AUSTRALIAN RAINFALL AND RUNOFF WORKSHOP

HWRS2008 - Adelaide

April 2008

Australian Rainfall and Runoff
A guide to runoff estimation

SCOPE

- Where it fits in the revision
- Framework used for development of revision
  - Concepts
  - Hydrologic models
  - Hydraulic models
  - Urban models
  - Application

CATCHMENT MODELLING

Recognised as an important component of generating information necessary for catchment management.

Typically used for extrapolation to

- New locations (i.e. ungauged); or
- New catchment conditions.

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CATCHMENT MODELLING

Main areas in proposed document are
- Book 5 – Hydrograph Estimation
- Book 6 – Flow Hydraulics
- Book 7 – Application of Catchment Modelling Systems

Also introduced into
- Book 2 - Approaches To Runoff Estimation
- Book 3 – Rainfall Estimation
- Book 9 – Runoff In Urban Areas

FRAMEWORK

Need flow estimates and associated probabilities

- Issues

Uncertainty in prediction.
Absence of data – PUB problem
Extrapolation.

- Scope

Range of frequencies.
Range of catchment scale.
Points and network systems.
Changing catchments.

- Estimation Methodology

Random storm event:
- Rainfall intensity ?
- Storm duration ?
- Temporal pattern ?
- Dry period ?

Mathematical Model of System

Streamflow Hydrograph

Random initial conditions:
- Catchment wetness ?
- Catchment storages ?
- Urbanisation ?
- Time of Year ?

CONCEPTS

Catchment modelling systems are not replications of the real catchments but rather are a simplification of the real system.

In general, the simplification takes the form of a mathematical representation of the many physical processes.

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CONCEPTS

Catchment modelling uses a system of process models.

These process models are embedded in software.

CONCEPTS

Purpose of ARR is to provide guidance on

- Suitable process models
- Use of software
  - Parameter estimation
  - Prediction uncertainty

RECOMMENDATION for particular software products not included in ARR.

CONCEPTS

Discussion of process models conceptualised into

- Generation
- Collection
- Transport
- Disposal

Generation
↓
Collection
↓
Transport
↓
Disposal

GENERATION

Concerned with the many models required to develop appropriate input data to the modelling system inclusive of

- Rainfall
- Loss Model Parameters
- Routing Parameters

Recognition of difference between design and analysis is essential.

GENERATION

Focus of a number of books, for example

- Rainfall - Book 3
- Loss Models – Book 5
- Model Parameters – Book 7

HYDROLOGIC MODELS

Focus of Book 5

Primarily concerned with estimation of direct runoff hydrographs (i.e. storm induced flood flows)

Will include some limited discussion of baseflow (i.e. long-term flows in drainage network).

HYDROLOGIC MODELS

Many alternative models for estimation of hydrographs including

- Time-Area methods
- Unit Hydrograph (Unitgraph)
- Conceptual Lumped Reservoir
- Kinematic models
- Hydrodynamic methods

HYDROLOGIC MODELS

These hydrologic models can be categorised as

- Simple
  - Time-area and Unit Hydrograph
- Runoff-routing
  - CLR, Kinematic, hydrodynamic methods

HYDRAULIC MODELS

Focus of Book 6.

Concern is the models necessary for the movement of the water within the network.

APPLICATION

Application guidance is a new chapter in AR&R.

Need for this chapter arises from frequent application of catchment modelling systems.

Recommendations are provided in the application and calibration of catchment modelling systems.

APPLICATION

Two important aspects are

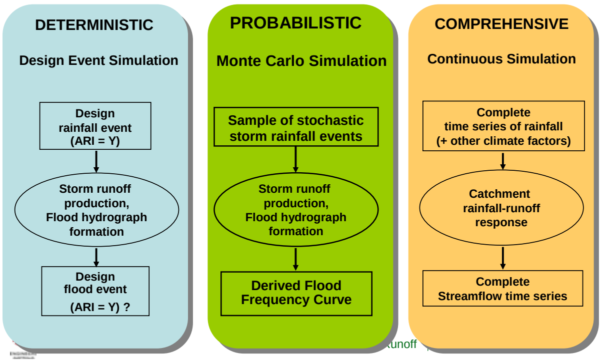
- Different problems will require different simplifications – same complexity is not required for all problems.
- A catchment modelling system implemented for one problem may not be suitable for a different problem.

APPLICATION

Guidance on application is being provided for

- Event Modelling – most commonly used approach.
- Continuous Modelling – generate flow sequences and then use FFA.
- Monte-Carlo techniques – used to overcome some issues with parameter estimation.

FLOOD SIMULATION APPROACHES



EVENT SIMULATION

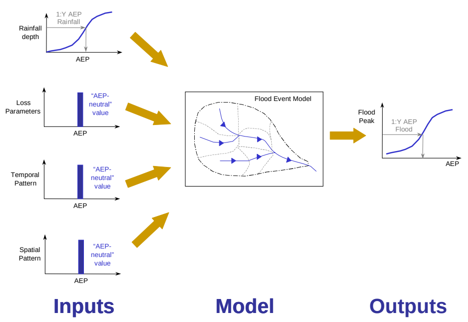
Traditional approach.

Issues include

- Volume of runoff, particularly when most intense burst used, i.e. existing AR&R temporal patterns.
- Storm variability and movement.

Guidance will be provided on usage.

DESIGN EVENT APPROACH

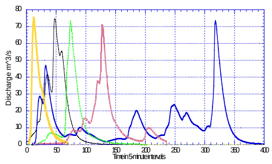


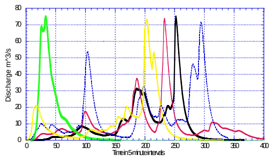
CONTINUOUS MODELS

- Basic idea is the reproduction of flow variability in the system.
- To achieve this requires consideration of parameter or information variability.
- Also removes the need to assume concurrence between rainfall and flow frequencies.

CONTINUOUS MODELS

- 2 year ARI events extracted from 100 years of simulated flows
- Differences in shape (one, two and three-peaked h/gs, duration and volume (ranging from 41 to 223 mm)
- No such thing as a 2-year hydrograph

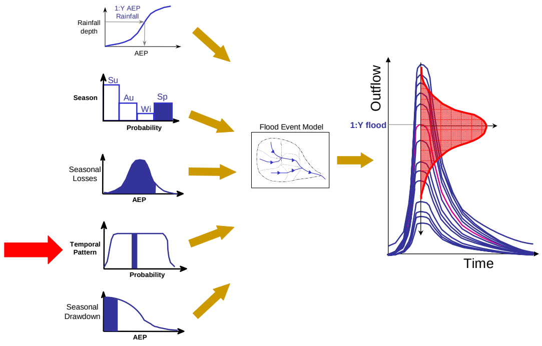




MONTE-CARLO APPROACH

- Based on development of event modelling.
- Needs information about variability of input parameters.
- Produces distribution of likely flood events and hence uncertainty in prediction.

MONTE-CARLO APPROACH



APPLICATION

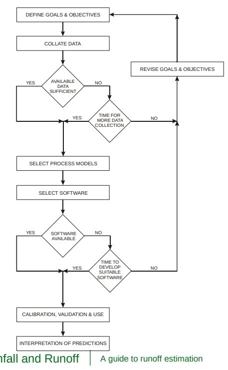
Steps in the application are

- Definition of goals and objectives;
- Collation of data;
- Selection of process models;
- Selection of software;
- System use; and
- Interpretation of predictions

APPLICATION

Note that there are loops in these steps.

For example, the unavailability of data may require a return to a previous step.



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APPLICATION

The volume of data required varies in direct proportion to the complexity of the problem and the desired accuracy of information

It maybe necessary to implement a data collection program if suitable existing data are not available.

APPLICATION

Within this step, the generic steps are

- Establishment (includes verification of software);
- Calibration;
- Validation; and
- Production

APPLICATION

There is a need to ensure that the software reproduces the process models adequately, i.e. to prove the software is true to its claims.

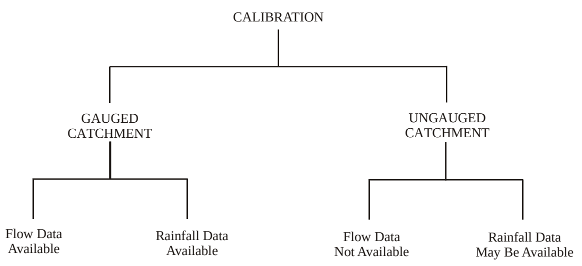
APPLICATION

The primary purpose of this step is the evaluation of the control parameters for the catchment modelling system.

Evaluation of control parameters is required for

- Gauged; and
- Ungauged catchments.

APPLICATION



APPLICATION

Calibration of control parameters for ungauged parameters is the most common problem encountered.

Values may be determined from

- Physical characteristics
- Regional relationships

APPLICATION

As in previous edition, regional relationships will be presented.

Guidance on reliability will be published also.

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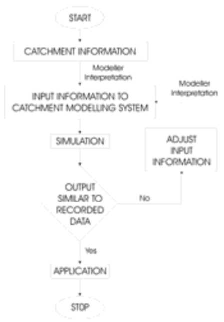
APPLICATION

The calibration process is one of systematically adjusting the control parameter values until satisfactory reproduction is achieved.

This systematic adjustment may be manual or it may be automatic.



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APPLICATION

Calibrated control parameter values for one event or sequence of events may not be applicable to a second event or series of events.

The calibrated control parameter values are a compromise.

Need to ensure that this compromise is robust for extrapolation of the system.

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APPLICATION

Validation is obtained by testing the catchment modelling system response to previously unseen data and assessing the accuracy of the predictions.

APPLICATION

Most important step.

While guidance can and will be provided with interpretation, AR&R cannot tell a modeller how to interpret their results.

Guidance will focus on prediction accuracy and uncertainty.

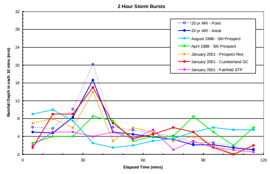
ISSUES

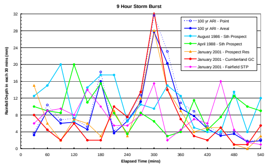
Issues associated with catchment modelling include

- Rainfall
- Loss Models
- Parameter Estimation
- Rainfall

RAINFALL ISSUES

- Spatial patterns
- Temporal patterns
- Partial catchment storms
- Areal Reduction Factors





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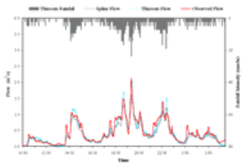
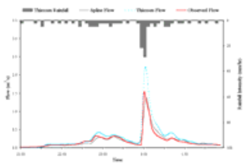
RAINFALL INFLUENCE

- Calibrated catchment model considered.
- Only change between alternatives was rainfall applied.
- Need to consider storm characteristics.





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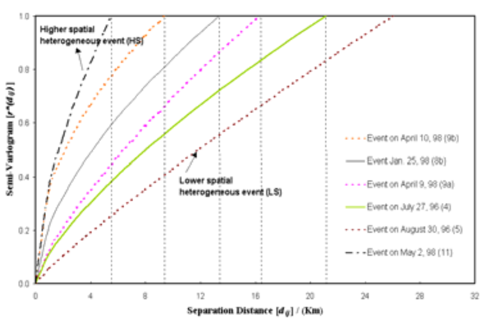
RAINFALL INFLUENCE

UPRC Variogram



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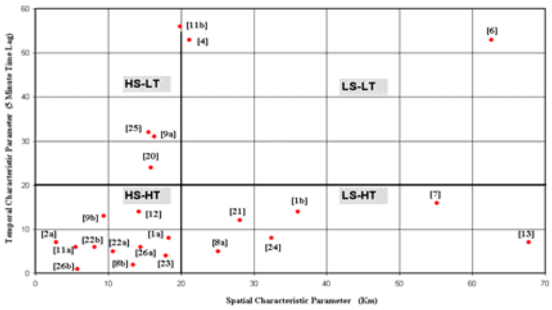
RAINFALL INFLUENCE

UPRC Characterisation



LOSS MODELS

- For event modelling, there is a need to recognise difference between design and calibration losses.
  - Calibration losses represent actual losses
  - Design losses represent design parameters
- Hill *et al*. have developed IL/CL design data
- Walsh developed IL data

LOSS MODELS

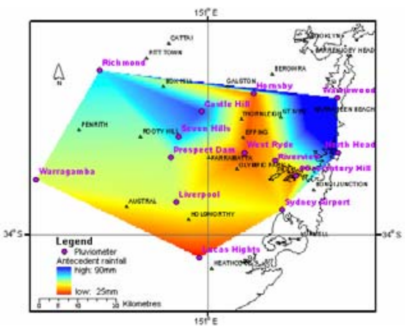
- For continuous modelling, need to consider formulation of model
  - Parameter consistency
  - Dry period / wet period interaction

AMC	EFF. IMP. %
< 2 dry days	43.9
2 - 5 dry days	43.6
6 - 10 dry days	35.2
> 10 dry days	35.7

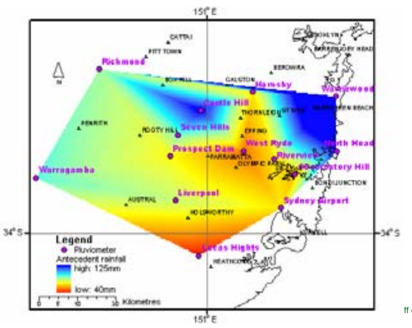
LOSS MODELS

- For event modelling there is a need also to consider the antecedent conditions
  - Needed for both Monte-Carlo and traditional approaches.

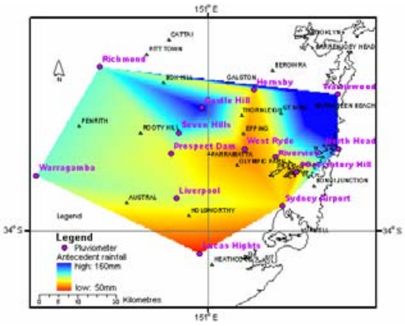
5 DAY RAINFALL PRIOR TO 24 HR 1 YR ARI RAIN



5 DAY RAINFALL PRIOR TO 24 HR 2 YR ARI RAIN

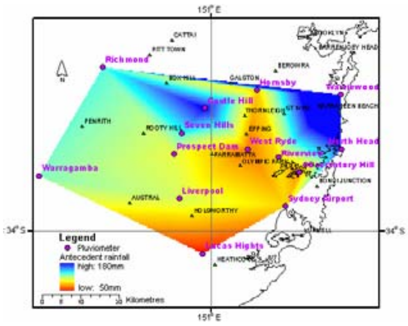


5 DAY RAINFALL PRIOR TO 24 HR 5 YR ARI RAIN



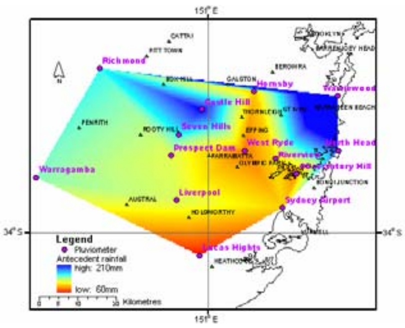
f estimation

5 DAY RAINFALL PRIOR TO 24 HR 10 YR ARI RAIN



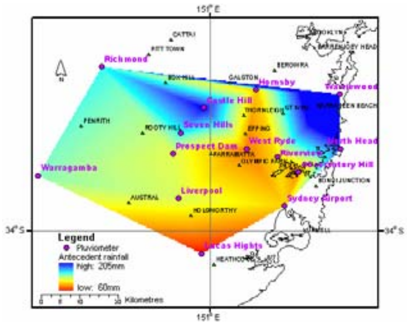
f estimation

5 DAY RAINFALL PRIOR TO 24 HR 20 YR ARI RAIN



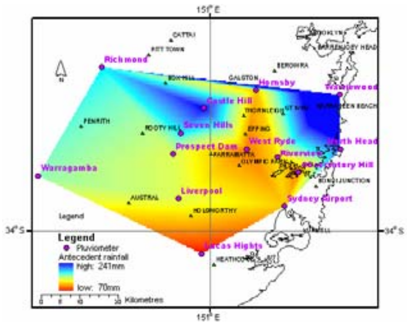
f estimation

5 DAY RAINFALL PRIOR TO 24 HR 50 YR ARI RAIN



f estimation

5 DAY RAINFALL PRIOR TO 24 HR 100 YR ARI RAIN



f estimation

PARAMETER ESTIMATION

Errors arise from

- Structural errors in the system;
- Data errors in the recorded data; and
- Parameter errors - input information to the modelling system.

Calibration is concerned with parameter errors while acknowledging other errors.

PARAMETER ESTIMATION

Desire is generic values for these parameters – values applicable to more than a single event and suitable for extrapolation.

Recognised now that there are numerous sets of parameter values capable of similar performance.

Hence, a pdf of possible parameter values can be developed.

PARAMETER ESTIMATION

A further complication is the arbitrary subdivision of parameters into measured and inferred parameters.

Usually, only values of inferred are sought – values of measured parameters are assumed correct.

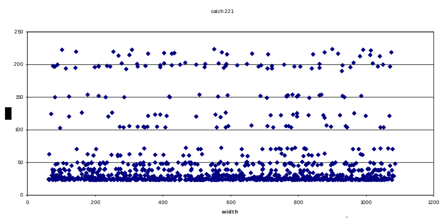
Ungauged catchments and inferred parameter values remain a major concern.

PARAMETER ESTIMATION

Inferred parameters are either

- Developed from a model – e.g. Manning's roughness
- Conceptual – e.g. k_c.

These parameters usually have flat response surfaces.



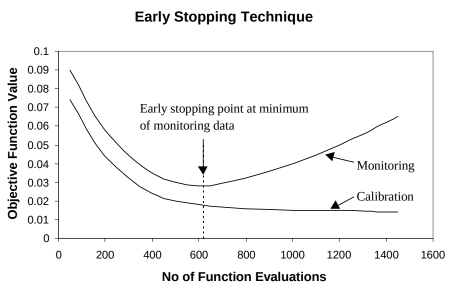
PARAMETER ESTIMATION

Monitoring of the calibration is one approach.

The results of the monitoring is used to define 'stop points' for the calibration.

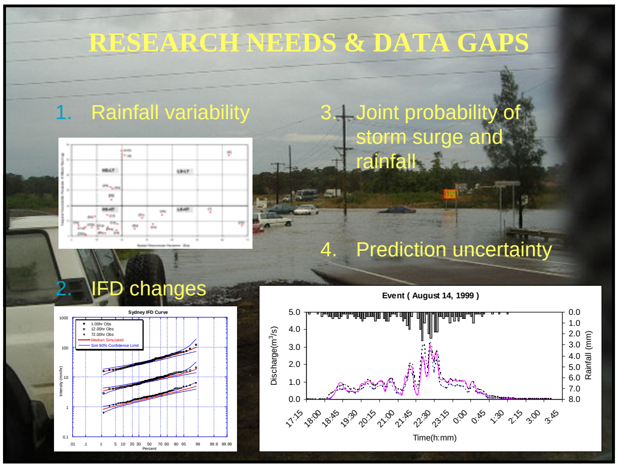
Will not result in best simulation for a single event but best simulation of numerous events.

PARAMETER ESTIMATION



JOINT PROBABILITIES

- Downstream boundary conditions
  - Tides
  - Storm surges
  - River / Lake levels when urban systems considered.


RESEARCH NEEDS & DATA GAPS
1. Rainfall variability
3. Joint probability of storm surge and rainfall
4. Prediction uncertainty
2. IFD changes
Sydney IFD Curve
Event (August 14, 1999)
Discharge(m3/s)
Rainfall (mm)
Time(h:mm)