REPORT TO COAG WATER SUB-GROUP

NATIONAL HYDROLOGIC MODELLING STRATEGY

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NATIONAL HYDROLOGIC MODELLING STRATEGY

EXECUTIVE SUMMARY

INTRODUCTION

The Council of Australian Governments has requested that an evaluation of the current hydrologic modelling activities be undertaken and that a proposal for a National Hydrologic Modelling Strategy (NHMS) be developed.

There is a strong consensus amongst water management professionals that a National Hydrologic Modelling Strategy is needed. This includes key Australian Government Agencies (BOM, MDBA) and the lead water management agencies in all states. These agencies have strong common needs that cannot be met easily by their current modelling technology. The technology would benefit from significant modernisation and increased functionality to address issues such as climate change, environmental water and water trade. The agencies have limited capability to meet these new challenges in-house and would benefit from a strategic national approach to the modernisation of hydrological modelling.

The NHMS will focus mainly on building, operating and supporting best-practise application of new enterprise models but recognises that many utility models will also be needed to support agencies as they deal with the emerging water management issues.

Enterprise models are those used to support the key business or statutory functions of agencies. They are generally developed to:

- manage water resource entitlements and allocations
- operate storages, rivers and supply systems
- forecast future water supply and demand, and
- account for water use.

They are used by agencies as part of the day to day operations. By contrast utility models tend to be used intermittently to support particular investigations or major decisions. Enterprise models require a much higher level of commitment to software engineering, training, support and development than utility models.

The Strategy can be implemented within the current levels of investment being made by the Commonwealth in this area of activity, which is largely through the eWater CRC. Funding does need to move between Commonwealth portfolios and change emphasis from broad research and education to include a focus on model development, support, training and use. There are significant savings to be achieved by states from participating in the Strategy.

STATE OF PLAY

Australia is facing unprecedented challenges in the management of its water resources and needs the best possible information and tools (models etc) to assist in making informed choices about future management options.

Models are an integral part of the tools used by water management agencies in the execution of their responsibilities. They are a mix of "in house" developed models and "commercial" models.

In the absence of any national approach states have developed their own modelling platforms. States have then worked to standardize the use of that model within their jurisdiction to maximise the efficient use of their resources. They have all recognised the need for standardisation to simplify the consideration of model outputs in the policy arena and to maintain documentation and a skilled workforce to use and update the models. Many of the models are on old software architecture which is approaching the end of its useful life and needs to be modernised.

The need to modernise Australia's major water management models has been recognised for many years. The former CRC for Catchment Hydrology started work on developing a stable modelling platform using modern and consistent architecture and this work has accelerated since the establishment of the eWater CRC with its 45 industry and research partners.

The CRC has demonstrated that significant efficiencies can be gained if the one modelling architecture (with supporting software engineering) can be used for the four main functions of any enterprise model. They are:

Planning ⟺ Management/Operations ⟺ Accounting ⟺ Forecasting

All developed on one modelling architecture

Now an extensive modelling platform together with a range of complimentary models exists. Work is underway to accelerate development of the key "River Manager" package which will, after trialling, be suitable to replace many of the existing modelling platforms in the Murray Darling Basin and elsewhere if considered necessary. This will be a foundation enterprise model.

The eWater CRC maintains a "Toolkit" of models (www.Toolkit.net.au) developed on its stable modelling platform called TIME. These models are accessed by 10,000 registered users who between them have downloaded 57,000 copies of models. A quarter of all downloads are by international users. The benefits of the "Toolkit" methodology are the common approach across many individual models, professional modern software engineering and documentation and confidence in the rigor and utility of the software.

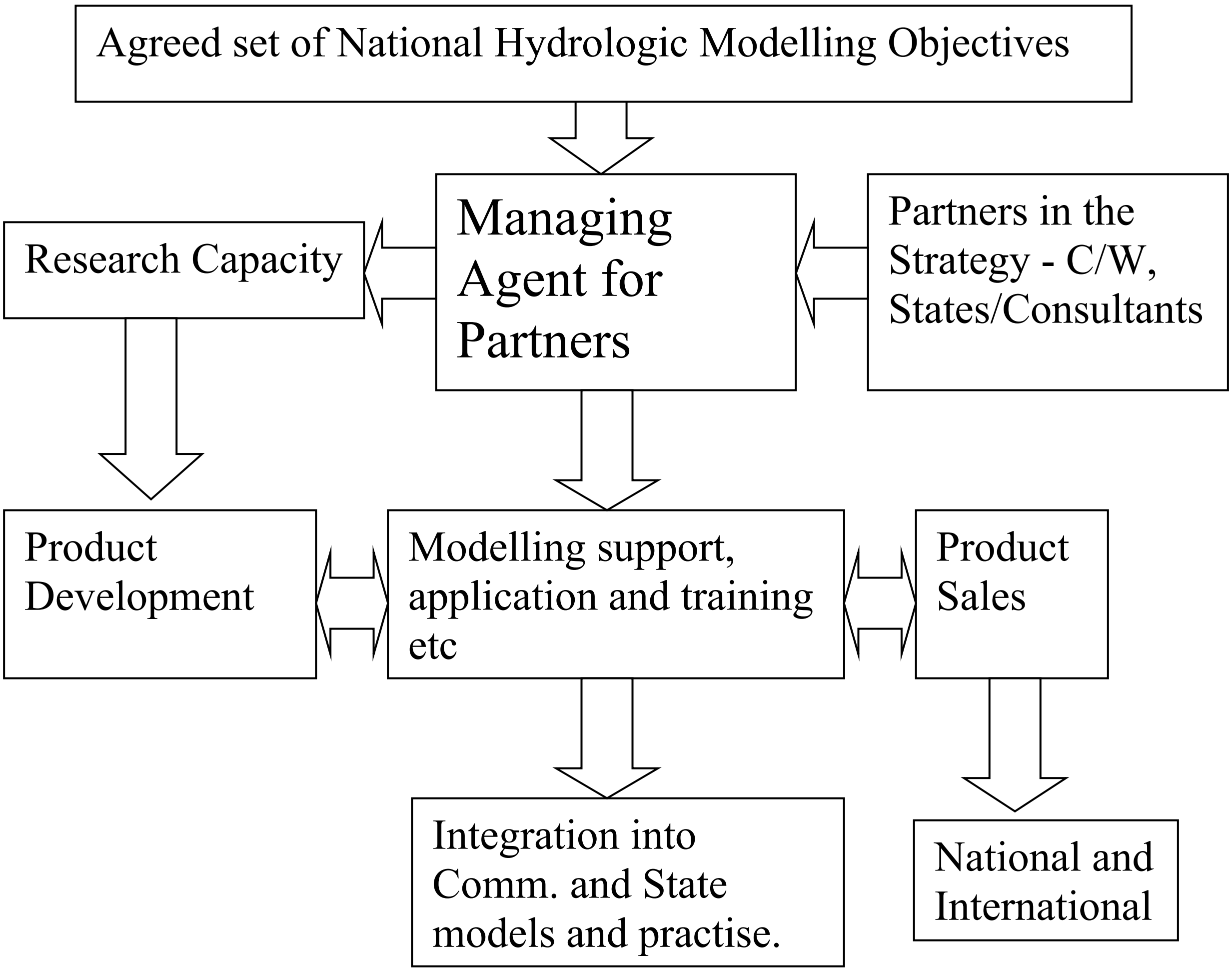
FUTURE NEEDS

The priority issues for joint action identified by state and Commonwealth agencies are:

Fundamental Knowledge necessary to improve modelling (top 5 issues)
- Climate change – downscaling and hydrology, climate variability, scenarios
- Ecological modelling of flows, and provision, floodplain modelling, environmental impact assessment
- Economic consequences and outcomes of water management
- Urban water demand modelling, new sources, security of supply requirements
- Groundwater – interactions with surface water, finer resolution, responsive to management

Improved model functionality/features (top 5 issues)
- Sophisticated scenario generation and functionality
- Integration of individual models
- Better documentation of models
- User support for multiple distributed agencies
- Improved database management

THE STRATEGY
The Strategy needs the elements shown in the diagram below to be effective.



Products developed under the strategy will be made freely available to Government partners.

The Objectives:

The objectives that govern the design of a strategy to ensure that the range of issues can be addressed in a well managed way are:

- Common software architecture for enterprise models
- Professionally engineered, modern, thoroughly tested and well documented models
- Common training arrangement
- Methods and guidelines for model parameterisation, calibration, testing and application
- Access to significant research capacity
- Avoid duplication
- Collective involvement in decision making and in investment in the Strategy
- At least a ten year life to ensure delivery
- Provide the opportunity for consultants to use the material developed to support their business interests
- Ability to modify the agenda in the light of new information

Community of Practice
Given the relatively small number of professionals involved in water modelling in Australia the strategy will provide a focus for their training, professional development and portability. This will focus on appropriate model practise for both existing models and the new platform.

Groundwater
Most management agencies use Modflow (with adjustments as necessary) as their base groundwater model. It is supported by a large community of practice and therefore should be adopted as the base model for future development.

Research Capacity
Model development of the complexity needed to inform future management of Australia's water resources will need sustained access to water systems research. This is to be contracted to various providers. It is critical that a long term contract (similar to a CRC) be established with CSIRO as they are the only agency with the breadth of research capacity required. Other specific research will be contracted as necessary. Research on the environmental water needs for inclusion in hydrological models is an essential requirement.

Product development
A detailed product plan together with its supporting research needs will be developed in the transition between the CRC eWater and the commencement of the Strategy.

Governance and Custodianship
Four possible approaches each with their own set of strengths and weaknesses exist for management of the Strategy.

The four general approaches are:

- A CRC
- Embedded in a Commonwealth agency
- An incorporated joint venture
- An unincorporated joint venture

Given the need to manage a broad range of stakeholders and to remain focussed on product development and delivery (including a private sector component) the most efficient arrangement would be an incorporated joint venture with the Commonwealth as the majority stakeholder. All jurisdictions want to be investors and want representation on the governing body. The Commonwealth is likely to have three direct investors: the Department of Environment Water Heritage and the Arts, the Murray-Darling basin Authority and the Bureau of Meteorology.

It will be the responsibility of the incorporated body to ensure that arrangements are in place to ensure effective engagement with the states and Commonwealth agencies. This will be true for the any of the other possible governance arrangements as well.

Private Sector

The major role for the private sector within Australia is to provide model services and applications to agencies. Several agencies have outsourced hydrological modelling to the engineering service industry. The private sector will also be purchasers of models for use in Australia and overseas.

Resourcing

The total investment required is about $15 M/year at full implementation. For the next three years many of the roles of the strategy are provided by the eWater CRC and a smaller amount of resources are required while the CRC continues. Currently the Commonwealth and states contribute to eWater CRC, which with additional contracts for hydrological modelling brings the total investment in eWater CRC to about $15M/year. Thus the strategy can be implemented within the current Commonwealth investment profile. There will however be changes to the investment. It will need to move from the Commonwealth Department of Innovation Industry Science and Research to the Department of Environment Water Heritage and the Arts. Once the eWater CRC had completed its 7 year term then the resource could be directed to this activity effectively transferring a research and development lead activity to a strategic national approach with a significant roll out of models and support.

Timing for implementation of the Strategy

The strategy should commence in 2009/2010, developing specific work programs, contracting the underpinning research and establishing management arrangements to broaden and compliment the work of eWater CRC. Full implementation should occur in 2010/2011 upon the completion of the eWater CRC. Ownership and governance of the enterprise model development and support functions of the CRC would transfer to the national joint venture. In the interim the eWater CRC will complete the River Manager and other suite of models and have them effectively trialled. While the eWater CRC continues the NHMS should focus on complimentary work such as groundwater model development, model applications and governance of model functionality emerging from the Sustainable Yields projects and the Bureau of Meteorology. Close cooperation is required between the NMHS and eWater CRC, which can be facilitated through common staffing in key areas such as governance.

CONCLUSIONS

1. There is strong support and immediate need for a National Hydrologic Modelling Strategy and if managed effectively it will put Australia in the

forefront of these activities worldwide. We need to be at the forefront given our hydrology and impending climate change and other threats. All jurisdictions want to be part of a NHMS from its inception.

2. The common need is for modernisation, consistency, and improved functionality of the in-house models used in the core business operations of water management agencies. The strategy would take responsibility for developing, adopting, supporting and training in new enterprise models.
3. There are research, model development, training, capacity building, model ownership, and sales to the sector that would all deliver efficiencies to the Australian community if managed as component parts of an integrated strategy.
4. eWater CRC is currently undertaking some of these activities but is totally focussed on Eastern Australia. The CRC completes its current term in 3 years.
5. It is possible to develop the strategy and implement it over 10 years with a budget of $15M/year with a refocusing of current net expenditure from the Commonwealth. This assumes that there is a contribution from participating States and from commercial sales.
6. The major water management agencies will use the enterprise models provided they are confident that they will be maintained for a reasonable period, significantly enhance the functionality of their current models, and will meet their needs for at least a decade. An example is the acceleration of the development of the River Manager product given the demand for its use in the MDB. Adoption of new model technology can be facilitated by effective engagement in and ownership of the technology. In groundwater management Modflow has largely been adopted as the groundwater "enterprise" model platform.
7. An incorporated joint venture is the most efficient way to manage the strategy with appropriate arrangements for effective representation, technical and policy engagement with the major stakeholders.
8. The implementation of the strategy should commence in 2009/10 and be fully implemented in 2011 to effectively take over and enhance the current eWater CRC activity in this area. Planning will need to include ongoing management of the Toolkit, TIME, and Intellectual Property that has been developed to date, in addition to planning of ongoing development, implementation and R&D.
9. The private industry and water utilities sectors will need to be engaged in the strategy. The two main areas will be to support agencies rolling out new modelling platforms and as a purchaser of models to use both here and overseas.

MAIN REPORT

1. SETTING THE SCENE

1.1 Introduction

Australia is facing unprecedented challenges in the management of it water resources and needs the best possible information and tools (models etc) to assist in making informed choices about future management options.

The Council of Australian Governments has requested that an evaluation of the current hydrologic modelling activities be undertaken and that a proposal for a National Hydrologic Modelling Strategy be developed. The terms of reference are at Appendix 1.

This report examines what should be included in a National Hydrologic Modelling Strategy and the options for its ongoing support and custodianship.

Models are an integral part of the tools used by water management agencies in the execution of their responsibilities. They are a mix of “in-house” developed models and “commercial” models.

The need to modernise Australia’s major water management models has been recognised for many years. The former CRC for Catchment Hydrology started work on developing a stable modelling platform supported by professional software engineering. This work has been accelerated since the establishment of the eWater CRC. Now an extensive modelling platform together with a range of complimentary models exists. Work is underway to accelerate development of the key “River Manager” package which will, after trialling, replace many of the existing modelling platforms in the Murray Darling Basin.

This report considers two general types of models:

- Enterprise Models. These are models that agencies use to support their day to day operation. They are large and complex and once developed generally remain in service for 15 to 25 years. Models such as IQQM, BigMod, and REALM all fall into this category.
- Utility Models. These are models that agencies use to deal with issue specific activities. Some are used regularly while others are only used to inform policy and programs and are then archived.

It will be important that in the future there is the ability to link many of the utility models to the larger enterprise models particularly to inform future planning. This has been the basis of all recent developments within the CRC eWater portfolio. There are also significant efficiencies to be gained if the one modelling architecture can be used for the four main functions of any enterprise model. They are:

Planning ⟺ Management/operations ⟺ Accounting ⟺ Forecasting

One modelling architecture

This report examines the following issues:

- How are models used now to inform policy and practise?
- What is needed in the future?
- Current activity on model development
- Science and knowledge gaps
- Capacity building and training
- Custodianship and Governance
- Resourcing need to sustain the modelling effort

This is the basis for determining the form of a National Hydrologic Modelling Strategy.

1.2 Changing Water Management Situation in Australia

Australia has the highest variability of rainfall of any continent. This has resulted in Australia constructing water storages to provide a reliable supply to its population and Australia now has the highest storage per capita of any country. This has resulted in significant changes to the downstream hydrology and environmental outcomes.

Over the past few decades there has been a growing concern about the future reliability of these supplies given predicted climate change for the future. Also the need to sustain our rivers has been at the forefront of community and government thinking and this agenda is still developing and evolving as new information becomes available.

Over the coming decades, climate change and increasing water scarcity will require that governments and communities remain focused on understanding and managing water. Given that Australia has a relatively small population of 21 million and a large water management area it is important that we deal with these challenges in the most efficient and effective way. Hydrological modelling is a mission critical tool in the management of water resources, but is technically challenging to do well and a skill base for it is difficult to sustain in a tight labour market.

The state agencies, together with the Murray-Darling Basin Commission, all have a long history in the use of hydrologic models to inform planning, operations and accounting for their water resources. Over the past 15 years or so there has been a significant reduction in the overall capacity in Australia in the area of hydrology and hydrologic modelling. Yet now more than ever there is a need to predict the hydrologic consequences of climate change and land use change on our diminishing water resources.

The major drivers impacting on water management agencies are:

- scarcity and competition for water will continue to increase, hence the pressure on water allocation decisions, and the science and data that underpins them, will escalate

- climate change predictions increase uncertainty and risk for water allocation and management
- a recognition that the environment requires formal water provision and may be inadequately provided for at present.
- an increased role in water management and policy setting for the Commonwealth, especially in the Murray-Darling Basin
- emerging need to support capacity building in the relevant Commonwealth agencies
- the possible development of water resources in northern Australia, and the need for good policy, management and science to underpin this
- the policy and management complexity that all these issues bring is driving demand for better forecasting models and decision tools, both in the public and private sectors
- skills shortages especially graduate engineers
- the continuing need for high quality, integrated science to support the defensibility of public policy and management decisions

As a result of these drivers all state agencies and the Murray-Darling Basin Commission are looking for ways they can effectively maintain their modelling effort. The Commonwealth now has three management groups who have a need for a stable modelling environment. These are the National Water Commission with its responsibility to audit compliance with the COAG Water Reform Agenda; the Bureau of Meteorology as it implements the 4 pillars of its water information agenda and the Murray-Darling Basin Authority as it assesses the future Cap on water use in the Basin.

In addition to the public sector groups at both Commonwealth and state levels there is also significant demand for enhanced modelling through the consulting industry and the major water utilities (such as Sun water).

2. MODEL DEVELOPMENT

2.1 Current Water Modelling Environment in MDB States

The Murray-Darling Basin Commission and the states of New South Wales, Victoria, Queensland and South Australia have in place competent enterprise models for their business. These models have all evolved since the 1980s. While the models are competent their foundations are now old and are not readily converted into a "modern" format. Given this and the emerging needs to incorporate new understandings in the models many water and catchment management agencies have been active in supporting and collaborating on new modelling platforms through the eWater CRC.

The CRC for Catchment Hydrology (CRCCH) developed a common open access model architecture, TIME, to underpin catchment modelling. This was a significant step toward models that had a common operating platform, linked fully with each other, and were independent of any propriety platforms. The CRCCH developed the TIME platform to build many utility models especially in the area of catchment hydrology, rather than river or basin scale hydrology. Their delivery of models through the Catchment Modelling Toolkit (see Appendix 4) shows the strength of demand for new models and the benefits of developing a community of practice of common model development in Australia. The toolkit has nearly 10,000 members and there has been 57,000 downloads of individual tools. Access to the toolkit is via the web (www.toolkit.net.au). While the majority of the interaction with the toolkit is from Australia over 25% of downloads are from international groups and individuals. The TIME framework is also being used by CSIRO to support a broader range of tools beyond the scope of CRCCH or eWater CRC.

eWater CRC superseded CRCCH and took responsibility for further development of TIME. Most importantly it has taken the success of a modern common modelling platform and applied it to develop a new generation of enterprise level models. These build upon the utility models developed earlier but are much larger and more sophisticated models. They aim to replicate all current functionality of enterprise models and provide much additional functionality in a common platform. eWater CRC has recently accelerated their model development, with increased Commonwealth support from DEWHA and the NWC over the next three years. The major new issues that are progressively being incorporated in the models are:

- Climate to hydrology so that the impacts of climate change can be effectively evaluated;

- Ecology so that the impact on ecology of various flow regimes can be evaluated;

- The incorporation of groundwater into the modelling base so that there is an effective planning and management tool for all of the water resources in a catchment.

- Water trade, ownership and demand functions

For these new models to be adopted into the business of water managers they require a higher level of verification, implementation support, training, and ongoing commitment to development than was provided in the utility catchment models of CRCCH. The CRCCH experience shows that as such technology is developed there is strong demand. The future need is to ensure that the implementation and support of the technology into enterprises is adequately resourced and governed. The more stringent user requirements of an enterprise model mean that professional support and development needs to be secured for at least a decade.

While all of these matters are under active development within the eWater portfolio their ongoing development is constrained within the limits of the budget of the CRC, its lifespan of seven years and the breadth of need of its 45 partners. The eWater CRC is in its third year and is attracting additional resources because of the increased urgency to move the models from the development phase to the fully operational phase. This shows a need to focus resources in future not just on model development, but their testing to users enterprises, and to professional application and training

All of the major water management agencies continue to maintain and, where appropriate, develop their existing software suites. NSW will continue to maintain IQQM but are looking for the new River Manager product from eWater to supersede it. The Murray-Darling Basin Commission has taken the same view. Victoria continues to use REALM and again would not migrate to a new modelling base until it has been successfully trialled.

It should be noted that a common and modern modelling architecture does not mean a single model that everyone is compelled to use. It is a range of compatible and interchangeable modules that reflect individual user needs.

Recently the Commonwealth has approved the acceleration of the development of the "River Manager" component of the modelling suite so that it will be available to support the roll out of a new Cap in the Murray-Darling Basin. While eWater will complete its seven year term in 2011 they have made the following assessment of what will warrant success for them at both 2011 and beyond 2015.

The major eWater tools that will be developed during its seven years of operation are:

- Water CAST – catchment runoff, water quality and management
- River Manager - rural water management
- Urban tools – for integrated urban water management and water sensitive urban design
- Environmental flows and restoration tools

Details of these tools and their development timelines are shown at **Appendix 2 and 3.**

2.2 Model Development in other States and Territories.

All the major water management agencies apply a range of utility and enterprise models to support their planning and management. Details of the models used in the other states are at **Appendix 6.**

Most of these models are a mix of in-house model development, some adoption of models from MDB States and additional commercial software as needed. There is no common approach and this makes aggregation of outputs between individual models difficult. It also means that for many agencies there is a very limited pool of people who are trained in the software development and use. Some agencies have expressed concern over the low level of support provided from in-house models such as REALM and the Catchment Modelling Toolkit. Agencies recognize that further model development is required to meet emerging management needs but most do not have the same high level of complexity and pressure on water resources as the MDB States to justify major investments in a transformational hydrological modelling platform. All agencies have indicated that they strongly support a coordinated approach to the research and development aspects of the NHMS, and the broad areas of model support and standards for model application that surround model development. They have indicated their support for the objectives of the NHMS and their willingness to participate in it. However, given the high level of past investment in and dependence upon their current enterprise models they will only transfer to a new common and modern platform when the benefits substantially outweigh the costs involved. This just show the need to take a professional and dedicated approach to new modelling platforms.

2.3 Groundwater Modelling

For some States groundwater is the major resource and in the others groundwater resources are becoming increasingly important as surface water resources become fully allocated. Groundwater modelling in Australia is in a different situation to the river modelling. There is a well established modern platform, Modflow, which is professionally supported and widely adopted across Australia. There is some use of other proprietary models as well.

While a common and modern platform is established for groundwater there is still considerable work to be done to improve groundwater modelling, with common needs expressed between States. Some States have added additional functionality around the base groundwater modelling platform, and all recognize the need for more of this type of work to address current and future needs of groundwater management. Three areas which need additional model development in groundwater are:

- recharge estimation in response to land use, land cover and climate change
- linkage of groundwater discharge to surface water systems and groundwater dependent ecosystems, and
- simplification of groundwater model behaviour for use in routine management decisions and management optimisation, including conjunctive use with surface water.

The strategy should consider how best to achieve these model developments in a way that achieves interoperability between surface and groundwater models. There may be benefits of partnering with the USGS, owners of ModFlow, to provide new tools not only for Australia but for an international market as well.

As with surface water modelling, there is a need to compliment the groundwater model platform with supporting procedures and guidelines for model use. Topics worthy of future development include:

- Criteria for deciding the appropriate level of technical assessment to support water allocation decisions. These might vary from simple recharge calculations for low priority groundwater systems to full multi aquifer model development for large and fully utilized systems.
- Input data specification. Appropriate input data such as aquifer characterization, recharge calculations and extraction rates are required to produce robust results. There are always uncertainties in the inputs, which have to be carried through to appropriate expression of uncertainty in the model results
- Model testing and calibration. As groundwater modelling grows in sophistication to include terms such as exchanges with surface water there is a matching need for new techniques to independently measure and verify the model outputs.

The strategy needs to be aware of two existing centres that provide some of the needs around groundwater modelling. The Centre for Groundwater Studies has a strong history of professional education and training in groundwater modelling, the underlying science behind and its professional application. The Australian Research Council, in partnership with the National Water Commission is establishing a Centre of Excellence in Groundwater Research and Training. The centre will focus on fundamental science of groundwater hydrology and groundwater dependent ecosystems and on post-graduate training. A national hydrological modelling strategy can facilitate adoption of the latest research into professional model practise. Both centres compliment a national hydrological modelling strategy but do not have the above topics of groundwater modelling as their core business.

2.4 Modelling Capability from the Sustainable Yields Projects

CSIRO has undertaken a detailed review of water availability across the Murray-Darling Basin, at the request of the 2006 Water Summit of Commonwealth and State Governments. That project added some additional models and model functionality to those of the State agencies. These are interim developments that will be useful within the Basin for the next two to three years before transformation to the eWater CRC model products. Similar model developments will occur in subsequent Sustainable Yields projects for Northern Australia, SW Western Australia, and Tasmania.

Appropriate management and governance of the new model capability is required for it to be adopted successfully into the agencies and for them to continue to have access to the capabilities of CSIRO and their partners who developed the models. The NHMS provides an opportunity to establish the required governance, management and resourcing to maintain the capacity.

2.5 The Bureau of Meteorology

The Bureau of Meteorology currently has an enterprise level model used for flood forecasting across Australia: ERBS. It aims to significantly advance this capability in the next few years. Through its new water information responsibilities it will also expand its water forecasting for other applications such as weekly, seasonal and climate change forecasts. The forecasting services will take advantage of significant developments being made by a joint Bureau and CSIRO push to significantly advance and unify numerical weather prediction and climate prediction. The water forecasting services will be most useful if they are fully compatible with the operational and planning models of agencies. Similarly, for its water accounting functions the Bureau will use models to interpolate and analysis water observations provided by agencies. The Bureau and the agencies thus have a mutual interest in having a common and professionally engineered platform that is used both within agencies for planning and operating with added functionality and reporting provided by the Bureau. The Bureau can also bring substantial new ICT infrastructure to host models and house water data and model assets together for efficient operation.

2.6 Private Sector/Agencies

A reasonable question to ask when developing a NHMS is why not leave it to the sector to invest in the development and roll out of new modelling environments.
The private sector uses a broad range of models to support their business. Many of the consulting groups regularly use models from the Toolkit to supplement their

activities. DHI (the Danish Hydraulics Institute) has developed and offer for commercial use a broad range of models. These models have wide application internationally and in some areas of Australia. While there is some overlap with the current models that are being developed in Australia they can largely be seen as a complimentary set of models but without some of the key features that Australia will need in the future These include climate to hydrology, Australia specific ecology and water accounting. In addition there are aspects of water planning in parts of Australia that are not well met by the DHI models.

While the private sector should be involved in the strategy and will be a key part of rolling out new models there is only limited capacity in the private sector to invest in the underlining research and development which will be fundamental to dealing with the emerging issues in Australia. The major role for the private sector within Australia is to provide model services and applications to agencies. Several agencies have outsourced hydrological modelling to the engineering service industry.

Water scarcity and the challenges posed by our hydrological variability are leading to innovation in river basin modelling and management in Australia. The Australian engineering services industry can capture many commercial opportunities internationally if we are able to put our hydrological modelling skill into a professional model architecture and support it well.

3. FUTURE NEEDS

3.1 Critical Science Gaps

To meet the identified needs of improved hydrological modelling requires sustained research and development on key components of water systems behaviour. The new understanding will need to be translated into improved model functionality for improved decision making.

The major drivers for water reform are requiring vastly improved hydrological modelling capability. Examples include the inclusion of risks to water from future climate change, ecological outcomes resulting from current and future environmental watering regimes, and the implications of trade, buybacks and infrastructure renewal on river operations. To produce hydrological models and broader water system models that represent these processes requires an improved quantitative understanding of hydrology and its consequences across Australia. For the knowledge to be useful it must inform decision making through incorporation in models that are used in the business processes of decision making, such as water planning.

The major areas of research need identified by water system modellers and by users of the models are:

- Climate change and flow forecasting
- Ecological outcomes modelling
- Economic consequences of water management
- Integration of groundwater and surface water modelling
- Urban water diversified supply, demand and waste water modelling
- Improved general model architecture and software functionality.

Climate Change and Flow Forecasting
Climate change and variability is a very active research area at present and will be for at least another decade. Climate change predictions and shorter term weather and seasonal forecasting methods will improve dramatically over that time. The hydrological modelling community needs to have deep and sustained links to climate and weather prediction to translate those predictions into hydrological forecasts and to influence climate and weather forecasting to ensure it meets the critical needs of hydrological modelling. There are significant challenges in areas of downscaling global climate predictions, understanding landscape hydrological response under a changed climate and deriving better techniques to represent current and future hydrological variability in enterprise models. Climate, weather and water modelling is an area of strength for the Bureau of Meteorology and CSIRO, who have joined capabilities in weather and climate prediction.

Ecological outcomes
There is increasing recognition that provision of environmental water may be inadequate to protect our wetlands, rivers and estuaries. There needs to be a sustained effort to quantify the condition of ecosystem assets, define their flow requirements, and describe how they would respond to changes in provision of water and to integrate environmental water into broader considerations of ecosystem health. The ecological understanding needs to be linked to surface and groundwater hydrology through description of how local flow regimes and hydraulics provide aquatic habitat and support food webs. This hydro-ecological knowledge needs to be incorporated into hydrological models to evaluate ecological objectives and consequences of water management.

Economic consequences of water management
Changes to water availability in the future will have economic consequences that could be substantial and need to be evaluated and compared to the costs of adaptation measures. This requires a better understanding of the response of industries and communities to changed water supply as well as other circumstances. Against that backdrop are the significant infrastructure and policy investments such as water buybacks, irrigation efficiency improvements and increased water trade. Models will need to include the effects of these changes on water demand and operations. Water demand modelling will also need to be responsive to changing climate and institutional drivers.

Once both ecological and socio-economic consequences of water availability are modelled well, scenarios of changed water sharing, river operations and other management options can be compared to seek optimal outcomes and identify relative costs and benefits.

Integration of groundwater and surface water modelling
Traditionally surface water and groundwater resources have been managed separately and have thus been modelled separately. With the move to joint management of the resource comes the need to integrate modelling of the two resources. There are substantial technical challenges to modelling surface water and groundwater together that will take sustained effort to resolve. These include better understanding of hydrological interactions such as how groundwater discharges into rivers and recharge from rivers responds to extraction rates, modelling recharge from floodplains and irrigation districts, modelling nutrient and salinity fluxes, and evaluating dependence of surface water ecosystems on groundwater discharge. Models should also be able to evaluate the possibilities for and benefits of conjunctive management of surface water and groundwater resources.

Urban water modelling
Most cities are moving to include new water sources that are independent of catchment runoff. These new supplies need to be part of integrated urban water system models, and will change demands on catchment water supplies. Together with changes to patterns of water use they present several new challenges for urban water management that need to be addressed in enterprise models. These include new operational requirements to deal with potential pollutants and changed concentrations of waste water. Urban water models will need to represent a greater diversity of systems and more complex supply infrastructure and operations. Urban water demand is changing, in response to pressures on supplies, new sources and to external drivers such as climate change. This will require new, more accurate, methods of modelling urban water demand on catchment supplies.

In the development of the business plan for the NHMS a detailed Research Investment Strategy will be incorporated. The Investment Strategy will determine the specific science requirements and who are best placed to deliver them. It is clear that CSIRO has by far the most significant capacity in this area and it will be fundamental to the success of the strategy that these resources are incorporated

3.2 Improved Model Architecture Functionality

There are several technological developments required to modelling platforms themselves to bring them up to modern standards. The need for a common architecture based on the most recent programming standards has already been described and is well in-hand. In addition attention should be paid to better front and back end systems around the models. Increased data requirements for models and the availability of vast new spatial data streams, from remote sensing for example, will require much improved and more automated database management. There will be an increasingly close relationship between data and models, particularly for the BOM's new functions in data management, water accounting and reporting. There will be growing demand to rapidly simulate multiple hydrological scenarios as part of adaptive risk-based approaches to water management. In turn these will require evolution of hydrological models to broader decision support systems and an ability to express complex and large output data structures as simple but powerful metrics to aid decision making and scenario evaluation.

In addition to these areas of new model functionality, there are required improvements to current model functionality. Topics that have been identified under this category include:

- finer spatial and temporal resolution in surface water and groundwater modelling to meet the needs of tighter management of water resources;
- improved hydrological representation of intercepting land uses, floodplain flows and transmission losses;
- salinity and other water quality modelling within water resource models;
- inclusion of more sophisticated operational rules, temporary trade, level of service provision, and irrigation crop demand; and
- flood forecasting, spill and event management

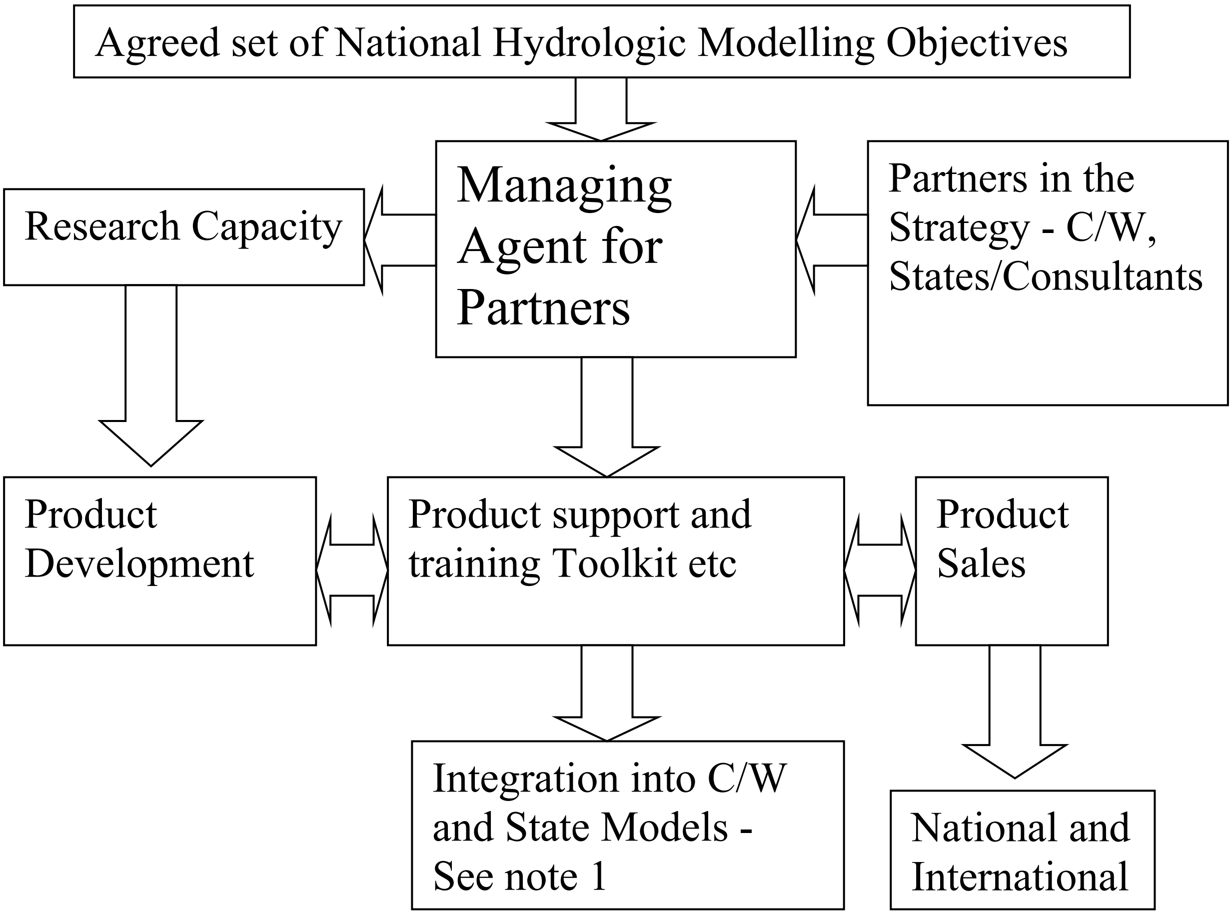
A national hydrological modelling strategy requires applied research to translate fundamental hydrological, ecological and socio-economic understanding into modelling technology, as outlined above. This is best achieved through a close relationship between model developers and those who undertake the more fundamental research on water system behaviour. CSIRO has the largest research capacity on water systems in Australia, through its Water for a Healthy Country Flagship Program. The Flagship encompasses approximately 350 staff across water ecosystems, river basin and groundwater systems, irrigation, urban water systems, and water resource information systems. The staff also link to more fundamental research on climate and weather prediction undertaken by CSIRO and the BoM in partnership.

CSIRO has recently increased its capacity in modelling of water systems. In addition to catchment river and groundwater modellers the staff now include professional software engineers, and information system engineers, and spatial modellers. The CSIRO staff provides the bulk of the hydrological model development capacity contained within the eWater CRC. Universities compliment the CSIRO capacity in some key areas, such as ecological response modelling, statistical hydrology, water economics and aspects of urban water systems. There are several collaborative arrangements that bring this expertise together, the most notable of which is the eWater CRC itself.

4. THE STRATEGY

4.1 Elements of the Strategy

The Strategy needs the elements shown in the diagram below to be effective:



Note 1. Software will be made freely available to Government partners.

4.2 The Objectives:

The following objectives have been developed to govern the design of the Strategy. These will ensure that the range of issues that would benefit from a national approach have been identified and included. They will also guide the establishment of arrangements to ensure they can be addressed in a well managed way.

Thee objectivers are:

- Common software architecture for enterprise models
- Transparent, defensible and well documented models
- Common training arrangement
- Methods and guidelines for model parameterisation, calibration, testing and application
- Access to significant research capacity
- Avoid duplication
- Collective involvement in decision making and in investment in the Strategy
- At least a ten year life to ensure delivery

- Provide the opportunity for consultants to use the material developed to support their business interests
- Ability to modify the agenda in the light of new information

4.3 Community of Practice

It is vital for the Strategy to promote a community of practice. Given the relatively small professional community involved in water modelling arrangement that enhance training, skills transfer and development will add to the efficiency of the program. The benefits of the agreed framework are maximised through leading practitioners sharing expertise formally through training and high quality documentation to support sound modelling practice. The advantage of a strategic approach to hydrologic modelling is that their will be a larger body of professional who can participate in model development because an agreed model framework has been developed and is being maintained. This provides opportunities for staff exchange and mobility. Key elements of a community of practice are engagement in the research and development agenda, common modelling platform, common training environment and structure approaches to exchanges experiences through workshops , annual conferences etc. Some of these are discussed in more detail below.

4.4 Research Capacity

To be contracted to various providers. It is critical that a long term contract (similar to a CRC) be established with CSIRO as their breadth of research capacity is fundamental to the success of the strategy. Other specific research will be contracted as necessary through universities and other specialist suppliers.

4.5 Product Development

A detailed product plan will be developed at the commencement of the strategy. The product development plan will integrate the needs of the management agencies with the capacity of the research community to deliver new information. The TIME modelling base will be fundamental to the future arrangements as it provides a stable base to build the models. An important part of the strategy will be to train a broader group of modellers in the use of TIME and to ensure that they are supported in their activity.

4.6 Governance and Custodianship

Four possible approaches each with their own set of strengths and weaknesses exist for management of the Strategy. It is critical that an appropriate management model is selected otherwise it will put at risk the delivery of the Strategy.

The four general approaches are:

- Option 1-CRC model
- Option 2-Embedded in a Commonwealth Agency
- Option 3-Incorporated joint venture
- Option 4-Unincorporated joint venture

A summary of the strengths and weaknesses of each approach is given below:

Option1-CRC developed specifically for model development and support – eWater Mark 2
Strengths
- Strong history of cooperation and development
- Brings broad range of skills

Weaknesses
- Too many partners resulting in high transactions costs
- Too much in kind support which is difficult to manage to provide timely responses
- Objectives of the CRC program not completely consistent with the required objectives

Option 2 - Locate within the BOM (or other C/W agency)
Strengths
- Has a strong interest in the NHMS succeeding given need to deliver on 4 pillars of its water business
- Will have significant hydrology capacity

Weaknesses
- Distraction from core business of implementing a major program
- Difficult to manage commercial transactions
- Any partnership with the States would be by committee and subject to a lowest common denominator behaviour.

Option 3- Joint venture between C/W and States established under appropriate legislation (Corporations law, CAC Act etc)
Strengths
- Structured approach to the partnership where role and responsibilities are clear
- Brings broad range of skills and ownership of the issues
- Supports delivery by the states
- Can manage commercial transactions

Weaknesses
- Incorporated body cements in place a long term relationship with owner which may not be to all participants liking
- Disconnect with investors could occur if management was remote from governance.

Option 4- Joint venture between C/W and states (Unincorporated and hosted by BOM)
Strengths
- Structured approach to the partnership
- Brings broad range of skills and ownership of the issues
- Supports delivery by the states

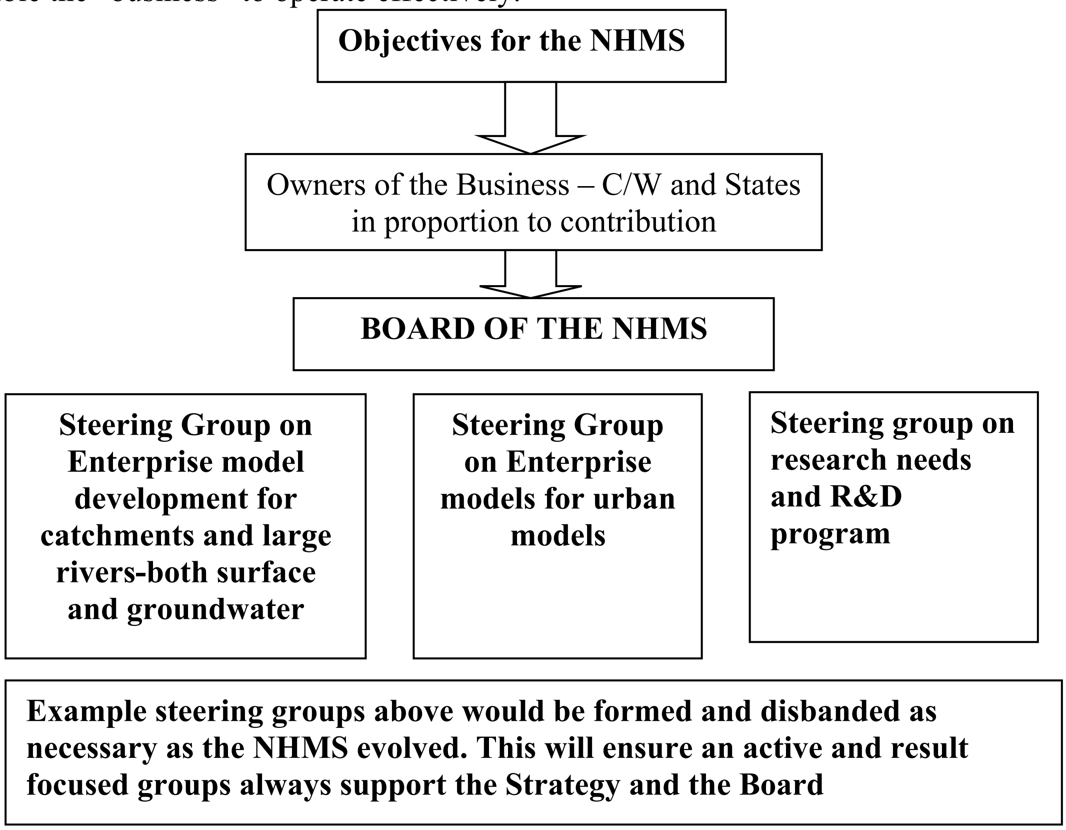
Weaknesses
- Commercial operations difficult
- Ability of partner to withdraw from joint venture
- More subject to influence from an individual partner

Given the need to manage a broad range of stakeholders and to remain focussed on product development and delivery (including a commercial component) the most efficient arrangement would be an incorporated joint venture with the Commonwealth as the majority stakeholder.

It will be the responsibility of the incorporated body to ensure that arrangements are in place for effective engagement with the states and Commonwealth agencies. The states have expressed a strong desire that each jurisdiction invests and is represented in the governing body in some way.

4.7 A suggested governance structure

A suggested structure is shown below that would enable both the effective engagement and communication with primary stakeholders to take place and also enable the "business" to operate effectively.



In the first five (5) years of the strategy the major beneficiaries will be the Australian Government through its policy agency DEWHA and operating agencies (BOM, MDBA, NWC) and all states. To ensure that the strategy has national reach while still meeting the needs of the eastern states and Commonwealth the following Board structure is suggested:

Board Composition (7 Members)

- Independent Chairman
- 2 Directors nominated by the C/W from BOM and MDA
- 3 Selected (by independent select panel) from nominations from the states.
- 1 independent with commercial business skills

This structure would be reviewed after 5 years and revised as necessary. It has the advantage of being small enough to “do business” but also having sufficient spread of Directors to enable effective communication with stakeholders.

The major misunderstanding that occurs in developing an effective structure is to consider the Board/Management arrangement as the surrogate for a proper and well resourced engagement strategy which evolves with need. This is particularly true with intergovernmental groups who often confuse the management and engagement role. Representation of each jurisdictions interests and engagement with them would occur most frequently through the steering groups, where it is intended that all major stakeholders are represented.

User engagement and management are prone to being confused in unincorporated joint ventures where management functions can degenerate into a debating club where lowest common denominator consensus can impede real progress. Improved hydrological modelling in Australia is too important and urgent to allow such an arrangement to dominate. Effective client engagement requires a strong management team that is able to understand and deliver to the needs of the owners and the broader customer base.

4.8 Resourcing

The total investment required is about $15 M/year at full implementation. For the next three years many of the roles of the strategy are provided by the eWater CRC and a smaller amount of resources are required while the CRC continues. Currently the Commonwealth and states contribute to eWater CRC, which with additional contracts for hydrological modelling brings the total investment in eWater CRC to about $15M/year. Thus the strategy can be implemented within the current Commonwealth investment profile. There will however be changes to the investment. It will need to move from the Commonwealth Department of Innovation Industry Science and Research to the Department of Environment Water Heritage and the Arts. Once the eWater CRC had completed its 7 year term then the resource could be directed to this activity effectively transferring a research and development lead activity to a strategic national approach with a significant roll out of models and support.

4.9 Structure of the National Hydrological Modelling Strategy

It is proposed that the entity itself would largely be a purchaser and coordinator of services from agencies, the research sector and the consultancy sector. The services required would be identified through close consultation with users through the various steering groups. At full operation the entity would have a staff of approximately ten covering the following business activities:

- Hydrological modelling R&D
- Professional software development and documentation
- Model platform maintenance, support and training
- Commercial sales and communication.

The main roles of staff would be in leadership, planning, contract management, coordination and reporting. Over 80% of the resources would be contracted out. The business model would be a similar to one of the rural sector research and development corporations.

4.10 Timing for implementation of the Strategy

The strategy should commence in 2009/2010, developing specific work programs, contracting the underpinning research and establishing management arrangements to broaden and compliment the work of eWater CRC. Full implementation should occur in 2010/2011 upon the completion of the eWater CRC. Ownership and governance of the enterprise model development and support functions of the CRC would transfer to the national joint venture. In the interim the eWater CRC will complete the River Manager and other suite of models and have them effectively trialled. While the eWater CRC continues the NHMS should focus on complimentary work such as groundwater model development, model applications and governance of model functionality emerging from the Sustainable Yields projects and the Bureau of Meteorology. Close cooperation is required between the NMHS and eWater CRC, which can be facilitated through common staffing in key areas such as governance.

5. CONCLUSIONS

1. There is strong support and immediate need for a National Hydrologic Modelling Strategy and if managed effectively it will put Australia in the forefront of these activities worldwide. We need to be at the forefront given our hydrology and impending climate change and other threats. All jurisdictions want to be part of a NHMS from its inception.
2. The common need is for modernisation, consistency, and improved functionality of the in-house models used in the core business operations of water management agencies. The strategy would take responsibility for developing, adopting, supporting and training in new enterprise models.
3. There are research, model development, training, capacity building, model ownership, and sales to the sector that would all deliver efficiencies to the Australian community if managed as component parts of an integrated strategy.
4. eWater CRC is currently undertaking some of these activities but is totally focussed on Eastern Australia. The CRC completes its current term in 3 years.
5. It is possible to develop the strategy and implement it over 10 years with a budget of $15M/year with a refocusing of current nett expenditure from the Commonwealth. This assumes that there is a contribution from participating States and from commercial sales.
6. The major water management agencies will use the enterprise models provided they are confident that they will be maintained for a reasonable period, significantly enhance the functionality of their current models, and will meet their needs for at least a decade. An example is the acceleration of the development of the River Manager product given the demand for its use in the MDB. Adoption of new model technology can be facilitated by effective engagement in and ownership of the technology. In groundwater management Modflow has largely been adopted as the groundwater “enterprise” model platform.
7. An incorporated joint venture is the most efficient way to manage the strategy with appropriate arrangements for effective representation, technical and policy engagement with the major stakeholders.
8. The implementation of the strategy should commence in 2009/10 and be fully implemented in 2011 to effectively take over and enhance the current eWater

CRC activity in this area. Planning will need to include ongoing management of the Toolkit, TIME, and Intellectual Property that has been developed to date, in addition to planning of ongoing development, implementation and R&D.

9. The private industry and water utilities sectors will need to be engaged in the strategy. The two main areas will be to support agencies rolling out new modelling platforms and as a purchaser of models to use both here and overseas.

Appendix 1 COAG Water Sub-group Project 5b (Water Information)

Discussion paper to inform proposed Work Package #1: National Hydrologic Modelling Strategy and Terms of Reference

Context

Over the coming decades climate change and increasing water scarcity will require that governments and communities remain focused on understanding and managing water. Given that Australia has a relatively small population of 21 million and a large water management area it is important that we deal with these challenges in the most efficient and effective way. Hydrological modelling is a mission critical tool in the management of water resources, but is technically challenging to do well and a skill base for it is difficult to sustain in a tight labour market.

The state agencies, together with the Murray-Darling Basin Commission, all have a long history in the use of hydrologic models to inform planning, operations and accounting for their water resources. Over the past 15 years or so there has been a significant reduction in the overall capacity in Australia in the area of hydrology and hydrologic modelling. Yet now more than ever there is a need to predict the hydrologic consequences of climate change and land use change on our diminishing water resources.

A significant start on this journey has already been undertaken by the work of eWater CRC, with its 45 partners (including CSIRO, universities, government agencies and consultants) and its predecessor the CRC for Catchment Hydrology. Surface and groundwater models are already been applied to new questions about the future availability of water and its uses through the Murray-Darling Basin Sustainable Yields project and subsequent assessments being requested of CSIRO by COAG. The Australian government's recognition of the importance of water is also reflected in the establishment of the Bureau of Meteorology's Water Division, with their focus on water data standards, water data management, water resource assessment, water accounting and hydrologic forecasting. The Bureau will be making substantial new investments in hydrologic modelling and seeks to align these with the needs and interests of other entities involved in hydrologic modelling.

It is now opportune, in a disciplined and cooperative way, to review the current situation regarding model development, use and maintenance and to chart a course for the future that builds on the efforts to date and is able to respond to the growing complexity of water management in Australia.

Proposal for going forward

It is proposed that this work package be performed by a consultant, with guidance by the contact group.

The purpose of this consultancy is to prepare a National Hydrological Modelling Strategy. The strategy is to be developed after consultation with key stakeholders. It should conclude with a list of actionable recommendations (including cost implications) that the Project 5b team can propose to the COAG Water Sub-group for consideration.

Scope of Work - Stage 1 (start June 9, end June 30)

During this phase the Consultant will consult with relevant stakeholders and provide a detailed outline of the Strategy to the Project 5b group.

The Strategy content should include at least the following:

- Priority uses of hydrologic models, emphasising the need to model the impacts of climate change and landuse change on the availability of water for consumptive and environmental needs
- Users of hydrologic models and their specific requirements
- Current and proposed future modelling technology, highlighting major model development programs in progress
- Critical science gaps that must be addressed to support the next generation of hydrologic models
- Training of model users and sharing of modellers across the water sector
- Arrangements for the long-term custodianship, hosting and maintenance of hydrologic models
- Resourcing

Deliverables for Stage 1 are:

1. Meetings and/or workshops with relevant stakeholders.
2. Document providing a detailed outline of the proposed National Hydrological Modelling Strategy, submitted by Monday 23 June 2008.
3. Presentation to the COAG Project 5b on Monday 30 June 2008.

Scope of Work - Stage 2 (start July 1, end July 31)

During this phase the Consultant will prepare the Strategy, taking into account input from the COAG Project 5B group and any further input obtained from stakeholders.

The Strategy should address how to align the major hydrologic modelling efforts undertaken by the eWater CRC, CSIRO, Bureau of Meteorology, MDBC and State agency modelling groups. It should conclude with a list of actionable recommendations (including cost implications) that the Project 5b team can propose to the COAG Water Sub-group for consideration.

Deliverables for Stage 2 are:

1. Meetings and/or workshops with relevant stakeholders.
2. A fully documented National Hydrological Modelling Strategy, submitted by Friday 25 July 2008
3. Presentation to the COAG Project 5b on Thursday 31 July 2008.

Requirements

The Consultant carrying out this task shall put together a small team that has extensive experience in the water industry covering direct operational and planning responsibilities and experience in delivering hydrological modelling capacity. The Consultant must have a record of effective communications and the ability to engage with a broad range of stakeholders.

Appendix 2 - eWater tools The next generation of forecasting and decision tools for the water management industry, featuring *integrated management*

FIRST VERSIONS OF eWATER TOOLS
- WaterCAST – catchment management
- RiverManager – rural water management
- Urban tools – for IUWM and WSUD
- Environmental flows and restoration tools

MAJOR TRIALS IN JURSIDICTIONS
Trial tools by applying to some of the most challenging NRM problems in SE Australian jurisdictions

INCORPORATE LATEST SCIENTIFIC ADVANCES
- Improved capability for managing droughts, climate change, reforestation
- Account for surface water AND groundwater
- Better represent complex water systems for improved solutions & more defensible decisions
- Unprecedented understanding & capacity to manage uncertainty and risk, optimise outcomes
- Seamless interoperability between tools, e.g.
  - conjunctive management of consumptive & environmental water
  - improved capacity to manage rural-urban water transfers

INCREASINGLY INTEGRATE NATIONAL DATA, TOOLS, KNOWLEDGE
- Direct links to water data geofabric being created by Bureau of Meteorology & partners
- Strong capacity to link with social and economic drivers & instruments

INCORPORATE ONGOING SCIENTIFIC ADVANCES
- Greater capacity to manage water scarcity
- Better forecasting of water quality
- Increasing ability to understand and manage trade-offs

INCORPORATE TOOLS INTO AUSTRALIAN BUSINESS FABRIC
- Australian businesses align business around standard water management tools
- International exports of tools and expertise
- Response to emergent policy challenges, e.g. reconciling energy & water use

Now	2009	2010	2011	2012	2013	2014	2015

RiverManager For sustainable water resource use in rural river systems: policy development, forecasting, planning, management and operations

V1 – BASIS FOR SINGLE PLATFORM
- RiverManager emulates existing tools
- PLUS Possible to create interoperable models across the MDB and other large Basins

GREATLY ENHANCED CAPACITY TO MANAGE RURAL WATER
- Conjunctive management of – surface-water and groundwater
  – consumptive and environmental water
- Improved capability for managing droughts, climate change, reforestation
- River planners, managers, operators can work from same knowledge base
- Explicitly characterise and manage risk & uncertainty, optimise outcomes
- Initial water quality enhancements (e.g. for managing salinity)

ROLL OUT IN MDB
Roll out in valleys of the MDB (extent subject to external investment)

BASIN PLAN
Scenario analyses to support formulation of MD Basin Plan

GO INTERNATIONAL
Contract trial in an international river basin

FURTHER INTEGRATE DATA, TOOLS, KNOWLEDGE
- Direct links to water data geofabric being created by Bureau of Meteorology & partners
- Strong capacity to link with social and economic drivers
- Increasing integration & optimisation of management, e.g. environmental & human water demand

INCORPORATE LATEST SCIENTIFIC ADVANCES
- More sophisticated management of water quality
- Better estimates of water quantity & demand, effects of climate

INCORPORATE INTO AUSTRALIAN BUSINESS FABRIC
- Accreditation of planners, managers and operators based on RiverManager expertise
- Australian businesses align business around RiverManager modelling base
- Export of RiverManager technology to international river basins
- Respond to emergent policy challenges

Now	2009	2010	2011	2012	2013	2014	2015

WaterCAST Management of rural and peri-urban catchments to improve water quality & quantity in receiving waters

IN MARKET
Tool in use in Australia & overseas

ENHANCEMENTS
- Improved forecasting of droughts and climate variability/change
- Includes surface-water AND groundwater
- Captures the effects of farm dams
- Can now be applied in both small and large catchments

APPLY TO BIG PROBLEMS
Trial improvements by applying to some of the most challenging NRM problems in SE Aus jurisdictions

BETTER MANAGE CLIMATE, POLLUTANTS
- Able to forecast the effects of climate change on streamflow and water quality at a local scale (with the joint CSIRO-BoM WIRADA initiative)
- Improved capacity to forecast the effects of roads & point source pollution & make local remediations
- Improved capacity to reduce sediment deposition in channels and water quality in receiving waters
- Better characterisation of uncertainty in predictions
- Seamless links to ecological restoration tools

FURTHER INTEGRATE DATA, TOOLS, KNOWLEDGE
- Direct links to water data geofabric being created by Bureau of Meteorology & partners

INCORPORATE LATEST SCIENTIFIC ADVANCES
- More accurate predictions of water quality and the effects of passage through rivers & storages
- Better estimates of the effects of climate

INCORPORATE INTO AUSTRALIAN BUSINESS FABRIC
- Ramp up international exports
- Australian businesses align business around RiverManager modelling base
- Respond to emergent policy challenges, e.g. nexus between carbon trading & water mgmnt

Now	2009	2010	2011	2012	2013	2014	2015

Urban water tools Promoting integrated urban water management – at lot to regional scales – for better water security & environmental values

V.1 – WSUD, WATER SECURITY, POLLUTION
- Lot to suburb to city-scale water sensitive urban design
- Evaluation of infrastructure options
- Management of regional water security & pollution to receiving waters
- Integrated urban-rural water management

APPLY TO BIG PROBLEMS
Trial improvements by applying to some of the most challenging NRM problems in SE Aus jurisdictions

BETTER INTEGRATED URBAN WATER MGMNT
- Improved predictions of urban water demand
- Better represent complex urban water systems for improved urban designs and more defensible decision making.
- Greatly enhanced 'decision functionality': explicitly estimates and ways to manage uncertainty & risk, and to optimally operate water supply systems
- Initial links to ecological restoration tools
- Improved capacity to manage rural-urban water transfers

FURTHER INTEGRATE DATA, TOOLS, KNOWLEDGE
- Direct links to water data geofabric being created by Bureau of Meteorology & partners
- Strong capacity to link with social and economic instruments, e.g. individual rights to urban water

INCORPORATE LATEST SCIENTIFIC ADVANCES
- Increasing capacity to manage water supply from non-rainfall dependent resources, including recycling
- More effective ecological management of urban streams

INCORPORATE INTO AUSTRALIAN BUSINESS FABRIC
- Begin exporting internationally
- Australian businesses align business around urban tools
- Respond to emergent policy challenges, e.g. reconciling energy & water use

Now	2009	2010	2011	2012	2013	2014	2015

Appendix 3 – Forecasting and Decision Tools for Water Management

eWater CRC	**Forecasting and decision tools for water management**

FEATURES

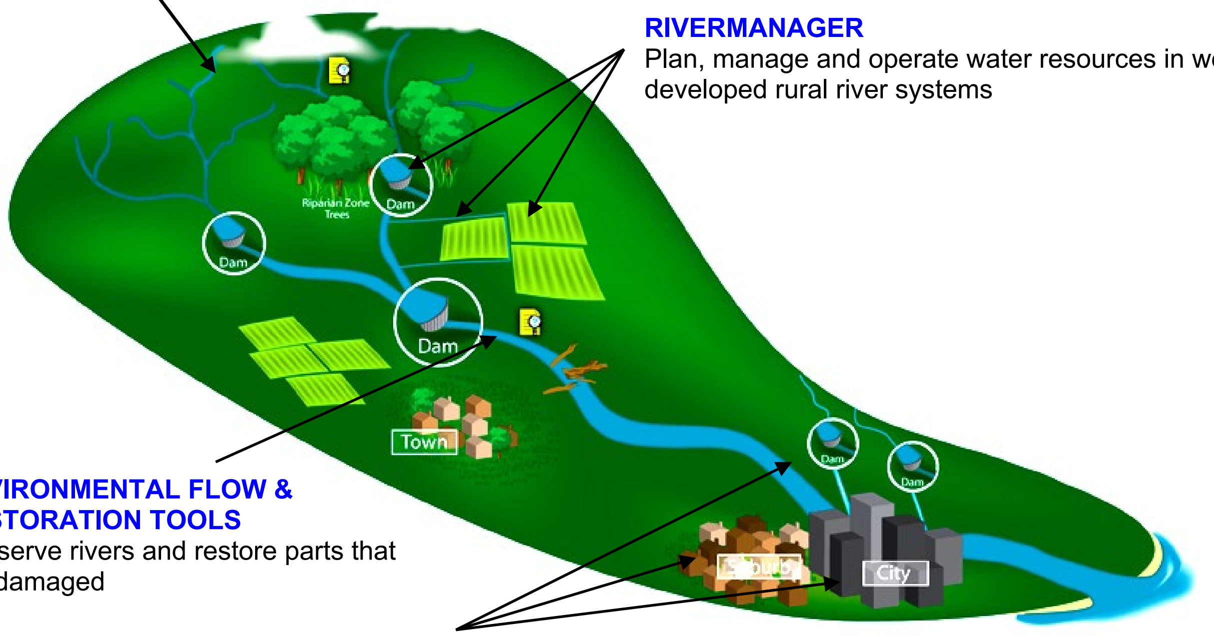
- Can be applied at local, catchment, basin and interbasin scales
- Tailored to integrated water management
- Advanced ability to be customised by users

TYPES OF TOOLS

- Frameworks for decision support
- Numerical forecasting models
- Searchable e-archives, e-libraries
- Web information portals

WATERCAST
Forecast and manage stream water quantity and quality and the effects of catchments on streams

RIVERMANAGER
Plan, manage and operate water resources in well-developed rural river systems



ENVIRONMENTAL FLOW & RESTORATION TOOLS
Conserve rivers and restore parts that are damaged

INTEGRATED URBAN WATER MANAGEMENT TOOLS
Conjunctively manage all the parts of the urban water cycle at a lot, suburb, city and regional scale, and promote water sensitive urban design

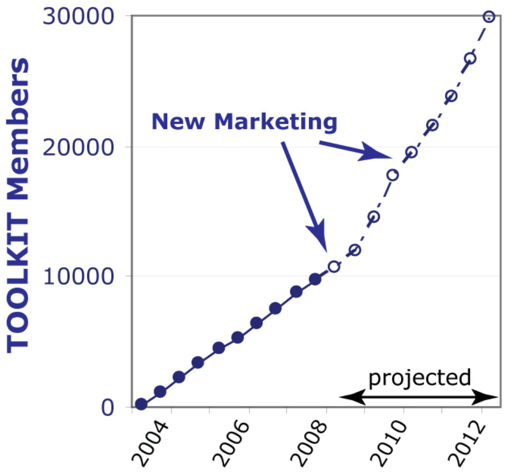
Appendix 4 – Catchment Modelling TOOLKIT

Catchment Modelling TOOLKIT

www.toolkit.net.au

The Catchment Modelling Toolkit (TOOLKIT) is a web 'shopfront' for advanced water resource forecasting and for management tools developed by Australia's leading scientists and engineers. These software tools are used by water management professionals, scientists and decision makers tackling a broad range of water resource problems.

Established in 2003, the TOOLKIT has nearly 10,000 members, indicating high industry recognition and an established water industry community. Membership provides users with access to tools, tool upgrades, support and training.



Tools

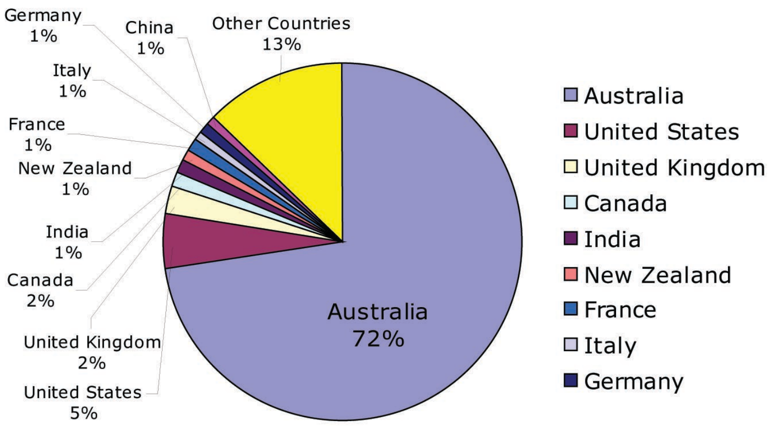
This 'shopfront' provides a gateway for access to 25 tools with relevance to both the Australian and international markets. Members have now downloaded more than 57,000 individual tools.

Features of the TOOLKIT site

- Tool downloads
- Supporting information for tools
- Highlights best practice in application and science
- Information regarding tool training
- Forums for discussion of tools

TOOLKIT visits

- 2,700 website visits/month
- 16,000 pages viewed/month
- Visitors from 151 countries (28% of all visits outside of Australia)



The future of the TOOLKIT

We aim to make the TOOLKIT an integral part of water business and technology, both within Australia and overseas, and the premier public platform for water tools.

Planned improvements include:

- Expansion from catchment modelling to include broader water management, forecasting and science
- Web services (tools hosted on a central server rather than downloaded)
- User Forums – discussions on water management and science within the water industry community
- Increased market presence – enhanced role in facilitating a community practice.

Appendix 5 – TIME Software Development Framework

TIME is a modern, software development framework for creating, integrating and delivering environmental simulation models. TIME has been used to develop the linked catchment and river systems models that underpin the eWater product offerings. TIME has been developed locally, for the Australian catchment modelling context and as such has a user interface tailored to the local user base, a development interface tailored to the local modelling skill set and a simulation environment tailored to the spatial and temporal data demands of Australian models.

TIME includes tools for the management, manipulation and visualisation of environmental data, as well as capabilities for testing, integrating and calibrating simulation models. TIME includes a range of generic support components for reporting and scenario management and archiving. TIME is scalable, with support for large spatial and temporal data sets, and the ability for parallel processing of large studies. Combined, this allows TIME based models to be presented through a professional user interface that facilitates training and uptake by jurisdictions.

TIME is available for use by modellers who program in one of a range of programming languages, allowing the eWater tools to be extended by agencies to suit their local requirements. Modellers with a basic level of programming skill can be trained in the development and extension of TIME models in under one week, while professional software developers have the flexibility within the framework to create sophisticated standalone or web based modelling applications.

Current development includes expanding the optimisation capabilities within TIME and developing new capabilities for the quantification and presentation of uncertainty and risk elements in models.

Appendix 6- Enterprise Models

State	Major Enterprise Models	Type	Functionality
Queensland	IQQM Modflow WATHNET	In-house (from NSW) Commercial	River planning model Groundwater model
NSW	IQQM ModFlow WATHNET CatSalt/2Csalt	In-house Commercial Catchment Modelling Toolkit	River planning model Groundwater model
ACT	REALM IGGM	In-house (from Vic) In-house	Planning and operations
Victoria	REALM PRIDE	In-house In-house	River planning model Irrigation water demand
Tasmania	HYDSTRA GMS Resource Modelling Associates (RMA)	In-house Commercial Commercial	River planning and operations model Groundwater Operations
South Australia	Watercress MSM-BigMod ModFlow MIKE SHE, MIKE 11	In-house Commercial	Catchment water yield River operations and planning Groundwater Flood hydraulics
Western Australia	PRAMS (ModFlow) MIKE Basin REG75	Commercial, In-house Commercial	Groundwater model
Northern Territory			
Murray-Darling Basin Commission	MSM Big-Mod	In-house In-house	River management including salinity