

Hydrological Modelling: How and Why it is Used



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WHY DO WE NEED A CATCHMENT MODEL?

Generally a hydrological model is developed to generate stream flow data to either:

- Fill missing gaps in existing records;
- Estimate current and/or natural flow and yields for ungauged areas of a catchment;
- Generate long term records to establish yield reliability estimates and other statistics;
- Provide input data for other research e.g. environmental flow or
- Undertake scenario or forecast modelling.

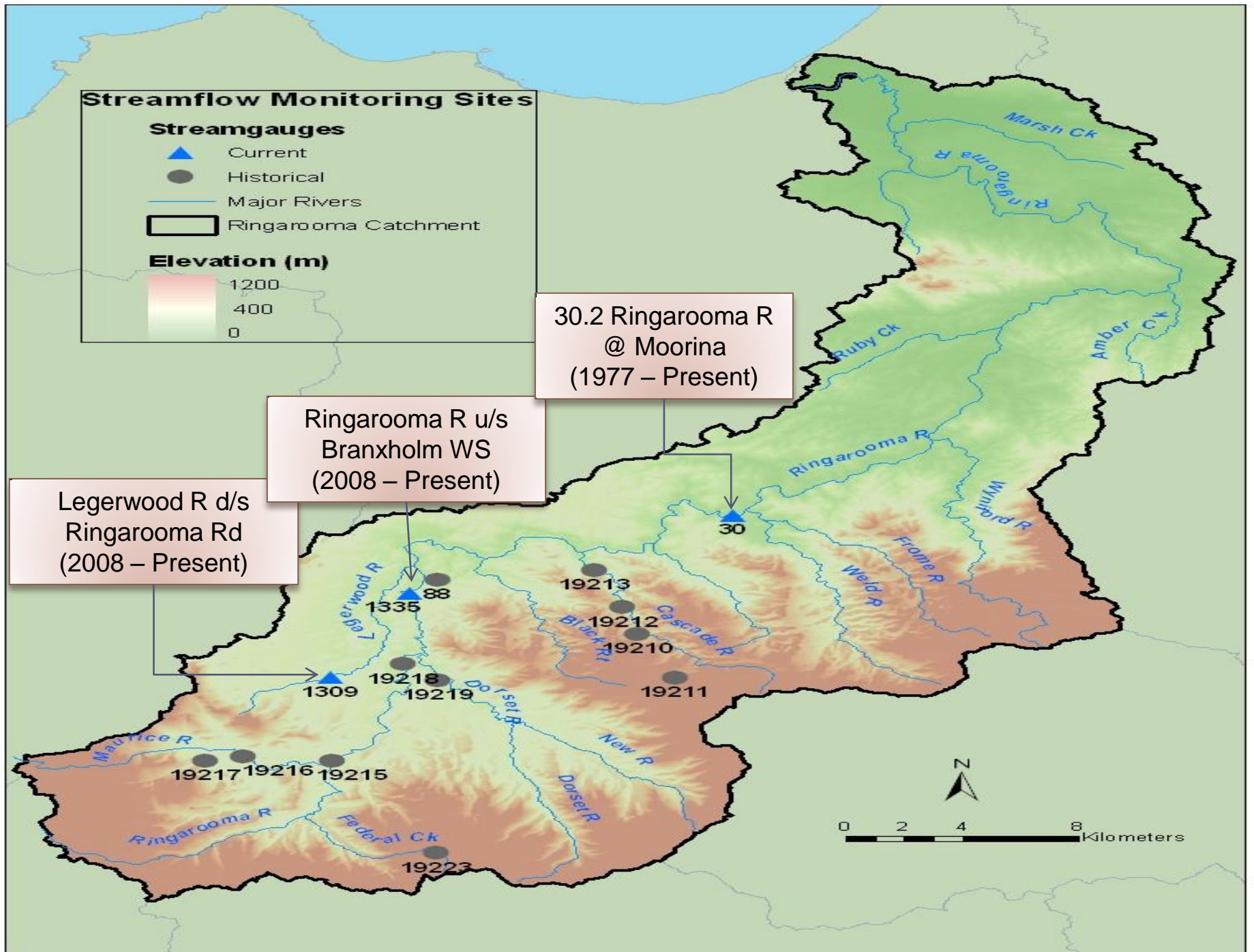
WHY DO WE NEED A CATCHMENT MODEL?

Generally there is only one or two long term stream gauging sites within a catchment.

Many stations may be established but are only maintained for a few years, not providing a long enough record to establish long term yields or trends, or there is no rating established to convert level data to flow data.

With only one or two monitoring points it is difficult to establish yields within a catchment.

A hydrological model can be used to estimate yields for all areas of interest in a catchment.



WHY DO WE NEED A CATCHMENT MODEL?

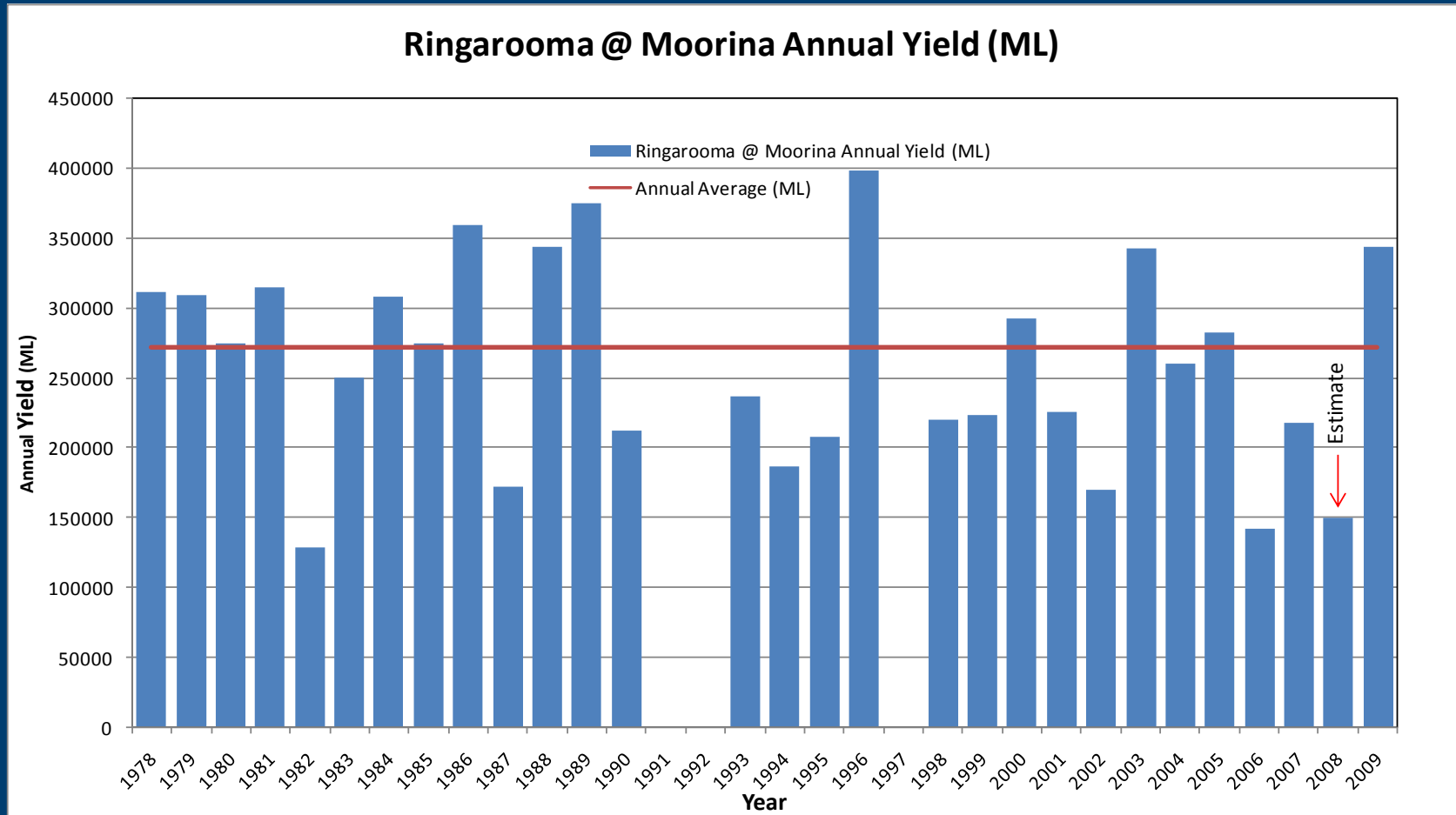
Station No.	Station Name	Record Period	Gauged Area (km ²)
30	Ringarooma R @ Moorina	1977 - Present	517
88	Ringarooma R @ Branxholm	1937 - 1988	277
1309	Legerwood R d/s Ringarooma Rd	2008 - Present	16
1335	Ringarooma R u/s Branxholm WS	2008 - Present	273
19210	Cascade R u/s Cascade Dam	1984 - 1996	22
19211	Cascade R u/s Mt Paris Dam	1985 - 1994	5
19212	Tin Pot Ck u/s Derby Jeep Track	1985 - 1990	4
19213	Cascade R d/s Cascade Dam	1985 - 1990	35
19215	Maurice R u/s Ringarooma R	1987 - 1990	63
19216	Maurice R d/s South Maurice R	1987 - 1992	31
19217	South Maurice R u/s Water Race	1987 - 1988	10
19218	Ringarooma R @ Ringarooma Rd Bridge	1987 - 1988	49
19219	Dorset R at Ruby Flats Rd	1987 - 1990	40
19223	Federal Ck u/s Ringarooma	1990 - 1992	3

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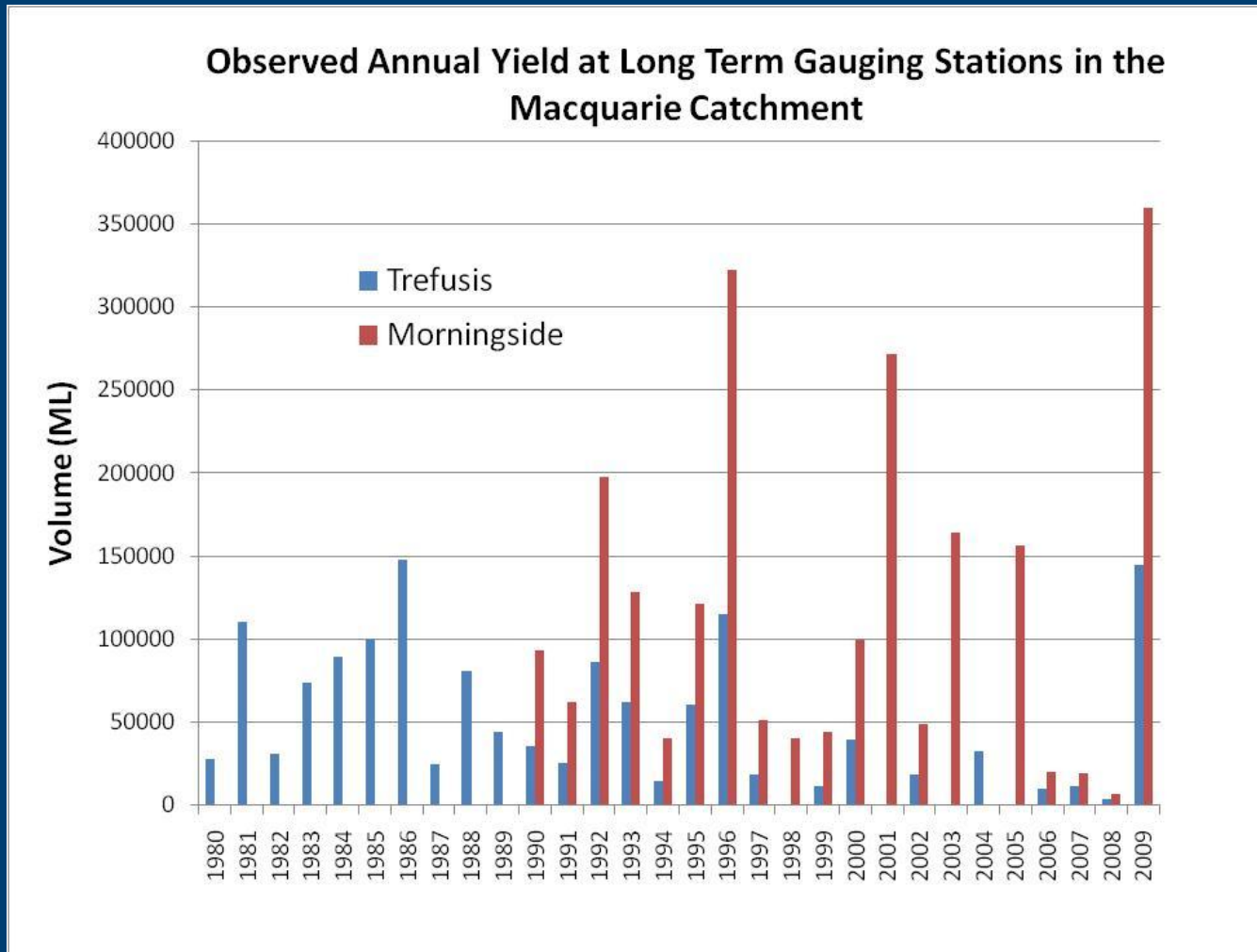
A hydrological model can generate stream flow estimates and trends over long periods. While a model can generate historical current or natural stream flow records, a model can also be used to generate future yields or scenario modelling.

Having a long term record allows statistical analysis to be performed over a period that is not influenced by extremes of droughts or floods.

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Forecasts of future seasonal stream flow records are valuable to a range of water managers and users, including irrigators, urban and rural water supply authorities, environmental managers and hydroelectricity generators.

Such forecasts can inform planning and management decisions relating to available water resources and to ensure security of supply. Examples of this type of modelling include the Tasmanian Sustainable Yields (TAS SY) and the Climate Futures for Tasmania (CFT) projects.

HOW IS A CATCHMENT MODEL DEVELOPED ?

There are several steps in developing a hydrological model, these include:

- Defining subcatchments within the catchment of interest;
- Selecting a rainfall runoff model;
- Ensuring adequate stream gauging data is available to calibrate the model;
- Sourcing adequate rainfall and evaporation data for the region;
- Establishing current water allocation amounts and usage patterns;
- Developing the model node and link network;
- Calibrating the model and
- Verifying the model

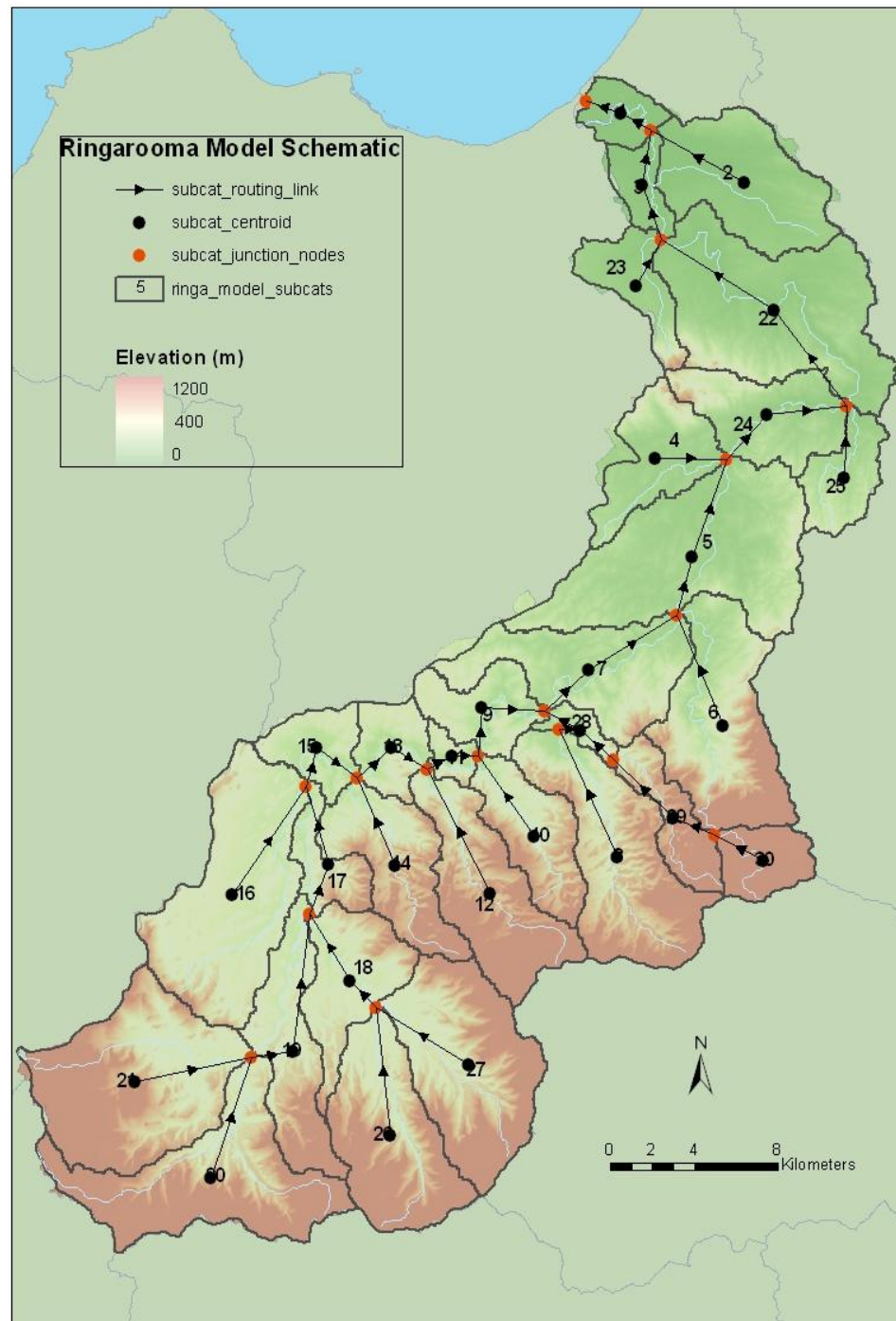
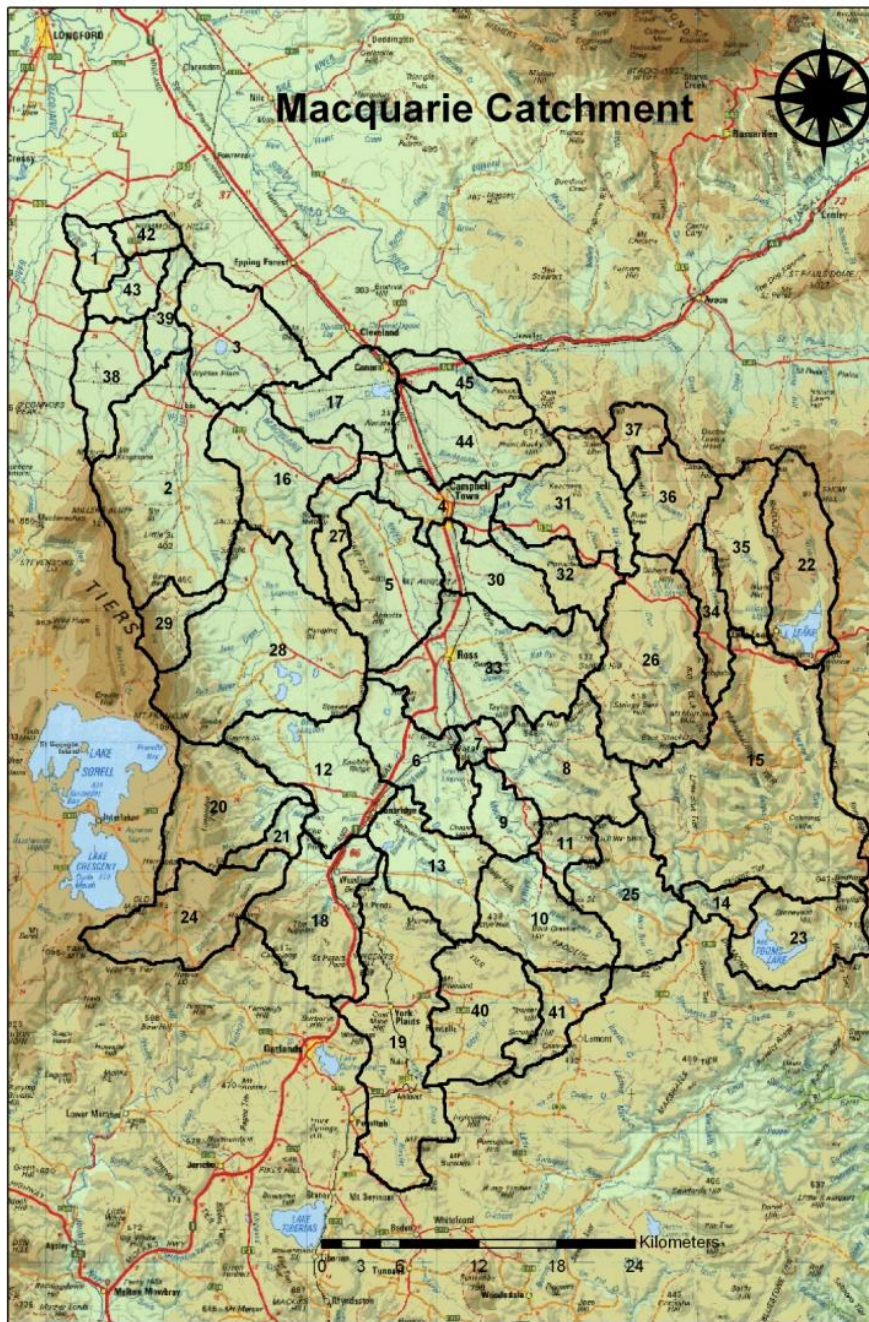
HOW IS A CATCHMENT MODEL DEVELOPED ?

Usually a catchment is broken down into several subcatchments using a GIS software package.

The smaller subcatchments are generally 10 to 30 km² in size and represent topographical or climatologically distinct regions e.g. rainfall or soil gradients, and the catchments river network.

The subcatchment breakdown can also include points of interest or known areas of data inputs e.g. large dams and gauging stations.

The subcatchment breakdown is used in the modelling to form the node component of the catchment network.



HOW IS A CATCHMENT MODEL DEVELOPED ?

There are several rainfall runoff models available, some are very complex and have several parameters while some are relatively simple with 5-10 parameters.

Some models used are SimHyd, Sacramento, IHACRES, SMAR and AWBM.

With increasing complexity there is a similar increase in the data requirements for models.

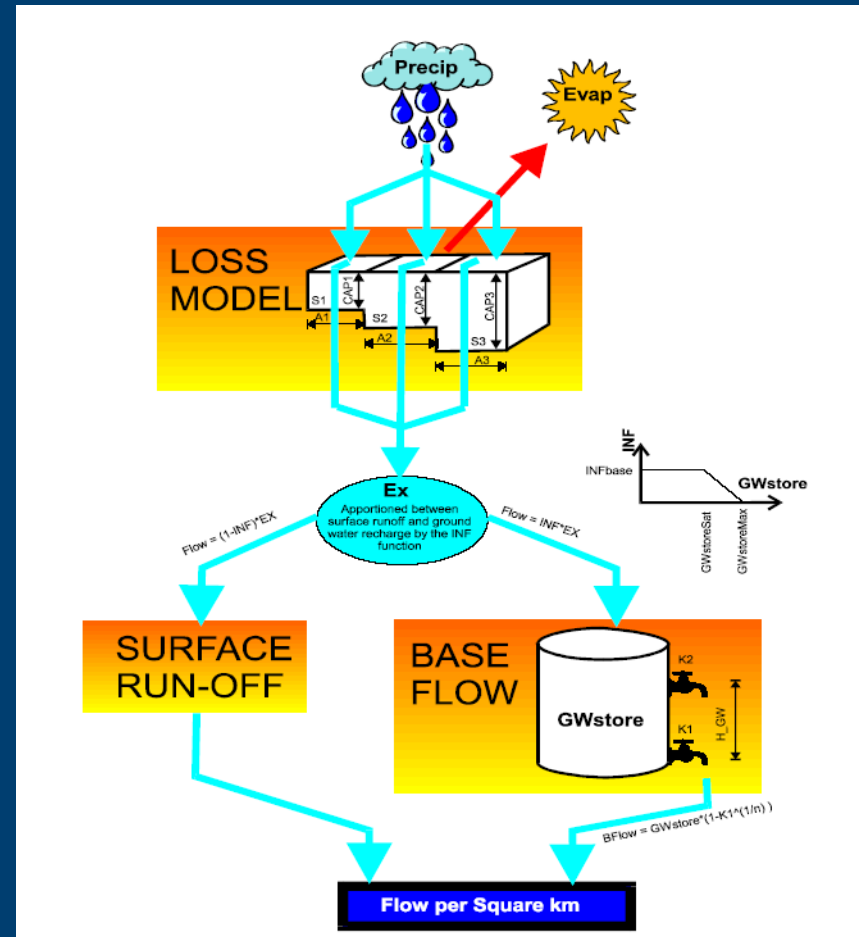
In Tasmania a variation of the AWBM has been used widely with consistently good outcomes.

The main inputs are rainfall and evaporation, subcatchment catchment area and river distances between nodes.

HOW IS A CATCHMENT MODEL DEVELOPED ?

Model used in the Macquarie and Ringarooma

Australian Water Balance Model 2 Tap (AWBM2Tap)



HOW IS A CATCHMENT MODEL DEVELOPED ?

Parameters of the AWBM2Tap model

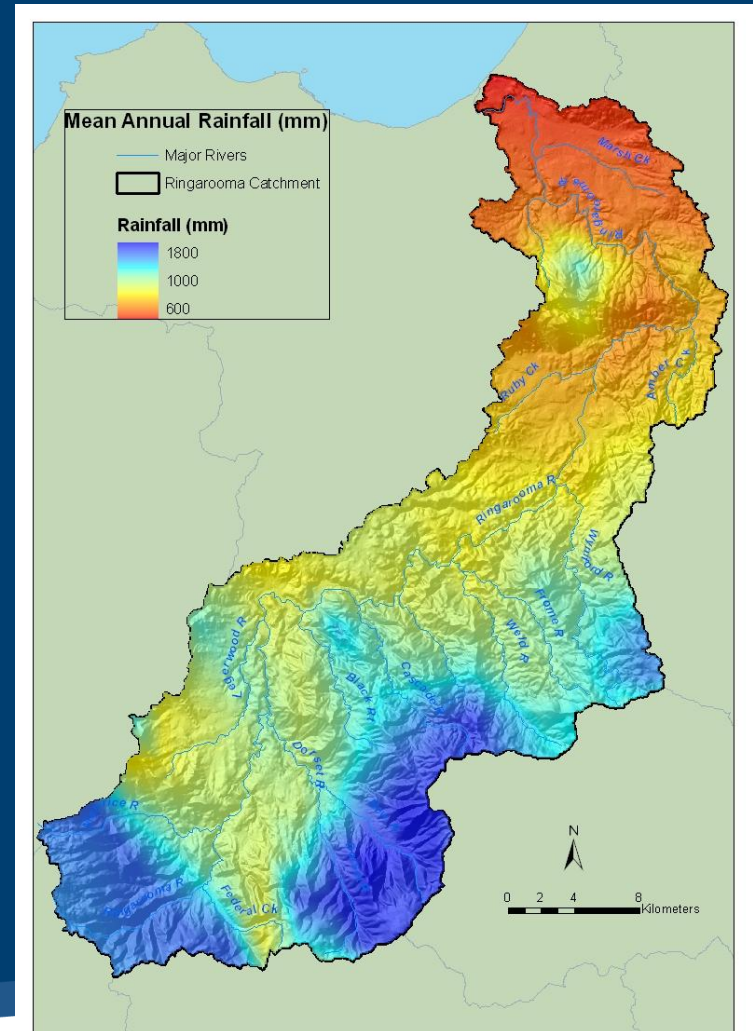
PARAMETER		PARAMETER	
INFBase		CapAve Jan	
K1		CapAve Feb	
K2		CapAve Mar	
GWstoreSat		CapAve Apr	
GWstoreMax		CapAve May	
H_GW		CapAve Jun	
EvapScaleF		CapAve July	
RainScaleF		CapAve Aug	
Alpha		CapAve Sept	
n		CapAve Oct	
		CapAve Nov	
		CapAve Dec	

Partial area of S1	$A1=0.134$
Partial area of S2	$A2=0.433$
Partial area of S3	$A3=0.433$
Capacity of S1	$Cap1= (0*CapAve/ A1) = 0$
Capacity of S2	$Cap2=(0.33*CapAve/ A2)=0.762*CapAve$
Capacity of S3	$Cap3=(0.67*CapAve/ A3)=1.547*CapAve$

HOW IS A CATCHMENT MODEL DEVELOPED ?

Rainfall and evaporation data is generally sparse across any given catchment.

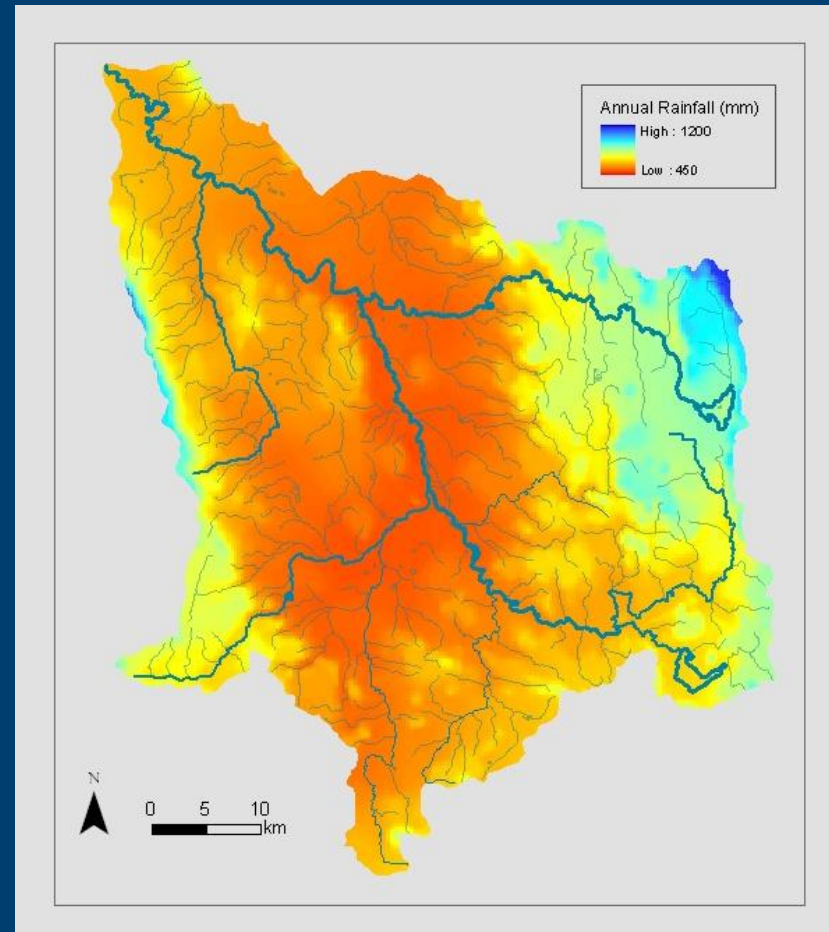
The Bureau of Meteorology and Qld Dept of Natural Resources produce a product “SILO Data Drill” that provides rainfall and evaporation data over a 5km² grid across Australia.



HOW IS A CATCHMENT MODEL DEVELOPED ?

For the Ringarooma and Macquarie catchment 9 to 10 locations covering the rainfall gradient were selected from the Data Drill product for use in the model.

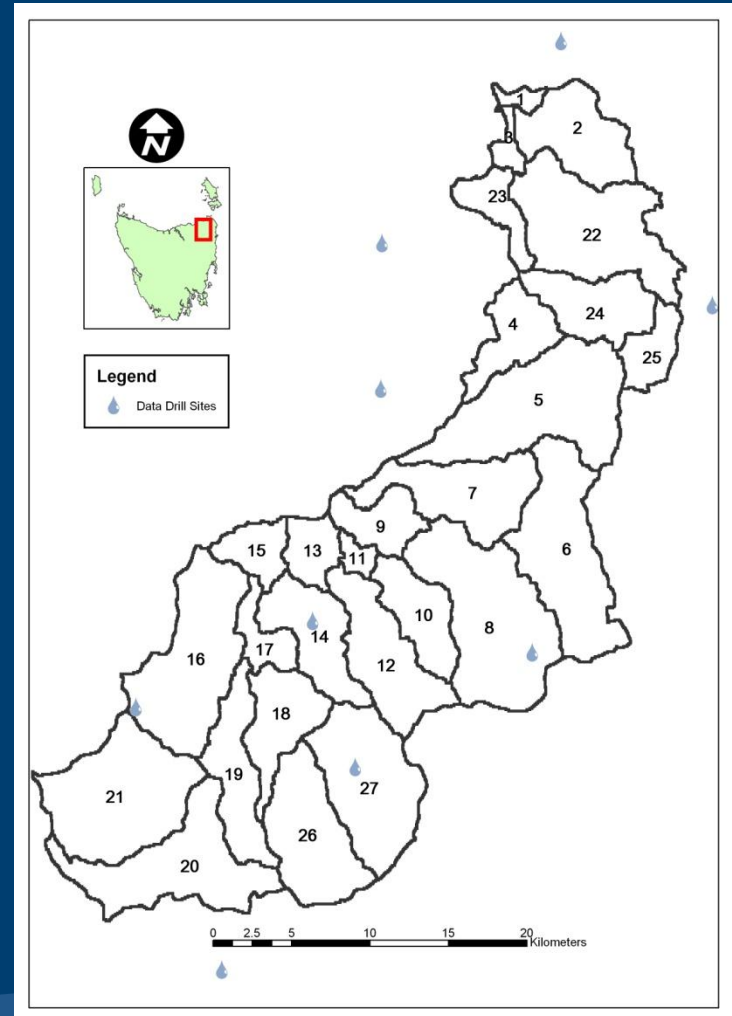
The rainfall and evaporation sites contribution to each subcatchment is determined using a weighting system of the 4 closest sites to the centroid of the subcatchment.



HOW IS A CATCHMENT MODEL DEVELOPED ?

The weighting system ensures that the closest sites have the main influence on the rainfall and evaporation inputs for any one sub catchment.

Using the Data drill data ensures the subcatchments are represented by an appropriate rainfall and evaporation input as oppose to the catchment wide average.

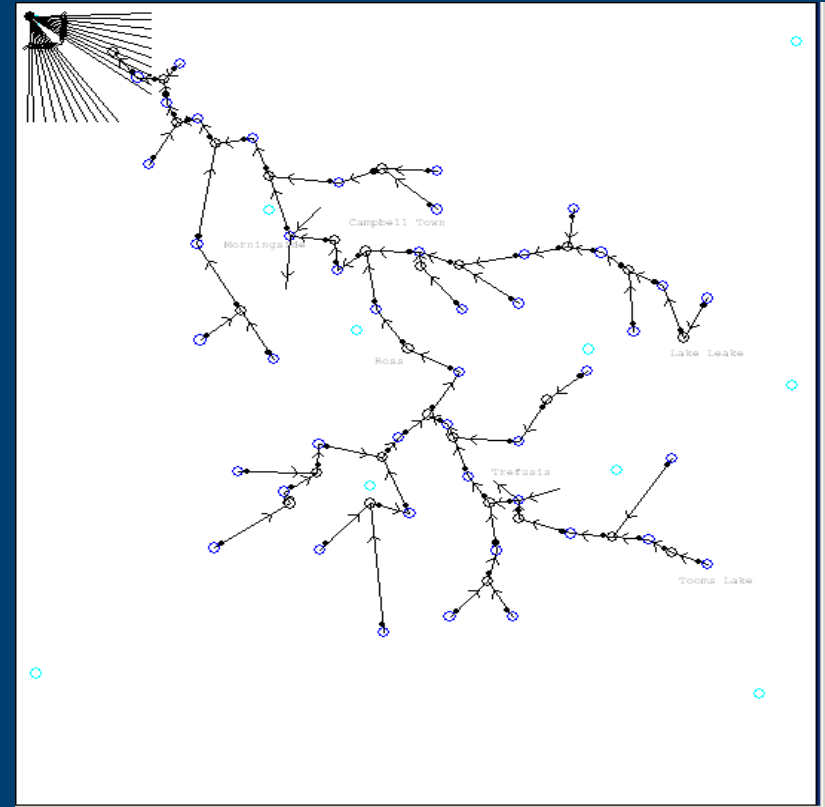


HOW IS A CATCHMENT MODEL DEVELOPED ?

The catchment breakdown and associated catchment area data is used as the template for node system for the hydrological model software.

Each node contains the code for the AWBM 2 Tap model.

The links between each node represent the river network



HOW IS A CATCHMENT MODEL DEVELOPED ?

Calibrating a model is a process where the parameters of model are adjusted, either manually or in an automated process, so the modelled outputs matches the observed gauged data as close as possible.

The gauged data is a result of all upstream influences, runoff, diversions, agricultural cropping, groundwater losses or gains, forestry, extractions, releases etc...

When estimating a “natural” flow the allocation data needs to be added to the observed record to estimate the natural flow.

HOW IS A CATCHMENT MODEL DEVELOPED ?

The Water Information Management System (WIMS) is the source for the allocation data. However in the instance of the Ringarooma model the 2004 survey results were used as the allocation amount.

As there is no record of yearly allocation usage some assumptions regarding water use needs to be made. This assumption, in the absence of any metered data, is that the daily use is equivalent to the total amount of water allocated divided by the number of days the allocation is licensed for. E.g. a 120 ML allocation over the period 1 Dec to 1 Apr equates to a 1ML/day use rate.

HOW IS A CATCHMENT MODEL DEVELOPED ?

As the amounts of allocation have changed over the years using the same allocation totals for any given year does not provide realistic outcomes.

To overcome this problem the water allocations included in the calibration model are adjusted to the time period of calibration by applying a Reduction Factor (RF).

HOW IS A CATCHMENT MODEL DEVELOPED ?

The RF was calculated by a method developed in the Tasmanian State of the Environment report (1996).

This states that water demand has increased by an average of 6% annually over the last 4 decades.

However, the RF was capped at 50% of the current water allocations. This prevented water allocations falling to unrealistic figures.

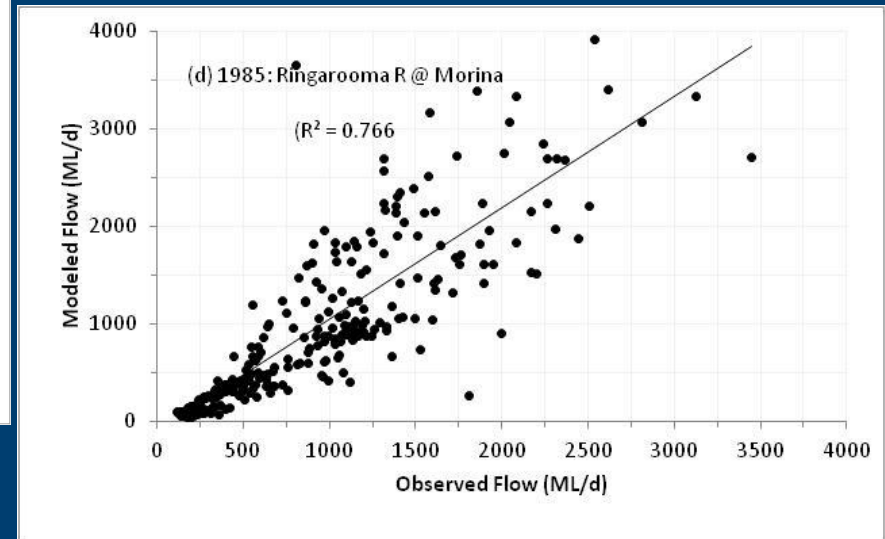
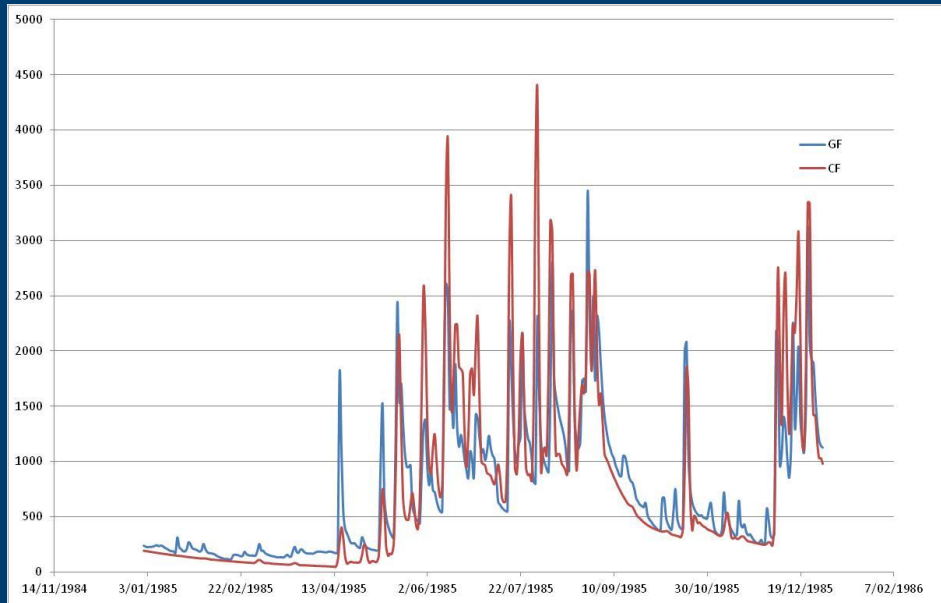
MODEL CALIBRATION

A model needs to be calibrated to match as best as possible the appropriate flow record over several years

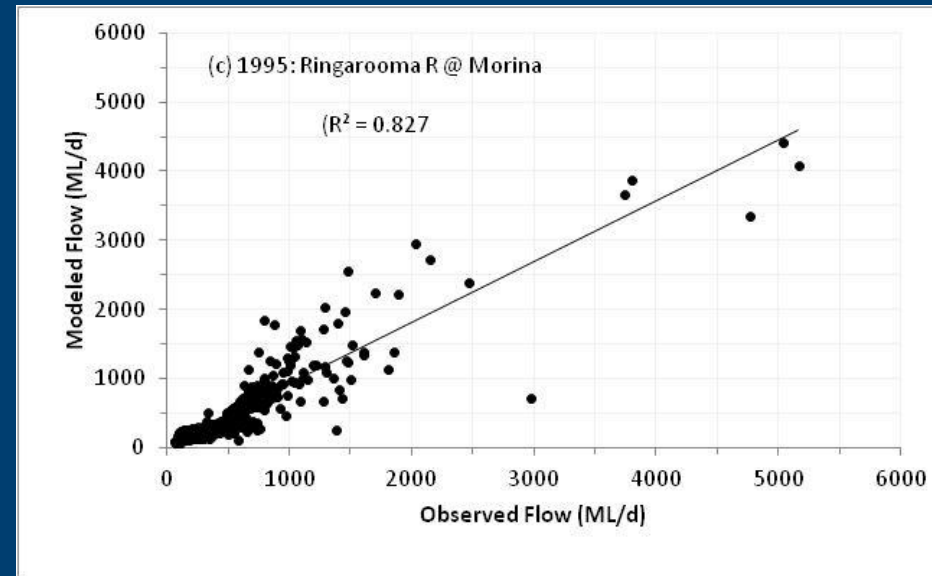
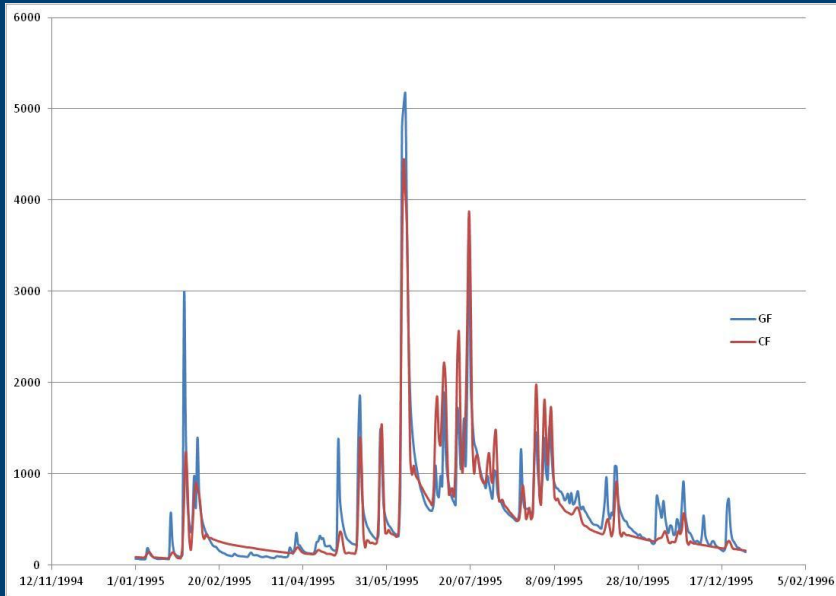
This has been a manual process in the past where several time slices are calibrated to and the resultant model then validated against the period not in the calibration.

Now automated processes are available to undertake the same task.

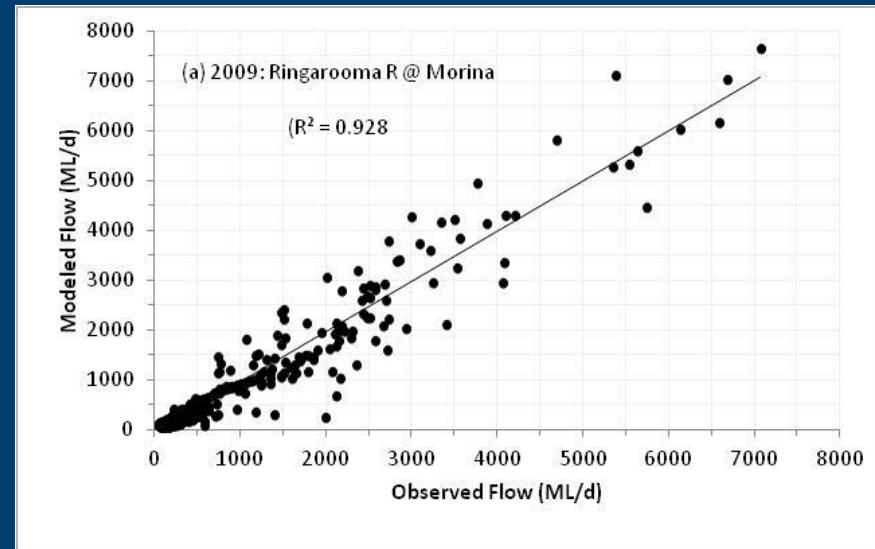
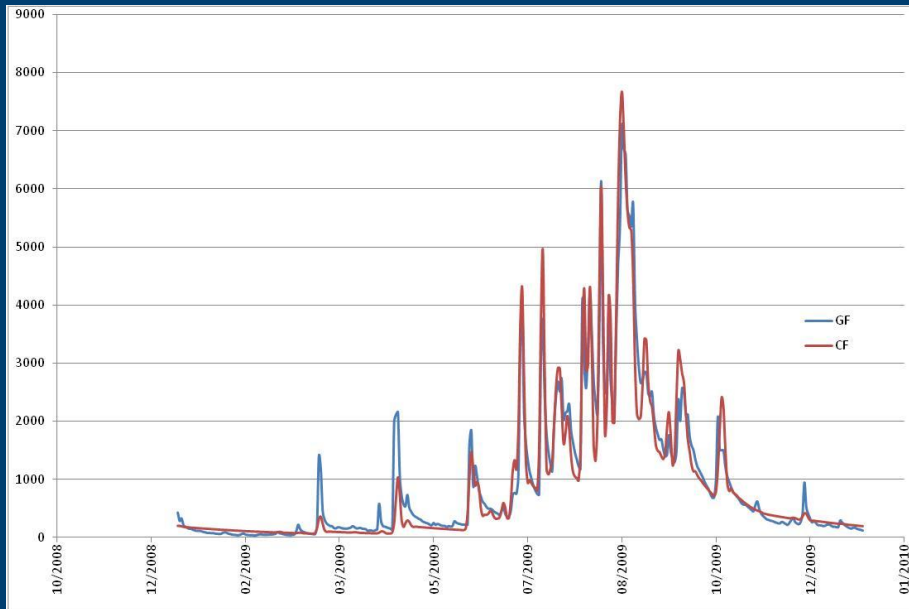
MODEL CALIBRATION



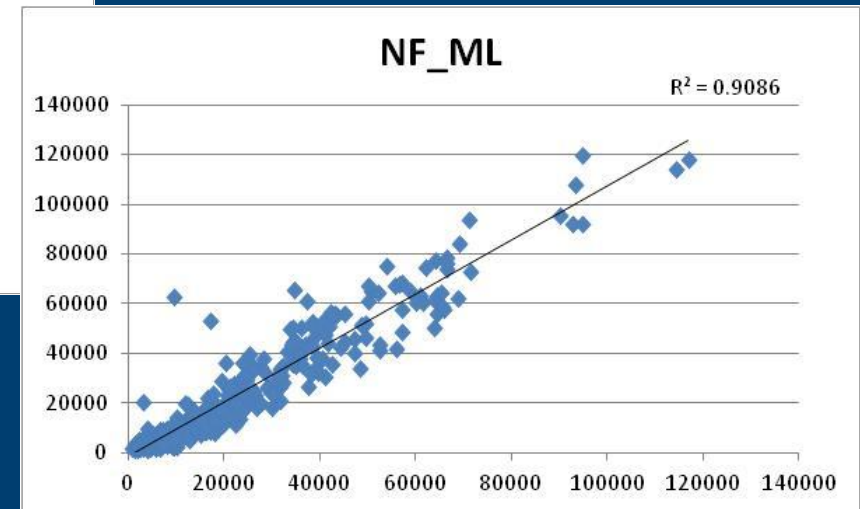
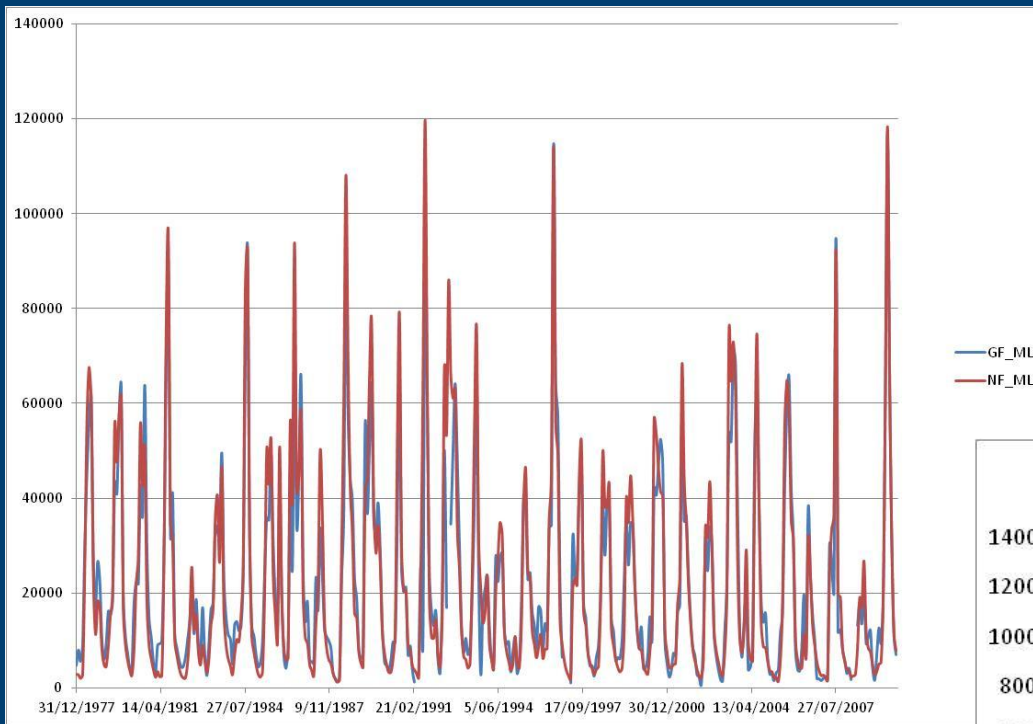
MODEL CALIBRATION



MODEL CALIBRATION



MODEL CALIBRATION (MONTHLY)



MODEL CALIBRATION

In the Macquarie catchment the model was calibrated using the two longer term stations at Trefusis and Morningside.

The parameter sets derived for the Trefusis gauge were applicable to the upper Macquarie catchment and the Morningside parameter sets were applied to the mid and lower catchment areas.

TasCatch Model		
	Trefusis	Morningside
Daily Flow (R^2)	0.55	0.58
Monthly Flow (R^2)	0.77	0.68

MODEL OUTPUTS

While models are generally calibrated to the same gauged data, sometimes the outputs can differ and this is generally due to the time period of application.

To highlight this the following are outputs from the DPIPWE, TAS SY and CFT models.

	Model		
	DPIPWE	TAS SY	CFT
Catchment	1970 to 2009	1924 to 2007	1961 to 1990
	Annual average	Annual average	Annual average
Ringarooma	414 GL	464 GL	390 GL
Macquarie	347 GL	319 GL	196 GL

MODELLING REVIEW

The hydrological modelling methodology utilised by DPIPWE has been independently reviewed by CSIRO and found to be robust and defensible.

All hydrological catchment and modelling reports are available via the departmental web site.

<http://www.dpipwe.tas.gov.au/inter.nsf/WebPages/CGRM-88T7KA?open>

<http://www.dpipwe.tas.gov.au/inter.nsf/ThemeNodes/RPIO-4YH8EZ?open>

DEMONSTRATION and QUESTIONS

Department of Primary Industries, Parks, Water and Environment

