THE FUTURE OF WATER MODELLING

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ABSTRACT

Water Modelling has certainly come a long way in the last thirty years. There have been a number of significant drivers for change, from ever increasing customer expectations and legislative changes to catastrophic events such as long-duration droughts and terrorism and more recently understanding and managing the effects of climate change on our infrastructure assets and communities. During this period there have been remarkable advances in technology and computing power which have exponentially changed our expectations and ability to collect, process and analyse and present vast amounts of data with powerful visual tools.

In parallel with these advances in technology we are seeing the evolution of a new generation of more “tech-savvy” operators. As a result water modelling is migrating from the planning domain into the “real-time” operational environment. We have also seen a transition from “Specialist Modellers” to “Engineer Modellers” as the tools have become more widely available and user–friendly. As models move into the control room environment we are seeing the emergence of a new type of modeller, the “Operator Modeller” and potentially “Field Operator Modellers”.

In this paper we will look at the journey so far and discuss what the future may hold for water modelling and the new generation of modellers.

KEYWORDS

Operational modelling, operations, incident response, system optimization, water quality modelling, whole of water cycle modelling

1 INTRODUCTION

Hydraulic Modelling has certainly come a long way in the last 30 years. There have been a number of significant drivers for change, from ever increasing customer expectations and legislative changes to catastrophic events such as floods and long-duration droughts. There is also the ongoing challenge of global urbanisation and managing the likely impact of climate change on our infrastructure assets and communities, where modelling is certainly a key tool for quantifying the problem and testing the effectiveness of adaptation strategies. During this period there have been remarkable advances in technology and computing power which have exponentially changed our expectations and ability to collect, process and analyse vast amounts of data and present the results with powerful visual tools.

In this paper we will look at some of the recent developments in hydraulic modelling, including the first trials of whole of water cycle modelling and the migration of models from purely the planning domain into the control room environment, where models are increasingly becoming real-time operational decision support tools.

2 A POTTED HISTORY

During the 1980’s modelling moved from being purely the realm of specialised physical model testing facilities to the desktop, with the development and increasing availability of personal computers.

Photograph 1: Modelling in the early 1980s

A range of modelling tools became available to support planning and design work across the three waters. Increasingly engineering consultancies and local authorities employed specialist modellers to support a wide range of analysis and design work and the age of the "Modeller" was upon us.

Through the 1990s and early 2000s modelling software became increasingly powerful and user-friendly, with first CAD and then GIS interfaces making the tools accessible to more non-specialist staff, and we entered the age of the "Engineer-Modeller". These Engineer-Modellers used models to support their work but did not consider themselves as "Modellers" per se.

During the last 10-15 years we have seen significant advances in computing power, and models have become increasingly integrated with key corporate systems such as SCADA, Asset Management Systems and GIS. We are now seeing rapid advances such as remote sensing and smart metering, opening up the path for regular or potentially constant updating of models at a customer level rather than just at a bulk meter level.

In parallel with these advances in technology we are seeing the evolution of a new generation of more "tech-savvy" system operators across the three waters. As a result, modelling is migrating from the planning domain into the "real-time" operational environment. As models move into the control room we see a growing need for a new type of modeller, resulting in the emergence of the "Operator-Modeller" and with mobile computing technology there is certainly scope for this trend to continue to include "Field Operator Modellers".

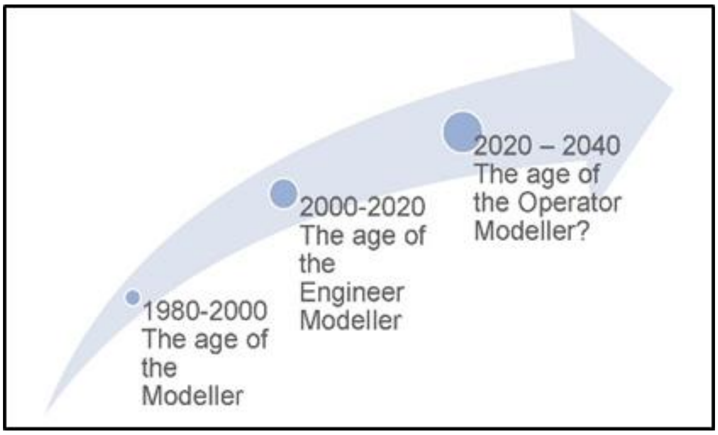

Figure 1: The Evolution of the Modeller

As well as the move to Operational Modelling for the three waters, we now have the computing power and software tools to support modelling of the whole water cycle in a single model. This presents an opportunity for a more holistic approach to three waters modelling which will support planning of sustainable urban development and in particular urban re-generation and intensification.

So let's have a look at Live Operational Modelling and Whole of Water Cycle Modelling in a little more detail.

3 RECENT ADVANCES

3.1 OPERATIONAL MODELLING

What is the fundamental difference between operational and planning models? Is a model that is used to assist the operations team plan operations a planning model or an operational model? It is perhaps more important to think about the tense of the model, whether you need to ask a question of the model based on what is happening now or what will happen in the future.

Even then it can be confusing as live models will generally provide a view into the future but generally this is the short term future, up to about 7 days maximum. So using a model to plan how to arrange the network or to look at how the network will respond for example during a treatment plant shut down required for maintenance in 6 months’ time would be better done in a planning model rather than an live operational model. However an emergency shutdown of a treatment plant due to a water quality incident would be better done in an operational live model.

The reason for this can be explained by how these models need to be built and set up to run. A planning model will generally be calibrated for a particular demand day or storm event. Representative models are then created for average day and peak day models for water supply models or design storm events for open channel models (stormwater, wastewater, rivers). Open channel models will generally have an additional verification step during calibration where the model is run with other real storm events to check that the model response is valid for a range of events, this step is rarely done for water supply models.

When constructing a live operational model it is essential to think about how valid the model will be for “any” day in the year. This would include two key considerations; how the model boundary conditions change each hour, each day, each season and how the model controls change over time. It is generally a good idea to assume that the base network will not change although obviously the network is changing constantly and this consideration is discussed later.

A common issue particularly with water supply models is the controls of pumps and valves in a network. For a planning model it is likely that the calibration day is a day in summer and potentially a weekday so to keep things simple when the model is built the controls that apply for the weekends and during winter may be ignored and a pump may have a simple level control logic. If this model was used directly as an operational model it may not give an accurate representation of the model on weekends or during winter. This particular issue can usually be resolved in the model by ensuring the model controls are valid for every day and that any control parameters can be updated from telemetry if required.

Perhaps a more complex consideration for operational modelling is the boundary conditions and how these boundary conditions can be updated. Is there an appropriate telemetry point at the boundary that can be used to set the starting point? Do any of the boundary points require some sort of forecast to ensure the model gives a more accurate representation of the network into the future? The most common boundary condition for a water supply model that has the most influence on the results would be the demand prediction.

The major difference between planning models and operational models is the integration with other systems. A planning model can reside quite happily on a single desktop machine as a stand-alone application with no interaction with any other systems after the initial model build and calibration process. An operational model by its nature must have access to some form of live data, usually this is a historic store of an organisations SCADA data that is regularly updated. These databases are usually well organised and well protected so appropriate permissions must be granted to the operational model to be able to extract and use this data. Once this access is configured and the operational model can use this data to set initial conditions and drive boundary condition forecasts then the operational model can perform simulations to give a prediction for the next “x” hours or days as required by the organisation.

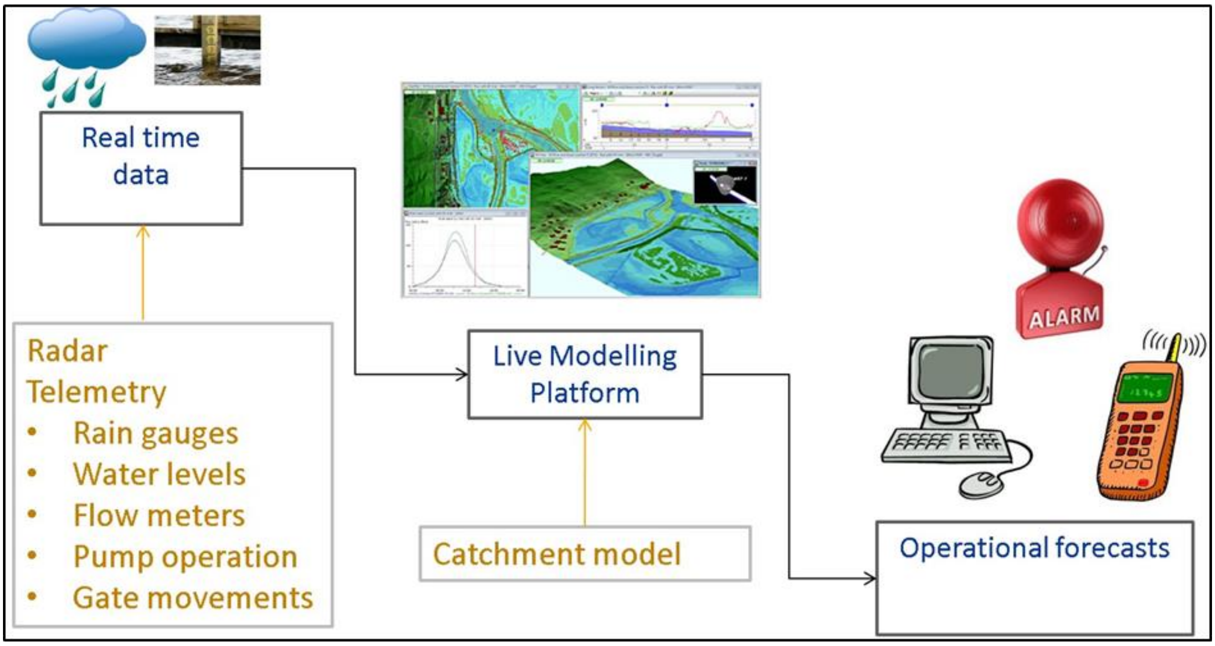

Figure 2: Operational Modelling for a River catchment

While this may sound like a relatively simple step it does generally require the need for collaboration between the operational modellers, the SCADA teams, operations team and the IT staff. This is usually the most complex and time consuming step of setting up operational models and that is purely due to it being a coordination exercise and ensuing all parties understand what is required of them and the appropriate permissions and hardware are in place.

This model could then be set to run every “y” hours from now until it is switched off. There is the potential to generate thousands of predictive simulations and corresponding results. This leads to the age old question of what to do with all of this data, does an organisation need to keep all of this data, what is the purpose of this data. Most of the software solutions will include automated tools to automatically delete simulations so that can help to reduce the volume of information kept but it is important to understand what data you need out of operational modelling and how to disseminate that information to people who need it.

3.1.1 THE CHALLENGES OF OPERATIONAL MODELLING

Hydraulic modelling can be complex and the software traditionally used to do modelling can also be complex. Software vendors have made attempts to simplify operational modelling software but perhaps they haven’t been able to do enough to make it truly user friendly to a busy operator who has multiple screens to monitor with multiple applications. There is the functionality available to export model results and analysis to an external database which means that this information could be displayed in the desired format that would be of most use to an organisation.

In some cases it may be that investing in operational modelling just doesn’t stack up. The resources required to link models to SCADA, automatically run them and analyse the results may not be worth it and just because you can do something doesn’t mean you should. However for some the benefits of operational modelling over traditional planning models are compelling, such as;

- Operator training, being able to try something on the network without actually doing it to see what happens and if it will improve the situation. Particularly relevant in organisations where experienced operators who have “lived and breathed” the network for decades are retiring
- Potentially identifying incidents in a network before they are reported or become a major issue that would normally trigger a SCADA alarm by comparing model predictions with real time data and reporting variances
- Potential cost savings due to pump optimisation and;
- More efficient operation of complex networks

Moving from the planning domain into the operational environment is presenting a number of challenges, both at a technical and organisational level. Modelling has traditionally been the responsibility of planning teams, the operations teams are not experienced in model management and front-line operators are simply not experienced modellers, and indeed many do not wish to be. Is it realistic to expect front-line operations staff to learn a new discipline when they usually have more than enough to contend with?

We see a growing need for the creation of a new role, the “Operator-Modeller”, a technical support role located within the control room environment, working alongside and supporting the front-line operators. In some cases this will be a part-time role supplemented by other technical support duties such as compliance monitoring, reporting system performance and leakage management.

As operational modelling is adopted by a growing number of utilities around the world, some issues have surfaced that will challenge and push the software developers. Updating the base underlying model can be a cumbersome task and this process of model updating and maintenance really requires some innovative thought to streamline the process. There is also a growing availability of more data from the SMART networks be it real time meter readings at a customer level or real time valve status information. The availability of large amounts of data at increasing frequencies has already caused problems with existing SCADA systems and hardware not being able to download and store this volume of data. This additional volume of data will require an extension of the existing software capabilities that are designed to update a few hundred data points to potentially updating tens of thousands of points in the network.

3.2 WHOLE OF WATER CYCLE MODELLING

In Australia there is a significant focus on urban regeneration and intensification as cities such as Sydney and Melbourne experience sustained and significant growth. Planners are having to understand and manage the whole water cycle within an area from stormwater management to water conservation and wastewater disposal. Understanding the potential role of stormwater detention, rainwater tanks, sewer mining and permeable paving for example is becoming increasingly important.

In response to this growing need, Melbourne Water have recently run a pilot project to model the Whole of Water Cycle (WOWC) in a single model. A joint project team consisting of CH2M Beca, Urban Water Solutions and Water Technology were selected by Melbourne Water to develop an integrated 1D potable water network, sewer network, stormwater drainage network and a 2D overland catchment model in InfoWorks ICM to replicate the water cycle down to an individual property level.

The proof of concept 1D/2D water cycle model has successfully been established at three distinct scales. These range from the local scale with 100 properties, to the precinct scale with 5,000 properties and then the suburb scale with 27,000 properties

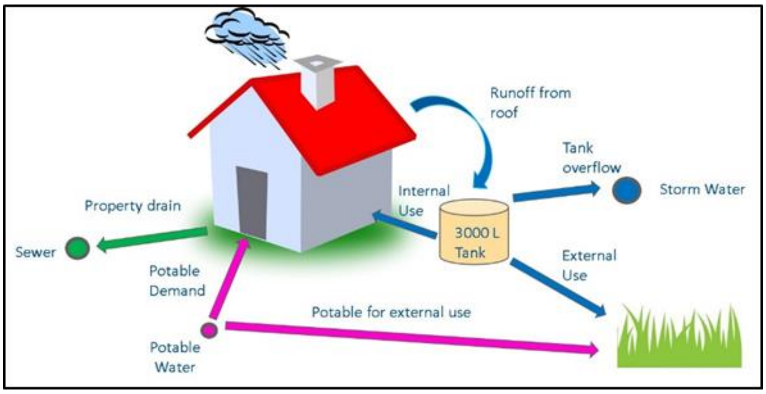

Figure 3: Whole of water cycle representation at a property level

Representing water, wastewater and stormwater in a single model is complex. Understanding the interactions between the processes is key to producing a meaningful representation of the integrated system. The combination of 1D and 2D elements, the mesh size and selecting a suitable simulation time-step to balance the calculation needs for each water and forming the inter-dependencies are all critical to the success of the model.

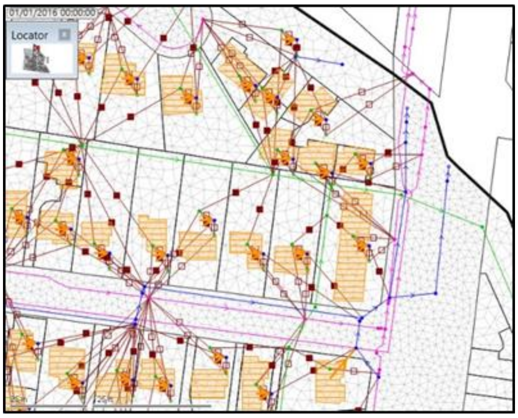

Figure 4: Whole of water cycle pilot model

This pilot project is a unique approach that leverages existing model tools in a way that has previously not been achieved. It opens the way to define new questions and measures for modelling water management that have up to now only been possible at a conceptual level or on a lumped or stochastic basis. By accurately replicating the physical characteristics of the urban water cycle it is possible to provide definitive results that reflect the impact of integrated water management measures.

There is no doubt that this pilot model tested the software to and sometimes beyond the limit, but this type of challenge is what drives development and improvement and propels our industry to the next phase

3.3 OTHER RECENT DEVELOPMENTS

For a number of years software vendors have been grappling with the best way to integrate modelling and GIS/ corporate asset databases. Is there a way to have a "single source of data" that meets a range of needs? There are fundamental differences between the way some elements need to be represented in models compared to other sources of data that continue to cause challenges, but we are seeing some significant software companies that have not traditionally been in the modelling space investing in developing ways to bridge the gap. It will be interesting to see what develops over the next 5-10 years and what level of integration is actually possible.

The technology is already in place for field operators to be able to run planning models on mobile devices in the field. Linking to live operational models is also possible but there are few if any field operators that have been trained and empowered to make use of this technology as yet. At this stage field operators are more likely to use portable devices with GIS capability with model results represented by GIS layers, giving them information on expected flows and pressures, or indeed which valves to close to isolate an area.

There are a number of smart technologies that have come into the market over the last few years such as smart valves and consequently the capability for dynamic DMAs. There is no doubt that in time as live operational modelling becomes more widespread, we will see these technologies represented in the models and potentially with more automation based on model predicted results.

There is a growing interest in multi-species water quality modelling and we are likely to see some progress in this area in the next 5-10 years. Calibration of water quality models continues to be a challenge and progress has certainly been slow up to this point. The main challenge to date has been the collection of complex water quality information at a network level and an affordable price. However, there have been significant advance in this field and affordable monitors able to collect information on multiple parameters are now becoming available. The "internet of things" will open up great opportunities in this area over the next decade and we may see significant advances in water quality modelling as a result, most likely linked to operational modelling.

4 CONCLUSIONS – SOME FINAL THOUGHTS

While many people now accept live operational modelling as a natural progression for the industry, recognising the potential benefits, adoption of the technology worldwide has been a little "patchy".

We have observed a range of different drivers that have encouraged the early adopters and leaders in this field. In Japan for example, the focus for water utilities has been very much on operational optimisation of water and wastewater systems. In the USA it has been more the need to embrace technology to train and support the next generation of operators as experienced staff leave the industry. In Europe and Asia there has been a take-up in operational models of river catchments which has not been reflected to the same extent in Australasia or the USA.

In Australasia, South Australia Water (Adelaide) were early adopters of Operational Modelling of Water Supply Systems. Driven by a significant investment programme as a result of connecting the new desalination plant to the transmission network and a need to optimise the network operation in the face of rapidly increasing power costs, SA Water have been able to achieve approximately $3M savings in their annual power consumption and in the order of $750k in other operational costs as a direct result of their investment in supply mix optimisation, optimising electricity consumption in line with electricity market prices and live operational modelling. Water providers in Melbourne, Victoria, are not far behind and are currently running pilot projects and moving toward wide-scale implementation of operational modelling programmes over the next couple of years. There is also a growing interest in New South Wales and Queensland where software trials are underway or planned.

So why has New Zealand been slow to adopt live operational modelling? A few years ago three waters modelling in New Zealand was at least tracking alongside or perhaps even ahead of Australia, but still a little behind the UK. Now many Australian water suppliers have teams dedicated to identifying and introducing smart technologies as they strive to create “Intelligent networks”. This was driven to a certain extent by the Millennium Drought and the need to become more innovative and carefully manage an increasingly scarce resource.

Fortunately New Zealand has not had such a challenge to date, although there is no doubt that live operational models linked real-time to the SCADA system would have been advantageous during the response to the Christchurch earthquakes, where planning models were used to support the operators as far as possible. There is no doubt the Australian Water Industry changed as a result of the drought and indeed the ongoing threat of another similar event, and we believe this has helped pushed them ahead of New Zealand in seeking out and adopting smart technologies.

Unlike the UK, New Zealand does not have a strong water industry regulator to drive efficiency and optimal performance, so while there is no lack of capability New Zealand lacks the legislative driving force to be a catalyst for change.

Whole of Water Cycle modelling is very much in its infancy. The Melbourne Water pilot model has demonstrated that it can be done, but there are certainly challenges, and the existing software packages are not designed with this in mind. Some “creative thinking” is required to accurately represent all the waters together until the tools are further developed and tested. The next stage will be to apply the lessons learned during the pilot project and to support a real urban regeneration/intensification project, hopefully during the coming 6-12 months.

Looking around at advancements in technology in other industries it is hard to imagine where water modelling may go in the future. In one respect technology is advancing at a rapid rate, for example there is a potential to deliver parts of engineering projects in augmented reality allowing clients to visually see how a final design may look on the actual site the project will be built. On the other hand these advancements need to be adopted by people and must fit within the budgets they have available. It is generally not the technology that is lacking but the affordability and willingness of people to adopt these new technologies.

For modelling to meet its full potential in the future, perhaps there needs to be a change from software vendors driving the advancements to users actively driving product development based on what they see in other industries and what would be of the most benefit to the industry as a whole. With its epicentre in Victoria but with links to others in Australia and the United Kingdom, a “community of interest” for operational modelling has been formed. The intention is that practitioners will discuss their needs and observations, debate possible solutions and then to speak with a unified voice to drive the development of operational modelling software forward based on practical application. It is hoped that this type of initiative will encourage the software vendors to keep pace and provide the tools necessary to usher the industry into a new era.

While the speed of future software development is hard to predict, we certainly see that modelling has taken its first real steps into whole of water cycle modelling and is starting to become more established in the control room environment. There is no doubt that modelling will continue to play a key role in utilities planning and design, but we believe it will play a pivotal role in more integrated three water planning in the future, especially in urban intensification and regeneration projects. Modelling will also become a more recognised and valuable tool for future generations of network operators, becoming key operational decision support tools linked to a wide array of real time network information.

ACKNOWLEDGEMENTS

The Authors would like to thank Melbourne Water, South Australia Water and Innovyze for their permission to refer to recent projects and use of figures 2, 3 &4.