Review of the Urban Water Security Research Alliance Research

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Urban Water Security Research Alliance

The Urban Water Security Research Alliance (UWSRA) is a $50 million partnership over five years between the Queensland Government, CSIRO's Water for a Healthy Country Flagship, Griffith University and The University of Queensland. The Alliance has been formed to address South East Queensland's emerging urban water issues with a focus on water security and recycling. The program will bring new research capacity to South East Queensland tailored to tackling existing and anticipated future issues to inform the implementation of the Water Strategy.

For more information about the:

UWSRA - visit http://www.urbanwateralliance.org.au/
Queensland Government - visit http://www.qld.gov.au/
Water for a Healthy Country Flagship - visit www.csiro.au/org/HealthyCountry.html
The University of Queensland - visit http://www.uq.edu.au/
Griffith University - visit http://www.griffith.edu.au/

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We would also like to thank Dr Judi Hansen for her valuable comments on the report.

FOREWORD

Water is fundamental to our quality of life, to economic growth and to the environment. With its booming economy and growing population, Australia's South East Queensland (SEQ) region faces increasing pressure on its water resources. These pressures are compounded by the impact of climate variability and accelerating climate change.

The Urban Water Security Research Alliance, through targeted, multidisciplinary research initiatives, has been formed to address the region's emerging urban water issues.

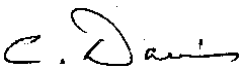
The Alliance is a partnership between the Queensland Government, CSIRO's Water for a Healthy Country National Research Flagship, The University of Queensland and Griffith University. It brings new research capacity to SEQ, tailored to tackling existing and anticipated future risks, assumptions and uncertainties facing water supply strategy. It is a $50 million partnership over five years.

Since October 2007 when the Alliance was formed, the water situation for SEQ has changed dramatically. The Alliance has responded accordingly to realign its research program, with a greater focus on reducing water grid demand, ensuring the quality of our diverse water sources and planning for efficiency and sustainability.

The Management Board decided it was timely to undertake a strategic review of the research program to ascertain whether the Government priorities have been met and to identify the need for further research. Dr Gary Bickford, Nestis Consulting and Mr Rod Lehmann, Water Strategies, were commissioned to undertake this review.

This report summarises the results of this review, the benefits of the research and identifies the value the research partners have provided to assist the Government in securing the water supply for SEQ. The report has also assessed the applicability of this research more broadly to Queensland as well as other jurisdictions. The further research needs identified in this report will help guide consideration by the Queensland Government of priorities for future urban water research.

Technical reports and publications summarising the output from the Urban Water Security Research Alliance and additional information about the Alliance can be found at http://www.urbanwateralliance.org.au/about.html.



Chris Davis
Chair, Urban Water Security Research Alliance

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Glossary of Acronyms

ADWG	Australian Drinking Water Guidelines
AWTP	Advanced Water Treatment Plant
CEO	Chief Executive Officer
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DERM	Department of Environment and Resources Management
DIP	Department of Infrastructure and Planning
DLGP	Department of Local Government and Planning
DRO	Desired Regional Outcomes
GL	Gigalitres
HWN	Healthy Waterways Network
IPA	Integrated Planning Act
IPCC	International Panel on Climate Change
IQQM	Integrated Quantity and Quality Model
L/p/d	Litres per person per day
ML	Megalitres
NDMA	*N*-Nitrosodimethylamine
NRM	Natural Resource Management
PRW	Purified Recycled Water
QCA	Queensland Competition Authority
QDC	Queensland Development Code
QWC	Queensland Water Commission
SCADA	Supervisory Control And Data Acquisition
SEQ	South East Queensland
SEQIPP	South East Queensland Infrastructure Plan and Program
STP	Sewage Treatment Plant
THM	Trihalomethanes
UWSRA	Urban Water Security Research Alliance
WSAA	Water Services Association of Australia

EXECUTIVE SUMMARY

Key Findings

- The Urban Water Security Research Alliance is delivering a comprehensive research program that addresses the key urban water security challenges in SEQ.
- The outcomes of the research are of direct relevance to water policy makers and planners in SEQ and can be adapted throughout Queensland and in other jurisdictions.
- The results of the research are available through publication of papers in refereed journals, books and reports.
- Stakeholders believe that the Alliance has been a suitable model for the delivery of this research program and provided an effective avenue for resource and information sharing amongst researchers.
- Further synthesis of the research findings within and across the themes can provide additional value to the Queensland Government.
- Knowledge transfer of the research outcomes to Queensland Government agencies must be a priority to maximise the benefits of the research.

The Urban Water Security Research Alliance was formed in 2007 to address South East Queensland's (SEQ) emerging urban water issues and, in particular, water security in the face of prolonged and severe drought. It is a $50 million partnership over 5 years between the Queensland Government, CSIRO, the University of Queensland and Griffith University. With combined dam storage levels dropping, the focus of the Alliance was initially on water supply and recycling. Due to significant rainfall in 2009, a review of the Alliance was conducted and the emphasis refocused on water security more generally.

In June 2011, the Alliance Board commissioned a strategic review of the research program to ascertain whether the Government priorities have been met and to identify the need for further research. This report summarises the results of this review.

The outcomes of the research to date can be summarised under four key areas:

- Making infrastructure more effective
- Managing a diverse supply portfolio
- Reducing per capita water use
- Water sensitive cites

Making Infrastructure More Effective. The Alliance recognises that it is imperative to use infrastructure as effectively as possible to delay future investment, while accommodating future population growth and the impacts of climate variability or climate change.

Although drought is not uncommon in SEQ, it was unclear whether the recent drought was due to early impacts of climate change. The Alliance has identified that while the recent drought was in the normal bounds of rainfall variability experienced in SEQ, other factors such as increased temperature and evaporation, together with reduced runoff could have been impacted by climate change. Preliminary research has indicated that yield of water storages will reduce by 10% by 2050 due to increased temperature and evaporation as a result of climate change. Ongoing work should significantly improve the reliability of this estimate and provide better guidance as to the likely changes at intermediate time steps. The research has resulted in more detailed predictions of climate change impacts at sub-catchment scales – currently 15-20 km grids. This research is being incorporated into water supply models by the Department of Environment and Resources Management (DERM) to predict the impact on storage yield for various climate change scenarios. This modelling will enable a more accurate prediction of the timing and size of future supply augmentation. It will provide a basis for determining the best mix of climate dependent (water storages) and climate

independent (such as purified recycled water and desalination) sources. The outcomes of the DERM modelling will enable the Queensland Water Commission to revise the SEQ Water Strategy based on more detailed information.

Effective use of infrastructure includes sound management of the existing water storages. A key aspect affecting storage performance is the rate of evaporation. The Alliance has developed a new tool to better predict evaporative losses from large storages, particularly under drought conditions. The research has also found that there is no technology as yet commercially available for cost-effective evaporation reduction from large storages.

Research was undertaken to determine the efficacy of reservoirs and receiving water bodies in removing microbial pathogens and trace organic compounds. Ongoing research aims to identify the source and persistence of pathogens using specific tracking techniques. The outcomes of this research will help guide the design of suitable treatment processes for water treatment, stormwater use and catchment management practices.

A new and sophisticated sensor tool has been developed to enable real-time monitoring of water quality in the sewerage network and the wastewater treatment plants to identify wastewater anomalies. Additional trials are now anticipated with water utilities to develop this new monitoring system. Research assessed whether hospital waste discharges into the sewerage system would impact the quality of purified water. The research has found this is not the case and critically, the research has developed methodologies that can be implemented to monitor licensed discharges into the sewerage network.

Managing a Diverse Supply Portfolio. The Alliance has undertaken research to optimise the management of a diverse water supply portfolio that includes water supply reservoirs, desalination and purified recycled water. It has also conducted a range of studies into smaller, decentralised water systems that include rainwater tanks.

The operation of the Water Grid will result in the mixing of water from a variety of sources in the distribution system and the potential for disinfection by-product (DBP) formation. DBPs may have human health implications if concentrations exceed guideline levels. The research has found DBPs are unlikely to be a concern from current treatment plant operations when chloramination is used, but may be a problem where chlorination is practised. Further research is needed to determine opportunities to mitigate DBP formation through plant operational changes or treatment improvements. Research into the potential formation of DBPs at the purified water plants has also been undertaken. The research found that changing the dosing point and contact time of chloramine reduced DBPs below guideline levels and these procedures may reduce operating and treatment costs.

During the drought, the Government embarked on a policy to provide subsidies to install rainwater tanks in households as a measure to further secure the regions water supply with savings estimated to be 36,000 megalitres per year by 2026. The Alliance has completed research to confirm water savings achieved by rainwater tank use, rainwater tank operation and water quality considerations. Rainwater tank yield depends on climate, roof area connected, and the extent of use of water efficient household appliances, waterwise awareness and water use behaviour in the household. The Government's policy anticipated that some 70,000 litres of savings per household per year would be achieved each year from rainwater tanks in detached houses. Through research into a limited number of households the average annual capture is likely to be 58,000 litres per household, noting that the overall water per capita consumption in the region has also fallen. The maintenance costs and energy use of the pumps associated with rainwater tanks represents a significant cost to the householder. Further research is required to establish optimum operating configurations for pumps. Pathogens were found in rainwater tanks, which validates the Government's policy that rainwater tank water in urban areas should not be used for potable consumption (unless it is effectively treated) and systems must be appropriately maintained to ensure ongoing protection of public health. Further evaluation of the costs of rainwater tanks compared to other supply options is a priority research project. A synthesis of the rainwater tank research is required.

Reducing Per Capita Water Use. A key aspect in managing future water supplies and accommodating increasing population is to understand how water is being used in and around the home, so policy and education programs can be well targeted. An advantage the Queensland Government has obtained by establishing the Alliance is the ability to share knowledge, ideas, thinking and research skills across research disciplines. The integration of social science and engineering research has highlighted the need to educate customers about water savings through better-targeted campaigns. Knowledge gained on how customers use water inside the home provides better information for developing water conservation programs and the likely savings from subsidies.

Water Sensitive Cities. With increasing population growth, urbanisation and climate change, there is a need to integrate water management approaches into the urban fabric through planning, policy and influencing consumer behaviour. The concept of water sensitive cities includes managing a diversity of water sources, recognising the role of the natural environment in maintaining and enhancing the quality of the built environment and the role of community preferences and consumer behaviour. Research in this area has recently commenced with a review of the concepts as they may apply in SEQ.

Cost Effectiveness and Capacity Building. The existing research program has provided good value for the Government, through substantial leveraging of its investment, realising some $38 million in research dividends from the $19 million invested to date. The review has highlighted the need for better engagement in the research program across Government agencies. While DERM, QWC and Queensland Health have been specific beneficiaries to date, other agencies may also benefit, such as the Department of Local Government and Planning. There is a need for the Alliance to synthesise the research outcomes and work closely with Government personnel so the knowledge gained is incorporated into planning and policy development.

Increased capacity has been developed in the research community, 36 additional full-time research positions, including 6 PhD studentships, have been created and filled in SEQ.

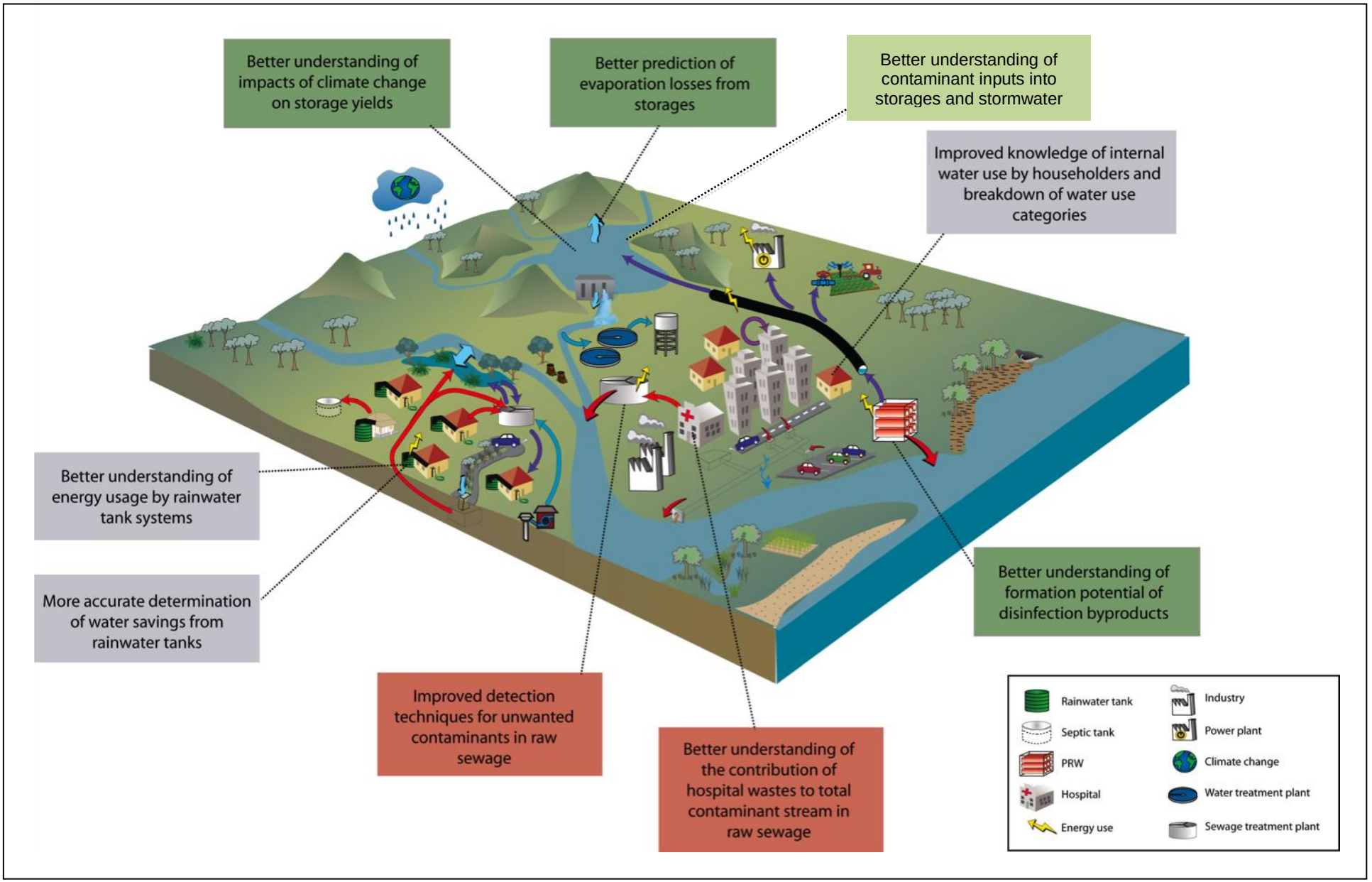
While the Alliance has played a valuable role in delivering scientific inputs which inform water policy for SEQ, pressing research questions remain and the Alliance could continue to address these issues. The Alliance has the demonstrated capacity and flexibility to address new issues bought about by the transition from drought conditions to flooding. The Alliance is well placed to focus on new challenges that the Government might face through changing climatic conditions or new information such as recommendations in the interim report into the flooding downstream of Wivenhoe Dam.

Future Research Needs:

Future research must be articulated by Government, water utilities and the Alliance to respond to the uncertainties associated with climate change, population growth and water demand. Some areas for additional research are:

- Climate change
- Decentralised system (including stormwater harvesting)
- Portfolio management of diversified supplies
- Economics of future supply options
- Cities of the future.

Figure 1. Schematic showing how the UWSRA has contributed to better urban water policy and planning in SEQ.



Thanks to Emily Saeck from Griffith University and Healthy Waterways Partnership for the production of the diagram.
2010. International Water Centre. SEQ Total Water Cycle Management Conceptual Diagram. Science-Policy Integration workshops.

1. BACKGROUND

The Urban Water Security Research Alliance (the Alliance), the largest regionally focused urban water research program in Australia, was established in 2007 to address SEQ emerging urban water security issues with a focus on water security and recycling. The Alliance is a $50 million partnership over five years between the Queensland Government, CSIRO's Water for a Healthy Country Flagship, Griffith University and The University of Queensland. The State Government provides $5 million to the Alliance each year, with a matching contribution from the research partners. The Alliance aims to bring new research capacity to SEQ, tailored to tackling existing and anticipated future challenges and inform the implementation of the SEQ Water Strategy.

To respond to continuing drought, projects were developed by the Alliance around the key research areas considered important in 2007. The research areas included water recycling, informed decision making and management of future water supply.

Since the Alliance was formed, the urban water situation for SEQ has changed dramatically, including:

- the positive demand response to the recent drought by the community;
- improved rainfall conditions filling the water supply storages to capacity;
- the decision by the State Government to supplement the grid water supply with purified recycled water only when the combined storage capacities fall below 40%; and
- the decision by the Commonwealth Government not to approve Traveston dam.

In light of these changes, the Alliance research program was reviewed in 2009 and the research priorities reassessed. As a result of the review, the program now consists of 17 inter-related projects delivered across three research themes with a greater focus on reducing Water Grid demand, ensuring the quality of the diverse water sources and planning for efficiency and sustainability. The three research themes are:

Research Theme 1 –	Reducing Water Grid Demand
Research Theme 2 –	Water Source Quality
Research Theme 3 –	Total Water Cycle Planning and Management to Enhance Sustainability and Efficiency

The Alliance Board has requested a strategic review of the performance of the Alliance.

1.1. Review Terms of Reference

The Alliance has completed more than three and a half years of its research program and has approximately 18 months to complete the initial phase. The parties can also agree to an extension of the program by two years.

The Alliance believes that it is timely to engage a suitably qualified consultant to provide a strategic review of the research that has been undertaken to date. The outcome of this review is to provide an "in-confidence" report that summarises the benefits of the research and identifies the value the research partners have provided to assist the Government in securing the water supply for SEQ.

Publications by the Alliance have been made available to the consultant as an input to the review. The consultant has also interviewed Alliance researchers and other stakeholders. Alliance partners have assisted the consultant by arranging meetings and providing research summaries and commentary detailing how the research projects have contributed to the overall objectives of the Alliance.

The review has assessed the links of the research conducted by the Alliance to various Queensland Government initiatives, such as Queensland Research and Development Investment Strategy and the SEQ Natural Resource Management Plan 2009–2031 and the SEQ Regional Plan 2009-2031. The review has also assessed the applicability of this research to Queensland as well as other jurisdictions.

1.2. The Alliance

1.2.1. Initial Research Programs

Initially, research by the Alliance was to be delivered through ten projects across three major research themes. A fourth theme was for contestable projects that were selected based on submissions made during the program. The themes were:

Closing the Loop

1. Purified recycled water reliability and safety
2. Stormwater Harvesting and Use - Identification of opportunities in SEQ
3. Decentralised Systems

Informed Decision Making

4. Systematic social analyses of how community values alternative water supply options
5. Institutional Change for Water Management in SEQ

Managing Our Future Water Supply

6. Climate change impact assessments
7. Life cycle assessment and system analyses
8. Water information management and integrated monitoring
9. Water loss reduction
10. Enhanced water treatment practices

Contestable Funded Projects

11. NDMA Formation Potential in PRW
12. Disinfection by-product (DBP) formation and minimisation in drinking water
13. Implications of using Purified Recycled Water as an adjunct to groundwater resources for irrigation in the Lockyer Valley
14. SEQ residential water end use study

1.2.2. Revised Research Plan

In 2009, a review was carried out to ascertain the need for any changes to the research program as a result of the urban water situation in SEQ and in particular the breaking of the drought. Following the review, the program was modified at that time to better reflect the prevailing issues of concern in regard to water supply. The following themes were then adopted:

Research Theme 1 – *Reducing Water Grid Demand*

Objective: Undertake research into off-Grid supply sources, water use efficiency and demand management behavioural measures to reduce demand on the SEQ Water Grid by about 35 GL per annum in 2026 and defer new infrastructure by up to five years.

Research Theme 2 – *Water Source Quality*

Objective: Undertake research to inform water quality management planning, regulation, guidelines and communication on the nature and level of risk to human health from a wide range of source waters within the SEQ Water Grid.

Research Theme 3 – *Total Water Cycle Planning and Management to Enhance Sustainability and Efficiency*

Objective: Undertake integrated urban water planning and management research to transform to a water smart SEQ region and enhance management efficiencies of the SEQ Water Grid and off-grid supplies.

The Consultant has carried out this review in light of the original research themes and the revised themes. The findings are presented in this report as follows:

- Chapter 2 summarises the key issues for SEQ's urban water supply
- Chapter 3 summarises the key Government planning instruments for future water management
- Chapters 4 through 7 review the Alliances' research program and research outcomes
- Chapter 8 examines research capacity in SEQ delivered as a result of the Alliance
- Chapter 9 summarises future research challenges
- Chapter 10 reviews the performance of the Alliance against the original program objectives as well as program governance
- Chapter 11 presents recommendations.

2. WHAT ARE THE BIG ISSUES IN SEQ WATER TODAY

2.1. Current Water Status

The Alliance was set up in 2007 during one of the worst droughts in the history of SEQ. By July 2007, dam levels had fallen to less than 20 per cent. As the drought took hold, the State Government initiated planning for the construction of the Water Grid, the Western Corridor Project and the Tugun Desalination Plant, as part of the emergency drought relief program, in the event that the drought continued. Following completion of planning, construction commenced for the Tugun Desalination plant in September 2006. The plant first commenced operation in February 2009. The Bundamba Advanced Water Treatment Plant (AWTP) was the first plant constructed to provide purified recycled water (PRW) as part of the Western Corridor Project. Construction was completed in July 2008. It was anticipated that the PRW would provide water for power supply stations as well as for drinking water supply via storage in Wivenhoe Dam. The Luggage Point AWTP was completed in October 2008 and the Gibson Island AWTP in December 2008. Purified recycled water (PRW) was first delivered to the Swanbank Power Station in August 2007 and to the Tarong Power Station in June 2008. Plans for Traveston Dam and Wyaralong Dam were also completed. While Traveston Dam was to be the next major dam for SEQ, the State Government ultimately deferred it indefinitely. The Wyaralong Dam however did proceed.

The drought broke in May 2009 with two days of intensive rainfall over the critical catchments and the combined dam levels rose above 40%. Whilst it was anticipated that PRW would be introduced into Wivenhoe Dam, the Queensland Water Commission (QWC) subsequently reviewed the issue. The QWC recommended that PRW be introduced into SEQ's drinking water supply when SEQ's combined dam levels reached a 40% trigger level. Therefore, PRW was not introduced to Wivenhoe Dam during this drought. However, PRW remains part of long-term planning considerations for drinking water supply to address both potential climate change impacts and population growth.

Higher than average rainfall occurred in 2010 and 2011 and there was a major flood in January 2011. The dams are currently about 85% full (July 2011).

Water consumption reduced significantly during the drought and was maintained after the drought broke. Prior to the drought in 2004/2005, water consumption across SEQ was 282 L/p/d. Water consumption reduced to 143 L/p/d in 2008/2009 in the peak of the drought. Currently it is 161 L/p/d (15 July 2011).

With the replenishment of the dams and continued low consumption, in 2011, the Government decided to place the Tugun Desalination Plant and the Luggage Point AWTP and one of Bundamba's two AWTP's on standby mode and to shut down water production at the Gibson Island AWTP.

As a result of the January 2011 flood and resulting devastation, the Premier established an independent Commission of Inquiry to examine the chain of events leading to the floods, all aspects of the response and the subsequent aftermath. Recommendations from the inquiry will potentially provide the Government with a need to re-examine the management of the regions water supply. The interim report has recommended that:

> "2.5 If the Bureau of Meteorology makes a similar seasonal forecast to that made for the 2010/2011 wet season, expressed with equal or greater confidence, for the 2011/2012 wet season, the Queensland Government should temporarily reduce the full supply level of Wivenhoe Dam to 75 per cent, with a concomitant adjustment to the trigger levels for the strategies in the Wivenhoe manual".

There will be a need to understand the consequences of this recommendation and the options to use the other available supply options, desalination, PRW, and stormwater, to determine the most effective way to ensure flood water protection and water security into the future. These interim recommendations need to be considered by the Alliance in the assessment of future research needs for SEQ.

2.2. Institutional and Regulatory Changes

Since the easing of the drought there have been a number of significant changes in the water industry and in the management of water. Institutional changes have resulted in three Water Utilities being established in SEQ to manage water supply distribution and sewage collection and treatment (Queensland Urban Utilities, Unitywater and Allconnex Water), a single Water Entity (Seqwater) to manage water storage and treatment, including manufactured water, and a Water Entity (LinkWater) to manage the bulk transfer of water. The role of the Water Grid Manager is to manage the SEQ Water Grid to maintain water security and quality for SEQ efficiently and cost effectively.

In response to the drought, the Queensland Government legislated mandatory water savings targets for applications lodged for the construction of new houses in SEQ from 1 January 2007, and state wide from 1 July 2007. The targets are outlined in Part 25 of the Queensland Development Code (QDC). This code requires Class 1 buildings (residential) that are supplied directly with water from the *reticulated town water supply system* to have an alternative source meeting a specified water target. The alternative source could be a 5,000 L rainwater tank for detached Class 1 buildings or communal rainwater tank or dual reticulation or stormwater use. For SEQ the water saving target is 70 kL/a for detached houses.

The Queensland Government also introduced the *Water Supply (Safety and Reliability) Act 2008* on 1 July 2008. This Act contains certain regulatory provisions from the *Water Act 2000* and, to protect public health, introduced new requirements relating to recycled water and drinking water. In part, it regulates infrastructure management and service provision by water and sewerage service providers, including asset management, customer standards and water conservation, the supply of drinking water by water service providers and the production and supply of recycled water in certain circumstances, including augmenting drinking water supplies. Importantly, the Act regulates certain sources of recycled water (including recycled water used for potable purposes), with water quality standards dependent on the source and use of the water.

2.3. Key Challenges for Future Water Supply

As a result of the recent drought, there have been significant changes to both water supply and demand in SEQ. Water demand per capita has decreased significantly and the sources of water supply have been increased and diversified. Planning and policy instruments currently in place specify outcomes for water management including total water cycle management along with water efficiency and water sensitive urban design. Regulatory provisions for the safety and reliability of the water supply have been legislated and water savings targets have also been legislated for new dwellings.

These issues, together with increasing population and the potential future impacts of climate change, need to be addressed in examining the future security of SEQ water supply.

Factors to be considered include:

1. Timing of water supply augmentation
2. Impacts of climate
3. Water conservation goals and water use patterns
4. Optimisation and operation of the water supply portfolio
5. Catering for growth of 750,000 dwellings by 2031
6. Optimising water storage management for water supply security as well as flood mitigation
7. Having sufficient capacity and knowledge to manage water supply challenges.

3. GROWTH IN SEQ WATER DEMAND – KEY PLANNING INSTRUMENTS

In 2004 the *Integrated Planning Act 1997* (IPA) was amended to provide a statutory, or legal, basis for regional planning. This led to the creation of the SEQ Regional Plan 2005-26, which provides the framework for managing growth, land use and development in the region. The SEQ Regional Plan 2009-2031 and the associated regulatory provisions, released in July 2009 which superseded the previous SEQ Regional Plan 2005-2026, identified new growth areas in SEQ and an estimated additional 750,000 dwellings required to cater for population growth in SEQ from 2006 to 2031.

The SEQ Regional Plan provides the overarching framework for ensuring the sustainability of the region. The Plan provides the guiding principles, policies and programs to achieve the desired regional outcomes. The Plan notes that sustainable development in SEQ is expected to include the following characteristics in relation to water:

- compact urban form that minimises impacts on natural resources and environmental values and reduces the need for travel by private vehicles.
- buildings that are designed and oriented to take advantage of the region's climate and reduce the use of energy, especially for cooling and heating.
- low levels of water, energy and material consumption, and high levels of recycling and re-use of natural resources, materials and waste products.
- generation and distribution of energy from renewable sources.
- total water cycle management to minimise impacts on the natural water cycle, including aquatic ecosystems.
- protection from natural hazards, including the effects of climate change.

The SEQ Regional Plan provides three policies in relation to "Efficient Water Use" as follows:

- Ensure that new and refurbished buildings meet the water efficiency and water savings target requirements of the Queensland Development Code (Policy 11.3.1).
- Exceed the water savings target in broad hectare development, where cost-effective compared with alternative sources of supply (Policy 11.3.2).
- Utilise water use targets to inform water supply and infrastructure planning and financial assessment (Policy 11.3.3).

The Plan provides two policies in relation to "Total Water Cycle Management" as follows:

- Incorporate total water cycle management and water sensitive urban design principles in land use and infrastructure planning (Policy 11.1.1).
- Ensure that planning and management of urban stormwater complies with the design objectives as set out in the SEQ Regional Plan 2009–2031 Implementation Guideline No.7: Water Sensitive Urban Design (Policy 11.1.2).

Integral to the SEQ Regional Plan is the *South East Queensland Natural Resource Management Plan 2009–2031* (SEQ NRM Plan). The SEQ NRM Plan is the pre-eminent, non-statutory environment and natural resource management plan for the region. It articulates measurable targets for the condition and extent of environment and natural resources aligned to desired regional outcomes (DRO) and policies in the SEQ Regional Plan. The SEQ NRM Plan desired regional outcome (DRO11) for water management is:

Water in the region is managed on a sustainable and total water cycle basis to provide sufficient quantity and quality of water for human uses and to protect ecosystem health.

The SEQ NRM Plan states that the efficient use of water by all users has been a high priority for the region during the drought. It also states that the domestic, industrial and agricultural water supply and water use efficiency strategies currently in place are a crucial component of total water-cycle management and should continue into the future. It notes that water sensitive urban design (WSUD) integrates total water cycle management into the built environment to minimise the effects of development on the natural water cycle and to address water supply and use. All developments in SEQ are to incorporate total water cycle management principles and water sensitive design.

The SEQ Regional Plan refers to the SEQ NRM Plan in Policy 4.1.1: Coordinate regional natural resource management, planning, investment, monitoring and reporting through implementation of the SEQ NRM Plan.

The SEQ Water Strategy was developed by the QWC to ensure that sufficient water is available to support a comfortable, sustainable and prosperous lifestyle while meeting the needs of urban, industrial and rural growth and the environment. The Strategy has identified management and infrastructure programs, which will meet the expected growth to 2056. The three principles of the strategy are:

- Conserving water;
- Being prepared; and
- Managing water efficiently.

In selected areas where large-scale development and significant infrastructure is to occur, the QWC will lead the development of sub-regional total water cycle management plans. The sub-regional plans will integrate land use policy and decisions with waterway health and water supply planning for urban and rural purposes, and involve the key organisations responsible for managing the water cycle. Plans will specify the location of key infrastructure, where major wastewater recycling will occur, and high-level objectives for development to protect water quality and to capture and use stormwater. The outcomes from sub-regional planning will be recommended for inclusion in the Regional Water Security Program under the *Water Act 2000*.

It is also stated that for areas that are not covered by sub-regional plans, decision-making should also be based on total water cycle management principles and should involve the relevant entities with responsibilities for the water cycle. Local governments should develop total water cycle management plans that address their core responsibilities for the water cycle, while considering how they integrate with facets of the water cycle managed by other entities.

Councils' total water cycle management plans will inform planning schemes and development assessment decisions as well as local government works programs. Councils will continue to have a controlling influence over stormwater and local water cycle management through planning instruments. Local governments are required to develop stormwater management plans under the Environmental Protection (Water) Policy. These plans should be incorporated into local government total water cycle management plans, along with other relevant plans such as catchment management plans.

The SEQ Water Strategy includes a demand management program to ensure that demand remains at least 24 per cent lower than it was before the recent drought. The residential consumption target is 230 litres or less per person per day on average across the region. Many households, particularly those with efficient appliances and alternative water sources, will achieve well below 230 litres. To achieve these savings, efficient water use must be considered as part of planning new communities and designing new buildings. New detached houses in SEQ must meet the water savings target by supplying 70 000 litres of non-grid water per year, while each townhouse must supply 42 000 litres. Options to achieve the targets include internally connected rainwater tanks, communal rainwater tanks, stormwater harvesting, and dual-reticulation recycled water systems. Acceptable solutions include the installation of rainwater tanks or a greywater treatment plant. Rainwater tanks must be plumbed into toilet

cisterns, washing machine cold water tap and an external tap. All new buildings and refurbished bathrooms must have water-efficient showers and toilets under the Queensland Development Code.

The Strategy not only addresses residential consumption but also requires that all businesses use water efficiently. Non-residential activities that use more than 10 million litres per year must complete a water efficiency management plan that demonstrates how they are achieving, or will achieve, best practice water use. Businesses using more than one million litres per year must have water-efficient appliances such as low-flow taps, showerheads, urinals, trigger sprays and cooling towers.

It is also noted in the Strategy that the "*Strategy will be revised as our understanding of the likely impacts of climate change on SEQ water supplies improves*."

The strong link between the SEQ Regional Plan and *South East Queensland Infrastructure Plan and Program* (SEQIPP) is also continued. The SEQIPP outlines the Government's infrastructure priorities for the region. Together the plans coordinate planning, infrastructure and service delivery in SEQ to ensure that the desired, more compact urban settlement pattern is achieved.

4. RESEARCH: MAKING INFRASTRUCTURE MORE EFFECTIVE

The SEQ Water Strategy (2010) identifies a plan for the region's future water supply, ensuring that security of supply is maintained in the face of population growth, climate variability and climate change. It identifies the opportunity to use water and operate infrastructure more efficiently. The strategy outlines the key planning assumptions impacting on the date for water supply augmentation as:

- Population growth
- Residential consumption
- Climate change impacts.

The Alliance is assisting the Queensland Government in this planning through strategic and formative research on supply side management. The pressures of population growth, climate variability and climate change will require upgrading of the water supply system in the future. It is imperative that existing infrastructure is used most effectively to delay capital expenditure for new infrastructure as long as possible. This is summarised in the Strategy as shown below in Table 4-1, which highlights the importance of using less water. For example, reducing the per capita demand from 230 L/person/day to 200 L/person/day would delay the next augmentation by some five years. Climate change might have the opposite impact by bringing forward the next augmentation. In addition rainwater tanks and other alternative sources such as stormwater will provide an increasing contribution to the regions water supply in the future and a full understanding of the overall contribution to the system yield from these alternative sources will be necessary for future planning. The Alliance is addressing all of these issues.

Table 1. Impact of reduced consumption on the timing of the next augmentation (SEQ Water Strategy, 2010).

Scenario	Regional average residential consumption	
	230 litres/person/day	200 litres/person/day
Earliest date with: high population growth provision for climate impact	2017	2022
Likely date with: high population growth	2021	2027
Likely date with: medium population growth provision for climate change	2020	2027
Latest date with: medium population growth	2026	2032

4.1. Storages

The Alliance has addressed three aspects of storage management. These are:

- Storage evaporation
- Greenhouse gas emissions
- Water quality

The role of existing water storages (reservoirs) is an important component of SEQ water security. The role that evaporation from these reservoirs contributes to system yield has usually been based upon Pan Evaporation measurements undertaken at specific locations. Under climate change, evaporation is expected to increase thus reducing the available water from storages, particularly in times of low water levels and high temperatures (as seen in the recent drought). The Alliance has developed an improved

measurement tool for evaporation assessment. This will enable water supply planners to more accurately determine system yields from the reservoirs and therefore more accurately predict total system supply. The research is now at the stage where it could be deployed across SEQ storages and other storages in Queensland. This new tool will complement the climate change research by the Alliance.

The research team has also carried out an extensive review of available technologies to reduce evaporation for these large reservoirs. While some technologies looked promising, particularly the polymer recently developed by the CRC for Polymers, the technology was not successful in initial field experiments. The team is continuing to pursue this with the CRC over the 2011 spring and summer months.

Research was undertaken to improve understanding of the contribution of water storages to greenhouse gas emissions (GHG). International research on GHG emissions from storages indicates that the emissions can be highly variable providing a great deal of uncertainty in regard to the accuracy of the predictions for SEQ storages. Alliance researchers monitored GHG emissions from two storages in SEQ to assess likely impacts. Researchers found that GHG formation occurs mainly in the upper arms of the storage, where there is high organic load and reduced flow velocities. Management options could include mixing and oxygenation to convert methane into CO_2. Better understanding of the formation of GHGs in storages may lead to improved management practices for SEQ storages and storages in other parts of Queensland and Australia.

To determine the efficacy of reservoirs and receiving water bodies in reducing contaminants, research was undertaken to determine the behaviour and fate of microbial pathogens and selected trace organics under different conditions within reservoir systems. There was little quantitative data on the treatment capacity of natural systems such as reservoirs, particularly under SEQ conditions. It is not expected that pathogens or trace organics would be present in reservoirs due to purified recycled water (PRW), but previous social research has shown the importance of developing public trust in purified recycled water and the effectiveness of multiple barriers. There are other potential sources of microbial pathogens and trace organics that can enter reservoirs. These sources include small sewage treatment plants from regional towns that discharge into creeks and stream that feed into the reservoirs. Runoff from agricultural land is another source of contaminants, particularly when stock has direct access to waterways. Contamination of the reservoir from other sources is more likely than via the PRW system.

The research findings show that most pathogens are effectively removed during storage by a variety of mechanisms with up to 1 log removal being achieved for most contaminants. The major issue that has been identified is the contamination contributed by the catchments and the need for improved catchment management.

4.2. Purified Recycled Water

A significant focus of the Alliance was initially placed on PRW. The early research examined potential sources of contaminants in sewerage systems (such as from hospital wastes), methods for detecting contaminants in the sewerage system and the fate of contaminants such as pathogens in storages. This research was undertaken to provide a greater degree of understanding of the risks involved and potential mitigation measures for the use of purified recycled water.

One of the early projects was to research the impact of hospital wastes on water quality entering and leaving sewage treatment plants (STPs). This work has highlighted that the waste stream from hospitals forms a low risk to water quality. The consistency of the findings of the research will enable confident prediction of likely impacts of hospital wastes for other STPs in Queensland. In addition, the monitoring methodology that was developed as part of the research will be able to be used for the investigation of contaminants from other sources as well as hospitals. The role of Queensland Health in this research has highlighted the benefits in having government tightly linked to the research development and outcomes.

Through collaboration within the Alliance, a new and sophisticated sensor tool has been developed to enable real-time monitoring of wastewater in the sewerage network, the wastewater treatment plant and effluent from wastewater treatment plants to identify wastewater anomalies. For example, the monitoring tool will be able to identify the occurrence of poor quality wastewater at the treatment plant or further upstream in the network such as may result from an illegal discharge of trade waste. This poor quality wastewater may seriously impact treatment plant performance. Further trials are now anticipated, in conjunction with water retailers, to develop this new monitoring system. Such a system would provide an early warning system for potential upsets in the treatment process.

Social sciences research has provided a focus on community behaviours and attitudes, not only to purified water, but also to water conservation programs and water education messages. Research on public acceptance and opinions of PRW revealed that 70 percent of people were willing to drink water containing PRW. However, given a choice the majority of respondents would prefer not to drink water that contained PRW. Results also suggested that support would be lower if viable alternatives to PRW were available. The research supported earlier findings of the QWC with respect to people's acceptance of PRW. Trust was determined to be a key factor. The project was subsequently discontinued as the water supply levels rose in the reservoirs.

4.3. PRW in the Lockyer Valley

The Alliance is assessing the option to supply 25 GL per year of PRW to augment the groundwater resources in the Lockyer Valley. The research is aimed at providing a better understanding of the potential impacts on groundwater and soils in the Lockyer Valley as a result of using PRW for irrigation. The existing groundwater models for the Lockyer Valley have been updated and assessed to test model accuracy. A Groundwater Visualisation System has also been developed to integrate existing bore data and define the configuration of the aquifer system and likely storage capacity.

Initial results suggest that careful management of irrigation supplies would be required to prevent an unwanted rise in water tables and the mobilisation of salt stored in soils. Deep soil coring results are now being examined to document changes in soil salinity over the last 12 years. These data will be used to validate models for deep drainage and salt transport resulting from irrigation with PRW. Both DERM and QWC are active contributors to this research program.

4.4. Climate Change Impacts

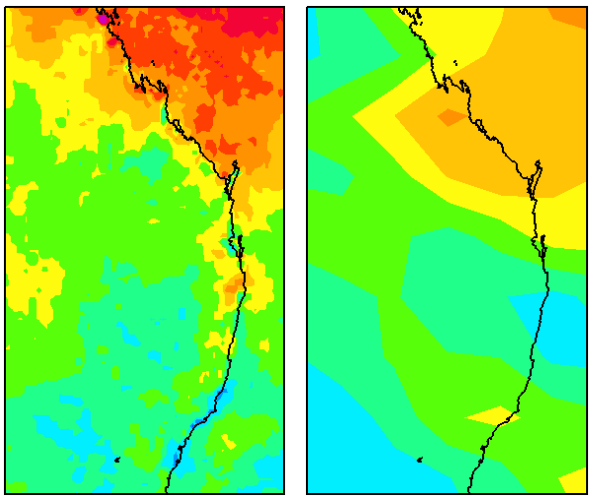
The overarching aim of the climate research is to assess and quantify the impact of climate variability and change on water supply in SEQ**.** This research will provide the information needed to develop hydrological models so that potential climate change impacts can be estimated.

This research is highly relevant to the SEQ Water Strategy, as it will improve forecasting of system yields due to climate change, assist in developing drought response plans, provide valuable information in the development of long-term water supply strategies and inform infrastructure investment decisions.

Throughout Australia, most major cities are assessing the impacts of climate change on their water supply strategies. The main issues confronting planners is the uncertainty across the range of IPCC climate models and the inability to develop climate adjusted run off models at appropriate scales. In the absence of catchment-scale climate change information, estimates of the need for water supply augmentation are highly uncertain. For example, the present SEQ Water Strategy incorporates a 10% reduction in system inflows due to climate change. If this eventuates, new water supply infrastructure could be required nearly a decade earlier than currently anticipated. More accurate models are required to better quantify the impact from climate change and to assess how such impacts will change over time.

These issues have direct implications for future water infrastructure investment decisions. In order to address these issues, regional and catchment-scale future climate information models have been developed.

Research is continuing to understand how sensitive the SEQ stream flow model (IQQM), is to the resolution of climate information. The IQQM has been run previously using low-resolution climate model outputs. DERM planners have been implementing a high-resolution grid version of the IQQM, using the downscaled outputs this research has generated. One example of rainfall trends with downscaled information is shown in Figure 2, using the IPPC Model CSIRO Mk3.0 and emission scenario A1B, highlighting the substantive increase in information using this technique.



a) Downscaled grid **b) Low-resolution grid**

Figure 2: Downscaled Information.

Research and planning between DERM and the Alliance is ongoing. New areas of research have been opened up as a result of the work carried out. This includes the study of floods – the frequency and intensity of floods in a warming world. The recent flooding experience in SEQ has highlighted the need to not only have an understanding of climate on drought and water supply, but also to better understand floods, particularly whether future climate would increase flooding frequency.

This is an area where the Alliance can build on existing knowledge and capacity to assist in developing new information for SEQ.

5. RESEARCH: MANAGING A DIVERSE SUPPLY PORTFOLIO

In all of Australia's major cities, there has been a considerable investment in water supply infrastructure to develop what is now commonly referred to as a 'portfolio' of water supply options. The concept is similar to that of an investor, who reduces risks and sudden shocks through a diversified investment portfolio. So too in the water industry, utilities now have a mix of rainfall dependent supply options, such as surface reservoirs, and those sources less dependent or independent of rainfall – such as desalination and to some extent potable water recycling.

One of the key challenges facing the urban water industry is how to mange these new supplies to maximise efficiency and effectiveness.

5.1. Maintaining Grid Water Quality

The SEQ Water Grid Manager holds the urban water entitlement for SEQ and manages the SEQ Water Grid to maintain water security and quality for SEQ. An important aspect of the Alliance's research has been to investigate water quality issues associated with treatment and delivery of water to customers.

Research has been undertaken to determine the potential for disinfection by-product formation from the portfolio of water sources and disinfection practices used in SEQ and to investigate mitigation measures. Disinfection by-products may have human health implications if concentrations exceed guideline levels. The research has found that disinfection by-products of concern are unlikely to result from current treatment plant operations when chloramination is practised but may be a problem where chlorination is practised. Researchers have reviewed possible treatment options to minimise disinfection by-product formation but further research is needed to determine if there are opportunities to mitigate disinfection by-product formation through plant operational changes or treatment plant improvements. Research into the potential for the formation of disinfection by-products at the purified water plants has also been undertaken. The research found that changing the dosing point and contact time of the chloramine significantly reduced disinfection by-product concentrations to well below guideline levels. These procedures may reduce operating and treatment costs. Veolia Water has adopted the research findings for its treatment plants in Queensland and internationally.

5.2. Decentralised Systems

The Alliance has conducted a range of differing studies into the issues of rainwater tanks as a component of the decentralised water supply. The research includes:

- Rainwater tanks
- Stormwater harvesting
- Cluster developments

5.2.1. Rainwater Tanks

Since the introduction of the Queensland Development Code, most new homes in SEQ will be provided with rainwater tanks. Exceptions include homes that are provided with permitted alternatives such as dual reticulation, communal rainwater tanks or stormwater use. It has been assumed that rainwater tanks will contribute 70,000 litres each year for the average household. Taking account the expected growth in population to 2026, this equates to a total annual contribution of 36,000 ML/a by 2026. Where rainwater tanks are provided as a requirement of the Queensland Development Code, water is typically used for gardening watering, toilet flushing, and clothes washing machines. Rainwater tanks have been used for many years in rural areas where this is the sole source of water supply and the owners have a vested interest in the proper management of the tanks. However, little is known about how well "mandatory" tanks will be managed and perform in urban areas.

The Alliance's research has highlighted that the maintenance costs and energy use of the pumps associated with rainwater tanks are a significant cost to the householder. Research has shown that rainwater tank pumps are required to operate over a wide range of flow rates. For low flows, such as required for toilet flushing, they operate very inefficiently and can have very high energy consumption per litre of water delivered (see Figure 6-1). This energy usage can be higher than other alternative sources such as purified recycled water and desalination. Washing machine use and garden watering on the other hand operate in the more efficient range. Correct pump sizing and informed selection of system components could improve overall energy efficiency significantly.

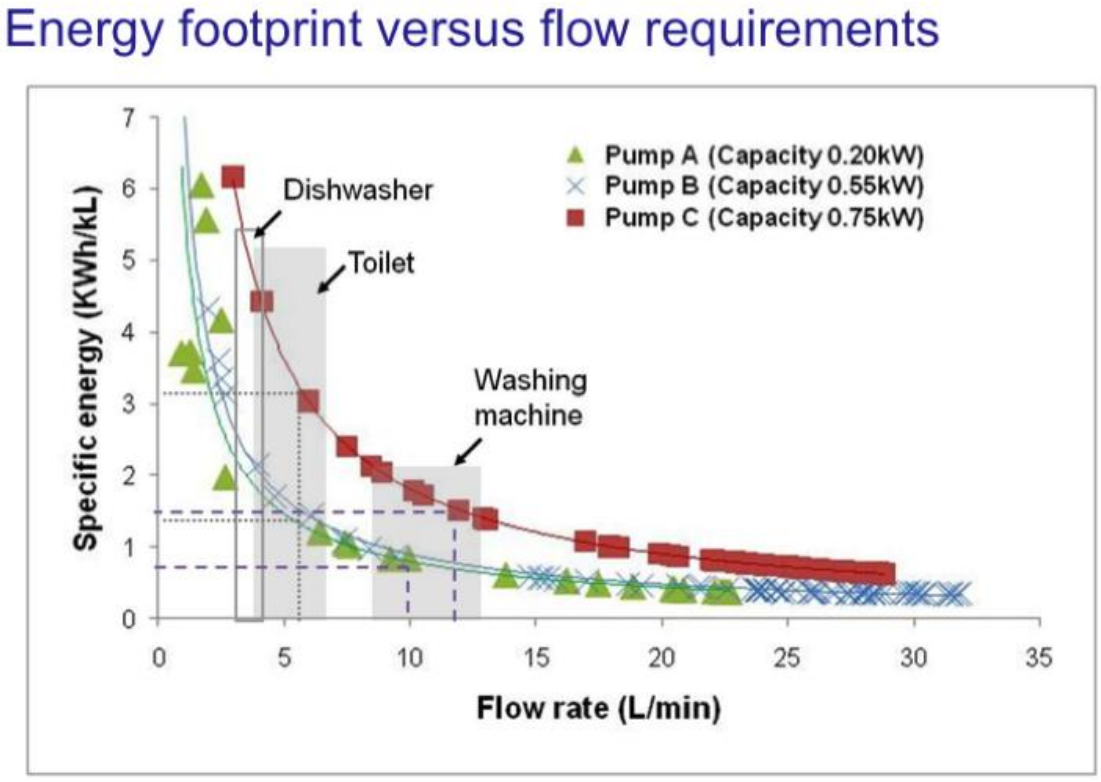


Figure 3. Energy Use Versus Flow Rate for Rainwater Tank End Uses in SEQ.

The Alliance research is also examining drinking water and human health aspects of rainwater tanks by monitoring water quality in tank water and at the tap. Preliminary research has indicated the presence of pathogens in the water in the tank and water from the tap. Most under sink treatment systems have been found to be ineffective in removing these pathogens. The source of the pathogens is likely to be possums, birds and other small mammals and reptiles. Further research has yet to be carried out to determine whether these pathogens are viable or infective. Longitudinal studies will be carried out, using a larger number of tanks to obtain better statistical confidence in the results. The results of this research should inform Government policy and guidance on the use of rainwater tanks for water supply.

Whilst rainwater tanks have been available for many years, little is known about minimum maintenance needs and the longer term impact of little or no maintenance. A survey of homes with rainwater tanks was carried out by the Alliance. Some people do not maintain rainwater tanks because the tanks are "mandatory" and they do not have any "ownership" in the tanks. They either are not interested or don't know what is required. This research project will determine how to engage householders in order to improve their knowledge and commitment to carrying out tank maintenance.

Alliance research into the use of rainwater tanks has been comprehensive and has included research into operations, maintenance, cost, water quality and owner attitudes. The Department of Local Government and Planning should be involved in the rainwater tank research as it has implications with respect to arrangements for rainwater tank installation. A synthesis of the Alliance rainwater tanks research is required to ensure that the results inform Government policy and planning. Research into the economics of rainwater tanks in comparison to other source options is also required for future water planning.

5.2.2. Stormwater Use

Stormwater use is an acceptable alternative source of water under the Queensland Development Code. Stormwater use can provide an important source of water for residential communities but there is limited knowledge in regard to quality and environmental impacts of stormwater harvesting.

In a collaborative project with the Urban Land Development Authority and Bligh Tanner Pty Ltd at the Fitzgibbon Chase development, the Alliance is monitoring a catchment to characterise stormwater quality including nutrients, sediment and pathogens. The efficacy of the treatment system in removing nutrients, heavy metals and sediments will be quantified, as well as the energy requirements. This research will lead to a better understanding on how to manage stormwater within catchments at a broader scale.

The other area that is being researched is the interface between hydrology and ecological degradation in creeks. Twelve creeks have been gauged and rating curves developed. The research will be looking to ascertain impacts of stormwater harvesting and WSUD on catchment health.

The research effort by the Alliance on stormwater has not been as comprehensive as first envisaged. The research needs to be expanded to better understanding some of the broader issues of stormwater management and how this support the idea of WSUD and complement the concept of Water Sensitive Cities.

5.2.3. Cluster Developments

A trend in SEQ is the emergence of cluster developments that provide integrated water management systems that minimise the need for importing treated water and exporting wastewater from the site. Research is being carried out at the Capo Di Monte development, a cluster development of 43 homes in North Tambourine. This development involves wastewater collection, treatment and reuse for non-potable purposes and rainwater collection, treatment and use for potable purposes. The research will determine per capita water use and per capita energy consumption and enable comparison with conventional developments.

6. RESEARCH: REDUCING PER CAPITA WATER USE

This chapter examines research into the role of more efficient water use in delaying further supply augmentation. The SEQ Water Strategy has set a challenge to maintain average residential water consumptions at or below 230 litres per person per day, without significantly changing the lifestyle that residents enjoy.

6.1. Demand Management

Studies in other major cities, such as Melbourne and Sydney, have shown that to achieve water efficiency in the home, and in the commercial or industrial sector, it is necessary to determine exactly how water is being used. This is referred to as 'end-use' analysis.

The Alliances end-use research program has provided detailed household water use information that will inform government policy on demand management, leakage management and behaviour change. The research has identified that water consumption inside the house is used in the shower 29 %, clothes washer (21 %), tap (19 %) and toilet (16%), which comprised the bulk of the water consumption in SEQ in winter 2010. Irrigation made up less than 5 % of average total consumption. Water wise initiatives, such as switching from top loader to front loader washing machines, saved on average 11 kilolitres per household per year, while high-efficiency showerheads saved 13 kL/hh/y. Water smart meters were used for the research and enabled measurement of diurnal use patters and peak flow. They also enabled the measurement of water leakage in the home. This research will provide water retailers with better information for the development of domestic consumption/network distribution forecasting models. Further research is required to obtain a better understanding of external water use as the monitoring work carried out to date has been substantially done during a wet period.

While water smart meters provided good information on water use, they were in themselves not an effective water conservation tool. So, the end-use analysis was linked to social research to examine household water conservation behaviour and the effectiveness of demand management strategies on water use in a study of 250 households in SEQ.

The research has shown that making people aware of their water end-use and what others are doing to reduce water consumption has a strong long term influence on changes to their own water use. Questions remain, however, as to whether this culture of water conservation can be maintained outside of drought and how the approach can be rolled out across a larger number of households. The research team is now examining ways to determine how the approach could be further applied in a cost effective way.

The results support the need for a review of water efficient appliance policy, demand management programs and social intervention for high water users. Researchers have identified a need to calculate potential savings for houses and then extrapolate this information across SEQ to calculate savings from interventions. The researchers have also identified a need to develop an online water use calculation tool.

7. RESEARCH: THE IMPERATIVE OF WATER SENSITIVE CITIES

The notion of Water Sensitive Cities has developed in recent times. The International Water Association and the Australian Water Association have been developing the definition and gauging an understanding of what such a concept might mean. This concept builds on some early work on Water Sensitive Urban Design, which has been supported by the Alliance through the research program on decentralised systems.

Monash University in Melbourne is a leading research organisation in this field, developing such information as a blueprint on "Cities as Water Supply Catchments", and leading an application to establish a CRC for Water Sensitive Cities. Monash University's Centre for Water Sensitive Cities provides the following description of a water sensitive city:

A Water Sensitive City is one where water's journey through the urban landscape is managed with regard for its rural origins, coastal destinations and spiritual significance. A philosophy of flexibility in supply and use to meet all users' needs underpins the collection and movement of water, and the technologies to facilitate the physical movement of water are designs that manifest these ideals visually for all to acknowledge and appreciate. Three principles set the foundation for this vision of a Water Sensitive City:

- *Cities as Water Supply Catchments: meaning access to water through a diversity of sources at a diversity of supply scales;*
- *Cities Providing Ecosystem Services: meaning the built environment functions to supplement and support the function of the natural environment; and*
- *Cities Comprising Water Sensitive Communities: meaning socio-political capital for sustainability exists and citizens' decision-making and behaviours are water sensitive.*

The Alliance has commissioned a review of water sensitive city concepts and initiated a pilot project. This review has examined how SEQ might build on and adapt water sensitive city concepts so that they would be applicable to SEQ. There is limited information available regarding the application to a sub-tropical city such as Brisbane. This is an area that further research could be conducted to establish policy guidelines for future urban development in Queensland cities. In view of the extensive work already undertaken by Monash University, collaboration with them would be strongly recommended should the Government wish to proceed.

8. BUILDING CAPACITY IN SEQ

8.1. Capacity Building

A key aim of the Alliance was to build research capacity in SEQ. The Alliance has built a critical mass of talented researchers and scientist in SEQ and more broadly across Australia.

8.1.1. Research Capacity

Significant capacity has been developed in the research community through the Alliance. Thirty six additional full-time research positions, including 6 PhD students, have been employed.

8.1.2. Agency and Water Utility Capacity

To date there has been little emphasis on the transfer of skills and capacity gained within the Alliance into Government agencies and water utilities. In the final year of this phase of the Alliance, considerable effort needs to ensure that technology and capacity is transferred from the Alliance to various Government agencies.

8.2. An Efficient Workforce

The Alliance is also carrying out research into building capacity within urban water utilities. Queensland has embarked on a number of institutional changes that are designed to ensure the efficient and effective operations of the SEQ Water Grid as outlined in the SEQ Strategy, 2010. However, change can also be an impediment to productive work due to disruptions and uncertainty. An Alliance research project is examining the issues of human factors in water utilities. LinkWater is providing an initial case study.

The initial research explored options for using human factors methodologies to improve the reliability of the water storage, treatment and delivery systems. Two key focus research areas emerged. They were an analysis of best practice in similar industries and an in-depth investigation of work practices, specifically interactions with technology. Expected outputs from the next stage of research include an appraisal of human-machine interactions, particularly examining SCADA systems and alarms. LinkWater is presently upgrading its supervisory control network, so the project is well situated to assess human factors and process control. Integration of human factor principles in the design phase of equipment is being examined. Multiple benefits arise from well-integrated human-machine interfaces, principally improvements to work performance. These improvements include changes to visual displays for ease of interpretability, changes to signalling processes to improve fault diagnosis, and changes to the extent and mode of automated processes.

The results of this research are likely to be applicable across the water industry and opportunities for knowledge transfer should be explored, particularly through water industry associations.

9. WHAT CHALLENGES MUST BE ADDRESSED?

What does the Alliance need to do to obtain additional value from the investment to date and position itself for future funding?

The challenges that need to be addressed if the Alliance's research program was to continue include:

- Research is relevant to the needs of SEQ.
- Research does not duplicate other research areas or programs.
- Research outcomes can be transposed to other areas of Queensland.
- The research program has good linkages with industry.
- The research provides value for money.
- Establishment of a suitable method of delivery.

These challenges are discussed further in the following sections.

9.1. Research is Relevant to the Needs of SEQ

Funds for research are limited and it is essential that any extension of the current research program specifically targets areas that address the needs of SEQ. As discussed below, there will be ongoing challenges in regard to urban water security including population growth and urban development, climate variability and climate change, new standards, changing customer expectations and increasing water utility costs. The need for additional research should consider the results of the research completed to date and potential longer term needs. Flexibility needs to be provided to respond to new issues and adjust the program as necessary.

Over the coming months, researchers need to ensure that research findings are synthesised in a way that clearly links research outcomes to agency and water utility needs. The results need to be synthesised for better take-up by key stakeholders and an assessment made of the future research needs and funding priorities. The Alliance researchers and DERM, QWC, Queensland Health, DLGP and the water utilities need to work together to agree future research priorities.

9.2. Research Does Not Duplicate Other Research Areas or Programs

There are many urban water research programs being carried out in Australia and it is important that any research undertaken does not duplicate other research areas or other programs.

In association with the review above, an analysis also needs to identify what other research is being conducted in Australia. This could most effectively be achieved through close collaboration with other research entities in SEQ and continued involvement in the newly formed Australian Water Research and Development Coalition at the national level.

There are also a number of other ways that overlaps can be minimised. Reference of proposed research programs to the newly formed Science Integration Panel would provide a check of the suitability of the proposed research programs in terms of State Government objectives and other State-wide and National research programs (Figure 9.1).

9.3. Research Outcomes can be Transposed to Other Areas of Queensland

It is apparent that much of the Alliance research is transferable to other parts of Queensland beyond SEQ. A process needs to be developed such that research activities are translated into actions that can be adopted by Government agencies, Councils and water utilities beyond SEQ. The process must ensure these results are captured within SEQ but then actioned (and modified where necessary) across the State.

Development of any new research by the Alliance should include consideration as to whether the relevance of the research could be enhanced by broadening it to other parts of Queensland or nationally. Opportunities to leverage additional funding from other agency or research partners should also be considered.

9.4. The Research Program has Good Linkages with Industry

An effective way of ensuring relevance of the research programs is to engage key stakeholders at the outset. This will require engagement of a wide cross section of people from Government agencies, research organisations, water utilities and industry.

It is also desirable to promote strong industry linkages and participation by agencies and utilities with the researchers as this adds a greater focus on outcomes. The review of programs currently under way showed that those programs with the best outcomes often had strong Government and/or industry inputs or linkages. This was particular the case when the research project had a Government leader actively involved in the project. It also necessary that the research program has in-built requirements for the transfer of research outcomes to key stakeholders through avenues such as forums and workshops. This is essential if the research is to be acknowledged as achieving its objectives and is seen as providing value for money.

9.5. The Research Provides Value for Money

The value of investment in research can be demonstrated in a number of ways:

- Peer review – Assess value based on independent peer review.
- Bibliometric analysis – Assess number of publications and outputs.
- Leveraging – funding from additional research investors.
- Rate of return – Assess value to economy of outcomes compared to the cost of the research.
- Benchmarking – Compare cost of research across different research programs.
- Case studies – Provide a narrative of research process and outcomes.

For the Alliance research, value for money can be summarised as follows:

The existing research program has provided good value for the Government, through substantial leveraging of its investment, realising some $38 million in research dividends from the $19 million invested by the State Government to date (end June 2011).

Government agencies, DERM, QWC, and Queensland Health, have been specific beneficiaries of the research outputs to date.

The number of research papers, reports and books produced from the research has also been very significant. As at June 2011, 37 technical reports had been published, with an additional 12 being in the final stages of review prior to publication. Fourteen papers have been published in high impact external journals. Two books have been published containing all the papers and posters presented at the Alliance Science Forums held to date. In addition, a book on Bioanalytical Tools in Water Quality Assessment is ready for submission for publishing by IWA Publishing, London, UK.

Although outside the scope of this review, an assessment of the value to the economy of the outcomes of this research compared to its cost could also be undertaken. For example, the benefits to the SEQ economy of increased water security resulting from application of climate change research and the effectiveness of water supply options could be assessed. Another example may be the economic benefits of avoided treatment plant downtime or injury to sewer workers as a result of the use of the Alliance developed monitoring tool to detect contaminants in the sewerage system.

9.6. Establishment of a Suitable Method of Delivery

The Alliance method of delivery has proved a satisfactory approach for the current program. It would be an efficient method of delivery for future research given the investment that has already been made to establish the Alliance, as well as business and governance processes. Refinements can be made to the Alliance as outlined in section 10.2, but if the level of investment in research was to remain the same or at similar levels for the next two to five years, the Alliance is likely to provide the most benefit to investors and stakeholders.

The Alliance has demonstrated that it can maintain the flexibility to realign research objectives in response to changed requirements bought about by its funding partners. It has now developed good project management expertise and has good experience in delivering research outcomes. It has brought together leading researchers with the skills and drive to provide solutions for SEQ.

9.7. Future Research Needs

The current priority for the Alliance is to focus a considerable part of its energy on the synthesis of existing research results, aligning closely with Government agencies and water utilities to transfer the knowledge gained and to build capacity within these organisations. The current SEQ population of 4.4 million is expected to approximately double by 2056. Faced with this increasing growth and highly variable rainfall, securing SEQ's water supply remains a major challenge for Queensland. Therefore, the Alliance needs to work with Government to consider, develop and support the case for further funding for new and continued research to ensure that SEQ remains at the forefront of water resource management. From a Government perspective, there is also a need and an opportunity to extend the research outcomes from SEQ across the state. There is also an opportunity to identify mechanism to transfer the findings from these important research outcomes nationally. There are opportunities to take some of the research findings into the international arena.

If the Alliance was to continue after 2012, there are a number of research areas that still require attention. Additionally, some areas of current research need additional work or may need to be extended to provide a greater amount of certainty. For example, some studies only have small sample sizes and thus would need to be extended to obtain more robust data that could be used as the basis for future policy. To date there has been little focus on some of the key economic aspects. To provide better balance in the overall program, research should be assessed from economic, social and environmental outcomes.

The review has found that there is scope for further research. This future research must be agreed between the Queensland Government and the Alliance partners. Suitable funding and resourcing will need to support the research program. Priority areas include:

- Climate change impacts.
- Decentralised systems (including stormwater harvesting and cluster development).
- Portfolio management of diversified supplies.
- Economics of future supply options.
- Cities of the future.

Some specific areas where additional research should be considered are:

- Further development work with the CSIRO and DERM to determine the impact of climate change on system yields for various time scales (i.e. 20 years, 50 years).
- Additional research on the overall economics of various source options (including rainwater tanks) and research into optimisation of multi-source systems.
- Further work on the mechanisms for disinfection by-product formation and mitigation measures for DBPs in water treatment systems.
- Further research to optimise water storage management for water supply security as well as flood mitigation and to assess any impacts on water security.

- Further research into stormwater management including continuing work to identify the mitigation measures to minimise stream degradation resulting from upstream urban developments.
- Additional research to determine how well cluster developments are performing.
- Additional research on rainwater tanks to improve the design of pump systems, to confirm impact of such systems on total system yield and to identify suitable treatment processes (for non Water Grid customers).
- The Alliance will be a need to consider the management of water storages and use of other supply options such as desalination, PRW, and stormwater to determine the most effective way to manage both water security and flooding into the future.

9.8. Research in SEQ

Since the Alliance was established in 2007, there have been some changes in the research capability in SEQ. The Australian Government has provided $20 million funding to the Australian Water Recycling Centre of Excellence through its *Water for the Future* initiative, a $12.9 billion investment to help Australia meet the challenges of our drying climate and rising demand for water. The Australian Water Recycling Centre of Excellence was established in 2010 and is hosted by Water Secure (now a part of Seqwater). An important goal for the Centre of Excellence is that the social, economic and environmental value of water recycling is demonstrated and enhanced.

The Smart Water Research Centre is a strategic partnership that builds, shares and applies new knowledge to improve water cycle management. The consortium partners include the Queensland Government, Griffith University, the University of the Sunshine Coast, Gold Coast City Council and Seqwater. The Centre incorporates a state-of-the-art research facility. The Centre provides four core capabilities as follows:

- Alternative water sources;
- Health and environment;
- Water and society; and
- Water quality and diagnostics.

The Centre also provides a program of education and training directed towards emerging industry needs as well as commercial laboratory services.

The Healthy Waterways Network is actively working with the State and Local Government in the development of guidelines and management advice for WSUD and integrated water cycle management. Close collaboration with the Healthy Waterways Network would be desirable if the Alliance was to invest further in this area.

In order to avoid duplication between research agencies and enhance collaboration, it is recommended that the SEQ Regional Planning Committee would provide an appropriate mechanism for testing the relevance of new research programs to SEQ. This could be done through the Executive Officer Group and the Science Integration Panel. The Science Integration Panel reports to the Executive Officers Group, which reports to the CEOs committee for NRM (refer Figure 4 below). The Science Integration Panel has been established in SEQ to advise government on research priorities.

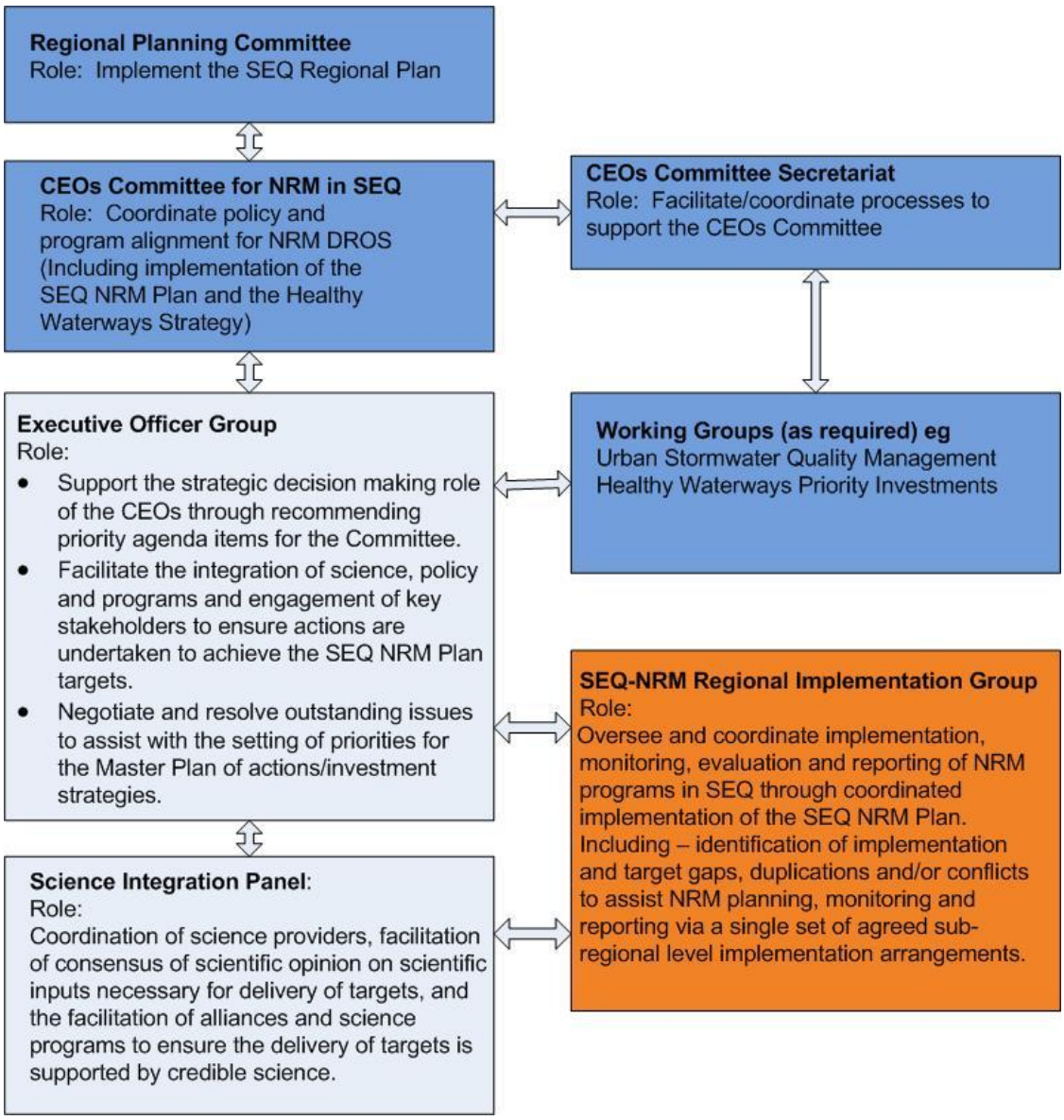


Figure 4. Governance Arrangements for CEOs Committee for NRM in SEQ.

10. VALUE AND GOVERNANCE

10.1. Research Outcomes and Value for Money

The Alliance has approximately eighteen months to run to completion of this phase of initial research. Approximately $19 million has been spent to date by the Queensland Government out of a total budget of $25 million. It is anticipated that the total investment will be in excess of $50 million as the research partners have contributed additional in kind funding and funding leveraged from other research programs.

Overall the Alliance has achieved a number of successes. Projects have contributed significantly to knowledge and understanding of public health issues, have resulted in the development of new monitoring tools and enabled a better understanding of climate change and water use. There have also been some projects where progress has not been as expected or where external factors have negated the benefit of the research.

Overall performance against the original objectives is shown in Table 2.

10.2. Governance Issues

In regard to governance, most stakeholders have identified the Alliance as being a suitable model for the delivery of the research program. Most parties thought that the model provided an excellent avenue for resource and information sharing. There were some comments made about the difficulty in obtaining research approvals, which seems to be complicated by the number of parties involved in the approval process.

Some stakeholders commented on the role of CSIRO and the funding model that guaranteed revenue support to their research effort. Some research partners identified the risk that the best researchers, across the Alliance, may not have been allocated to a specific research project. A "Best for Project" approach should be considered.

One way of achieving a "Best for Project" approach is through a competitive model, such as the one currently used by the Australian Water Recycling Centre of Excellence and may lead to better research outcomes. This matter will need to be resolved before a new bid is contemplated.

Issues were raised with the reviewers regarding the composition and role of the Alliance Board. There is a view that there is a potential conflict of interest with Board Members in their decision making. There needs to be clarity as to whether Board members are acting on behalf on their home agency or whether they are acting on behalf of the Alliance as an entity. There needs to be consideration given as to whether the balance in the Board is producing the best outcomes. A review of the Board makeup and the addition of additional independent Board members might assist in this regard.

A number of questions were also raised with the reviewers about the overlaps with other research organisations that may have emerged in the last few years (such as with the Australian Water Recycling Centre of Excellence and the Smart Water Research Centre). It will be important that for any future program there are no overlaps with other existing or proposed research programs. This has been further addressed in section 9.8 where the roles of various government forums may assist in limiting research overlaps across various programs.

Funding for future research will need to be discussed between existing funding parties and any potential new parties. CSIRO would be a prominent party in these discussions and has expressed a willingness to participate in future research if the appropriate governance and funding arrangements can be agreed. CSIRO remains of the belief that this is an important area of research for the organisation in which to continue. The synthesis of existing research, transferring knowledge and capacity into government planning and policy is a key component for the Queensland Government. An agreed research program would need to be developed before additional funding was sought.

Table 2. Alliance Performance

	Goal	Outcomes	Benefit	No of Technical Publications
1	Ensure research is well scoped and managed to deliver outcomes that expand on current knowledge	Each project has been clearly scoped and managed to deliver outcomes. Most but not all projects have expanded on current knowledge.	Budget effectively utilised.	
2	Research to ensure the reliability and safety of recycled water systems.	Results show that hospitals are a significant contributor to pharmaceuticals entering wastewater treatment plants but concentrations are very low. Trace chemical contaminants and endocrine disrupters are effectively removed during treatment. Most pathogens in reservoirs effectively removed in storage. Better management of other contaminants entering storage from catchment.	More certainty about the nature of contaminants leaving wastewater treatment plants and fate of pathogens in reservoir systems. This gives greater certainty about removal efficiency. May lead to improvements in design of AWTPs. New technology developed for measuring fate of contaminants in reservoirs will be used in another research project.	9
3	Advise on infrastructure and technology for recycling wastewater and stormwater.	Non-membrane recycled water plants can produce high quality water at less cost, no brine production and less greenhouse gas production.	Non-membrane recycled water plants could be suitable for smaller communities due to lower cost and GHG emissions and elimination of salt waste.	8
4	Build scientific knowledge into the management of health and safety risks in the water supply system.	Results show that there is low risk of NDMA formation in water supplies from SEQ catchments but a higher risk of THMs being formed and exceeding ADWG values for some waters. Some initial work carried out to determine effectiveness of different methods of treatment to reduce THMs. Needs further work. NDMA that was formed during chloramination at the pre-treatment step of the AWTPs has been effectively reduced as a result of research, which identified a low cost solution to minimise NDMA formation. Research into the human risk factors in water management will provide useful inputs to enable better management of new technology water treatment processes.	Improved knowledge of DBP precursors and potential mitigation measures. Identification of measures to significantly reduce NDMA formation at AWTPs may lead to future cost savings in treatment. Improved management practices to minimise risk to water supply operations.	8
5	Increase community confidence in the future of water supply.	Climate modelling work being carried out by CSIRO/DERM will provide sound basis for determining likely future impact from climate change. Work needs to continue to further refine initial findings.	Improved knowledge for planning future infrastructure.	10
6	Understand community behaviour and preferences with regards water use.	Results show community has strong beliefs and that changing some community beliefs like trust in Government will result in acceptance of some water issues. Research on core beliefs (psycho-social and socio-demographic approach rather than market driven) assists in understanding how community makes informed decisions. Residential water end use studies have provided definitive information on water use within a household. Further work required for external use.	Results support the use of intervention programs to encourage water savings. Good data now available for demand estimation for internal household use.	13
7	Provide improved methods to analyse water, energy and nutrient balances across the SEQ water system to inform future water strategy development.	Development of suitable methods, tools and models still ongoing.	May not completely achieve desired outcome within the current program.	8

11. RECOMMENDATIONS

The consultants recommend the following be carried out before a bid for additional funding is made:

1. In its current form the Alliance is due to wind up in around 18 months. All current projects should be assessed to ensure they would be completed in the time frame allocated. Some projects may need to be revised or wound up.

2. The research should be synthesised into summary reports that will provide information that can be used by the Queensland Government. For example, the outcomes for all of the rainwater tank projects should be bought together into a single report in such a way that Government can assess the outcomes and implications for current policy. This would also provide information for the Alliance to demonstrate the context and need for future research priorities.

3. Building on recommendation 2, a process should be initiated whereby the researchers (or knowledge brokers) directly engage with Queensland Government agencies to transfer the research outcomes to key agency personnel. The written reports only provide the starting point for transfer of information from research to policy.

4. A strategy should be developed to define the future research priorities for the Alliance based upon the outcomes of this review and the information obtained from the recommendations above. It should identify the resourcing (cash and in-kind), the organisations that would contribute to the Alliance and the form of the Alliance. This would provide the basis for a submission to the Queensland Government for further Alliance research.

5. The Alliance Board should carry out a review of the current governance arrangements.

6. The Alliance has played a valuable role to deliver scientific inputs which inform water policy for SEQ, pressing research questions remain and the Alliance could continue to address these issues. The Alliance partners should work collaboratively to develop the key areas and specific projects for future research. Research objectives and expected outcomes should be linked to Government agency and water utility business priorities and form the basis for a business case to the Queensland Government for additional research funding.