CRC for
Water Sensitive Cities

RESEARCH
2012 to 2016

An Australian Government Initiative

CRC AUSTRALIA

Research Overview

Summary of Initial Projects

A nine-year research and development program has been developed for the Cooperative Research Centre for Water Sensitive Cities (CRCWSC). The program is split into three distinct phases. The first phase covers years one to four and involves 35 discrete research projects.

Phase Two includes the research program for years five to seven. In Phase 3 (years eight and nine) we will be directing our efforts towards establishing an enduring legacy for the CRCWSC. To do this, we will be monitoring and documenting the effectiveness of our research adoption activities and working closely with our stakeholders to ensure that they can apply our research outputs in ways that deliver the maximum possible benefits.

The 35 research projects, identified as priorities for Phase One, have been grouped into four research themes or Programs. To effectively address the complex inter-dependencies between the projects we will employ a matrix style interdisciplinary delivery approach. This approach will place practitioners, policy makers and regulators in inter-disciplinary teams with researchers whose expertise may be in areas such as: water engineering; urban planning; commercial and property law; urban ecology; climate science; social and institutional science, organisational behaviour; change management; the water economy; risk assessment; social marketing; and community health. These teams will be located at research hubs in Brisbane, Melbourne, Perth, and Singapore.

Program A – Society

This program will focus on understanding and delivering the social transformations needed to support water sensitive cities, including community attitude and behavioural change, governance and economic assessment practices, management systems and technological innovation. By developing a richer understanding of underpinning social norms and behaviours, the research will provide evidence-based guidance on institutional rules and economic and regulatory frameworks for water sensitive decisions, policies and practices. The goal is to deliver governance models, policy tools and practical guidance that will facilitate social, institutional, regulatory and economic reforms that are mutually reinforcing, flexible and adaptable to different social scales and contexts.

There are four projects grouped under this program:

Project A1 - Economic modelling and analysis

- Project A1.1 (Cities as water supply catchments – economic valuation)
- Project A1.2 (Valuation of economic, social and ecological costs and benefits)
- Project A1.3 (Economic incentives and instruments)

Project A2 – Societal innovation and behaviour change

- Project A2.1 (Understanding social processes to achieve water sensitive futures)
- Project A2.2 (Accelerating transitions to water Sensitive cities by influencing behavior)
- Project A2.3 (Engaging communities with water sensitive cities)

Project A3 – Governance and regulatory reform

- Project A3.1 (Better governance for complex decision making)
- Project A3.2 (Better regulatory framework for water sensitive cities)
- Project A3.3 (Strategies for influencing the political dynamics of decision making)

Project A4 – Social-technical transitions

- Project A4.1 (Cities as Water Supply Catchments – Society and institutions)
- Project A4.2 (Mapping water sensitive city scenarios)
- Project A4.3 (Socio-technical modelling tools to examine urban water management scenarios)

CRC for
Water Sensitive Cities

Program A: Society | Project A1.1 | Project duration: July 2011 – June 2014

Cities as water supply catchments - An economic evaluation

Overview

There are many characteristics that impact a person's willingness to pay for public goods. Willingness to pay for environmental services, such as stormwater quality improvement or cooler temperatures in suburbs, varies significantly across regions and households with different incomes. Insights on community preference and the value placed on various environmental services and their benefits are helping inform decisions on project investment and policy design.

This project aims to place an economic value on the various environmental (non-market) benefits of stormwater management such as greater water supply security, flood protection, more liveable landscapes and increased biodiversity. It also identifies the communities' willingness to pay for those benefits taking into account key socio-economic factors such as income and education, and psychological factors like risk perception, personal experiences and preconceptions.

Key outcomes

The project provides a monetary evaluation of non-market benefits of stormwater management in metropolitan areas in Australia. In particular, the project will:

- provide preliminary monetary values and preferences for stormwater harvesting and determine the willingness to pay for stormwater harvesting in a range of different "markets" and context such as if the community has recently experienced flooding
- explore how individuals' risk aversion influences their willingness to pay for different environmental services
- explain the variation of the willingness to pay for the benefits of stormwater management between different Australian states and cities
- support the development of business cases for water sensitive city projects and programs by allocating non-monetary values to a range of benefits for use in cost-benefit analyses.

This project will also deliver tested and validated methodologies for undertaking choice experiments and calculating willingness to pay.

Early insights into who is willing to pay?

The CRC for Water Sensitive Cities can now estimate people's willingness to pay for specific environmental services and their benefits and how this varies by income, over time and across regions. Figure 1 displays the predicted average contribution (costs ranged from $0-30) based on several variables of interest. Income and education both increase average contributions, whereas older respondents contribute less.

The survey sampled households from four councils, two from Victoria and two from New South Wales, to examine how average contributions vary across geographic locations. The study showed that the level of contributions and the relationship between age and contributions vary across councils. For example, while the average contributions were found to be higher in council 1 compared to council 2, younger households contributed relatively more in council 2. This shows how both levels and trends can vary geographically.

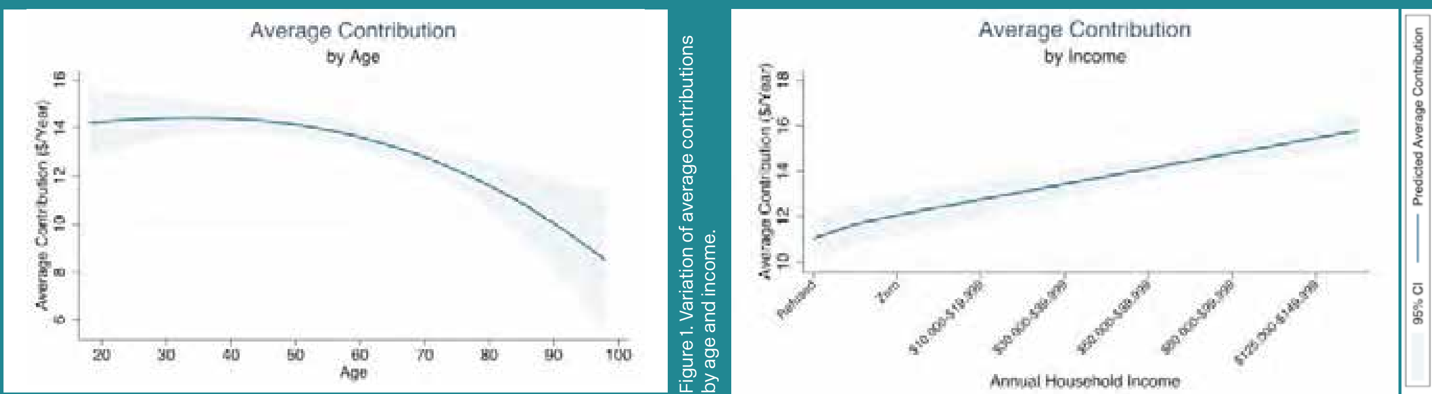


Figure 1. Variation of average contributions by age and income.

An Australian Government Initiative

CRC AUSTRALIA

Project design

While many benefits of stormwater harvesting and management have already been realised in the field, it is sometimes difficult to observe preferences and attitudes of individuals toward stormwater management. In addition, a number of recent innovations relating to stormwater harvesting have not been implemented in practice, making it difficult to estimate values for market data.

The research project conducted a number of different survey types (choice and field experiments) across local councils in metropolitan areas of New South Wales and Victoria recognising that stormwater management is usually managed at a council level. The researchers looked at five benefits relating to best practice stormwater management:

- lifting water restrictions
- reducing the frequency of flash floods
- improving stream health
- improving recreation and amenities
- lowering summer temperatures.

These benefits were selected through a discussion with scientists and policy-makers from local councils and were tested in focus groups. Staff from Manningham and Moonee Valley Councils in Victoria and from Fairfield and Warringah Councils in New South Wales helped develop and test the survey.

A choice experiment is a survey that presents a set of alternative scenarios or choices from which respondents select their most preferred options. The choice experiments firstly elicited a specific value attributed to each of the benefits of stormwater management mentioned above. Then the surveys unearthed a preference for different sources of water supply, for example, stormwater harvesting versus recycled water. Choice experiments allow interviewers to compare individual willingness to pay for environmental services over time and across different geographic areas.

In the field experiments, 981 owner-occupied households in four councils across metropolitan areas in New South Wales and Victoria were interviewed and data on their income and demographic characteristics was collected. These councils are all comparable in terms of their socio-economic make-up, yet differ in terms of their history of heavy rainfall and flash flooding events.

Outlook

This project on economic evaluation of cities as water supply catchments links to Project A1.2 (Valuation of economic, social and ecological costs and benefits of strategies and systems for water sensitive cities, and on Project A1.3 (Economic incentives and instruments).

The combined outcomes of these projects will provide decision-makers with the knowledge and tools to make informed decisions about water infrastructure investment that strike the best balance between economic, social and environmental outcomes so that benefits to the broader community are maximised.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Lata Gangadharan
lata.gangadharan@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A1.2 | Project duration: January 2013 – January 2017

Valuation of economic, social and ecological costs and benefits of strategies and systems for water sensitive cities

Overview

Over the past five years water utilities in Australia have made substantial investments in a range of different technologies, such as dam expansions, construction of desalination plants and water recycling projects, to supplement water supply to urban areas. In total, the capital investment in water augmentation projects over the period 2005/06 to 2011/12 by Australia's largest water utilities is estimated by the Productivity Commission to have been around $30 billion. Both industry and government require clear evidence about the full range of costs and benefits of investments in new systems and infrastructure before they can wisely invest.

This project will estimate the costs and benefits of strategies and systems for water sensitive cities (WSC) and provide best practice guidelines for the integrated economic evaluation of existing and new approaches to water infrastructure investment. An economic analysis of costs and benefits, including those related to energy, carbon, environmental and social factors, will be undertaken for water sensitive infrastructure in greenfield and retrofitting scenarios. This analysis will also take into account a variety of water sources such as recycled water, stormwater and dam water for different water needs; centralised and decentralised water supply systems; and new water sensitive technologies.

Key outcomes

This project will provide industry and government with new knowledge and tools to make sound water infrastructure investment decisions that strike the best balance between economic, social and environmental outcomes. There are very few studies in Australia or internationally that focus on the issues that will be addressed in this research project which include understanding:

- the economics of water conserving technologies and infrastructure for urban areas
- an economically optimal mix of water sources
- the benefits of improving urban liveability through enhancing water sensitivity
- the incorporation of non-market values when calculating costs and benefits
- the use of a real options decision framework.

This research project will fill a number of key gaps in the water economics literature.

Key findings: How valuable are living streams?

A case study investigated the replacement of parts of a main drain with a constructed stream in a suburb in Perth. The study examined what benefits local residents can gain from replacing traditional concrete main drains with constructed living stream infrastructure.

Early findings showed that the conversion of a traditional main drain to a constructed stream resulted in an increase in the price of houses in close proximity to the restored drain. Given the conversion involved extensive earth works and time for the vegetation to become established, the increases in house prices did not appear until about four years after the restoration project was initiated. The study also showed that within 200 metres of the restoration project house prices were raised by between $17,000 and $26,000 per house. This effect was in addition to the general trend of increasing house prices in the area.

In general, different types of drainage infrastructure also result in external costs and benefits that are associated with the specific drainage project such as recreational benefits from water quality improvements. It was found that only when the full range of project-related and external costs and benefits of a restoration project is being considered, traditional main drains may after all not be the cheapest option for drainage infrastructure.

Living stream case study area (© SERCUL)

An Australian Government Initiative

CRC AUSTRALIA

Project design

To estimate the costs and benefits of strategies and systems for WSC, the project uses various types of economic analysis exploring five common interrelated issues associated with delivering WSC. These issues are the:

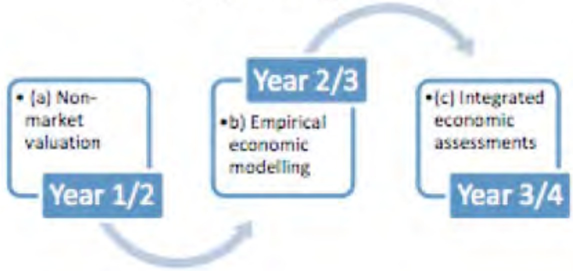
- costs and benefits of investment in water sensitive infrastructure
- costs and benefits of alternative systems for combining portfolios of water from different sources, including recycled water, stormwater, groundwater, desalinated water and dam water
- relative costs and benefits of centralised and decentralised systems for water supply
- economic viability of new technologies and systems which are being researched by the CRC for Water Sensitive Cities (CRCWSC)
- economic impacts of low probability events and the economics of options to reduce these impacts.

These issues will be assessed using the following types of economic analysis:

- non-market valuation to estimate the values of environmental and social benefits such as waterway health, urban biodiversity and liveability
- empirical economic modelling to identify optimal investment and management strategies and to estimate impacts
- integrated economic assessment.

In the field experiments, 981 owner-occupied households in four councils across metropolitan areas in New South Wales and Victoria were interviewed and data on their income and demographic characteristics was collected. These councils are all comparable in terms of their socio-economic make-up, yet differ in terms of their history of heavy rainfall and flash flooding events.

Figure 1. Project workflow



Outlook

This project is strongly linked to the CRCWSC Project A1.1 (Economic evaluation of cities as water supply catchments and Project A1.3 (Economic incentives and instruments). The combined outcomes will provide decision-makers with expert advice and better tools and frameworks to assess new technologies and undertake integrated modelling of complex factors when making investment decisions regarding water sensitive infrastructure that will generate a net welfare gain.

The outputs will include specific guidelines for economic evaluation of water sensitive infrastructure systems and technologies that can be used by water utilities, state and local planning authorities, and water service providers.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Dr James Fogarty
james.fogarty@uwa.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A1.3 | Project duration: July 2012 - July 2016

Economic incentives and instruments

Overview

Economists and policy-makers heavily rely on economic and non-economic incentives to encourage the take-up and adoption of new systems and technologies by industry and the society at large. This is particularly the case in the environment sector where incentives either do not exist or are not properly aligned to socially desirable behaviours such as the adoption of water sensitive practices.

This project aims to design effective economic policy mechanisms to encourage take-up of water sensitive practices by individuals and organisations, investment in new infrastructure and technologies by agencies and utilities, and reduction in pollution of waterways. It will analyse the optimal mix of policy mechanisms and develop appropriate funding mechanisms considering public and private benefits and who should pay for the implementation of water sensitive urban design solutions.

Key outcomes

This project will deliver recommendations on and economic instruments for the design of an optimal mix of policy and funding mechanisms (including regulatory, market, incentive and educative mechanisms) to promote take-up of water sensitive practices that focus more on costs and benefits to the wider community rather than just private individuals or companies. These outcomes will significantly broaden the portfolio of existing policy options available to policy-makers and regulators in government and industry.

This project will deliver the tools and guidelines on economic incentives and instruments relating to:

- non-point source pollution
- water conservation and water pricing
- economic and non-economic motivations to promote water sensitive practices
- an optimal mix of policy mechanisms
- funding mechanisms for improving environmental outcomes such as crowdfunding.

Early insights into peer pressure around households' water consumption

The project on mechanisms for pollution reduction has produced several interesting results. For example, it found that social mechanisms and norms such as peer sanctions and peer communication can have different impacts in different kinds of social dilemma scenarios.

The research on water conservation programs relies on social comparisons to understand water use. For example, normative messages that compare a household's water use to its peers were found to reduce consumption between 2-6%. Larger water users save more water and there is significant variation in savings across different water utilities.

An Australian Government Initiative

CRC AUSTRALIA

Project design

This project consists of a number of components looking at policy mechanisms for improving environmental outcomes, water conservation programs, risk perceptions of experts, and cost-benefit analyses of different policies for reducing private household emissions in a specified local government area.

The study on policy mechanisms compares a formal regulatory mechanism with informal peer monitoring and social sanctions and examines its effectiveness in reducing pollution in waterways as compared to formal regulatory approaches. It also investigates how different kinds of informal mechanisms, such as social sanctions and peer communication, work and which are more effective. The project on water conservation programs analyses data from randomised experiments utilising social norms to promote water conservation. Another project researches and tests crowdfunding mechanisms for financing water sensitive urban design projects. The research will be one of the first forays into crowdfunding for public goods.

The cost-benefit analysis comprises a case study in Western Australia's Southern River catchment in collaboration with the Western Australian Department of Water and the Swan River Trust. It will measure seasonality and trend in nitrogen and phosphorus emissions in the catchment and relate these to land use changes over time, especially land clearing for development. The purpose of this work is to measure the rate at which emissions are changing. The case study will also assess the cost and benefits of different policies for reducing emissions including behaviour change among households, local authorities' policies and restrictions on developers.

Outlook

One of the next steps is to compile the findings on using social norms for water conservation into a working paper which is scheduled for release by mid 2015.

Results from the water pricing experiment, which is expected to go into the field in 2014/15, will uncover whether scarcity pricing can reduce water use during droughts. This project has close links to Project C5.1 (Intelligent urban water systems) which is using advanced metering data and data-mining algorithms to identify behavioural patterns of water use.

In terms of crowdfunding research, the project team is in discussion with industry participants and working on scoping a survey which is scheduled for completion by mid 2015. It is anticipated that a crowdfunding platform will be established by mid 2016 with agreements with industry participants in place to begin collecting data. The crowdfunding project will bridge many pillars of the CRC for Water Sensitive Cities' programs by providing an adoption pathway for its research and establishing a business case for industry partners why they should adopt water sensitive urban design.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Lata Gangadharan
lata.gangadharan@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A2.1 | Project duration: July 2012 - June 2016

Understanding social processes to achieve water sensitive futures

Overview

The built form of Australian cities reflects the economic and cultural preferences of generations of migrants and settlers for low-density suburban living and the detached "home" rather than the urban apartment. This has resulted in some of the most sprawling cities in the world. In seeking to understand why our expanding cities seem to make such poor use of scarce water supplies, it helps recognise the power of historical and cultural dwelling and lifestyle preferences that cannot easily be undone. The path to more sustainable water usage will mean that the vast bulk of residential buildings that have been constructed over more than two centuries, and the ways in which residents use these, will need to be adapted to meet the new urban water challenges.

This project aims to create an understanding of the social and historical processes of domestic water use and lifestyle in Australian cities. Understanding the reasons for the current built form of our cities and the ways in which Australians use their dwellings and backyards will help inform future policy and guide the development of interventions and strategies to support the adjustment and adaptation to different water sensitive lifestyles.

Key outcomes

This project will document the economic, social and cultural forces that have shaped Australian cities resulting in low density, detached dwellings being the dominant residential form today. It will also identify key water use cultures in our cities and the social meanings and processes that shape people's everyday water use practices to inform the development of realistic, socially acceptable and effective water sensitive policies. Finally, it will examine people's understandings about water and the "Australian way of life" and how geographic location, gender, ethnicity and socio-economic factors affect these understandings.

The project will ultimately provide a characterisation or typology of water use cultures and contexts including information about community values, ideals and perceived risks and recommendations for the development of effective and socially acceptable water sensitive interventions. This information will be particularly useful for demand forecasters, local policy-makers and marketing and communications professionals in the water sector.

Early insights into peer pressure around households' water consumption

Differing cultural values and contexts impact on how technological solutions such as rainwater tanks are taken up and utilised. As an outcome of the literature review four domains - systems and infrastructure; social and geographic capital; domestic water use contexts and technologies; and everyday practices and values - were identified. These domains need to be taken into account in order to adequately understand Australian water use cultures before seeking to change existing water use practices. The findings of the literature review have been published in the report Australian Domestic Water Use Cultures.

The meso level of household and community context (social class, ethnicity and geography) is important and an under-researched field. Early analysis of survey data shows that water use and water sensitive practices are driven by a range of interrelated factors such as household configuration, lot size, age, education, income, attitudes toward sustainability and geographic location. In the coming months the project will explore these interrelated factors and develop a typology of water use cultures. This will provide research partners with a nuanced picture of population groups across Australia and their differing approaches to water use and water saving.

Figure 1. Four domains relevant for understanding water cultures.

An Australian Government Initiative

CRC AUSTRALIA

Project design

The multi-layered research design comprises a number of components. The first one is a systematic review of research on water use cultures. A large-scale national online survey of 5172 people in major urban centres across different climatic zones in Australia is used to shed light on actual water use practices and knowledge. A series of urban water histories will study the foundation, growth, and economic, social and cultural development of Melbourne, Brisbane and Perth and will investigate how state and local governments as well as residents have adapted to water scarcity. Focus group interviews will explore key water use cultures and what meanings and values these specified social groups attribute to domestic water use. Another part of this project will look into the implications of social inequality for the development of water sensitive cities. It will explore the apparent need for engaging privileged groups with high levels of water literacy, positive water saving attitudes but low practical commitment to water conservation.

Systematic literature review of water use cultures ↓

Large-scale national survey to identify key water use patterns ↓

Urban histories of water use in Melbourne, Brisbane and Perth ↓

Focus group study of diverse communities and households ↓

Synthesise the findings into a typology of water use cultures to identify drivers and barriers to water sensitive practices

Outlook

The next steps are further analysis of the national survey. A report on the history of urban water use from 1788 through to the present with a particular focus on the three major cities covered by the CRC for Water Sensitive Cities – Melbourne, Perth and Brisbane – will be ready in June 2015. Finally, the typology of Australian water use contexts and cultures is under development and will be completed in 2015.

In summary, this project offers a unique opportunity to combine findings from social history reviews, surveys and focus group interviews to generate deep knowledge about Australian water use cultures and opportunities for and barriers to community change and adaption to a water sensitive future.

← *Figure 2. The components of the multi-layered project design.*

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Jo Lindsay
jo.lindsay@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for **Water Sensitive Cities**

CRC for
Water Sensitive Cities

Program A: Society | Project A2.2 | Project duration: July 2012 – July 2016

Accelerating transitions to water sensitive cities by influencing behaviour

Overview

While traditionally water in Australia has been seen as a secure, clean and cheap resource, drought and flooding events of the past two decades have substantially challenged if not changed this view. Responses to drought, flood and water scarcity in a changing climate will need to consist of water sensitive engineering and design solutions as well as of economic, social and policy levers that encourage Australian households to play their part in addressing these challenges.

This project works on the assumption that household behaviours affect water consumption, water quality and stormwater runoff, and hence fostering desirable behaviours is an important part of the solution to the issues of drought, flooding and pollution.

The project aims to identify household behaviours that would reduce water consumption, flooding risk and pollution and prioritise them to show a path to greater water sensitive communities. It will create a water sensitive typology based on behaviours. Knowing who is performing what behaviours will be useful to the water industry to gauge how these behaviours can be used as leverage to achieve behaviours with greater impact.

Key outcomes

This project will provide a sequenced behavioural road map to greater water sensitivity. This map can be used to gauge where a population currently sits in terms of water sensitivity as well as to show the next tranche of behaviours to target in a progression toward water sensitive cities.

It will provide stakeholders with a behavioural assessment database documenting prioritised behaviours and assessing them for the impact they can have on, for example, flooding risk or pollution. This database can be used by the water industry to assess desirable target behaviours before attempting to influence them.

On the back of testing this framework, policy advice on individual and collective interventions to influence prioritised behaviours of households will be given.

Early insights into water sensitive behaviour profiles

Using the data on water professionals' and the general public's perceptions of impact and likelihood of behaviours, a national survey found that although there are some differences in perceptions, the water industry, in general, has a pretty accurate understanding of their communities' water sensitive behaviours. Following water sensitive behavioural profiles can be drawn from the survey:

- **"Water savers"** are people who turn off taps, wash full loads of clothes, take short showers, use half flush and fix leaks. These people are older, have strong environmental attitudes, are well educated and willing to support desalinated water, but only show moderate support for the use of recycled water.
- **"Garden enthusiasts"** are people who choose less polluting products and climate suitable plants and use garden chemicals appropriately. These people are of average age, live in average size houses and are strong supporters of policies for the use of recycled water.
- **"Effortful water savers"** are people who mulch garden beds, water in the mornings and evenings, hose with a trigger or timed watering system and collect water in sinks. These people are younger and live in smaller houses with a large percentage of them owning them either with or without a mortgage. They don't support the use of recycled water.
- **"The young and unconcerned"** are placing cigarette butts in bins and prevent animal waste from entering waterways. These are the youngest and least educated group with the highest level of employment. They have bigger houses with more people living in them. Their support for desalinated water and recycled water is the lowest of all groups.
- **"The others"** wash their cars at a car wash and put rubbish in bins. These people are older and have the least number of people living in a household.

An Australian Government Initiative

CRC
AUSTRALIA

Project design

The project involved desktop research and consultation with industry and academic participants of the CRC for Water Sensitive Cities to identify and prioritise a set of water sensitive behaviours. Prioritisation was done on a number of criteria falling into the categories of perceived impact (individual and collective) and likelihood of adoption (by assessing ease). Once measures of these two criteria have been completed, behaviours will be mapped onto a grid of impact and likelihood.

The behavioural road map will be looking to move people from low impact-high likelihood behaviours to more desirable low likelihood-high impact behaviours. The objective over the two final years of the project is to test the efficacy of market, social marketing and regulatory tools for accelerating this process.

Outlook

The behavioural assessment database is complete and will be released soon. Over the coming six months, the project will finish the typology and behavioural road map. It is planned to make the national survey data accessible to industry.

In the long term, the project will bring about a greater understanding about relationships between individual water sensitive behaviours as well as how to use these relationships to influence transitions from one to another. It will bring the perspective of behavioural psychology into planning processes aimed at water sensitivity and will be looking to move people from low impact-high likelihood behaviours to more desirable low likelihood-high impact behaviours.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Dr Liam Smith
liam.smith@monash .edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A2.3 | Project duration: July 2013 – July 2017

Engaging communities with water sensitive cities

Overview

The transition to water sensitive cities (WSC) requires broad community acceptance of changes in policy, practice and technology. To achieve this, water practitioners and government agencies will need to effectively engage communities. This project aims to identify effective community engagement strategies that will promote knowledge about water management, build trust in water institutions, and leverage support for policies that promote sustainable water management.

A critical first step in the engagement process is identifying the community's current water related knowledge, termed "water literacy". Little is known about the Australian community's knowledge of water related issues and to what degree this knowledge is important for water conservation behaviours or support of policies related to sustainable urban water management (SUWM). This project will also identify community-friendly terminology and visuals that easily convey key messages relating to SUWM and evaluate what types of messages are more effective in engaging communities.

Key outcomes

The project benchmarks water literacy in Australian communities identifying key gaps in water literacy and key groups within the population to target for improving water literacy. The project will also create an understanding of community attitudes to policies that affect the implementation of SUWM. The project will deliver:

- a database of terms, images and messages about SUWM that effectively inform and engage community members
- capacity building of researchers, experts and practitioners to effectively engage diverse communities, and communicate new or complex information in the area of SUWM
- strategies for researchers, experts and practitioners to effectively engage communities in the transition to WSC.

Early insights into Australian water literacy

A survey was conducted with a representative sample of Australian adults. A series of questions examined knowledge of catchment management, impact of household behaviours on waterways, domestic wastewater and stormwater management, and delivery of drinking water. The survey also investigated attitudes toward water conservation and water conservation behaviours.

Water literacy in Australians is somewhat low, with only 15% of the population exhibiting high water literacy (defined as answering at least 80% of water knowledge questions correctly). Queensland has the highest water literacy (20%) and Victoria the lowest rate (10%).

At least two thirds of respondents know that:

- household actions can influence water quality
- household fertilisers can impair waterway health
- stormwater from houses can impair waterway health
- planting trees near waterways can improve waterway health.

However, less than half of the respondents know that a catchment is the total land area that drains to a river or waterway. In addition, less than one third know that:

- domestic wastewater is treated before entering waterways
- stormwater is not treated before entering waterways
- wastewater and stormwater are carried via different pipes.

The study showed that poorer water literacy is associated with younger age, lower income, lower education, and use of languages other than English in the home. These groups may need more intensive support to promote water literacy. Importantly, water literacy is related to a range of behaviours, including installation of water saving devices in the home, use of water saving strategies in the garden and the home, and greater acceptance of alternative water sources.

Project design

This project involves a series of studies that all work toward development of effective community engagement strategies that support the transition to WSC. A national survey of water literacy in 2014 has identified strengths and gaps in community knowledge of water related issues as well as attitudes to SUWM, and identified potential key groups for targeting interventions to promote water literacy.

A desktop review will examine national and international community engagement strategies in areas related to SUWM. This review will showcase best practices and identify what works in community engagement.

A series of interviews, surveys and experimental studies will examine how consumers interpret and respond to language and images used to communicate SUWM. These studies will inform the development of a database of effective and community-friendly terminology and visuals for use in community engagement activities.

Conduct a national survey of water literacy and identify gaps in knowledge ↓

Conduct a desktop review of community engagement strategies, and identify "what works" ↓

Develop a database of community-friendly terminology and visuals that support community engagement ↓

Synthesise findings to develop strategies for engaging communities in the transition to water sensitive cities

Outlook

The findings from these studies will collectively inform and support the development of strategies that will allow researchers, experts and practitioners to effectively engage communities in the transition to WSC.

On a practical level, project outputs will include guidelines and recommendations for researchers, experts and practitioners for engaging communities in SUWM; and industry workshops to disseminate the findings. Ensuring engagement strategies are aligned with current best practice will improve targeting of resources and optimise the support and participation of all communities in the transition to WSC.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Dr Kelly Fielding
k.fielding@uq.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A3.1 | Project duration: July 2012 - June 2016

Better governance for complex decision-making

Overview

Commercialisation of public utilities, the rise of integrated water management, the emergence of national policy frameworks, and extended drought and major flood events have driven significant shifts in urban water management, policy and governance in the last 20 years. With these developments has come an increased awareness that governance arrangements can sometimes act as substantial obstacles to improving water policy and management outcomes.

Water governance in a water sensitive city (WSC) will require the integrated management of water sources and services to deliver both efficient and effective multi-functional water solutions. Future arrangements will also require responsiveness and flexibility to meet evolving needs and uses of water, and to cope with unpredictable environmental conditions.

This project aims to examine current institutional challenges to better enable the sustainable water management of a WSC. The project explores how the complex decision-making processes involved might be supported through more adaptive governance arrangements, identifying where and how current centrally controlled governance systems can be supplemented with more flexible governance instruments.

Key outcomes

The project will produce a set of governance guidelines and tools that help practitioners develop strategies to address governance barriers in specific contexts. This project will achieve this by:

- assessing the current mix of hierarchical, market- and network-based frameworks at all levels of government in Australia for addressing WSC issues
- assessing the international range of models for governance associated with complex issues
- assessing best practice approaches for the use of expert knowledge in evidence-based innovation and strategy development, together with the organisational requirements (skills, resources, processes) for evidence-based development of WSC strategies
- developing new models for effective partnerships and networks for knowledge development and capacity building
- identifying best practice governance models for local and regional scales.

Key findings on urban water governance challenges

In December 2013 the report Specifying the urban water governance challenge was released, reviewing major shifts in Australian water policy over the last 20 years. Based on a desktop review and on discussion with industry practitioners, the report identified a list of governance challenges hindering transition toward the integrated and adaptable water management models which underpin a WSC.

A key lesson which emerged was the importance of collaboration to build the partnerships and the trust needed to resolve water management integration issues as well as to navigate complex and unclear decision-making arrangements. Three common features underpinned the resolution of many governance challenges, namely:

- encouraging innovation - strengthening incentives (and weakening sanctions) for developing new ideas into alternative solutions, and encouraging the organisational change and leadership needed to facilitate the take-up of these innovations through policy and practice change
- building policy capacity - diversifying skills and designing tools more suited to policy work on complex issues, such as holistic options assessment methods, criteria for making trade-off decisions, protocols that can balance risks and benefits and apportion risk appropriately, guidance on which mix of policy instruments can deliver the desired outcomes, and strategies for selling policy change to key decision-makers
- enhancing collaboration - undertaking stakeholder and citizen engagement in various aspects of water governance and management, guidance for designing participatory processes for different engagement purposes, and developing the workforce skills and provision of resources to incorporate collaboration into everyday practice.

Subsequent research activities will develop relevant governance solutions by using the above three features as focal points for identifying the governance instruments that have proved successful in cases of policy innovation.

An Australian Government Initiative

CRC AUSTRALIA

Project design

A range of cases of policy innovation from a variety of jurisdictions and levels in Australia, as well as from international examples, will be studied to reveal the structural mechanisms, good practices and policy processes that can overcome current institutional barriers and provide more adaptive governance mechanisms. For example, cases where technological innovation has influenced policy and regulatory change may reveal how future solutions can be scaled up as a timely response to new needs or changed conditions. In cases where policy implementation has been conducted across different departments at different government levels, strategies for collaboration in multi-stakeholder, multi-level environments might be found.

The results of these studies will provide the tools and structures for building more flexible models of governance, as well as the strategies and contextual considerations for operationalising these governance instruments.

Outlook

By June 2015, best practice approaches and process models for governing complex policy issues will be distilled from water and policy governance literature and from a number of national and international case studies. The latter phases of the project will apply and refine the findings through practitioner workshops in order to specify the governance arrangements, tools and capacities the Australian urban water sector needs to transition towards WSC. The envisaged outputs of the project will include:

- a set of best practice principles of governance in a WSC
- a compendium of structures, strategies and tools which can be used to operationalise these principles
- guidance on how these governance instruments are best utilised for different political contexts and government scales
- process models and tools that can be used to improve evidence-based decision-making in policy development.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together inter-disciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Brian Head
brian.head@uq.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A3.2 | Project duration: July 2012 – July 2016

Better regulatory frameworks for water sensitive cities

Overview

A crucial barrier to advancing water sensitive cities (WSC) to date has been the existing regulatory arrangements. The need for an improved regulatory framework has been widely accepted but understanding complex existing frameworks as well as how best to reform these has been challenging.

This project will assess current barriers to the adoption of new urban water practices, technologies and alternative water sources arising from legislative and regulative frameworks. It will also assess the risks associated with projects that utilise alternative water sources.

Key outcomes

This project seeks to better understand existing institutional and traditional practices by examining the webs of regulatory rules, tools, constraints and incentives which either help or hinder more sustainable water sensitive practices. It examines how a wide variety of regulatory methods can assist in achieving better public policy outcomes as required in a WSC. The project will:

- assess current regulatory frameworks embedded in state legislation to identify gaps and overlaps in relation to alternative water sources and water sensitive urban practices
- identify elements for more comprehensive, co-ordinated and integrated regulatory frameworks
- classify and evaluate mechanisms for assessing, allocating, sharing and distributing risks associated with alternative water sources and water sensitive urban design (WSUD) technologies
- develop a new model for risk assessment and diversification.

Key findings on Melbourne's urban water regulation

The report "Conceptualising Urban Water Regulation – The Melbourne System", released in February 2014, presents a preliminary conceptual model and issues paper which suggests areas where research is needed. It maps current regulatory frameworks that impact on urban water management in Victoria, with a particular focus on the Melbourne metropolitan area. It also synthesises and presents detailed descriptions of the principal actors or stakeholders, roles, responsibilities, legislation and tools that characterise the Melbourne urban water regulation space.

How can we reduce the complexity of the regulatory infrastructure in Victoria?

Urban water management in Victoria is made up of multiple, complex webs of regulatory tools across the five key systems relating to water resources, service delivery and pricing, built environment, and environmental and public health. This suggests that regulators need to think in more detail about how these multiple webs link together so that their combined influence pushes in the desired direction.

How can we improve service delivery and price regulation?
Current frameworks for service standards and price setting in Melbourne's urban water sector operate largely within an economic efficiency paradigm. These are not well aligned to emerging concepts of sustainability, and there are likely to be significant challenges in aligning these conceptual frameworks.

How can we improve the regulation of the built environment?
Over recent years there has been a transition from the use of hard infrastructure for delivering drainage services to the use of softer infrastructure that also provides environmental benefits. This area of the regulatory space is still evolving and the interactions between these tools and their relative effectiveness are under-explored.

How do we protect environmental health through effective regulation?
Traditionally, Australian environmental health regulation regimes have focused on the control of point source pollution. Victoria's point source pollution controls are seen as robust and effective. However, environmental health regimes for the control of non-point source pollution and threats to the environment caused by stormwater flow are less developed, less coherent and, even when present, are poorly enforced.

An Australian Government Initiative

CRC AUSTRALIA

Project design

The project consists of two components. Component 1 involves an analysis of the current regulatory frameworks in Western Australia, Victoria and Queensland to identify gaps, inconsistencies and deficiencies in the regulation of various types of alternative water sources and WSUD projects.

The mapping will encompass provisions made in the Water Acts of each state which determine, for example, governance, water rights and allocation; environmental legislation and guidelines; health legislation and guidelines; pricing of water supply and services; environmental impact assessment regimes; and drought restrictions. It will also identify those regulatory tools that either help or hinder water sensitive practices. Component 2 involves collaborating with industry to develop new risk assessment and diversification tools.

The research will focus on both traditional and emerging WSC risks and analyse a range of decentralisation scenarios to gain insights into how traditional WSC risks might be differently allocated in the future under different ownership and operational regimes.

Outlook

Both the completed state legislative reviews as well as the above mentioned report provide crucial foundations on which the remainder of the project is to be built. Future work will use these legislative mappings as well as the conceptual framework as the basis for a comparative analysis of the regulatory regimes surrounding urban water management in Victoria, Western Australia and Queensland. It will also encompass new insights into how future regulatory frameworks might better allocate risks through both ownership and ongoing operation.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Graeme Hodge
graeme.hodge@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A3.3 | Project duration: July 2012 - June 2015

Strategies for influencing the political dynamics of decision-making

Overview

Achieving water sensitive cities (WSC) is a mammoth task; they are difficult to define, and the issues are complex and often involve many players and decision-makers in industry and government. Politicians, policy-makers and business leaders play a vital role in enabling a successful transition to WSC in the long term, but they often have limited understanding of the principles. Equally, scientists and other reseachers, and practitioners may struggle with limited knowledge of the political arena and how to navigate and influence the political decision-making process successfully and to inform public opinion effectively.

This project is designed to address the question of how the voices of researchers, experts and practitioners might be better heard and positioned in the policy-making process; particularly in evidence-based decision-making processes. The long-term goal is to develop the capacity of the CRC for Water Sensitive Cities (CRCWSC) to interact more effectively with policy- and decision-makers at all levels to ultimately influence the development of new policies that will help achieve water sensitive cities.

Key outcomes

This project is designed to build the capacity of researchers and develop strategies for influencing the political policy- and decision-making that work toward achieving water sensitive cities. The project aims to:

- identify current perspectives and attitudes of senior decision-makers (politicians, policy-makers and water executives) on evidence-based policy-making integrating research findings and scientific advice
- identify how policy-makers and political leaders make decisions and develop policies that affect the implementation of water sensitive cities
- identify how policy- and decision-makers can engage more effectively with, and harness the knowledge of, researchers, experts and practitioners
- generate models for decision-making that will assist key decision-makers in policy analysis and development
- build capacity of researchers, experts and practitioners to better understand the policy-making process and to ensure that their expert advice is being considered
- develop strategies for researchers, experts and practitioners to engage more effectively with the public, community stakeholders and decision-makers to influence policy-making.

Early insights into a case study on water policy reform

One case study exploring water policy reform in Australia has unearthed some of the tensions and often differing agendas of science and politics and the fundamental problems in connecting the two spheres. The case study, informed by interviews with 30 key players and a comprehensive documentary analysis, produced the following early findings:

- Researchers who are highly attuned to political messages and think strategically both in the way they develop a political case for science and communicate their agenda seem to be most influential in the policy-making process. Researchers need to be able to articulate clearly what policy outcomes they want to achieve and then craft messages in a way that aligns with the objectives of government and policy-makers.
- Due to constrained and constricted timeframes, researchers often struggle with packaging and presenting scientific information in such a way that it will have an effective impact on policy- and decision-making.
- Timing is also critical because "policy windows" or periods in which there is significant political and government commitment to policy change, are infrequent and brief in the water policy area. Researchers need to be better prepared for these windows and provide input quickly and collaboratively when they appear.
- Researcher networks and credibility play a critical role in influencing political decision-making. Researchers and their associations need to build stronger networks with policy- and decision-makers and better maintain those networks.
- Often just a handful of scientists are consistently approached for advice and interpretation of scientific information in the policy-making process. Researchers need to build their capacity in engaging and communicating with policy advisors and political decision-makers for a broader base of scientific voices to be heard. Researchers also need to identify who the trusted voices are and collaborate with them. Only a small selection of scientists may ever get direct access to policy-makers.

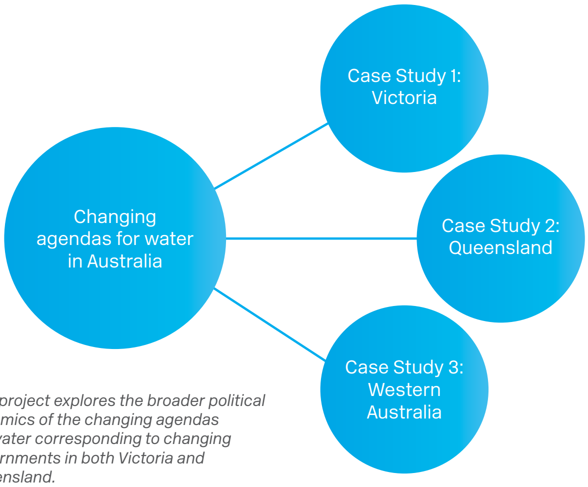
An Australian Government Initiative

CRC AUSTRALIA

Project design

Policy- and decision-making processes, especially those intended to achieve significant change, come with a number of inherent dilemmas: they are often highly complex, tend to be bound by their history and need to engage different agencies and players with often differing interests, preconceptions and agendas. There is also a heightened expectation to engage the community in the policy development process.

This research project explores water decision-making processes in Victoria, Queensland and Western Australia in three case studies. Up to a 100 interviews with five target groups including ministers, policy advisers, researchers, practitioners and implementers inform and underpin this research.



This project explores the broader political dynamics of the changing agendas for water corresponding to changing governments in both Victoria and Queensland.

Outlook

By June 2015, two more case studies in Queensland and Western Australia will be developed and the findings published. On a practical level, this project will deliver a number of tangible outputs such as:

- manuals and training modules to help scientists and practitioners communicate WSC principles and latest research findings more effectively to decision-makers, and for them to assist in building capacity in evidence-based decision-making
- a set of recommendations of sophisticated governance structures and processes that link science and expert advice to policy-making more effectively
- models and tools to inform and improve policy- and decision-making
- leadership forums and training for senior decision-makers that build awareness of the benefits of WSC and the importance of implementing supporting policies.

In the long term, it is envisioned that this research will build scientists' and practitioners' capacities to communicate their findings and to influence policy-making with greater impact; to generate WSC related decisions that are better informed and based on evidence; and to better inform public opinion and foster community engagement that will build long-term support for change.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor James Walter
james.a.water@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A4.1 | Project duration: July 2010 - December 2014

Cities as water supply catchments – Society and institutions

Overview

Despite broad agreement on the need for a transition toward more sustainable urban water systems, there remain significant social and institutional barriers to such a change. These include insufficient skills and knowledge about sustainable urban water management (SUWM), organisational resistance, lack of political will and limited regulatory incentives to implement SUWM.

This project aims to address these barriers by identifying the key social and institutional structures and processes needed to actively advance the mainstream application of SUWM, in particular decentralised urban water systems such as stormwater harvesting and treatment. The practical focus of this research project is to understand how to facilitate widespread application of stormwater systems and improve the industry's and community's receptivity or willingness to accept such an approach.

Key outcomes

The project will deliver tools and guidelines to help Australian cities transform their water management. These tools are specifically targeted at water practitioners, including policy-makers, urban designers and engineers. This project will provide stakeholders with:

- an understanding of the structures and processes of effective urban water governance for urban water systems
- guidance to enable co-governance of combined centralised and decentralised water systems operating at different scales and with different sources
- risk profiles of different water systems as viewed by Australian urban water practitioners
- design and management guidelines for green infrastructure to enhance its appreciation and acceptance by Australian communities.

Early insights into peer pressure around households' water consumption

In a water sensitive city, a hybrid mix of centralised and decentralised water systems and water sources will operate at a range of scales to provide fit-for-purpose water that will provide environmental quality, intergenerational equity, and certain landscape features of use or value to the public such as parks. Governance of these systems is likely to differ from traditional arrangements by involving multiple stakeholders who must work together to manage risk. Trust will be essential for the effective governance of those systems.

A survey and focus group discussions have unearthed interesting findings regarding the community's perception of governance of green infrastructure such as rain gardens. This project explored the attitudes of Australian urban water practitioners toward ownership and management of different water systems likely to exist in a water sensitive city, including who they would trust to manage the associated risk. Some insights are summarised below:

- It was found that Australian urban water practitioners supported the idea of different stakeholders owning and managing different urban water systems depending on the scale of the system and the water source, but restricted their trust to government-related entities to manage the risks. Homeowners were only trusted to manage risks associated with rainwater tanks.
- Shared knowledge and social values are likely to enhance this trust and facilitate the management of risk involving all stakeholders. These might be developed through sharing technical information for non-experts and enhanced communication between experts and local stakeholders.
- There are several different perceptual lenses through which people might view a landscape, affecting the way in which they perceive it. For example, people can view landscapes as providing visual or aesthetic benefit, or as habitat for different life forms. Others may look at landscapes from the perspective of working with the land and looking after it or feeling attached to it because it gives them a sense of place and identity.
- Appreciation and acceptance of rain gardens are likely to be influenced by the perceptual lens through which they are viewed thereby affecting their adoption and implementation.
- It is suggested that dominant community perceptions should inform the design of landscapes intended to function as green infrastructure.

An Australian Government Initiative

CRC AUSTRALIA

Project design

This project consists of four independent, but highly interrelated sub-projects which:

- describe the range and significance of different perceived risks or risk perceptions which urban water practitioners associate with a diverse range of water technologies, including stormwater harvesting and treatment systems
- assess the relative strengths and weaknesses of existing urban water governance strategies to determine whether they are fulfilling their intended purpose
- examine the emergence and operation of co-governed decentralised urban water systems
- identify community perceptions of green stormwater infrastructure.

A multitude of different methods will be used, including literature reviews, case studies, focus groups, workshops, online surveys and interviews with urban water practitioners, land developers, local governments and community members.

Outlook

Next steps include the continued analysis of survey data of how the community perceives green infrastructure. This will provide useful insights and recommendations on how to build community appreciation and acceptance of green infrastructure built into water sensitive urban design projects. Design guidelines for stormwater harvesting infrastructure that are likely to be in line with community perceptions, together with industry guidelines on facilitating co-design and co-management of stormwater harvesting technologies, are scheduled for release by the end of 2014.

← *These rain gardens located in two different contexts can be expected to be viewed or perceived differently through a perceptual lens of care and understanding. © M. Dobbie*

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Dr Meredith Dobbie
meredith.dobbie@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program A: Society | Project A4.2 | Project duration: July 2014 – July 2017

Mapping water sensitive city scenarios

Overview

Traditional approaches to managing urban water systems are based on planning large-scale centralised infrastructure that aims to reduce uncertainties and control variables such as water supply and demand. As pressures from climate change, urbanisation, pollution, resource scarcity and ageing infrastructure increase, so do the complexities and uncertainties of integrated water systems that support a city's sustainability, liveability and resilience. There is now growing recognition that new approaches and methods for urban water planning and management are required.

This project aims to develop tools that can support and influence strategic planning to enable a city's transition to a water sensitive future. These tools include methodologies for the participatory development of water sensitive city (WSC) visions and transition strategies, which together are known as transition scenarios, at different scales and by different stakeholder groups.

Key outcomes

By integrating perspectives from community, government, industry and research through novel participatory processes, this project will provide guidelines for how WSC transition scenario methodologies can be integrated effectively into formal planning processes of local, state and national scales. It will also deliver:

- city and catchment-scale transition scenarios for Melbourne as a future WSC, that include long-term aspirational visions and transition strategies to establish the enabling conditions for a WSC
- transition scenarios for Brisbane and Perth as future WSC, following the application of lessons and developed methodologies in collaboration with industry partners
- step-by-step guidance for developing transition scenarios and recommendations for how the process can be integrated effectively into formal policy development, strategic planning and decision-making activities at local, state and national levels to enable transitions toward WSC.

Insights into forming water sensitive cities transition scenarios

A pilot case study, undertaken as part of the former Cities as Water Supply Catchments program, developed WSC transition scenarios for two adjacent local government areas in Melbourne, Victoria. The research found that:

- social learning amongst participants of the process is as valuable as the documented outputs generated. Transitioning to WSC requires many different stakeholders to work together in new ways. Ensuring strategic and operational alignment across organisations is critical and must be facilitated through forums that encourage people to reach mutual understandings, recognise their interdependencies and challenge each other's perspectives.
- Involving a broad range of stakeholders is important to ensure the many relevant perspectives are incorporated into the visions and strategies that form the transition scenarios. Participants should come with a deep understanding of their operating context but need to be willing and able to think beyond any current constraints to bring a creative, strategic and aspirational approach to the process.
- Transition scenarios need to be translated to have value for different stakeholder groups so they can meaningfully consider how their activities can best support the transition to WSC. The scope, focus, language and visual representation of the scenarios need to be tailored to the audience which includes community members, engineers, designers, economists and politicians.
- Downscaling and upscaling between city-wide and local precinct transition scenarios is important to capture the full spectrum of strategic initiatives that will be necessary to enable WSC transitions in practice. Further research is needed to understand how integration across multiple scales can be done effectively so that different types of strategies and visions are accommodated in the scenarios. Careful consideration needs to be given to local synergies and trade-offs.

An Australian Government Initiative

Project design

The project will take an action research approach involving a series of participatory workshops to develop:

- detailed visions for how the societal, infrastructural and ecological aspects of a place would operate if the principles of a WSC were implemented
- transition strategies that will identify enabling institutional conditions and implement specific integrated solutions for transforming an urban water system's social elements (such as planning rules, engagement processes and institutional arrangements) and biophysical elements (such as stormwater technologies, public space designs and natural waterways) to achieve a WSC.

These strategies will also be designed to enhance the system's resilience to population growth, climate change and other extreme conditions.

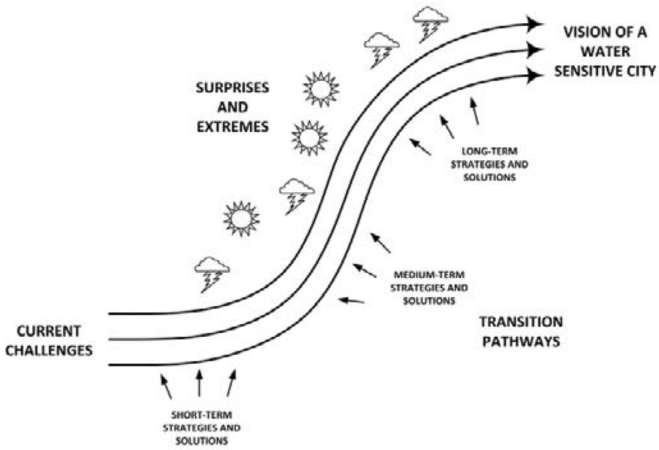


Figure 1. Transition scenario process (© CRCWSC).

The process will be facilitated for a local catchment in Melbourne and will trial novel methodologies developed during the project. Outcomes from this pilot process will be integrated with the existing city-scale scenarios for Melbourne, generated in the former Cities as Water Supply Catchments program.

Draft guidelines for how to develop integrated local and city-scale transition scenarios in participatory workshop settings will be prepared. Lessons from the Melbourne pilot will then be applied to Brisbane and Perth in collaboration with local industry partners, providing an opportunity for the guidelines and recommendations to be tested and refined.

Outlook

The early focus of the project will be to design the methodologies for developing and integrating WSC transition scenarios across community and city-scales and to trial them in Melbourne in 2015. From this work, an initial set of guidelines for developing integrated local and city-scale transition scenarios in participatory workshop setting will be prepared.

Activities to support industry partners in applying the lessons for Brisbane and Perth will commence at the beginning of 2016, with transition scenario results from these processes likely to be released by the end of 2016. The final stage of the project will refine the guidelines and develop recommendations for how transition scenario methodologies can be integrated effectively into formal planning processes at local, state and national scales to enable transitions toward WSC.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Dr Briony Rogers
briony.rogers@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

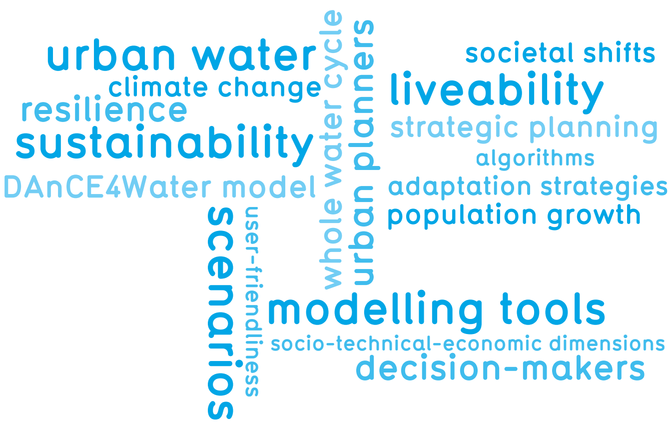
Program A: Society | Project A4.3 | Project duration: July 2013 - June 2016

Socio-technical modelling tools to examine urban water management scenarios

Overview

Urban water systems are complex and dynamic, constantly evolving and adapting to changes in society and the urban environment. New management approaches use this complexity to their advantage to increase urban liveability, sustainability and system's resilience by combining a portfolio of strategic measures. These include integrating centralised and decentralised infrastructure systems, embedding technologies into the urban landscape and introducing planning regulations and financial incentives. To understand and test the performance of possible water management strategies, new computer-based models are required. This project takes ground-breaking steps toward the next generation of water modelling tools to address this gap.

The project will develop a user-friendly computer-based modelling platform to inform planning and decision-making about water management and adaptation strategies at the city or regional scale. The model, known as DAnCE4Water (Dynamic Adaptation for enabling City Evolution for Water), simulates technical, social and economic dimensions of a city's integrated urban water system as it changes over time in response to water management strategies and drivers such as climate change, societal shifts and population growth. By using the model to explore many future scenarios, users can identify strategies that result in resilient urban water outcomes, as well as strategies that will most effectively achieve transition to a water sensitive city.



Key outcomes

A key outcome from this project is a decision-support tool that supports the strategic planning of integrated water systems. The development of DAnCE4Water's algorithms will produce detailed insight into the dynamic feedbacks between the socio-economic system, urban form and water infrastructure in response to water management strategies. The project will produce guidance and recommendations on how to develop water management strategies that are effective and robust under a variety of climate change, population growth and societal change scenarios.

Outputs from the project will be consolidated in a user-friendly web-based modelling platform designed to facilitate collaborative planning and decision-making processes. Users from different organisations will be able to access common sets of urban data, future scenarios and management strategies via the DAnCE4Water platform, enabling planners and decision-makers to explore water management opportunities and implications across organisational boundaries and at multiple scales.

Early insights into the development of DAnCE4Water

Insights into the development of DAnCE4Water to date include:

- A new generation of decision-support tools is required to support strategic planning of integrated water systems that include decentralised water technologies. These tools need to be capable of considering the urban form and water infrastructure as an integrated system, as well as understanding the influence of socio-economic dynamics in how the system evolves. DAnCE4Water is one of the first modelling tools of this kind.
- Infrastructure planning is typically based on assumptions about future dynamics in population, climate and urbanisation patterns; however, the significant uncertainty that comes with long-term projections means strategies that are optimised for a given set of assumptions may fail if these assumptions do not eventuate. Planning decisions should therefore be based on strategies that are robust against many different future conditions, rather than optimised. DAnCE4Water provides insight into the effectiveness and implications of possible decisions to inform the selection of water management strategies that increase water system's resilience.
- DAnCE4Water is designed as an integrating platform that allows existing tools, as well as new models developed in this project, to be integrated within a single computer-based environment that accesses common sets of data and input scenarios. This type of platform provides the flexibility for tools and data to be utilised in the combinations that make most sense for the planning question being asked.

Project design

The project builds on previous research undertaken by Monash University in partnership with Innsbruck University and Melbourne Water which developed DAnCE4Water as a scientific prototype for stormwater management. Research in this current project improves the model by extending the algorithms to simulate the whole water cycle incorporating economic dimensions and developing a user-friendly web platform.

Following these developments, DAnCE4Water will be able to be used to test the effectiveness of different water management strategies under a wide range of future scenarios by modelling the:

- likelihood of different water servicing options being taken up as societal needs change
- development and redevelopment of urban form as population and demographics change
- dynamic placement of water infrastructure systems as the urban form and preferred water servicing solution changes
- performance of integrated water systems, in terms of the water services provided (for example, supply security, flood protection, pollution control) and economic benefits and costs.

Outlook

In 2015 DAnCE4Water will be applied to a case study in the south east of Melbourne to test the algorithms and gain insight into the dynamic feedbacks between the socio-economic system, urban form and water infrastructure in response to water management strategies.

The software will be issued on a rolling release basis once it is operational as a full prototype, so that industry partners have the opportunity to explore the tool in its early development phase. By June 2016, the project will deliver the guidance materials needed to support industry take-up of DAnCE4Water, including a software manual, tutorials and short courses. It will be developed as an open source product and will incorporate interfaces with commonly used water industry models (e.g. MUSIC, SWMM) to complement and add value to the existing set of tools available to support decision-makers in the Australian water industry.

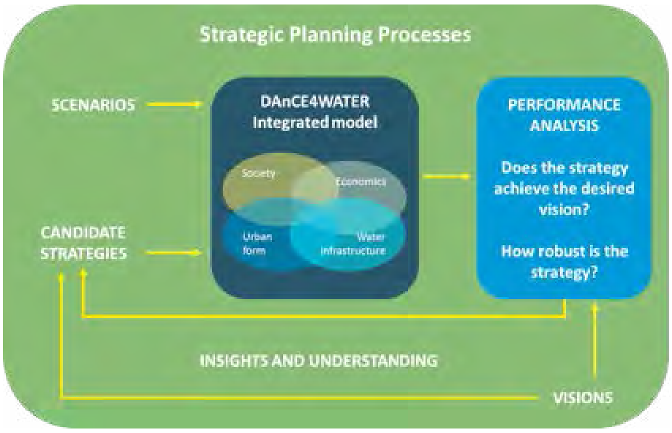


Figure 1. Strategic planning processes with DAnCE4Water

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together inter-disciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Rebekah Brown
rebekah.brown@monash.edu
Professor Ana Deletic
ana.deletic@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

Program B – Water Sensitive Urbanism

This program will focus on the influence of urban planning on resource flows across a range of scales. It will apply green infrastructure and climate responsive design principles to water security, flood protection and the ecological health of terrestrial and aquatic landscapes from whole-of-catchment to street level. It will establish integrated socio-technical urban planning and design processes that will deliver the practical tools required to improve resilience of Australian urban environments. There are 5 projects grouped under this program:

Project B1 – Catchment-scale landscape planning for water sensitive cities in an age of climate change

- Project B1.1 (Cities as Water Supply Catchments – Urban rainfall in a changing climate)
- Project B1.2 (Catchment-scale landscape planning for water sensitive city-regions in an age of climate change)

Project B2 – Planning, design and management to protect and restore receiving waters

- Project B2.1 (Cities as Water Supply Catchments – Stream ecology)
- Project B2.2 + B2.3 (Protection and restoration of urban freshwater ecosystems: informing management and planning)
- Project B2.4 (Hydrology and nutrient transport processes in groundwater/ surface water systems

Project B3 – Water sensitive urban design and urban microclimate

- Project B3.1 (Cities as Water Supply Catchments – Green cities and microclimate)
- Project B3.2 (The design of the public realm to enhance urban microclimates)

Project B4 – Building socio-technical flood resilience in cities and towns

- Project B4.1 (Social-technical flood resilience in water sensitive cities – quantitative spatio-temporal flood risk modelling in an urban context
- Project B4.2 (Socio-technical flood resilience in water sensitive cities – Adaptation across spatial and temporal scales)

Project B5 - Statutory planning for water sensitive urban design

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B1.1 | Project duration: July 2012-December 2014

Cities as water supply catchments – Urban rainfall in a changing climate

Overview

Throughout its history, Australia has faced a highly variable natural climate with extreme weather events such as droughts, floods and bush fires. A changing climate will likely exacerbate this situation in terms of frequency and intensity of events and place more stress on communities, infrastructure, food production and ecosystems. This will also mean that the performance of stormwater treatment and harvesting systems as part of a sustainable urban water management system may be impacted heavily. Resilience to a changing climate, i.e. the ability to perform well under a variety of different scenarios, is therefore a necessary component of any infrastructure development, particularly one that seeks to harvest rainfall. With that comes the need to better understand rainfall patterns and develop enhanced tools for rainfall projections at the scale relevant to the design of stormwater systems. In particular, it is necessary to include a quantitative prediction of the uncertainties in the projections so that the systems can be designed to match our true knowledge of rainfall changes.

This project aims to develop a comprehensive model to simulate probable rainfall in Adelaide, Brisbane, Melbourne and Sydney at a small enough scale (~ 2 kilometres) that would reliably support rigorous design of stormwater treatment and harvesting systems. The project also aims to provide reliable quantitative estimates of the uncertainties in such projections.

Key outcomes

This model is the first of its kind that combines statistical information from historical weather radar observations on local rainfall distribution with dynamical information of larger-scale weather patterns. The project will deliver an insight into what the current most important large-scale weather conditions for rainfall in the chosen cities are, how well global and regional climate models are able to simulate these conditions, and how these large-scale weather patterns will change with climate change. This information will then feed a comprehensive statistical model of the space-time distribution of rainfall at small scales to provide the information needed to model the stormwater system performance.

This model will help urban planners and designers in government and industry better predict future rainfall in Australian cities to ensure that new or alternative urban stormwater management systems are environmentally and economically resilient to the uncertainties and extremes of a changing climate.

Key findings on weather regimes

A key innovation in the approach developed in this project is the use of weather regimes when deciding on model parameters. Each of the major Australian cities has a unique set of regimes associated with its rainfall with different rainfall amounts and different spatial patterns of rainfall. Figure 1 (over page) illustrates this for Melbourne. Once the days with no rain at all in the Melbourne area (about 40% of all days) are removed, five main rainfall patterns emerge. It ranges from widespread light rainfall (left, 71% of all rain days) to widespread heavy rainfall (right, 1.5% of all rain days) with medium amounts of various spatial distributions in-between (middle 3 panels). The mountains and hills to the east and southwest of Melbourne are a prominent feature in several of the rainfall patterns. Each of the five patterns corresponds to a different meteorological situation, a fact that will be exploited when determining this "weather state" from climate models.

An Australian Government Initiative

CRC AUSTRALIA

Project design

The central theme of this research project is to provide high-resolution projections of future rainfall for Adelaide, Brisbane, Melbourne and Sydney together with reliable estimates of the uncertainty in these projections. To achieve this the project quantifies the range of uncertainty in the climate simulations of rainfall over Australia using a range of currently available models, and then uses this information to drive a statistical model of the space-time distribution of rainfall at a city- and suburb-scale. To do so more reliably the key weather regimes for each city are identified and the capabilities of current climate models to simulate these regimes are evaluated. Models that pass the test will be selected.

Their simulations of changes in key weather regimes in future climates will provide the foundation for the small-scale rainfall projection tool that results in a large ensemble of projected rainfall for each of the cities selected. The ensemble of possible outcomes provides not only the most likely rainfall change, but also contains the full range of uncertainty, enabling different decision-making approaches. As predictions will cover the entire city area, users can choose which part of the city to consider selecting areas as small as 2x2 square kilometres.

Outlook

The project will be completed by the end of 2014 when the model developed to assess all future rainfall scenarios for the end of 2014 when all future rainfall scenarios for Adelaide, Brisbane, Melbourne and Sydney will be made available to the CRC for Water Sensitive Cities.

The project team is working with national and state governments and other agencies that deliver climate scenarios in Australia, such as the Bureau of Meteorology, to discuss the possible adoption of the model in their future programs and activities.

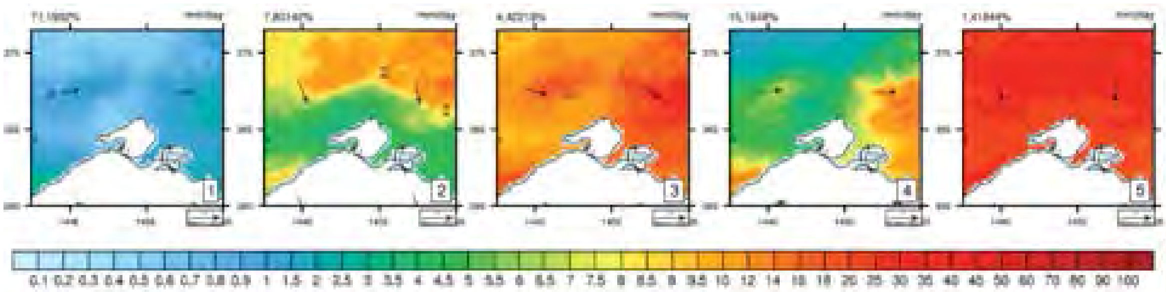


Figure 1. The five main rainfall patterns for Melbourne.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Christian Jakob
christian.jakob@monash.edu
Professor Michael Reeder
michael.reeder@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B1.2 | Project duration: July 2013 - July 2017

Catchment-scale landscape planning for water sensitive city-regions in an age of climate change

Overview

Cities are not isolated entities, they exist within, connect with and ultimately depend on landscapes which extend far beyond their actual built edge or boundary. A water sensitive city (WSC) needs to be understood in relation to its broader catchment, the different landscape types and the various local needs for water that occur within that catchment. The need for food production and industry such as resource extraction must be balanced with the needs of the natural environment, urbanisation and related activities such as outdoor recreation.

The future of these landscapes, recognising all of these values, needs to be planned in an integrated manner with a whole-of-catchment perspective to sustainably manage Australia's projected population growth and build resilient communities.

The project aims to develop an integrated approach to whole-of-catchment planning and management that is capable of linking the ecology and hydrology of cities to their region whilst accommodating urban and peri-urban growth adapted to a changing climate. It will explore alternative institutional arrangements for catchment planning and management from a landscape-scale perspective.

Key outcomes

This project will provide state, regional and local planning agencies, including Catchment Management Authorities (CMA) and natural resource management bodies (NRMB), with a comprehensive whole-of-catchment landscape planning process and methodology which acknowledges the critical dependency that cities have on secure and high-quality water sources. It will deliver policy guidelines for state, regional and local planning agencies for the management of growth at the city-region or catchment level. The outcomes of the project will also inform CMA and NRMB in the preparation of their catchment action plans and investment strategies.

Ultimately, the growth scenarios developed for the city-region or catchment areas will assist decision-makers in dealing with the high degree of uncertainty and inconclusive science associated with climate change and population growth by providing insight into plausible futures and a "test bed" to assess their policies. These outcomes will create a more balanced and scientific approach to statutory and non-statutory land use planning and decision-making.

This project will also provide:

- a comparative assessment of the statutory and non-statutory planning systems for the case study regions
- a strategic assessment of the future of each case study region in terms of water security
- an account of the diverse sources, uses and functions of water in the city-region and an understanding of the trade-offs between them
- guidelines and training packages for statutory and non-statutory planners mainly in the land use, environmental, landscape and natural resource management fields.

Early insights into existing planning frameworks

To inform the development of a city-regional scale urban metabolism framework, a comparative document analysis of the case study regions of South East Queensland and the metropolitan areas of Melbourne and Perth was completed. It examined the institutional arrangements and regulatory frameworks for water management with specific reference to hydrological and environmental connections, resilience, future changes and uncertainties, planning, and institutional arrangements and governance.

Surface and groundwater hydrological and environmental connections were often identified, especially the impacts from urbanisation on water quality. The impact of climate change was widely acknowledged although there were very few specific references to climate change adaptation. However, the need for a resilient water sector was highlighted with specific reference to climate extremes of floods and droughts.

The analysis also showed that future uncertainties facing the water sector included the impacts of climate change, extreme weather events and population growth. The effective role of statutory planning mechanisms in securing water quality and improved stormwater management was recognised. However there were calls for better integration between water and urban planning to maximise the potential of land use planning in aiding the management of water resources.

Recognition of the need for water planning to consider broader regional and landscape scales was rare. More common was the acknowledgement of the role of open space in urban areas as an aid to stormwater management, water harvesting and flood mitigation and the provision of amenity and recreational opportunities.

The analysis highlighted the need for improved vertical and horizontal integration, and cooperation and adaptive management approaches to better manage and plan for water resources.

An Australian Government Initiative

CRC AUSTRALIA

Project design

The initial phase of the project consists of a comparison of the different statutory and non-statutory planning systems that exist in South East Queensland and the Perth and Melbourne metropolitan areas. A second phase will determine essential components of an integrated greenspace framework that incorporates natural ecosystems and green infrastructure, and links cities to their regional catchments regarding their critical water-related connections.

The next phase will involve the development of a city-region/whole-of-catchment systems model that is capable of addressing the various landscape values at that scale. This will include a city-region metabolism framework that can be employed to evaluate regional water budgets across multiple landscape types aimed at ensuring regional water security. Following that, alternative urban growth scenarios for each case study region, incorporating climate science, will be developed. The last phase will see knowledge synthesis and the development of future scenarios for rapidly growing metropolitan regions that adopt a whole-of-landscape outlook that links cities ecologically and hydrologically to their regions.

Outlook

In three years, the project will have developed an urban metabolism framework capable of incorporation into a conceptual model of a city-region or whole-of-catchment system. This conceptual model will assist in evaluating regional water budgets and urban growth scenarios along with methods for incorporating ecological and water science into statutory planning processes.

The next steps are to determine the essential components of an integrated greenspace framework incorporating natural ecosystems and green infrastructure and linking the city with its region, which will form part of the conceptual model.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Darryl Low Choy
d.lowchoy@griffith.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B2.1 | Project duration: July 2012-December 2014

Cities as water supply catchments – Stream ecology

Overview

Urban streams are commonly degraded by stormwater that runs off hard surfaces such as roofs and roads. Built-up, impervious urban areas result in large, intense flows of stormwater through pipes and drains resulting in less water infiltrating into the ground, and decreased evapotranspiration and baseflow which all lead to deteriorating water quality and higher frequency flow regimes. The results are drastically altered geomorphology and ecology of urban streams. However, integrated stormwater management and harvesting offers the potential to protect urban streams from this degradation, or to return ecological function to already degraded streams.

A common concern of stormwater harvesting is the perception that it will lead to a starving of urban streams of their natural flow. However, the opposite is almost always the case. In existing urban areas stormwater harvesting helps reduce the frequency and flow volume of excess runoff, potentially restoring it to near pre-development levels if enough water can be harvested.

The project aims to determine the impact of integrated stormwater management strategies, including stormwater harvesting, on the hydrology and water quality of streams, and to assess the subsequent ecological and geomorphic responses.

Key outcomes

The project will produce a conceptual model and indicators that will underpin operating guidelines for stormwater harvesting. This will provide a more informed basis a more informed basis for managing stormwater by quantifying explicit relationships between stormwater and ecological and geomorphic condition. This includes targets for stormwater harvesting and retention and identification of treatment and infiltration-based technologies that can improve and protect the aquatic ecosystem health of existing urban areas and greenfield developments.

In addition to the stormwater focus the program identifies opportunities for improving urban stream health through managing sediment loads and riparian zones (for example, by providing more space for natural stream movement). Results could be incorporated into state and national guidelines for improving waterway health and stormwater harvesting by determining the optimal volume and pattern of water extraction from the catchment.

Early insights into stormwater harvesting – Little Stringybark Creek

The Little Stringybark Creek project is a rare catchment-scale restoration experiment. It aims to restore the health of Little Stringybark Creek in Mt Evelyn, east of Melbourne, by tackling the main cause of the creek's poor health: excess urban stormwater runoff. Working with the catchment community and Yarra Ranges Council, the project team installed more than 280 stormwater control measures across the catchment. Combinations of harvesting and infiltration (raingarden) systems that harvested and treated runoff from impervious areas ranging from 100 square metres to more than one hectare resulted in reduction and treatment of stormwater runoff from most of the roofs and roads in the catchment.

The project has already been influential in driving new approaches to stormwater management in Melbourne, nationally and internationally.

Importantly, it is underpinned by a long-term ecological monitoring program of the creek, its three tributaries as well as sets of equally degraded urban control streams and forested streams against which variation in ecological condition can be assessed over time. In 2014, less than a year after completion of most of the works, no biological changes biological changes associated with the construction works have been detected, but the tributary with the most complete retention of urban stormwater runoff shows trends suggestive of increased baseflow and reduced nutrient concentrations. With different degrees of catchment intervention or management action among tributaries, this study will allow important inferences regarding the necessary extent and intensity of interventions to improve in-stream ecological condition.

An Australian Government Initiative

CRC AUSTRALIA

Project design

The first part of the project involved the development of indicators, such as runoff frequency or rainfall retention capacity, that were used to assess the impact of stormwater harvesting on the hydrology and water quality of streams. This was followed by the development of predictive models of likely ecological responses. The second part used, among other strategies, two case study catchments to measure the effect of stormwater harvesting, applying the indicators and conceptual models previously developed. The primary empirical testing has been undertaken through the Little Stringybark Creek case study.

Geomorphic monitoring and investigations have been undertaken on 17 streams around Melbourne, each representing a different level of urbanisation as measured by directly connected stormwater systems. The results demonstrate that the extent of channel erosion, channel size and the amount of physical habitat can all be related to stormwater design. In addition, opportunities have been identified to better manage stormwater control infrastructure to reduce ongoing sediment maintenance and improve appropriate levels of sediment supply to streams. All studies will be combined to inform the development of algorithms relating hydrology and water quality to stream ecology.

Outlook

This project will conclude at the end of 2014 providing final design, operating rules and analysis tools for stormwater harvesting to deliver optimal stream health outcomes. Lessons learned from the Little Stringybark Creek project will also be published by the end of this project.

The outputs that this project delivers include:

- conceptual models and indicators to underpin stormwater harvesting operating guidelines
- case studies of hydrologic restoration using stormwater harvesting and other stormwater retention strategies.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

A/ Professor Chris Walsh
cwalsh@unimelb.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B2.23 | Project duration: July 2012 – December 2016

Protection and restoration of urban freshwater ecosystems: informing management and planning

Overview

Rivers, streams, drains and wetlands are important components of urban landscapes. These freshwater habitats are valuable to people because they help create a safe environment by mitigating flooding and keeping our water clean. By providing homes for native plants and animals, streams reinforce our sense of local identity and enhance our connection to nature. If we can keep our streams healthy we can avoid algal blooms, fish kills and plagues of nuisance insects, and we can enjoy the recreational and physical amenities they provide.

Unfortunately, streams face many threats including altered hydrology, elevated levels of nutrients and other pollutants, increased water temperature and sedimentation, and reduced biodiversity. For management efforts to be targeted and effective, managers need to understand the key ecological drivers in their bioregion and how they vary among freshwater habitats (such as wetlands and streams). They also need to understand how the key drivers vary with local characteristics such as position in the catchment and soil type. This project investigates the extent to which ecological drivers vary among freshwater habitats and across a range of geographic scales in southern Australia. It also explores the sensitivity of these drivers and the extent to which improvements in different drivers deliver improvements in ecosystem function.

Key outcomes

The project will deliver conceptual urban waterway typologies or categories which identify the key ecological drivers of ecosystem health and function. It will also develop region-specific urban waterway management frameworks that will support decisions for optimising management and restoration efforts over a range of scales.

The outcomes of this project will be used by water planners in state and local governments to guide their policy and planning, and by developers, consultants and local natural resource management bodies to inform on-ground management and restoration of urban waterways.

Key findings on current institutional arrangements relating to WSUD

Recent studies have revealed that the impact of urbanisation on stream health varies among cities and bioregions. This finding suggests that the key drivers of freshwater function may differ with climate, geology, the position of the site in the landscape, the spatial scale of interest, and past land use. Specific insights include:

- Cities built on flat landscapes with sandy permeable soils with high infiltration capacity should be less affected by flashy run-off driven flows than cities built on sloping topographies with impermeable soils.
- Repairing the height and quality of groundwater is particularly important for the function of urban wetlands and streams in regions with welldeveloped superficial aquifers; while repairing river-floodplain connectivity is particularly important for the function of floodplain wetlands.
- The ability to assess urban-associated degradation in function depends on the quality of reference sites available. If reference sites are already degraded, for example by unsustainable agricultural practices, then the impact of urbanisation may be underestimated.
- Current restorative efforts in urban freshwaters focus on improving aspects of the physical environment, but this approach overlooks the importance of biotic processes for healthy ecosystem functioning. Indeed, recent evidence indicates that severe species loss can be just as detrimental to ecological function as degradation of the physical environment. The marked loss of species in urban freshwaters makes a compelling case for making biodiversity a restoration goal in urban freshwaters.

An Australian Government Initiative

CRC AUSTRALIA

Project design

This project will review the literature and interrogate existing datasets to investigate the extent to which ecological drivers vary among freshwater habitats and across a range of geographic scales in southern Australia. Secondly, the project will explore the capacity of degraded systems to improve their delivery of ecosystem services.

The project will develop a management framework that will guide the restoration or protection of urban waterway typologies from a variety of physical and social threats.

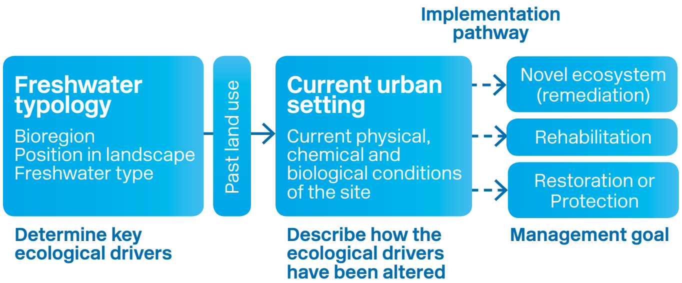


Figure 1. A framework for assessing and implementing on-ground management actions to improve the ecosystem function of urban freshwater streams. Steps in the implementation pathway refer to on-ground management actions that repair the ecological drivers; for example, protect nearby refuges or ensure upstream development is in accordance with water sensitive urban design.

Outlook

By June 2015 the project will deliver conceptual urban waterway typologies and will have explored the capacity of degraded systems to traverse to improved ecological condition. At completion of the project in 2016 the following outputs will have been delivered:

- graphical typologies that illustrate the key drivers of ecosystem function at multiple spatial scales and over time
- a decision process that guides management actions to improve and protect the important drivers of waterway condition from urban threats
- a suite of indicators that managers can use to evaluate the ecological status of urban waterways.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Anas Ghadouani
anas.ghadouani@uwa.edu.au
Professor Peter Davies
peter.davies@uwa.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B2.4 | Project duration: July 2012 - July 2016

Hydrology and nutrient transport processes in groundwater/surface water systems

Overview

In many urban regions of Australia, the interactions between groundwater and surface water strongly impact the overall urban hydrology affecting the effectiveness of water sensitive urban design (WSUD).

This project is designed to advance the understanding of how water and nutrients are transported from the surface to the receiving waters (including groundwater), and how the nutrient cycling works that occurs along the way. This project aims, in particular, to define the hydrological responses to the urbanisation of areas where groundwater-surface water interactions exist, including those areas with high or perched groundwater tables. It also helps define the impact of modifying hydrological regimes on nutrient transport in these areas.

Key outcomes

This project will provide tools for urban designers, local government, waterway managers and developers to assess which WSUD elements should be used to help reduce nutrient inputs to rivers and waterways. It will provide insights into how high groundwater might compromise the effectiveness of WSUD and the application of water sensitive city principles. The project will lead to refined design specifications for biofilters, infiltration basins and living streams in sandy environments with significant groundwater–surface water interactions.

Results of this project will also help refine a tool developed by the Western Australian Department of Water to assess the load of nutrients coming off new urban developments. Called Urban Nutrient Decision Outcomes (UNDO), the modelling tool is specifically designed for the sandy environment of the Swan Coastal Plain in Western Australia. It will enable developers and government agencies to calculate nutrient runoff in new developments and assess proposed developments against appropriate targets to ensure that acceptable levels are achieved. The outcomes of this research project will help make UNDO a more powerful tool and fill some research gaps in the understanding of nutrient dynamics.

Project design

A key part of this project is to understand how water and nutrients move through a system with WSUD treatment (for example, with biofilters and rehabilitiated streams) by creating water mass balances that quantify all the water inputs and outputs of a system.

Comparing a water mass balance with a nutrient mass balance will identify what contribution groundwater makes to the total nutrient load entering a receiving water body and therefore can help direct resources to the right place. A few Swan Coastal Plain monitoring sites have been established to develop and validate water and nutrient mass balances, providing an understanding how nutrients are attenuated across the urban landscape and how the attenuation varies across seasons. Finally, hydrological typologies across the Swan Coastal Plain case study will be developed resulting in a classification and a series of maps for urban water designers and managers showing how these typologies are distributed.

Outlook

The monitoring sites have been established and water balances are currently being calculated. By the end of 2015, nutrient mass balances will be developed for these sites. Workshops with practitioners will be undertaken in Western Australia throughout this project to communicate findings and transfer knowledge to industry practitioners. Specific project outputs will include:

- a meta-analysis of existing urban water monitoring datasets from the Swan Coastal Plain in Western Australia
- an identification of urban water data gaps
- daily water and nutrient mass balances for selected WSUD elements
- quantification of groundwater-borne nutrient load to receiving water bodies
- guidelines for WSUD design in areas with significant ground-water-surface water interactions
- a protocol for urban water monitoring of flow and nutrients.

An Australian Government Initiative

CRC AUSTRALIA

Early insights into the hydrology of the Swan Coastal Plain

The characteristics of the Swan Coastal Plain – the narrow coastal strip stretching 650 kilometres from Geraldton in the north to Busselton in the south of Western Australia – pose a particular challenge for urban development. The issue of excess nutrients contaminating waterways is compounded by the interaction between surface water and groundwater. The dominant soil type of the plain is highly permeable with little capacity for retaining nutrients. Unlike in many eastern-state cities, surface runoff is minimal; instead stormwater rapidly infiltrates the soil and percolates through, taking nutrients with it to recharge the superficial aquifers which in turn flow into rivers and lakes. Too much phosphorus and nitrogen, in particular, can lead to excessive algal growth, which depletes oxygen resulting in bad odours and fish kills.

Early findings indicate that the very high variability in the depth to groundwater across the coastal plain ranging from more than 15 metres to less than 1 metre creates highly variable responses of hydrology to urbanisation.

This presents a challenge for a common understanding of urban hydrology in the region and for the development and application of regional WSUD guidelines.

Future urban development is planned for areas with very shallow groundwater; ironically, in some recently developed areas groundwater flooding is occurring during an acute drought. Management of this groundwater flooding may focus on reducing infiltration that is in apparent contrast to typical WSUD guidelines.

Because of the flat landscape, very old sandy soils and rapid infiltration rates, nearly all of the nutrient load to receiving waters is in dissolved form. Preliminary analysis also suggests that in areas with high groundwater tables, organic nitrogen may dominate the dissolved nitrogen signal, however, biofilters and living streams have been designed to attenuate inorganic nutrients. Data suggests that these systems may actually be a source of organic nitrogen to surface waters. The project continues to develop an understanding of the organic nitrogen dynamics and its bioavailability.

Figure 1. Depth to groundwater across the Perth coastal plain ranges from greater than 15 metres to less than one metre.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Carolyn Oldham
Carolyn.oldham@uwa.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B3.1 | Project duration: July 2012 - December 2014

Cities as water supply catchments – Green cities and microclimate

Overview

Reduced water availability and vegetation cover, as well as the high thermal mass of impervious surfaces associated with urban development, limit evapotranspiration in urban areas, leading to unique urban climates in Australia. At the city-scale, this transformation can lead to an Urban Heat Island (UHI) effect where the urban areas are often warmer than the surrounding rural areas, especially at night. Drought, water restrictions and the implementation of drought tolerant landscapes all contribute to drier urban landscapes which can exacerbate urban heat. This will be further intensified by the projected increases in the intensity, frequency and duration of extreme heat events under climate change. The combined drivers of excessive urban heat from urban development and climate change increases heat stress and puts vulnerable populations at risk of heat related illness and mortality.

Implementing stormwater harvesting systems that incorporate vegetation offers unique opportunities to build water sensitive, low-energy and visually attractive cities with improved urban microclimates. This project aims to understand the climatic benefits of stormwater harvesting, water sensitive urban design (WSUD) and urban greening at the household- to neighbourhood-scale, including the relationship between extreme heat and health outcomes.

Key outcomes

This project, in partnership with the National Climate Change Adaptation Research Facility (NCCARF), has identified threshold temperatures above which mortality and morbidity increase in all Australian capital cities, and have developed a mapping tool to identify areas of high vulnerability during extreme heat events. The vulnerability maps can be used for emergency response planning by hospitals, the ambulance service and local governments to protect vulnerable residents and to plan for the future. Even small temperature reductions of 1-2°C can save many lives. Researchers also found a clear association between area-based measures of extreme heat vulnerability and heatwave morbidity. Research demonstrates the critical role of shade in reducing outdoor heat stress, demonstrating that trees should be incorporated as a WSUD feature. Providing fit-for-purpose water to ensure trees and vegetation remain healthy will deliver positive benefits for human thermal comfort.

Together with the Victorian Centre for Climate Change Adaptation Research (VCCCAR) and other universities, this project has also established a framework for prioritising urban greening interventions based on population vulnerability, areas of excess heat and behavioural exposure (areas of high population activity). This framework provides a step-by-step guide to the selection and placement of green infrastructure, especially trees, to maximise cooling benefits. This project will determine how effective stormwater harvesting technologies, tree cover, green infrastructure and WSUD are improving urban climates at a range of scales. It will also identify the key characteristics required to reduce temperatures to save lives under heat wave conditions and to enhance human thermal comfort and liveability.

Key findings on how WSUD can mitigate urban heat

The project has found that heat extremes and the number of days exceeding the critical heat-health thresholds are projected to increase in all Australian capital cities in the coming decades. Therefore, city planners and urban designers should be guided by heat vulnerability maps to integrate WSUD principles into high vulnerability areas. WSUD principles such as vegetation and water and stormwater harvesting are potential solutions for mitigating urban heat through shading and cooling.

- High resolution thermal remote sensing data has shown that during hot and dry conditions, trees and water bodies show considerably lower land surface temperatures during the day than urban surfaces like concrete. Land surface temperatures of irrigated grass can be up to 20°C cooler than non-irrigated grass.
- Based on the relationships between vegetation cover, built area index and land surface temperature for the three Victorian local government areas of Darebin, Melbourne and Monash, researchers have found that for every 10% increase in tree cover there is a reduction in land surface temperature of between 0.5°C and 1°C.
- Satellite images of Dubbo, New South Wales, taken during extreme summer temperature days while the city was in severe drought between 2000-2011 and while it was experiencing flooding rains between 2010-2011, shows that the use of irrigation water on green infrastructure in Dubbo's urban landscape had a cooling effect. In one instance, when air temperatures reached nearly 40°C, Dubbo's urban landscape was 3-5°C cooler than the surrounding rural areas.

Project design

There are two main streams of research in this project. The first one uses a combination of observational, remote sensing and modelling approaches from the household- to the neighbourhood-scale to determine the microclimate impacts of decentralised stormwater harvesting solutions. This includes assessments of how microclimates change through tree cooling processes, lighter coloured roofing material and evapotranspiration from green roofs. Other components look into local-scale and landscape-scale variability of surface and air temperatures and their relationship to green infrastructure and built environment. This will inform the development and validation of urban climate models at a range of scales.

The second stream draws on a range of data sources to understand the relationships between extreme heat and heat-health outcomes including mortality and morbidity. Assessments of threshold temperatures across a range of cities and identification of optimal environmental conditions for human thermal comfort help set benchmarks for improving urban climates through WSUD.

Outlook

The next step is to draw together the key findings of the observational, remote sensing and modelling research on WSUD elements and evaluate their capacity to mitigate urban heat and improve human thermal comfort. From this, strategies to incorporate WSUD principles and green infrastructure into existing or new developments to create cooling effects will be outlined. The final step involves a shift from evaluating individual WSUD elements (such as green roofs, street trees and biofiltration systems) to assessing the climatic benefits of wider implementation in neighbourhoods and catchments.

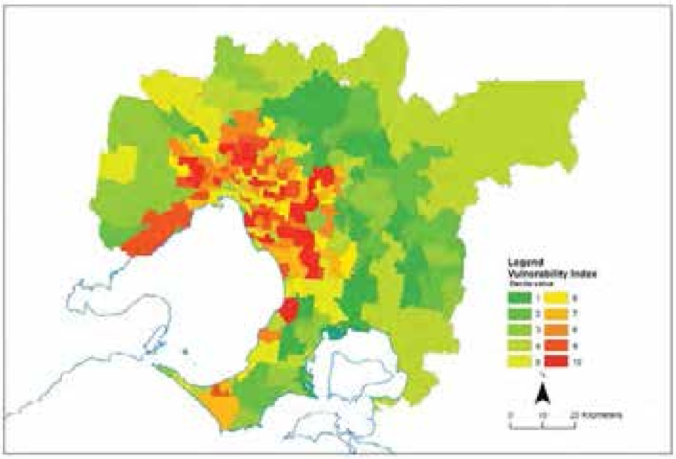


Figure 1. Heat vulnerability map of Melbourne identifying the city's most at-risk suburbs (© CRCWSC)

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Nigel Tapper
nigel.tapper@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B3.2 | Project duration: January 2015 - January 2019

The design of the public realm to enhance urban microclimates

Overview

The trend toward excess urban warmth in Australian cities in combination with global warming and the impact this can have on human mortality and morbidity, means that new mitigation and adaptation strategies for excess urban heat are required as a matter of priority. Thoughtful design of the public realm can create thermally comfortable, attractive and more sustainable urban environments by enhancing positive natural and man-made features through architecture, planning and landscape design. This project links closely to Project B3.1 (Cities as water supply catchments – Green cities and microclimate) which explores how green infrastructure and water sensitive urban design at the household- to neighbourhood-scale can modify the urban microclimate.

This project is designed to examine the processes linking urban climate, water sensitive urban design (WSUD), green infrastructure and health from street- to city-scales. The project aims to address how water sensitive cities (WSC) and their communities can benefit from green infrastructure and climate sensitive design. It will also determine the effectiveness of different heat mitigation strategies on climate and hydrology of selected Australian cities.

Key outcomes

The project outcomes include a better understanding how WSUD and green infrastructure can positively affect the microclimate of our cities and the health of their communities. Building on the findings of Project B3.1, a key outcome of this project is the evaluation of various urban design scenarios at the street- to city-scale to assess the impacts on urban climate. Having understood the potential cooling effects of different WSUD elements, informed design scenarios can be developed. This will inform and support urban planners and designers in the development and implementation of strategies that mitigate excess urban heat.

Microclimate modelling at the street-scale is currently lacking in the scientific community and the project will provide appropriate tools to address the aspects of small-scale design to derive optimal strategies for the implementation of WSUD. The base of knowledge and data developed in Project B3.1 will be used in validating urban climate models in this project. It is critical that urban climate models are performing correctly and capturing the important processes that drive urban climates.

Urban design scenarios at the neighbourhood- to city-scale will be linked to heat-health outcomes to determine the effectiveness of WSUD strategies in reducing heat related illnesses. Urban design scenarios will also provide insights into the climate sensitive design options that reduce heat stress. While the outcomes of this project will be relevant to all urban landscapes, the implementation and effectiveness of WSUD and green infrastructure in general will depend largely on the climatic zone.

Early insights into microclimatic benefits of WSUD

While the project does not commence until January 2015, some initial urban climate modelling research is beginning to highlight the effectiveness of urban greening and WSUD on urban microclimate in the Australian context at a range of scales.

- Research using the SOlar and LongWave Environmental Irradiance Geometry (SOLWEIG) model is demonstrating the effectiveness of trees in reducing radiant temperature which is the dominant contributor to the human heat budget during warm and sunny daytime conditions. After validating the model using data collected at Mawson Lakes in Adelaide, South Australia, scenarios of increased tree canopy cover have shown extensive reductions in radiant temperatures, leading to positive benefits for human thermal comfort.
- After validating the Community Land Model – Urban with data obtained in Melbourne, Victoria, CRCWSC's researchers are exploring the adoption of biofiltration systems throughout the urban landscape. Results are promising with results showing an increase in neighbourhood-scale evapotranspiration rates, which is anticipated to have a positive benefit on urban climates.

An Australian Government Initiative

CRC AUSTRALIA

Project design

This project utilises a combination of observational and modelling approaches from street- to city-scales to understand the processes linking urban climate, WSUD and human health. At the street-scale, micrometeorological observations will continue to quantify the efficiency of green infrastructure in improving urban climate with a particular focus on street trees.

The relationships between urban vegetation, water and urban climate will also be evaluated for selected cities through numerical modelling approaches. In addition, remote sensing and GIS techniques will be used to identify the multiple ecosystem service benefits and values of green infrastructure such as reduction of urban heat and stormwater runoff, increase of carbon sequestration and improvement of air quality. The effectiveness of different urban climate mitigation strategies, such as implementing different urban vegetation, will also be assessed using an urban land surface model. Finally, the potential health benefits of green infrastructure and WSUD, like reduced heat related stress and mortality, will be quantified by utilising a range of data sources including state government hospital admission records and Bureau of Meteorology climate data for Australian capital cities.

Outlook

This project commences in January 2015, however, it is already evident from the current Project B3.1 that WSUD and stormwater reuse comprise potentially powerful and effective approaches to mitigate the effects of urban excess heat and global climate change and to dramatically enhance urban resilience. In addition, WSUD and stormwater harvesting and reuse will positively influence urban water runoff, infiltration, drainage and soil moisture that interacts with urban stream water regimes and vegetation dynamics.

Outputs that this project will produce include:

- toolkits to provide guidance for fit-for-purpose and fit-for-place (i.e. locally appropriate considering climate) green infrastructure
- new microclimate modelling approaches for use in the evaluation of WSUD and green infrastructure at the household-scale.

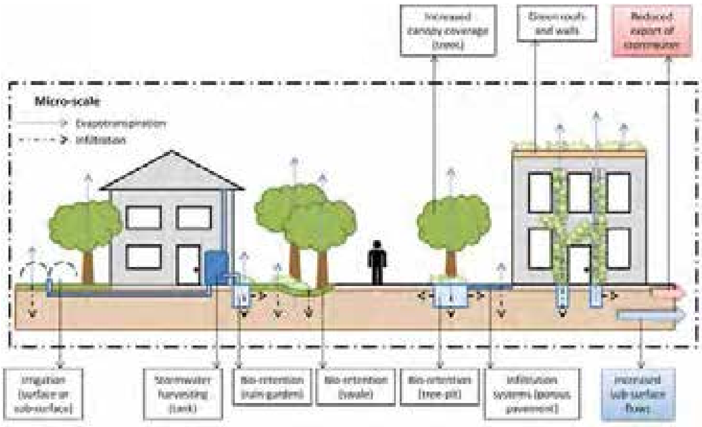


Figure 1. Conceptual design of integrating microclimate aspects and WSUD (© Coutts et al 2012)

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Nigel Tapper
nigel.tapper@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B4.1 | Project duration: July 2012 - July 2017

Social-technical flood resilience in water sensitive cities – Quantitative spatio-temporal flood risk modelling

Overview

Recent urban floods have highlighted the need for integrating the planning of urban water systems with other aspects, notably spatial urban planning processes. A number of worldwide studies have found that water in an urban context needs to be given more physical space than what is currently allocated. However, attempts to allocate space for flooding events that occur less frequently than the planning cycle of urban development allows often fail.

The project aims to address the question of how flood risk can be integrated with other spatial planning and management practices to improve the protection of infrastructure assets and help facilitate the overall objectives of a water sensitive city (WSC).

Key outcomes

The project outcomes consist of a variety of tools that will enable better land use planning processes in an urban environment by presenting geographically distributed hazard and risk maps and identifying adaptation options which are based on different factors such as economics and ethics. For the first time, these tools will be able to model both city development and changes in flood hazards within one model whereby historical and potential future linkages between these two processes can be explored. This process will bring together professionals from different fields and allow the development of better and more flexible options of land use in urban areas. Another outcome is the development of a decision-support tool that can evaluate impacts of urban design and planning on flooding which is invaluable for strategic decision-making directed at improving flood resilience. The tools and methods developed will also enhance Australian state-of-the-art flood risk analysis and mitigation methods, thus enabling better decision-making on local and regional scales and perhaps also facilitating statutory changes in the long term.

Early insights into land use changes and flood risk

The initial work focuses on the integration of the models and making offline simulations. The testing occurs then in the context of Scotsmans Creek in Melbourne, a catchment where data is available and which has been used in other CRC for Water Sensitive Cities' projects. Part of this project also examines the changes in distributed flood risk historically and with different projected scenarios as well as tests simplified modelling approaches.

The figure below shows the historical development of the catchment from the initial development to present time and gives an example of a future development scenario. So far, the flood risk for the historical and present time periods have been calculated indicating low to moderate flood risks, even though some areas intended for residential housing have a higher probability of being flooded than desired.

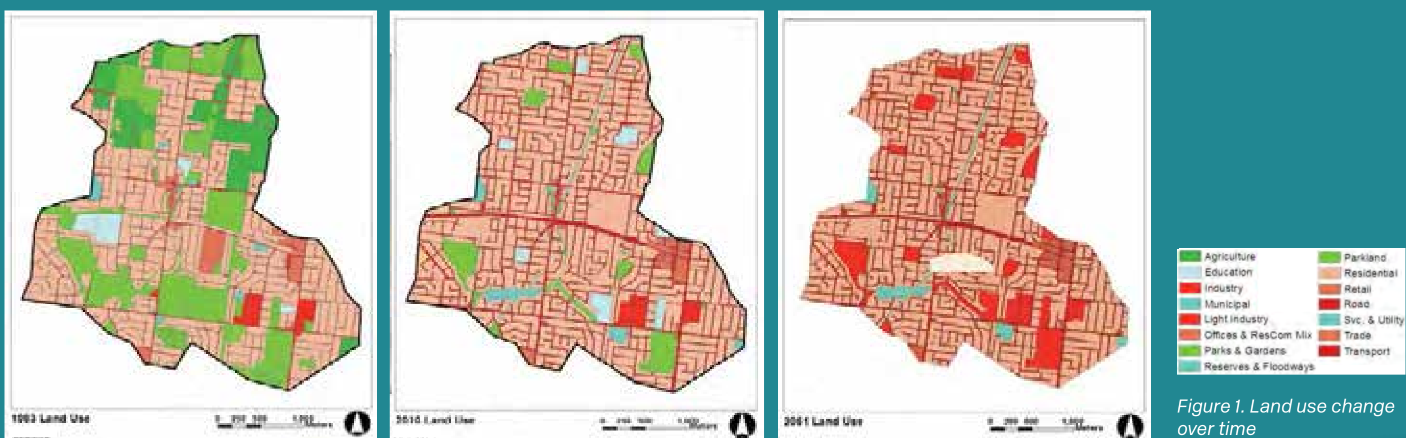


Figure 1. Land use change over time

An Australian Government Initiative

Project design

This project develops a range of tools and models including a framework for describing concurrent hydrologic hazards, a dynamic model for stormwater harvesting and treatment technologies, and a flood risk modelling tool which integrates an economic valuation of physical assets threatened by these hydrological hazards. Australian cities will be selected as case studies to collect site-specific data to describe recent flooding events. Historical as well as projected future scenarios for urban land use scenarios will then be developed leading to different urban and social developments and changes. Of particular interest in this project is the description of how the public perceives flood risk and the impact it has on risk aversion over time.

Outlook

Currently no framework exists that dynamically describes possible paths for both future city development and multiple hazards occurring at the same time with probabilities that vary over time. Both the type of adaptation solutions to be implemented as well as the timeframes are key variables in the decision-making.

A key output of this project will be the development of a module that dynamically links the integrated flood risk modelling tool with the DAnCE4Water platform (Dynamic Adaptation for enabling City Evolution for Water), which was developed in Project A4.3 (Socio-technical modelling tools to examine urban water management). DAnCE4Water will then enable an assessment of dynamic changes in hazards and vulnerabilities for certain landscapes due to factors like climatic changes and population growth. Linking these two tools will facilitate a leap in the understanding of the complex dynamics of city development, flood resilience and interactions with other water values in order to facilitate the planning of multi-functional and resilient cities.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Karsten Arnbjerg-Nielsen
karn@env.dtu.dk

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B4.2 | Project duration: August 2012 – August 2017

Social-technical flood resilience in water sensitive cities – Adaptations across spatial and temporal scales

Overview

In recent years the prolonged drought in Australia has been interrupted by heavy rainfall causing flooding in many urban and rural areas. Rules for responding and adapting to changing flood and drought risks, in an integrated fashion, are still evolving. Cycles of floods and droughts, for example in Europe, have prompted the development of new approaches for adaptation in the last few years on which this project is partially based. The project will further develop existing Dutch and other European flood risk management practices and adapt them to an Australian context.

The project aims to improve adaptation-related decision-making to focus expenditure on greatest return on investment to deliver robust infrastructure and achieve a community resilient to flooding and other risks.

Key outcomes

This project brings together a number of European approaches of embedding flood resilience into planning and will further develop the science and techniques required to integrate flood resilience into urban development processes.

The project will deliver guidance for urban planners, designers and policy-makers on how to achieve resilient social and technical adaptation to changing flood risks in the most cost-effective and efficient way. The implementation of the developed guidance will be demonstrated and tested in case studies in Australia, the Netherlands and Vietnam. It will build capacity in decision-makers to utilise the developed and enhanced methods and to inform policy-making in the regulatory process.

Early insights into flood risk management approaches

A case study on the management of flood risk in Can Tho, Vietnam, has provided initial insights into tolerable risk levels and available responses. These insights have been obtained through a literature review, stakeholder consultation and flood modelling.

- The community in Can Tho has a relatively high acceptance of flood with low depths. Flood depths of less than 20 centimetres (for about 1 hour duration) are acceptable to 90% of households. Yet, flood depths between 20 and 50 centimetres are acceptable to only 11% of households.
- 72% of the households have raised their floor levels to prevent floodwater from entering the houses. It has been found that the cost of raising floor levels beyond 50 centimetres is almost five times higher than the cost of raising floor levels up to 50 centimetres, as major structural adjustments are required such as raising of doors, windows and roofs.
- Four out of 270 hectares (1.5%) are expected to be inundated above 20 centimetres under the current design rainfall. The inundated area will double with a 30% increase in rainfall intensity. These modelling results reveal that an adaptation tipping point is reached already for the current situation, because the tolerable risk level is likely to be compromised.
- The tipping point analysis gives insight into the earliest date when the current strategy is no longer effective. This will help stakeholders decide on the selection of adaptation options and the timing of implementation of these options.

Figure 1. Raised floor levels in Can Tho, Vietnam (© UNESCO-IHE)

An Australian Government Initiative

CRC AUSTRALIA

Project design

There are two key components being used in this research project: the Adaptation Tipping Point (ATP) method and the Real-In-Options (RIO) accounting tool. Both will be further developed for Australian application through literature review, analysis and stakeholder interviews and workshops.

A tipping point occurs when a system or a service reaches a point, where it no longer delivers the expected performance, for example, when the flow in a stormwater system exceeds the hydraulic capacity. Analysis of performance to define tipping points is in its infancy and this project will allow the approach to be developed beyond the standard application in climate change and hydraulic capacity to include the three domains of flood risk management: day-to-day challenges, technical standards and events that exceed the maximum capacity of infrastructure.

Real-In-Options (RIO) is a recognised procedure to handle uncertainties in infrastructure investments by providing physical choices about a system and more management flexibility in choosing the most effective option to maintain expected performance. Further developing RIO in this context would mean, firstly, to decide when, where and how best to adapt to comply with the technical standards for flood risk, and then to address day-to-day challenges and events that exceed the maximum capacity of infrastructure.

Outlook

While focusing on cultivating flood resilience in the most cost-effective and efficient way, this project will also take a closer look at water stress and associated critical urban infrastructure in the approaches developed. It will be essential to work with practitioners such as Melbourne Water and state and national planning agencies to assess these approaches and facilitate the take-up of the novel tools and outputs, which include:

- prototype software tool for an enhanced ATP method
- prototype RIO accounting tool with a user guide
- recommendations for the application of the enhanced ATP method and RIO accounting tool for flood risk management in Australian cities
- a set of policy recommendations for enhancing social and technical flood resilience in Australian urban systems.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Richard Ashley
r.ashley@sheffield.ac.uk
Dr Berry Gersonius
b.gersonius@unesco-ihe.org

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program B: Water Sensitive Urbanism | Project B5.1 | Project duration: August 2012 – August 2016

Statutory planning for water sensitive urban design

Overview

Most developments must go through statutory planning processes including approval of structure plans, zoning, development permits and planning appeals. The likelihood of wide-scale adoption of water sensitive urban design (WSUD) could be vastly enhanced if WSUD principles are embedded in statutory planning regulations and processes. The project considers the extent to which WSUD has already been adopted in modern statutory planning frameworks and whether current frameworks are able to maximise the take-up of WSUD opportunities.

The project aims to assess the role of statutory planning legislation, regulation and processes in facilitating or constraining the adoption of WSUD and identify best practice planning legislation and policies to facilitate water resilience in cities.

Key outcomes

The project will demonstrate how synergies between WSUD principles and other town planning policies can be created and exploited in order to minimise the cost on housing and maximise public benefit when implementing WSUD. The project will deliver:

- a set of benchmark town planning policies and standards for applying WSUD to developments of different planning scales (for example greenfield and in-fill)
- better linkages with methodologies for costing WSUD infrastructure in town planning processes (for example, through the use of development levies) as an alternative to relying on funding of large-scale capital items through expenditure of public funds
- recommendations for integration of WSUD principles with other planning policies (for example, links between WSUD and public open space planning policy).

Key findings on current institutional arrangements relating to WSUD

From a regulatory perspective, the most important finding from a preliminary survey is the very strong support for a clearer legislative mandate for WSUD. However, support for mandatory targets is much lower. Local government and community stakeholders were particularly concerned about the need for mandatory targets and enforceable obligations fearing it would foster a prescriptive approach that could inhibit innovation. According to stakeholders, any legislative reform would benefit from clarifying roles, responsibilities and obligations. They thought that the reform agenda should also consider the role of maintenance costs and obligations, whether real or perceived, as a barrier to greater implementation of WSUD practices.

Those involved in the management and funding of infrastructure at a local government level have also expressed concerns and acknowledged a lack of data regarding the costs of decentralised stormwater infrastructure, though examples are known of developers who supported decentralised approaches that were more cost effective. Further research will seek to unearth the experiences of developers and consultants where economic, environmental and social benefits have been revealed through an integrated approach to water.

There are markedly different approaches to WSUD being adopted across jurisdictions. Some states have focused on the development of precinct-based approaches to WSUD, whereas others have policy frameworks which focus on residential subdivision. Other states have established processes which seek to integrate the funding of local water infrastructure with state and regional priorities by allowing price regulators to evaluate the costs and benefits of local infrastructure plans. There are local examples of targeted policies to address specific local issues or environmental values.

The research to date reveals that:

- Governance and institutional arrangements for integrated water management vary widely across states, which is unlikely to assist in the long-term development and implementation of town planning policy objectives related to WSUD. Funding and governance of infrastructure at metropolitan, regional and local scales is fragmented, which presents challenges when dealing with cross-catchment water management and planning.
- Policy frameworks, objectives and standards for integrated water management also vary widely across states, despite there being a high degree of commonality as to the key objectives of WSUD. There are opportunities to reduce red tape through the development of harmonised approaches to best practice integrated water management across jurisdictions.
- At the local government level there is a need for better understanding the costs and benefits of WSUD infrastructure at varying scales. Some states have carried out regulatory impact assessments which provide valuable insights for other states, and which should inform further research.

Project design

Research activities in the first year included high-level workshops with key policy- and decision-makers from state and local governments, urban water authorities, development industry as well as with architects, engineers and consultants who provided baseline information on how planning frameworks are delivering or hindering WSUD outcomes.

The second and third year see a stocktake and literature review of existing laws, regulation and town planning policies relating to WSUD as well as detailed consultation and interviews with key players across the five capital cities Brisbane, Sydney, Melbourne, Adelaide and Perth around the effectiveness of different statutory planning frameworks and possible options for reform.

In the final year, the project will produce a report identifying best practice policy frameworks for town planning for WSUD and processes that could serve as a benchmark for facilitating water sensitive cities. These will be tested through interviews and workshops with key players in the statutory planning system.

Outlook

This project will identify planning legislation, policies and processes which can enhance urban liveability through WSUD, for example, the planning and management of public open space. Another opportunity is to identify the resourcing and leadership requirements of local government planners and to consider how local government can best work with urban water authorities to deliver WSUD initiatives. A final report on current application of WSUD and options for reform and a recommended model of planning regulation and policy benchmarks for WSUD will be delivered by mid-2016.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

info@crcwsc.org.au

Barnaby McIlrath
barnaby.mcilrath@maddocks.com.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities


3t AND
OVER

Program C – Future Technologies

This program will develop integrated and multi-functional urban water systems that manage and/or use multiple water sources at a range of scales. It will deliver innovative technologies for: integrated management of the urban water systems; fit-for-purpose production of water; the recovery of energy, nutrients and other valuable materials embedded in urban water; minimising the carbon footprint and ecological impacts of water systems; and maximising the potential multiple beneficial values of urban water services.

There are five projects grouped under this program:

Project C1 - Innovative technologies for fit-for-purpose water production

- Project C1.1 (Cities as Water Supply Catchments – Sustainable technologies)
- Project C1.2 (Cities as Water Supply Catchments – Risk and health: understanding stormwater quality hazards)
- Project C1.3 (Fit-for-purpose water production)

Project C2.1 – Resource Recovery from Wastewater

Project C3.1 – Managing interactions between decentralised and centralised water systems

Project C4.1 – Integrated multi-functional urban water systems

Project C5.1 – Intelligent urban water systems

CRC for
Water Sensitive Cities

Program C: Future Technologies | Project C1.1 | Project duration: July 2012 - December 2014

Cities as water supply catchments – Sustainable technologies

Overview

Stormwater has emerged as a viable alternative water resource. In the past few years, stormwater runoff has been increasingly harvested on small scales using mainly non-sustainable, energy-intense technologies. However, technological solutions that could deliver large volumes of harvested stormwater with low-energy and low-carbon footprints still need further research and development. The aim of this project is to both develop new and refine existing stormwater harvesting technologies, building upon the proven concepts of water sensitive urban design (WSUD). Solutions are to be flexible, ranging from lot to regional scales.

Key outcomes

The project is designed to fill knowledge gaps around the removal of pathogens and toxic chemicals by WSUD systems, focusing on stormwater biofilters. The work has led to the development of novel biofiltration media that can passively remove pathogens from stormwater. A range of effective plant species has also been identified, leading to the development of a new generation of biofilters for stormwater harvesting.

This project has included one of the world's first studies on removal efficiency of micropollutants (herbicides, oil and petrol derivatives, disinfectants etc.) by stormwater biofilters. The project has also delivered some preliminary insights into pathogen removal by constructed wetlands. The project has delivered "Adoption Guidelines for Stormwater Biofiltration Systems", which are an updated version of the Facility for Advancing Water Biofiltration (FAWB) biofiltration guidelines published in 2009.

The project has concurrently delivered UrbanBEATS (Urban Biophysical Environments and Technologies Simulator), a modelling tool to assist in the strategic planning of stormwater treatment technologies, which is now being incorporated into the Water Sensitive Cities Modelling Toolkit developed under Project D1.1 (Integration and demonstration through urban design). UrbanBEATS integrates urban planning and urban form with stormwater management infrastructure planning, design and placement. It can be used to engage a multi-disciplinary group of stakeholders in identifying suitable water management opportunities.

Insights into pollutant removal capacity of biofilters and constructed wetlands

A final report on WSUD treatment technologies released in October 2014 summarises the findings from a series of studies designed to investigate biofilters and constructed wetlands – two of the most common WSUD technologies used in Australian stormwater harvesting schemes. Some of the key findings are summarised below:

- Research showed that WSUD technologies, particularly well designed biofilters, are capable of reducing a range of stormwater pollutants, and therefore are an important treatment step that should be incorporated into stormwater harvesting systems.
- It is important to select appropriate design characteristics (for example, system size, filter media composition and depth, vegetation etc.), which are able to achieve specific water quality objectives for the stormwater harvesting and reuse system in question.
- The selection of plant species remains critical, particularly for nutrient removal, and a mixed planting including both effective and ineffective plant species for nutrient removal (minimum 50% effective species) is suggested over a single plant species.
- Biofilters designed according to current best practice were able to reduce the majority of micropollutants to very low levels (for example, heavy metals, oils and petrol derivatives), but were not effective in removal of herbicides.
- Current biofilters are capable of achieving 1 log reduction of indicators of pathogenic organism. They are also performing well in removing key reference pathogens, particularly protozoa.
- Pathogen removal by biofilters that contain the newly developed layered biofilter media is almost 1.5-2 times better than that of conventional designs. These systems are less affected by operational conditions than the conventional designs, making them more robust.
- Constructed wetlands were generally shown to be promising in reducing indicator microorganism concentration, yet a large variance in removal performance remains.
- A constructed wetland receiving pre-treated runoff from an industrial catchment was effective in reducing concentrations of nutrients, metals and the bacterial indicator *E. coli*, but was less effective in reducing biological oxygen demand and chemical oxygen demand.

An Australian Government Initiative

Project design

The project has undertaken a series of laboratory studies and tests to refine biofilters and non-vegetated filters to more effectively collect and pre-treat stormwater for subsequent use. The work has included the monitoring of a number of existing field-scale biofilters and wetlands. Modelling has also been undertaken to describe the behaviour of microorganisms and micropollutants in WSUD systems.

In parallel, the project developed model algorithms that simulate the conceptual design and landscape integration process of different WSUD systems for runoff volume and pollution control as well as stormwater harvesting.

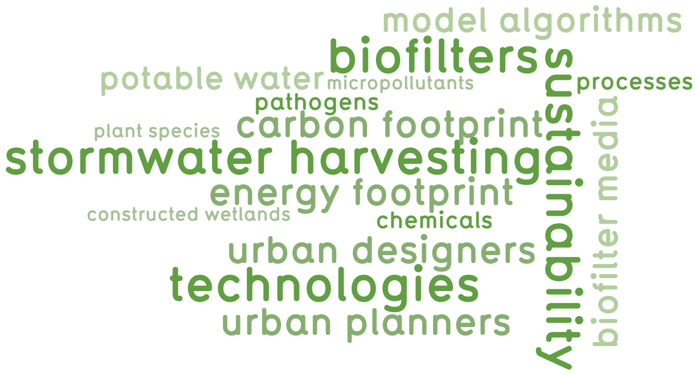
Figure 1. Dosing laboratory-scale biofilter columns using semi-synthetic stormwater (© Monash University).

Outlook

The project has been completed and delivered the following key outputs:

- novel designs of filters and biofilters for pathogen removal in urban stormwater
- models of WSUD treatment performance of faecal indicators and micropollutants.
- UrbanBEATS.

New adoption guidelines for the design, maintenance and operation of biofiltration systems for stormwater treatment and harvesting will be published in early 2015.



About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Ana Deletic
ana.deletic@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program C: Future Technologies | Project C1.2 | Project duration: July 2012 – December 2014

Cities as water supply catchments – Risk and health: Understanding stormwater quality hazards

Overview

Harvesting and reuse of stormwater runoff provides ecosystem services and increases water security. Impediments to the implementation of stormwater harvesting systems are mainly related to concerns regarding potential public health risks. Testing stormwater for micropollutants, toxicity and pathogens is costly and time consuming and has not been undertaken on a large scale, particularly for raw or blended stormwater.

The project aims to characterise the chemical, microbial and toxicological quality of raw and blended stormwater in Australian catchments with diverse land use and climatic characteristics. Comprehensive water quality testing and characterisation which includes a broad range of regulated and non-regulated pathogens and micropollutants will be conducted. The project will apply in vitro bioassays (biological assessments of substances to determine their activity and the effect they have on a living organism) to evaluate toxicity to screen for chemical pollutants that cannot be measured. In addition, water quality data will be combined with data from catchment audits to increase knowledge regarding the influence of catchment characteristics on stormwater quality.

Key outcomes

This project addresses the knowledge gaps in understanding the human health risks associated with pathogens and chemicals in untreated stormwater. Information gained in this study will contribute to the improvement of guidelines for stormwater harvesting and the development of stormwater treatment technologies to provide fit-for-purpose water. Methodology recommendations for identifying hazards within a catchment and assessing and characterising catchment-specific risks associated with stormwater quality will also be developed.

Key findings on stormwater quality hazards in urban catchments

Through studies of urban catchments in Victoria, Queensland and New South Wales the project has shown that urban stormwater in some catchments can have characteristics similar to secondary treated wastewater, with remnants of pathogens found. This is an important finding that informs the selection of stormwater treatment technologies to produce fit-for-purpose water supplies.
The studies pinpoint a need for continuing research into the public health implications of pathogens, and recommend interim design and water quality guidelines for the use of stormwater for non-drinking purposes.

Pesticides and pharmaceuticals were found in samples from Victoria, Queensland and New South Wales, however, detection values were well below the human health guideline values outlined in the Australian Guidelines for Water Recycling: Augmentation of Drinking Water Supplies. Heavy metals were frequently detected at concentrations near or above guideline values. Caffeine was the only detected chemical that exceeded guideline levels.

High estrogenicity (female hormones) was found in two sampling events and could be related to sewage overflow; whereas genotoxicity (material that has harmful effects on genetic material), dioxin-like activity and oxidative stress response were found in only three of the samples where the stormwater drain was situated next to a heavy traffic road, confirming that road runoff is a potential source of contamination.

The presence of pharmaceuticals and food ingredients combined with detections of bacteria and viruses specific to humans suggest sewage ingress into stormwater is occurring more frequently than previously anticipated and stormwater will require treatment prior to reuse. The level of treatment required will be guided by risk management guidelines associated with the end use. Factors determining the effect on people's health included: the exposure route (ingestion, inhalation, skin contact); the volumes of water individuals will be exposed to; and the frequency of exposure.

An Australian Government Initiative

CRC AUSTRALIA

Project design

Sampling campaigns were conducted in catchments within Queensland, New South Wales, South Australia, Victoria and Western Australia. Catchments included sub-tropical, moderate or mediterranean-style regions and were classified as residential, commercial or industrial. Rainfall event samples were analysed for a range of chemical, microbial and toxicological parameters. Findings were collated into a water quality database on chemical contamination, pathogens and toxicity. Risk assessments were conducted on identified water quality hazards and priority hazards were identified. A catchment audit tool was developed to gather information on sewer and stormwater infrastructure age and design; land use; share of impervious surfaces; housing and traffic density; roofing materials; active transport modes; domestic pets and wildlife. The findings flowed into the characterisation and prioritisation of risks caused by chemical and microbial hazards in stormwater.

Another component focused on the use of different analytical methods as surrogates for particular risk factors, for example, the use of chemical analysis to qualitatively and quantitatively identify sewage ingress into the stormwater system. This is particularly important, as sewage ingress is currently believed to be one of the biggest risks to the microbial water quality of stormwater.

Outlook

The project is nearly complete with the final recommendations for industry on the risk assessment process being released by the end of 2014. Additional outputs of this project include:

- a water quality database on chemical contamination, pathogen and toxicity
- a characterisation and prioritisation of risks caused by chemical and microbial hazards in stormwater
- recommendations for the usage of chemical surrogates to characterise stormwater quality hazards.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Jane-Louise Lampard
jlampard@usc.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program C: Future Technologies | Project C1.3 | Project duration: July 2014 - July 2016

Fit-for-purpose water production

Overview

Clothes and car washing, toilet flushing, watering lawns, cooking and drinking are just some of the many uses of water. Not all of these call for high-quality drinking water; yet paradoxically potable water is the only kind currently supplied to most urban communities in Australia. Decentralised fit-for-purpose water production provides an excellent opportunity to sustainably, reliably and cost-effectively meet growing demands for water of various quality levels, thereby complementing centralised water supply systems. Widespread implementation of such treatment is however currently hindered by a lack of understanding of the risks for some raw water sources, in particular, stormwater; an absence of passive, low-energy consumption technologies that can reliably remove pathogens; and unknown operational and maintenance requirements for emerging technologies.

This project aims to deliver low-cost and low-energy filtration technologies that can produce fit-for-purpose water from a variety of sources including stormwater, greywater and wastewater. The focus is primarily on the required treatment of chemical and microbiological hazards in source waters to enable end uses such as unrestricted outdoor irrigation, indoor non-potable uses, and possibly in the future also potable uses.

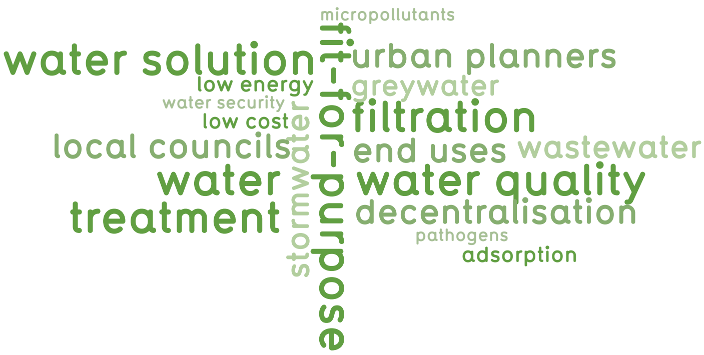
Figure 1. Biofilter monitoring (© Monash University).

Key outcomes

The project will address critical knowledge gaps in national research efforts on urban water security, which are primarily focused on centralised wastewater recycling or desalination, while stormwater and wastewater systems at local scales remain significantly under-utilised. The project will deliver a range of fit-for-purpose water technologies which, along with other systems, will be able to provide a comprehensive solution to water security problems in Australian cities and towns.

This project has only recently commenced in July 2014. The research is envisaged to be easily applicable by industry in the future. Novel treatment materials, such as those based on both adsorption and inactivation of pathogenic microorganisms, are being developed as part of this project. These systems, for example, could be incorporated into existing biofiltration systems similar to the copper-based zeolites which are being developed and tested in conjunction with Project C1.1 (Cities as Water Supply Catchments – Sustainable technologies). They could even be used at the household scale to treat greywater for irrigation or toilet flushing.

The project will continue to develop novel frameworks to robustly test new technologies coming out of Project C1.1, so that the end users can confidently utilise the designs under even the most challenging conditions. The project outcomes will ultimately assist water management agencies in implementing a wider range of water supply and treatment technologies, making their cities and towns more water resilient in the future.



Project design

The first part of the project consists of a literature review investigating benefits and limitations of fit-for-purpose technologies currently used in Australia and around the world. A second stage will develop new passive treatment systems that can be employed as building blocks in modular and composite systems to provide a high level of flexibility in delivering fit-for-purpose water for a specific end use.

To provide reliable and effective treatment of pathogens and micropollutants, technologies which utilise dual process removal mechanisms (for example, adsorption and inactivation) will be given priority. Following laboratory studies, the project will apply developed novel filter materials at the field-scale by incorporating them into existing systems and establishing new pilot plants.

A final stage will develop validation methodologies to ensure that these systems are fulfilling their required function, and provide operational monitoring regimes which demonstrate their performance during operation.

Outlook

Within the next two years the project will develop, test and refine a suite of novel decentralised, low-energy treatment technologies that can deliver fit-for-purpose water production by drawing on the lessons learned from existing treatment systems.

Additional outputs from this project include:

- recommendations for designing and assessing fit-for-purpose technologies, including treatment trains for a range of applications and for different water sources, end uses, scales and climates
- training programs and user manuals for asset managers and end users to ensure systems are constructed correctly and continue to function into the future.

Biofilter monitoring (© Monash University).

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Dr David McCarthy
david.mccarthy@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program C: Future Technologies | Project C2.1 | Project duration: January 2014 – January 2017

Resource recovery from wastewater

Overview

Wastewater treatment currently uses significant amounts of energy to remove valuable nutrients such as nitrogen, phosphorus and potassium. These same nutrients are major components of agricultural fertilisers critical for plant growth and replenishment of depleted soils, which are industrially produced for the agricultural sector at immensely high costs.

This project aims to develop technologies which can recover energy, water and valuable elements such as phosphorous, nitrogen and potassium from wastewater making the resource recovery energy and cost neutral. The ultimate goal is to develop a suite of technologies that together can supplement or completely replace existing domestic wastewater treatment systems at all scales.

Key outcomes

The project will deliver groundbreaking new technologies such as the partition-release-recovery method that recovers nutrients from wastewater while also producing methane gas, which is recovered for generating electricity, making the system energy neutral. Industries who will derive massive benefits from these new technologies are the agricultural and water sectors, making their operations more cost-effective, sustainable and carbon neutral. Industry stakeholders, in particular technology providers, will be consulted throughout the project to assist in the development of these new resource recovery technologies. This will engage specific and highly specialised industry groups which include precipitation specialists, chemical suppliers (particularly of ion exchange resins and adsorpents), membrane suppliers and electrochemical equipment suppliers.

Early promising results of these technologies have prompted strong direct support from Victorian water utilities (via the Smart Water Fund) and from key industry bodies such as the Grains Research and Development Corporation to sponsor this project.

Early insights into promising resource recovery technology

This project is developing a world-first technology for a next-generation resource recovery process which will be able to replace existing wastewater treatment technology in the not so distant future.

This technology has the potential to recover vital fertiliser compounds such as potassium (close to 100% of this resource are currently imported) and phosphorous, which is a non-renewable essential element. Another huge advantage of this technology is that it meets or exceeds the technical performance capability of existing technologies. There is strong multi-sector support from the waste and wastewater industry, agri-industry and farmers.

An Australian Government Initiative

CRC AUSTRALIA

Project design

The project consists of three modules looking at 3-step nutrient accumulation, release and recovery technologies. These three steps comprise separate technologies and are individually applicable to specific wastewater streams. It is intended that they be integrated from the start of the project for the purpose of domestic wastewater treatment at a range of scales.

In particular, the project is developing novel methods to enable fast growing, photoactive organisms such as purple bacteria and algae to remove nutrients rather than destructively converting them to nitrogen gas. When assimilated by these microbes, the nutrients transform into solid form. Solids are then separated from the water by filtering it through a membrane and are later further concentrated mechanically.

To extract the concentrated nutrients, they must be released back into a liquid stream. This is done by anaerobic digestion, producing a nutrient-rich brew one hundred times more concentrated than the original wastewater. Various chemical and physical methods are then used to finally recover the nutrients. Methane gas that is generated from anaerobic digestion is captured for electricity generation, making the system energy neutral. The nutrients can be processed into fertilisers that compare favourably with current commercial products. Another advantage of the partition-release-recovery method over traditional treatment is the small volume of sludge remaining at the end of the process, which means less waste for disposal and reduced transport costs.

Apart from actual technology development, a key requirement, especially for acceptance at a decentralised scale, is to build pilots to demonstrate its effectiveness in the field.

Outlook

The next steps are to continue to develop and refine the technologies in the laboratory before going into the field. A pilot processing plant will be built this year as part of the larger innovation centre at Brisbane's Luggage Point Advanced Water Treatment Plant. More pilots are also planned with the support of Victorian utilities.

A key step over the next two to five years will be to fit the technology into existing conventional infrastructure; for example, replacing nutrient destruction techniques with nutrient recovery. Within five years, it is expected that smaller-scale processing plants could be built using this technology. The system is designed to work as a drop-in replacement for existing treatment plants; so in the longer term the technology could be expected to roll out over decades replacing activated sludge treatment as new plants are built and ageing infrastructure is replaced.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

A/Professor Damien Batstone
damienb@awmc.uq.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program C: Future Technologies | Project C3.1 | Project duration: January 2014 - December 2016

Managing interactions between decentralised and centralised water systems

Overview

Water strategies in all Australian cities include initiatives to reduce water consumption and supplement water supplies with decentralised systems that produce water with fit-for-purpose quality from locally available sources such as stormwater and greywater. The use of decentralised systems will not only reduce the demand for centrally supplied water, but also change both the flow and composition of wastewater discharged to sewer networks that collect and transport wastewater to centralised wastewater treatment facilities. The latter will potentially have very significant implications on the management of corrosion, odour and greenhouse gas emissions in sewer networks.

This project aims to assess the interactions between decentralised water treatment and reuse systems and central infrastructure to support and optimise the integration of decentralised and centralised systems.

Key outcomes

The key outcomes of the project are decision-support tools and guidelines to support state and local governments and water utilities in managing water demand and the interactions between centralised and decentralised systems. One important outcome is the enhanced SeweX model. The current model, developed by The University of Queensland, describes in-sewer physical, chemical and biological processes. The enhanced SeweX model will be able to predict the effect of reduced sewer flow and changed wastewater characteristics on sewer management.

In addition, a methodology for improving financial and environmental performance forecasting (including water balance) of decentralised systems will be developed which addresses uncertainty in climatic conditions, urban growth and end use demand. This will aid in improving the integrated design and operation of multiple-source water supply systems applicable to greenfield developments and city infill rehabilitation.

Early insights into factors impacting on a decentralised system's performance

Decentralised water schemes, such as rainwater and stormwater harvesting and wastewater recycling, have been implemented at various scales in Australia over the past decade. Some schemes have been largely successful in demonstrating performance and sustainability attributes, though some have encountered compounding technical, financial, social and/or environmental challenges. Such schemes have subsequently been decommissioned, including Inkerman D'Lux greywater recycling in Melbourne and Pimpama Coomera dual reticulation at the Gold Coast in Queensland, which were considered too expensive to continue operating.

One of the major factors impacting on the performance of integrated decentralised and centralised water management schemes for residential purposes in urban areas is the development of a scheme on the basis of demand projections which do not eventuate. Water demands vary dependent on a number of factors including population changes, climatic conditions and water conservation behaviours and attitudes, and are often exacerbated by the time delay between planning and implementation of a scheme.

Uncertainty analysis on climatic conditions, urban growth characteristics, behavioural changes of end users and technical failures of system components can be incorporated into the long-term performance forecasting of a decentralised system to enable improved estimates of the supply, demand, and financial and environmental performance of integrated urban water management schemes. Integrating uncertainty into the decision-making process may reduce initial capital expenditure and enable decision-makers to learn more about system requirements during the lifetime of a project.

An Australian Government Initiative

Project design

One of the sub-project gains an understanding of the impact of reduced sewer flow and increased solids concentration in sewage on solids sedimentation in sewers through designing a model and testing it in the field on selected sewers. Another sub-project will look into the impact of reduced sewer flow, more concentrated sewage and the discharge of waste sludges from various types of decentralised water production systems on the corrosion of, and odour and greenhouse gas emissions from sewer networks. This will be delivered through integrated laboratory studies, field measurements and trials, and mathematical modelling that will enhance the SeweX model by using experimental and field data. The model will then be calibrated for various flow, wastewater and solids discharge conditions to support the water industry to manage corrosion and odour problems as well as greenhouse gas emissions in future scenarios.

A third sub-project will develop a methodology for improving performance forecasting of decentralised systems that addresses uncertainty in climatic conditions, urban growth and water end use demand. This will be achieved through a case study which will identify major uncertainties and risk characteristics, develop a tool to assess the long-term performance of decentralised systems, and apply improved performance forecasting to an integrated decentralised and centralised water scheme in a greenfield or infill development.

Outlook

Next steps are to complete the case study investigation to understand the risk factors affecting the performance of integrated decentralised and centralised schemes, and to incorporate the findings within a framework that enables improved long-term performance forecasting of schemes.

A conceptual model on sedimentation and erosion will be developed and laboratory and field studies will be conducted. This will feed into the enhancement of the SeweX model, which, in its current form, is already being used by many water utilities in Australia. It is envisioned that the enhanced model will be made available to end users either through specialised consulting service or through commercially available software licenses. Similarly, the decision-support framework for incorporating uncertainty and risk analysis into long-term performance forecasting of integrated decentralised and centralised schemes will also be made available to end users, primarily water utilities. In addition, training workshops will be offered for the use of such tools.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Zhiguo Yuan
z.yuan@awmc.uq.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program C: Future Technologies | Project C4.1 | Project duration: July 2012 - July 2017

Integrating multi-functional urban water systems

Overview

Stormwater biofilters (also known as rain gardens or bioretention systems) and constructed wetlands are currently regarded as two of the most promising water sensitive urban design (WSUD) technologies. For example, biofilters are highly efficient in reducing runoff volumes, and in removing solids, nutrients and metals from stormwater while having a relatively small footprint. Stormwater wetlands, that can be very effective flood control measures, are often regarded as the key amenity assets in our urban areas. These systems are multi-functional technologies that harvest water for people's use, protect waterways from polluted and elevated urban discharges, beautify urban landscapes, and improve microclimate by enhancing evapotranspiration.

This project will deliver multi-functional hybrid WSUD systems capable of treating multiple water sources (such as stormwater, greywater, partially treated wastewater and polluted groundwater) within urban landscapes. It will focus on water recycling of multiple water sources in urban areas, and further development and optimisation of stormwater biofiltration and wetland systems to better protect our waterways and cool our cities. It will also focus on estates of biofilters to incorporate ornamentals and climbing plants.

Key outcomes

The key outcomes of the project include the development of:

- constructed stormwater wetlands that can function well within groundwater dominated hydrology systems of the Coastal Plains around Perth
- green wall technologies that could treat greywater while providing thermal isolation to buildings and cooling to the surrounding areas
- hybrid biofilters for treatment of multiply water sources within urban landscapes, for example, harvest stormwater during wet periods and treat greywater during dry periods
- stormwater biofilters that are esthetically pleasing as well as effective in water treatment
- adoption guidelines for these new technologies including guidance on design, operation and maintenance.

These new WSUD technologies could be adopted by local and state planning authorities and water utilities. Water system technology manufacturers and service providers, urban land developers, building contractors, and engineering and design consultants will also benefit from these developments.

Multi-functional biofilter and wetland performance: Facts and insights

So far the work has been done only on monitoring stormwater wetlands located in Perth, Western Australia. The hypothesis is that stormwater wetlands that are under influence of natural groundwater systems will have different performance compared to stormwater constructed wetlands that are disconnected from the groundwater. The first preliminary results are still inconclusive.

The work on multi-functional and hybrid biofilters, including green walls and living walls for greywater and stromwater treatment, commenced in July 2014 and involves the selection of light weight media as well as ornamental and climbing plants that can support healthy green and living walls. It also includes a laboratory study on ecological carbon sources (low-cost waste products) that can enhance nutrient removal in the submerged zone of biofilters, which is of particular importance for treatment of wastewaters of high nitrogen strengths.

Current knowledge about green and living walls includes the following:

- Green and living walls can reduce summer temperatures on a street by 9oC, offering a direct advantage to business and commercial districts.
- They considerable reduce the need for cooling of the buildings on which they are installed, while also creating an aesthetically pleasing feature.
- A current disadvantage is their need for large amounts of water to function (approximately 1-5 litres per square metre each day), which is the main reason why they are not commonly used in Australian cities.

An Australian Government Initiative

CRC AUSTRALIA

Project design

The project will compare wetland systems from the Coastal Plains around Perth including a natural groundwater dominated system and a constructed system disconnected from the water table. This will result in the development of a wetland model able to simulate ecological and hydrolgoical responses to changes in water availability.

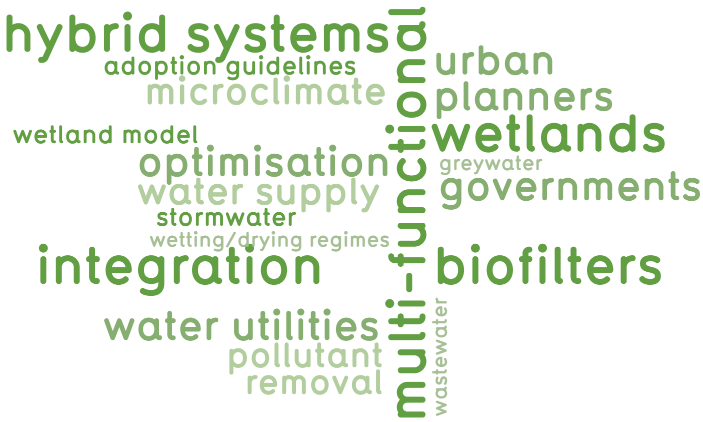
Laboratory studies (large-scale column tests) will help optimise stormwater biofilters capable of treating wastewater as well as polluted groundwater for a number of flow rates and wetting/drying regimes. This will lead to the development of hybrid biofilters that can treat polluted groundwater and wastewater during dry weather as well as capture and treat stormwater during wet weather. The project will particularly focus on the development of living walls and green walls for water recycling, thermal isolation of buildings, cooling of urban environments, and greening dense urban areas. A crucial part of the project is to optimise the operational and maintenance regimes for each developed hybrid design, which include specification of application and resting periods as well as application flow rates, through controlled laboratory studies.

Figure 1. A living wall that has microclimate, thermal insulation and aesthetic functions, but cannot treat water (left). The proposed concept to the right adds treatment function to the green wall system.

These novel systems will be implemented in the field at a demonstration site and tested to verify the laboratory findings. To be able to assess the performance of these systems, mathematical models will be developed.

Outlook

Next steps are to rigorously apply and validate the developed wetland ecohydrological model using available vegetation, hydrological and nutrient data and running different flow and management scenarios. The coming years will see the development and modification of green walls to treat greywater and stormwater, but also tests of multi-functional hybrid green infrastructure in the field. The project will also develop adoption guidelines on the new technologies. At the end of the project by mid 2017, it is envisioned that short courses on the design of these hybrid systems will be offered in various Australian cities to increase their up-take.



About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Ana Deletic
ana.deletic@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program C: Future Technologies | Project C5.1 | Project duration: July 2012 – December 2016

Intelligent urban water systems

Overview

Intelligent urban water systems use state-of-the-art sensors, telemetry as well as decision-making and optimisation software for various components of an urban water system. These elements are applied all the way from the catchment via water treatment facilities to households. This means sensor information can be continuously monitored and analysed, for example, smart water meter readings being reported in real-time. This results in detailed information such as water consumption by hour, day or season, total volumes consumed, or minimum hourly flow per day. An extensive computerised data-mining process can reveal some unexpected or interesting patterns of consumption such as periods of peak use, periods of continuous supply of water and possible leak locations in networks. This knowledge, in turn, can greatly enhance decision-making around urban water management.

The project aims to develop innovative analysis techniques for smart water data to optimise the efficiency and safety of urban water systems and to learn more about water consumption behaviours of customers. The project will focus on smart household water meters and water pumping in pipe delivery systems that manage water from alternative sources.

Key insights into water use behaviours through smart water meter data-mining

The project analysed information from smart meters, which were installed in households and businesses in Kalgoorlie-Boulder by Western Australia's Water Corporation utility to provide a clearer and more detailed picture of water use. Kalgoorlie-Boulder, Australia's largest outback city, experiences little rain throughout the year and completely relies on drinking-quality water piped 600 kilometres from Perth. The analysis made some interesting discoveries:

- Continuous flow patterns, for instance, where at least two litres of water are metered for every hour in a 24-hour period, may be evidence of leakage in appliances or pipes. In Kalgoorlie, 84% of households showed at least one day of continuous flow in the study period, accounting for 10% of total water use among the sampled households.
- The Water Corporation was able to apply this information derived from the data-mining exercise and followed up affected households to determine the cause of the water loss. Data from the smart meters helped show the cost of leaks relative to normal water consumption and provided a convincing argument for fixing leaks where they existed. Over 90% of customers affected took appropriate action within thirty days. Properties are now monitored continuously, enabling the detection of small leaks before water loss becomes costly.
- Data from smart meters also revealed householders who, over time, had lapsed into watering their gardens outside the days designated by the Western Australian statewide water efficiency regulations. Armed with this evidence, the Water Corporation was able to monitor customers' use better and help change the behaviour of those non-compliant households.

The figure below shows a summary of programmed patterns of a city's population. Each bubble represents one household water meter. The size of a bubble represents the number of day-hour combinations for which a programmed pattern was observed, ranging from 1 to 25 programmed hours per week (168 hours) for active meters. The green colour represents the number of days per week on which regular patterns were detected. The orange and red bubbles show the lapse into illegal watering on non-designated days.

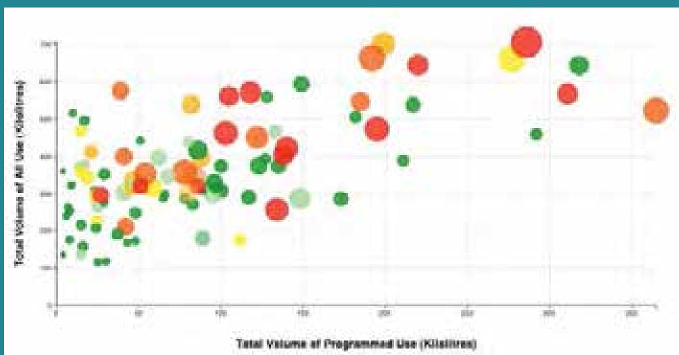
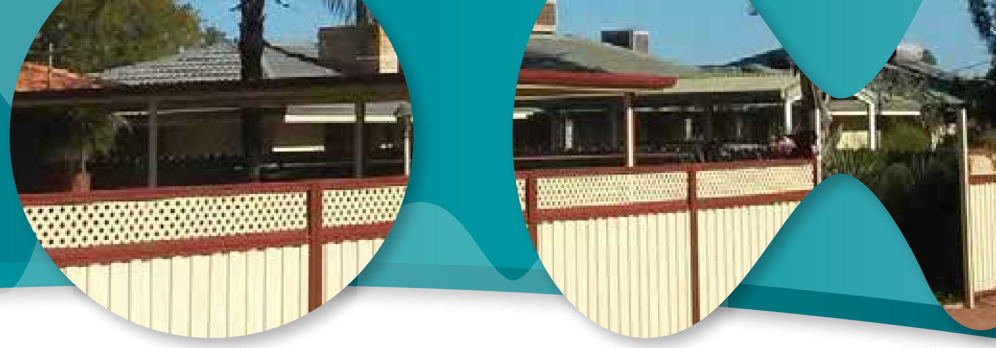


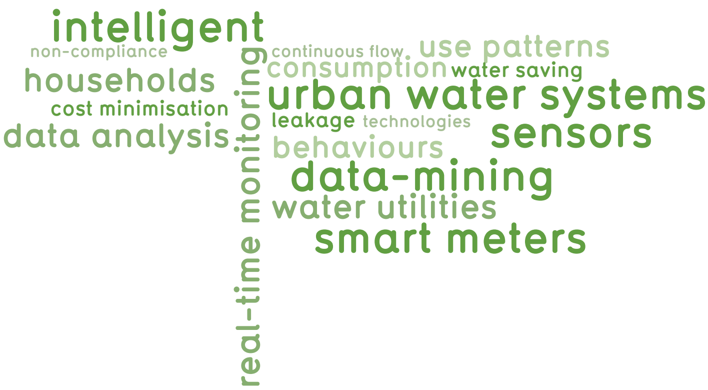
Figure 1. Population summary of programmed patterns (© The University of Western Australia).

An Australian Government Initiative



Key outcomes

The project will deliver new techniques for automated large-scale, real-time data collection and analysis. One of the techniques developed is the Water Use Signature Patterns model. It combines cyclic daily and seasonal patterns of water use with peaks in consumption to arrive at an in-depth understanding of consumption over time. This will generate a better understanding of water consumption behaviours and patterns and enhance water utilities' decision-making on water supply, control and management. The information, fed back to customers, will contribute to long-term behavioural and lifestyle changes in terms of using water more wisely.



Project design

The project will develop and evaluate a number of real-time analysis techniques and software tools to support effective decision-making for smart urban water systems. Western Australia's Water Corporation is providing data for this project from their ongoing smart meter trials of more than 13,000 residential, commercial and industrial properties in Kalgoorlie-Boulder and 500 customers in Karratha. Another project component looks into optimising pumping systems applied across a range of alternative types of water delivery systems in terms of minimising operational cost, energy use and green house gas emissions.

A case study with the Orange City Council, New South Wales aims to develop optimal operating rules for pumping with multiple alternative water sources. The goals are to minimise cost, spill from the main reservoir and environmental impacts while maximising water quality. A third component brings together all project outcomes to deliver practical solutions for the design of sensing and analysis systems for urban water, aiming to minimise their cost and complexity.

Outlook

Smart meter data-mining as a tool for water management has a promising future, in particular for an envisioned roll-out across Australia. The project anticipates even greater potential for additional significant water savings in the future as information yielded by the data leads to better targeted management responses.

Beyond the obvious benefits of conserving water, other environmental and social benefits include lower energy consumption with lower greenhouse gas emissions from pumping water into the region, and continued availability of water for recreational use. Additional benefits for the water utilities are cost savings in infrastructure augmentation, operation and maintenance, and the ability to adjust their internal processes to consumption patterns such as peak flows.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Rachel Cardell-Oliver
rachel.cardell-oliver@uwa.edu.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

Program D – Adoption Pathways

The program will deliver a suite of capacity building projects and socio-technical modeling tools that will provide a focus for participants and stakeholders at a national regional and community level to interact, experiment, and learn from each other. This in turn will: improve community engagement; enrich educational and training programs at the professional and sub-professional levels; and support the development of robust science-policy partnerships. There are six projects grouped under this program. Two will finish in 2014 and one will commence in early 2015.

The projects are:

Project D1 – Integration and demonstration

- Project D1.1 (Cities as Water Supply Catchments – Integration and demonstration through urban design)
- Project D1.4 (Integration and demonstration through urban design – Phase 2)

Project D3 – Influencing water sensitive cities policy

- Project D3.1 (Science-policy partnerships)
- Project D3.2 (Influencing water sensitive cities policy)

Project D4.1 – Strengthening educational programs to foster future water sensitive cities leaders

Project D5.1 – Urban intensification and green infrastructure: Towards a water sensitive city

Project D6 – Water sensitive cities impact and assessment

- Project D6.1 (Development of an evaluation and learning framework to inform CRCWSC impact assessment)
- Project D6.2 (Developing a water sensitive cities index)


CRC for Water Sensitive Cities

Program D: Adoption Pathways | Project D1.1 | Project duration: July 2012 – December 2014

Integration and demonstration through urban design

Overview

The project facilitates knowledge sharing between researchers and industry partners through the development and application of the Water Sensitive Cities Modelling Toolkit and coordination of a number of water sensitive demonstration projects to provide proof-of-concept for water sensitive initiatives. The toolkit provides a platform for the synthesis of green infrastructure and stormwater management research from across the CRC for Water Sensitive Cities (CRCWSC) and its application by industry as part of planning and design projects at a range of scales. Demonstration projects build researchers' and practitioners' knowledge and capacity through learning-by-doing and provide vital case studies to support the transition to water sensitive cities.

The application of the toolkit enables a wide range of green infrastructure scenarios for stormwater management and urban heat mitigation to be generated in response to user defined objectives and targets, and multiple benefits provided by different scenarios to be quantified and compared. Users can also assess specific benefits of water sensitive initiatives through the standalone application of individual scenario assessment modules.

Key outcomes

This project provides tools to support the transition to water sensitive cities and towns, and coordinates the application of research outputs from across the CRCWSC to water sensitive demonstration projects delivered by industry partners.

A fully functional version 1 beta of the toolkit was launched in July 2013, with version 2 beta released in October 2014 for testing and validation by end users. Researchers, water utilities, local governments, consultants and other organisations applying this toolkit will be able to better understand, quantify and compare multiple benefits associated with potential green infrastructure and stormwater management strategies within their area.

Application of research in demonstration projects delivered by CRCWSC partner organisations is another key outcome of this project. Examples include the development of a strategy to protect the ecological values of Gum Scrub Creek in Melbourne, Victoria, as urban development occurs within the catchment. Knowledge and capacity built through the co-planning for and co-management of a biofilter for stormwater harvesting, treatment and use in Marrickville in New South Wales (proposed for 2015) is another key outcome.

Insights into developing the toolkit: a knowledge synthesis activity

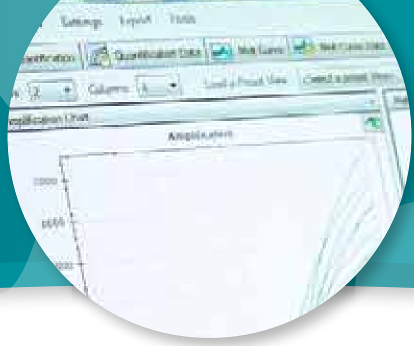
The concept for the toolkit was initially developed by the Cities as Water Supply Catchments research program which is now part of the CRCWSC. Projects that have contributed research outcomes to the toolkit include Project C1.1 (Sustainable technologies) through planning for stormwater treatment and harvesting; Project B1.1 (Urban rainfall in a changing climate) by simulating uncertainty and variability in future rainfall and evaporation at a fine spatial scale; Project B2.1 (Stream ecology) through understanding and managing the impacts of stormwater and urban waterway health; and (Project B3.1 (Green cities and microclimate) by looking at microclimatic benefits of green infrastructure at a precinct scale. Project A1.1 (Economic valuation) is currently undertaking research that will inform a non-monetary benefits module.

The toolkit comprises a scenario generation model (UrbanBEATS) and a number of scenario assessment modules that can be applied individually or collectively: stream health (hydrology, water quality and stream erosion), peak flow (minor flood reduction) and urban heat mitigation. A rainfall prediction module (local variability and uncertainty) and an economic valuation module (non-monetary benefits of green infrastructure) continue to be developed. Dynamic links to the model for urban stormwater improvement conceptualisation (MUSIC) allow scenario assessment modules to use flow and pollutant data generated by MUSIC.
The process of developing the toolkit has involved extensive collaboration and engagement between the various CRCWSC research projects that have contributed to the toolkit. This process has required researchers to reflect on how new research needs to be presented to be accessible and useful to practitioners, and to clearly define the possible applications, assumptions and limitations of their work.

Input and feedback from industry participants throughout the development process have also been critical enabling partners to understand how the toolkit may support the planning and design activities of their organisations.

An Australian Government Initiative

CRC AUSTRALIA



Project design

The current beta version of this toolkit is the result of stormwater management research from the CRCWSC's forerunner, the Cities as Water Supply Catchments research program. Projects that have fed insights and recommendations into the toolkit include Sustainable Technologies (focused on stormwater treatment and harvesting), Rainfall in a Changing Climate (simulating future rainfall and evaporation conditions at a much finer spatial scale), Stream Ecology (understanding the impacts of stormwater management on the health of urban waterways), and Green Cities and Microclimate, which is investigating the climatic advantages of harvesting and using stormwater at a precinct scale.

There are multiple benefits of the toolkit: It allows for environmental benefits to be illustrated through computer modelling and simulations deriving a set of environmental benefit indices. This provides urban planners with convincing arguments for the implementation of water sensitive urban design. The user-friendly toolkit also comes with an intuitive graphic interface to guide users through the four stages of its application (data input, scenario generation, simulation and assessment). Another key benefit lies in its ability to automatically generate a large number of different stormwater management interventions or scenarios through the use of spatial data and urban planning considerations.

Figure 1. The Water Sensitive Cities Modelling Toolkit user interphase

Outlook

The toolkit is currently being applied to a number of case studies to test and validate the underlying concepts and algorithms across a range of urban settings.

Over the next six months, the activities of the project are expected to increase knowledge and understanding to support the transition to water sensitive cities and towns. The development of a database of future rainfall projections for many Australian capital cities will further support this transition.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Ross Allen
ross.allen@crcwsc.org.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program D: Adoption Pathways | Project D3.1 | Project duration: March 2013 – June 2014

Science-policy partnerships

Overview

The outcomes of the CRC for Water Sensitive Cities (CRCWSC) research programs will have the potential to guide capital investments estimated to be more than $100 billion by the Australian water sector and more than $550 billion of private sector investment in urban development over the next 15 years. These impacts will be realised when the knowledge generated by the CRCWSC is adopted and incorporated into the key policies and strategies that shape our cities and guide investment in infrastructure and service provision.

Relationships that facilitate dialogue and discussion between researchers and policy makers, referred to as "science-policy partnerships", are a key adoption pathway that specifically targets the integration of research outcomes into policy-making processes to influence the transition toward water sensitive cities (WSC). This project worked with industry participants to develop new, or strengthen existing, relationships that increase the adoption and use of CRCWSC research in policy. It has tested relevant partnership models that focus on policy championed by state and local governments.

Key outcomes

This project has supported the creation of new science-policy partnerships which have helped further the adoption and integration of CRCWSC's research outcomes into national, state and local government policy agendas. Building capacity to better understand and use CRCWSC's research has been an important part of creating these partnerships.

Pilot science-policy partnerships were established with Blacktown Council and Ku-ring-gai Council in New South Wales, and the Department of Water (DoW) in Western Australia. The CRCWSC acted as a knowledge broker to the Blacktown Water Working Group to support its program to strengthen the council's water sensitive urban design policy, capability and capacity. The Ku-ring-gai Council's science-policy partnership provided expert knowledge to assist the council in the review and enhancement of their key water related policies to transition them towards a water sensitive city.

A number of important lessons from these pilot projects have been identified and will help guide other stakeholders seeking to establish their own science-policy partnership arrangements. Some of the lessons learned are outlined below:

- Science-policy partnerships help build participants' confidence to initiate policy projects in the case of DoW and Ku-ring-gai Council, or to strengthen initiatives in the case of the Blacktown Council.
- Early impacts have come from two-way "sharing" of CRCWSC knowledge with the participating organisations rather than linear "transfer".
- Alternative strategies of "influence" (rather than knowledge transfer) are based on the confidence and capability of the messenger rather than the message itself.
- There is not a single model for science-policy partnership arrangements, rather tailored solutions are necessary to match the particular circumstances and requirements.

Key findings from the Department of Water - CRCWSC partnership to support the transition to a WSC

The first workshop held in November 2013 between the CRCWSC and DoW was an early step in building a long-term science-policy partnership between the two organisations. Twenty-five department staff, including senior executives, participated in the one-day workshop to share ideas about future urban water management, and to identify opportunities for CRCWSC's research to contribute to evidence-based policy.

The workshop generated many ideas about what successful urban management could look like, including:

- having an agreed, shared vision across government and communities for managing water to create liveable cities
- building stewardship of water resources for the greatest good of society and the environment
- having an enduring, bipartisan, whole-of-government position on urban water
- fostering water sensitive behaviours across society.

The vision for urban water management started to take shape with staff identifying a future where a community of practice is managing water effectively in Western Australia's cities and towns, and where the world looks to the state for leadership in providing water security, creating vibrant cities and towns, and protecting the health of water environments.

An Australian Government Initiative

CRC AUSTRALIA

Project design

This project sought to create strong and lasting relationships between CRCWSC researchers and industry participants through the development and enhancement of partnership arrangements associated with specific strategic policy initiatives. The structure of the partnerships were informed and shaped by the local context, particular policy drivers or issues, the roles of the various participants, the knowledge pathways involved, and the resources available.

The key steps in the process included:

1. Establishing models for science-policy partnerships from literature and analysis of comparable knowledge transfer and science-policy relationship.
2. Identifying partnership opportunities and analysing the policy roles and science needs of participant.
3. Establishing pilot science-policy partnerships
4. Monitoring and reviewing to enable further development and refinement of partnership models.

A series of three pilot science-policy partnerships were established to help test the conceptual model.

Figure 1. Department of Water - CRCWSC workshop (© Now for Future).

Outlook

This project was completed in July 2014. A summary of lessons from the pilot projects will be available in early 2015. The CRCWSC will continue to support the building of partnerships between researchers and policy-makers through a variety of activities and initiatives, including continuing to work with the Department of Water to support the development of future water sensitive city policy tools and strategies.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Fiona Chandler
fiona.chandler@crcwsc.org.au

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program D: Adoption Pathways | Project D4.1 | Project duration: July 2013 – July 2016

Strengthening educational programs to foster future water sensitive cities leaders

Overview

The ambition of the CRC for Water Sensitive Cities (CRCWSC) is to play a critical and catalytic role in re-shaping how urban design and urban water are viewed and managed with respect to one another. This is necessarily a multi-scale agenda across different sectors and disciplines which will require the development of capacity in urban planning and water professionals from a wide range of government, utility, consulting and community bodies.

The project aims to develop a set of professionally targeted Master level modules, programs and short courses aimed at building the capacity of emerging urban leaders to stimulate and drive processes of innovation toward the realisation of water sensitive cities (WSC).

Key outcomes

This project will provide a pathway for translating CRCWSC's research insights and outcomes into transdisciplinary learning processes which build the relevant capacities of urban professionals to drive the implementation and delivery of innovations in urban water management, planning and design.

These learning processes will be delivered through new modules and programs within the mid-career professional Masters and post-graduate programs offered by the International WaterCentre (IWC) and UNESCO-IHE, and through targeted short courses that are based on those modules.

Insights into professional, problem-based learning for real world change

The project has redeveloped and delivered a module on urban water for IWC's professionally targeted Master of Integrated Water Management (MIWM) program. The module, called "Urban futures: delivering water sensitive cities", explores the drivers and challenges for urban water services and aims to help participants of the Masters program understand why a change and transition toward more water sensitive practices is needed, and how it can be facilitated.

The module promotes an interdisciplinary approach, examining the interplay between society, technology and urban design. Along with technical elements such as climate-responsive design, flood mitigation and waterway health, the module has a strong emphasis on socio-technical change. It investigates the "actors" — water utilities, government organisations, the community — as well as possible mechanisms of transition to a WSC.

The Masters module is designed and delivered around practical, real world case study learning and integrates field visits and problem-based learning with specialist lectures, interactive workshops, in-depth discussions and exercises. The module is being delivered for the second time between July and November 2014 to a range of water professionals from countries including Australia, Bangladesh, Chile, China, Honduras, Indonesia, India, Indonesia, Japan, Laos, Mexico, Namibia, Sierra Leone, the United States of America and Vietnam.

Project design

Delivering WSC outcomes requires skills and knowledge in urban professionals to work across departmental, organisational and disciplinary boundaries in complex and innovative ways — what can be termed a T-shaped skills profile.

This project has been working to characterise the kinds of skills and knowledge required to deliver WSC outcomes by interviewing WSC project and program champions from across Australia, the Netherlands, Vietnam, the Philippines, Indonesia and China. The results of this work will feed directly into the product design and market assessment of WSC education and short course programs.

Outlook

Current postgraduate programs offered by IWC and UNESCO-IHE have a clear water focus and are intended for water professionals, but they appear to be of limited appeal to the broader urban planning and design market in their current form. This project will seek to determine if there is a sufficiently strong demand for an integrated mix of water management, regional and urban planning and design skills to underpin a new Masters program to target planners, urban designers and water managers.

Outputs associated with the project will include:

- an assessment of the knowledge and skills needs of professionals from Australia, the Netherlands and a range of Asian cities in relation to their capacity for driving innovation toward water sensitive city outcomes, to be released by the end of 2014
- market research assessment of different education and short course topics delivered in different ways (accredited, non-accredited, online, face to face, half day to multi day) at different levels of cost and interactivity
- a standardised curriculum for a range of market tested, professionally targeted postgraduate Masters level modules and short courses, each with a set of teaching materials
- a syllabus for a new standalone Masters program or route within an existing program, comprising the new modules plus others as informed by the knowledge and skills needs assessment.

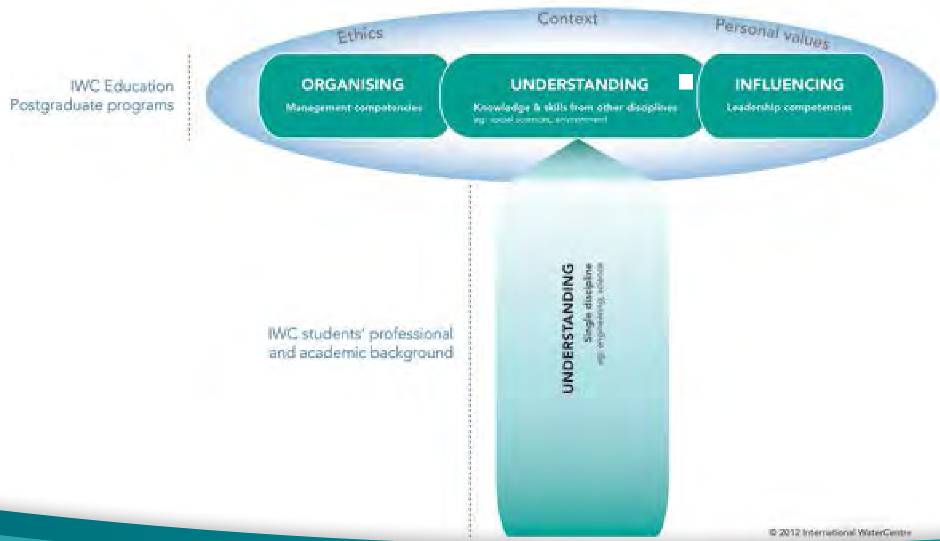


Figure 1. T-shaped skills profile of water professionals. ((c) IWC)

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Dr Brian McIntosh
brian.mcintosh@watercentre.org
Dr Assela Pathirana
a.pathirana@unesco-ihe.org

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program D: Adoption Pathways | Project D5.1 | Project duration: July 2014 – July 2017

Urban intensification and green infrastructure: towards a water sensitive city

Overview

Water sensitive urban design (WSUD) is commonly best implemented at a precinct-scale. This enables an integrated approach and the employment of an appropriate mix of design and technologies for a spatially considered, climate resilient and resource sensitive outcome where local water capture, storage, treatment, use and reuse can be introduced as a contributor to the urban environment.

This project examines the issues and processes involved in delivering best practice WSUD through demonstration precinct development and redevelopment projects in Victoria, Western Australia, South East Queensland and in international cities. The scale, design and delivery of each project will be determined by the particular constraints and contexts of each location. Design projects will seek to integrate both the physical and environmental characteristics of the location, such as climate, building density, availability of open space and local catchment issues as well as the social, cultural and legislative aspects, such as development regulations, community needs and qualities of place. The precincts, which include greenfield, greyfield and activity centres, will incorporate an integrated and holistic approach to water systems and activities.

Key outcomes

This project will develop plans, visualisations, design guidelines and demonstration outputs that support government agencies, policy-makers, developers and consultants in facilitating the adoption of WSUD principles at precinct-scale.

A key outcome will be the demonstration of how the various social, science and economic outputs of the CRC for Water Sensitive Cities (CRCWSC) can influence design and the visualisation of what these sites, precincts and cities of the future might look like.

Visualisation of Tonsley's master plan (© CRCWSC)

Early insights into master planning water sensitive urban design

The closure of the Mitsubishi car manufacturing plant in Adelaide's Tonsley Park in 2008 created a unique opportunity to redevelop a 61 hectare inner-city urban renewal site in a sustainable context. Renewal SA, the government body responsible for delivering Tonsley's new master plan, teamed up with the CRCWSC to explore a range of "what-if" scenarios, with a view to incorporating best practice WSUD principles into Tonsley's master plan. This project provided an excellent opportunity for the CRCWSC to demonstrate its technical capability to provide input into a large-scale, mixed-use redevelopment. A CRCWSC Industry Partners' Worksop held in October 2013 culminated in Ideas for Tonsley — a report capturing important design principles and suggestions for the implementation stage. These include:

- diverting and distributing stormwater to irrigate shade trees which form part of an urban forest along pedestrian and cycle routes
- (partially) "daylighting" drains and creeks that are currently piped which slows the flow of water and helps sustain a range of vegetation; reduces downstream flooding; captures, cleans and reuses otherwise wasted water; increases moisture content in the soils; and improves groundwater to support an urban forest and biodiversity. An open creek would also greatly improve public amenity for residents of Tonsley and neighbouring suburbs, which keeps with the intention to integrate this redevelopment into the broader landscape and maintain certain cultural linkages
- storing excess winter rain harvested from roofs and stormwater in large tanks to use for evaporative cooling and spray misting in summer. Using this water to irrigate shade trees during summer, for example, could cool the shaded areas by 2–3°C during the day and 4–5°C at night
- collecting runoff from the 8 hectare large shed roof in steel storage tanks providing cooling during summer and heat repositories (enhanced by solar panels) during winter.

Project design

The project will undertake a number of interrelated research sub-projects for the incorporation of WSUD in a range of precincts in Australian and international cities and towns. Each sub-project will facilitate an exchange of expertise, information, skills and knowledge across the project-leading universities and cities. In particular, these sub-projects involve:

- designing strategies for precinct-scale development and redevelopment that achieve high-quality and higher density dwellings that respond to a changing demographic; as well as interconnected open space for social, recreational and ecological purposes
- developing a design and performance toolkit and assessment framework consisting of mechanisms, tools and processes for identifying suitable land for precinct development and redevelopment; innovative financing models; and the assessment of a range of environmental, economic and social benefits of proposed precincts
- identifying best practice principles for precincts resilient to events such as flooding, storm surges, droughts and temperature extremes
- developing best practice principles for incorporating renewable energy and resource recovery solutions.

Outlook

The next steps will continue to identify, scope and design various demonstration projects in Australia and internationally at a range of scales. A research repository will be developed in order to document and integrate the research findings and learnings from other CRCWSC programs into the development of design projects.

Final outputs of the project will include:

- a repository of CRCWSC's research relevant to built environment outcomes
- design project case studies and appropriate visual representations of a mix of precinct types and scales in Australia and internationally
- a toolkit demonstrating key design principles that best support the integration of resilient water sensitive precinct design. This will include a process for testing these principles for their suitability to be built into regulations and to challenge existing regulations that inhibit best outcomes.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Professor Shane Murray
shane.murray@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program D: Adoption Pathways | Project D6.1 | Project duration: September 2014 – June 2015

Development of an evaluation and learning framework to inform CRCWSC impact assessment

Overview

The CRC for Water Sensitive Cities (CRCWSC) brings together over 80 research, industry and government participants with the aim of undertaking collaborative research that will revolutionise water management in Australia and overseas. The CRCWSC is required to demonstrate the level of influence, adoption and overall impact the investment in research and engagement activities is having on changing current practice.

The purpose of this project is to develop, test and refine an evaluation and learning framework to critically inform key CRCWSC processes, protocols and pathways for adopting water sensitive cities (WSC) concepts, tools and practices within national and international urban water contexts.

Key outcomes

This project will deliver the necessary evaluation tools, techniques and processes for collecting and analysing data to reveal what impact CRCWSC's research and activities have. Specifically, it will:

- map and characterise the expected adoption pathways for CRCWSC's research outcomes
- deliver an evaluation and learning framework appropriate for a large-scale, complex research program
- test the evaluation and learning framework to assess its effectiveness in providing relevant impact information and, where necessary, refine the framework ready for implementation.

Key findings on maximising CRCWSC's research outcomes

A recent evaluation of the Cities as Water Supply Catchments program, a forerunner of the CRCWSC, focused on assessing and characterising the adoption and impact pathways that have resulted from researchers collaborating with industry. This evaluation involved examining five case studies at different scales which reflect a change in policy or practice related to improved urban stormwater management. The review identified two critical processes: seeding, supporting and sustaining networks at different scales; and building individual and organisational capacity as essential precursors to generating tangible impacts such as an on-ground structural project. The evaluation provides a series of recommendations for increasing research utilisation and maximising the impact of ongoing and future research-industry collaborations:

- It is important for researchers engaged in ground-breaking research to recognise that industry partners need to be taken along on their journey in order to implement innovations. Industry partners require practical support from researchers to stay connected.
- Demonstration projects remain an important mechanism for testing technological feasibility and building practitioners' confidence. These projects need to be designed as much more than just implementing technology on the ground. There are significant process-based lessons which emerge from undertaking the planning, design and implementation of such projects. Understanding and characterising these processes will assist in the widespread replication of demonstration projects to generate broader impacts.
- The research revealed high dependence on lead researchers for achieving impacts in both demonstration projects and organisations. Credibility, reputation and good standing of these individuals are being identified as critical for enrolling high-level decision-makers in CRCWSC's cause and overcoming "road blocks" in projects.
- Industry partners place importance on having access to approachable and visible researchers. This insight will be of specific importance for future CRCWSC regional-based activities, particularly as the number of industry partners has significantly increased and is set to continue to grow. Activities within these regions need to draw on research leaders' knowledge and visibility, but also ensure they are showcasing the breadth of research activities. A variety of engagement and information exchange activities is also important for synthesising and disseminating valuable research insights.

Project design

The development of the evaluation and learning framework will draw on evaluation processes that focus on how, and to what extent, research outcomes are being adopted and utilised by government and industry to achieve WSC. This embeds monitoring and assessment protocols that go beyond traditional indicators of research output (i.e. number of academic publications) to also capture process-related information relevant to determining practice change. By understanding how knowledge is exchanged, adopted and utilised by key players, the CRCWSC can replicate these pathways and processes to generate broader impacts.

The development of the framework will involve a staged process which includes the mapping of adoption and impact pathways which will demonstrate who the intended audiences of CRCWSC's research are, how they will use the research outputs and what impacts are expected to arise from the utilisation of these outputs. Case studies, interviews and online questionnaires, when applied, will provide concrete insights into how the research outputs from specific projects are being utilised by key industry participants, and whether there has been any influence on organisational policy or practice.

Three pilot case studies will test the framework design and approach.

An implementation plan for using the framework beyond this project will complement and extend existing evaluation approaches designed for CRCWSC's activities such as industry and research workshops.

Outlook

It is expected that this project will enhance capacity and capability within the CRCWSC to understand, apply and analyse the results of the evaluation and learning framework. The important insights generated by this project will contribute towards CRCWSC's Adoption and Stakeholder Engagement Plan by identifying potential 'industry needs and knowledge gaps' that require attention (for example, training needs of particular industry groups), and by demonstrating success stories, which illustrate the benefits of applying CRCWSC's research and the associated pathways to achieving impact.

Once the framework has been implemented as an ongoing CRCWSC activity, it will provide a mechanism to benchmark impact, identify emerging issues, successes and areas for improvement, and enhance communication and engagement with key government, industry and research participants.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Dr Annette Bos
annette.bos@monash.edu
Dr Megan Farrelly
megan.farrelly@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities

CRC for
Water Sensitive Cities

Program D: Adoption Pathways | Project D6.2 | Project duration: October 2014 – September 2016

Developing a water sensitive cities index

Overview

Two years into the life of the CRC for Water Sensitive Cities (CRCWSC) a considerable knowledge base has been established that will support the development of tools, products and processes to enable transitions toward water sensitive cities. This recently established project aims to provide a platform to consolidate this knowledge in a Water Sensitive Cities (WSC) Index. Ultimately, the index will underpin a reliable and user-friendly web tool that can be used for city assessments across Australia and the rest of the world.

Key outcomes

This project will deliver a WSC Index and accompanying tools for assessing the water sensitivity of urban places ranging from metropolitan to local government areas and informing management responses to improve water sensitive practices. The tools will be packaged with a web-based platform and user manuals to assist self-assessment by end users.

The value of this project lies in equipping CRCWSC's industry partners with the capacity to monitor and evaluate the performance of their water management practices and explore measures that would realise water sensitive potential. This outcome will critically support CRCWSC's mission of revolutionising water management to enhance the liveability, sustainability and resilience of our cities. End users will include local and state governments, public agencies and water utilities, consultancies, land developers, community groups, technology providers and research organisations.

Project design

The CRCWSC vision refers to liveability, sustainability and resilience as key components of water sensitivity. Therefore the tool will apply these three concepts as "lenses" through which water sensitivity is assessed.

The first stage involves the consolidation of existing knowledge to identify preliminary indicators for hallmarks of water sensitivity, such as good governance, adaptive water infrastructure and ecological health.

These preliminary indicators and proposed algorithms for calculating the liveability, sustainability and resilience scores will then be compiled in an initial prototype version of the WSC Index, ready for early trials with CRCWSC's stakeholders. The trials will involve local government stakeholders using the tool with data on local water management practices. In tandem with the development of the prototype, and continuing throughout the trial phase, extensive research will provide the scientific underpinning of a reliable version for application across Australian cities. Research will also help develop processes and analytical methods to support these applications. The WSC Index will be made available as a web-based platform, consisting of:

- a database containing geographical, biophysical, socio-demographic, climate and environmental data; data on the characteristics of water management practices; and context-specific data to be entered by the end user
- algorithms for conducting assessments of water sensitivity
- a website which includes a secure login for partners to ensure sensitive user data and assessment results can be protected; templates for data input to support self-assessment; and interactive displays of assessment results including maps, graphs and tables.

A range of reporting templates will also be created that support the synthesis and effective communication of the assessment. These communication tools will be highly visual, appealing and appropriate for a wide range of technical and non-technical audiences. They will be instrumental for decision-makers to understand the implications of the assessment, to ensure broad ownership and support of the results, and to engage other audiences such as developers and the general public.

The WSC Index and accompanying tools will then be piloted in Brisbane, Melbourne and Perth to develop contextualised indicators for local water sensitive visions. The local assessments will be validated through participatory workshops that reflect on the accuracy and reliability of the tool's results, as well as on comparisons across cities. Lessons from these pilots will be incorporated to refine the indicators, analytical and process methodologies and the web-based platform.

The refined WSC Index and tools will then be rolled out together with a manual that guides end users through the methodologies for their effective use.

An Australian Government Initiative

With the project having a strong emphasis on users' self-assessment, CRCWSC's key stakeholders have been engaged from the very beginning of the project. They will continue to do so through project advisory and user groups which will help build their ownership and capacity to support the pilots and roll out the final version of the tools.

The project has strong links with two other CRCWSC projects, namely Project A4.2 (Mapping water sensitive city scenarios) and Project A4.3 (Socio-technical modelling tools to examine urban water management scenarios). The pilot applications will build on outcomes from Project A4.2, in which visions for Brisbane, Melbourne and Perth will be developed through participatory workshops with policy-makers, water practitioners, urban designers, community leaders and academics.

Outlook

It is anticipated that a prototype will be delivered by March 2015 followed by testing to be undertaken with two Melbourne councils. After this initial validation, the development of the web-based platform will begin, followed by city-scale pilot applications in Brisbane, Melbourne and Perth from early 2016. A full beta version is scheduled for release by September 2016.

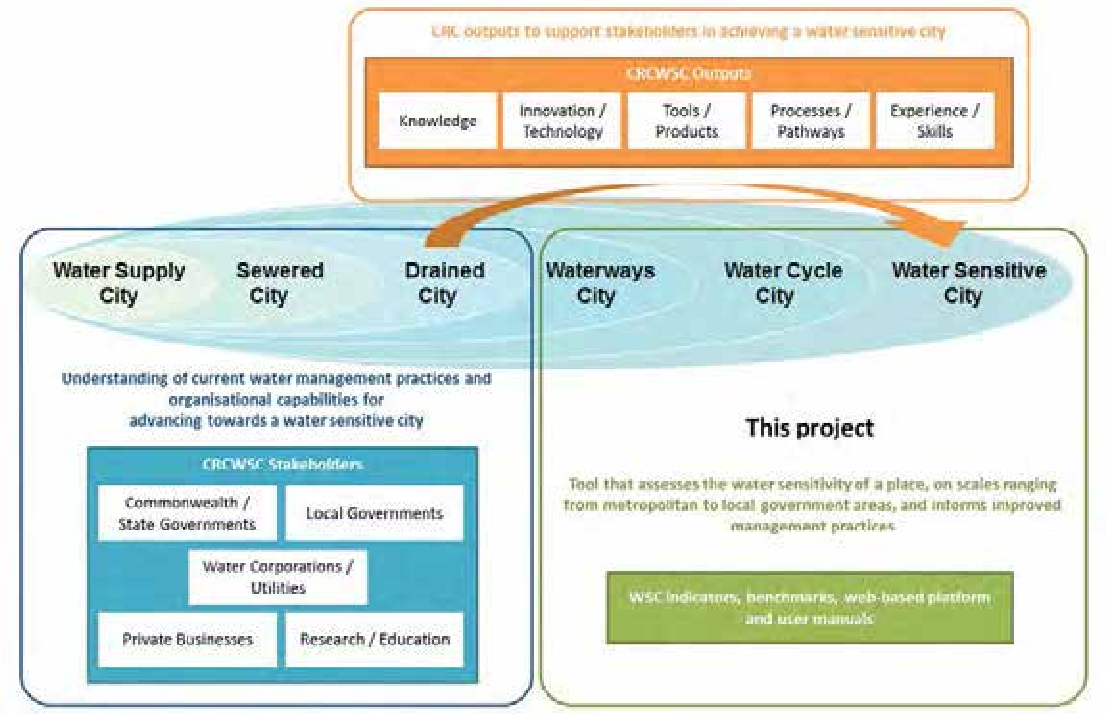


Figure 1. Conceptualisation of how this project supports CRCWSC's mission.

About the Cooperative Research Centre for Water Sensitive Cities

The Cooperative Research Centre for Water Sensitive Cities (CRCWSC) brings together interdisciplinary research expertise and thought-leadership from Australia and the world to address current urban water management challenges facing our cities and regions. In collaboration with over 80 research, government and industry partners, it develops and synthesises knowledge into powerful tools and influences key players aiming to achieve sustainable, resilient and liveable water sensitive cities.

Further information

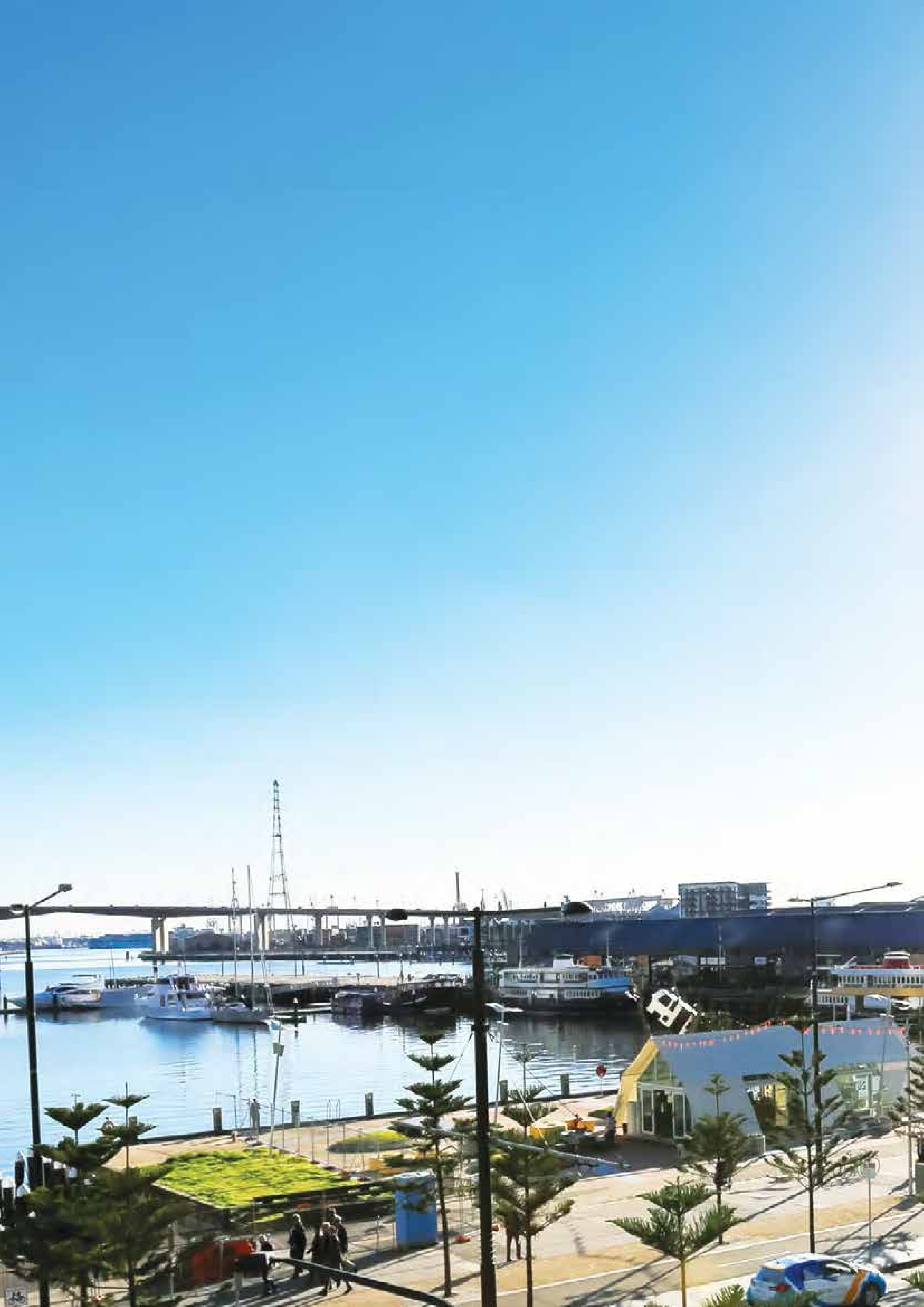
Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

Chris Chesterfield
chris.chesterfield@monash.edu
Professor Rebekah Brown
rebekah.brown@monash.edu

info@crcwsc.org.au

www.watersensitivecities.org.au

CRC for
Water Sensitive Cities



CRC for
Water Sensitive Cities

POSTGRADUATE RESEARCH 2012 to 2016

PhD candidates and masters students are an important aspect of the CRCWSC and a major deliverable under the Commonwealth Funding Agreement. In 2014, there were 49 PhD and other postgraduate students working on CRCWSC-related research. The CRCWSC is working to develop a cohort of world-class graduates who excel in their field, are industry-ready, and will be ambassadors for water sensitive cities in Australia and around the world.

CRC for
Water Sensitive Cities

Zack Dorner
Monash University

Program A1
Economic Modelling and Analysis

Greener sources of water?
Preferences by level of education

Introduction

If a city requires a new source of water in order to maintain reliability of supply to their residents, do residents care where that water comes from or do they just care about cost? Preliminary results from a survey of 981 residents in NSW and Victoria suggest that residents do care about where the water is sourced. Most strikingly, more highly educated respondents were more receptive to what could be considered the “green” choices – stormwater and recycled.

Participants of the survey were asked if a new source of water were required, which would they prefer. They made ten choices each between six options (Figure 1), which varied by price per kilolitre and uses for which the water was approved (quality). New dam and desalination always provide potable water; the other sources could offer non-potable water, supplied to the property using a third pipe.

Figure 1: Overall preference for new water source

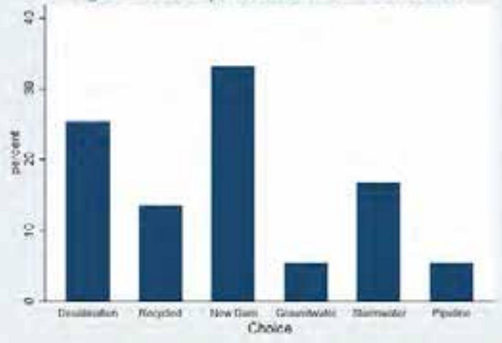
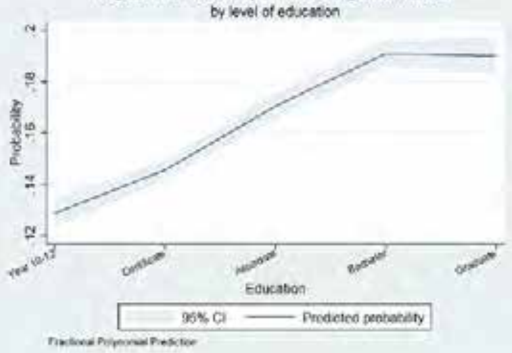


Figure 2: Probability of choosing stormwater
by level of education



Preliminary survey results

The more educated residents are, the more likely they are to choose recycled and stormwater as their preferred sources. Figure 2 shows that a resident with a secondary education has a 13 percent chance (a probability of 0.13) of choosing stormwater, controlling for water quality and cost. Someone with a university education has a 19 percent chance of choosing stormwater. Recycled water shows a very similar trend, going from around 11 percent chance (secondary education) to a 14 percent chance (university). Residents participating in the survey were not prompted as to which water sources may be “greener”.

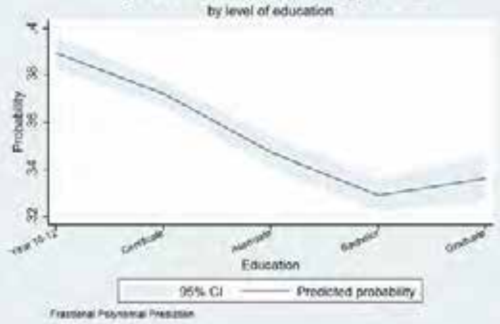
In contrast, Figure 3 shows those with a higher education being less likely to choose a new dam. New dam was the most favoured option overall, thus the probability of choosing a new dam is higher than stormwater for all levels of education.

Discussion

These preliminary results provide evidence that residents do care where their water comes from and that education is an important factor in determining these preferences. Preliminary results also suggest preferences vary with age.

It is worthwhile investigating the reasons why residents’ overall top choices were new dam and desalination (Figure 1) and to what extent cost and water quality were factors in these decisions. Another avenue for this research is to analyse residents’ risk preferences (collected for some residents in the survey) to determine whether those more inclined to take risks are more likely to prefer previously untapped sources of water such as stormwater.

Figure 3: Probability of choosing new dam
by level of education



CRC for Water Sensitive Cities

Achieving Resilience Through Decentralisation

What are the effects of system diversification and how can they be better understood? A wastewater services perspective

Jeddah Breman, Dr Christian Urich, Dr Matt Hardy, Prof Ana Deletic

Program A4.3

Socio-technical modelling tools to examine urban water management scenarios

The Challenge...

Although centralised infrastructure has provided urban areas with reliable and safe services, such as wastewater treatment, it is now accepted that these systems do not provide resilient solutions against stressors such as population growth. Instead, it is envisaged that resilience can be achieved through the diversification of water infrastructure.

Achieving infrastructure diversification by implementing more decentralised systems brings with it an increase in overall system complexity. Tools are therefore needed to help understand how a more diversified system functions and how the interactions between centralised and decentralised systems could increase the resilience of the overall system.

Diversification = a more complex system

- **More interactions and feedback loops**
  - **Between infrastructure**
  - **Between actors**
- **Many wastewater treatment technology options at different spatial scales**

How can we help to better understand this?

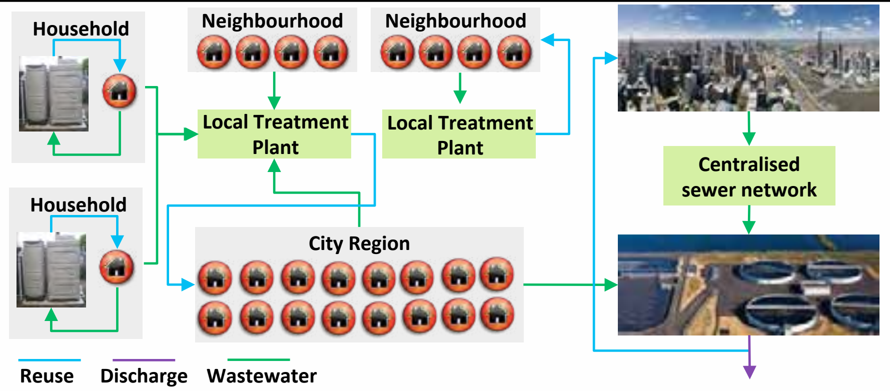


Figure 1. Example of a more diversified wastewater service network

Improving Our Understanding of Diversification

This research project develops a computational modelling tool that can dynamically represent (both spatially and temporally) and model the performance of a city's wastewater infrastructure within its urban environment.

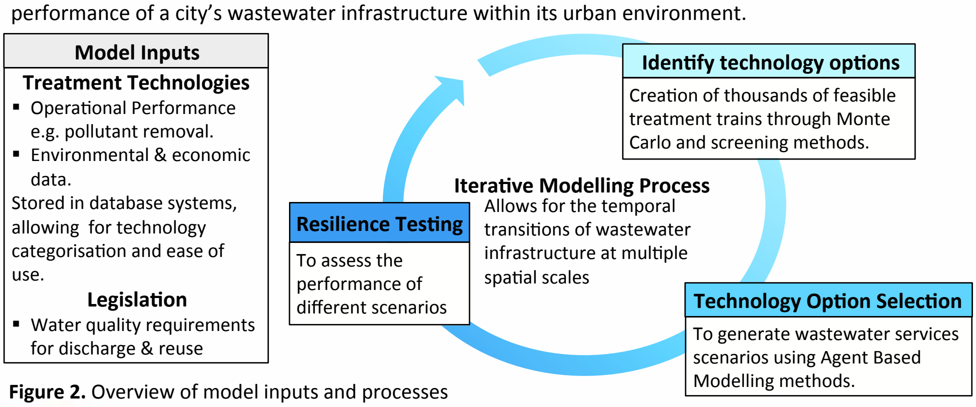


Figure 2. Overview of model inputs and processes

Model Benefits

- Uses an exploratory modelling approach allowing for thousands of scenarios to be tested.
- Allows scenarios under different legislative conditions to be developed and tested.
- Allows users to better understand interactions within the system.
- Allows for system resilience against stressors to be quantified for different levels of infrastructure diversification.

CRC for Water Sensitive Cities

Christoph Brodnik
Prof. Rebekah Brown
Program A 3.1
Better Governance for Complex Decision Making

YOU ARE THE CHANGE !

Individuals and organizations matter the most

To realise a **W**ater **S**ensitive **C**ity profound changes in the institutional foundations of urban water management have to take place. Research has repeatedly shown that individuals and organizations are the key for this change in order to widely adopt and mainstream water sensitive practices. However, current understandings of management and influence fall short in explaining the types of actions needed for this complex task. We therefore urgently need:

A) a new set of strategies to help individuals and organisations fundamentally change the urban water management system

B) to know when and how best to use them to turn a Water Sensitive City into reality

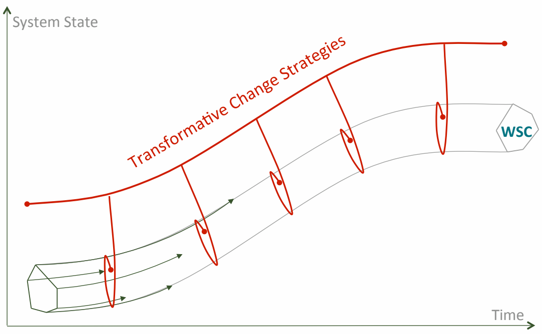


Fig 1: Transformational change in the system and its dimensions over time

A Holistic Approach for a Strategic Action Portfolio

Change thus far has been fragmented, leading to isolated advances in different areas (e.g. policy, organizational, technological) . This way, change is slow and superficial. A holistic approach to strategic action is the way forward (= Transformative Change Strategies – see Fig 1). My research looks at the nature and timing of highly successful strategies that lead to system wide change processes. In doing so I will look closely at the actions of key Individuals from the private and the public sector in Adelaide, Melbourne and Sydney. Through this analysis I will develop a strategic action portfolio for decision makers and others for moving towards a **W S C**.

Transformative Change Strategies - what do you do and when do you do it ?

Research discovered a range of strategies for driving change in complex systems. But which ones are most useful for realising a Water Sensitive City? Who is doing what and when is the best moment to do so? Tell me if you find yourself in one of them and how you think it effects water sensitivity in your working area:

Building Trust, Legitimacy & Social Capital (gain recognition by formal authorities; mediate between organization & public; represent stakeholder heterogeneity)

Identify and Communicating Opportunities for 'Small Wins' (identify (often small) projects upon which actors involved can agree; reconceptualise issues at system level)

Vision Building (provide a common vision that attracts many supporters; create community cohesion across different aspirations)

Recognise and Seize Windows of Opportunity (timing when to connect and mobilize; create the right links at the right time with the right issues)

Develop Social Networks (bonding: link with similar others; bridging: between different groups; linking: engage with key players of other sector)

Facilitating Knowledge Building and Utilization (generate and integrate diverse ideas and solutions; promote & steward experimentation; catalyse community awareness + social learning)

Facilitate Conflict Resolution and Negotiations (fair and low cost conflict resolution)

Facilitating / Developing (social) Innovation (identify and introduce alternative options; foster innovation by bringing together different kinds of thinking)

Preparation & Mobilization for Change (prepare a system for change – raise awareness; leverage resources; build vertical social capital, link innovation to resources)

CRC for Water Sensitive Cities

Disciplinary processes and dynamics in the design of multifunctional projects

Ana Guzman Ruiz [1]
email: ana.guzman@monash.edu
Prof. Rebekah Brown [2]
Dr. Meredith Dobbie [3]
Program A
A4 Socio Technical Transitions

Introduction

The design of multifunctional projects is fundamental for Water Sensitive Cities. These types of projects offer multiple benefits and are generally more desirable than monofunctional or single purpose projects. Currently, few projects have certain level of multifunctionality. The purpose of this research is to understand these exemplary projects in terms of disciplinary dynamics, processes and mechanisms used by individuals and organizations

Service delivery functions: Adaptive, **multifunctional infrastructure** & urban design that reinforce water sensitive values & behaviours

Research design

Multiple (3) cases studies will be conducting in Melbourne, Brisbane and Sydney. In each case, three research objectives will be applied:

1) Map the chronological development of organizing processes that lead to the exemplary multifunctional project.
2) Assess each case description in relation to disciplinary practice typology
3) Define key mechanisms and strategies employed by individuals and organizations to enable multifunctional outcomes.

The participants of this research will be mainly project teams. Different social techniques will be used such as semi-structured interviews, focus groups, observations and surveys. **Current status of the research:** Selection criteria for exemplary projects and semi-structured interviews to project teams. **Next steps:** Survey participants from local government (30) associated with the CRC for Water for Sensitive cities or interested in this research.

Impacts for industry and water sensitive cities

The research will develop an explanatory framework of the disciplinary processes dynamics and mechanisms that enables the design of multifunctional project. This practical guideline is relevant for water practitioners, policy makers and researchers interested in design projects that can provide different environmental benefits while increasing social interactions and acceptance.

CRC for Water Sensitive Cities

Can water saving behaviours spill over in Australian households through 'spillover'?

Sarah Kneebone

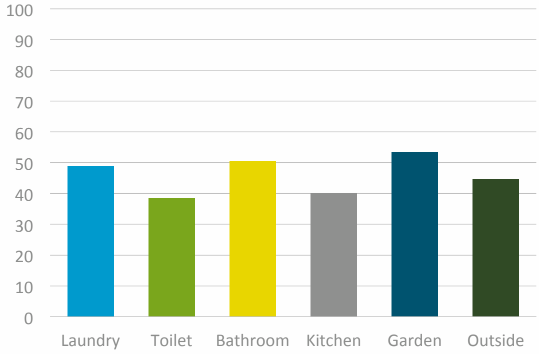
A2.2 Accelerating transitions to water sensitive cities through behaviour change

Project leader: Liam Smith

Reducing water demand through spillover

Australia's varied climate, the impact of climate change and an increasing population means that reducing household water demand will become increasingly important. Most households in Australia (79%) report participation in at least one water saving behaviour (ABS, 2013). It may be possible to leverage off households' existing behaviours for additional water saving. This leveraging is known as catalytic behaviour change (Austin et al., 2011) or 'spillover'. So far, the existence of spillover, and the mechanisms behind it, have undergone only limited research (Poortinga et al., 2013). However, if spillover works, it could provide a demand management tool for water managers and policy makers throughout Australia.

Fig 1: Percentage of Australian households currently saving water around the home (ABS, 2013)



Do householders see these behaviours as similar? If people already turn off their taps, can this be used to leverage filling their dishwasher?

Fostering spillover

Researchers propose that spillover, using existing behaviours to lever further behaviour uptake, takes place due to changes in self-perception, increased knowledge or skills (Crompton & Thøgersen, 2009), activation of personal environmental values (Verplanken & Holland, 2002) or through a desire for consistency (Thøgersen, 2004; Thøgersen & Noblet, 2012). The likelihood of spillover taking place is also thought to increase by promoting behaviours that are 'similar' to existing practices. Similarity may depend on the type of activity, the location it takes place, the amount of effort involved in participation and so on (Thøgersen & Crompton, 2009; Stern, 2000). By investigating perceptions of similarity of water saving behaviours we can identify key behaviours to target through behaviour change intervention programs.

Early findings: Impacts on perception

To investigate the similarity of water saving behaviours around the home we sent an online survey to 150 householders across Australia. Respondents scored 46 behaviours on the impact they could have on water saving (at an individual and aggregate level) and the physical, mental and financial effort involved in participating. An interesting early result was that householders' perceptions of the behaviours were affected by their own identity as water savers. People with a higher water saving identity ('water savers') saw behaviours as being more impactful and less effortful than those with a lower water saving identity ('water users').

Scores: 1= very low 5 = very high	Average score of behaviours by 'water savers'	Average score of behaviours by 'water users'
Water saving if everyone adopts the behaviour	3.47	3.13
Water saving if a household adopts the behaviour	3.42	3.02
Physical effort involved in performing the behaviour	2.59	2.76
Thinking and planning needed to do the behaviour	2.43	2.74
Financial cost of the behaviour	2.68	2.79

Table 1: Differences in perceptions of similarity of water saving behaviours by 'water savers' and 'water users'.

Next steps.... Can you help?

We are looking for an industry partner to help identify a field work location and provide access to participants to test behaviour interventions for water savings. **Please get in touch if you are interested!** Sarah.kneebone@monash.edu

MONASH University | Monash Sustainability Institute

BehaviourWorks AUSTRALIA

www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for Water Sensitive Cities

Understanding spillover

Investigating the influence of contribution ethic

Nita Lauren

Program A

A2.2 Accelerating transitions to Water Sensitive cities by influencing behaviours

What is spillover?

Spillover is the notion that engagement in water sensitive behaviour (WSB) can spill over or influence engagement in other WSB. Spillover can be positive, where it leads engagement in more WSBs. It can also be negative, where it inhibits engagement in WSB.

Contribution ethic is the sense of contributing a fair share to a collective effort. It is theorised to prevent spillover (see Figure 1.).

Figure 1.
Thøgersen's (2013) model of negative spillover

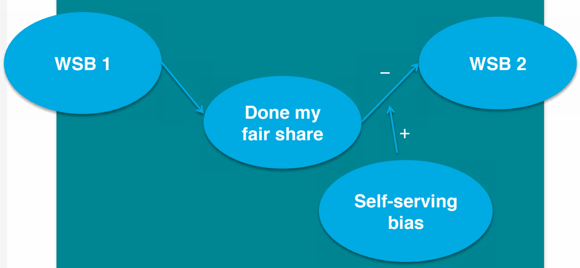


Figure 2.

Manipulation of contribution ethic

Please rate the following behaviours according to how much you engage in them (1 = never, 5 = all of the time):

1. Use a sink strainer to prevent food waste going dow
2. Put rubbish in bins when in public
3. Recycle waste, e.g. plastics, bottles, cans, etc
4. Re-use or recycle plastic water bottles
5. Prevent litter entering stormwater drains by placing rubbish in appro bins
6. Dispose of bathroom waste (e.g. cotton buds, condoms, ta the bin and not down the toilet
7. Take rubbish with you when there are no public bins
8. Clean up oil/petrochemical/paint spills

Yeah! I feel like I've done my environmental good deed for the day.

Wow, look at all the things I do that protect the health of the waterways!

Method

51 participants (M *age* = 31 years) took part in the experiment, with 62% being university students.

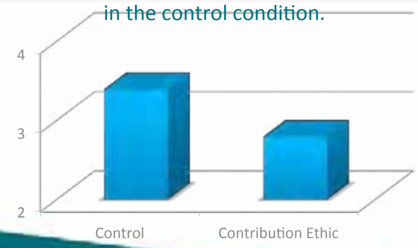
Participants were either in the experimental or control condition. Contribution ethic was manipulated via a behavioural scale, which reminded participants of their past WSB (see Figure 2.).

Dependent measures included behavioural intentions, ecological worldview, environmental attitudes, identity, perceived norms and moral norms.

Results

Direct effect of contribution ethic

Those who experienced contribution ethic (been reminded of their past WSB) had lower intentions to engage in collective behaviours to protect water quality than those in the control condition.



Environmental identity influences experience of spillover

Identity significantly moderated the relationship between contribution ethic and global intentions ($\beta = .775$, $p = .047$). Those with high identity had marginally higher intentions after experiencing contribution ethic than control ($\beta = .274$, $p = .088$). This effect was not found for those with low identity ($\beta = -.188$, $p = .239$).

The University of Queensland Australia

www.watersensitivecities.org.au

An Australian Government Initiative

CRC Australia

CRC for
Water Sensitive Cities

Shirin Malekpour

CRCWSC Program A

A4-Socio-Technical Transitions

Diagnosing Disrupters of Strategic Planning for Sustainable & Resilient Cities

Introduction

There is widespread agreement on the notion of sustainable development and environmental sustainability has been embraced as a vision in many policy documents. Processes of strategic planning for public infrastructure, including water systems, are instrumental to materialising that vision. However, investments in infrastructure with adverse environmental impacts continue and selection and prioritisation of sustainable alternatives often fails to occur beyond ad hoc project interventions.

The disrupters of strategic planning, i.e. factors that distort the planning process to an extent that it deviates from achieving its vision of sustainable development, have never been empirically and systematically identified.

Research Objective

This study puts forward a diagnostic framework to identify disrupters of strategic planning processes for sustainable development. It provides a tool for retrospective analysis of infrastructure investment decisions and the planning processes that have led to them, to identify causes of deviations from sustainability objectives from within the planning process itself. The framework is then applied to the case of Melbourne's water sector.

Methodology:.

- The literature on sustainable development, strategic planning and transitions have been used to develop the diagnostic framework.
- To apply the framework empirically, a series of oral histories were collected from senior practitioners who have been involved in long-term planning in Melbourne's water sector, regarding the processes of planning for major investments in Melbourne's water systems.

Table 1: Stages in the diagnostic framework to identify disrupters of strategic planning for sustainable infrastructure

Stage 0	Identification of an infrastructure investment decision that deviates from the principles of sustainability
Stage 1	Assessing the process of strategic planning that have led to above decision against the characteristics of planning for sustainability transitions proposed by the scholarship
Stage 2	Identifying the disrupters of strategic planning, i.e. the factors that have led to the failure of the process to fulfil the characteristics of strategic planning for sustainability transitions

Insights

Figure 1 summarises a series of factors, internal to the strategic planning process ,that reinforce each other and lead to conventional large infrastructure investments, despite the existence of a desire for sustainable and decentralised solutions. These factors are derived from the historical case of strategic planning for water resources in Melbourne.

Implications

For a strategic planning model to work successfully in practice and facilitate sustainable infrastructure investments in the water sector, the disrupters of planning need to be recognised and dealt with explicitly as part of the planning practice. As Figure 1 suggests, the issue of resilience and catering for deep uncertainty of the future plays a key role for such a transition.

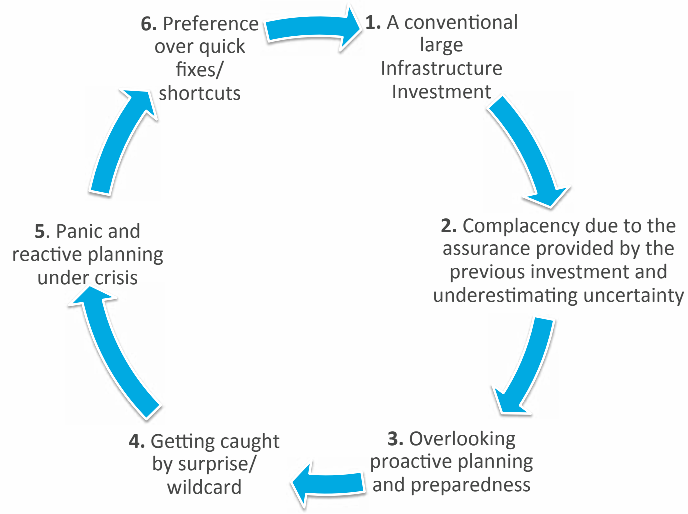


Figure 1: Vicious cycle of historical disrupters of strategic planning for sustainable development in Melbourne's water sector

CRC for Water Sensitive Cities

Social Inequality & Water Sensitive Cities

Mr Paul Satur

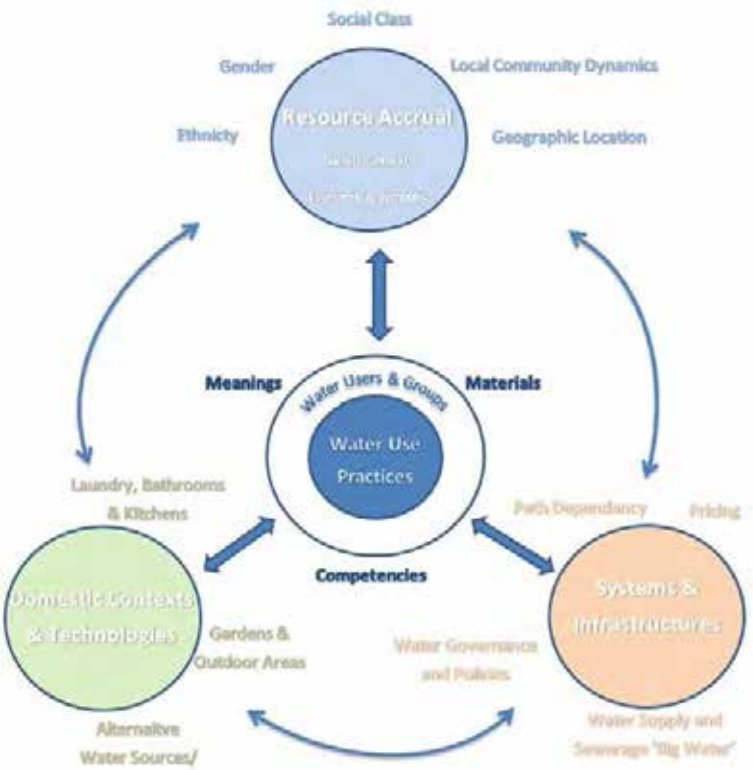
Program A2.1 Understanding Social Processes to Achieve Water Sensitive Futures

Water use practices both shape and are shaped by an evolving dynamic between Systems and Infrastructures, Domestic Contexts and Technologies and the Socio-cultural Contexts of water users and managers.

The transition towards more sustainable, water sensitive cities, requires a greater understanding of existing socio-cultural drivers (eg. class, gender, ethnicity, community dynamics), their influence on water use practices, and the barriers and opportunities they present for building engagement and capacity for water sustainability.

To investigate the relationship between social inequality and water use practices, I have developed a model (presented below) that places a particular emphasis on the interrelation of the Social and cultural dynamics that shape user and management perspectives, values and behaviours, and the existing socio-technical frameworks (systems, technologies etc.) that embed them.

A Model for Understanding Water Use Practices



Investigating Social Inequality and Water Use Practices

This study will seek to:

1.Understand the role and nature of social inequality in water use practices in Australia

2.Identify the barriers and opportunities social inequality presents for achieving water sensitive cities

3.Develop solutions for socially equitable and sustainable water use practices to ensure an effective transition to water sensitive cities

I Want you!

Attention Industry partners, stakeholders and water users alike!

This study is seeking participants for the development of case studies and focus groups for participatory research in **Melbourne**, **Brisbane** and **Perth**

Your involvement will contribute to new insights into the water use practices of groups in varying socio-cultural contexts, and the development of more effective tools for community engagement and social change.

For further details please contact Paul Satur at **paul.satur@monash.edu**

www.watersensitivecities.org.au

MONASH University

An Australian Government Initiative

CRC

CRC for Water Sensitive Cities

PhD Project Overview

Images that engage communities with water sensitive cities

Tracy Schultz, UQ
Program A: Society

The creation of a water sensitive city relies on a community that is actively engaged with the issue of sustainable urban water management (SUWM; Brown & Farrelly, 2009). One effective way to engage people is through the use of images (O'Neill, 2013), especially through social media channels like Facebook.

The goal of this 4 year project is to **identify the properties of images that psychologically engage people with SUWM** issues and practices, such as domestic storm water management, fit-for-purpose water recycling and the impact of cities on water catchments.

Aligned with the key deliverables of Project A2.3 "Engaging communities with water sensitive cities", this project will provide empirically **tested recommendations to water industry professionals about how best to use images in communications aimed at Australian communities.**

Phase 1

- Conduct an **audit of images** currently used by water professionals in communications about SUWM.
- The audit will provide preliminary insights into the different types of images used and for what purposes, as well as how frequently some images are used.
- Conduct a **literature review** to establish a theoretical framework for the project.
- To be completed by 2016.

Phase 2

- Using a **mixed-methods approach**, including Q-sorts and experiments, this phase will identity the properties of images that engage people with key SUWM issues and practices identified from Phase 1.
- Demographically diverse study **samples will be drawn from communities in three distinct geographic locations** (Queensland, Victoria and Western Australia).
- To be completed by 2017.

Phase 3

- The key findings of Phase 2 will be field tested during Phase 3.
- **Field experiments** will be conducted in Queensland, Victoria and Western Australia, with a focus on the use of images in **social media**.
- The core objective will be to test the efficacy of using engaging images on **outcome measures such as policy acceptance, understanding, trust and risk.**
- To be completed by 2018.

Research Snapshot: Q-method

Q-methodology is a research method used to elicit participants' subjective viewpoints on a particular topic through a process of Q-sorts.
This methodology will be used during Phase 2 of the project whereby participants will be asked to sort arrays of images along a number of dimensions designed to measure engagement, for example, salience and self-efficacy.

Contact

If you would like more information or would like to be informed of the project outcomes scan the above QR Code or email t.schultz1@uq.edu.au.

CRC for Water Sensitive Cities

Lara Werbeloff[1], Prof Rebekah Brown[2]

CRCWSC Program A

A3.1- Better Governance for Complex Decision Making

Institutionalising Radical Innovations

Institutional change to facilitate integrated water management

Introduction

A supportive institutional framework is necessary for the realisation of Water Sensitive Cities. However, not much is currently known about how institutional change unfolds, particularly in the context of transformative system change.

This research project will examine four case studies of successfully embedded innovations within the Australian urban water sector in order to understand the process and mechanisms of institutional change.

Ultimately, the project aims to offer insights into how to bring about institutional change to support more integrated water management.

Research Objectives

- Identify patterns of change in cases of successful institutionalisation of a radical innovation
- Identify mechanisms of institutional change
- Develop an explanatory framework to describe the role of institutional change mechanisms in transformative system change

When is a practice institutionalised?

For a practice to be institutionalised, change across three key domains is required; culture, structure and practice (Fig 1). The changes in each dimension need to be complementary and mutually reinforcing in order to embed the radical innovation within the sector.

A practice is taken to be institutionalised when:

- it is widely used within a sector; and
- has a foundation enabling it to persist.

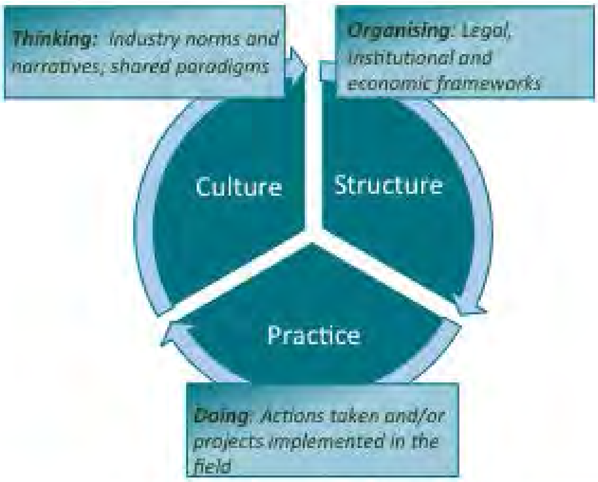


Figure 1: Domains of institutional change

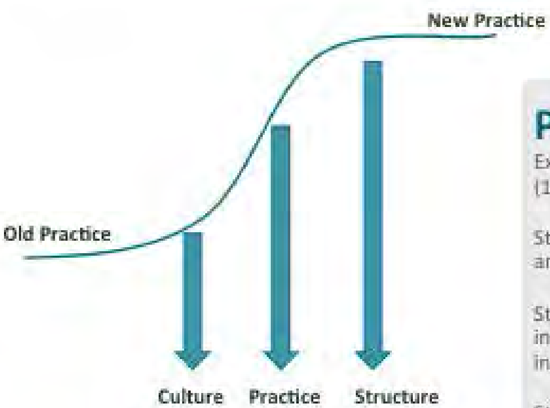


Figure 2: Evolution of institutional change

Patterns of institutionalisation?

Examination of the evolution of stormwater quality management in Melbourne and Brisbane (1960s to present) has revealed a general overarching pattern of institutional change (Fig 2).

Step 1: Culture change emerges at the beginning of a transition pathway to legitimise the need for an alternative practice and develop a shared understanding of possible solutions

Step 2: Communities of practice develop around possible solutions and refine technical innovations; successful demonstration projects eventually give way to frequent implementation by industry leaders and a growing coalition of practitioners

Step 3: Once practice is relatively widespread, formal legislative change and enforceable industry standards are introduced to mandate and/or regulate implementation of new practice

Next steps: identifying mechanisms that can help bring about change in each domain

CRC for Water Sensitive Cities

CRCWSC Program B

with Ailie Gallant, Nigel Tapper, Danijel Belusic, Timo Vihma, Alex Pezza

Stephanie Jacobs

stephanie.jacobs@monash.edu

Mitigating the urban heat island to improve thermal comfort

Modelling human energy budget:

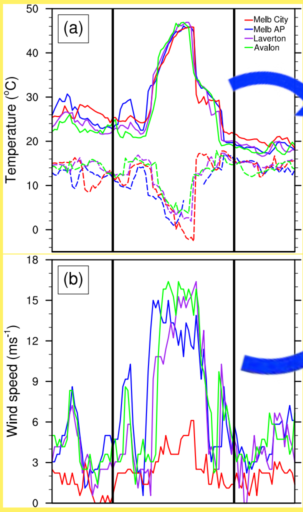
Black Saturday conditions:

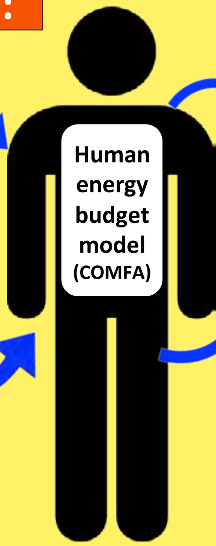
Hot, dry, windy!

Temp > 46°C

RH < 5%

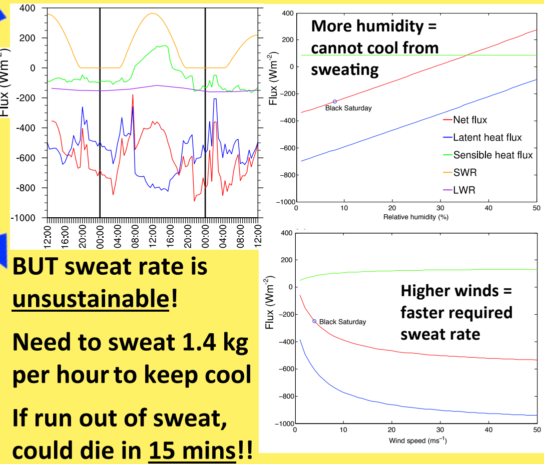
Gusts > 80kmhr^{-1}





Net flux ≈ -500 Wm^{-2}

lose heat through sweating



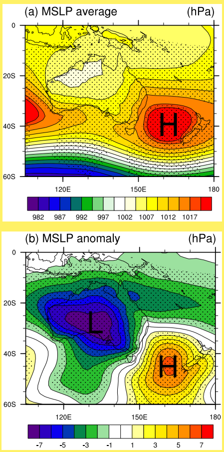
BUT sweat rate is <u>unsustainable</u>!

Need to sweat 1.4 kg per hour to keep cool

If run out of sweat, could die in <u>15 mins</u>!!

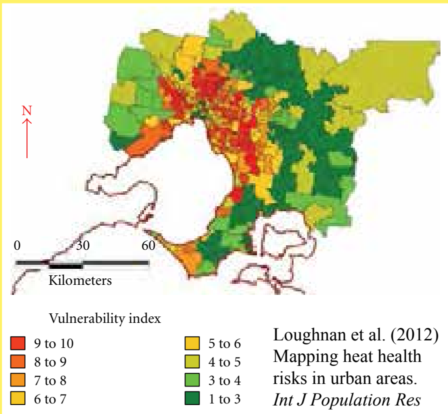
Modelling and mitigating heat stress over Melbourne

Model heat event



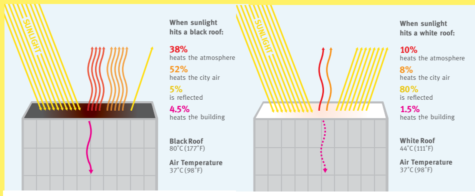
Warm air travels from central Australian desert to Melbourne

Map vulnerability and land surface



Loughnan et al. (2012) Mapping heat health risks in urban areas. *Int J Population Res*

Water sensitive urban design



Reference: Kalkstein et al. (2013) http://www.coolrooftoolkit.org/wp-content/uploads/2013/12/DC-Heat- Mortality-Study-for-DDOE-FINAL.pdf

Cooler citizens

Further reading

Jacobs et al. (2014) Heat stress during the Black Saturday event in Melbourne, Australia. *Int J Biometeorol* DOI 10.1007/s00484-014-0889-2

Jacobs et al. (2014) A new bio-comfort perspective for Melbourne based on heat stress, air pollution and pollen. *Int J Biometeorol* 58:263-275I

CRC for Water Sensitive Cities

Visitors' thermal comfort in Melbourne Botanic Garden

Cho Kwong Charlie Lam[1], Margaret Loughnan[1], Nigel Tapper[1]
[[1] School of Earth, Atmosphere and Environment, Monash University]

Program 3.2 The design of the public realm to enhance urban micro-climates

Research question

Do overseas tourists perceive thermal comfort differently from local residents in summer?

Methods

The project compared weather data with survey data to examine the thermal perception of visitors to the garden.

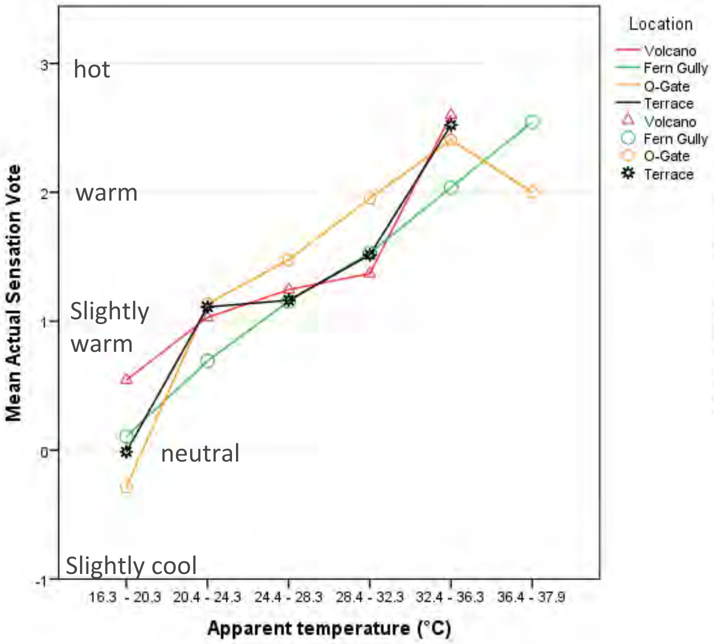


Figure 1: Visitors' thermal comfort in different garden locations

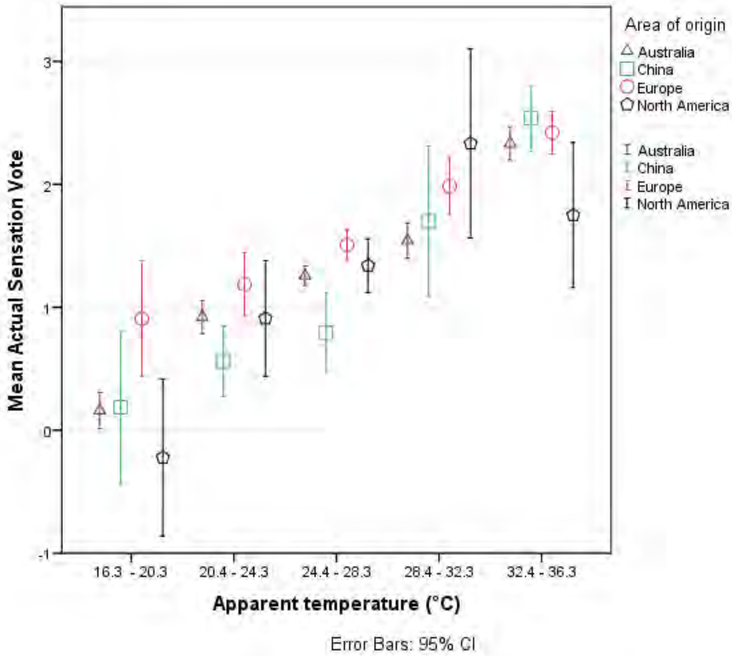


Figure 2: Visitor's thermal comfort (selected area of origin)

Main findings

European tourists generally felt hotter than other visitors possibly due to lack of acclimatisation.

Fern Gully has a misting system and visitors perceived Fern Gully to be cooler than other locations.

Visitors felt comfortable between 16.3 and 20.3 °C (apparent temperature).

Visitors felt warm to hot after apparent temperature exceeded 32.4 °C.

CRC for Water Sensitive Cities

The Impact of Urban Green Spaces on Urban Climate during Heat Events:
A Case Study on Urban Green Spaces in Melbourne

Asieh Motazedian
asieh.motazedian@monash.edu
Andrew Coutts
Nigel Tapper
CRCWSC Program B

Research Aim

This research investigates the interaction between urban green areas and their surrounding built environment in relation to the park characteristics and surrounding urban design (Figure 1).

The study will identify the cooling capacity of parks and ways for improving this effect under various urban densities.

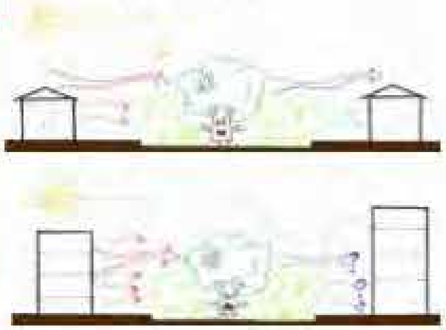


Figure 1: Research Hypothesis- densification reduces the parks' cooling capacity on surrounding urban areas.

Research Questions

1. What is the climatic and bio-climatic nature of the current interactions between the park and its surrounding urban environment?
2. What are the parameters influencing the climatic and bio-climatic interactions between a park and its surrounding urban environment?
3. What is the optimal configuration of a green space and its surrounding urban environment to maximize park's cooling effect and improve human thermal comfort?

Research Methodology

Field measurements + **Simulations**

Study sites selection

Lincoln Park- Carlton

Long-term Observations

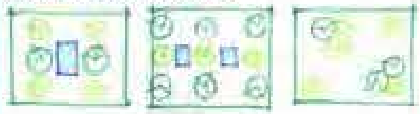
11 weather stations installed

Short-term Observations

21 Transects in total

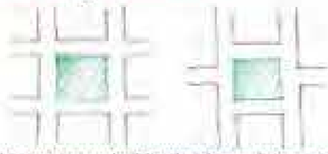
3 pm, 9pm, 5am

Park Design Scenarios



e.g. Different tree distribution and presence of water.

Urban Design Scenarios



Considering various building heights and street design.

Research Outcome

Recommendations for park design to improve microclimatic and bioclimatic conditions within and around the park.

MONASH University

www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for
Water Sensitive Cities

What is the optimum trade-off for our wetlands?

Amar Nanda, Anas Ghadouani, Matt Hipsey
@amarnanda

Water Sensitive Urbanism
Project 4.2: Socio-Technical Flood Resilience

Since European settlement over 80% of the Swan Coastal Plain wetlands have been lost. The growth of Perth jeopardises the ecosystem functioning of remaining urban wetlands. Ecosystem functions are trade-offs in decision making. However, the optimum situation to meet all functions is not fully understood. Conditions for an optimum situation depend on governmental level; the scale of policies and regulations; physical infrastructure; biophysical environment; and socio-economical boundaries of stakeholders. The adaptable approach (Figure 1) could enhance urban wetland ecosystem services by determining the optimum balance between socio-economic and environmental trade-offs (Figure 2).

What is your priority?

Figure 2: Wetland trade-offs

What is the relevant scale for policy, legislation, hydrology, and urban wetland ecosystems?

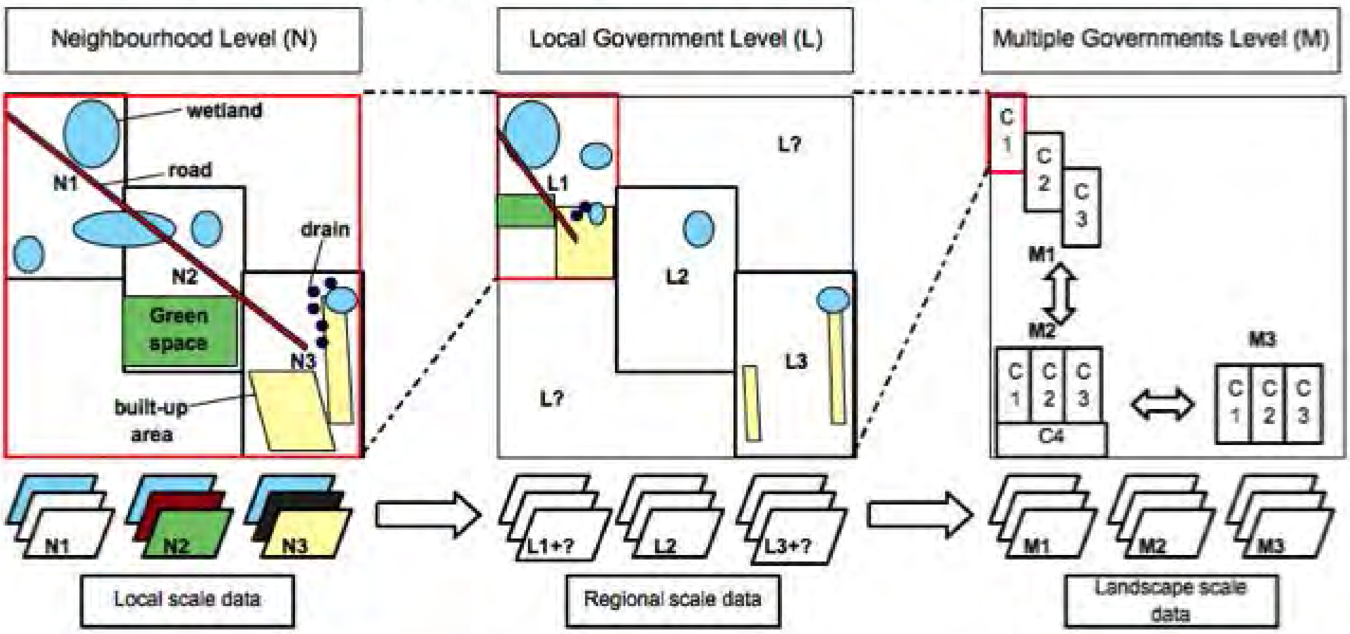


Figure 1: Methodology framework which combines local data sets from various locations in a catchment area and represented across multiple scales (local, regional, landscape) and levels (N, L, M).

www.watersensitivecities.org.au

The University of Western Australia

An Australian Government Initiative

CRC

CRC for Water Sensitive Cities

Kerry Nice
Program B - Water Sensitive Urbanism
Project B3 Water Sensitive Urban Design and Urban Micro-climate

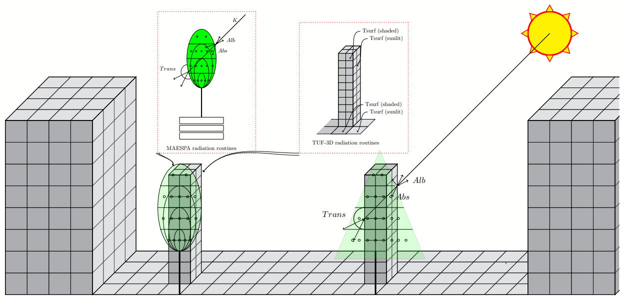
An urban micro-climate model for assessing impacts of Water Sensitive Urban Design

Introduction

- Assessing positive climatic impacts on human thermal comfort (HTC) of Water Sensitive Urban Design (WSUD), through associated increases in vegetation and water in urban areas, requires a suitable modelling tool
- Observation studies have shown that increased tree cover is effective in promoting positive HTC in urban areas (White et al., 2012).
- Modelling HTC at a microscale must fully account for both physical and physiological properties of vegetation, as well as the full soil/plant/atmosphere water cycle. No models were found which fulfilled this requirement.
- The TUF-3D model (Krayenhoff and Voogt, 2007) was modified in a novel way to tile the MAESPA tree model (Duursma and Medlyn, 2012) within the TUF-3D urban canyon and calculate vegetation radiation transmission.
- The modified model (TUF-3D/MAESPA) provides parameters of air temperature, radiant temperatures, wind, and humidity at a suitable scale to assess HTC in urban canyon simulations.
- This tool can be used to determine optimal positioning of vegetation to maximize the impact, as well as determining the climate response of each tree and its relative value in urban canyons.

Modifications to TUF-3D radiation modelling

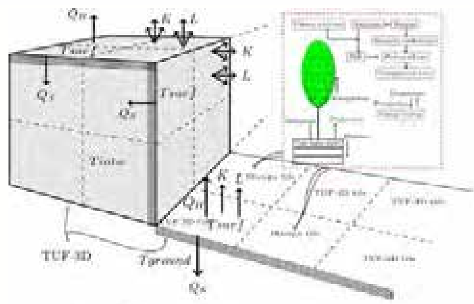
- Modifications allow TUF-3D to resolve urban canyon radiation flux movement using placeholder vegetation structures which call MAESPA vegetation absorption, transmission, and reflection routines.
- TUF-3D/MAESPA uses cube shaped structures (as TUF-3D uses to represent buildings) to represent vegetation. These cubes store the surface properties and states and interact with the rest of the TUF-3D domain.
- The vegetation's true shape is represented in MAESPA and calls underlying MAESPA routines to calculate the vegetation's interactions with the urban canyon and radiation movement.



Integration of MAESPA tree model into the TUF-3D model radiation fluxes routines

Tiling MAESPA within TUF-3D

- Using a novel approach, MAESPA tiles replaces TUF-3D ground surfaces with vegetated MAESPA surfaces and use MAESPA's photosynthesis and water cycle routines to modify TUF-3D's energy balance calculations.
- Each embedded MAESPA surface calculates a full 3 dimensional tree or tree stand (along with associated soil and movement of water within the stand) and feeds results back to TUF-3D ground surface energy balances.



TUF-3D energy balance modelling with new MAESPA tiles

Conclusions

- Integration of MAESPA tree model into TUF-3D creates a tool suitable to model HTC impacts of WSUD.
- Future work on TUF-3D/MAESPA:
  - Completion of modifications
  - Full validation testing
  - Running comprehensive set of WSUD scenarios

MONASH University

www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for
Water Sensitive Cities

Tackling uncertainty - Enhancing adaptation using flexible urban flood risk management systems

Mohanasundar Radhakrishnan,
Assela Pathirana,
Berry Gersonius
[UNESCO-IHE Institute for Water Education]

B4.2: Socio-Technical Flood Resilience in Water Sensitive Cities – Adaptation across spatial and temporal scales

Research Gap & Scope

✓Lack of assessment criteria or frameworks for flexibilities in urban flood risk management systems (UFRM);
✓Lack of thorough understanding of coupling major and minor drainage system effects with flexibility;
✓Lack of Comprehensive assessment and evaluation of flexibility of drainage elements satisfying design, extreme and day to day events.
✓Uncertainties and complexities could be considered as opportunities for the development of multifunctional solutions using Real Options - a capital budgeting tool that deals with uncertainty, complexity and flexibility of investments - and Real In Options (RIO) approach.

Fig 1. Inundation map of Can Tho

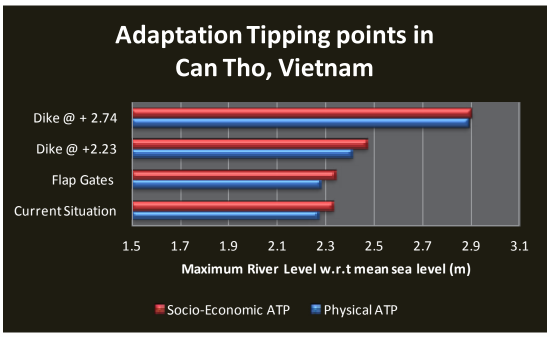
Research Questions

1) What is the framework for flexibility evaluation and RIO analysis of UFRM systems?
2) How can the Flexibility of UFRM be enhanced using aboveground and underground drainage systems?
3) What are the ways to enhance flexibility through asset management ?
4) What is the role of multiple use of urban space in improving flexibility?
5) How does RIO influence decision making in UFRM?

Fig 2. Household adaptation measures in Can Tho

Developing knowledge base and tools

➢Anticipate uncertainty and identify all right options and all plausible scenarios
➢Evaluate the project as it evolves and as uncertainty is revealed
➢Situation assessment and pre-screening of options based on Adaptation Tipping points approach
➢Incorporate and evaluate flexibilities in engineering designusing Real Options and Real in Option (RIO)
➢Demonstration using case studies in Vietnam and Australia



UNESCO-IHE Institute for Water Education

FRG FLOODRESILIENCEGROUP

An Australian Government Initiative

CRC

CRC for
Water Sensitive Cities

Program B – Water Sensitive Urbanism

The Urban Heat Island effect during Heatwaves in Australian Cities

Cassandra Rogers, Nigel Tapper and Ailie Gallant

School of Earth, Atmosphere and Environment, Monash University

Cassandra.Rogers@monash.edu

The Problem

Australian heatwaves are getting more frequent and hotter

Largest impacts of heatwaves are in cities

Research Questions

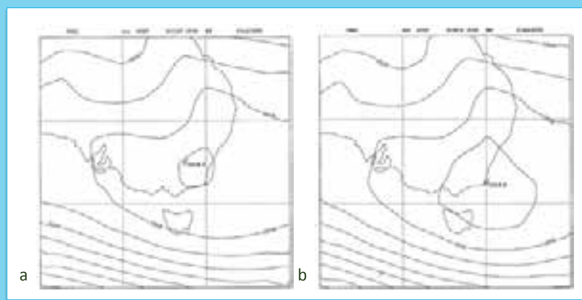
Are heatwaves in Australian cities intensified by the urban heat island (UHI)?

Water sensitive urban design could mitigate the potential enhancement of heatwaves in cities due to the UHI effect

Are heatwaves and the urban heat island associated with the same types of air mass characteristics?

Understanding air mass characteristics can shed light on what processes cause both heatwaves and UHIs, which may help to determine future changes to both aspects

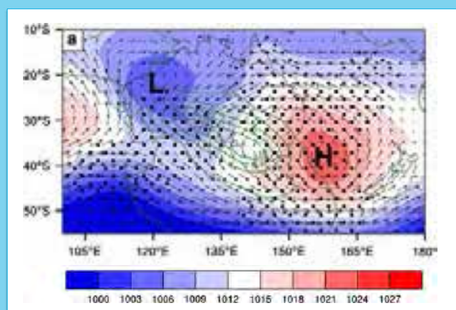
Synoptic conditions during Urban Heat Island events in Melbourne



MSLP (hPa) for UHIs over Melbourne where (a) 2°C ≤ UHI < 3°C and (b) UHI ≥ 3°C. Adapted from Morris and Simmonds, 2000.

Synoptic conditions during UHI events are characterised by high pressure systems over the south-east coast of Australia

Synoptic conditions during Heatwave events in Melbourne



Summer MSLP (hPa), temperature anomalies (K), and winds (ms^{-1}) on the first day of heatwaves in Melbourne. Number of events is 13. Stipled MSLP areas are statisically significant (95%). Adapted from Pezza et al., 2012.

Synoptic conditions during heatwave events are characterised by high pressure systems off the east coast of Australia

References

Morris, C. & Simmonds, I. 2000. Associations between varying magnitudes of the urban heat island and the synoptic climatology in Melbourne, Australia. *International Journal of Climatology,* 20, 1931-1954.

Pezza, A., Van Rensch, P. & Cai, W. 2012. Severe heat waves in Southern Australia: Synoptic climatology and large scale connections. *Climate Dynamics,* 38, 209-224.

MONASH University

www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for
Water Sensitive Cities

Adaptation Pathways for flood resilience and water sensitivity

Carlos N.A. Salinas-Rodriguez,
Berry Gersonius,
Richard Ashley
[UNESCO-IHE Institute for Water Education]
B4.2: Socio-Technical Flood Resilience in Water Sensitive Cities – Adaptation across spatial and temporal scales

Introduction

There is a need for managing and using water more effectively.

Water sensitive urbanism (WSU) demands the participation of water sector, the municipal sector or any other to develop synergies.

Risk management and uncertainty analyses are demanding more attention from water researchers and practitioners.

Research Questions

RQ1. How can water sensitivity and flood/drought resilience be defined and understood in mutual relation? (Fig. 1)

RQ2. Which indicators can be defined for the assessment of water sensitivity and flood/drought resilience to make these concepts operational and quantifiable?

RQ3. How can the impact of climate change on water sensitivity and resilience be analyzed and responded to by Adaptation Pathways method?

RQ4. How the identification and use of adaptation opportunities stemming from structural Adaptation Tipping Points influence on the adaptation pathways for water sensitivity and resilience?

RQ5. Can a modelling approach be developed for adaptation pathways for water sensitivity and resilience? What type of processes should such approach include?

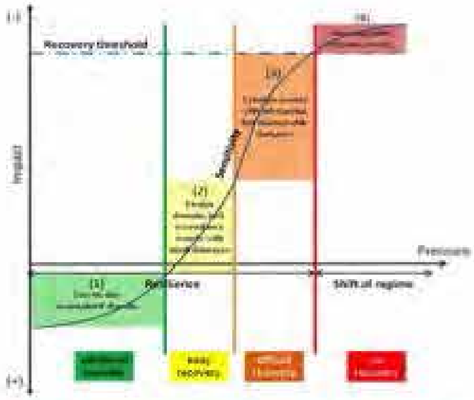


Fig 1. The four domains approach. Sensitivity and resilience in mutual relation (RQ1)

Adaptation Tipping Points (ATP) for Spaanse Polder, Kralingen and Center (Rotterdam-NL) (RQ4)

Fig 2. Sewer network for Spaanse Polder, Rotterdam (NL)

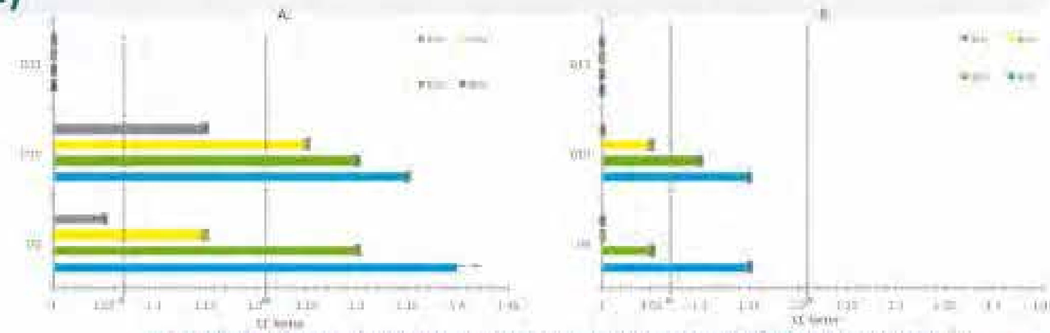


Fig 3. ATP for Spaanse Polder's sewer system. A. Return period of 1/1 B. Return period 1/2

UNESCO-IHE
Institute for Water Education

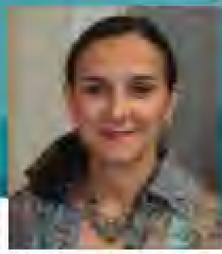
www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for Water Sensitive Cities

The Impact of Flow Conditions on Nitrate Attenuation in an Urban Living Stream



Ana Catarina Singh- Masters Student , UWA

Carolyn Oldham- Project B2.4 Leader, UWA

CRCWSC Programme B2.4
Hydrology and nutrient transport processes in groundwater/surface water systems

Introduction

Discharge of nutrients into urban drainage systems causes degradation of surface water ecosystems. Previous studies on drainage systems converted into living streams suggested nutrient transformation processes, occurring within the in-stream environment, are influenced by their residence times. The objective of this study is to investigate the correlation between hydrological factors (flow, velocity and groundwater interaction) with the residence time and observed variations in nutrient concentrations (nitrate) in the living stream during base flow conditions. The study of these hydrological factors will ultimately support the improvement of current, and possibly new, urban drainage design standards, in particular WSUD and stormwater BMPs.

Fig 1 : Photos of the living stream. On the left an upstream view and on the right a downstream view from a section of the reach in study.

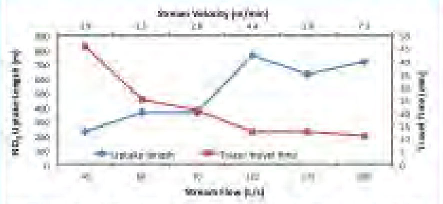


Fig 2: Variation of NO_3 uptake and tracer travel time with stream flow/ velocity

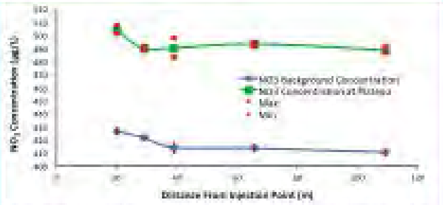


Fig 3: Variation of NO_3 concentration along the reach before and during injection

Methodology and results

Conservative (NaCl) and non-conservative ($NaNO_3$) tracers are injected simultaneously at constant flow for a period of time into a well mixed 125m reach of the living stream. The variation in conductivity is measured downstream from the injection point, as a proxy to detect the tracer's breakthrough curve (BTC), from which the residence time (tracer's travel time to plateau) is estimated. During plateau stage, water samples are collected at different distances along the reach and the concentration of nitrate is determined.

- For flows below 100L/s, there is a correlation between the hydrological regime of the stream and the nutrient attenuation/uptake. In contrast, for flows above 100L/s, variations in the travel time are greatly diminished and no longer correlate with the nutrient's uptake length (Fig 2).
- Nitrate attenuation appears to be localised to a reach section of length 30-40 meters downstream from injection point. More recently, results have also shown that along the 40m reach length the uptake is more pronounced for water samples collected closer to the right bank of the stream, as opposed to the left side, where it tends to be significantly decreased and in some cases completely absent (Figs 3 and 4).

Conclusions and further work

At higher flows, variations in the uptake between the left and the right side of the stream may be correlated with variations in tracer's travel time between the right and the left side. Preliminary tests have shown the tracer's travel time on the right side to be up to twice the value of that on the left side (Fig 5).

From here, correlations between travel time, nitrate uptake and exchange flows in the hyporheic zone will be studied, with particular focus on the the right side of the 40m reach of the living stream.

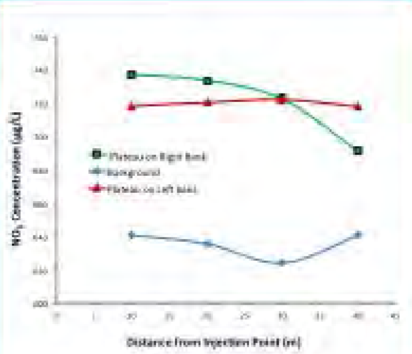


Fig 4: Difference in the variation of NO_3 concentration at plateau between the right and the left side.

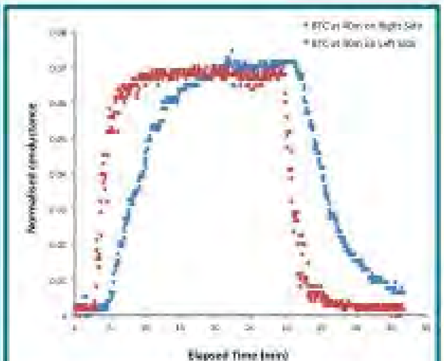


Fig 5: Tracer's BTCs showing the difference in travel time between left and right sides of the living stream at 160L/s.

THE UNIVERSITY OF WESTERN AUSTRALIA

www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for
Water Sensitive Cities

Influence of Land Use Planning Systems on WSUD Practice

Don Williams

Program B – Water Sensitive Urbanism

Project B5.1 – Statutory Planning for WSUD

Why Investigate Planning Regulation?

The recognition and support of water sensitive urban design (WSUD) in Australian land use planning systems is ad hoc and inconsistent. This reflects a lack of empirically based knowledge about how planning regulatory systems should use policy objectives, performance measures and targets to foster the adoption of WSUD practices.

Research is needed to better understand how planning regulation actually assists, or hinders, the implementation of WSUD practices, to inform the development of better regulatory frameworks.

"A current knowledge gap identified is the lack of research on the relationship between urban water and land use planning"

A K Sharma, et al., 'Impediments and constraints in the uptake of water sensitive urban design measures in greenfield and infill developments' (2012) 65(2) *Water Science & Technology* 340 -352

The Research Program

Key research questions include how WSUD is interpreted in planning regulatory frameworks, how planning regulatory frameworks influence WSUD practices and how planning regulatory frameworks could be varied to better support WSUD.

The research will use methods such as reviewing planning legislation and policies, case studies and mixed methods investigations to identify how planning regulatory frameworks facilitate, or hinder, WSUD implementation and how to design a more integrated policy and regulatory framework to support WSUD.

The research program commenced with a preliminary survey of WSUD practitioners and policy makers across Australia, to understand how they believe planning regulation influences WSUD practice. All the survey participants strongly supported (rating of 4 or 5 on a 5 point Likert scale) a ***Clearer legislative mandate for WSUD***.

Linking the Research with Practice

The research outcomes will include an improved theoretical understanding of the links between planning regulation and WSUD implementation, and knowledge that will inform the design of regulatory frameworks which facilitate the implementation of WSUD.

More broadly, the research will link with Project B5.1, *Statutory Planning for WSUD* and contribute to the project's assessment of how statutory planning, regulation and processes affect the adoption of WSUD and the identification of policy and legislative frameworks that facilitate water resilience in cities

"The CRC for Water Sensitive Cities brings together the inter-disciplinary research expertise and thought-leadership to undertake research that will revolutionise water management in Australia and overseas"

watersensitivecities.org.au/about-the-crc/

MONASH University

CRC for Water Sensitive Cities

Campylobacter spp. in Australian stormwater:

human health implications for harvesting and reuse

Jane-Louise Lampard[1]
Heather Chapman[1], Anne Roiko[1], Helen Stratton[1], David T McCarthy[2]

C1.2 Risk and Health

[1]Griffith University, [2] Monash University

Aims

Health risks associated with pathogens in stormwater remain poorly characterised. Nevertheless, harvesting and reuse of stormwater and urban runoff is occurring in many Australian catchments. This study aims to identify and enumerate *Campylobacter* spp. present in three central stormwater drains from inner city precincts within a metropolitan city during dry and wet weather conditions.

Methods

Ninety-four grab samples and thirty-eight composite samples were collected from stormwater drains in three inner city Melbourne catchments over a seven month period. Grab samples were collected during dry weather conditions and represent base flow. Event mean concentrations were obtained from composited 1L samples collected across the hydrograph at flow weighted intervals .

Identification and enumeration of *Campylobacter* spp. followed the AS/NZ 4276.19:2001.11 membrane filtration protocol. Species confirmation was achieved using cell morphology, gram stain and oxidase tests.

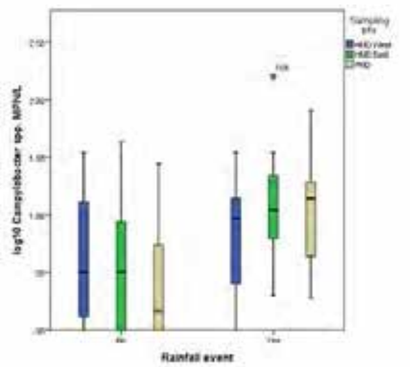


Figure 1: Detections of *Campylobacter* spp. in three Melbourne stormwater drains May – Nov 2011

Results

Campylobacter spp. were detected in 84 percent of dry weather samples (n=94) and in all but one wet weather sample (n=38). Highest counts were observed in rainfall event samples, detections ranged from 1-160 MPN/L, compared to dry weather where detections ranged from 1-43MPN/L (see Table 1).

Table 1: *Campylobacter* spp. detections in Melbourne stormwater drains May – Nov 2011

	Dry weather grab samples			Wet weather event composite samples		
Location	**Total samples**	**Detects (%)**	**Range [a] (MPN/L)**	**Total samples**	**Detects (%)**	**Range [a] (MPN/L)**
HMD East	37	86	<1-43	11	100	2-160
HMD West	37	89	<1-35	15	94	<1-35
PMD	20	70	<1-28	12	100	2-81

a LOD = <1MPN/L

Detections were highly variable during both rainfall events and dry weather conditions at all sites across the sampling period. Median *Campylobacter* spp. detections were significantly different for rainfall events compared to dry weather/base flow conditions at two of the three sites, HMD East (Wet *Mdn* = 11.0, Dry *Mdn* = 3.2, U = 95, p=0.007) and PMD (Wet *Mdn* = 14.0, Dry *Mdn* = 1.55, U = 38.5, p=0.001) (see Figure 1).

Conclusions

This is the first Australian study to quantify *Campylobacter* spp. in stormwater captured in drain rather than in a receiving water body. Maximum detections from these drains (28–160 MPN/L) exceeded the highest reported detections in samples from waters receiving stormwater in Australian sewered urban catchments (15 MPN/L) (Page & Levett 2010; NRMMC, EPHC & NHMRC 2009; AWQC 2008) by at least two fold in most instances. At two of the three sites the maximum detection in wet weather exceeded the 95th percentile concentration reported from a creek in an unsewered peri-urban catchment (70MPN/L) (Roser & Ashbolt 2007).

Results of this study indicate *Campylobacter* spp. may be present in higher numbers in stormwater than previously reported and more prevalent in wet weather samples compared to dry weather. This is important to developers and managers of stormwater harvesting and reuse schemes to ensure fit-for-purpose stormwater reuse that is protective of public health. Knowledge from this study will inform the development of future guidelines for stormwater reuse.

References

AWQC. 2008. *Pathogens in stormwater*. Report prepared by P. Monis, Australian Water Quality Centre, Adelaide. NSW Department of Environment and Climate Change and the Sydney Metropolitan Catchment Management Authority.

NRMMC, EPHC, NHMRC. 2009. *Australian guidelines for water recycling: managing health and environmental risks (Phase 2) Stormwater harvesting and reuse*. Natural Resource Management Ministerial Council, the Environment Protection and Health Council and the National Health and Medical Research Council.

Page D. & Levett K. 2010. Stormwater harvesting and reuse risk assessment for various end uses. CSIRO Land and Water: Water for a Healthy Country National Research Flagship.

Roser D. & Ashbolt N. 2007, Source water quality assessment and the management of pathogens in surface catchments and aquifers. Research report 29, Cooperative Research Centre for Water Quality Treatment.

CRC for Water Sensitive Cities

Elisabet Andrés García

CRCWSC C 1.3.

Fit-for-purpose water production

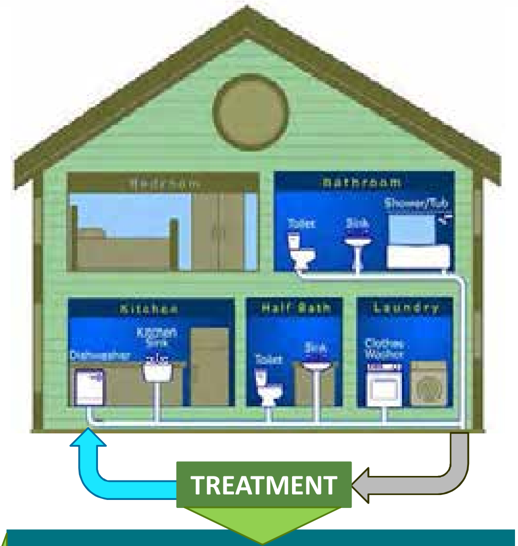
COMBINED ADSORPTION AND ELECTROCHEMICAL OXIDATION IN A 3D REACTOR FOR WASTEWATER TREATMENT

Elisabet Andrés García, Jurg Keller, Miriam Agullo-Barcelo, Wolfgang Gernjak, Jelena Radjenovic

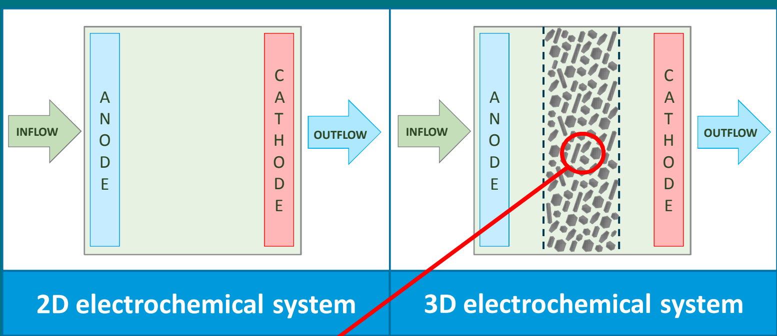
Electrochemical technology for wastewater treatment

There is a growing demand for decentralised water recycling systems to increase the robustness of water supply networks.

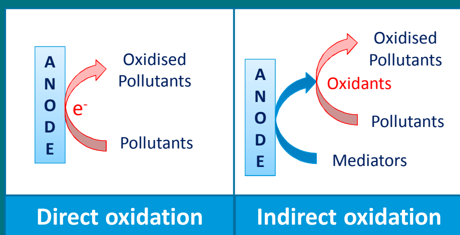
Electrochemical technologies for wastewater treatment have gained worldwide importance during the past two decades, and are comparable with other technologies in cost and efficiency[1-3].



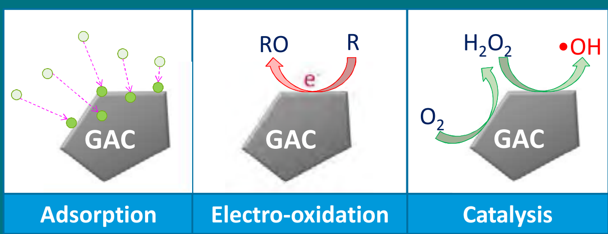
2-D vs. 3-D Electrochemical systems



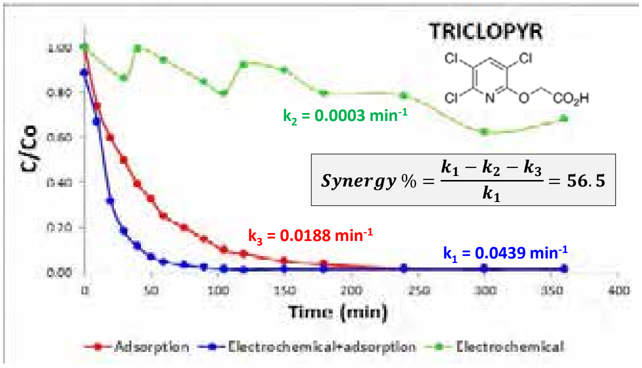
Electrochemical oxidation of wastewater[1,2,4]



Activated carbon as a third electrode[4]



PRELIMINARY RESULTS



$$Synergy\ \% = \frac{k_1 - k_2 - k_3}{k_1} = 56.5$$

BDD Anode // SS Cathode // Initial concentration 2 µM // 50 g GAC (≤ 2 mm) // Electrolyte $NaNO_3$ 10 mM // EC ≈ 1.12 mS/cm^{-1} // 14 $L\ h^{-1}$ // Applied current 150 mA

Preliminary results

Combined electrochemical oxidation and activated carbon adsorption present better efficiencies for persistent organics removal.

1. Cañizares, P., *et al.*, *Combined adsorption and electrochemical processes for the treatment of acidic aqueous phenol wastes.* Journal of Applied Electrochemistry, 2004. **34**(1): p. 111-117.
2. Can, W., *et al.*, *Treatment of secondary effluent using a three-dimensional electrode system: COD removal, biotoxicity assessment, and disinfection effects.* Chemical Engineering Journal, 2014. **243**(0): p. 1-6.
3. Zhou, M. and L. Lei, *The role of activated carbon on the removal of p-nitrophenol in an integrated three-phase electrochemical reactor.* Chemosphere, 2006. **65**(7): p. 1197-1203.
4. Zhu, X., *et al.*, *Synergies between electrochemical oxidation and activated carbon adsorption in three-dimensional boron-doped diamond anode system.* Electrochimica Acta, 2011. **56**(3): p. 1270-1274.

The University of Queensland Australia
Advanced Water Management Centre
BECAS CHILE
www.watersensitivecities.org.au
An Australian Government Initiative
CRC

CRC for
Water Sensitive Cities

Optimal Pumping Operations

Minimising Cost and Greenhouse Gas Emissions

Lisa Blinco[1,2], Angus Simpson[1,2], Angela Marchi[1,2], Martin Lambert[1,2]

[[1]University of Adelaide [2]Cooperative Research Centre for Water Sensitive Cities]

Program C: Future Technologies

Project C 5.1: Intelligent Urban Water Networks

Introduction

Pumping operations use a lot of energy, and can make up a signification portion of a water utility's operating budget. Pumps may be controlled by trigger levels or scheduling. By optimising pump operational strategies, the cost, energy use and greenhouse gas (GHG) emissions of pumping can be minimised. Optimisation has been performed on two traditional water distribution systems (Fig 1.), and produced a 39% cost saving for a real South Australian network. This methodology will also be applied to alternative water source systems.

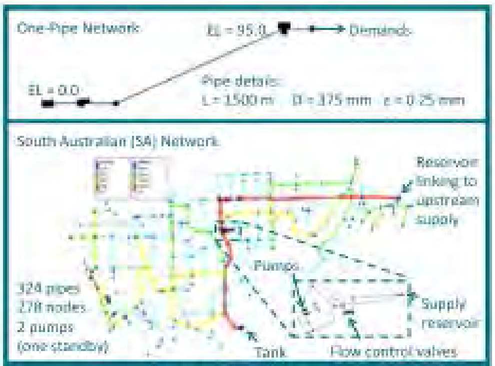


Figure 1: Network Diagrams

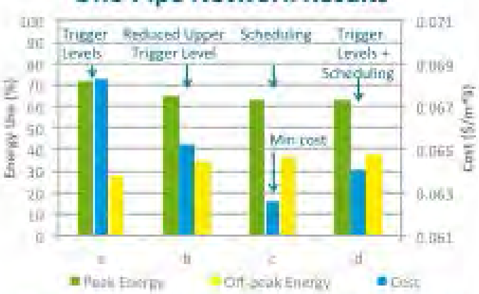


Figure 2: Cost of various optimal solutions compared with the percentage of energy used in the peak and off-peak periods

Minimising Cost

When peak and off-peak electricity tariffs are taken into account, minimising the pump energy does not necessarily also minimise cost. Fig. 2 shows the cost and peak/off-peak energy usage of four different operational strategies for the one-pipe network. Generally, when pumping is deferred from the peak electricity period to the off-peak electricity period, the cost is reduced. The use of variable speed pumps in solution 'c' contributes to its significantly lower cost compared with solution 'd', which has a similar peak/off-peak energy use ratio. For the SA network, the current operational strategy had half of the pumping occurring during the peak period. The pump was capable of pumping the entire days demand during the off-peak period, however, so costs could be reduced by almost 40%. Fig. 3 shows the current and optimised pump operational strategies for the SA network.

Minimising Greenhouse Gas Emissions

Minimising GHG emissions is also often assumed to be equivalent to minimising energy, however, variation in GHG emissions factors can occur throughout the day due to variations in contributions from different energy sources, such as solar and wind. When the daily variation in solar photovoltaic energy output is taken into account, optimal GHG solutions will pump more during the middle of the day, when there is more energy produced from solar photovoltaic energy and hence the overall GHG emissions factors are lowest. In this case, the optimal GHG solutions are more inline with the optimal cost solutions than the optimal energy solutions.

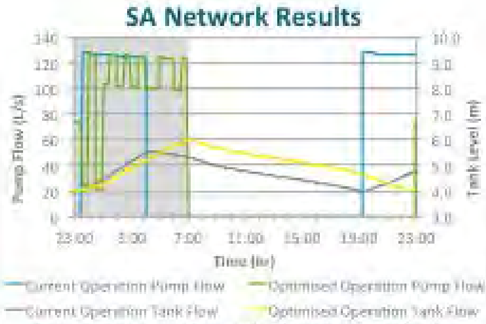


Figure 3: Daily pump flow and tank level variation for the current and optimised operation of the real-life network

THE UNIVERSITY of ADELAIDE

www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for Water Sensitive Cities

Energy and Fertiliser from Algae and Wastewater

Andrew Carruthers
@andytallman101
Supervised by: Anas Ghadouani, Elke S Reichwaldt, Damien Batstone

Program C: Future Technologies

Project C 2.1: Resource Recovery from Wastewater

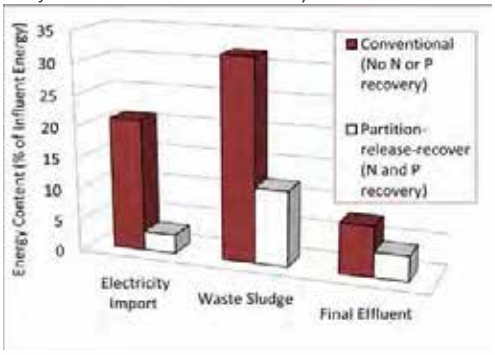


Fig 2. Energy contents of various streams for conventional and PRR wastewater treatment. Adapted from (Batstone et al. 2014).

Background

Human kind now faces the emerging crises of food shortages. To combat these, the nutrients vital for crop growth (e.g. nitrogen (N) and phosphorous (P)) must be reused wherever possible. Growth of algae in wastewater can help achieve this objective, as the algae remove N and P from the wastewater into their cells where it can be recovered later.

Objectives

Algae can be used in a complete wastewater treatment process described as partition-release-recover (PRR) by Batstone & Virdis (2014) (Fig 1). The process relies on microbial growth for nutrient removal, and anaerobic digestion for energy generation. PRR can produce clean water and high-grade fertiliser products while using far less energy and creating far less waste sludge than conventional wastewater treatment (Fig 2).

My research will evaluate the potential of the microalgae-PRR process when using mixed cultures grown from wastewater under natural light. The results will aid in proving the viability of the process, and if adopted this will address food shortage problems while lowering operating costs for wastewater treatment plants.

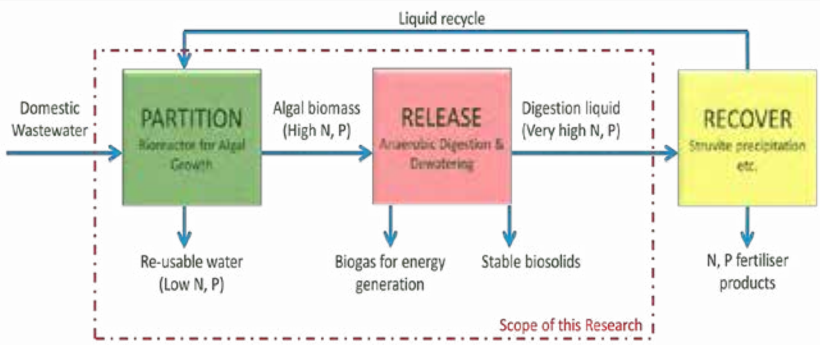


Fig 1. Conceptual diagram of the microalgae partition-release-recover process for complete wastewater treatment. Adapted from (Batstone et al. 2014).

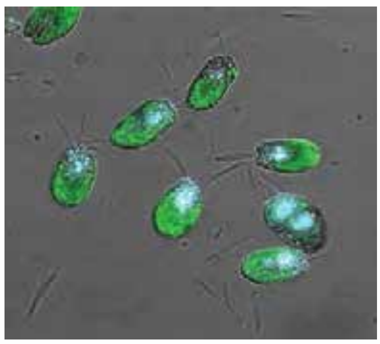


Fig 3. Confocal microscope image of the microalgae species, Tetraselmis suecica. Reproduced from (Greenwell et al. 2010)

References

Batstone, DJ, Hulsen, T, Mehta, C & Keller, J 2014, 'Platforms for energy and nutrient recovery from domestic wastewater: a review', *Chemosphere [In Press].*

Batstone, DJ & Virdis, B 2014, 'The role of anaerobic digestion in the emerging energy economy', *Current Opinion in Biotechnology*, vol. 27, no. 0, pp. 142-149.

Greenwell, HC, Laurens, LML, Shields, RJ, Lovitt, RW & Flynn, KJ 2010, 'Placing microalgae on the biofuels priority list: a review of the technological challenges', *Journal of the Royal Society Interface*, vol. 7, no. 46, pp. 703-726.

The University of Western Australia

Advanced Water Management Centre

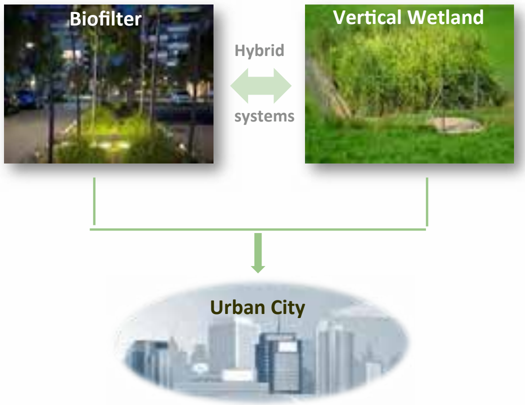
CRC for Water Sensitive Cities

Optimisation of biofilters for treatment of high strength waters

Harsha Fowdar[1], Peter Breen[1], Belinda Hatt[1], Perran Cook[1], Ana Deletic[1]

[1]CRCWSC Program C

C4.1: Integrated multi-functional urban water systems



Research Context

The management of our water resources in an effective and sustainable manner and ecosystem protection are both central to the vision of a water sensitive city. Green technologies such as sub-surface vertical flow wetlands and stormwater biofiltration systems are effective techniques to remove nitrogen from wastewater and stormwater respectively. Combining the best attributes of each of these systems to develop hybrid biofiltration systems will result in multi-functional systems that can treat multiple water sources, improve micro-climate, and enhance aesthetics of the surrounding environment.

Research objective: To optimise current biofiltration systems for nitrogen removal from higher strength waters, e.g partially treated wastewater, light greywater. Sub-objectives include (1) Improve denitrification rates in biofilters (2) Identify biofilter designs and operating conditions to successfully treat light greywater.

Contributions: In addition to making considerable advancements in biofiltration treatment processes, this project will provide industry with a multi-functional, green technology that will support potable water savings, capture nutrients from grey water, minimise wastewater disposal and provide cool and more pleasant urban environments.

Phase 1: Selected electron donors

Phase 2: Column study set-up

Method

Phase 1: Evaluation of electron donors for promoting rapid denitrification in biofilters

- *Water types tested*

  (1) Pure nutrient solution (made up of laboratory grade chemicals, no organic content);
  (2) Light greywater (wastewater collected from a typical bathroom, spiked with potassium nitrate);
  (3) Secondary treated wastewater (collected from a local wastewater treatment facility, spiked with potassium nitrate).

- The water medium, electron donor and denitrifying bacteria were incubated for 5 to 12 days in laboratory flasks, during which time oxidised nitrogen concentrations were monitored.

Phase 2: Determination of optimal biofilter designs and operating conditions for treatment of light greywater

- 11 plant species
- 2 submerged zone designs
- Copper zeolite amended filter media

Key Findings

The results of Phase 1 reveal that cotton, spent grain and rice hulls (as waste materials) are good performers. Denitrification rates were higher in the presence of light greywater. The results indicate that a biofilter treating light greywater may require no external carbon source to drive denitrification. This finding has been incorporated in Phase 2 experiment which is currently under progress.

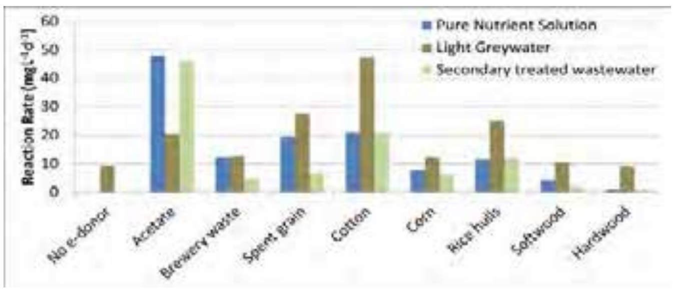


Table 1: Average nitrogen removal rates of e-donors in the presence of pure nutrient solution, light greywater and secondary treated wastewater

Acknowledgement: Advice and technical support provided by colleagues within the water group department of civil engineering, and within the water studies centre, Monash University

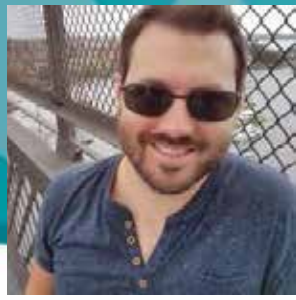
www.watersensitivecities.org.au

MONASH University Engineering

An Australian Government Initiative

CRC

CRC for Water Sensitive Cities



Sludge Fermentation

On-Site Production of VFAs for PPB Nutrient Recovery

Robert Hoelzle[1], Daniel Puyol[1], Tim Huelsen[1], Bernardino Virdis[1,2], and Damien Batstone[1]

[1]AWMC, University of Queensland

[2]CEMES, University of Queensland

Program C: Future Technologies

Project C2.1: Resource Recovery from Wastewater

Introduction

Purple phototrophic bacteria (PPB) are able to efficiently remove nitrogen and phosphorus from wastewater to discharge limits. However, standard domestic wastewater COD:N:P ratios of 300:50:10 are unbalanced in COD, limiting PPB growth and N and P uptake efficiency. COD must be added to the feed stream to an optimal ratio of 100:8:1.2 in order to make up this deficiency (Fig 1).

Fermentation of PPB sludge produces soluble organics that can be recycle to the main process for achieving optimal COD/N/P ratio. However, ammonia production must be managed to ensure that the COD:N ratio is increased to enable full uptake of N and P. In this study, we aim to optimise sludge fermentation for maximum fermentation product generation with minimal ammonia production.

PPB Growth in Carbon-limited System

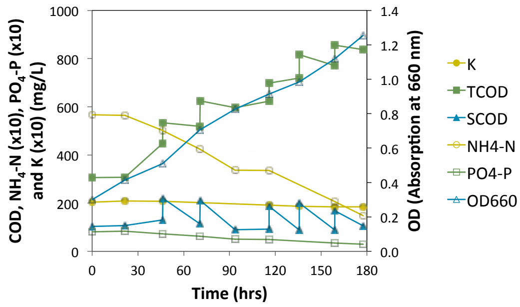


Figure 1: PPB biomass (OD_{660}) increases with spiked acetate (SCOD) while consuming ammonia (NH_4-N) in batch system.

Culture Enrichment Gas Production

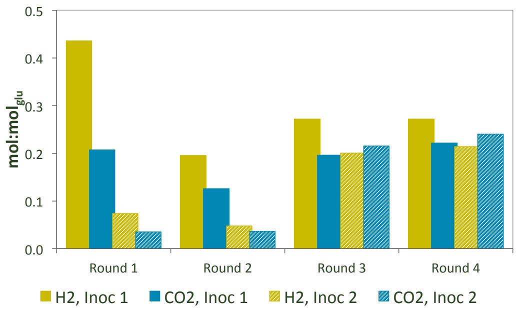


Figure 2: Molar yields of H_2 and CO_2 through culture enrichment.

Method

- Enrichment: Thermophilic sludge (*Inoculum 1*) & anaerobic granular sludge (*Inoculum 2*) + 4 substrate spikes.
- Experimental conditions: 1% VS substrate, 2.5% VS inoculum. 5 d. 30, 37, 55°C (*Inoculum 1*) & 30°C (*Inoculum 2*)
- Substrate: PPB biomass, waste activated sludge (WAS), Algae biomass, + Control (glucose)
- Analytical: VFA, alcohols, NH4-N, biogas.

Preliminary Results

- ✓ **Successful enrichment** after 4 spikes: ↑CO2 and ≈H2 yields (Fig 2)
- ✓ **Initial screening**: First 2 d fermentation dominates. Methanogenesis prevails onwards (Fig 3)
- ✓ Full analysis of enrichment, screening and fermentation experiments is **currently ongoing**

Screening Round Gas Production

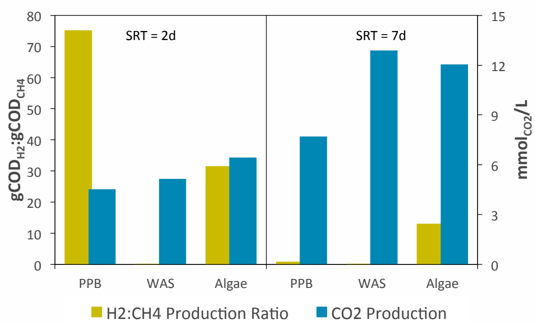


Figure 3: Ratio of H_2 to CH_4 production and total production of CO_2 from initial screening experiment at different digestion times.

American Australian Association Established 1948

Smart Water Fund

CRC for Water Sensitive Cities

Phototrophic bacteria for complete nutrient recovery from domestic wastewater

Tim Hülsen

Daniel Puyol, Edward M. Barry, Jürg Keller, Damien J. Batstone

Program C: Future Technologies. Project C2.1: Resource Recovery from Wastewater

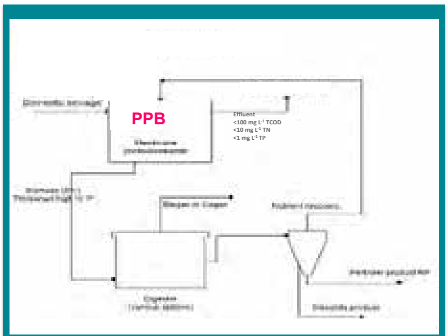
Introduction

Photo of the photo anaerobic Membrane bioreactor.

Current wastewater practice is wasteful of energy and nutrients. Resources need to be recovered

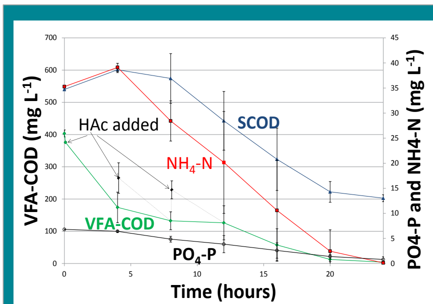
New concept: Partition-Release-Recover to achieve full nutrient recovery.

Purple phototrophic bacteria grow anaerobically with small light energy needs and no need of CO_2.

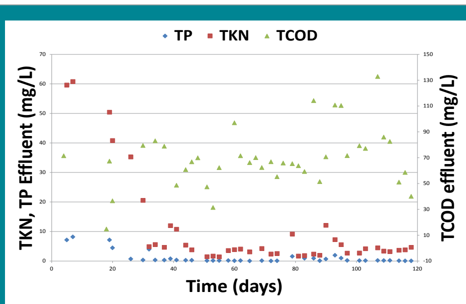


Accumulation-Release-Recovery concept.

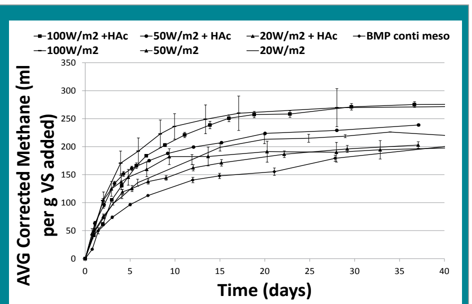
Results



Batch test achieves full N and P removal.



Continuous reactor achieving target effluent limits.



Phototrophic bacteria can be fully digested.

Key Findings

Batch tests: COD, N and P removal to discharge limits.

Continuous operation; effluent concentrations of 65 mg TCOD L^{-1}, 1 mg NH_4 L^{-1}, 0.1 mg PO_4-P L^{-1}.

Recovery potentials after anaerobic digestion for COD, N and were >70%, >45% and >57%

Conclusion

Domestic wastewater can be treated and nutrients can be accumulated by PPB from domestic wastewater in one tank.

Effluent limits match current activated sludge technology

This work was jointly funded by the Smart Water Fund (project 10OS-023) and the CRC for Water Sensitive Cities (project C2.1).

www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for Water Sensitive Cities

Will the metabolism of purple phototrophic bacteria affect nitrogen recovery in wastewater?

Yi Yuan Lee
Supervised by Anas Ghadouani, Elke S. Reichwaldt and Damien Batstone

Program C

Project C2.1: Resource Recovery from Wastewater

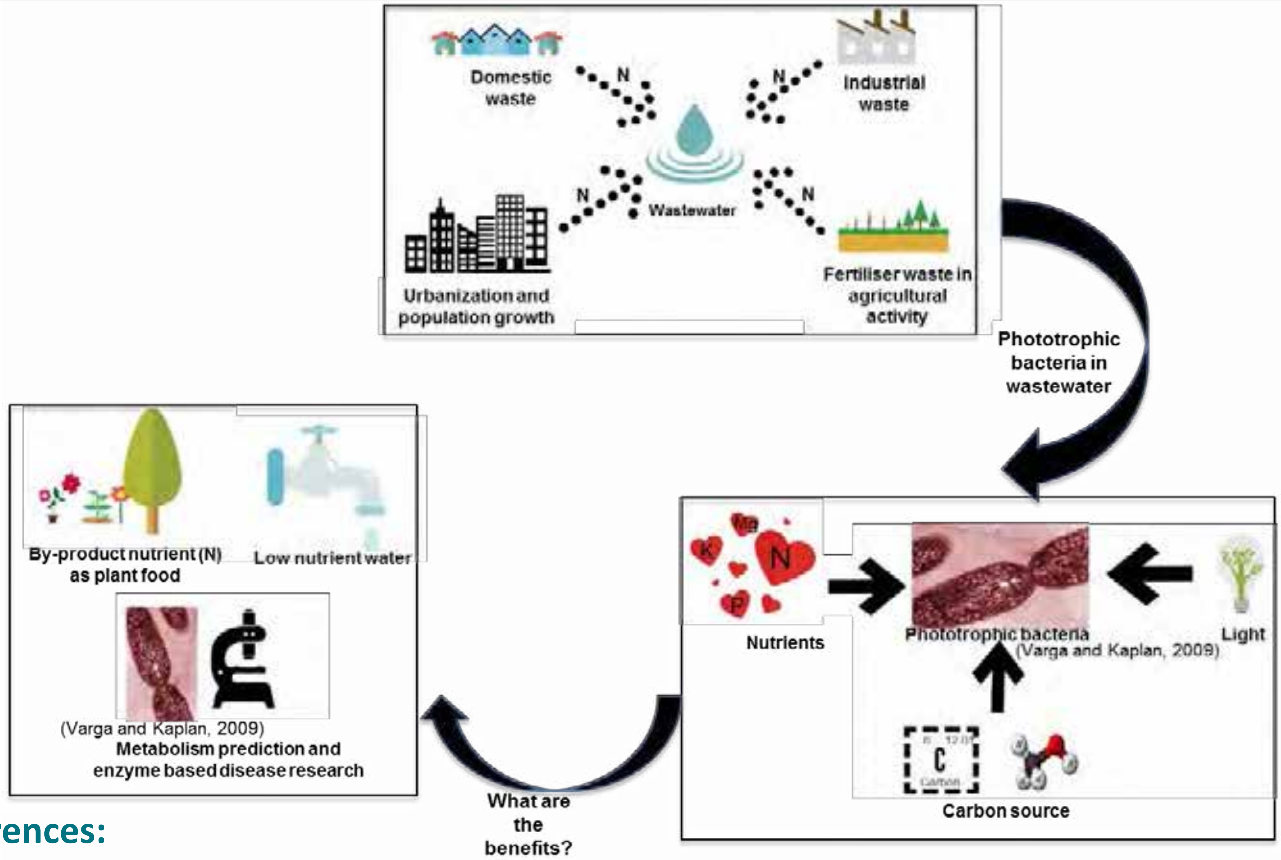
About this research:

Nitrogen (N) can be recovered from purple phototrophic bacteria (PPB) such as *Rhodobacterals sphaeroides* instead of destroyed through conventional activated sludge. As this is an emerging area, the mechanism of how PPB assimilates nutrients is unclear.

This study aims to investigate N assimilation, particularly the fate of N once it is assimilated in PPB and how operating factors such as light properties and carbon (C) source affects the process.

Objectives:

- How PPB uptakes and assimilates N from its surroundings and utilises the N?
- How will the N assimilation of PPB respond to different conditions?
- Which amino acids are generated to assimilate N, and how can this be increased?
- How can this research contribute to sustainable food production and wastewater treatment?



References:

VARGA, A. & KAPLAN, S. 2009. LOV story [Online]. Available: http://www.the-scientist.com/?articles.view/articleNo/27347/title/LOV-story/.

The University of Western Australia

An Australian Government Initiative

CRC

Will Decentralized Wastewater Treatment Block our Sewers?

Investigating the impacts of decentralized wastewater treatment and water efficiency measures on sewer sedimentation

Madhu Krishna Murali[1], Matthew Hipsey[1], Anas Ghadouani[1], Zhiguo Yuan[2]

[1]University of Western Australia
[2]University of Queensland

CRCWSC Program C – Future Technologies

Project C3.1: Managing interactions between decentralized and centralized wastewater systems

Sewers are a valuable investment

With the estimated value of Australia's sewer network at $100 billion, it is apparent that sewers are one of our most significant water infrastructure investments[1]. In the last few years, as Water Sensitive Urban Design (WSUD) has come to the forefront of urban water planning in Australia, many cities have developed water strategies encouraging the use of decentralized treatment (such as greywater recycling and sewer mining) and improving water efficiency. Figure 1 provides a visualisation of this phenomenon.

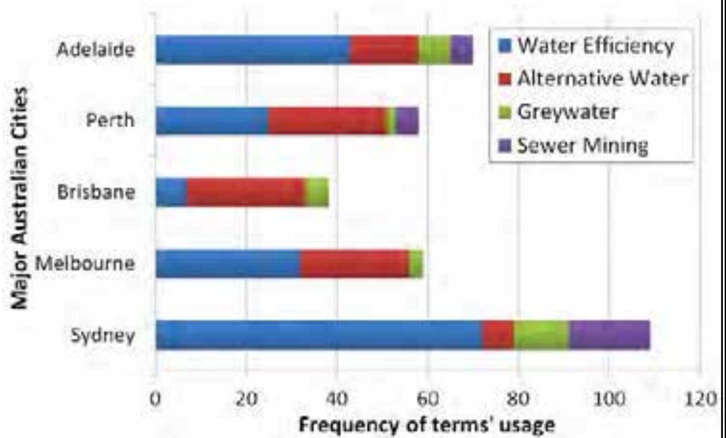


Figure 1: Emphasis on Water Efficiency and Decentralized Wastewater Treatment in recent urban water strategy documents, visualized by frequency of occurrence of WSUD terms in the respective documents[2],[3],[4],[5],[6]

Maximizing Impact, Reducing Issues

This project focuses on the assessment of the increased use of alternative water sources and improved water efficiency on the sedimentation patterns in existing sewer infrastructure. The outcomes of this project along with its methodology are outlined in Figure 2 below. The main outcome of the project will be a customizable sewer sedimentation modelling program which can predict the effects of a number of decentralised wastewater treatment technologies and water efficiency measures on sewer infrastructure.

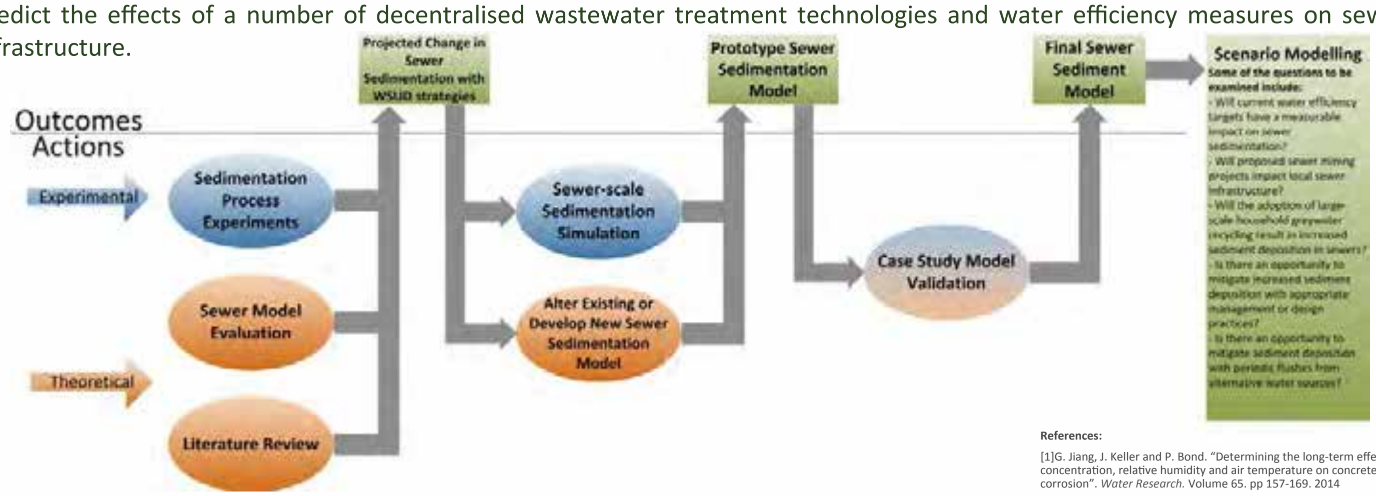


Figure 2: Flowchart displaying project methodology and outcomes

References:

[1]G. Jiang, J. Keller and P. Bond. "Determining the long-term effects of H_2S concentration, relative humidity and air temperature on concrete sewer corrosion". *Water Research.* Volume 65. pp 157-169. 2014

[2]Government of South Australia. 2005. *Waterproofing Adelaide 2005-2025.*

[3]Department of Water (WA). 2009. *Perth-Peel Regional water plan 2010-2030.*

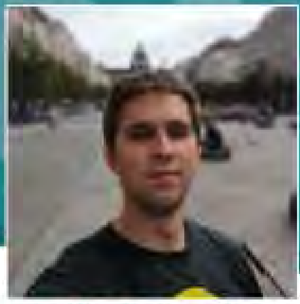
[4]Brisbane City Council. 2010. *WaterSmart Strategy.*

[5]Office of Living Victoria. 2013. Melbourne's Water future.

[6]NSW Metropolitan Water Directorate. 2010. *2010 Metropolitan Water Plan.*

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

CRC for
Water Sensitive Cities



Veljko Prodanovic, Ana Deletic, Belinda Hatt, David McCarthy
Monash University, Australia

CRCWSC Program C4.1
Integrated multi-functional urban water systems

Green walls for greywater recycling

Vegetation in Urban Areas

Tree lined streets · Parks · Green roofs · Wetlands

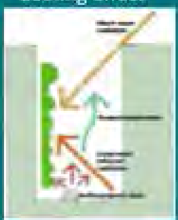
The multiple benefits that vegetation provides in urban areas are well established to date (air pollution reduction, cooling, stormwater management, biodiversity protection, etc.). But in densely built urban environments, where traditional greening systems cannot be used, new, sustainable solutions are required.
Green walls provide all the benefits mentioned above, with the added benefit of space saving. As the big part of the integrated green infrastructure, green walls should be further investigated and developed towards effective and more sustainable future.




Green walls

Benefits

Cooling effect



Energy savings

Reducing carbon footprint

Challenges

Expensive construction and maintenance

High water consumption

Solution – watering with and recycling of greywater

This research aims to convert the current green wall technology into water producers, by developing new designs with specific media and plants for effective greywater purification and much needed cooling and greening to our cities.

Research Steps

- **Current knowledge**: Taking apart traditional green wall systems and re-evaluating every component (and adding some more)
- **Step 1**: Selecting and testing pollutant removal capacity of suitable media types
- **Step 2**: Testing plants nutrient uptake and how to effectively increase it (introduction of mycorrhizal fungi)
- **Step 3**: Interaction between media, plants and greywater

From idea into practice

Construction and monitoring of prototype Green Wall which can provide cost/benefit analysis and recommendations for watering and maintenance for these systems.

MONASH University | Monash Sustainability Institute

www.watersensitivecities.org.au

An Australian Government Initiative

CRC

CRC for Water Sensitive Cities

Adam Shypanski

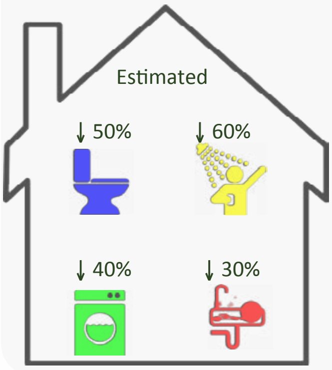
Program C

Impact of Water Source Management Practices on Biological Generation of Sulfide and Methane in Sewer Systems

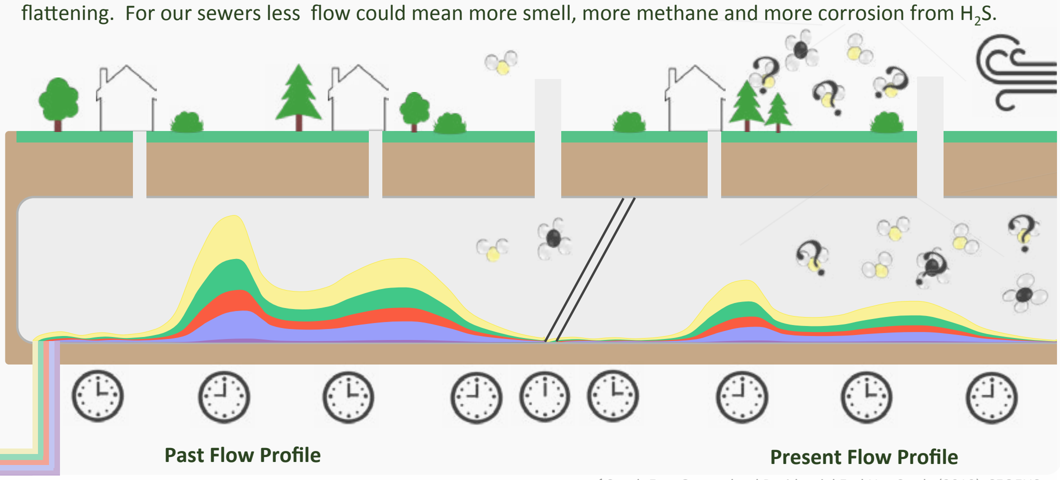
We use less water today…

260 L/person/day, (est.)
Indoor 2003 Brisbane

148 L/Person/day
Indoor 2010 Brisbane[1]



We now take shorter showers, flush using dual mode toilets and clean our clothes and our dishes with modern water efficient machines. These improvements may have unintended impacts in our sewers. In sewers water is used to move our waste and with less water the diurnal flow patterns we normally see in gravity sewers is flattening. For our sewers less flow could mean more smell, more methane and more corrosion from H_2S.



[1] South East Queensland Residential End Use Study (2010), SEQEUS

We'll use less water tomorrow…

Wastewater generation will decrease further with growing adoption of both centralized and decentralized water re-use systems.

Challenges

Decreased flow rates in sewers is predicted to:

- Decrease Dissolved Oxygen
- Increase Sediment Accumulation
- Increase Organic Carbon (TOC) Concentrations
- Increase Residence Times

Potential for greater hydrogen sulfide and methane generation.

Current Research

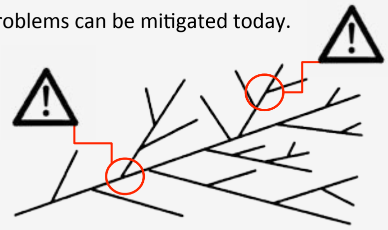
A variety of custom lab scale reactors are being used to isolate and study the impacts of decreased flow on:

- Dissolved oxygen on the sediment & biofilm
- Increased TOC concentrations on the biofilm
- Contact area in sewers and residence time

To better understand the changes to the biological systems generating methane and H2S.

Outcomes

An enhanced corrosion and emission model that has the capability to identify current and future areas of potential concern based on predicted flow changes so that future problems can be mitigated today.



CRC for
Water Sensitive Cities

Stormwater nutrient attenuation by Anvil Way Compensation Basin

Tanveer M Adyel[1,2], Ana L. Ruibal[2], Carolyn Oldham[1], Matthew R Hipsey[2]
[1]School of Civil, Environmental & Mining Engineering, [2]School of Earth and Environment, The University of Western Australia

Program: C
Project C4.1 : Multi-functional urban water systems

Introduction

Constructed wetlands (CWs) are engineered bioreactor and water sensitive urban design (WSUD) elements for urban stormwater treatment. They are able to improve overall water quality by acting as preliminary filters, stripping suspended sediments, dissolved nutrients, gross and micro pollutants before discharging the water into downstream natural water-bodies.

The performance of CW depends on wetland design, hydrological regime, soil and vegetation dynamics.

This work aims to investigate stormwater nutrient attenuation by a living stream-"Anvil Way Compensation Basin (AWCB)".

Fig 1. Map of study area showing sampling points (left), main inlet (top-right) and outflow weir (bottom-right).

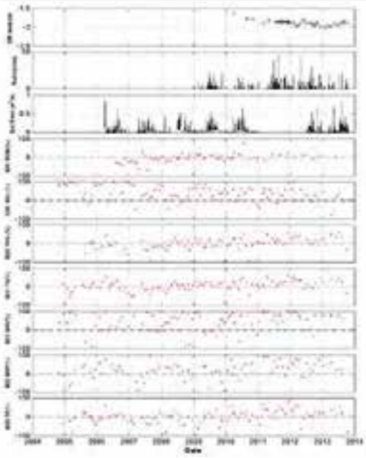


Fig 2. Temporal variability of groundwater, rainfall, outflow and standardised delta concentration of nutrients in AWCB.

Data Analysis and Findings

Field Site: AWCB in WA, a roughly triangular shaped basin with meandering flow path (Fig 1).
Data source: Current research, Swan River Trust, Department of Water, South East Regional Centre for Urban Landcare (SERCUL)
Calculation: Stormwater nutrient attenuation as standardized delta concentration

$(\Delta Conc) = C_{in} - C_{out} / C_{in}$, where C_{in} and C_{out} is the nutrient concentration at main inlet and main outlet respectively.

Nutrient attenuation varied at spatial and temporal scale (Fig 2). P attenuation was less frequent. Above ground biomass (stem and leaves) contained more TKN and TP than below ground biomass (root) (Fig 3).
Nutrient accumulated in higher content in the site close to main inlet (Fig 4).

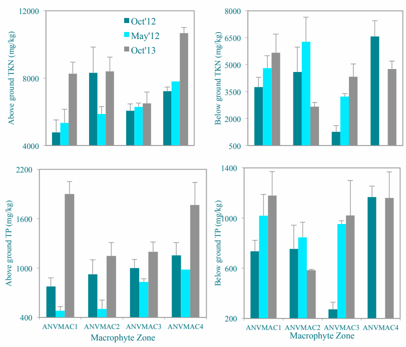


Fig 3. Distribution of TKN and TP in above-and below ground biomass of macrophytes.

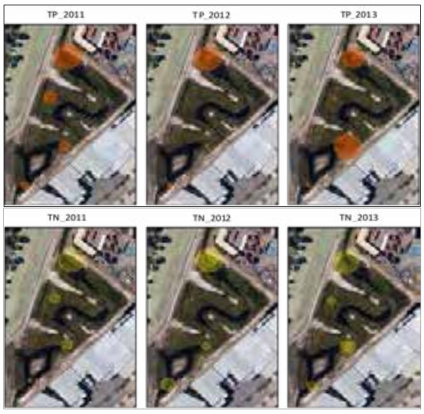


Fig 4. Spatial and temporal dynamics of TP and TN in sediment of AWCB. Width of the circle is proportional to the nutrient concentration.

Ongoing & Future Works

- Investigating influence of riparian sediment saturation on stormwater nutrient i.e., NH_4, NO_3, NO_2,TKN, TN, ON, PN, FRP, TP, OP, PP, DIC, DOC etc attenuation
- Estimating of aquatic metabolism as a proxy of wetland function
- Optimizing nutrient attenuation pathways within AWCB

The University of Western Australia
Achieve International Excellence
An Australian Government Initiative
CRC

CRC for Water Sensitive Cities

Assessing risks to the performance of integrated water schemes in urban areas

Camilla West[1]
Zhiguo Yuan[1], Steven Kenway[1], Keshab Sharma[1]
[1]University of Queensland

Project C3.1 – Managing interactions between decentralised and centralised water systems

Addressing risk and uncertainty in the performance assessment of integrated decentralised and centralised water schemes in urban areas

Uncertainty in water balance

When designing an integrated water scheme, getting the water balance right is important. A variance in demand or supply from that projected can lead to significant technical and financial challenges.

Table 1: Risk factors impacting supply and/or demand from decentralised water source

Risk Factor	Gradual impact	Sudden impact
Political	Change in government policy	
	Water restrictions implemented or relaxed	Scheme decommissioned
Environmental	Seasonality of rainfall and stormwater flows	Drought ends
	Change in climatic conditions	
Social	Different rate of property sales	
	Behavioural changes	
Technical	On-going minor technical issues	Changes in source quality or quality requirements
		Technical issues causing periodic shut down of scheme
Regulatory	Delay due to regulatory processes	
Financial	Change in economy	
	Cost of non-potable water	

(Adapted from Institute for Sustainable Futures [1])

[1]Institute for Sustainable Futures (2013). Making better recycled water investment decisions; Building Industry Capability to Make Recycled Water Investment Decisions. Prepared by the Institute for Sustainable Futures, University of Technology, Sydney for the Australian Water Recycling Centre of Excellence.

Understanding and assessing risk

The project aims to identify the risk factors that influence the water balance of an integrated decentralised and centralised water scheme and the resulting impacts to the long-term viability of the scheme. Risks, and the likelihood and consequence of risks, will be identified through case study investigation.

A decision support framework will be developed that utilises the learnings from case study investigation to facilitate improved water balance forecasting and financial assessment for integrated water schemes.

Incorporation of risk factors in the scheme water balance, assessment of associated impacts and development of management measures is essential if the performance, sustainability and long-term viability of integrated water schemes in urban areas is to improve.

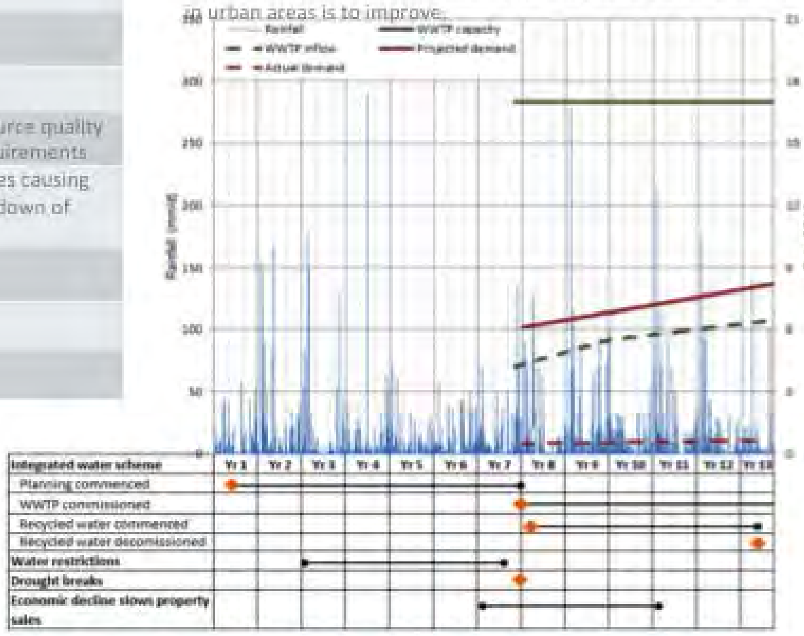


Figure 1: Impact of changing climatic, regulatory and economic conditions on recycled water demand

www.watersensitivecities.org.au

The University of Queensland Australia

An Australian Government Initiative

CRC Australia

CRC for
Water Sensitive Cities

Validation of Stormwater Biofilters

A new validation modelling tool

Kefeng Zhang
Ana Deletic
David McCarthy
C1.1
Cities as Water Supply Catchments – Sustainable Technologies

Introduction

Stormwater biofilters are increasingly being used for urban stormwater treatment. However, **treatment validation is required** before they can be fully accepted compared with engineered treatment systems. This study proposes using modelling methods, combined with laboratory based assays as an alternative tool for validation monitoring. The objective of this study is to **develop a modelling tool to support validation of the removal of micropollutants within stormwater biofilters**.

Methods

In-situ testing (Monash Car Park Biofilter)

Laboratory experiments

Adsorption

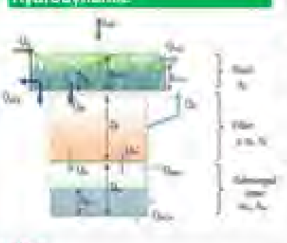
- *Sterile soils*
- *Mixed with synthetic stormwater and shaken on a rotator at 15±0.5°C for 32 hrs*
- *Samples taken at 0, 0.5, 3, 6, 9, 24 and 32 hours*
- *In triplicate*

Biodegradation

- *Mixed with synthetic stormwater and incubated at 15±0.5°C in dark for 21 days*
- *Samples taken at 0, 0.25, 1, 2, 3, 7, 14 and 21days*
- *In triplicate*

Process based model

Hydrodynamic



Pollutant transport

- *Sorption process: **chemical non-equilibrium two-site sorption model***
  - *Instantaneous (f_e)*
  - *Kinetic (k_d, α_k)*
- *Biodegradation process- **first order decay** (k_{bio})*

Results

Figure 1 shows measured and modelled results of the *in-situ* tracer testing. The results show the tool was successful in predicting the flow of the S-SZ biofilter. However, the tool failed to reproduce LS-noSZ biofilter, which experienced soil swelling problem during the tests due to very high organic matter content in the loamy sand media.

Tool Overview

Proposed modelling tool for validation

1. Lab batch methods
Process study:
-*hydrolysis*
-*adsorption*
-*biodegradation*
-*etc.*

\+

2. Process-based model
-*Hydrodynamic: dispersion, advection*
-*Pollutant transport processes: adsorption, biodegradation...*

↔

***In-situ* testing** for Validation

Verify the tool by comparing the results from the tool with the in-situ testing.

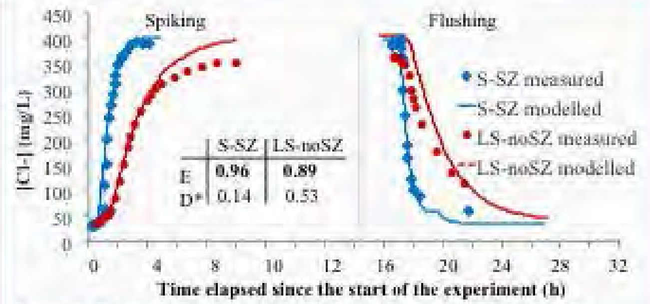


Figure 1: Measured and modelled results of the in-situ tracer testing

Figure 2 presents the measured and modelled results using laboratory parameters. As shown, the tool produced conservative predictions for S-SZ (Nash-Sutcliffe Coefficient, E=0.67); for LS-noSZ, the modelled results had poor agreement with measured results due to the hydrology issue of this biofilter.

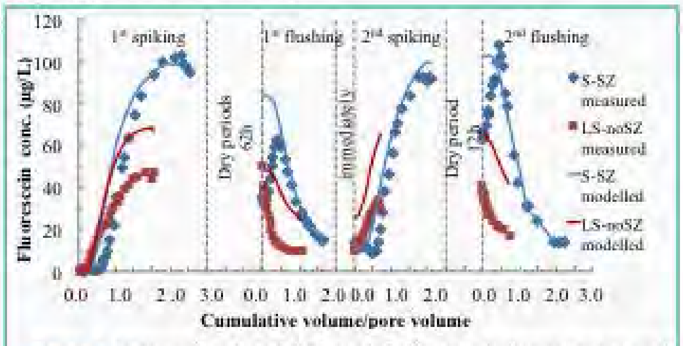


Figure 2: Measured and modelled results of in-situ challenge testings with parameters estimated from (a) laboratory batch experiments

Conclusion

The proposed validation modelling tool was proved to be a good tool for validation study of well-designed stormwater biofilters (S-SZ).

Cooperative Research Centre for Water Sensitive Cities

Level 1, Building 74
Monash University, Clayton
Victoria 3800, Australia

info@crcwsc.org.au

www.watersensitivecities.org.au