Australian Methods for Estimating Large to Extreme Floods

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BIOGRAPHICAL SKETCH

Dr. Rory Nathan is the Principal Hydrologist with Sinclair Knight Merz, and is an Honorary Research Fellow at both the University of Melbourne and Monash University. He is the Australian representative on the ICOLD floods committee and lead author of the national guidelines for the estimation of large to extreme floods. He has published over 130 research papers on environmental and engineering hydrology in refereed journals and conference proceedings. He has won several national and international awards for his research publications, including being named national "Civil Engineer of the Year" by the Institution of Engineers.

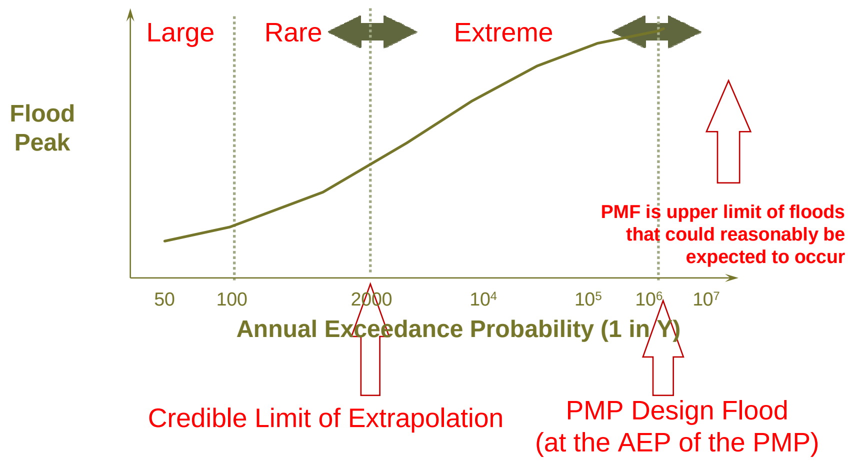
ABSTRACT

This paper broadly describes the range of flood estimation procedures used currently in Australia. It presents the context for the range of different approaches used, and discusses the overall rationale for transitioning from the use of flood frequency analyses for the estimation of frequent floods, through to the use of rainfall-based procedures for the estimation of extreme events. The importance of reconciling differences between the different approaches used is emphasised. The different frameworks used to undertake flood simulation are discussed, and the relative advantages between deterministic, joint probability, and continuous simulation approaches are briefly mentioned.

Introduction

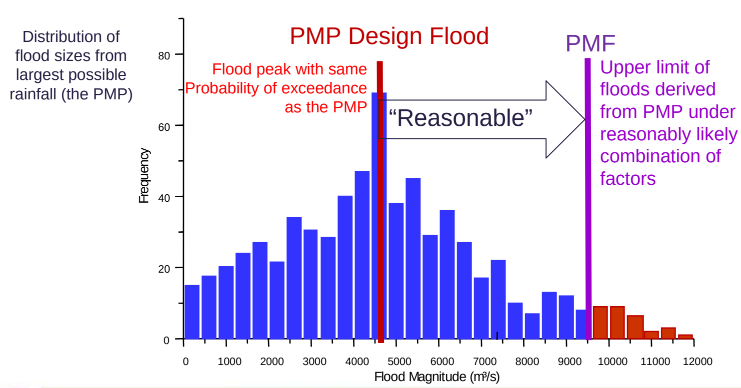
- Flood estimation in Australia governed by guidelines "Australian Rainfall and Runoff" published by the Institution of Engineers:
  - Divided into 8 books covering hydrologic, meteorologic, and hydraulic aspects of flood estimation
  - Book VI is concerned with the "Estimation of Large to Extreme Floods"
  - Book IV (II) covers Flood Frequency Analysis
  - Remainder currently under (slow) process of revision
- Scope of document covers the estimation of events between 2 yr ARI flood up to the PMF.
- These are guidelines, not prescriptive, and they can be departed from with justification

Event classes

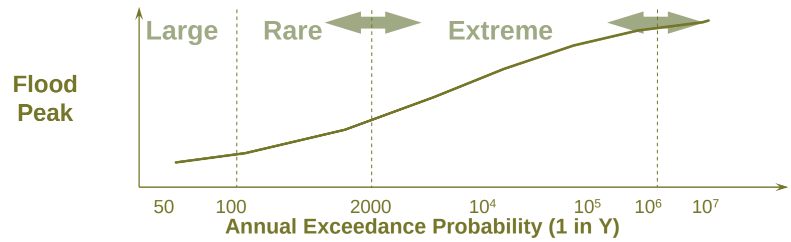


PMF vs Probability-Neutral PMP Flood

> The guidelines differentiate between a flood derived from the PMP under probability-neutral assumptions (“PMP Design Flood”) and that under upper limiting assumptions (“PMF”)



Event classes



- Fewer observations
- Increasing uncertainty
- Increasing prescription required
- Increasing need for rainfall-based procedures

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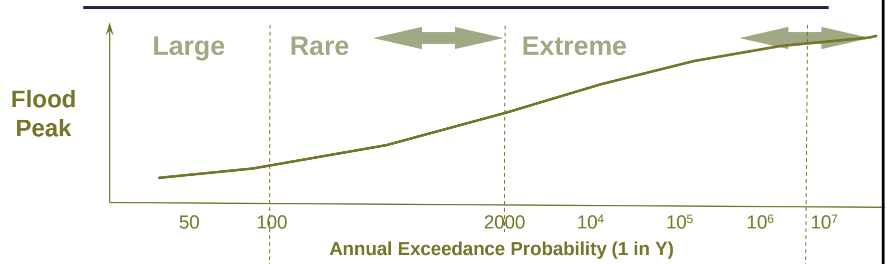
Stochastic variability vs. uncertainty



Method:	Calibration	Extrapolation	Simulation
Basis:	Data	Data & hydrologic knowledge	Modelling hypotheses
Dominant Feature:	Stochastic variability	Parameter uncertainty	Model uncertainty

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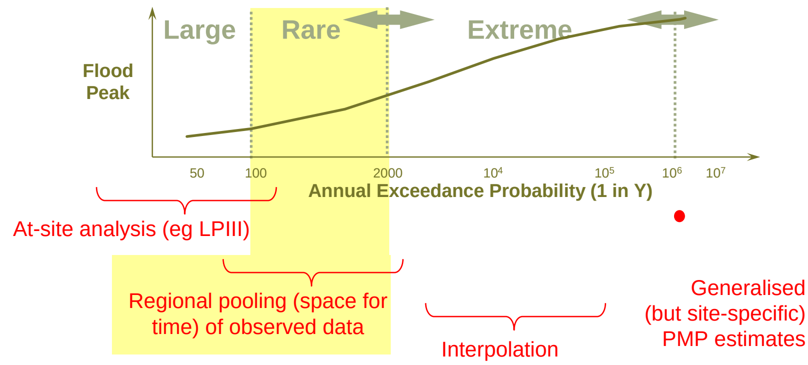
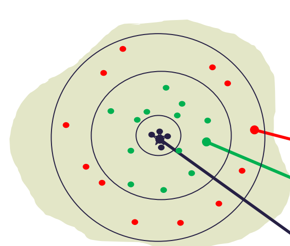
Summary of Rainfall Procedures

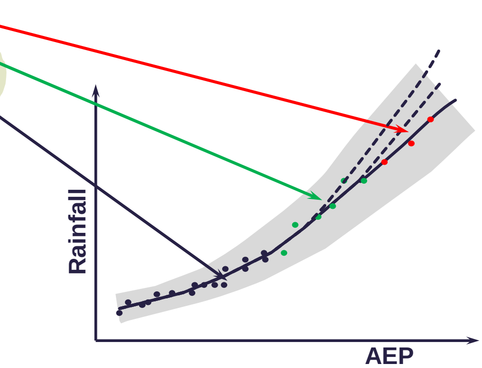


Regional Pooling

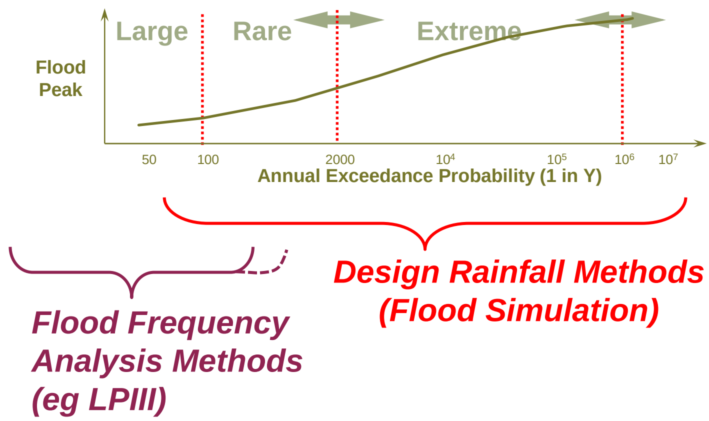


1. Data collation
2. Standardisation
3. Allowance for correlation
4. Fitting of statistical model(s)

Easier to apply to rainfalls than streamflows



Range of Flood Estimation Procedures



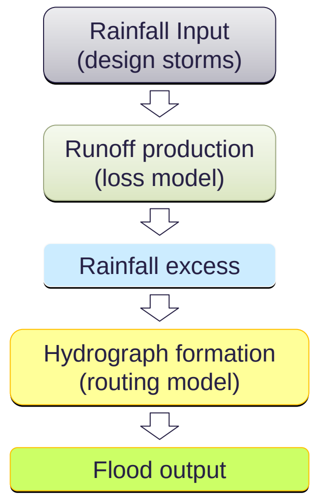
Flood Frequency Analysis (FFA)

> Current procedures effectively same as Bulletin 17B, but draft revision recommends range of distributions (GEV, GPO, GUM, LP3, EXP) and fitting of parameters by Bayesian calibration

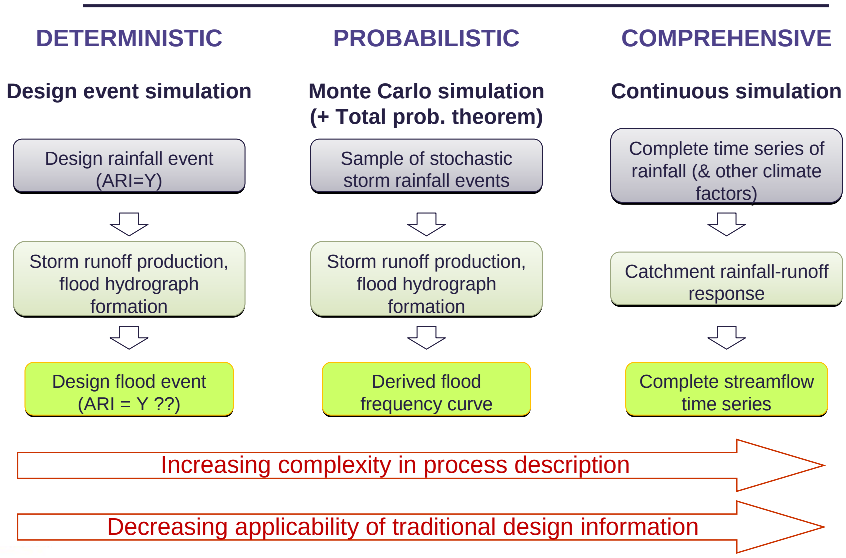
> Literature on theoretical advantages extensive, but in practice the factors that most dominate are:
- Relevance of gauged site to point of interest
- Length of available record
- Quality of streamflow gauging extrapolation
- Stationarity of flood producing factors in the catchment
- Availability of historic events (prior to collection of systematic record) and paleo evidence

> Little point giving undue attention to theoretical advantages of a particular FFA method if data availability is poor

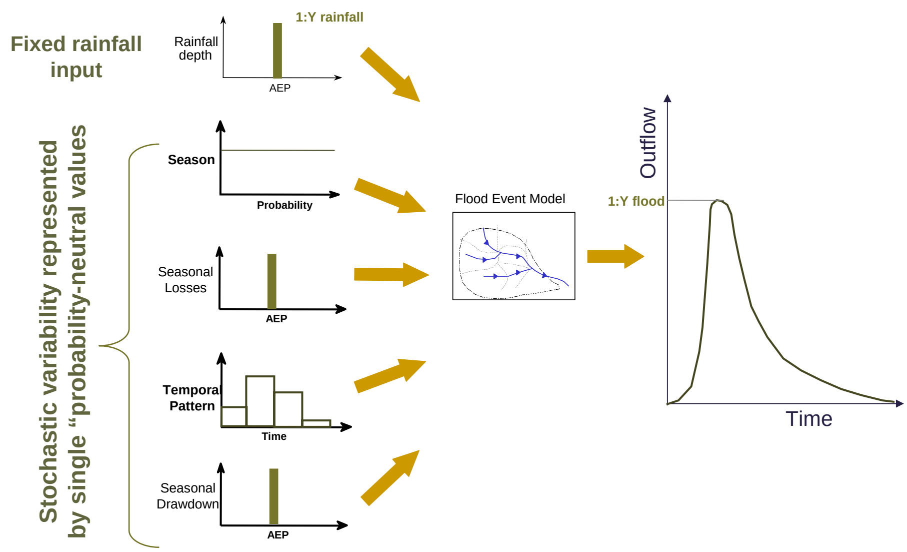
Flood Simulation Concepts



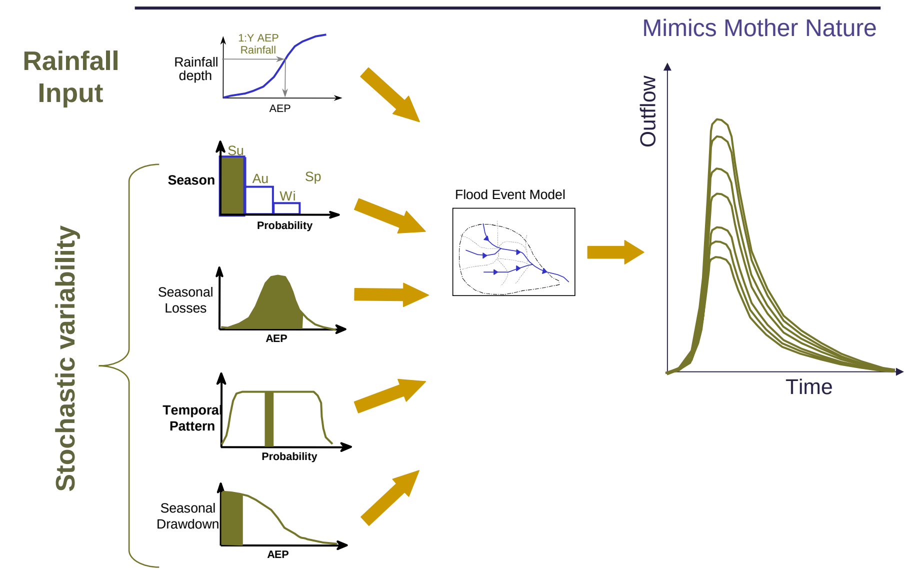
Flood Simulation Approaches



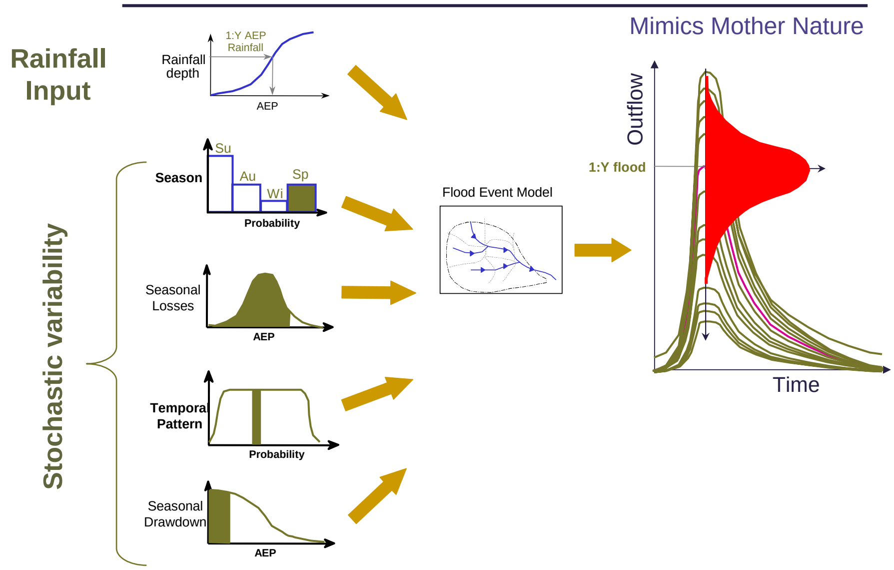
Deterministic ("Design Event" Approach)



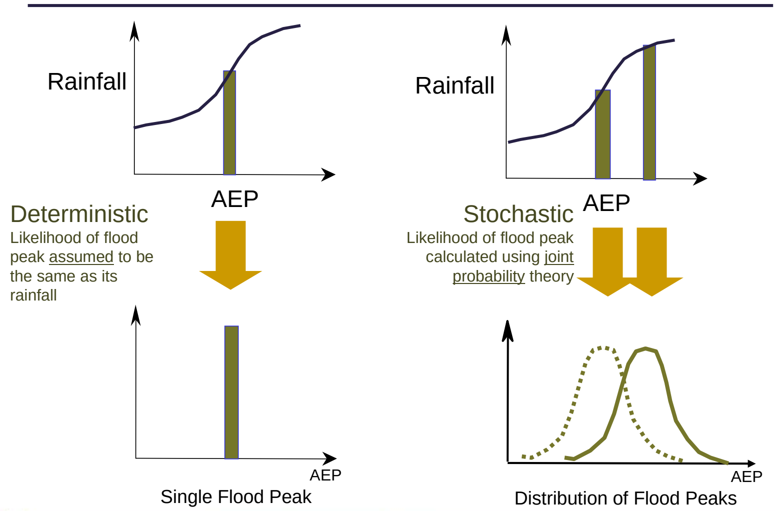
Probabilistic (Monte Carlo Simulation)



Probabilistic (Monte Carlo Simulation)



Design Event Approach | Monte Carlo Approach



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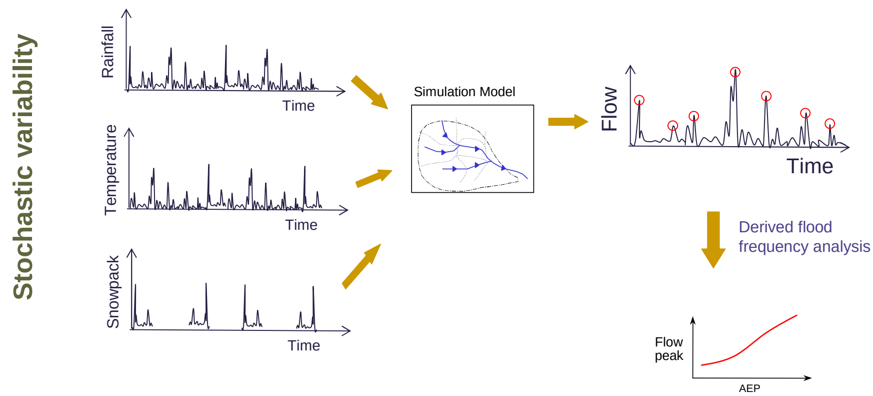
Continuous simulation



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Method selection

- Flood frequency analyses:
  - difficulty with extrapolation to rare floods
  - … and to locations of interest,
  - but valuable use of at-site data.
- Continuous simulation:
  - also limited by length of available record
  - … unless using (complex) stochastic data generation
  - well suited to handling complex interactions
- Monte-Carlo approaches:
  - Good extension of traditional flood event models
  - Makes extended use of available design information
  - Need to focus on dominant stochastic influences

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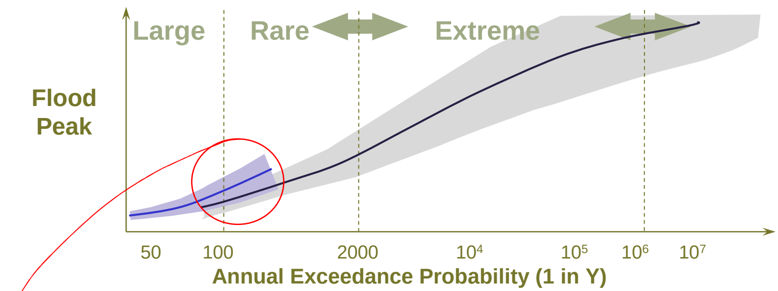
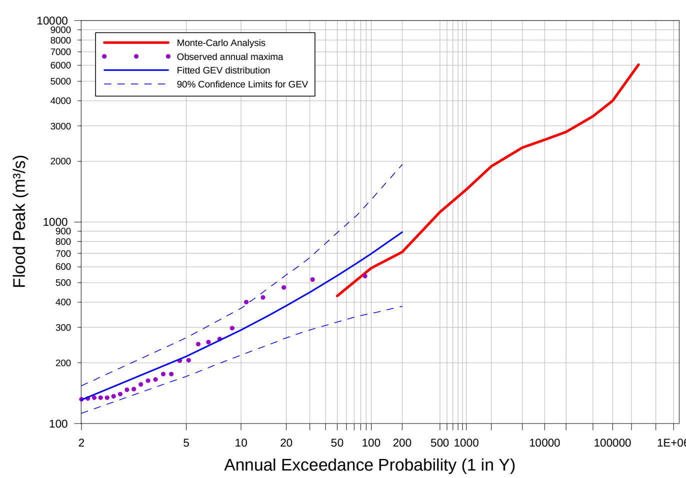
Reconciliation



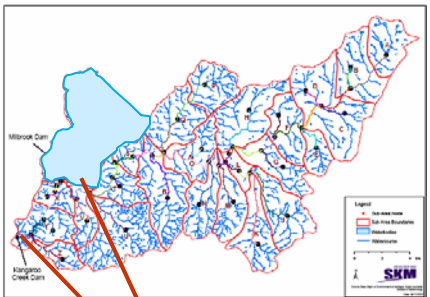
> Reconciliation between different flood estimation approaches very valuable and very important.

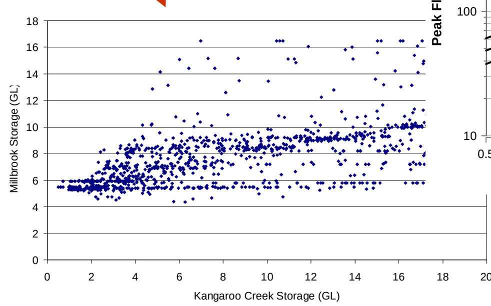
> Particularly if independent data / methods used (eg flood frequency approaches and rainfall-based approaches)

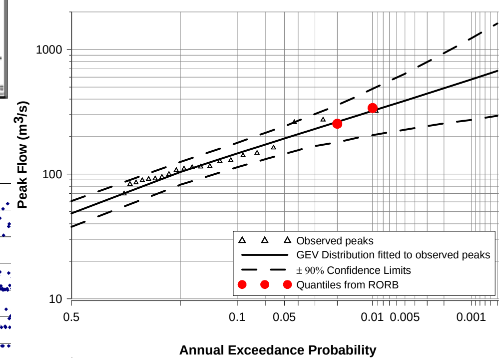
Reconciliation b/w Monte Carlo Simulation and FFA, d/s of a large dam



Reconciliation b/w Monte Carlo and FFA d/s of two correlated storages

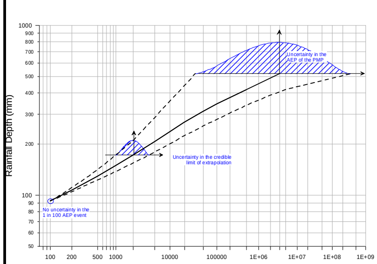


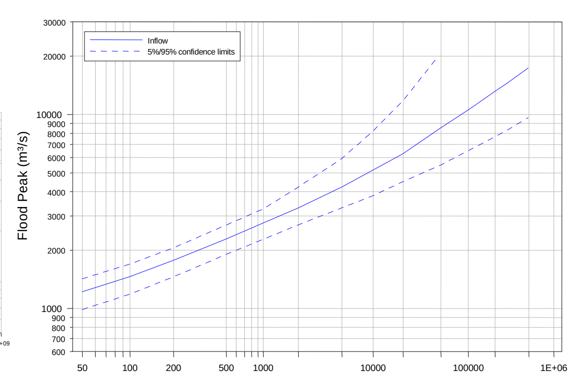




Monte Carlo simulation of uncertainty

Uncertainty function of:
-AEP of PMP
-Model parameters
-Pragmatic assumptions





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Conclusions

- Australian design practice firmly wedded to risk-based concepts, though many areas where more confidence is required in reducing uncertainty in analyses
- Guidelines based on use of flood frequency analysis of at-site data, transitioning to rainfall-based procedures for more extreme events
- Important emphasis placed on reconciliation of estimates from different data sets and procedures
- Draft chapter on revised flood frequency methods recommends range of distributions (GEV, GPO, GUM, LP3, EXP) and fitting of parameters by Bayesian calibration (ie move away from B17B procedures).
- The flood guidelines are currently under revision, and will be encouraging practitioners to move towards Monte-Carlo and continuous simulation techniques