Brigham Young University
BYU ScholarsArchive

International Congress on Environmental Modelling and Software

1st International Congress on Environmental Modelling and Software - Lugano, Switzerland - June 2002

Jul 1st, 12:00 AM

Catchment Modelling – A Resource Manager's Perspective

J.E. Caminiti

Follow this and additional works at: https://scholarsarchive.byu.edu/iemssconference

Caminiti, J.E., "Catchment Modelling – A Resource Manager's Perspective" (2002). *International Congress on Environmental Modelling and Software*. 131.
https://scholarsarchive.byu.edu/iemssconference/2002/all/131

This Event is brought to you for free and open access by the Civil and Environmental Engineering at BYU ScholarsArchive. It has been accepted for inclusion in International Congress on Environmental Modelling and Software by an authorized administrator of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.

Catchment Modelling – A Resource Manager's Perspective

Joanne E Caminiti

West Gippsland Catchment Management Authority, Victoria, Australia
(joannec@wgcma.vic.gov.au)

Abstract: Models are invaluable tools for resource management. Models help resource managers develop a shared conceptual understanding of complex natural systems, allow testing of management scenarios, predict outcomes of high risk and high cost environmental manipulations, and set priorities. Catchment modelling is a specialist field, and different modelling approaches are specialist areas in themselves. There are a plethora of models available that apply to integrated catchment management, from micro to landscape scales, from deterministic models to broad-brush models. Different philosophies abound; with some experts advocating top-down systems approaches and others who dismiss these as being too uncertain and based on opinion rather than fact. Even when the approach is agreed, experts may be at odds over which modelling product is superior and have a vested interest in their particular product. So, how does the resource manager obtain objective, independent technical advice on needs and applications, and then choose the best modelling approach? Model development can be onerous, expensive, time consuming, and often bewildering for the resource manager. It is also an iterative process where the true magnitude of the effort, time and data required is often not fully understood until well into the process. Resourcing can become problematic. This paper explores the dilemmas faced by resource managers who dare to venture down the path of catchment modelling and proposes ways to minimise the pain and maximise the gain.

Keywords: *catchment management; resource manager; environmental modelling; decision support*

1 INTRODUCTION

1.1 Catchment Management Framework in Victoria, Australia

In the State of Victoria, Australia, nine catchment management authorities were established in 1997 under the *Catchment and Land Protection Act 1994* to protect land, water and biodiversity in partnership with other government agencies, industry and the community.

Catchment management authorities, with their community advisory structures, provide a mechanism for determination of natural resource management priorities by regional stakeholders who have to live with both the problems and solutions. These are documented in *Regional Catchment Strategies* that take into account environmental, social and economic factors.

1.2 West Gippsland Region

The West Gippsland Catchment Management Authority region comprises 18,852 km^2 with a population of 192,000 making it the most densely settled rural area of the State. The region contains three river basins, two of which drain to the internationally significant Gippsland Lakes, and the other consisting of several smaller river systems that drain directly to inlets and estuaries along the coast.

Industries in the region draw directly on the natural resources, with agriculture, coal fired electricity, gas, water and forestry being the most significant. Outstanding natural features such as Wilson's Promontory and the Gippsland Lakes on the coast, and wilderness areas in Victoria's high country support a vibrant tourism industry.

A variety of catchment models and decision support systems have been used in the development of priorities for the *West Gippsland Regional Catchment Strategy* and supporting action plans 'to achieve a sustainable balance between the human need to utilize the natural resources of the region and the responsibility to ensure that these natural resources remain available for future generations' [West Gippsland Catchment & Land Protection Board 1997].

The material presented in this paper is a synthesis of the author's experiences with several modelling exercises undertaken to better manage the natural resources in Gippsland.

2 MODEL DEVELOPMENT AND USE

2.1 The Need for Modelling

Models are invaluable tools for resource management. Models help resource managers develop a shared conceptual understanding of complex natural systems, allow testing of management scenarios, predict outcomes of high risk and high cost environmental manipulations, and set priorities. These are all essential components of developing *Regional Catchment Strategies* and associated action plans.

In Victoria's catchment management framework, it is important for the resource managers and other regional stakeholders, including representatives of the broader community, to have an understanding and ownership of how priorities for natural resource management are developed. If models or decision support systems are used to help develop priorities, then sufficient understanding of the processes and inputs is required to have confidence in the outputs on which the priorities are then based. The level of confidence depends on trust and rapport with the modellers and the degree of contention that may surround the particular resource management issue and it's resolution.

2.2 Model Selection

There are a plethora of models available that apply to integrated catchment management, from micro to landscape scales, from deterministic models to broad-brush models. The resource manager is typically knowledgeable enough to recognize the benefits of modelling but not necessarily which modelling approach to take. Model development can be costly in terms of funds, time and data, so how does the resource manager choose the most appropriate modelling framework?

Environmental modelling is a specialist field, and different modelling approaches are specialist areas in themselves. Different philosophies abound; there are experts who advocate systems approaches using conceptual models and others who dismiss these as being too uncertain and based on opinion rather than fact. Even when the approach is agreed, experts may be at odds over which modelling product is superior. Sometimes the needs of the resource manager appear to be lost in the technical debate between modellers who support fundamentally different approaches. The tensions between resource management and science are explored by Cullen (1990) and are especially applicable to environmental modelling which can be expensive and highly technical.

Resource managers are aware that modellers may have vested personal or commercial interests in particular modelling approaches and products. Privatization and commercialization of public sector technical services and competitive tendering for government-funded projects appears to have entrenched this. Competition policy is often at odds with the principle of developing cooperative partnerships to work towards a mutual understanding of natural resource management issues and their solutions. In this climate, how does the resource manager obtain objective expert advice on the most suitable modelling approaches and products?

The resource manager can reduce their exposure to these risks in a number of ways. Conducting a multi-stage process for the selection of the appropriate modelling approach and the development of the selected model will help to limit the risk of developing a model that may be challenged by other experts after it has been completed. The resource manager may also engage a modelling expert to help scope the project and develop the project briefs prior to seeking tenders. Technical review of each stage by an independent expert or an expert panel can further reduce risks. The resource manager may also enlist the aid of other stakeholders in a project steering committee to help with the selection of appropriate modellers. A proposed model development flowchart is shown in Figure 1.

So what does the resource manager do when the experts engaged to assess their modelling needs and those engaged to review the assessment cannot agree? Seeking additional expert advice may help the resource manager make the appropriate selection. However where there are significant differences in expert opinion, it may be preferable to abandon the modelling project and use other less controversial means to determine the priority management actions to be implemented.

The preferences of those who control the funding should also be considered when selecting a model. If the resource manager selects a technically appropriate model that is out of step with the prevailing preferences, they may find their access to funding for future implementation is affected. To help reduce the possibility of this happening the resource manager should ensure that the funder has ownership of the approach taken by inviting them onto the project steering committee or by ensuring that their views are considered by the experts engaged to assess the modelling approach. Since modellers rarely have a stake in the implementation of priority actions that are derived from their models, it is incumbent on the resource manager to specify these requirements as clearly and in as much detail as possible.

The *Gippsland Lakes Environmental Study* [Webster *et al.* 2001] and the *Macalister Irrigation District Surface Water Model* [Sinclair Knight Merz (forthcoming)] adopted representative project steering committees and independent expert reviews at various stages of model development. A series of expert panels were also used in the development of a statewide environmental water requirements methodology [Cooperative Research Centre for Freshwater Ecology *et al.* (forthcoming)]. While reducing the risk, these all add to the time, cost and complexity of model development, and the benefits and costs must be weighed up by the resource manager.

2.3 Model Development

Assuming that there is agreement on the modelling approach, the next step is to engage someone to develop the model. The resource manager may require technical help to develop the specifications for the model development. The specifications need to include information on the objectives of the resource manager, how the model is to be used, model scope and boundaries, available data sources, compatibility requirements with other models, documentation of model inputs, format of model outputs, assessment of model uncertainties, ownership of the model and supporting documentation, description of scenarios to be tested, the level of stakeholder participation, communication of the model development and outputs, reporting arrangements, budget constraints, and a clear end point.

Model development can be an iterative process where the true magnitude of the effort, time and data required is not fully understood until well into the process. Resourcing can become problematic if significant contract variations are required. Even if additional resources are available, contract variations that exceed certain limits may contravene competitive tendering policies. Informed project specification and tender development will help to reduce these risks, but will not eliminate them. By adopting a staged approach, the resource manager can further divide the risks into more manageable chunks.

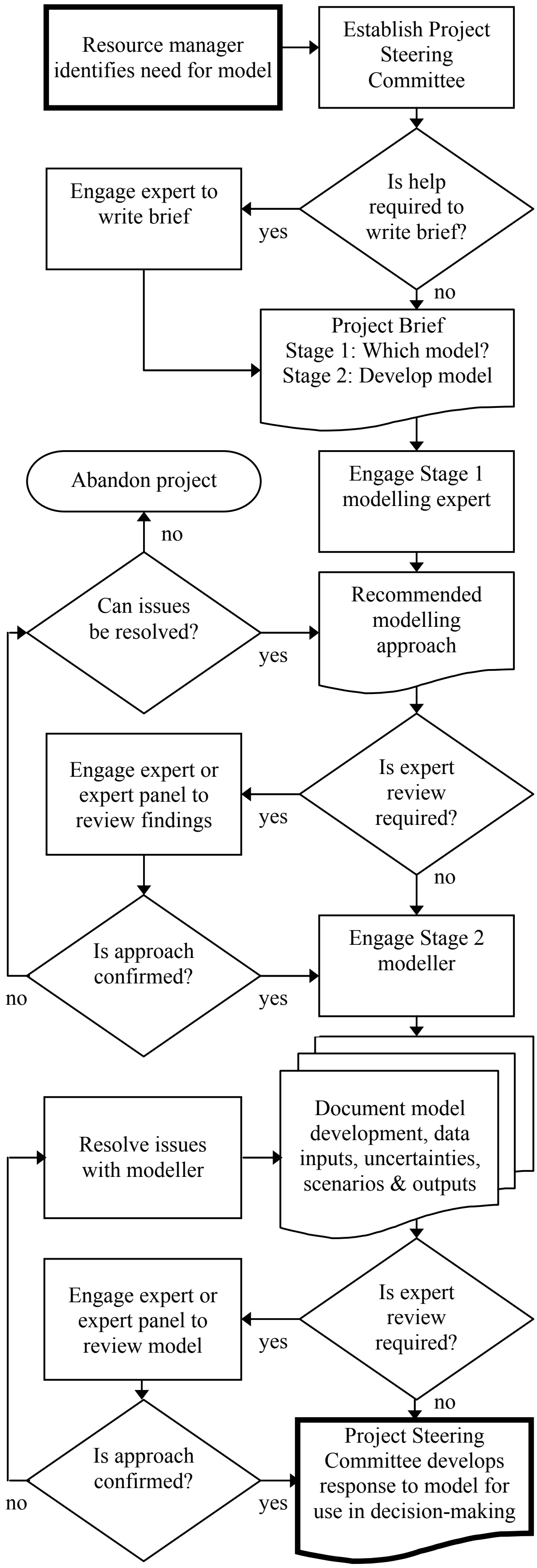

Figure 1: Model Development Flowchart

The technical challenges of model development can sometimes overwhelm the original objective of the modelling exercise. The larger and more compartmentalized the model, the greater the likelihood that modellers can become disconnected from the resource manager's needs and expectations. Increasing demands for data inputs can result in the resource manager serving the model rather than the model serving the resource manager. The resource manager and the project steering committee need to keep their objectives firmly in mind and ensure that the modellers do too.

2.4 Sensitivity and Scenario Testing

Models can help with the understanding of natural systems, but their main attraction to resource managers is their ability to test management scenarios that enable informed decisions on how to better manage the resource. The resource manager usually has a very good idea of the management scenarios that they would like to test, but the conversion of these scenarios into meaningful model inputs can be complicated and time consuming. Both the resource manager and modeller when developing and responding to the project specification can overlook this.

Sensitivity testing is used to provide information about the major levers in the model and uncertainties in the model and possible scenarios by modifying one variable at a time by an arbitrary and often large percentage. Scenario testing is where inputs or variables are modified to represent the consequences of a realistic management action. Sometimes sensitivity testing of the model is confused with testing management scenarios. Each provides valuable information to the modeller and the resource manager.

Developing the management scenarios may require new information and judgments that were not a part of the base model. For example, a scenario on the effect of improved irrigation management on the phosphorus load of a river receiving irrigation drainage from several drain catchments requires a series of judgments where the data does not exist. These include the magnitude of improvement in both drainage volume and concentration expected from changes in particular irrigation practices, and whether these changes are additive or need to be discounted if multiple changes are made on the one area; whether the magnitude of the improvement is affected by other variables such as soil type, and by how much; what is the current rate of adoption of particular practices; and whether adoption of new practices is likely to be uniform.

If the time-lines and budget are tight because the magnitude of effort required to develop management scenarios was underestimated, it may be tempting to only undertake sensitivity testing rather than using the model to its full potential to test genuine management scenarios. In some cases, this might not matter, and the resource manager must decide what level of sophistication is required for use in the planning process.

In the recent *Gippsland Lakes Environment Study* undertaken to help develop options to reduce cyanobacterial blooms, three models were developed for hydrodynamics, ecological processes and sediment/water interactions [Webster *et al.* 2001]. One of the scenarios tested was a 20 percent reduction in river flows to the Lakes. Four-year daily flow time-series for each river system needed to be generated to input to the model. After much discussion, the project steering committee decided to reduce each daily flow in the base case time-series by 20 percent, and not generate a more realistic scenario based on projected increased extractions using existing flow models unless the results warranted further investigation.

The *Macalister Irrigation District Surface Water Model* was recently developed to refine management actions for nutrient and salinity mitigation and assess impacts of salinity control measures such as groundwater pumping identified through the *Lake Wellington Catchment Irrigation and Dryland Salinity Management Plan* [Anon. 1993]. The *Macalister Irrigation District Nutrient Reduction Plan* [Anon. 1998] was developed to identify priority actions to be implemented to achieve a 40 percent reduction in phosphorus loads set by the Environment Protection Authority [1996] to improve the health of the Gippsland Lakes. In this case, the project steering committee decided that it was important to develop realistic management scenarios to fully utilize the power of the model to test the assumptions in the above plans and aid decision making, despite the extra time and budget required. The decision was based on the needs of the planning process [pers. comm. Keogh 2002].

2.5 Dealing with Uncertainty

There will always be some degree of uncertainty because models are a simplification of reality. Uncertainties in model outputs can arise from conceptualization of the processes modelled, quality and quantity of data, constraints of the modelling technology, and assumptions used in the scenarios tested. For a particular model, some results may be more certain than others because of the interaction of the above factors. This can be a difficult concept to convey to stakeholders. The model results may recommend actions ‘a’, followed by ‘b’ and then ‘c’, but the decision is taken to implement action ‘b’, because there are too many uncertainties associated with action ‘a’. This situation has arisen with the *Gippsland Lakes Environmental Study* where the course of action that the model indicated would have the greatest benefit will not be undertaken until significant further investigation is carried out to reduce the uncertainty and consider other environmental, social and economic implications [Webster *et al.* 2001].

One of the often-criticized aspects of models, particularly where data is sparse and processes are poorly understood, is that they are merely systemizing assumptions into a form that carries greater credibility. However this approach gives a powerful framework for resource managers and others to scrutinize the ‘current understanding’ of a particular system or process, so long as the assumptions are stated up front. The resource manager and the modellers must not lose sight of this as they become embroiled in the model development and appropriate care must be taken in the use of model outputs.

Deterministic models that have a high data requirement sometimes highlight previously unrecognized inconsistencies between data sources. The danger is that the data is often assumed to be correct, therefore the model is manipulated to get a better match with the flawed data. The modeller and resource manager need to question the veracity of the data rather than trust it implicitly.

During calibration of the *Macalister Irrigation District Surface Water Model*, there were inconsistencies in river flow that previous authors had attributed to groundwater interactions [Environment Protection Authority 2000]. However examination of a duplicate data set for the same location from another source showed major systematic inconsistencies. Problems were found with the ratings table used for the first data set, proving the inconsistencies to be an artifact of erroneous data [pers. comm. Keogh 2001].

Uncertainties, assumptions and limitations of models and their outputs need to be meticulously documented by modellers and borne in mind by resource managers when using the model and results to set priorities and make decisions. It is more effective to do this throughout the model development rather than reconstruct the uncertainties underlying model inputs at the end of the process.

2.6 Use and Communication of Model Results

Model development and scenario testing can be a long and intensive exercise. If a consultative approach has been taken, the resource manager and the project steering committee will generally have a good understanding of the model and a high level of comfort with the model outputs and their associated uncertainties. However, not all of the stakeholders who need to understand and use the model results can be as closely involved. So how does the resource manager ensure that the results are not taken out of context or, worse still, taken as ‘the answer’?

A ‘black box’ approach should be avoided. Model development needs to be sufficiently transparent so the non-expert can understand the basic components and limitations. The resource manager should determine whether they want a model that they can operate themselves, or one that requires expert operation. A model that one can operate without expert help may be appealing, but may require so much simplification that it cannot serve the purpose it was intended for. A ‘user friendly’ front end to the model may allow the resource manager to test scenarios within certain limits without over simplifying the underlying model. Another option may be to ensure that the model outputs are ‘user friendly’, and make arrangements with the modeller for the future development and testing of additional scenarios after the modelling exercise has been completed.

Format of the model outputs need to be considered early in model development. Possible formats include visual map based outputs; conceptual diagrams; exceedance tables to show the number of occasions a parameter exceeds preset limits; time-series plots; or descriptive interpretations of different scenarios. It may also be helpful for the modeller to develop a multimedia presentation that the resource manager can use to inform stakeholders of the model and results.

Expectations of the stakeholders and wider community need to be carefully managed from the outset of a modelling exercise. They need to be made aware that a model is only a sophisticated tool that will be helpful in better managing the resource, but it is not 'the answer' and may not take into account all of the environmental, social and economic factors that resource management decisions are based on.

3 CONCLUSION

Models are invaluable tools for resource management. However modelling can be such an onerous, time consuming, expensive, and often bewildering exercise for the resource manager that they hesitate to venture down the modelling path. Both the resource manager and the modellers can take steps to minimize the pain and maximize the gain from environmental modelling.

The pitfalls and steps the resource manager can take to avoid them are discussed above and summarized in a model development flowchart in Figure 1. The risks can be minimized and managed by establishing a representative project steering committee, preparing detailed project specifications, adopting a multi-staged process, and the judicious use of independent expert review at key stages of model selection and development.

Modellers can help by trying to understand the needs and expectations of the resource manager who may not have the technical knowledge or language to express them. While it may be tempting to take an attitude that modelling is too technical and complicated for the resource manager to understand, the support of the resource manager is dependent on their level of knowledge and comfort with the modelling process. Consultation and engagement throughout the modelling process are paramount.

4 ACKNOWLEDGEMENTS

The ideas presented in this paper could not be developed without the invaluable input of others. Particular thanks go to Eleisha Keogh and Peter Erlanger for their enlightening discussions and comments. The author gratefully acknowledges the support of the West Gippsland Catchment Management Authority, her husband, Paul, and son, Ben, in the preparation of this paper.

5 REFERENCES

Anon., *Lake Wellington Catchment Irrigation and Dryland Salinity Management Plan*, Department of Natural Resources and Environment, Maffra, Victoria, Australia, 1993.

Anon., *Macalister Irrigation District Nutrient Reduction Plan*, Department of Natural Resources and Environment, Maffra, Victoria, Australia, 1998.

Catchment and Land Protection Act 1994, State Government of Victoria, Australia, 1994.

Cooperative Research Centre for Freshwater Ecology, Sinclair Knight Merz, Lloyd Environmental Consultants, and Department of Natural Resources & Environment, *FLOWS – a method for determining environmental water requirements in Victoria*, forthcoming.

Cullen, P., The turbulent boundary between water science and water management, *Freshwater Biology*, 24, 201-209, 1990.

Environment Protection Authority, *State Environment Protection Policy (Waters of Victoria) Schedule F5 (Waters of the Latrobe & Thompson River Basins and Merriman Creek Catchment),* EPA, State Government of Victoria, Australia, 1996.

Environment Protection Authority, *Total Phosphorus Loads for the Agricultural Drains in the Macalister Irrigation District,* State Government of Victoria, Australia, 2000.

Sinclair Knight Merz, *Macalister Irrigation District Surface Water Model Technical Report*, prepared for the Department of Natural Resources and Environment, Maffra, Victoria, Australia, forthcoming.

Webster, I.T., J.S. Parslow, R.B. Grayson, R.P. Molloy, J. Andrewartha, P. Sakor, Kim Seong Tan, S.J. Walker, and B.B. Wallace, *Gippsland Lakes Environmental Study – Assessing Options for Improving Water Quality and Ecological Function,* Final report to the Gippsland Coastal Board, CSIRO, Glen Osmond, SA, Australia, 2001.

West Gippsland Regional Catchment & Land Protection Board, *Regional Catchment Strategy – Catchment Description, Condition, Management, Actions and Priorities*, West Gippsland Catchment Management Authority, Traralgon, Victoria, Australia, 1997.