CRC for
Water Sensitive Cities

on-ground practices | enabling structures | social capital

2nd Water Sensitive Cities Conference

Brisbane City Hall, 8-9 September 2015

#2wscc

Australian Government
Department of Industry and Science

Business
Cooperative Research
Centres Programme

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—
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Welcome from the Chair

After more than three years in operation, the CRC for Water Sensitive Cities (CRCWSC) is making excellent progress in our mission to change the way we build our cities by valuing the contribution water makes to economic growth and development, our quality of life and to the ecosystems of which cities are a part.

Last October, the CRCWSC brought together research and industry partners for an extremely engaging and vibrant inaugural conference. On behalf of the Board, I am very pleased to welcome you to the 2nd Water Sensitive Cities Conference.

This event will provide a unique opportunity for the CRCWSC to share its latest research insights that integrate some 20 different disciplines, and stems from more than 35 individual research projects and research synthesis and adoption activities.

Many of our researchers will share project outcomes and achievements and I hope you enjoy the presentations and networking opportunities over the next two days.

— **Cheryl Batagol**, Chair, CRC for Water Sensitive Cities

Welcome from the Lord Mayor

It gives me great pleasure to welcome the second Water Sensitive Cities Conference to Brisbane, Australia's New World City. Brisbane prides itself on ensuring we are a liveable and sustainable city and we welcome people who share this focus.

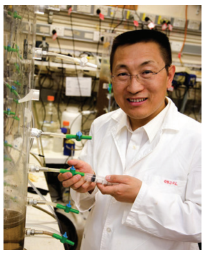
Brisbane City Council is a proud local government participant of the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) and we are delighted the CRCWSC has brought this conference to our city in its second year.

As the Lord Mayor, one of my top priorities is to make Brisbane the cleanest and greenest city in Australia. Our WaterSmart Strategy focuses on protecting our waterways, maintaining sustainable water resources and systems, designing infrastructure with water and flood risk in mind and ensuring our community plays a role in managing water sustainability.

I'm sure delegates are looking forward to hearing about the CRCWSC's insights and the practices that make water sensitive cities a reality. I wish you a productive and enjoyable conference.

— **Graham Quirk**, Lord Mayor of Brisbane

Keynote speakers



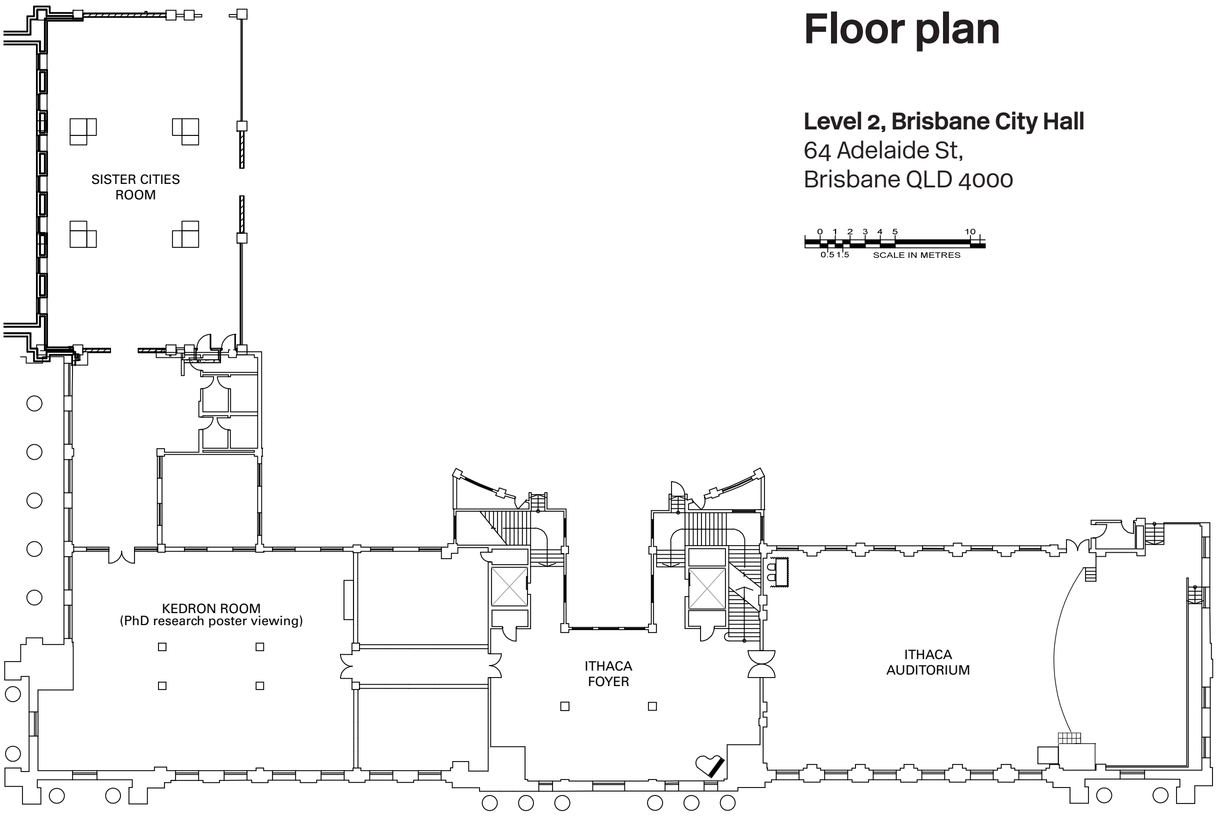
Zhiguo Yuan
Professor Zhiguo Yuan is the Future Technologies Program Leader (Program C). He has a doctoral degree in aeronautical engineering and was a postdoctoral research fellow in wastewater management at Ghent University, Belgium before joining the Advanced Water Management Centre at The University of Queensland in 1998, where he leads the Centre as Director. His research achievements and leadership have been recognised through national and international awards with the most recent being the 2015 ATSE Clunies Ross Award and the International Water Association (IWA) 2014 Global Project Innovation Award (Applied Research Category) – as Project Leader. Zhiguo is an IWA Fellow and was named as one of Engineers Australia's Top 100 Most Influential Engineers for 2015.

Chris Chesterfield
Chris Chesterfield has a background in biology and philosophy and has worked for the last 20 years in technical and management roles in the Department of Water Resources, Department of Sustainability and Environment, Office of Living Victoria, Parks Victoria and Melbourne Water. He is the Director of Stakeholder Engagement at the CRC for Water Sensitive Cities and is a Commissioner with the Victorian Environmental Water Holder. Chris has played a significant role in the management of Victoria's waterways and is a widely recognised champion of sustainable water management and water sensitive urban design.

Nancy Grimm
Nancy B. Grimm is Professor of Ecology and Senior Sustainability Scientist at Arizona State University, where she studies the interaction of climate variation and change, human activities, and ecosystems. Her interdisciplinary research in both urban and stream ecosystems has focused on disturbance, resilience, and biogeochemical processes. Since 1997, Grimm has directed the Central Arizona–Phoenix Long-Term Ecological Research program, with pioneering studies of urban social-ecological systems that conceptually expanded ecology. Beginning in 2015, she co-directs a Sustainability Research Network focused on urban resilience to weather-related extreme events. Grimm has been President of the Ecological Society of America and is a Fellow of the American Association for the Advancement of Science and of the Ecological Society of America. She is an editor for Earth's Future, a past program director for the U.S. National Science Foundation and senior scientist for the U.S. Global Change Research Program, and a lead author for two chapters of the U.S. National Climate Assessment, released in 2014.

Floor plan

Level 2, Brisbane City Hall
64 Adelaide St,
Brisbane QLD 4000



Conference Program

Tuesday 8 September 2015

Ithaca Foyer

8:30	**Registration**

Ithaca Auditorium

9:00	**Opening Plenary** Chair: Tony Wong
	Welcome to Brisbane Rob Nelson, General Manager (Business Events), Brisbane Marketing
	Conference Welcome Cheryl Batagol, Chair, CRC for Water Sensitive Cities
	The magic of a small molecule — it all started from an accidental observation Zhiguo Yuan, Director, Advanced Water Management Centre, The University of Queensland and CRC for Water Sensitive Cities
	User-facing product development leading industry change: A Water Sensitive Cities Index Chris Chesterfield, CRC for Water Sensitive Cities

Kedron Room

10:30	*Morning Break*

	Ithaca Auditorium	*Sister Cities Room*
	Stream 1: Enabling Structures	**Stream 2: On-ground Practices**
11:00	**1a. Vision and Direction Setting** Chair: Jamie Ewert, CRCWSC	**2a. Managing the Ecological Benefits of a Water Sensitive City** Chair: Nancy Grimm, Arizona State University
	Developing shared visions and strategies: Participatory processes to guide water sensitive city transitions Briony C. Rogers, Monash University, CRCWSC *Mapping water sensitive city scenarios (Project A4.2)*	**Repairing urban freshwater ecosystems: informing management and planning** Leah Beesley, The University of Western Australia, CRCWSC *Protection and restoration of urban freshwater ecosystems: Informing management and planning (Project B2.23)*
	Melbourne's lowlands: Two swampy suburbs with broader implications for urban design Nigel Bertram, Monash University, CRCWSC *Urban intensification and green infrastructure: Towards a water sensitive city (Project D5.1)*	**Understanding and management of groundwater - surface water systems for improved protection of receiving waters** Ana Singh, The University of Western Australia, CRCWSC *Hydrology and nutrient transport processes in groundwater/surface water systems (Project B2.4)*
	Case Study: Exploring Elwood's flood challenges: A collaborative approach for a complex problem Briony C. Rogers and Nigel Bertram, Monash University, CRCWSC, Karsten Arnbjerg-Nielsen, Technical University of Denmark, CRCWSC	**Managing the social and ecological values of Sydney's waterways** Daniel Cunningham, Sydney Water
		Evidence-based raingarden design to promote community acceptance Megan Farrelly, Monash University, CRCWSC *Society and institutions (Project A4.1)*
	Panel Discussion	**Panel Discussion**

Kedron Room

12:30	*Lunch*

13:30	**1b. Planning and Climate Resilience** Chair: Darryl Low Choy, Griffith University	**2b. Liveability and the Water Sensitive City** Chair: Nigel Tapper, Monash University
	High-resolution Downscaling of Rainfall Using STEPS (HiDRUS) for Urban Hydrology Bhupendra Raut, Monash University, CRCWSC *Urban rainfall in a changing climate (Project B1.1)*	**The effect of irrigation on microclimate during heatwave conditions** Ashley Broadbent, Monash University, CRCWSC *The design of public realm to enhance urban microclimates (Project B3.2)*
	Flood risk assessment as an integral part of urban planning Karsten Arnbjerg-Nielsen, Technical University of Denmark, CRCWSC *Social-technical flood resilience in water sensitive cities – Quantitative spatio-temporal flood risk modelling (Project B4.1)*	**An urban micro-climate model to assess temperature moderation from increased vegetation and water in urban canyons** Kerry Nice, Monash University, CRCWSC *Green cities and microclimate (Project B3.1)*
	Accounting for synergies between ongoing and future actions in climate adaptation pathways Chris Zevenbergen, UNESCO-IHE, CRCWSC *Socio-technical flood resilience in water sensitive cities - Adaptation across spatial and temporal scales (Project B4.2)*	**Case study: What is the optimal use of an open space? – A planning and management approach for delivering multiple benefits** Sally Boer, E2Designlab
	Towards a methodology for monitoring integrated water management through an urban metabolism approach Silvia Serrao-Neumann, Griffith University, CRCWSC and Marguerite Renouf, The University of Queensland, CRCWSC *Catchment-scale landscape planning for water sensitive city-regions in an age of climate change (Project B1.2)*	**Case study: Liveability in Western Sydney and the new Australian Dream?** Alan Hoban, Bligh Tanner
	Panel Discussion	**Panel Discussion**

Kedron Room

15:00	*Afternoon Break*

15:30	**1c. Governance and Regulatory Planning** Chair: Brian Head, The University of Queensland	**2c. Tools for Integrated Decision Making** Chair: Ross Allen, CRCWSC
	Delivering public good through urban water management: A review of governance and practice in Australian cities Yvette Bettini, The University of Queensland, CRCWSC *Better governance for complex decision-making (Project A3.1)*	**DAnCE4Water - A collaborative decision support tool to test urban water management strategies** Christian Urich, Monash University, CRCWSC *Socio-technical modelling tools to examine urban water management scenarios (Project A4.3)*
	How to create better regulatory frameworks for water sensitive cities Tara McCallum, Monash University, CRCWSC *Better regulatory frameworks for water sensitive cities (Project A3.2)*	**Informing strategic planning through the application of water-sensitive modelling tools** Peter Bach, Monash University, CRCWSC *Integration and demonstration through urban design (Project D1.1/D1.5)*
	Statutory planning for water sensitive urban design Linda Choi, Maddocks Lawyers, CRCWSC *Statutory planning for water sensitive urban design (Project B5.1)*	**Case study: Life-cycle assessment of Water Sensitive Urban Design** Lara Dark, Brisbane City Council
	Case study: Contested spaces in infill areas – The WSUD challenge Marcus Mullholland, Brisbane City Council	**Case study: eWater's modelling tools – Aiming to offer comprehensive integrated water cycle management (IWCM) solutions** Ashis Dey, eWater
	Panel Discussion	**Panel Discussion**

Kedron Room

17:00	**Research poster viewing**

Kedron Room

18:15	**Pre-dinner drinks**

Ithaca Auditorium

19:00	**Water Sensitive Cities Annual Participants Dinner**

Wednesday 9 September 2015

	Ithaca Auditorium	*Sister Cities Room*
	Stream 1: Enabling Structures	**Stream 2: On-ground Practices**
9:00	**1d. Valuation Frameworks** Chair: David Pannell, The University of Western Australia	**2d. Smart Technologies** Chair: Zhiguo Yuan, The University of Queensland
	Hedging supply risks: An optimal water portfolio Anke Leroux, Monash University, CRCWSC *An economic evaluation (Project A1.1)*	**Wastewater treatment technologies for resource recovery: Economic and technological feasibility** Damien Batstone, The University of Queensland, CRCWSC *Resource recovery from wastewater (Project C2.1)*
	Quality and Security: Preferences for new sources of water supply Zack Dorner, Monash University, CRCWSC *Economic incentives and instruments (Project A1.3)*	**A biofilm model to predict the impacts of wastewater flow and composition on the in-sewer reaction kinetics** Keshab Sharma, The University of Queensland, CRCWSC *Managing interaction between decentralised and centralised water systems (Project C3.1)*
	Understanding social preferences to reduce land use conflicts in wastewater treatment plant buffer zone Fan Zhang, The University of Western Australia, CRCWSC *Valuation of economic, social and ecological costs and benefits of strategies and systems for water sensitive cities (Project A1.2)*	**Demystifying high water use: Data analytics for personalised customer feedback about peak days** Jin Wang, The University of Western Australia, CRCWSC *Intelligent urban water systems (Project C5.1)*
	Case study: A Business Case for Water Sensitive South East Queensland Chris Tanner, Bligh Tanner	**Case study: Using big data for network optimisation** Stephen Fernando, Mackay Regional Council
	Panel Discussion	**Panel Discussion**

	Kedron Room
10:30	*Morning Break*

	Ithaca Auditorium	*Sister Cities Room*
	Stream 3: Social Capital	**Stream 2: On-ground Practices**
11:00	**3a. Organisational Capacity** Chair: Andre Taylor, Andre Taylor Consulting	**2e. Alternative Water Resources** Chair: David McCarthy, Monash University
	Developing organisational capacity for water sensitive cities Brian McIntosh, International WaterCentre, CRCWSC and William Veerbeek, UNESCO-IHE, CRCWSC *Strengthening education programs to foster future water sensitive cities leaders (Project D4.1)*	**Green grey-water infrastructure** Ana Deletic, Monash University, CRCWSC *Integrating multi-functional urban water systems (Project C4.1)*
	Case study: Building organisational capacity towards a water sensitive city – Blacktown's story Natalie Payne and Keysha Milenkovic, Blacktown City Council	**Pathogen removal by biofilter for greywater reuse – Its potential and future direction for fit-for-purpose water production** Juri Jung, Monash University, CRCWSC *Fit-for-purpose water production (Project C1.3)*
	Case study: Embedding water sensitive thinking in councils Sara Lloyd, E2Designlab	**Human health hazards in Australian urban stormwater runoff** Jane-Louise Lampard, Sunshine Coast University, CRCWSC *Risk and health: Understanding stormwater quality hazards (Project C1.2)*
	Case study: WSUD on campus - Creating spaces for learning and liveability Dale Browne, E2Designlab	**Case study: Building a business case for an integrated water project** Andrew Chapman, South East Water
	Panel Discussion	**Panel Discussion**

Kedron Room

12:30	*Lunch*

13:30	**3b. Harnessing Communities** Chair: Carol Howe, ForEvaSolutions	**2f. Influencing Policy for a Water Sensitive City** Chair: Chris Chesterfield, CRCWSC
	Prioritising water saving behaviours in households using measurements of impact and likelihood Paula Wright, Monash University, CRCWSC *Accelerating transitions to water sensitive cities by influencing behaviour (Project A2.2)*	**Capacity-building for science-to-policy interactions** Matthew Laing, Monash University, CRCWSC *Strategies for influencing the political dynamics of decision-making (Project A3.3)*
	The new normal: Changing domestic water use habits after drought in Melbourne, Perth and Brisbane Jo Lindsay, Monash University, CRCWSC *Understanding social processes to achieve water sensitive futures (Project A2.1)*	**Science – policy case study: Making potable water reuse palatable to politicians - Learnings from a science-policy capacity building workshop** Kelly Fielding, The University of Queensland, CRCWSC
	Engaging communities in stormwater management Angela Dean, The University of Queensland, CRCWSC *Engaging communities with water sensitive cities (Project A2.3)*	**Science – policy case study: Service portfolios to maximise urban water value** Steven Kenway, The University of Queensland, CRCWSC
	Case Study: Recent Advances in Water Sensitive Urban Design (WSUD) in Brisbane City Council Mark Gibson, Brisbane City Council	**Science – policy case study: A whole-of-government approach to delivering Water Sensitive Cities** Tony Wong, CRCWSC David Pannell, The University of Western Australia, CRCWSC
	Panel Discussion	**Panel Discussion**

Kedron Room

15:00	*Afternoon Break*

Ithaca Auditorium

15:30	**Closing Plenary** Chair: Tony Wong, CRCWSC
	How urban infrastructure can be made resilient in the face of weather-related extreme events Nancy Grimm, Arizona State University
	Outlook for 2016 and beyond Tony Wong, CEO, CRCWSC

16:30	**Close**

List of Abstracts

Session 1b | Project B4.1

Flood risk assessment as an integral part of urban planning

Löwe, R.[1,4], Urich, C.[2,4], Sto. Domingo, N.[3], Wong, V.[2], Mark, O.[3], Deletic, A.[2,4] and Arnbjerg-Nielsen, K.[1,4]

[1] *Dept. of Environmental Engineering, Technical University of Denmark (DTU)*
[2] *Department of Civil Engineering, Monash University*
[3] *DHI Water and Environment*
[4] *CRC for Water Sensitive Cities*

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Background and relevance

Keeping flood risk at an acceptable level is a key aspect of urban planning. A flood-proof city can only be achieved in an economically viable manner if the reduction of flood risk becomes a part of other planning processes in the city. Recent developments in modelling urban growth (Urich and Rauch, 2014) have made it possible to evolve potential futures of cities in a modelling space and to link those futures to drivers of change, e.g. climatic changes and population growth, and to test the effectiveness of WSUD. The integration of a flood risk assessment framework allowing time varying inputs (Zhou et al, 2012), enables flood risk to be simulated over time in an automated manner and for a multitude of future scenarios.

Successful urban flood risk management strategies often involve the implementation of measures affecting the urban from. Examples are the redesign of road spaces, the implementation of policies that require freeboards for houses in flood prone areas or the implementation of new urban layouts that modify flow paths on the surface. Evaluating the potential of such measures requires detailed hydraulic simulations that consider surface flows and has so far not been possible in the integrated approach described above. We have therefore integrated the 1D-2D hydraulic simulation software MIKE FLOOD with DAnCE4Water's urban development component to be able to test the effectiveness of WSUD for urban flood risk management.

Results and Summary of key findings

Key variables of urban development that affect simulated flood risk are the location and extent of buildings and roads, the implementation of water sensitive measures such as rainwater harvesting, modifications of the terrain and changes of the stormwater pipe network, such as the increase of pipe diameters. We transfer such changes from DAnCE4Water to MIKEFLOOD by modifying runoff model parameters, pipe network description and digital elevation model in an automated manner (Figure 1.1).

We have tested the approach for the Scotchman's Creek catchment, Melbourne, where we focused on testing the effect of policies to reduce housing densities in areas of high flood risk by penalizing development in such areas. Implementing such policies lead to a significantly reduced flood risk as compared to a business as usual scenario (50% less buildings were expected to be flooded per year). In addition, we could minimize the areas subject to such policies iteratively, by repeatedly updating the urban development simulation with simulated flood hazards.

Discussion and application to industry

For the Scotchman's Creek catchment we have been able to demonstrate that it is possible to make flood risk modelling a part of integrated urban modelling and that this approach is beneficial in the urban planning process. A current focus of our work is to assess the required complexity of the models and to reduce simulation time.

In another case study in Elwood we are testing the approach in a large scale catchment and as a part of a progressive urban planning process. Potential futures for this very flood-prone area are explored in workshops with community and stakeholders and translated into tangible solutions by architects. These solutions are evaluated in a combination of urban development and flood risk modelling for a multitude of potential future scenarios. In conjunction with modern decision making approaches that balance investment cost, benefits and expected flood risk reduction for different solutions, we can identify robust and economically viable urban layouts in an iterative process.

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References

Urich, C. and Rauch, W. (2014) Exploring critical pathways for urban water management to identify robust strategies under deep uncertainties. Water research, 66C, 374–389.

Zhou Q, Mikkelsen PS, Halsnæs K, Arnbjerg-Nielsen K. 2012. Framework for economic pluvial flood risk assessment considering climate change effects and adaptation benefits. Journal of Hydrology, 414-415, 539-549.

Session 2c

Project D1.1/1.5

Informing strategic planning through the application of water-sensitive modelling tools

Bach, P.[1,2]*, Zhang, K.F.*[1,2]*, Allen, R.*[2]

[1] *Monash Water for Liveability, Department of Civil Engineering, Monash University*
[2] *CRC for Water Sensitive Cities*

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Background and relevance

A water-sensitive approach to urban planning and development can deliver multiple benefits to governments, industry and community. Identifying potential benefits associated with particular interventions (e.g. green infrastructure for stormwater management and heat mitigation) and predicting the likely magnitude or impact of these benefits can support the development of robust water-sensitive strategies and plans.

The Water-Sensitive Cites Toolkit (the Toolkit) and UrbanBEATS are two independent but related numerical modelling tools being developed by the CRCWSC and Monash University. UrbanBEATS can be used to investigate how green-infrastructure can be implemented in urban catchments to deliver user-defined water management objectives with consideration of biophysical and urban planning constraints. Multiple benefits associated with different green-infrastructure scenarios generated in UrbanBEATS (e.g. stream health, minor flooding and urban heat mitigation) can subsequently be quantified with the Toolkit.

In this presentation the application of these water-sensitive modelling tools is explored through two case studies: (1) Wyndham North Precincts (VIC), with a focus on the extent to which stormwater harvesting can contribute to alternative water supplies while also achieving stormwater quality management objectives; and (2) City of Unley (SA), with a focus on urban heat mitigation through streetscape green-infrastructure.

Results and Summary of key findings

Potential opportunities for stormwater harvesting within the Wyndham North urban development area in the west of Melbourne were identified using UrbanBEATS in order to understand the relationship between water quality management and stormwater harvesting objectives. The model was used to identify a range of different green-infrastructure systems and arrangements that met user-defined objectives (e.g. reliability of stormwater supply, pollutant load reductions). For a selection of green-infrastructure realisations, a number of performance indicators were calculated. These included: volume of harvested stormwater for non-potable use (irrigation of public open space), the area land required and the pollutant load reductions.

Urban heat mitigation delivered by a proposed water-sensitive upgrade of Leader Street in the City of Unley (SA) was assessed using the Microclimate – Extreme Heat Module of the Toolkit. The impact of different green-infrastructure initiatives on land surface temperature during extreme conditions along the street was quantified. Figure 1 shows the predicted extent and degree of land-surface cooling. Land-surface temperature reductions of up to 3oC across 40% of the site are predicted as a result of land cover changes due to WSUD intervention. Following establishment of tree canopies, an additional 10% of the street area will experience land-surface temperature reductions, with a reduction of 3-6oC across 15% of the total street area.

Discussion and application to industry

Exploration of the relationship between water quality management and stormwater harvesting objectives at Wyndham North using UrbanBEATS helped to quantify the additional land area required to achieve specified alternate supply targets beyond that which is required to meet water quality management objectives. This activity formed part of a broader investigation of potential drivers and institutional arrangement for implementing and managing green-infrastructure that delivers different benefits to different stakeholders.

Modelling a proposed water-sensitive street upgrade in the City of Unley with the Toolkit enabled land-surface temperature reductions associated with this initiative to be quantified. The primary objective of this case study was to demonstrate the functionality and potential applications of the Toolkit Microclimate Module in a local government context. Subsequent application of this Toolkit module across a larger urban area within the City of Unley is currently being explored to understand and demonstrate the value of the Toolkit Microclimate Module as part of strategic planning for green-infrastructure and water-sensitive urban design.

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References

Bach, P. M. (2012). "UrbanBEATS - An exploratory model for strategic planning of urban water infrastructure." Retrieved 23rd July, 2013, from www.urbanbeatsmodel.com.

Dotto C. et al. (2014). Towards water sensitive urban precincts: modelling stormwater management opportunities. 13th ICUD conference, Malaysia.

Coutts, A. and Harris, R. (2013). A Multi–Scale Assessment of Urban Heating in Melbourne During an Extreme Heat Event and Policy Approaches for Adaptation. Report for the Victorian Centre for Climate Change Adaptation Research (VCCCAR). Monash University

Oxigen, 2015. Leader Street Upgrade Concept—Final, prepared for the City of Unley.

Coutts, A. and Harris, R. (2013). A Multi–Scale Assessment of Urban Heating in Melbourne During an Extreme Heat Event and Policy Approaches for Adaptation. Report for the Victorian Centre for Climate Change Adaptation Research (VCCCAR). Monash University

Oxigen, 2015. Leader Street Upgrade Concept—Final, prepared for the City of Unley.

Session 2d

Project C2.1

Wastewater treatment technologies for resource recovery: economic and technological feasibility

Batstone, D.J.

Advanced Water Management Centre, The University of Queensland, Australia
CRC for Water Sensitive Cities

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Background and relevance

There has been a large amount of developmental work recently on next generation technologies for wastewater treatment, which can meet existing nutrient removal limits while recovering resources such as energy, nitrogen, and phosphorous. Some of these processes are nearing market readiness, but the technological capability and economic feasibility vs existing processes of these emerging options has not been evaluated.

Results and summary of key findings

The three key options for resource recovery include enhanced, or high-rate activated sludge, direct anaerobic wastewater treatment, or the use of emerging processes such as phototrophic bacteria and algae. These have a varying level of market readiness, potential economic benefit, and flexibility in resource delivery. In particular, processes such as high-rate activated sludge treatment are currently being implemented in major installations.

Discussion and application to industry

These processes will potentially determine the next major round of infrastructure investment in resource sensitive wastewater treatment infrastructure, and the potential value of nutrients, in both a global and city perspective is becoming increasingly important. This is coupled to an increasingly compelling economic argument to install emerging, highly efficient treatment processes.

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References

Urich, C. and Rauch, W. (2014) Exploring critical pathways for urban water management to identify robust strategies under deep uncertainties. Water research, 66C, 374–389.

Zhou Q, Mikkelsen PS, Halsnæs K, Arnbjerg-Nielsen K. 2012. Framework for economic pluvial flood risk assessment considering climate change effects and adaptation benefits. Journal of Hydrology, 414-415, 539-549.

Session 2a

Project B2.23

Repairing urban freshwater ecosystems: informing management and planning

Beesley, L.[1,3]*, Quinton, B.*[2,3]*, Close, P.*[1,3]*, Pettit, N.* [1,3] *Davies, P.M.*[1,3]*, and Storer, T.*[2,3]

[1] *The University of Western Australia*
[2] *Department of Water (Western Australia)*
[3] *CRC for Water Sensitive Cities*

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Background and relevance

Management of urban waterways currently focuses on actions to minimise the adverse effects of stormwater (Burns et al. 2012; Fletcher et al. 2014) - a consequence of the dramatic increase in runoff caused by impervious surfaces (Arnold and Gibbons 1996) and the importance of the flow regime in maintaining healthy aquatic ecosystems (Bunn and Arthington 2002, Poff et al. 2007). Recognition is growing however, that the susceptibility of streams to urbanisation, and their capacity for recovery, varies among regions and among sites (Brown et al. 2009, Hopkins et al. 2015). Managers and scientists are increasingly calling for urban waterway restoration strategies that are sensitive to regional and local conditions (Utz et al. in press).

Project B2.2/3 is addressing this management need by developing a flexible and systematic framework that considers both landscape and local conditions to assist managers to confidently prioritise their effort. The project brings together traditional disciplines and sectors and the product will support smart and efficient business practices that are sensitive to the spectrum of waterway and liveability values. The product will be useful to regional and local managers (state and local government), consultants and community groups looking for flexible and adaptive restoration options.

Approach and Summary of key findings

The framework addresses the options management have for waterway restoration at the site-scale and is based on three main principals:

1. that the relative importance of drivers of stream function vary among systems and along the length of rivers;

2. that the severity of urban stress differs with the type of urban development, and the landscape setting of the focus waterway; and,

3. that urban constraints (space limitations, policies and infrastructure) influence the restoration options available to waterway managers.

Together, these overarching principals support the prioritisation of the ecosystem drivers available for repair by waterway managers (see Figure 1.1). The preliminary framework has been presented to industry users to test its usability and is being refined. The next phase is to undertake a data-gap analysis to support the framework/model with quantified drivers.

Discussion and application to industry

The framework brings together knowledge from multiple scientific disciplines to assist in the prioritisation of management effort, thus creating a flexible and adaptive road-map for urban waterway site recovery. The product will support smart and efficient cross agency practices that are sensitive to the spectrum of waterway and liveability values. The product will be useful to regional and local managers (state and local government), consultants and community groups looking for flexible and adaptive restoration options.

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References

Arnold, C.L., and Gibbons C.J. (1996) Impervious surface coverage: the emergence of a key environmental indicator, Journal of the American Planning Association, 62, 243–258

Bunn, S.E. and Arthington, A.H. (2002) Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity, Environmental Management, 30, 492-507

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Utz, R.M., Hopkins, K.G., Beesley, L., Booth, D.B., Hawley, R.J., Baker, M.E., Freeman, M.C. and Jones K.L. (in press) Ecological resistance in urban streams: the role of natural and legacy attributes, Freshwater Science, 36

Session 1a

Project D5.1

Melbourne's 'Lowlands': two swampy suburbs with broader implications

Bertram, N.[1], *Neustupny, M.*[2], *Murphy, C.*[1] *and Pasman, R.*[1]

[1] *Monash University, CRC for Water Sensitive Cities*
[2] *University of Queensland*

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Background and relevance

This paper reframes Melbourne's low-lying metropolitan areas currently under intensive redevelopment pressure as part of a much broader territory that reaches across the state and has been referred to as the 'Southern Lowlands', a region characterised by a range of swampy depressions, lakes and lagoon systems that connect to the sea or each other only in times of flood. Taken as a whole, this physiographic region displays distinct characteristics and repeated patterns that can help us understand the limitations of past attempts to engineer and control the natural cycles of water when developing these areas where they fall within metropolitan boundaries. This line of thinking also suggests a re-ordering of current hierarchies of urban organisation and decision-making to make our intensified cities more responsive and sympathetic to their underlying tendencies and potential. The paper combines geological structure, indigenous land use, natural ecological systems, man-made historical modifications and the behaviours of above and below-ground water cycles together as an interrelated set of data informing design decisions and influencing urban form.

Results and Summary of key findings

The authors argue that such a cultural, historical and geomorphological starting point is an aid to reconceptualise current urban development and intensification through a wider lens – one where water issues form a primary foundation for the urban futures of low-lying areas. This approach has the potential to re-organise our thinking about both past and future metropolitan growth and the ongoing management and health of our collective living environments.

The research finds that there is a close alignment of contemporary urban water issues exacerbated by development density and climate patterns in these low-lying areas, with their underlying geological and topographic structure, historical land uses and man-made modifications to natural systems over time. Considering such sites from both a natural-environmental and a historical-cultural perspective at the same time is a necessary and useful addition to conventional urban planning criteria and can increase the relevance and resilience of new urban neighbourhoods.

Discussion and application to industry

The analysis is illustrated in detail through the lens of two current demonstration project sites forming part of Project D5.1: Arden-Macaulay and Elwood, both developed on low-lying areas of previous marshy lagoons and swamplands. Elwood has a distinct social identity and localised sense of place, while Arden-Macauley is of considerable strategic importance to Melbourne's current brownfield expansion and transport infrastructure plans. These two sites have problems and potentials that are intimately linked to macro-scale underlying water issues, which can only be addressed by precinct and catchment-scale thinking.

In collaboration with industry partners including the City of Melbourne, Melbourne Water and the City of Port Phillip, other key stakeholders and CRCWSC researchers such as Program A4.2, the ongoing research will develop an in-depth understanding of the issues and opportunities arising from the particular combination of forces that influence the Arden-Macaulay and Elwood areas. These include development pressures, environmental pressures and the potential for positive change in both the private and public realms. The projects will be design-led, working with the tangible social, environmental and experiential implications of water-based precinct and city-scale issues.

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Session 1c

Project A3.1

Delivering public good through urban water management: a review of governance and practice in Australian cities

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Background and relevance

The management of water in Australia's urban environments delivers many benefits additional to potable supplies, such as watering public open spaces, reducing flood risks, and protecting urban waterway ecosystems and amenity values; all key ingredients of a Water Sensitive City.

Governance arrangements for delivering and regulating water services are currently based on the central role of corporatised water utilities. Government-owned utilities are licenced and regulated to deliver safe and secure drinking water, remove and treat wastewater, and in some jurisdictions manage stormwater discharge and/or quality. In the business models of these utilities, the additional social and environmental benefits that could be provided by water utilities (beyond traditional water services) can be difficult to cost or justify. Moreover, the financial and regulatory risks to which water utilities are exposed can make the delivery of multi-benefit solutions (with broader public good outcomes) unpalatable in corporate decision-making processes.

This research project explored the legislative, regulatory and policy instruments governing the behaviour of water utilities in Brisbane, Melbourne and Perth, to identify which of these mechanisms have been, or could be, used by utilities to justify and deliver social and environmental outcomes. Through a legislative and regulatory review and interviews with practitioners involved in water management and services activities, the project aims to develop a better understanding of how governance of corporatised public utilities can deliver a broad range of services and outcomes in the public interest, within the boundaries of economic prudence.

Results and Summary of key findings

The results of this research confirm that 'hard' institutional barriers like legislated provisions and regulatory instruments are not seen as insurmountable barriers to the delivery of multi-benefit solutions in urban water services and management activities. In all three jurisdictions, participants noted that strong intent to deliver a broad range of public good outcomes can drive a gradual reinterpretation of perceived institutional or cost constraints on water infrastructure or service provision. The establishment of clear roles and responsibilities for water quality management, whether through drainage or catchment management functions, can boost accountability and authority to pursue wide goals and deliver these broader outcomes. In the absence of this clear accountability, finding practical 'work-arounds' requires good will, shared goals and benefits, and specific efforts to build trust and confidence between relevant policy, regulatory and service delivery organisations. Such collaboration is often time-consuming and takes resources away from 'core business,' and so may require significant policy signals and political/executive support.

Similarly, overcoming cost constraints requires robust models to justify expenditure beyond least-cost principles, and confidence from regulators and the organisational executive that solutions will not expose the organisation to unacceptable levels of risk. Participants also reported that a perceived barrier is the absence of clear mechanisms under the financial model to provide subsidy funding to support proposed projects or works which deliver wider benefits.

Discussion and application to industry

Water utilities are critical partners to achieving WSC. Their role in managing water in the urban landscape and providing various services through this role are core to how water resources are sustained and contribute to urban liveability. However, contemporary governance arrangements for water resource management and delivery are still configured along the principles of separate roles and responsibilities, and service optimisation through least-cost options. This makes it difficult for water utilities and other departments and agencies to find clear justification and authority to deliver the multi-benefit services and solutions that constitute a WSC. This research is seeking to address this gap by identifying the key governance instruments that water utilities currently rely on to deliver multiple benefits through their water management activities, which include: a clear mandate for water quality management, clear funding opportunities and costing methods for multi-benefit options, and executive leadership that sees a role for delivery agencies beyond regulatory compliance.

By making use of and strengthening these institutional features, governmental leaders can enable the water management practices that will deliver a water sensitive city. The research identified the 'soft' or informal governance features important for utilising institutional structures, which include: collaboration and partnership with key delivery organisations and regulators, internal policy capacity with linkages to policy entrepreneurs and policy systems, and executive leadership that can provide and maintain authority to perform beyond regulatory compliance under conditions which often encourage regulatory and political risk aversion.

Overall, while all three jurisdictions studied are able to deliver multi-benefit options on some occasions in the urban water service delivery space, this is usually delivered ad hoc at the project level, and requires significant investment in time and human resources to identify the specific regulatory barriers (whether in relation to human health, financial cost/benefit, or environmental protection) and to develop and gain formal support for appropriate 'work-arounds' or negotiated problem-solving to achieve goals under conditions of uncertainty. There is a real need for formal institutional features to be reconfigured to reflect these negotiated work-arounds, in order to institutionalise the new practices and better facilitate the delivery of multi-benefit options in the future.

Session 2b

Case study

What is the optimal use of an open space? — a planning and management approach for delivering multiple benefits

Boer, S., Markwell, K., and Breen, P.

E2Designlab

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Background and relevance

Open space in our cities such as waterway corridors are highly contested spaces. Use of these spaces for flood management and mitigation, passive and active recreation, waterway health protection, ecological habitat and stormwater treatment can have competing outcomes. Planning of these spaces and adjacent development sites is typically undertaken by separate council departments and therefore opportunities for optimal outcomes can be missed. This paper presents a holistic approach to the planning, delivery and management of open space to deliver multiple benefits through the identification of primary and secondary functions and desired standards of service. Case studies are presented to demonstrate the process and outcomes.

Results and Summary of key findings

The holistic planning approach consolidates all information to:

- identify primary and secondary functions
- identify areas where competing outcomes might occur
- identify the optimal use of the open space
- identify opportunities to coordinate investment to provide multiple benefits
- facilitates economic outcomes through combining redevelopment and open space planning
- provides a strategic framework to guide future works
- enables actions to be identified and budget planning

The asset management approach provides:

- a clear definition of the desired standards of service based on the primary and secondary functions
- provides a vision for coordinated management across council departments
- provides a consistent communication tool for development assessment and stakeholder consultation
- provides a transparent measure of how a council's portfolio of green assets are performing
- identifies where maintenance or rectification is required
- communicates the funding required to provide the desired standards of service
- provides a basis for measuring the effectiveness of management actions
- enhances the value and function of open space to the benefit of the community and the environment

Outcomes:

- Waterway health, recreation and amenity, flood management, passive and active recreation, ecological habitat, stormwater treatment and urban development are provided in the right locations and in the right combinations for optimal environmental, social and economic outcomes.

Discussion and application to industry

The holistic planning and asset management approach presented can be adopted by councils to assist in the transition to a water sensitive city. The approaches are adaptable in both scale and context and unravel the complexities of planning and managing green assets and multiple use open spaces.

Session 2b

Project B3.2

The effect of irrigation on microclimate during heatwave conditions

Broadbent, A.[1,2], Tapper, N.[1,2], Coutts, A.[1,2], Beringer J.[3], and Demuzere, M.[4]

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[3] *University of Western Australia*
[4] *KU Leuven*

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Background and relevance

In conventional urban areas, the majority of rainfall is exported out of the environment through the stormwater drainage system. This loss of stormwater is balanced by importing potable water, which is used for irrigation and gardening watering. Stormwater runoff can reduce urban moisture availability, leading to reduced evapotranspiration and increased sensible heat flux, which can cause higher urban air temperatures. This is particularly relevant in Australia, which has experienced extended dry periods and heat waves over the last two decades, especially in the major southern cities: Perth, Adelaide, and Melbourne.

The ongoing drought has placed pressure on potable water resources and led to water restrictions and irrigation bans. These compounding consequences of drought: water restrictions, xeric gardening practices, and reduced health of urban vegetation, further exacerbate urban warming and energy demands. In the context of climate change this additional urban warming effect is of particular concern. Heatwaves are well known to cause a marked short-term increase in mortality and/or morbidity of exposed populations. Extreme temperatures have been shown to be particularly damaging to the elderly, and as urban populations age, exposure to heat could represent a significant health cost for greater society. The need to mitigate heat and protect vulnerable people, such as the elderly, is essential for maintaining good public health and wellbeing.

Reintegrating stormwater into the urban environment, may help to modulate the effects of urban warming, while also improving stream ecology and conserving valuable potable water resources. However, the climatological implications of water scarcity, stormwater reintegration, and changing irrigation practices, for urban climate are often ignored in mitigation modelling research. The objective of this research is to understand the cooling potential of irrigation on microscale air temperature in a mixed-residential environment during heatwave conditions.

Results and Summary of key findings

The analysis was conducted in a WSUD suburb using the Town Energy Balance (TEB) model. We used TEB's built in irrigation scheme to test the cooling potential of a series of irrigation regimes during an extreme heat event case study. Hypothetical scenarios suggest the average maximum cooling associated with irrigation during the heatwave was up to 4 °C at 3pm, and 1.5 °C at 3 am. It was also found that nighttime irrigation (11pm – 5am) was more effective than daytime irrigation (11am – 5pm) at reducing exposure to adverse heat health conditions (daily average air temperature >34 °C). Overall, irrigation and stormwater reintegration show potential to cool microclimate in suburban areas during heatwave conditions, and reduce exposure to damaging extreme heat.

Discussion and application to industry

Irrigation has been shown to have cooling benefits for microscale air temperature. This suggests that cooling can be achieved in suburban areas, through irrigation, and without changing the structural characteristics of the urban land surface. Irrigation could be a very effective way to achieve distributed cooling in areas where targeting cooling is needed. Lakes, wetlands, and rain tanks can be used for capture, storage, and treatment of stormwater, while irrigation is used to distribute the water to the areas where exposure to heat is greatest. Unlike other permanent heat mitigation measures, the rate and timing of irrigation can be modified and tailored to different seasons/environments to achieve the most efficient cooling benefits. Irrigation is a possible adaptive cooling strategy that could be beneficial in existing developments that do not have mitigation features, but require air temperature cooling. The re-integration of stormwater through irrigation is not only beneficial for the ecology of receiving waterways, but it also has the potential to cool urban microclimate, and reduce exposure to extreme heat in urban areas.

Session 3a | Case study

WSUD on campus — creating spaces for learning and liveability

Browne, D.[1], *Breen, P.*[1], *Lindsay, S.*[2], *Wright, M.*[3], *McGrenahan, D.*[4], *McCarthy, D.*[3] *and San Martin .R*[3]

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[2] *Monash University*
[3] *Rush Wright Associates*
[4] *Wood & Grieve Engineers*

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Background and relevance

The integration and retro-fitting of water sensitive urban design (WSUD) within highly constrained urban environments such as university campuses, streetscapes and activity centres continues to present a challenge to practitioners in terms of negotiating numerous challenges such as services, sub-optimal existing drainage layouts, barriers to new infrastructure and conflicting needs. Constructed projects that show this can be done and how it can achieve significant benefits for liveability through integration of WSUD with multiple functions and overcome these challenges can help industry practitioners see potential opportunities and pathways forward rather than the barriers.

It is recognised there is also a need for emerging research to be 'given a chance' through implementation within field projects in an environment where real-world testing and further research can occur. The inclusion of novel filter media and monitoring will facilitate future research by the CRCWSC which will help confirm research outcomes for industry application.

Results and Summary of key findings

Monash University is transforming its Clayton Campus through an ambitious landscape program. The Western Landscape works will create modern and attractive landscaped areas, walks and a WSUD feature with a wetland and biofilter surrounded by seating and lawn areas to increase liveability and encourage outdoor study and relaxation.

Rainwater from a building roof is harvested through the wetland into a storage tank with top-up from the University's non-potable ring main supplying treated stormwater for irrigation use. This maintains vegetation health and increases evapo-transpiration for urban cooling.

A range of constraints and challenges had to be overcome to realise the project vision. These included keeping stormwater close to the surface to flow into the biofilter, working around substantial services infrastructure including a large stormwater drain and the Universities large service culvert. These were overcome through creative drainage design and a charged pipe into the wetland inlet fountain as well as detailed coordination of landscape, civil and WSUD elements.

The design incorporates the CRCWSC's biofilter research with inclusion of a submerged zone and biochar in the biofilter media to enhance pollutant removal and improve soil moisture retention, which is emerging as a key requirement for successful biofilters.

Recognising the need for accessible test sites for the CRCWSC and Monash students, the design includes monitoring capacity for research on water flows and quality. Monitoring systems will connect to an artistic and educational feature with a visual live feed illustrating conditions within the treatments and a beacon to send information to mobile phones in proximity of the WSUD feature.

The project creates a showcase for the integration of WSUD within a highly constrained and challenging urban environment to deliver liveability, integrated treatment and reuse outcomes and support research.

Discussion and application to industry

The project has yielded a number of learnings that could be helpful for industry.

- The significant value of multi-functional assets. By focusing on creating a central aesthetic feature using the WSUD while still requiring functionality, the attainment of 'best practice stormwater treatment' became an easily achieved 'side benefit' rather than the main focus of design. Similarly, a potentially ugly set of monitoring cabinets was transformed into a central artistic feature with educational value through lateral thinking, demonstrating the value of a multi-disciplinary approach.

- Accurate services details early in projects are essential in allowing potential difficulties to be identified and resolved.

- Emerging technologies are creating opportunities to make WSUD fun, support education and enable research by allowing the community to interact with WSUD in different ways and better understand their purpose

Session 2e

Case study

Building a business case for an integrated water project

Chapman, A., Westcott, J.

South East Water

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Background and relevance

This paper works through the opportunities, issues, challenges and pitfalls often faced when trying to develop a business case for a water sensitive integrated water solution for urban development. If we are to achieve the desirable objective of more liveable cities which are water sensitive, robust business cases need to be developed which capture the benefits of a more sustainable approach. This is not easy when there is already existing conventional infrastructure in existence which are regarded as sunk costs (free?) competing against decentralised systems with upfront costs. The paper seeks to inform researchers and practitioners of the practical challenges often faced in development of Water Sensitive City projects to help focus research outputs to meet practitioner needs and facilitate implementation of future projects.

Results and Summary of key findings

The paper draws on over 10 year's experience in developing business cases for Recycled Water / Integrated Water / Whole of Water Cycle projects at South East Water who service over 1.7 million customers in Melbourne. The range of projects have included large and small scale dual piped greenfield development (Casey Clyde Growth area), inner city high density re-development (Fishermans Bend), agricultural reuse (Boneo), industrial schemes(Logis), recreation irrigation supply (Mornington Recreation) and stormwater mitigation (Botanic Ridge). Consideration of alternative water from treated sewage, stormwater and rainwater. Not all business cases that will be explored have been successful, but there is often more to be learned from failure than from success.

The paper will discuss identified challenges that typically need to be addressed and provides hints on facilitating a successful business cases for integrated water cycle projects. These points are summarised in the table below and will be explored in the presentation.

IWM Challenges

- The Water Balance
  Balance between supply and demand, how will the peak be supplied
- Devil in the Detail
  What looks good at strategy level is difficult to implement
- The Tyranny of Distance
  Pipelines and transport of water is expensive
- Where does the Waste go?
- Who will operate and maintain?
  Needs to be sorted out early
- Who takes the risk?
  No one wants risk especially new unknown risks
- Who benefits and who pays?
  How do we capture the benefits to help pay for the costs?
- Dealing with multiple stakeholders

IWM Hints

- Available Water Resources
  What water resources are available?
- Opportunities to Enhance sustainable living
  Water facilitates greener environment and watercourses public open space
- Look for Efficiency
  Where can we use less water?
- What are deferrable or avoidable costs
  What are future big costs that could be avoided?
- Whole of Community Costing basis
  Find the best solution and work out who pays later
- No Water is a waste its an Opportunity
  Consider stream separation are there uses that could use lesser quality water?
- Wetlands and waterways enhance parkland
- Water and Energy are often linked

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User-facing product development leading industry change: a Water Sensitive Cities Index

Chesterfield, C.

CRC for Water Sensitive Cities

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"If you don't know where you are going, you will probably end up somewhere else."

— Laurence J. Peter

The journey towards a water sensitive city is one that has defined itself gradually over many years through the efforts of researchers, scientists and practitioners from across the globe. As a result, we have more information than ever about what the water sensitive city as a destination looks like; its characteristics and terms of citizenship. What we have been lacking, however, is an effective roadmap for how to get there. The Water Sensitive Cities Transitions continuum (Brown et al, 2009) suggests there are stages through which a city progresses in order to reach the Water Sensitive City but can this conceptual framework help us to get there?

Conceptual models or frameworks have been increasingly used in Government as a basis for decision making. Good models can help us articulate goals and targets for service delivery, link actions with outcomes and track progress.

The need has emerged among practitioners to adapt the knowledge amassed over the life of study into water sensitive cities into a form to support decision making.

The CRC has begun development of a tool to meet this need to support practitioners to implement the existing knowledge that has been developed on water sensitive cities called the Water Sensitive Cities Index.

The Index is being designed to benchmark and rank cities based on water sensitivity performance, to set targets based on the best available research, and compare potential management responses to make the most impact with available resources. It will be supported by a web platform with powerful visualisations that help to make the data digestible and practical for a range of audiences including policy makers, service providers and community. The application of the Index also relies on cross-organisational knowledge sharing and collaboration that will strengthen industry relationships with progress toward a shared vision. Breaking down silos and opening up communication channels will be part of the greater benefits that come with implementing the Index framework.

The Index is being developed and delivered in partnership with industry practitioners and tested through multiple phases of development. A prototype phase with two Melbourne councils has just been completed. The protoype index is now being revised for a city scale pilot to be implemented in 2015/16.

This paper will describe how alternative conceptual models for the Index have been evaluated and how the results of prototype testing have been incorporated into the latest version of the Index in preparation for city scale pilot testing.

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Session 1c

Project B5.1

A Review of the Policy Framework for Water Sensitive Urban Design (WSUD) in Five Australian Cities – Brisbane, Sydney, Melbourne, Adelaide and Perth

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The implementation of WSUD requires an enabling framework. In the planning context, the policy frameworks relevant to WSUD vary from State to State. Some have State-wide policies that have general applications, and others require State policies to be adopted by councils at a local level. In most States, councils are at the forefront of policy development which has led to varying approaches to WSUD and implementation at the local level.

This presentation provides an outline of key findings arising from literature reviews for WSUD policy frameworks in five Australian cities (Brisbane, Sydney, Melbourne, Adelaide and Perth), and considers possible opportunities for harmonising and reforming the WSUD policy frameworks within and across these jurisdictions.

The main issues emerging from the literature reviews are:

1. variation in the application of water quality targets as a key driver of WSUD policy frameworks. In some States water quality objectives derive from environmental legislation and have a binding status, whereas, in other States the water quality targets are 'recommended' or are applied in a discretionary sense;

2. that different States provide councils with varying degrees of autonomy in adopting and implementing WSUD policies. This arises because the legal status of WSUD policy requirements varies from State to State. In some States, there are State-wide performance standards and objectives that are applied generally , whereas elsewhere, State policy has to be adopted into a planning scheme and applied at the local level for it to take effect; and

3. the sheer volume of policy and guidance literature that applies in each State. In most States, planners need to navigate large quantities of policy and guidelines in dealing with WSUD policy which is often dispersed across a number of policy instruments. Project B5.1 considers whether this hinders or assists planners, and whether future policy development should seek to harmonise, consolidate and simplify policy framework, and provide cost-benefit data which is easier to access and better tailored for use by decision makers.

Session 2a

Case study

Managing the social and ecological values of Sydney's waterways

Cunningham, D. and Birtles, P.

Sydney Water

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Background and relevance

Sydney's iconic waterways provide a range of social, environmental and economic values that underpin the liveability of the city. But with increasing urbanisation and fragmented management, these waterways are under increasing pressure. Contemporary approaches view waterways as socio-ecological systems that incorporate interconnected values or services. This is particularly important when considering waterways from a community or customer perspective where qualities such as aesthetics and amenity are often seen as a priority. In order to protect and enhance Sydney's waterways Sydney Water recognises that it will need to play a changing role.

Results and Summary of key findings

A 2014 self-assessment of Sydney Water's progress along the urban water continuum found that it is transitioning from a "drained city" to a "waterway city". This transition aligns with expectations being revealed through customer and stakeholder research. In order to leverage the multiple benefits of a water sensitive city for its customers, a series of key challenges and opportunities have been identified.

Sydney Water is responding to these challenges and opportunities through its role in waterway management. As part of the planning for green field growth in the South Creek region, Sydney Water is envisioning the desired future social and ecological values and working to create these through integrated growth servicing plans.

Through its proposed waterway health capital program Sydney Water aims to improve the water quality and liveability of Sydney's waterways through WSUD. The outputs of the program would be new WSUD assets such as wetlands, rain gardens, bioretention systems and stormwater harvesting schemes retrofitted into highly urbanised areas. Delivery of these projects will rely on partnering, particularly with local councils, building capacity and ensuring aesthetic and social outcomes are also achieved.

Its recently completed Cooks River naturalisation is the first time Sydney Water has taken an alternative approach to the renewal of one its large concrete stormwater channels. The project saw 1.1km of deteriorated concrete riverbank removed and the banks laid back to a more natural slope stabilised with sandstone and over 100,000 native plants. The project sites include new pathways, seating, interpretive signage as well as the creation of a wetland and areas of saltmarsh. This approach to asset renewal is now being planned for several other deteriorated channels.

Discussion and application to industry

In the face of increased population growth and the densification of urban areas, understanding waterways as socio-ecological systems and applying this understanding from planning through to asset renewal it is possible to maximise the liveability benefits for today's communities as well as for those of the future.

Case study: Life-cycle assessment of Water Sensitive Urban Design

Dark, L.

Brisbane City Council

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Water Sensitive Urban Design (WSUD) including Natural Channel Design (NCD) has been established in Brisbane for well over a decade. However, there is limited documentation regarding lifecycle including quantification of benefits and costs. This project examined the lifecycle cost-benefit and performance of the Bowman Park, Bardon natural channel design project and Hoyland St Bioretention System in order to provide options, recommendations and direction for future use and management of natural channel design projects in Brisbane.

Bowman Park NCD essentially enhances 'nature' in the urban environment by delivering a range of health and wellbeing benefits, such as amenity, shade and ecological health. Bowman Park NCD is approximately 15 years old and there is no evidence that the system is nearing its end of life. This is likely due to key planning, design and construction elements, such as appropriately graded banks and the use of native vegetation to provide shade and leaf litter. The site essentially replicates a natural creek and, therefore, is not expected to have an end of life. The benefit to cost ratio is approximately 2 and, therefore, the system provides a high value for money to Brisbane residents.

Bowman Park NCD is currently delivering a range of benefits that outweigh costs compared to the previous concrete channel and it does not have an end of life replacement cost. Therefore, reinstating natural channels in place of concrete channels may provide a positive solution to ageing infrastructure in Brisbane.

Hoyland Street bioretention system is approximately 12 years old and there is no evidence that the system is nearing its end of life. This bioretention system is currently functioning well, as indicated by vegetation health and adequate levels of permeability of the filter media. The Hoyland Street bioretention system provides a range of benefits, including environmental and social benefits, such as sediment capture. The benefit to cost ratio is approximately 6 and therefore the system provides value for money to Brisbane's residents.

Session 3b	Project A2.3

Engaging communities in stormwater management

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Background and relevance

The transition to water sensitive cities requires broad community acceptance of changes in policy, practice and technology, which, in turn, will require effective community engagement. A critical first step in this process is identifying community perceptions about stormwater, and the policies and behaviours that aim to reduce stormwater pollution. This study explored community knowledge about stormwater, perceptions and awareness about individual and household behaviours to mitigate stormwater pollution, and perceptions about water sensitive urban design initiatives.

Results and Summary of key findings

A series of focus groups were held in six locations across Australia (Brisbane, Townsville, Perth, Geraldton, Melbourne and Bendigo). Focus groups were recruited via a social research company and reflected a representative mix of genders, ages and incomes.

When asked “what comes to mind when you see the word stormwater', most respondents reported concepts related to excess water, and flooding. Almost two thirds of participants reported either 'flooding', flash flooding', 'water from the sky', or pointed towards the impacts of flooding, with descriptions such as 'full gutters', 'overflowing pipes', 'blocked pipes', 'drains', water down the street' and 'leaks'. Only six of the 40 participants considered water quality issues with stormwater, and only 2 respondents mentioned impact on waterways.

Results also indicate that community members have limited awareness about household or precinct level strategies to minimise impacts of stormwater pollutants. Further discussion indicated that one of the challenges with raising awareness of stormwater issues was lack of visibility of the issue, and lack of visibility of effective solutions.

Discussion and application to industry

In Australian adults, knowledge and attitudes about stormwater may impact community acceptance of behaviour change and policy initiatives to manage stormwater pollution. Key factors identified that would leverage community support for stormwater management include: improved understanding of ecosystem benefits; continued maintenance of aesthetic values of urban areas; and overcoming perceived lack of relevance by linking stormwater impacts with daily lives of individuals. These findings will support ongoing research exploring effective ways to motivate communities in issues related to stormwater management.

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Session 2e

Project C4.1

Green grey-water infrastructure

Fowdar, H.[1,2], Prodanovic, V.[1,2], Schang, C.[1,2], Payne, E.[1,2], Hatt, B.[1,2], McCarthy D.[1,2], Cook, P.[2], Breen, P.[2] and Deletic, A.[1,2]

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Background and relevance

The multiple benefits of vegetation in urban areas are widely recognised. In densely built urban environments, where traditional greening systems cannot be used, new solutions are required. Green and Living walls can provide all the benefits, with the addition of space saving. However, these systems have a high water demand, and the cost of watering and maintaining these systems outweigh their benefits. If green and living walls could be developed to treat water sources such as greywater, these systems could be transformed into water producers rather than water consumers.

Green and living walls work in similar way as stormwater bifiltration systems. These systems, also commonly known as rain gardens or bioretentions, are successfully implemented stormwater pollution management tools. Their popularity stems from the ability to treat a wide range of pollutants, including nutrients, heavy metals, suspended solids, and pathogens (Bratieres et al., 2008, Chandrasena et al., 2012); a flexible design (Payne et al., 2015) and low maintenance. In terms of pollutant removal, whilst they perform effectively during wet weather periods, poor performance has been recorded during dry periods (Zinger et al., 2007).

It has been proposed to develop biofilters to treat other water types than stormwater (e.g. light wastewater) during dry weather, making them more robust and flexible. Such novel systems will, essentially, operate in dual-mode treating stormwater during wet weather and these other water types at other times. It remains a fact that the ability of biofilters to treat light wastewater needs to be identified in the first instance. A large scale laboratory column study was set up to investigate the treatment performance of biofilters subject to light greywater (discharges from washing basins, showers only) inflow. In an attempt to enhance the aesthetics appeal of these systems, nine ornamental plant species, including climbers, were tested for their effect on system performance. The columns are in their ninth month of operation as of July 2015.

The first step in optimisation of green walls for greywater purification is the selection of appropriate media, which would maximise pollutant removal. An extensive survey of potential media was conducted to identify eight different lightweight media types. The infiltration and pollutant removal capacity of these media under different loading rates and drying regimes were tested in a laboratory column study. Inflow and outflow water quality samples were collected on 11 occasions over a period of two months and analysed for nitrogen, phosphorus, oxygen demand, suspended solids and pathogens.

Results and Summary of key findings

Sampling results so far show promising biofilter potential for treatment of light greywater, particularly where nitrogen and BOD removal are concerned. Results show that the incorporation of ornamental plants such as Canna lilies, Boston ivy can still deliver good system performance. The results also confirm the vital role plants play in improving nitrogen and phosphorus removal. The results also identified two promising media types (coir and perlite) in terms of pollutant removal, but also showed that some medias were susceptible to clogging and physical stability issues. Further process study will look deeper into nature of pollutant uptake of these two media types, identifying main pollutant removal drivers. This will result in creation of optimal media mix for green wall application. The next stage of research will be designed to test pollutant uptake capacity of the plants, and there interaction with media and microorganisms. Results of that research should give provide preliminary green wall system design, capable of greywater treatment.

Discussion and application to industry

These studies will help to inform the practical adoption of living walls and green walls for greywater treatment, thereby alleviating wastewater disposal through conventional methods, promoting water re-use whilst creating more liveable, green cities.

The results of this study will also guide the design of a bioretention system incorporated as part of a living wall system for greywater recycling at the Monash Council's Eastern Innovation Business Centre.

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Session 2c

Case study

eWater's modeling tools — aiming to offer comprehensive Integrated Water Cycle Management (IWCM) solutions

Dey, A.

eWater Solutions

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Managing and assuring reliable alternative water resources is one of the key challenges in IWCM implementation. Most of the available water resources management tools have been developed for larger (regional) scale applications with limited applicability to small (allotment) scales. To achieve comprehensive IWCM goals, modelling capability is necessary at smaller scales, particularly given the rapidly developing landscape across Australia. In addition, most previously developed tools do not employ functions to measure ecological impacts. These cannot be ignored when achieving IWCM. Hence, a tool needs to be developed that would provide the ability to simulate all three urban water cycle service networks (water supply, stormwater, wastewater), ranging in scale from a single allotment up to large clusters or subdivisions. This tool must model both quantity and quality with options for efficient system optimisation.

eWater MUSIC is the water industry's standard tool to conceptualize, assess and manage stormwater quality. This tool supports stormwater harvesting modelling up to certain extent. However, optimisation among all alternative water sources is not available in MUSIC. MUSIC does not have any mechanism to generate the centralised or decentralised water demands. Urban Developer (UD) has been created in recent years in order to achieve the goal of IWCM. This is an integrated urban water cycle modelling tool that can simulate all these three urban water cycle service networks (water supply, stormwater, and wastewater), ranging in scale from a single allotment up to large clusters or small subdivisions.

UD has the capability to generate centralised and decentralised water demands based on the Behavioural End-use Stochastic Simulator (BESS). However, UD does not consider water quality and related ecological impacts. While both tools have their merits and limitations, however, their integration would offer a powerful tool for the comprehensive integrated solutions considering quantity and quality modelling with system optimisation of all available water sources.

At eWater we are aiming to develop a comprehensive small-scale Integrated Water Cycle Management (IWCM) modelling tool (MUSIC^{PRO}) that offers metrics that associate with the concept of liveability and its various surrogate measures. If the framework is being developed appropriately, MUSIC^{PRO} can be integrated with CRCWSC tools and other large scale models such as eWater SOURCE to achieve the ultimate goal.

Quality and Security: preferences for new sources of water supply

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CRC for Water Sensitive Cities

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Background and relevance

Centralised water supply is the primary mode of supply in Australia (ABS, 2013). Dams account for the bulk of supply (84% in main towns and cities in 2009/2010), but newer sources are gradually being added to the water supply portfolio, including desalination (2.8%) and recycled and stormwater (3.8%) (Productivity Commission, 2011:18). Communities in Australia are also beginning to install third pipes, which pump lower quality water to households for restricted uses (Productivity Commission, 2011). Australia is at a crossroads for meeting new demand with added capacity to the conventional system or by introducing alternative sources of supply. This research investigates household preferences for different water supply sources, controlling for the cost and quality of the new water source and the respondents' attitudes to risk.

We undertake a discrete choice experiment (DCE) with 981 homeowners in four councils in Victoria and New South Wales. Participants are asked for their preferred new source of water in the event that their city requires extra supply. The water supply options are desalination, recycled, new dam, groundwater, stormwater and water piped from outside the catchment. We control for the cost per kilolitre of new supply and its quality, which we describe as 'outdoor use only', 'limited indoor use' and potable. Respondents are told that they will not incur any connection or third pipe installations costs from receiving lower quality water.

Results and summary of key findings

Figure 1.1 shows the overall choices made by participants. A new dam is the most preferred source, followed by desalination, stormwater and recycled water. When controlling for water source and cost, respondents are indifferent between water restricted to outdoor use and potable water, both of which are preferred to limited indoor use.

A subset of the survey respondents participate in an incentivised risk game (Holt and Laury, 2002), that is designed to reveal their attitude to risk on a scale from 0 (risk loving) to 9 (highly risk averse), where 4 is associated with a neutral attitude to risk. Figure 1.2 summarises these results. For each water source (rows), the figure displays the predicted probability of someone choosing that source, given their level of risk aversion and demographics (columns). Holding quality and cost constant, we find that education, age, income and risk aversion are important drivers in selecting a preferred water source. In particular, we find risk averse people are more likely to choose sources of water that are more secure in a drought – desalinated and recycled water – and less likely to opt for a new dam, which is susceptible to water shortages. Younger, more educated, and wealthier respondents are more likely to choose stormwater and recycled water.

Discussion and application to industry

When it comes to the acceptance of new sources of water, we find a general reticence towards limited indoor use water, which can be utilised for toilets and laundry, but not for drinking. However, outdoor only water is generally accepted. Therefore, perceptions may need to be shifted before limited indoor use water is rolled out. When controlling for cost and quality, a concern among risk averse individuals appears to be security of supply, rather than health risks associated with recycled water. Given that people are risk averse on average (including in this study), it is important to include information about supply security in public communications about new supply sources. Greener water sources are seen more favourably by younger, more educated and higher income individuals. Thus, the demographics of an area can help predict the preferred new water source, which could help decide where to install new third pipes using stormwater and recycled water.

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Session 2a

Project A4.1

Evidence-based raingarden design to promote community acceptance

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Background and relevance

Raingardens are innovative and visible components of water sensitive urban design (wsud), which are fundamental to the water sensitive city (Wong and Brown 2009). Their retrofit to existing urban areas at various scales is critical for the full benefits of wsud to be realised (Weber et al. 2009), but it will also demand "major shifts in accustomed ways of life and neighbourhood aesthetics (my emphasis), a reversal of some of the modern trajectories 'baked in' to our existing water systems, and redefinitions of what counts as water infrastructure and the distinctions between private use and public responsibility" (Sofoulis 2005, p. 460). Community resistance to the different appearance of the water sensitive city might impede the widespread implementation of wsud, acting as a barrier to the realisation of the water sensitive city. We need to understand community perceptions of raingardens in order that we can design them to fulfil both technical and aesthetic functions. Anecdotes abound about community preferences for raingardens. What we need, though, is empirical evidence to inform raingarden design, grounded in science. This study provides that evidence.

Results and Summary of key findings

Survey data of 139 residents of eight suburban streets in Melbourne revealed attitudes that support harvesting and use of treated stormwater and the associated implementation of raingardens. Streetscapes with raingardens were generally preferred to those without. Most residents of streets with raingardens liked their street, and noticed the raingardens and liked them. Analysis of data describing residents' liking for their street and their suggestions for improving its appearance identified key attributes and elements of raingardens that should be considered in their design, to optimise community appreciation and enhance their acceptance. Context is critical. Once context is understood, decisions should be made about raingarden placement in the street, and its consequences, e.g. loss of on-street parking; plant selection, including use of trees; maintenance regime; and signage or communication strategies. Although the same attributes and elements should be considered in each raingarden design, context will determine specific details. Each attribute or element is likely to differ in different raingardens, dependent on context.

Discussion and application to industry

Evidence-based guidelines can be immediately and directly implemented in the design of raingardens in Melbourne specifically and the rest of Australia more generally, to advance their adoption and progress towards the water sensitive city. The principles underlying streetscape preferences of Melbourne-based communities reflect the results of other studies conducted in the United States and Europe (e.g. Kaplan and Kaplan 1989; Nassauer 1995; Gobster et al. 2007). In urban landscapes, people like controlled, manicured nature, with trees, green vegetation, and signs of human care. To optimise appreciation and acceptance of raingardens in a specific residential street, their design should reflect the context and landscape preferences of the residents, revealed in their own gardens, so that the raingardens can fulfil both technical and aesthetic functions.

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Session 2d

Case study

Using Big Data for network optimisation

Fernando, S. and Brooker, D.

Mackay Regional Council

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Background and relevance

In the recent past, Mackay registered some of the highest population growth rates in the country. With growth comes an increased demand for services, and finding the right balance between meeting community service expectations while maintaining tariffs at reasonable levels, has proven to be challenging. One major aspect of this challenge for Mackay Regional Council has been to identify how to efficiently and effectively manage the region's existing water & sewerage infrastructure and to meet the growing needs, without having to invest millions in new infrastructure.

A key element of responding to this challenge was the Water and Sewerage Network Optimisation Project (WSNOP), which commenced in early 2011.

Results and Summary of key findings

The sensors deployed initially were in the form of automatic water meters readers (AMRs). The AMRs were deployed on all customer meters (used for billing) as well as on network meters (supply and DMA meters). These AMRs provide hourly consumption data, which has resulted in the following:

1. Much better understanding of the adequacy of the existing network capacities to cater to current demand patters.

2. Ability to segment customers based on usage patterns and create customised communications for a range of micro segments, significantly improving the effectiveness of the demand management communications.

3. Early detection (with 2-3 days) of customer leaks and automated alerting, resulting in a significant reduction in water wasted through leaks. Minimising of leaks also reduces the demand on treatment capacity.

4. Opportunity to provide detailed consumption information to customers (through a website - see www.myh2o.qld.gov.au - as well as on mobile devices, with functionality built into the MDM system), empowering customers to make more informed decisions about their water consumption,

5. Detection of network losses through water balancing at a DMA level (generally 1-2 suburbs, no more than 2000 metered properties). Prior to the project Mackay was experiencing network losses in the region of around 15-18%.

As a second stage, sensors were also deployed to monitor sewer levels at selected manholes. Along with the sewer sensors, rainfall sensors were also deployed at a “catchment” level .

The level information provides early warning of potential sewage overflows, enabling crews to move from reactive rectifications (i.e. clean-up) to proactive preventions. These early warnings have resulted in reducing environmental impacts of overflows, especially in dry weather situations.

The level information collected during wet weather events, coupled together with rainfall information and ground water levels, have provide valuable insights in to the inflow and infiltration patterns, enabling inflow and infiltration prevention resources to be deployed in a much more efficient manner.

Sewer monitoring is still as a trial stage with around 100 manholes being monitored. It is expected that this will be expanded to around 500 - 100 manholes in the next 1-2 years.

Discussion and application to industry

Water Service Providers can achieve significant operational savings and more importantly reduced capital investments by obtaining more granular consumption pattern data.

Session 2f

Science-policy case study

Making potable water reuse palatable to politicians: learnings from a science-policy capacity building workshop

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[2] *Monash University, CRC for Water Sensitive Cities*

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Background and relevance

At a recent CRCWSC Science-Policy Capacity Building Workshop our group of researchers was given the challenge of devising and 'selling' a policy to enable reuse of alternative water sources for drinking water production to an Australian state government. In our view this policy proposal was primarily about managing risk in a Water Sensitive City. In particular, managing the risk that Australian water supply systems will be adequate, resilient and affordable into the future. Our argument was that the best way to manage this risk would be by allowing water utilities to consider all appropriate sources and available technologies, including direct potable reuse, to meet future demand for drinking water. Undertaking this exercise and the feedback we received highlighted some of the approaches that could be successful, as well as some of the potential pitfalls that need to be avoided in attempting to 'sell' such a policy proposal.

Results and Summary of key findings

Key learnings from undertaking the exercise were that:

1. It is essential to have a clear policy proposal and a set of considered and well grounded recommendations for the government to implement.

2. It is best to concentrate on highlighting the benefits and/or the risk management opportunities of the proposal. These opportunities include:

    a. Preventing future cost blow outs generated by investing in over-priced 'emergency' solutions (e.g. desalination plants), where alternative options are no longer "achievable".

    b. Not being locked into long-term sub-optimal solutions, such as non-potable (purple pipe) supply systems, which do not necessarily have the best long-term cost and risk profile.

    c. Being able to build resilience into the supply system by having diverse supply options.

    d. Providing potential commercial opportunities for Australian businesses as pioneers of new technologies.

3. However, it is also important to be aware of the risks inherent in the proposal and to be able to offer informed and pragmatic solutions to address these when challenged.

4. Having credible economic data to support the policy proposal makes the case for change stronger.

Discussion and application to industry

Multi-disciplinary learning opportunities, such as this exercise, are a valuable way for researchers from disparate CRCWSC projects to come together and attempt to translate research findings into real world outcomes.

Session 3b

Case study

Recent advances in Water Sensitive Urban Design (WSUD) in Brisbane City Council

Gibson, M.R.

Brisbane City Council

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Brisbane City Council (BCC) has been working on advancing Water Sensitive Urban Design (WSUD) designs with a long term objective of creating a more sustainable, resilient and liveable city. Recent projects undertaken have provided excellent insights into future directions and possible better outcomes for Brisbane. This presentation focuses on two types of these projects.

The first of these project types focus on "street trees" which incorporate the principles of WSUD. The traditional street tree planting design in BCC (i.e. without kerb connection or underdrainage) is evolving into a more sustainable approach, which provides increased nutrients to street trees, promotes growth, increases resilience, reduces pollutant levels in stormwater and reduces watering costs . Street trees provide shade, reduce urban heat island effects and increase human comfort. BCC is keen to integrate WSUD into its street tree projects and capital works schedules.

This paper documents BCC's current technical knowledge and practical application of street tree infiltration pits in Paddington and Dutton Park and suggested improvements to WSUD techniques.

The second project type are titled "Creek Filtration" projects. Creek Filtration projects were conceived as a four-year trial of a range of WSUD systems aimed to enhance waterway health in four of Brisbane's major catchments. The creek filtration systems essentially are works which divert stormwater from pipes and remove pollution before the stormwater enters the creek.

The filtration systems remove sediment, nutrients and heavy metals via plant uptake, deposition and infiltration. Stormwater enters the creek much cleaner than when it was in the pipe. This helps to improve waterway and bay health.

The creek filtration projects have be written up in numerous news articles, journals and news reports and have won a number of awards including the:

- Lord Mayor's Award for Excellence in Environmental Achievement (2014)
- Healthy Waterways – Urban Renewal Award (2014); and
- Stormwater Queensland - Excellence in Integrated Stormwater Design Award (2015).

The paper will present some of the lessons learned from the design, construction and maintenance of these new WSUD treatment systems.

Closing plenary

Keynote

Developing a concept of social-ecological-technological systems to characterize resilience of urban areas and infrastructure to extreme events

Grimm, N.B.

Arizona State University

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Climate change is widely considered one of the greatest challenges to global sustainability, with extreme events being the most immediate way that people experience this phenomenon. Urban areas are particularly vulnerable to these events given their location, concentration of people, and increasingly complex and interdependent infrastructure. We are developing a conceptual framework for urban social-ecological-technological systems (SETS) that will allow researchers and practitioners to assess how infrastructure can be resilient, provide ecosystem services, improve social well being, and exploit new technologies in ways that benefit all segments of urban populations.

The framework integrates the three domains of social and equity issues, environmental quality and protection, and technical/engineering aspects, to form a concept of infrastructure that occurs at the intersection of the domains. Examples show how the more common socioecological systems and socially sensitive engineering approaches that fail to incorporate the third dimension may elevate vulnerability to climate-related disaster. The SETS conceptual framework bridges currently siloed social science, environmental science, and engineering approaches to significantly advance research into the structure, function, and emergent properties of SETS.

Extreme events like heat waves in Phoenix, coastal and urban flooding in the wake of superstorm Sandy in New York, NY and following hurricanes in Miami, FL; drought in Hermosillo, Mexico; and urban flooding in Baltimore, MD, Portland, OR, San Juan, PR, Syracuse, NY, and Valdivia, Chile provide examples of the impacts of and vulnerability to extreme events that demand a new approach. The infrastructure of the future must be resilient, leverage ecosystem services, improve social well being, and exploit new technologies in ways that benefit all segments of urban populations and are appropriate to the particular urban contexts. These contexts are defined not only by the biophysical environment but also by culture and institutions of each place. Ultimately, the SETS conceptual framework will be applied to nine western hemisphere cities in diverse settings to test hypotheses about the relative efficacy of strategies for resilient SETS infrastructure in cities contrasting in event type, biophysical setting, and cultural and institutional contexts.

Session 2b

Case study

Liveability in Western Sydney and the new Australian Dream?

Hoban, A., Birtles, P., Tippler, C. Shoo, B., Davies, P., Wright, I.

Bligh Tanner Pty Ltd

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Western Sydney could be Australia's largest case study in the application of water sensitive cities principles to new green field development.

Western Sydney is one of Australia's major urban growth corridors. The plains between Blacktown and the Blue Mountains are expected to become home to an additional one million people over the next twenty years, along with 4,500 hectares of commercial and industrial employment lands and Sydney's new airport.

The growth areas are almost wholly within the catchment area of Sydney's longest freshwater creek - South Creek. The transformation of a majority of the 630km^2 catchment from peri-urban, pasture and market gardens to an urbanscape will radically change South Creek's form and ecology.

Urbanising the catchment means water and wastewater services will need to be provided and stormwater and flooding managed. Considerable capital will be invested by Sydney Water, local councils and developers in delivering these essential services. The liveability outcomes delivered through these investments will vary significantly dependent on the water servicing approach.

We have applied research into livability (CRC Water Sensitive Cities), wellbeing, place-making, geomorphology, aquatic ecology, water cycle strategies and adaptive leadership (seeking to distribute, rather than concentrate, responsibility and ownership).

A workshop was held in early 2015 to explore issues affecting the South Creek catchment and to understand the implications of various future scenarios. Ideas from that workshop have then been developed into three scenarios for the catchment, which have been translated by an urban designer into 3D imagery to help facilitate further engagement and discussion.

This work is helping inform the Western Sydney Strategic Servicing Plan.

Session 2e

Project C1.3

Pathogen removal by biofilter for greywater reuse — its potential and future direction for fit-for-purpose water production

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CRCWSC for Water Sensitive Cities

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Background and relevance

Biofilters have been successfully adopted for stormwater treatment due to their simple integration within urban landscapes and removal capacities for nutrients. Treated greywater would bring considerable reduction of household scale potable water demand and the concurrent generation of domestic wastewater. As of our knowledge, there are studies of greywater treatment focusing on pathogen removal with sand filters or its modifications (Dalahmeh, Jönsson et al. 2014) but not with biofilters yet. Biofilters in our study is designed for household scale and green wall in the urban setting, treating a few litres without taking too much space at low energy input. Moreover, biofilters in our study included climbers and small plants which are aesthetically beautiful as well as having excellent function. Therefore, our current research is one of most extensive biofilter studies for greywater reuse specifically focusing on treatment of greywater-borne microorganisms including faecal indicator organisms.

Results and Summary of key findings

80 biofilters consist of 5 replicates of 16 different configurations by plant species, presence of antimicrobial media and electron donor and type of saturated zone. As an antimicrobial media, copper coated zeolite was chosen based on its successful performance in the long-term stormwater biofilters (Li 2014). We have been monitoring E.coli removal for 8 months with synthetic greywater at high/low volumes, dry and wet period. Simultaneously, we are collecting samples for metagenomics to understand the microbial community changes by time, different dosing conditions and biofilter configurations. All matured biofilters show above 2.8 log removal of E.coli (median value of 3.2) as faecal indicator bacteria after 8 months of dosing greywater every day (Figure 1). Compared to other stormwater study, current greywater log removal is higher (Chandasena, Deletic et al. 2011, Chandrasena, Pham et al. 2014). Figure 2 shows increasing log removal by the time, which indicate as the removal mechanism is related to system maturity.

Discussion and application to industry

The results are promising for microbial removal but as well as other micropollutants removal such as N, P, BOD and TSS so far. Moreover, the antimicrobial media in the biofilter has shown additional removal compared to sand media and some plants are doing better than the others. Likewise, we will assess which design factors and mechanisms are most dominant in microbial removal by comparing the results statistically and linking with microbial diversity. Especially, mechanisms of microbial removal have not been fully understood in the biofilter even though there are many possible mechanisms such as predation by other microbes, competitions, natural die-off and adsorption. At the moment, we have collected data for E.coli removal as faecal indicator bacteria. However, from next sampling other pathogen data will be analysed and this will be the first study of using biofilter for greywater pathogen removal. Our study is expected to provide extensive information of biofilter performance for pathogen removal and be utilised to extend the usage of biofilters in greywater beyond stormwater reuse.

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Session 2f

Science-policy case study

Service portfolios to maximise urban water value

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Background and relevance

A major challenge for water service providers, and related urban planners and regulators relates to how to maximise urban water cycle outcomes (value per unit cost). Increasingly there is a need to position utility actions and strategies as making contributions to city-wide targets. Such targets are progressively being integrated across domains of the water cycle (water supply and security, wastewater and stormwater), and also for energy and greenhouse gas emissions, protection of natural systems and human liveability.

This paper summarises a science-to-policy plan for governments to initiate actions that help achieve city-wide targets; by incorporating recent science to position water utilities as an active contributor to these outcomes through their water service delivery and management activities

One driver for the work is that centralised systems have sunk costs and spare capacity that suggests marginal growth in demand can be achieved cheaply using a business as usual approach. But experience and research? Shows that augmentation of such systems is expensive and political. Additionally, customers' costs across many essential services (eg water, energy) are rising and there are opportunities for water management and financial cost-benefit at a range of scales simultaneously: from households to cities. Incorporating energy considerations into water supply options can help find least-cost solutions. With a growing centralised network and postage-stamp pricing, opportunities for local scale alternatives will are emerging to profit from spare system capacity and unused, or under-utilised resources. These opportunities are likely to be seized by third party entrants. New business models and governance frameworks are necessary to enable utilities to capitalise on these opportunities to grow improved service options.

Results and Summary of key findings

There is a need to develop future integrated water visions and processes which:

- engage policy, community and stakeholders more proactively in the development of long-term plans and give certainty to stakeholders and builds towards supportive governance arrangements
- proactively manage long-term the supply-demand balance for multiple benefits.
- reduce costs per unit value for consumers. This can be achieved by providing urban water services, including water supply, wastewater treatment, waterway and drainage services, that are delivered in an integrated manner across utilities and councils,
- position utilities as an active contributor to city-wide action to improve liveability, build resilience and respond to climate change.
- reduce exposure to rising energy costs of water and climate variability, improve system resilience, and customer self-reliance.
- protect and enhance natural assets within the city, specifically waterways and vegetated public open space, and improve connections between cities and their supply catchments and regions.
- improve knowledge and information on the wastage of water from currently poorly designed urban spaces and systems, and take advantage of these flows for improved urban futures.
- provide a first to market advantage through leadership and innovation in products and services offered to customers.

Improved connections of utilities to city and planning development (eg via total water mass balance analysis, understanding energy implications, and supportive reporting and management) adds value to existing supply-demand balance and utility performance indicators. A staged series of collaborative trials across service delivery, policy and regulatory stakeholders is argued as a critical path to finding new solutions for urban water strategies that contribute broader liveability outcomes.

(Continued)

Discussion and application to industry

There are three key initiatives identified as necessary to implement a staged approach to new service portfolios:

1. Development of a collaborative vision, strategy and targets that move beyond single sources and towards a suite of objectives, within a mass balance framework focussed on the performance of the city, and the role that water service providers can play within those targets.

2. Outlining the role of the utility in delivering city-wide outcomes, together with the business case based on the water cycle and other benefits (or costs) that can be achieved (including energy and greenhouse gas impacts).

3. A series of pilot projects or programs to demonstrate the services, quantify benefits, and build support from stakeholders including regulators, community, and the water sector.

Several strategic principles underpin this expansion of the services portfolio:

- A move away from past technology/asset driven approach of focusing on reusing a percentage of wastewater (as recycled water) to an outcome target (e.g. potable substitution from any source)

- Services offered may include recycled water, stormwater, energy or other resources, and in-home initiatives to manage energy and water budgets

- A mass balance approach to identify and assess options, outcomes and benefits across the water cycle (for example energy and biophysical outcomes

Development of a service expansion strategy represents a distinct move away from single, highly-optimised services. It goes beyond business as usual, and will therefore challenge certain aspects of utility's business operations, the policy and regulatory environment, and customer expectations. As such, an implementation strategy will need to be collaborative to test the regulatory and policy settings and market for the proposed services. Success is expected to depend on:

- Technical feasibility
- Cost effectiveness within potentially new business models
- A market for services (i.e. community acceptance)
- Political and policy maker acceptance
- Regulator acceptance
- Internal organizational acceptance and capacity building

Session 2f

Project A3.3

Capacity-building for science-policy interactions

Laing, M. and *Wallis, P.*

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CRC for Water Sensitive Cities

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Background and relevance

Research conducted by Project A3.3 has established that the most problematic bottleneck preventing good science from becoming good policy is the traditionally weak representation of scientific voices in key translation and advocacy spaces, and poor performance of research organizations in formal and informal processes through which policy is made (see A3.3's Science and Policy Influence: A Literature Review). Ameliorating this situation requires investment in a wide range of areas, but few are more important than fostering strong policy entrepreneurs from the scientific sector who can readily transition from research to policy contexts, and just as importantly effectively translate and communicate research into the language of policy and politics.

To this end, in July 2015, a pilot science-to-policy capacity-building workshop was held by A3.3 in which thirteen CRC researchers in four teams were charged with developing a 'policy pitch' based on their research that would: a) be presented to panels of current and former decision-makers from politics and industry for discussion and critique, b) be used as a basis for communications training with a professional media training group, and c) be part of a general discussion in light of political and policy, rather than scientific, imperatives. The workshop was framed as an action research inquiry to improve further science-policy capacity building initiatives.

Results and Summary of key findings

The workshop confirmed some of the findings of our research, for example while decision-maker panels were generally very receptive to the vision and broad mission of the submitting teams, there was a gap between the information decision-makers needed and the information scientific teams were able to provide. The submission teams engaged in robust discussions with their panels, but often struggled to translate the consequences of their research in policy terms. However, media training experts found the vast majority of participants to be of a higher standard than most groups that undergo media training.

Overall the majority of participants reported that the workshop improved their ability to influence policy and gave them valuable experience in communicating their research to politicians, industry and government. Some reported having too little time to prepare or that they felt like they were being thrown in the deep end, which reduced their confidence. Recognising that it was a pilot, the majority judged the workshop to have been successful. Recommendations were given for designing future events, such as engaging more with policy practitioners in developing the pitches, and providing additional time and guidance to participants.

Discussion and application to industry

Improving the capacity of scientists to translate their work and effectively communicate its significance to political and industry stakeholders is a vital and ongoing task.

Some of the problems revealed speak to broader problems the scientific community faces. For example, though all participants agreed that the task of translating science into policy was vitally important, few were able to dedicate sufficient time or attention to preparation for the workshop to achieve the desired level of buy-in from the scenario panels. Other issues, such as protecting scientific credibility whilst operating as policy advocates, continue to be important debates for the CRC beyond a workshop setting.

However this and future workshops are one way to create more spaces and more imperatives for scientists to take their work beyond a research or university setting, and goes hand in hand with some of the practice-orientated capacity-building exercises such as synthesis workshops.

Session 2e

Project C1.2

Human health hazards in Australian urban stormwater runoff

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[4] Advanced Water Management Centre, The University of Queensland
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Background and relevance

Reusing stormwater runoff will enable communities to strengthen their resilience to meeting water supply needs. As populations grow and climate patterns water supply managers and property developers are under increasing pressure to develop a suite of tools to meet changing water supply demands. Understanding the human health hazards associated with differing water supplies is a critical foundation step in developing a water supply strategy that ensures protection of public health for all exposure scenarios. The water quality characteristics of urban stormwater runoff in Australia are considered likely to differ somewhat from data previously described in the literature, much of which relates to stormwater conveyance systems in Europe where stormwater and wastewater are combined. To develop stormwater reuse schemes that provide fit-for-purpose water it is first necessary to understand the range and concentration of contaminants of human health concern in stormwater at the point of capture. Ninety-four samples of untreated urban stormwater runoff samples collected during rainfall events across 10 diverse catchments were analysed to identify potential chemical and microbial human health hazards.

The catchments were a mixture of commercial, industrial, residential land uses in temperate, sub-tropical and Mediterranean style climates. Samples were collected from: within the stormwater drain, waters that receive stormwater and at the inlets to wetland treatment systems to be representative of the broad range of capture locations stormwater reuse schemes may utilise.

Results and Summary of key findings

Chemical analyses focused predominantly on groups of contaminants present in the dissolved phase such as metals, nutrients, and hydrophilic trace organic contaminants such as pharmaceuticals, pesticides and endocrine disrupting chemicals. Some pharmaceutical and personal care substances were found above the limit of quantification (LOQ) with varying frequency and only one substance exceeded the guideline values listed in the AGWR-ADW (NRMMC, EPHC, & NHMRC 2008), which is caffeine. Of the 35 pesticides measured many were never found or only rarely found above LOQ (0.01 ug/L for most substances) with the maximum values of those found being at least 1% of their respective AGWR-ADW guideline. Endocrine disrupting chemicals that were detected (nonylphenol, 4-t-octylphenol and bisphenol A) were found to be considerably below their respective guideline values stated in the AGWR-ADW (NRMMC, EPHC, & NHMRC 2008). In-vitro bioassays were conducted for six biological endpoints, targeting different modes of toxic action: non-specific toxicity, phytotoxicity, dioxin-like activity, estrogenicity, genotoxicity and oxidative stress. For most of the tests applied, the toxicological burden of concern in untreated stormwater is in the range of a well-treated secondary effluent. Microbial analyses focused on faecal indicator bacteria (FIB), pathogenic bacteria and viruses and human biomarkers. Faecal indicator bacteria were consistently detected in all stormwater samples regardless of the catchment. Presence of waterborne pathogens varied a lot depending on the catchment site and on the stormwater event within the same catchment. However, high intra-site variability and inter-site variability was observed for both FIB and pathogens.

Discussion and application to industry

Untreated stormwater was found to be in principle a suitable and well treatable water source for a range of applications. Water quality data from chemical, toxicological and microbial analyses suggest the presence of sewerage ingress into stormwater occurs more frequently than generally perceived in these catchments with separate storm sewer systems. To protect human health, treatment of stormwater is recommended prior to reuse. Pre-characterisation of water quality in each site is recommended; the level of treatment required for a scheme will be different in each site and will vary dependent upon water quality characteristics and the end use exposure scenario.

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Session 1d

Project A1.1

Hedging supply risks: an optimal water portfolio

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CRC for Water Sensitive Cities

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Background and relevance

Water scarcity is increasingly problematic due to the demands of growing populations and climate change. As municipalities look to invest in new sources of water, it is important to account for the supply risks and costs associated with each of these sources.

Flows of water into both reservoirs and stormwater harvesting systems are weather-dependent. However, because of differences in scale, harvesting technique and location, the supply risks are not identical for both sources. In comparison, the flow from treated wastewater and desalinated seawater is independent of rainfall. It is therefore possible to hedge the supply risks between these different sources of water supply. This is akin to constructing an optimal finance portfolio (Merton, 1969) where the risks of different investment opportunities are assessed and hedged.

Results and Summary of key findings

We construct a stochastic model to determine the optimal contributions of different water sources to the overall water supply portfolio. The model accounts not only for supply risks but also for dam levels, as well as the supply costs associated with each source (see Table 1 for an overview). The supply risks are estimated by observing historical volatility of rainfall and reservoir inflows.

The model is applied to Melbourne's water supply system. This water system relies primarily on reservoirs, making it comparable to that of many other cities around the world. Melbourne's water system came under stress during a major drought that took place between 1997 and 2009, which led to a large investment in seawater desalination.

Optimal supply portfolios were derived for three conditions of the water system:

1. System in crisis: represents the supply conditions under Australia's 'Millennium Drought'
2. Average system: represents 'normal', long-run water supply conditions
3. Vulnerable system: represents an intermediate, vulnerable water supply situation

Discussion and application to industry

Figure 1 compares the actual contributions of each water source to the optimal contributions based on the model. These results show that:

- Important risk hedging opportunities between the naturally occurring water sources exist in all scenarios
- A desalination plant of half the current capacity would be sufficient in drought years, while no contributions from desalination are required under the normal or intermediate scenarios.
- The optimal share of harvested stormwater is fairly constant across the three scenarios, at between 11% and 14% of the total water supply.

A comparison of the total costs of supply from the observed and optimal portfolios revealed potential cost savings of between $43 million and $463 million per year depending on the scenario.

These findings suggest that future investments in Melbourne's water supply should target rainfall dependent sources of water ahead of rainfall-independent sources.

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Session 3b

Project A2.1

The new normal: changing domestic water use habits after drought in Melbourne, Perth and Brisbane

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CRCWSC for Water Sensitive Cities

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Background and relevance

One of the major challenges in the move to water sensitive cities is to change everyday water use habits in Australian households. This paper provides an insight into the distinct water cultures in different Australian cities and how residents have responded to water scarcity and drought and their commitment to gardens and showers. The paper reports on findings from focus groups with 62 people and summary information from the national survey (N=5194). We suggest options for industry and government to build the social conditions for change in the diverse urban locations of Melbourne, Perth and Brisbane.

Results and Summary of key findings

Melbourne, Perth and Brisbane have distinct environmental, geological, social and cultural attributes. All three cities have experienced drought, to varying degrees, over the past 15 years and each city has responded differently. Water restrictions and climate changes have impacted on people's everyday lives in varied and profound ways.

Melbourne participants described a sense of water crisis during the drought but since the drought has broken they no longer feel the sense of crisis so acutely. However, the changes they made have largely been continued and people have become more water conscious. Participants acknowledge that they have not returned to their pre-drought water habits, they continue to conserve water albeit in different ways than those imposed during the drought. Brisbane participants experienced unprecedented water shortages during the drought but have recently experienced substantial floods so many feel the city now has a problem with too much water. Their water habits have changed showing a mixed picture. On the one hand water is understood to be finite resource in response to the drought but the need to conserve is less pressing now water is abundant. Perth's drying climate has been addressed by technological solutions including the construction of two desalination plants and reliance on ground water and aquifer recharge which has seemingly mitigated any palpable sense of crisis. Perth participants see themselves as water savers but describe heavy water use habits – particularly in the garden and in showers. The national survey data show that Perth residents, in contrast to Melbourne and Brisbane, do not believe that others in their community make efforts to save water (Figure 1).

Illustrative quotes

Substantially reducing water use would be difficult but people would adapt

> *"If it happened and everyone had to, of course we'd all get used to it. It would just be how you lived and you'd forget you knew any different but there would be a kind of yucky transition period I guess."*
>
> (Vicky, Melbourne Focus Group)

The new normal after restrictions:

> *"I think a lot of the tactics they tried to get you to employ while the drought was on have just become habit for people. Turning the tap off when you're brushing your teeth, you know, I was doing that every day… I make a conscious effort. I look at the level of the dams almost daily in the paper and I still turn the tap off when I brush my teeth. It just becomes second nature."*
>
> (Oliver, Brisbane Focus Group)

Discussion and application to industry

The research demonstrates that context is important in encouraging people to become water sensitive citizens. Geographic location, climate and policy responses all have an impact on everyday water habits. Our research has found that water use habits can and do change in response to crisis but post crisis (when the drought has broken or technology has solved shortages) habits can partially revert. Our findings illustrate that Australians are open to changing their water consumption patterns and willing and able to adapt to water regulations/restrictions once they are firmly convinced of the need for change.

Session 3a

Case study

Embedding water sensitive thinking in councils

Morgan, C., Markwell, K. and Boer, S. (Lloyd, S)

E2Designlab

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Background and relevance

This paper reflects on the learnings from the development of the water sensitive Maroondah and water sensitive Darebin strategies (two municipalities in metropolitan Melbourne). The strategies, led by the councils and developed in collaboration with local partners, set visions for a resilient, green and sustainable cities, where water management underpin broader liveability aspirations. Both strategies seek an integrated approach to water management and to urban greening, seeking to address local flooding issues, improve waterway health, and increase use of alternative water sources to support a lush and green environment. The paper explores key techniques used to ensure stakeholders within and outside council are 'bought in' to the vision, and that an action plan is in place to deliver both structural and non-structural change.

Results and Summary of key findings

An important aspect of the development of the strategies was the consultation and engagement process which brought together a full cross-section of council departments to identify barriers to communication and stumbling blocks in delivery processes. The creation of a pro-active water sensitive culture was just as important as the development of the understanding of the physical opportunities for change. A comprehensive action plan was developed for each of the strategies key outcomes, by utilising an assessment of six key transition factors drawn from emerging CRC research into transitions:

- Council leadership
- Roles and responsibilities
- Communication processes
- Knowledge and training
- Demonstration and innovation
- Challenge and ongoing improvement

Sitting behind the documents, is a more detailed toolkit for council use, designed for a working group to use to prioritise projects and monitor progress towards the key targets. These actions plans explicitly use the transition factors to ensure all essential elements are covered to allow the council and its municipality to move towards its water sensitive city vision.

Another key aspect of the Maroondah strategy was the development of a tailored communication document for all audiences, including a narration of a walk through Maroondah in 2040. The development of clear messages in an up-front document was key to internal and external engagement with the strategy.

The presentation will share the methodology used to develop the strategies, key successes and learnings, and recommendations for cross-council engagement and development of local integrated water management plans.

Discussion and application to industry

The methodology and consultation techniques developed as part of these two strategies are directly transferable to any council developing and integrated water management or water sensitive city strategy. Aside from the physical analysis of the water cycle, the consistent challenge in driving delivery of a new approach in councils is gaining support and momentum. The engagement and consideration of cultural and procedural transition needs was a key element of the success of these strategies.

Session 1c

Project A3.2

How to create better regulatory frameworks for Water Sensitive Cities

McCallum, T. and Boulot, E.

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Background and relevance

Adopting innovative technologies and new practices in the management of urban water offers the chance to make our cities more sustainable, resilient, productive and liveable. Yet current regulatory and risk allocation frameworks have been said to be key impediments to the wider adoption of such technologies and practices. We have undertaken a comparative review of urban water regulation across three contrasting Australian cities (McCallum and Boulot 2015) to better understand how these regulatory frameworks impact upon urban water innovation. From this research emerge some pointers about how Australian governments could create regulatory frameworks that better support and encourage the development of Water Sensitive Cities.

Results and Summary of key findings

What do we mean by regulatory frameworks? Regulation includes legal rules, but also includes other tools aimed at deliberate behaviour change, such as codes, guidelines and economic incentives. A regulatory framework is the web of these tools that surround a particular area of endeavour. Regulatory frameworks relevant to urban water seek to meet multiple, potentially competing, policy objectives in areas as diverse as public health, environmental protection, water security, urban amenity and consumer protection. No wonder regulation aimed at urban water management is often highly complex and can occasionally be contradictory in terms of desired outcomes.

Have you ever wondered why sensible innovations are thwarted by legal rules? Across Melbourne, Perth and Brisbane the current regulatory frameworks and institutional arrangements have been shaped in response to a conventional model of urban water management and service delivery. Yet these very frameworks and institutional arrangements may now be impeding innovation. For example, our institutional arrangements are not integrated across the water cycle and our legal definitions of water do not fully capture the variety of potential sources available for exploitation.

Can regulation be your friend? We are beginning to discover that restrictive regulation is not as significant a barrier to innovation as are gaps within existing regulatory frameworks. In the absence of specific regulation, discerning the allocation of legal risk under the background law may be extremely costly and time- consuming. This is likely to operate as a significant disincentive to innovate. Enabling regulation can play an important role in providing certainty and lowering transaction costs and may also allow the risks of the new practice to be specifically allocated, and potentially shared, in more desirable ways.

What may be the greatest challenge and how could we solve it? Significantly we have also observed that the economic incentive to innovate in urban water service provision is currently very weak. Governments could do much to strengthen the enabling environment for innovation by using regulatory levers to target specific negative externalities around land development and stormwater management.

Discussion and application to industry

Our research identifies the extent to which regulation in Australia may be acting as an enabler to innovation, so that this role may be more widely encouraged and adopted. We also identify where regulation may be acting as an impediment to innovation, to enable innovation to flourish through the removal of such impediments. Our findings are intended to inform the policy debate about how best to reconfigure regulatory frameworks across Australian cities to better enable Water Sensitive Cities to develop.

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Session 3a

Project D4.1

Transformation and development – capacity building to deliver Water Sensitive Cities across Australia and the global south

McIntosh, B.S.[1,2], *Pathirana, A.*[2,3], *Orams, P.*[1,2], *Verbeek, W.*[2,3], *Wegener, P.*[1,2]

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Background and relevance

While as a concept WSCs were largely conceived in relation to first world and particularly Australian cities, it is equally important and relevant to apply the principles to the developing world – the global south. For developed cities like those of Australia, successful delivery of WSCs will occur as a consequence of the capacity of the organisations responsible for managing water, water services and urban planning to innovate. In contrast particular challenges are encountered when introducing WSC aims and practices to so-called secondary cities due to the high rate of their often uncontrolled urban development. However, those same circumstances also provide great opportunities. Whilst in Australia the WSC challenge can be framed as being one of innovation and transformation of existing infrastructures and services, in order to embed WSC outcomes into broader global urbanization processes, it is crucial to turn the secondary city challenges into opportunities.

Results and Summary of key findings

Work by the CRCWSC (McIntosh et al. 2015a) has revealed the primary skills and knowledge needs across the Australian urban water sector for the successful delivery of water sensitive city outcomes as being related to economically justifying new approaches. In particular, for the local governments who operate at the front line of urban transformation, the need to develop greater skills in constructing and using business cases to secure commitment to and funding for water sensitive projects and programs is critical.

Further work by the CRCWSC (McIntosh et al. 2015b) has demonstrated that Australian urban water sector professionals prefer to learn through face-to-face approaches potentially blended with online delivery, that only a few days of face-to-face contact is feasible in terms of time and money, and that real life case studies and problem-based learning are key. This set of learning preferences presents some challenges to but also opportunities for delivering effective skills development for WSC projects and programs – opportunities to utilise blended, problem-focussed and work-based approaches to professional learning.

For secondary cities, the skills and knowledge needs results suggest a using similarly problem-focussed and work-based approach to capacity building. First of all, in secondary cities basic infrastructure is sometimes missing or is unevenly distributed over the city meaning that authorities are grappling a need to adapt and integrate WSC thinking with development practice and the building more 'traditional' capacities (e.g. asset management etc.). Secondly, due to the limited experience of especially local authorities in the integrative aspects of WSC, many of them can benefit from a 'learning-by-doing' approach – learning organised around projects or case studies.

Discussion and application to industry

Being able to develop and use business cases to generate support for innovative projects and programs which act to transform urban form, stormwater management and water supply lies right at the heart of the WSC capacity needs of Australian urban water professionals. Introducing WSC concepts to secondary cities has the potential to assist economic and social development processes by through more sustainable and integrated forms of urban water cycle management. Further, due to their rapid expansion many secondary cities are currently experiencing, commercial opportunities are available to Australian industry, particularly across Asia. Yet, these require tailored approaches and a good knowledge of local capacities, the associated institutional settings and a wide range of other factors that require a careful strategy.

The purpose of this presentation is to critically articulate how the CRCWSC is engaging in developing capacities in (i) Australian local government urban water professionals to develop and use project and program level business cases and (ii) secondary city urban management professionals in Indonesia and Vietnam to incorporate WSC thinking into their urban development plans and processes.

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Session 1c

Case study

Contested spaces in infill areas — the WSUD challenge

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Brisbane City Council

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The Brisbane local government area is turning its development focus from greenfield to infill. This process has been underway for several decades, but the difference starting roughly from 2000 onwards is that infill development is now the major form of housing development occurring in the city. With this increased share of the housing development supply line, the nature of infill development has also been analysed and a key outcome is that small scale and 'patchwork' development will overwhelmingly be the scale at which infill development will occur. While there are more well-known 'flagship' larger scale infill developments occurring in the city, somewhere in the region of three questers or more of the future infill dwelling supply will be delivered on sites in the 400-1600 m^2 range in the form of 2-3 storey townhouses through to 5-8 storey or more apartments and mixed use development.

This reality of future infill development presents a major challenge for these scales of development to cost effectively incorporate water quality and wider ecosystem services, liveability and sustainability measures into them. There is an increasing range of expectations from the community, market and regulators about what housing needs to achieve. Likewise, the public realm in these infill areas is also a contested space for increased expectations around recreation, transport, landscape, habitat, utilities and basic matters such as conveyance of stormwater and are required to support multiple outcomes and possible comprises in traditional levels of services.

Typical water quality approaches have focused on greenfield and large scale brownfield development. The size and scale of these developments has allowed a variety of water treatment measures to be incorporated and operated. Many lesson can be learnt from that experience. The area of least attention has been understanding how these principles can be applied to much smaller scales of development where the space is tighter and margins are harder to achieve if typical larger scale water treatment solutions are applied.

Contemporary water sensitive urban design (WSUD) bioretention systems may therefore be required to consider wider place making and design outcomes in addition to water quality objectives, which adjustments to technical design requirements. This approach supports placing an increasing reemphasis on 'design' in WSUD.

This issue has been complicated by current regulatory jurisdictions such as the State legislative requirements in Queensland which identify a threshold 2500 m^2 before triggering water quality objectives to be applied to the development. This regulatory situation limits the ability for WSUC mechanisms to be incorporated into a most of the development scales that are going to deliver infill development in Brisbane. A more sophisticated range of incentives and education of industry will be required coupling the benefits of addressing water quality issues in the context of sustainability, resilience for climate adaptation and liveability.

This paper contends that the challenge for further research for the case of Brisbane is to understand how small scale development can incorporate water treatment measures to contribute to overall water quality outcomes. Failing to do so, will place greater emphasis for other solutions to do the heavy lifting – typically features built at public expense in public land. This paper highlights the challenges that meeting this objective will face and offers some pathways for the application of water sensitive urban design principles into these smaller scale development settings.

Session 2b
Project B3.1

VTUF-3D: An urban micro-climate model to assess temperature moderation from increased vegetation and water in urban canyons

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[5] *University of Western Sydney*

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Background and relevance

With urban areas facing future longer duration heat-waves and temperature extremes, adaptation strategies are needed. Examining the role that increased tree cover and water availability can have on human thermal comfort (HTC) in urban areas as part of these strategies has been done using observations, but further work requires a modelling tool suited for this task. Sufficient model resolution is needed to resolve variables used to calculate HTC as well as the ability to model the physiological processes of vegetation and their interaction with water. The lack of such a tool has been identified as a research gap in the urban climate area and has impaired our ability to fully examine the use of vegetation and water for improved human thermal comfort.

Results and Summary of key findings

A new model, VTUF (Vegetated Temperatures Of Urban Facets), addresses this gap by embedding the functionality of the MAESPA tree process model (Duursma 2012), that can model individual trees, vegetation, and soil components, within the TUF-3D (Krayenhoff 2007) urban micro-climate model. An innovative tiling approach, allows the new model to account for important vegetative physiological processes and shading effects. It also resolves processes at sufficiently high resolution to calculate HTC and air and surface temperature, humidity, and wind speed across an urban canyon.

Discussion and application to industry

Model validations using a variety of urban observations data sets (Coutts et al. 2007; Coutts et al. 2013; Coutts et al. 2015; Gebert et al. 2012; Motazedian 2015) have shown performance improvements of the model and a suitability to use it to examine critical questions relating to the role of vegetation and water in the urban environment. Analysis using this model includes scenarios quantifying the impact each individual tree can have on temperatures in urban canyons as well the optimal arrangement and quantity of trees to maximize temperature moderation effects.

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Session 3a

Case study

Building organisational capacity towards a Water Sensitive City: Blacktown's story

Payne, N., Milenkovic, K. and Taylor, N.

Blacktown City Council

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Background and relevance

Blacktown City Council (Council) is a progressive and diverse city located 35 kilometres west of Sydney. It is the largest council in New South Wales (NSW) by population with over 300,000 residents. It is a rapidly growing local government area (LGA) with its population expected to reach over 500,000 by 2036.

Considered as a growth council, Blacktown City Council's transition to a water sensitive city has accelerated since 2006, when the concept of water sensitive urban design (WSUD) was adopted into two key NSW state planning documents that applied to land within Blacktown. Since then Council has been under pressure from developers to lead, and provide clear policy and direction for WSUD. In response, Council developed its Draft WSUD and Integrated Water Cycle Management Development Control Plan (DCP).

During this time Council identified the need for increased WSUD awareness and training of its staff so that it could assist developers and the community to better understand and integrate WSUD into the landscape. Following this the Blacktown City Council WSUD Capacity Building Program was initiated with the objectives to:

Identify relevant human resources available (e.g. technical and leadership skills)

Determine Council's intra-organisational capacity such as key processes, systems, cultures, resources, agreements, relationships, and informal and formal networks both within and external to Council

Examine the external rules and incentives available (e.g. regulations, policies and incentives)

Understand and strengthen internal Council (individual and business unit/ team based) relationships.

To help develop the Capacity Building Program an external consultant was engaged to work in-house for a period of 18 months. Figure 1.1 below provides an overview of the six steps taken to develop Blacktown City Council's WSUD Capacity Building program.

This six step process helped to identify the following two significant outcomes:

1. A set of actions to address high priority institutional capacity building needs
2. The development of stronger relationships between key people within Council who need to collaborate in order to implement WSUD.

The six step process and its outcomes assisted with the development of Blacktown City Council's Capacity Building Program Action Plan, which is highlighted in Figure 1.2 below. As part of this Action Plan, three delivery models were identified and 11 program actions were set to help equip Council with knowledge, tools and resources to assist the transition to a water sensitive city.

Results and summary of key findings

As part of the development and implementation of the WSUD Capacity Building Program at Blacktown City Council the following was identified:

There was no clear business unit that appeared to be the 'nucleus' of WSUD at Blacktown; rather there were three or four business units that were 'enablers' that helped to drive WSUD. These business units tended to work in groups of three or four in supportive relationships

An analysis of business units identified that in most instances their working relationships were reciprocal

The perception of Blacktown City Council individuals was that Council is in the 'growth' phase of organisational development

Clear barriers identified within Council included insufficient capital and human resources along with an uncoordinated policy framework.

To complement these findings the WSUD Capacity Building Program has undertaken and achieved the following outputs to provide Council with the knowledge and understanding of WSUD so that it can be more easily implemented:

- WSUD standard engineering drawings
- WSUD fact sheets
- MUSIC modelling guidelines
- WSUD intranet hub and website resources
- Introduction to WSUD training module
- WSUD technical training modules for constructed wetlands, waterway health monitoring
- WSUD technical tour for Blacktown Showgrounds

(Continued)

In addition to these, Blacktown City Council is currently working on the following projects to build capacity and understanding of WSUD across Council. These projects include:

- WSUD project audits and case study development of four key projects
- WSUD project review pilot study and mentoring project for the Waller Creek Rehabilitation project
- WSUD maintenance and monitoring package including maintenance and monitoring guidelines, maintenance and monitoring plan template and asset inspection checklists for a range of vegetated and non-vegetated assets
- Review and updating of the WSUD fact sheets
- WSUD asset handover protocol
- Review and updating of the MUSIC modelling guidelines
- WSUD technical training on Deemed to Comply solutions currently being developed, the WSUD maintenance and monitoring package, asset handover protocols, MUSIC modelling, stormwater harvesting and reuse scheme maintenance
- WSUD lifecycle costing study

The following are a list of projects that Blacktown City Council has identified as future projects to undertake as part of building WSUD capacity to embed WSUD practices and mainstream across council:

- WSUD standard clauses and design principles
- Business case for WSUD
- Incentives for WSUD study
- Water strategy
- WSUD roles and responsibilities audit

Discussion and application to industry

Since the inception of the program more than 200 Blacktown City Council staff have engaged with the Capacity Building Program. This engagement process has ranged from surveys, face-to-face interviews, workshops, training and tours. The number of Council staff engaged through the program continues to grow as the program's actions are developed and specific projects are further developed.

The WSUD Capacity Building Program has grown in strength since its inception and continues to provide the tools, resources and training to equip council with its transition to a water sensitive city. The program has the potential to address similar challenges faced by other local governments and organisations so that organisational WSUD capacity can be further developed and implemented.

Blacktown City Council's WSUD Capacity Building Program is unique in its organic origins, being developed directly by the beneficiary of the program's outputs. This ensures the process produces a program that is uniquely tailored and addresses the individual needs of the organisation, whilst being transferrable.

There are a number of outputs that Blacktown City Council's WSUD Capacity Building Program has developed and that are transferable to industry. Some of these outputs include:

- A process and templates for the development of an organisational capacity building program
- Copies of business unit reports and correspondence, including memos and council reports that can be easily adapted for other organisations
- Training materials
- Tools and resources such as fact sheets, case studies, guidelines, manuals and checklists
- Process for conducting a policy and process audit within an organisation

It is noteworthy that some of the above outputs may replicate similar types of resources produced by other capacity building programs; however these resources have been based from an understanding of Blacktown City Council's exact needs and wants, while being adapted to suit Council's individual needs.

When Council produced its capacity building resources it was known as an emerging leader and not necessarily a leader in industry. Its resources are historically not as developed and are considerably shorter than other materials available. The outputs from this program are designed for the organisation that is starting or has recently commenced its journey to being a water sensitive city.

The Blacktown story will help equip practitioners and LGAs to drive change across their council and adopt innovative ways to effectively manage stormwater. Blacktown will share its story about how the WSUD

Capacity Building Program was developed, share findings and resources that have been developed, and explain how internal support was obtained.

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Session 1b

Project B1.1

High-resolution Downscaling of Rainfall Using STEPS (HiDRUS) for urban hydrology

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Background and relevance

Rainfall data is a main requirement in modelling hydrological processes and it is always a major source of uncertainty and errors in such calculations. These errors and uncertainties are due to the observational errors and bias, lack of high space-time resolution and irregular coverage in space and time.
Use of climate change projections to account for the future changes in rainfall is also desirable for designing flood resilient infrastructure and sustainable water harvesting technologies. However, this requires GCM rainfall projections to downscaled to a space-time resolution of up-to a km and few minutes.

Methods and Summary of key findings

In this project we have attempted to use a current nowcasting method developed in Bureau of Meteorology (Seed et. al., 2013) to generate a very high-resolution simulations of GCM rainfall predictions. The Short Term Ensemble Prediction System (STEPS) uses multiplicative cascades to decompose the structure of the observed radar rainfall. The computed cascade parameters can be stored and use to simulate the rainfall with the given space-time structure but with different evolution (life cycle) of the individual rain cells (Raut et. al., 2012). Thus, producing a wide variety of storms at required space-time resolution. We drive this model with GCM predicted daily rainfall and sample the cascade parameters from the historical radar data. The model is shown to reproduced PDFs of rainfall in the historical data.

Discussion and application to industry

The downscaled data can be use for computation of exceedance probabilities or FDI curves at suburban scales. A large number of simulations from this model would be helpful in estimating the uncertainties involve in such predictions.

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Raut, B. A., de la Fuente, L., Seed, A. W., Jakob, C. and Reeder, M. J. (2012) Application of a space-time stochastic model for downscaling future rainfall projections. Hydrology and Water Resources Symposium, ISBN: 9781922107626. http://www.baraut.info/publications/

Seed, A. W., Pierce, C. E., and Norman, K. (2013) Formulation and evaluation of a scale decomposition-based stochastic precipitation nowcast scheme, Water Resources Research, 49(10), 6624–6641.

Session 1a Case study

Exploring Elwood's flood challenges: a collaborative approach for a complex problem

Rogers, B.C.[1,2,3], Bertram, N.[1,4], Gunn, A.[1,2,3], Löwe, R.[1,5], Murphy, C.[1,4], Pasman, R.[1,4], Radhakrishnan, M.[1,6], Urich, C.[1,3,7], Arnbjerg-Nielsen, K.[1,5]

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The delivery of water sensitive practices requires the water system to be understood as an integral part of the urban landscape, providing water and ecological services that meet society's needs for water supply, sanitation, flood protection, amenity, recreation and ecosystem health. Through the embedded nature of water sensitive urban design, novel multi-functional solutions can be found at the interface between environmental engineering and urban design approaches that benefit local communities. The identification and delivery of such opportunities is best facilitated by a collaborative place-based approach that integrates multiple disciplines and community participation to co-design strategies that fit the local cultural, geographical and ecological context.

This presentation discusses how CRCWSC research teams across social science, architecture and environmental engineering are collaborating to identify opportunities for increasing the sustainability and liveability for the flood prone suburb of Elwood in Melbourne, while increasing its resilience to pluvial flooding. Elwood was selected as the location for this integrated case study because it is facing a range of long-term planning challenges, has a history of water management issues such as flooding and pollution, and is home to an active and vocal community engaged in flood and sustainability issues.

This integrated approach combines latest research on engaging with communities to better understand their concerns, aspirations and ideas for water sensitive practices, new approaches to sustainable urban densification and the activation of such urban forms for increasing flood resilience, and advances in engineering modelling that simulate interactions between urban form and water management solutions to test the performance and robustness of proposed solutions. The specific contributions of individual CRCWSC projects are outlined below and summarised in Figure 1:

- A4.2 is facilitating a series of three transition scenario workshops with local community members, aiming to examine the significant long-term challenges and objectives of water management in Elwood. These workshops, each approximately three hours long and taking place in July, August and September 2015, draw on principles of envisioning and backcasting and will develop a community-led strategy for achieving a water sensitive Elwood in 2065.

- Based on these community visions and strategies, D5.1's contribution is design-led, working with the tangible social, environmental and experiential implications of water-based issues. Through an iterative process, the content and ideas of the workshops are being documented with follow-up design synthesis between workshops. This process aims to raise awareness of potentials and processes through visualising and analysing change scenarios in a cumulative manner. These scenarios range in scale from catchment-wide thinking to key local Elwood sites identified for immediate action. The generated imagery will include maps, diagrams, schematic designs and other material.

- A4.3's DAnCE4Water, an emerging CRCWSC computational decision-support tool, has been set up to simulate urban development scenarios for the Elwood catchment and coupled with B4.1's flood risk assessment framework, underpinned by the MIKEUrban modelling software that assesses flood risk in space and time. These tools will be used to analyse the interactions between Elwood's urban forms and flood risk, allowing the flood mitigation potential (and associated costs and benefits) of decentralised stormwater solutions and innovative urban designs (identified through D5.1, for example the redirection of overland flow paths) to be tested under different scenarios of urban development and climate. They will also inform analysis of the overall costs and benefits of different adaptation pathways in B4.2, involving the sequencing of sets of possible adaptation strategies in response to changes in climate, land use, demography and socio economics.

As this research is currently in progress, the session will present integrated findings to date and facilitate a panel discussion reflecting on the experience and value of taking this collaborative interdisciplinary place-based approach to developing solutions and strategies for addressing specific issues in a local context.

Session 1a

Project A4.2

Developing shared visions and strategies: participatory processes to guide water sensitive city transitions

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As pressures from climate change, urbanisation, pollution, resource scarcity and ageing infrastructure grow, urban water is increasingly recognised as an integrated system that encompasses complex dynamic processes of change, high levels of uncertainty and a limited ability to control variables such as water supply and demand. This new understanding demands novel strategic planning methods to ensure outcomes that support a city's liveability are delivered in a sustainable and resilient manner over the long-term.

Scenario development is an increasingly popular approach for long-term future planning. Transition scenarios are a particular type, comprising a desired future vision and transition strategies for achieving this vision (Figure 1.1). CRCWSC Project A4.2 is an action research project aiming to design and implement novel transition scenario methodologies to support and influence formal policy development, strategic planning and decision-making activities at local, state and national levels to enable transitions toward water sensitive cities.

This paper presents interim findings from two case studies for Project A4.2 currently underway in Perth and Elwood (a Melbourne suburb). The Perth case study is focused on envisioning the transition to Perth as a water sensitive city by 2065 and involves a series of five half-day workshops with 32 water, planning and urban development professionals working in Greater Perth. The Elwood case study takes a more local scale approach, engaging with 25 community members through three evening workshops to envision Elwood's transition to a water sensitive precinct.

Both workshop series are currently in progress so the content of their respective transition scenarios are only midway through development. The focus of this paper will therefore be to reflect on the process and methods being implemented, drawing preliminary insights on how long-term visioning and strategic planning approaches for water sensitive city transitions can be most effectively designed and facilitated.

Key insights across both case studies include:

- Recruitment of participants needs dedicated attention, as it is critical to attract people with the desired level of influence and strategic understanding and with a mindset that is open, curious and visionary, as well as able to commit to the full series of workshops (as far as practicable). Strategic endorsement of the process by key stakeholders can be important for demonstrating its value and authorising people's active participation.

- While the underlying logic of transition scenario approaches is relatively consistent, the process design details need to be tailored for their particular implementation context. Consideration should be given to the strategic positioning of the process, expectations of participants and other stakeholders, the type of end products being developed and the background and interests of the participants.

- The personal dynamics within the workshops, as well as participants' expectations, need careful management to ensure the experience is interesting, rewarding and ideally inspiring. This is to ensure the process is meaningful and valuable, as well as to encourage people's ongoing commitment and momentum for implementing strategies and actions after the process has ended. Skilled facilitation is important to encourage learning amongst participants so that they reach mutual understandings, recognise their interdependencies and challenge each other's perspectives, as a means for ensuring strategic and operational alignment across different stakeholder groups.

The workshop series for Perth and Elwood will be completed and reported on by December 2015. The next stage of the project will draw on the lessons from these two case studies to refine the methods for implementation in another Australian city, in collaboration with local CRCWSC industry partners in 2016/17.

Session 1b

Project B1.2

Towards a methodology for monitoring integrated water management through an urban metabolism approach

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[2] University of Queensland, School of Chemical Engineering
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Background and relevance

Globally, water resources management in urbanised areas is facing increased challenges. Challenges relate to both water quality and quantity under ongoing pressures from population growth, increased urbanisation rates through to climate change impacts. Urbanisation processes generate hydrologic and water quality changes that significantly impact, and will continue to impact, hydrological systems at the city-region scale. Urban systems are not isolated entities. They depend and impact on existing resources such as water beyond their jurisdictional boundaries. Hence, water resource management needs to acknowledge hydrological connectivity at the landscape scale which in turn needs to be better understood by, and considered in, decision-making processes concerning urban areas. Without such consideration there is an impending risk that urban areas will continue to be metabolically inefficient in how they use water, and may struggle to be resilient in the future.

However, to date, there is a lack of frameworks and methods for evaluating urban water performance at the city-region scale. This constrains how well urban areas are designed and managed for overall water efficiency, security, resilience, and sustainability. While individual components of urban water systems may be 'water sensitive', it is difficult to assess their combined performance at the city-region scale. In this paper, we start to address this gap in knowledge by presenting a conceptual evaluation framework that generates information about the water metabolism of city-regions: an urban water metabolism evaluation framework. We argue that through this framework knowledge and metrics can be generated to inform decision-making processes concerning urban areas and therefore enable more holistic urban water management. Specifically, we demonstrate how this information can be applied to the implementation of integrated water management at the local government level.

Results and Summary of key findings

The framework is based on the concept of urban metabolism, which is a metaphor for conceptualising how resources flow through urban areas similarly to ecosystems. The framework enables the quantification of all flows of water (both natural and anthropogenic) into, through and out of urban areas, using a water mass balance method. The water balance data is used to generate indicators of water metabolic efficiency, account for the diverse sources and functions of water, link urban areas to its region, and account for other water-related resource flows (energy).

This approach was applied to a master plan urban development to quantify the water metabolism characteristics before and after urbanisation, and under a range of alternative water servicing options (including stormwater harvesting and reuse and wastewater reuse). The analysis showed how the different scenarios influence the water efficiency of the overall urban development as a whole, the 'naturalness' of the urban hydrology (i.e., departure of natural flows from pre-development state) and extent of local-sufficiency. Indicators generated by the framework are particularly useful to monitor the effect of integrated water management strategies at local government level.

Discussion and application to industry

The framework creates a new way for assessing the hydrological performance of urban areas at multiple spatial scales (e.g., precincts, neighbourhoods, allotments and city-region). By quantifying all water flows (natural and anthropogenic) as well as stored water reserves, the framework can drive accuracy into urban water accounting and provide quantitative performance indicators for integrated urban water plans. In particular, it can assess: (i) the degree of system centralisation; (ii) the naturalness of hydrology; and (iii) the 'replaceability' of centralised water flows (e.g., with alternative sources such as stormwater, or wastewater). The framework is particularly useful for jointly quantifying the influence of the form and function of urban areas and their water system and therefore improve how urban and regional planning decisions can better account for the challenges confronting water resources at present and into the future.

Session 2d

Project C3.1

A biofilm model to predict the impacts of wastewater flow and composition on the in-sewer reaction kinetics

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Background and relevance

Reliable modelling of sulfide and methane production from sewer systems is desirable for efficient sewer emission management. However, current mathematic models for predicting sulfide and methane production consider the effect of wastewater flow and composition on biofilm activities through model calibration. This limits the ability of the models as a planning tool for water management scenario analysis, as in most scenarios data may not be available for the calibration of the models.

As the production of both sulfide and methane occurs in the sewer biofilm, transport of substrate from bulk liquid to the inner surface of the biofilm is important. Water velocity in a sewer pipe affects the mixing conditions, which is often characterized by hydraulic shear stress. The thickness of boundary layer, which is related to the hydraulic shear stress at the biofilm surface, influences the activity of the biofilm (Wanner et al., 2006). A decrease in flow velocity increases the thickness of stagnant boundary layer at the biofilm surface and hence the resistance to diffusional transport of substrate into the biofilm. The effects of flow velocity on the activity of sewer biofilm therefore needs to be considered in sewer modelling.

Availability of substrates and hence the growth of microorganisms responsible for sulfide and methane production also depends upon the substrate concentrations in the bulk. Current sewer models use activity based kinetic expressions (Sharma et al, 2008, Guisasola et al., 2009) and as such, lumped biofilm activity rates (production rate per unit surface area of biofilm) are used. Any change in wastewater composition needs re-assessment of the activity rate, requiring re-calibration of the model parameters for each case with respect to wastewater composition characteristics. For a generalised approach, an understanding of the relationship between the concentrations of key substrates and the sewer biofilm activity is needed.

This study was carried out to: (i) examine the change in sewer biofilm activity due to the change in sewer flow, and (ii) characterize the effects of the changes in wastewater sulfate and soluble chemical oxygen demand (sCOD) concentrations on sulfide and methane generation by sewer biofilm. A detailed biofilm model was developed to simulate sulfide and methane production in rising main sewers, and employed to simulate a number of scenarios with varying sulfate and soluble COD concentrations. The model was calibrated and validated with separated experimental data sets. Similar biofilm model was employed to determine the dependency of biofilm activity on the shear stress and hence the sewer flow rate. A computation based simulation study was conducted to reveal the extent of impacts under wide range of flow conditions, which was further verified through experimental data.

Kinetic expressions taking into account the impacts of wastewater flow and composition have been developed for sewers. Once implemented in current sewer model, the model should be able to accurately predict the sulfide and methane emission from sewers under a wide range of flow and wastewater characteristics.

Results and Summary of key findings

Both the simulation and the experiment results demonstrated significant impacts of flow velocity on the rate of sulfate reduction and methane production by sewer biofilm, especially under the low flow velocity (Figure 1). The biofilm activity increased with the increase in flow velocity and hence the shear stress. The increase was significant when the shear stress was below a threshold level (0.4 Pa for sulfide production). Beyond this; the increase in velocity had only minor impacts. The results of this study further highlighted the need for considering the effect of flow in sewer models for the accurate prediction of sewer emissions.

Model based analysis shows that the short-term variation of sulfate concentration in the wastewater would significantly affect the sulfide production activities but not methane production activities of the sewer biofilm. On the other hand, long-term variation of sulfate concentration and both short-term and long-term variation of soluble COD concentration in the wastewater would affect both sulfide and methane production activities of the sewer biofilm (Figure 2). Empirical models for describing the effect of sulfate and soluble COD concentration difference on sulfide and methane production activities are proposed based on the results of the detailed biofilm model simulation.

Discussion and application to industry

These empirical models developed in this study could be incorporated into current sewer model for improving the prediction of sewer emissions. Various options implemented for cost-effective water demand management would in most cases result in decreased sewer flow and more concentrated wastewater. The outcomes of this study would enable water utilities, consultants and planners making assessment of changes in water management practice in terms of sewer emissions and developing strategies for mitigating such emissions.

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Session 2a

Project B2.4

Nutrient attenuation hotspots in Bannister Creek Living Stream

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Urban streams have frequently been used as drainage systems to transport and divert runoff away from populated zones. As a consequence urban streams are often characterised by flashy flows and elevated nutrient loads that may inhibit stream ecological functioning. In areas with shallow groundwater, these streams may also be subject to increased base flows and groundwater-borne nutrients which further promote eutrophication, algal blooms and oxygen-depleted waters.

CRC WSC-Project B2.4 is quantifying the impact of urbanization on these systems, with a focus on understanding both the hydrology and the nutrient transport pathways, and how urban streams and wetlands can be used to optimize nutrient attenuation prior to discharge into receiving waters. Research literature has traditionally focused on gross uptake of nutrient injections along urban streams and has progressed our understanding of processes affecting attenuation. However estimating net-attenuation (by monitoring background nutrient concentrations) may be more helpful to assist with stream and wetland design as it reflects the net result of the balance between uptake and release processes. In this study, the objective was to identify specific areas of net-attenuation of nutrients (hereafter "attenuation") in a restored urban stream. The temporal and spatial variability in attenuation were studied along with the impact of hydrological shifts (travel time) during high baseflow and the associated changes in the connectivity with retention surfaces.

We hypothesized that nutrient attenuation was associated with travel time and was also affected by hydrological shifts that promote attenuation hotspots. In particular we were interested in determining hydrological interval over which the attenuation was observed by assessing the existence of a travel time threshold that could be indicative of shifts in a stream's retention capacity and the resulting effect on nitrate, ammonium, and phosphate (FRP). Finally we aimed to improve our understanding of the hydrological regimes acting in urban streams and their effects on nutrients attenuation, and to provide insights into the optimal design of these restored systems to minimize nutrient discharge into receiving waters during high baseflow conditions.

We analyzed the impact of hydrological shifts during stream flows ranging from 245L/s to 39L/s. Spatial and temporal variations in the attenuation were characterised by studying the impact of travel time and that of different features along the stream's banks. Nitrate and ammonium uptake lengths were determined from the observed decrease in concentration at background conditions with distance on each side of the stream whilst for FRP and nitrite no decrease was observed. Travel times, determined from breakthrough curves of NaCl injections at different flows, did not fully explain the observed variations in nutrient uptakes lengths, which showed an overall decrease as travel time increased, but also revealed the opposite effect at very high flows on both sides of the stream.

To identify which stream sections and which hydrological conditions were most controlling nutrient uptake, attenuation coefficients were estimated using the observed concentration decreases and travel times across each stream section. Higher attenuation coefficients were obtained at higher flows and at specific stream sections. It became evident that stream connectivity with certain bank features (e.g. dense root mattes) created retention hotspots and suggested a trade-off effect in the retention capacity as travel time increased. This finding of increased attenuation in specific ecological features has the potential to be incorporated into urban stream/wetland restoration design.

Session 1d

Case study

A Business Case for Water Sensitive SEQ

Tanner, C.

Bligh Tanner Pty Ltd

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Background and relevance

A Water Sensitive SEQ is a big leap and despite some obvious advantages may seem like an unattainable goal with too many hurdles: technical, regulatory and social. People and organisations may have vested interests or be concerned about their ability to manage the necessary changes, or the pathways to reach the end vision are not clear raising the spectre of getting lost on the way, so resistance to a change like this is probably inevitable. However, a well resolved business case should deal with all these things. This paper provides a vision for a Water Sensitive SEQ and a Business Case to achieve it. Whilst hypothetical, the author will draw on his significant experience with the design and implementation of some of SEQ's most innovative water projects to sketch out how a Water Sensitive SEQ could be achieved. The template used for the business case will be adopted from the CRC for WSC publication.

Results and Summary of key findings

This paper presents a vision for a Water Sensitive South East Queensland then, adopting the CRC publication on How to Build a Business Case, examines the business case for it.

My preliminary proposal for a Water Sensitive SEQ are:

- A financial mechanism to value Integrated Water Management providing a $value for broad based and long term benefits
- A new Multi Benefit Charge that deals better with who pays and who benefits
- Expanded State Policy that first: enshrines WSC outcomes, for example, sustainable water use, healthy waterways, healthy communities; and second provides a head of power to the state policy;
- Sets up state management so that there are enabling links between urban and rural water, water and energy, water and livability/social outcomes
- Provides for rolling adaption and innovation supported by seed funding for projects/programs that test new legislation and policy, monitor the outcomes, providing a strong resource base for widespread implementation of relevant schemes.

Whilst the paper is a 'hypothetical' many parts of the elements above are already used in a disjointed way across SEQ so will have considerable relevance. The author will examine the need for integration across the water industry, the possible policy and regulatory settings, and how financial value can be better realised to all.

Discussion and application to industry

This case study will provide insight into the issues associated with adoption of Water Sensitive SEQ and how they could be resolved. It will be based on the authors long experience in the introduction of change to traditional engineering. It will be useful to private and public practitioners, policy writers and regulators.

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References:

CRCWSC (2014) Strategies for Preparing Robust Business Cases

Session 2c

Project A4.3

DAnCE4Water — a collaborative decision support tool to test urban water management strategies

Urich, C.[1,2,3], Rogers, B.C.[2,4], Iftekhar, S.[2,6,7], Schilizzi, S.[2,7], Bach, P.M.[1,2,3], Malekpour, S.[1,2,4], Breman, J.[1,2,3], Brown, R.R.[1,2,4], Rauch, W.[5] and Deletic, A.[1,2,3]

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Background and relevance

It is now well understood that to increase urban liveability, sustainability and resilience of urban water systems requires a collaborative approach that considers a portfolio of non-structural and structural measures (Ferguson et al., 2013). Such measures include integrating centralised and decentralised water infrastructure systems, embedding water into the urban landscape, introducing planning regulations, financial incentives, and many more. To support planners and decision makers to use the complexity of the urban water system to their advantage and to better understand which combination of strategies are robust under uncertain future scenarios, a new generation of decision support tools is required (Urich and Rauch, 2014). DAnCE4Water (Dynamic Adaptation for enabling City Evolution for Water) aims to address this gap by developing a collaborative decision support tool that embedded in a strategic planning process, will be able to be used to test the effectiveness of different water management strategies in achieving desired performance outcomes under a wide range of future scenarios by modelling the:

- Development and redevelopment of urban form based on zoning regulations and as population and demographics change
- Dynamic adaptation of water infrastructure systems as the urban form and preferred water servicing solution change
- Likelihood of different water servicing options being taken up as service levels change
- Performance of the integrated water system, in terms of the water services provided (e.g. supply security, flood protection, pollution control) and economic benefits and costs (market and non-market values)

This presentation discusses first insights in the application of DAnCE4Water for the Southeast metropolitan area of Melbourne simulating the impact of rapid population growth on the urban water system and showcases how DAnCE4Water can be applied in a participatory setting testing interactively the effectiveness of different management strategies.

Results and Summary of key findings

For the presented case study, covering the Southeast metropolitan area of Melbourne, we particularly focus on the impacts of increased densification and urban sprawl on the urban water system. We simulate therefore changes in the urban from under different zoning regulation and population projections at parcel level detail. Subsequently we assess the implications of the increased urbanisation on the water demand patterns and on the pluvial flood risk, which is assessed for the embedded Scotchman's Creek catchment.

The DAnCE4Water's collaborative web platform is showcased for the embedded Scotchman's Creek catchment testing interactively the effectiveness of zoning regulations as well as financial incentives to implement rainwater-harvesting tanks to increase supply security and pluvial flood protection.

Discussion and application to industry

To support strategic planning of integrated water systems a new generation of decision-support tools is required. 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 the socio-economic dynamics in how the system evolves. DAnCE4Water is one of the first modelling tools of this kind, providing a common representation across different parts of the water system so that critical feedback loops can be simulated. DAnCE4Water can be used as a tool to support an exploratory planning approach, by providing insight into the effectiveness and implications of possible decisions to inform the selection of water management strategies that increase the water system's resilience. It 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 computational 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.

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Session 2d

Project C5.1

Demystifying high water use: data analytics for personalised customer feedback about peak days

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Background and relevance

Smart metering and intelligent water networks (IWNs) are growing industry trends. A recent Australasian survey reported that 80% of utilities were actively pursuing IWN projects and 66% had projects underway (Beal and Flynn 2014). However, harnessing smart meter data for improving utility efficiency and customer service excellence remains a challenge. It has been shown that “although people often perceive that they are doing all they can to save water … if they are motivated and provided with effective information they can achieve even greater reductions.” (Beal et al 2013). On the other hand, a voluntary water efficiency behaviour change pilot program in the Pilbara region of Western Australia (WCWA 2014) found that “Households found it very difficult, and rarely were able to attribute their high water use to any one particular activity”. These findings point to the need for data analytics that generate evidence-based feedback to enable customers to understand how they could save water, rather than simply reporting volumes of water use.

This presentation introduces a new method for generating customer feedback about their peak days of demand. Peak days are targeted because they are relatively rare, they account for a high proportion of annual demand, and they are likely to be caused by discretionary activities such as leaks, bursts or unintentional use. In order to help explain peak use to customers we use population norms discovered from the different patterns of hourly use behind peak days together with calendar information for the peak days.

Results and summary of key findings

Phase 1 of our method uses an anomaly detection algorithm to identify peak days of the year for individual customers. Using a case study sample of 440 households from Kalgoorlie, in Western Australia’s eastern goldfields, it was confirmed that peak days are relatively rare (6% of days) but highly significant (24% of annual demand). The temporal distributions in Figure 1.1 illustrate a seasonal bias (most peak days occur in December) but little local bias (peaks are only slightly more frequent on Sundays). These results are for global peak days from a whole year of use. Local peaks, relative to the season or month rather than the whole year, have also been analysed. In phase 2, a sequence mining algorithm was used to discover the most common hourly patterns behind peak days (Xing et al 2010). Figure 1.2 shows the four main types of peak day patterns that were identified: continuous, burst, sporadic and regular. Regular patterns are similar to sporadic, but their peak hour pattern is frequent for that customer.

Discussion and application to industry

Future smart meters will include in-board data analytics for personalised, timely feedback to customers about their water use. The peak day analytics proposed here would be one of the functions offered by a future smart meter. In the shorter term, peak day analytics can be used by water utilities for centralised analysis, with personalised feedback offered via online web portals or channels such as social media. Utilities can also use peak day analytics to realise the main IWN business case drivers of improving infrastructure planning and deferring infrastructure augmentation through better peak demand management (Beal and Flynn 2014).

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Session 2f

Science-policy case study

Coordinating a whole-of-government approach to deliver multiple benefits through integrated urban water and land use planning, investment and implementation

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The multiple threats of droughts, floods, poor water quality, increasing heat-wave conditions and bushfires, are stark reminders of the vulnerability of our cities and towns to climatic extremes, compounded by pressures of population growth, housing affordability and urban densities. Dealing with these challenges requires solutions that rely on alignment of objectives across urban land-use planning and water-system planning, such as the provision of green spaces and vegetation corridors that accommodate water recycling and stormwater-harvesting technologies at local scales.

These "green infrastructure" approaches are emerging as innovative practices to secure resilient and cost-effective water supplies for a growing population, but also offer additional functions that enhance urban liveability and long-term sustainability. For example, enhancing people's thermal comfort, providing beautiful places to live, increasing urban biodiversity, protecting water environments from stormwater pollution, providing safe detention and conveyance of flood waters, harvesting stormwater, and recovering water, nutrient and energy resources from sewerage are essential building blocks of a sustainable, resilient, productive and liveable city. However, these multiple benefits cannot be achieved when land-use planning and water planning are conducted in isolation from each other.

There is growing research evidence from Australia and around the world to indicate the benefits of infrastructure investment through aligned water and land-use planning. Despite this growing evidence of economic benefit, research reveals that existing structures and processes for sharing authority, responsibility, knowledge and resources do not support water-sensitive approaches for dealing with projected population growth and for rapidly responding to economic and climatic changes. For example, there are significant challenges associated with incoherent or conflicting legislative and regulatory frameworks, fragmented organisational roles, responsibilities and accountabilities, and inadequate incentives and processes for collaboration across government agencies and other stakeholders at multiple scales.

These governance conditions make it difficult to move beyond the current practice of compartmentalising the functions of individual government agencies and adopting narrow financial criteria when evaluating the benefits and costs of policies and programs. The consequence is that public investments fail to deliver the range of benefits to the community that they could and should.

A whole-of-government approach to planning urban water infrastructure can realise significant value and return on investment in urban development. This requires better integration and alignment between the Victorian water sector and organisations responsible for urban development (local government, relevant state government departments, department units and agencies).

Session 3b

Project A2.2

Prioritising water saving behaviours in households using measurements of impact and likelihood

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Background and relevance

Households are an important end user of water, and large reductions in the consumption of potable water supply can be achieved when households undertake water-saving behaviours. Promoting water-saving behaviours to individuals and households can effectively reduce water consumption, but there is little research that identifies which behaviours should be targeted for change. To address this gap, we use a behaviourist approach to assess a range of water-saving behaviours available to householders: each behaviour is evaluated according to its water saving impact and the likelihood it will be taken up by individuals in their homes.

Results and Summary of key findings

In project A2.2, Accelerating transitions to Water Sensitive Cities by influencing behaviour, a range of key water saving behaviours have been identified along with indications from consumers of the ease of taking these up (a “likelihood” measure). This valuable data describes which behaviours would be easily taken up by householders and which are perceived as more difficult. Consumer surveys assessing barriers to adopting water-saving behaviours indicate that behaviours which have a high likelihood of being adopted by individuals include turning off taps while brushing teeth, and reducing the frequency of car washing. Behaviours for which greater barriers to adoption are reported include replacing lawn with drought-tolerant grasses, and installation of greywater systems and rainwater tanks.

The other key data is that of impact- the degree of value the behaviour brings to water saving. This is embodied as the amount of water saved by undertaking a specific behaviour (impact). Combining the impact of performing these behaviours, with the likelihood that they will be adopted by households, we can identify four groups of water-saving behaviours in an impact-likelihood matrix (Figure 1). The matrix illustrates the impact and likelihood of the behaviour and provides the basis for a behavioural roadmap, which will be presented in this presentation. This roadmap supports selection of priorities for behaviour change, and potential pathways for change that build on existing uptake of behaviours.

Discussion and application to industry

This Behavioural Roadmap is a tool which can be used by professionals to identify the most appropriate water saving behaviours to advocate to individuals. Selective targeting of most important behaviours allows water managers to allocate resources to efficiently support behaviour change by their customers.

The magic of a small molecule – it all started from an accidental observation

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For a decade, a research team at the Advanced Water Management Centre (AWMC) of The University of Queensland, led by Professor Zhiguo Yuan, has been working on the science and applications of the effects of free nitrous acid (FNA i.e. HNO2) on microorganisms. The research has not only led to dozens of high quality publications but also a number of technologies that are being commercialized through two spin-off companies.

The research was initiated by an accidental observation. In late 2004, Mr. Vel Vedivalu, a PhD student at the time, submitted an experimental report summarizing the results of an experiment aimed to determine the maintenance energy requirement by nitrite-oxidizing bacteria (NOB). An unexpected trend was detected in the oxygen update rate by the NOB culture, which increased slightly with the decreased nitrite concentration. This was initially believed to be due to experimental errors, but repeated experiments ruled out this hypothesis. This accidental observation led to the birth of a very significant research program at the AWMC, which is still on-going.

It was subsequently confirmed that FNA has an inhibitory effect on the metabolic processes of microorganisms, which include not only NOB, but also ammonia oxidizing bacteria (AOB), polyphosphate accumulating organisms (PAOs) and glycogen accumulating organisms, all of which are key organisms involved in wastewater treatment. It was further revealed that FNA has a much stronger inhibitory effect on the anabolic processes than on the catabolic processes. These findings have significant implications to the design and operation of wastewater treatment processes. A key feature of the FNA research in this period was that its concentration was limited to parts per billion levels, which are in the range commonly found in a wastewater treatment process.

At the same time, another research team also led by Professor Zhiguo Yuan was working the control of hydrogen sulfide in sewers. Hydrogen sulfide is formed by biofilms growing on the inner surfaces of sewer pipes. The formation could be stopped if the biofilms could be removed or deactivated. This was however not possible at the time. The Eureka moment came in 2009. Can FNA help achieve this goal if its concentration in sewage is artificially boosted from parts per million levels (i.e. 100-1000 times of what would normally be found in wastewater)? The hypothesis was that FNA at such levels could be biocidal thus able to deactivate sewer biofilm. This was proven to be true by another PhD student at the time, and now a research fellow in Prof Yuan's team, Dr Guangming Jiang. This led to the development of the Cloevis technology, which controls sulfide in sewers through intermittent (8 hours every one to a few weeks) dosing of FNA. This technology substantially reduces the costs for sulfide control. The technology has been successfully tested in several field studies, and is now being rolled out to many sites in the US.

Bioenergy production from sludge is a big operational goal in sustainable wastewater management. One key limitation to achieving this goal is the limited biodegradability of wastewater sludge. FNA has more recently been demonstrated to significantly increase the biodegradability of activated sludge and could thus increase biogas production by 30-100%. This is being marketed as Lodomat.

There are currently five commercial products based on the use of FNA. However, the magic of FNA is not limited to the above, and is being further discovered. Prof Yuan's team is currently working on an FNA-based technology to enable a complete paradigm shift in wastewater treatment.

Session 1b

Project B4.2

Adaptation Mainstreaming opportunities (AMO): theory and best practices from vanguard cities across the globe

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UNESCO-IHE

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Cities are facing multiple water-related challenges (e.g. water scarcity, flooding issues, drainage and/or pollution issues). Urban (re)development including maintenance of buildings and infrastructure may provide opportunities for adapting cities to become more resilient to deal with the challenges posed by present and future climate. In most existing urban areas, there is a continual turnover of existing property and infrastructure, which is renewed, replaced or enhanced in processes of rehabilitation and renovation. The opportunities this affords for greening and climate proofing urban areas as part of a resilience enhancing process is a key element of adapting to cope with an uncertain future. Many of such adaptation interventions can be implemented synergistically with 'routine' redevelopment and enhancement of existing urban areas.

The moments of synergy when and where this can occur are defined here as Adaptation Mainstreaming Opportunities' (AMOs). We surveyed the adaptation mainstreaming practices in 5 cities (Copenhagen, Melbourne, Rotterdam, Singapore and Tainan) in climate adaptation to find out how well these cities are doing and what strategies they were doing in exploiting AMOs. These cities are considered to be frontrunners in climate adaptation.

Moreover, Melbourne, Rotterdam and Singapore are key 'incubator' cities of the CRC for Water Sensitive Cities. Our findings suggest that (i) successful exploitation of AMOs will require a paradigm shift of planned adaptation from its primary focus using stand-alone interventions to a broader focus on increasing the performance of the city and this requires strategic planning, (ii) mainstreaming is in practice often not free of cost (as previously argued). It is about adding societal value against relatively low cost, (iii) present planning provisions are not enabling mainstreaming, because the time between signalling an opportunity and project realisation is usually shorter than the time for allocating budget (e.g. MIRT in NL), (iv) mainstreaming requires a stakeholder who is leading the process as well as effective stakeholder partnerships (both between and within organisations) in order to recognise opportunities, get support, link investment agendas and implement/maintain projects.

Understanding social preferences to reduce land use conflicts in wastewater treatment plant buffer zone

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Background and relevance

Growth in urban centres and increased housing density in the urban environment are global trends. Water utilities are, consequently, under increasing pressure to better manage their urban foot print, including areas surrounding wastewater treatment plants. Wastewater treatment plants are an important part of the urban water management infrastructure, and should, more generally, be thought of as potential resource recovery centres rather than wastewater treatment plants. The process of treating wastewater is, however, associated with odour emissions. To mitigate odour complaints water utilities can invest in costly technology and infrastructure to reduce odour emissions; relocate wastewater treatment plants to relatively remote locations; or purchase the land surrounding treatment plants to create large buffer zones. Another option is to work with planning authorities and local communities to manage the land uses in areas adjacent to treatment plant such that the relevant land provides the highest value use to the local community. If the community values the land use in the buffer zone it is then possible to create relatively small buffer zones. Smaller buffer zones, that deliver outcomes that are acceptable to the community, can free up valuable land for development without creating conflict between local residents and the operator of the treatment plant.

Our case study area comprises metropolitan and regional settings in Western Australia, where there are 108 wastewater treatment plants serving more than 2.4 million people. By understanding residents' preferences for buffer zone land use options it is possible that substantial benefits could be realised.

Results and Summary of key findings

To understand the combination of land uses the Western Australian community most prefers in wastewater treatment plant buffer zones we have implemented a choice experiment. Working closely with Water Corporation we identified four potential land use options: natural conservation, sporting and recreation, commercial or industrial, and agricultural. Analysis of the data from the first survey wave (400 completed questionnaires) indicates that the most preferred land use option, by some margin, is natural conservation, followed by sporting and recreation land uses. The least preferred land use option appears to be commercial/industrial use.

Discussion and application to industry

Our results are preliminary, but at a minimum they suggest that the community values some buffer zone land uses more highly than other land uses. By focusing on the buffer zone land uses the community most values it is possible to minimise the tension between local residents and operators of treatment plants and associated infrastructure. Ultimately the study results will be an important input into the process of developing land use planning guidelines for buffer zones surrounding treatment plants and similar infrastructure such as pumping stations.

Essential Participants

VICTORIA
State
Government

Government of **Western Australia**
Department of **Water**

Government of **Western Australia**
Department of **Housing**

MONASH University

THE UNIVERSITY OF QUEENSLAND
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