Book V Chapter 6 Application of Catchment Models

James E Ball

Introduction

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.

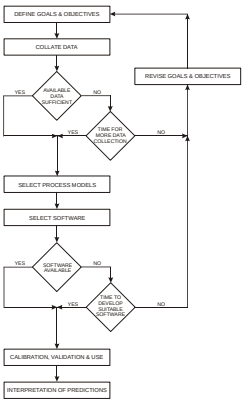
Usage Steps

- Definition of goals and objectives;
- Collation of data – Book I, Chapter 2;
- Selection of process models – Book 5, Chapters 2, 4 & 5;
- Selection of software;
- System use – this chapter; and
- Interpretation of predictions

Usage Steps

Note that there are loops in these steps.

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



Collation of Data

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.

System Use

Within this step, the generic steps are

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

Verification

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.

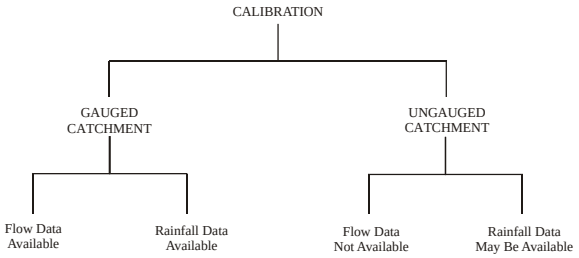
Calibration

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.

Calibration



Calibration

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

Values may be determined from

- Physical characteristics
- Regional relationships

Calibration

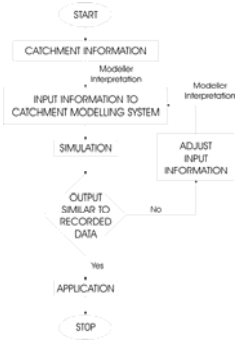
As in previous edition, regional relationships will be presented.

Guidance on reliability will be published also.

Calibration

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.



Calibration

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.

Validation

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

Interpretation

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,

Example Application

Liverpool and Fairfield City Councils manage the Cabramatta Creek catchment.

This catchment is located in the south-western suburbs of Sydney.

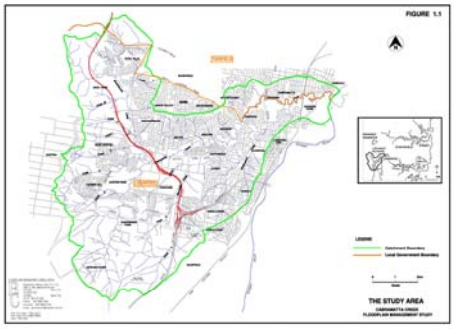
The catchment is important for the expansion of Sydney urban region.

Example Application

Cabramatta Creek is a major tributary of the Georges River with an area of the catchment is 74km^2.

Major tributaries of Cabramatta Creek include Hinchinbrook Creek, Maxwells Creek, and Brickmakers Creek.

Example Application



Example Application – Goals and Objectives

The problem faced was the expansion of Sydney's urban extent into the Cabramatta Creek catchment and the urbanisation of the catchment.

The goal, therefore, was to obtain a knowledge of flood issues associated with urbanisation of Cabramatta Creek catchment.

Example Application

To achieve this goal, the objectives of the study, were

- Definition of the flood levels for designated annual exceedance probabilities; and
- Definition of any flood mitigation works necessary to minimise the potential for increased flooding arising from urbanisation within the catchment.

Example Application – Data

There are many forms of data needed for a catchment wide study.

In general, data needed is

- Historical flood events;
- Design storm events; and
- Topographic data.

Example Application – Data

Historical flood event data is needed for the calibration and validation of the catchment modelling system.

While gauged data is preferable, there are no long-term continuous flood records available within the Cabramatta Creek catchment.

Example Application - Data

A number of flood events have occurred over the past 50 years.

The most recent are

- August 1986;
- April 1988;
- July 1988;
- April 1989; and

Example Application - Data

There is also some evidence of larger floods occurring in the late 1800's.

Floods with a 1% AEP (or less) are believed to have occurred on the Georges River in 1873, 1889, and 1898.

These are thought to have resulted in flooding of Cabramatta Creek also.

Example Application – Data

To assess the catchment response to potential future events design storm bursts were developed.

AR&R87 were used for this purpose.

Example Application – Data

Topographic data is necessary also.

Given the available topographic data, it was deemed appropriate to collect additional topographic data for this study.

For this purpose, a special series of low level laser aerial photography of the catchment area was undertaken.

Example Application – Data

Photogrammetric analysis together with additional ground survey produced the following maps

- Catchment map - 1:10,000 scale maps with 2m contours and an estimated ground level accuracy of ±0.6m;

Example Application – Data

- General map series - 1:2,000 scale maps with 1m contours and an estimated ground level accuracy of ±0.12m; and
- Detailed map series - 1:1,000 scale maps with 0.5m contours and an estimated ground level accuracy of ±0.06m.

Example Application – Data

These maps were considered essential if the desired aim of defining flood prone areas was to be achieved.

Example Application – Data

Data related to environmental issues were collected also to enable the assessment of potential flood mitigation options with a view to minimising environmental impacts of these works on the existing environmental qualities of the catchment.

Example Application – Data

Finally, data related to the social characteristics (primarily land use and population characteristics) of the catchment were collected to enable an understanding of the community values with respect to current and future development within the catchment.

Example Application – Process Models

It was recognised that

- a hydrologic model was needed to estimate flows throughout the catchment; and
- a hydraulic model to route these flows through the creek system thereby determining the flood levels and flood velocities.

Example Application – Process Models

As the catchment contained both urban and rural areas, the hydrologic model had to be capable of simulating runoff from both types of development.

Furthermore, the hydrologic model had to have the capacity to consider development in a spatially distributed manner.

Example Application – Process Models

A further hydrologic consideration was the need for simulation of concentrated catchment storages at the existing and proposed retarding basins.

For the hydraulic modelling, it was believed that a two-dimensional hydraulic model was appropriate.

Example Application – Software

The software packages selected for this study were

- XP-RAFTS; and
- RMA-2V.

Example Application – Software

XP-RAFTS is capable of simulating runoff hydrographs at defined locations throughout a catchment for a set of predefined catchment conditions and specific rainfall events.

Additionally, a RAFTS based model had been established previously as part of an earlier investigation of flood flows in the catchment.

Example Application – Software

RMA-2 is a very flexible model that may be used for estuarine and river simulation in steady state or dynamic mode.

RMA-2 permits control structures such as weirs, tide gates or culverts to incorporated as one or two-dimensional elements within the overall network.

Example Application – Software

The mention of these software packages is not meant to imply that these were the most appropriate or the only software available.

Rather their mention is only to reflect their selection by the consultants undertaking the study being discussed.

Example Application – Use

The implementation, calibration and validation of the catchment modelling system was undertaken in two parts which are

- the hydrologic modelling; and
- the hydraulic modelling.

Example Application – Use

The previous RAFTS model was adopted with refinement to reflect existing and potential future catchment conditions.

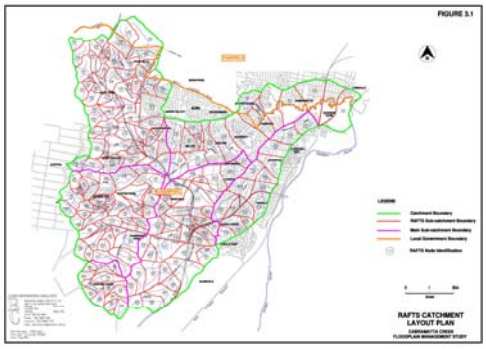
Parameters influenced by different land uses within the catchment were modified to reflect the spatially variable catchment conditions.

Example Application – Use

Hence, extensive amendments were required to ensure that the hydrologic models and software were suitable for the current study.

This is not unusual and commonly occurs when existing catchments are used.

Example Application – Use



Example Application – Use

Calibration of the hydrologic model was undertaken using the NSW Department of Land and Water Conservation (now DIPNR) gauging station located on Cabramatta Creek at Orange Grove Road.

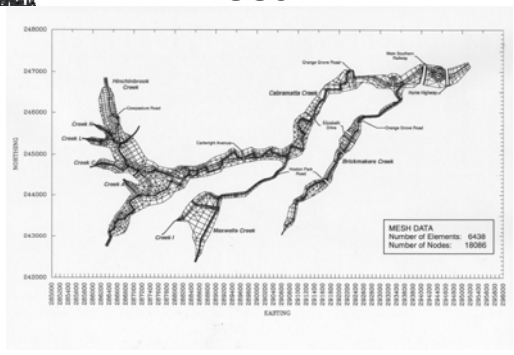
Historic floods that occurred in July 1988, August 1986, April 1988, and April 1989 were used for this purpose.

Example Application – Use

Previous hydrodynamic models were not available to provide an initial mesh.

Consequently, the full mesh for the hydrodynamic model had to be developed for this study.

Example Application – Use



Example Application – Use

The hydraulic models were calibrated using data collected during the April 1988 flood event.

This calibration of the parameters was validated using data collected during the August 1986 flood event.

Example Application - Use

An assessment of the likely accuracy of the catchment modelling system was undertaken.

Both the hydrologic and hydraulic calibrations had been based on information collected at the downstream portion of the catchment and the predicted flood levels for the calibration event were within ±0.2m of the recorded levels.

Example Application - Use

It was considered that, in the lower reaches of the catchment, the accuracy of the predicted flood levels was ±0.2m for design floods up to the 100 year ARI.

In other regions of the catchment, it was considered that the likely accuracy was less and to be of the order of ±0.5m.

Example Application – Use

The catchment modelling system after calibration was used to define the design 20, 50 and 100 year Average Recurrence Interval flood levels as well as the design level for the Probable Maximum Flood.

This was achieved by determining the design storm burst for the desired frequencies and durations.

Example Application – Use

These design storm bursts were used to provide predicted design flood levels along the river system.

Design flood levels determined in this manner were used with the catchment topography to produce maps of potentially flood prone land for the existing catchment conditions.

Example Application – Use

The development of a catchment management plan required information extending beyond the potentially flood prone land for existing catchment conditions (considered to be the development in existence in 1996).

Example Application – Use

The flood liable land had to be determined also for

- Previous catchment conditions (1989);
- Future catchment conditions on completion of all development; and
- Ultimate catchment conditions which were based on the maximum development likely to occur over the next 50 years.

Example Application – Use

Flood mitigation measures were simulated using the catchment modelling system also.

Based on the catchment conditions, the predicted flood levels were used with digital maps for the variety of catchment conditions considered during the investigation.

Example Application – Interpretation

The final stage of the application of a catchment modelling system is the interpretation of predictions obtained from the catchment modelling system. In this particular case, the information obtained during *Step 5* was used in the development of the floodplain management plan.