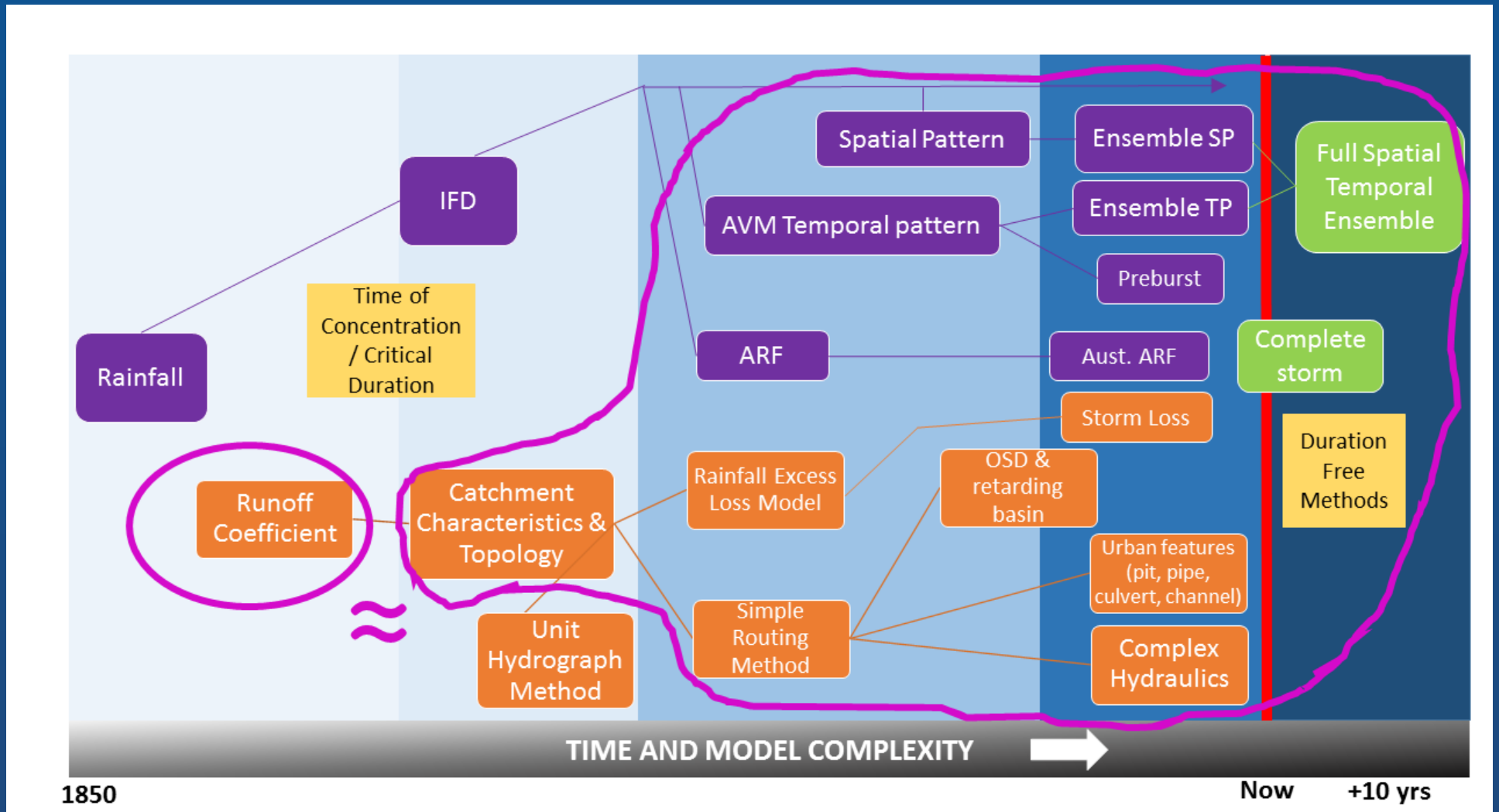

Spatial Pattern
IFD
AVM Temporal pattern
Time of Concentration / Critical Duration
Rainfall
ARF
OSD & retarding basin
Rainfall Excess Loss Model
Runoff Coefficient
Catchment Characteristics & Topology
Simple Routing Method
Unit Hydrograph Method
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs


Spatial Pattern
Ensemble SP
IFD
AVM Temporal pattern
Ensemble TP
Preburst
Time of Concentration / Critical Duration
Rainfall
ARF
Aust. ARF
Storm Loss
Rainfall Excess Loss Model
OSD & retarding basin
Runoff Coefficient
Catchment Characteristics & Topology
Urban features (pit, pipe, culvert, channel)
Simple Routing Method
Unit Hydrograph Method
Complex Hydraulics
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs


Rainfall
IFD
Time of Concentration / Critical Duration
Runoff Coefficient
Catchment Characteristics & Topology
Unit Hydrograph Method
Spatial Pattern
AVM Temporal pattern
ARF
Rainfall Excess Loss Model
Simple Routing Method
Ensemble SP
Ensemble TP
Preburst
Aust. ARF
Storm Loss
OSD & retarding basin
Urban features (pit, pipe, culvert, channel)
Complex Hydraulics
Full Spatial Temporal Ensemble
Complete storm
Duration Free Methods
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs


Spatial Pattern
Ensemble SP
Full Spatial Temporal Ensemble
IFD
AVM Temporal pattern
Ensemble TP
Preburst
Time of Concentration / Critical Duration
Rainfall
ARF
Aust. ARF
Complete storm
Storm Loss
Duration Free Methods
Runoff Coefficient
Catchment Characteristics & Topology
Rainfall Excess Loss Model
OSD & retarding basin
Urban features (pit, pipe, culvert, channel)
Unit Hydrograph Method
Simple Routing Method
Complex Hydraulics
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs


IFD
Rainfall
Time of Concentration / Critical Duration
Runoff Coefficient
≈
Catchment Characteristics & Topology
Unit Hydrograph Method
Rainfall Excess Loss Model
Simple Routing Method
Spatial Pattern
AVM Temporal pattern
ARF
Ensemble SP
Ensemble TP
Preburst
Aust. ARF
Storm Loss
OSD & retarding basin
Urban features (pit, pipe, culvert, channel)
Complex Hydraulics
Full Spatial Temporal Ensemble
Complete storm
Duration Free Methods
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs


Spatial Pattern
Ensemble SP
Full Spatial Temporal Ensemble
IFD
AVM Temporal pattern
Ensemble TP
Preburst
Time of Concentration / Critical Duration
Rainfall
ARF
Aust. ARF
Complete storm
Storm Loss
Duration Free Methods
Runoff Coefficient
Catchment Characteristics & Topology
Rainfall Excess Loss Model
OSD & retarding basin
Urban features (pit, pipe, culvert, channel)
Unit Hydrograph Method
Simple Routing Method
Complex Hydraulics
TIME AND MODEL COMPLEXITY
1850
Now
+10 yrs