CRC for
Water Sensitive Cities

4th water sensitive cities conference

Australian Government
Department of Industry and Science

Business
Cooperative Research
Centres Programme

Session 6a: Urban metabolism: concepts, applications and use for water sensitive cities

Steven Kenway, CRCWSC and The University of Queensland

26-28 March 2019

Overview

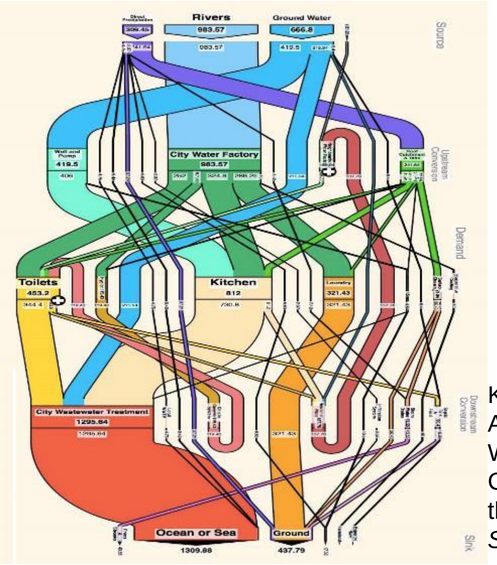
Concepts

- How can frameworks shift our thinking?
- What is Urban Metabolism?
- Transforming cities and measuring improvement

Applications and use for Water Sensitive Cities

- Examples from IRP4
- Energy – an opportunity for WSC

Urban metabolism conceptualisations differ with discipline and functions

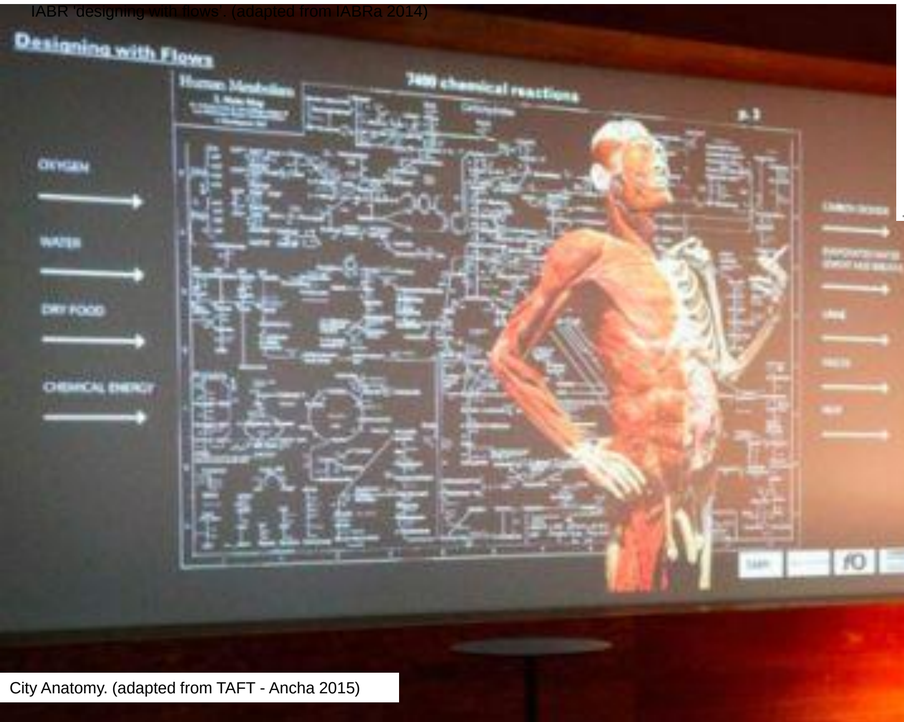


King, S., Kenway, S. J. & Renouf, M. A. (in press 2019). How has Urban Water Metabolism Been Communicated? Perspectives from the USA, Europe and Australia. *Water Science and Technology*.

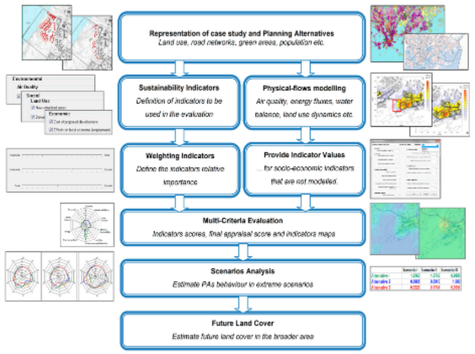
	Organismal perspective	Ecosystem perspective
Scientific foundation	Biology	Ecosystem ecology
Disciplinary focus	Life processes	Abiotic/biotic interactions
Orientation	Inward	Internal processes, external linkages
Metabolism meaning	Food/waste	Energy processing, production/respiration (C balance)
Metabolic units	Volume	Energy or carbon (or other materials)
Movement	Input–output	Feedbacks
Flows	Throughput	Structure–function linkages
System regulation	Homeostasis	Homeorhesis
Stability	Resistance	Resilience
Time	Climax succession	Disturbance dynamics
Structure	Morphostatic	Multiple stable states
Space	Uniformity	Fine-scale spatial heterogeneity (patch dynamics and gradients)
Agency	Single actor	Social, biological, and physical entities
Consumption	Heterotrophy	Internal transformations and teleconnections
Scope	Black box	Subsystems
Environmental context of city	Separate but connected, hinterland	Integrated social–biological–physical system

King 2018, Urban metabolism metaphors. (adapted from Golubiewski 2012)

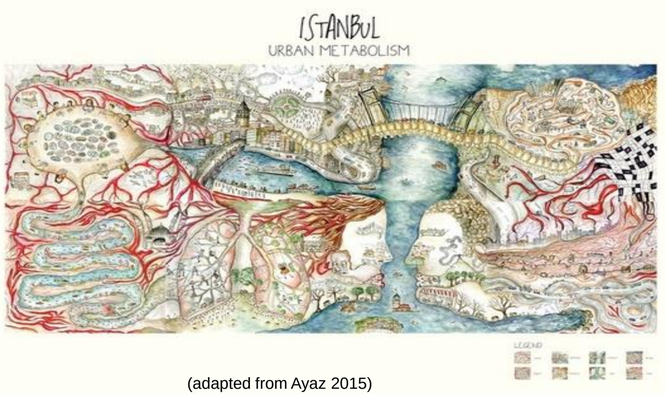
IABR "designing with flows". (adapted from IABRa 2014)



City Anatomy. (adapted from TAFT - Ancha 2015)



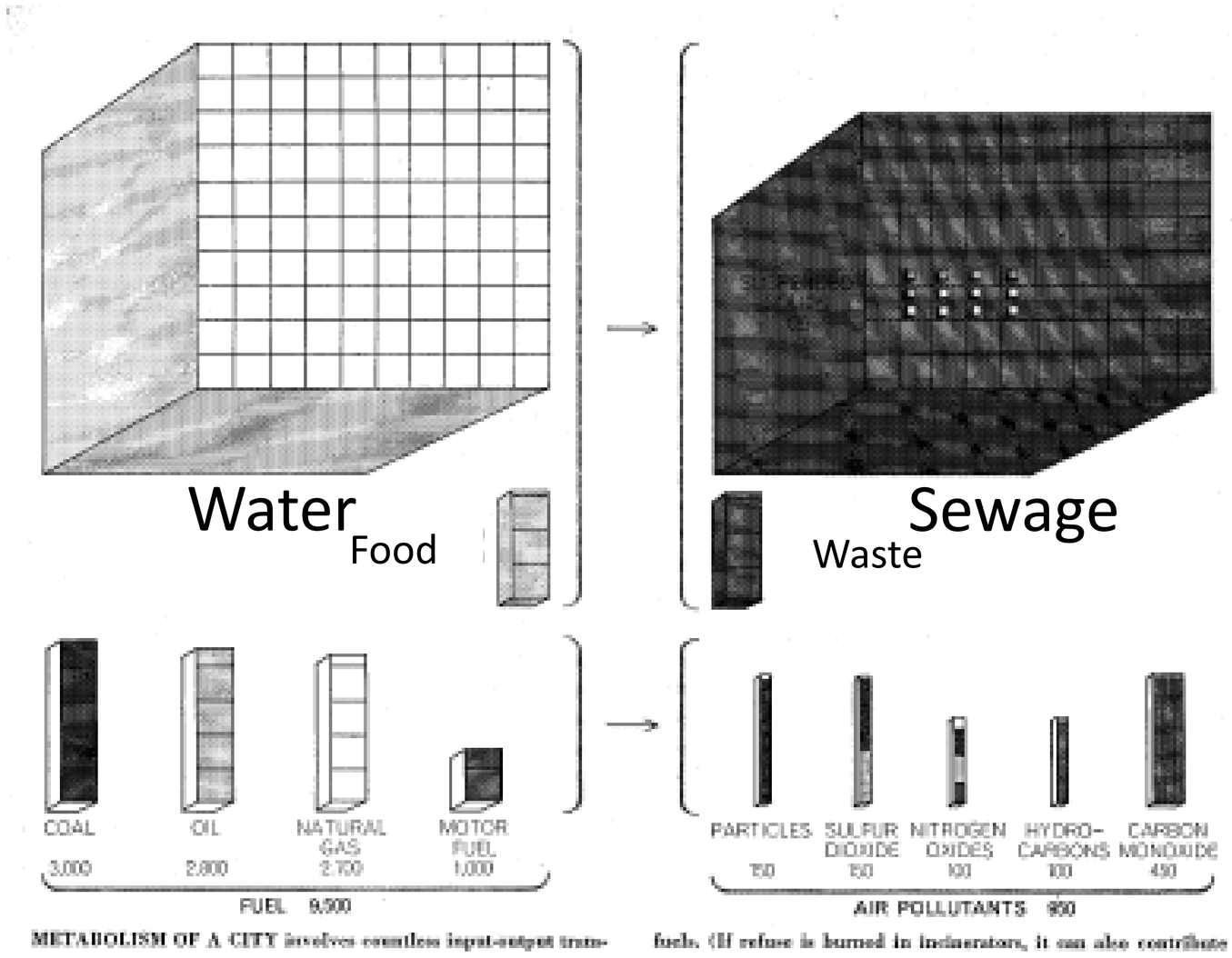
BRIDGE project. (adapted from Metraka et al. 2014)



(adapted from Ayaz 2015)

What is Urban Metabolism?

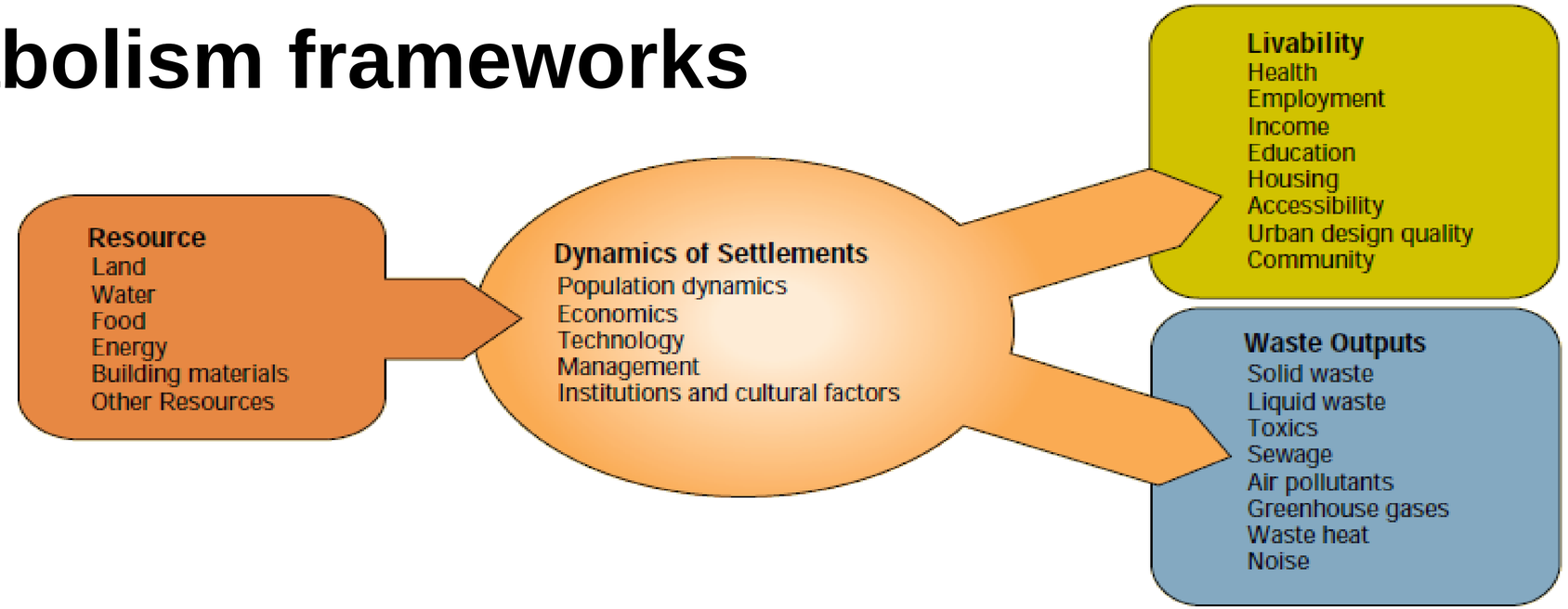
In 1965, Abel Wolman, AWA president, used metabolism as a concept to simultaneously deal with shortages of water, pollution of water and air….and public economic decisions

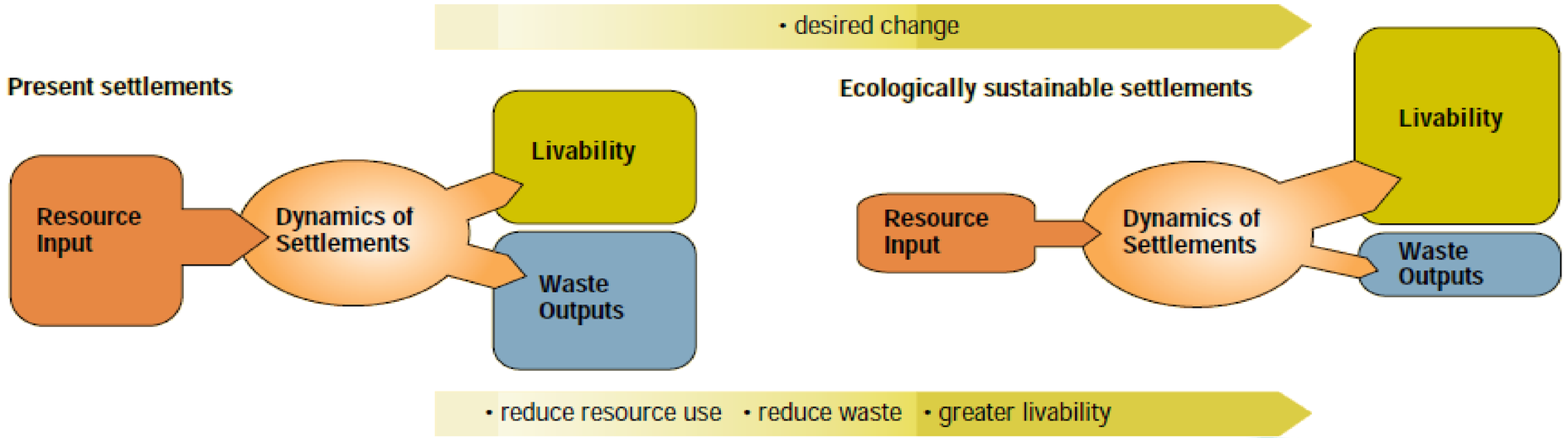


He concluded "there is no shortage of water, however there is a need for long-term thinking"

Wolman, 1965, The Metabolism of Cities (Scientific American)

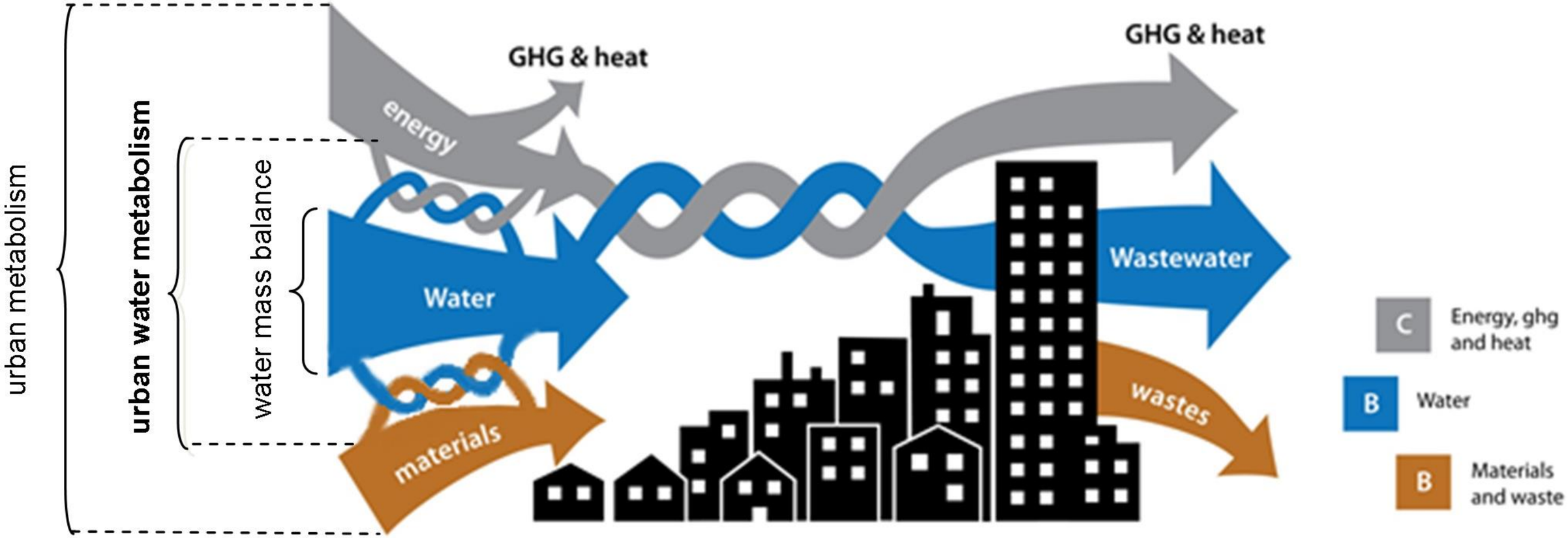
Urban metabolism frameworks





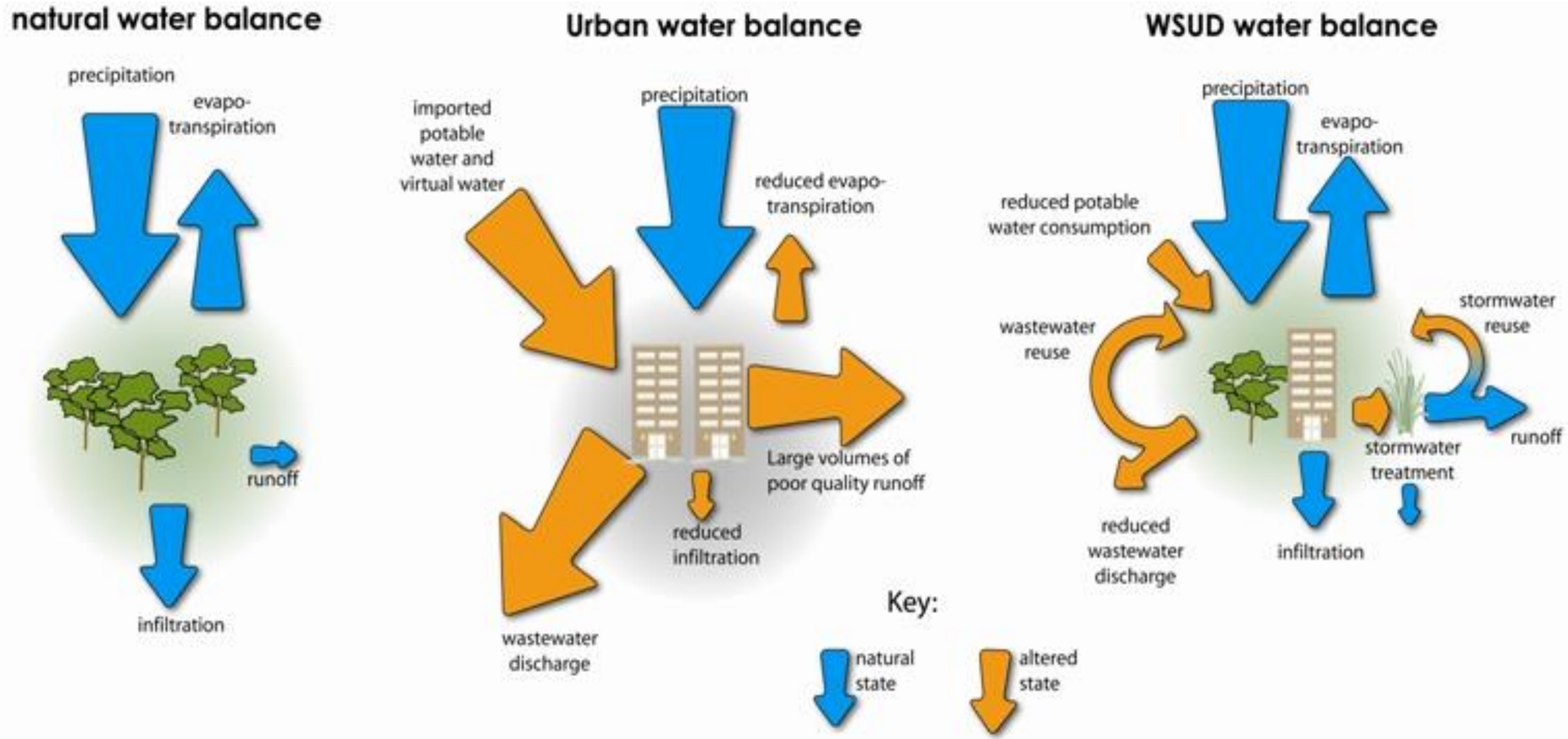
Newman (1999)

Urban Water Metabolism…and Water Mass Balance



Kenway 2012

Urbanisation and water….

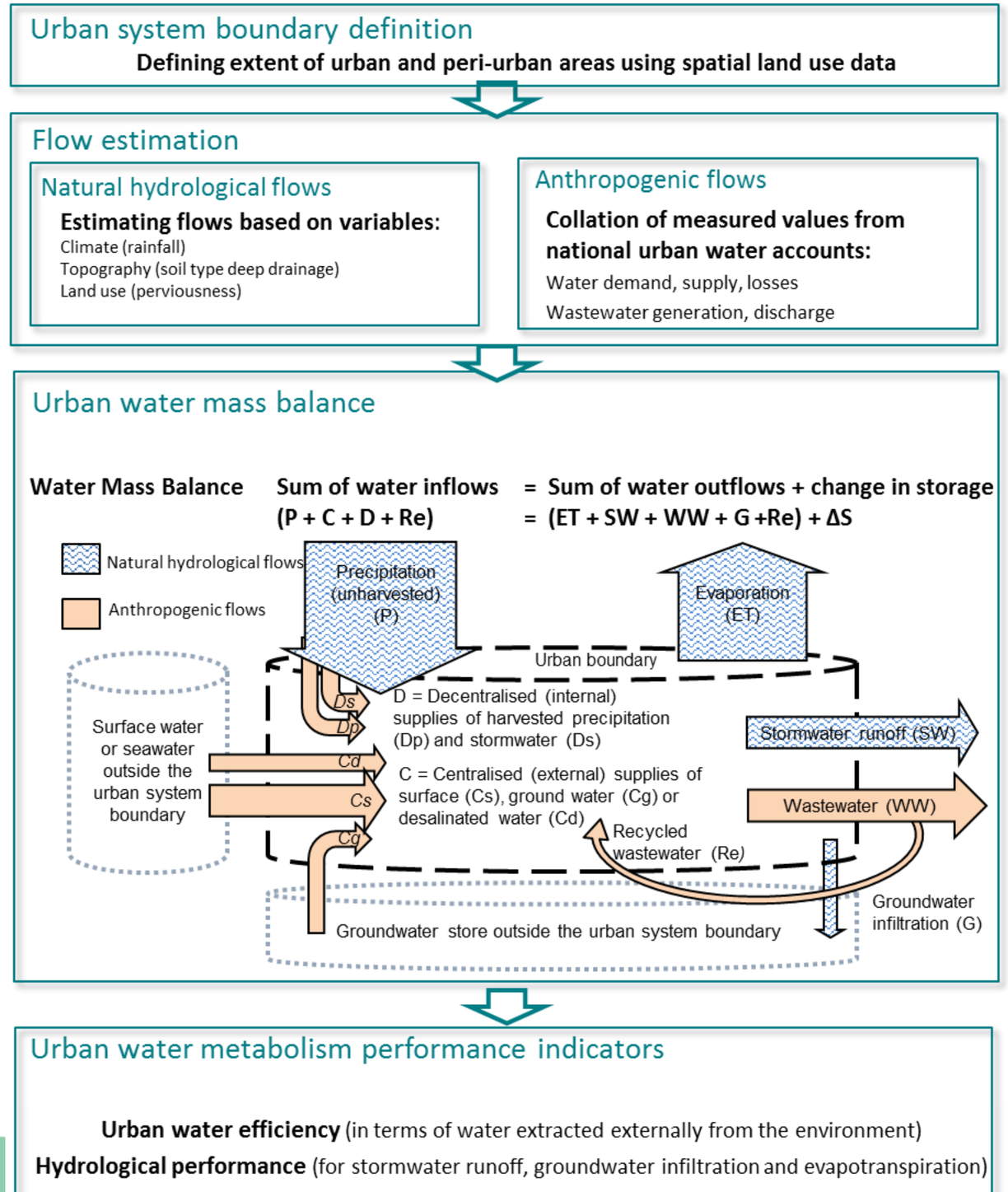


Source: Source Healthy Waterways Ltd. ©

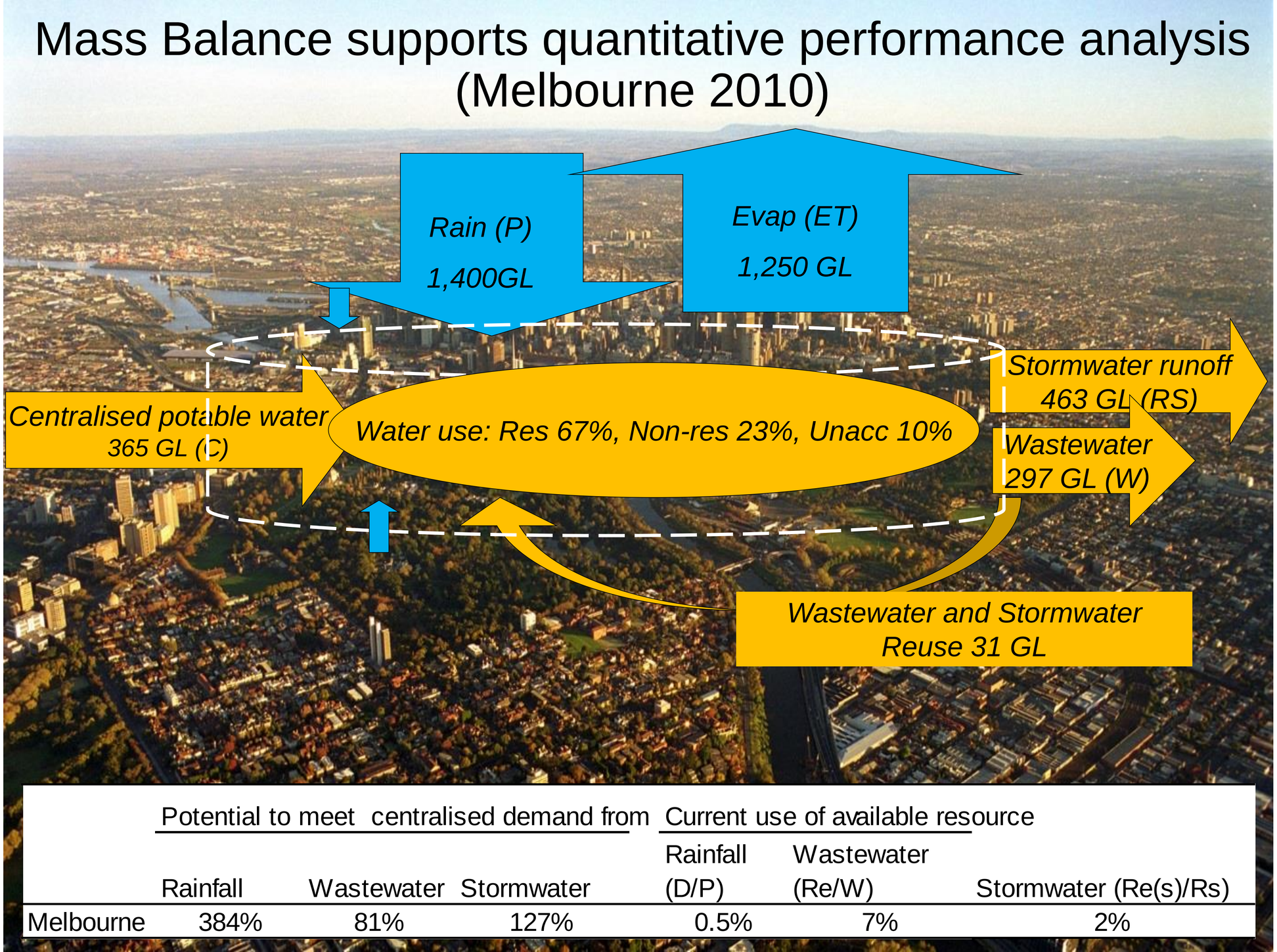
Urban metabolism evaluation framework (UMEF) for water (B1.2)..water mass balance as main analytical approach

[See report]

Renouf, Kenway, Lam, Weber, Roux, Serrao-Neuman, Morgan, Low Choy (2018) Water Research Vol. 137.



Mass Balance supports quantitative performance analysis (Melbourne 2010)



	Potential to meet centralised demand from			Current use of available resource		
	Rainfall	Wastewater	Stormwater	Rainfall (D/P)	Wastewater (Re/W)	Stormwater (Re(s)/Rs)
Melbourne	384%	81%	127%	0.5%	7%	2%

Could cities match the metabolic water efficiency of the human body?

Baby Born

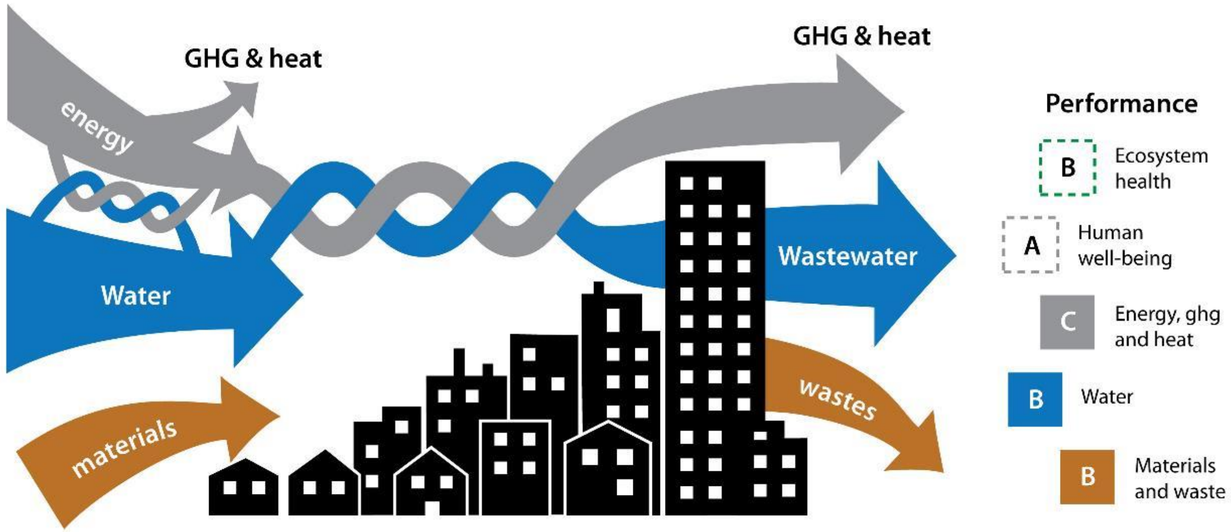
(0% water reuse)

Human body (2000% reuse)

Cities now (1-4% reuse)

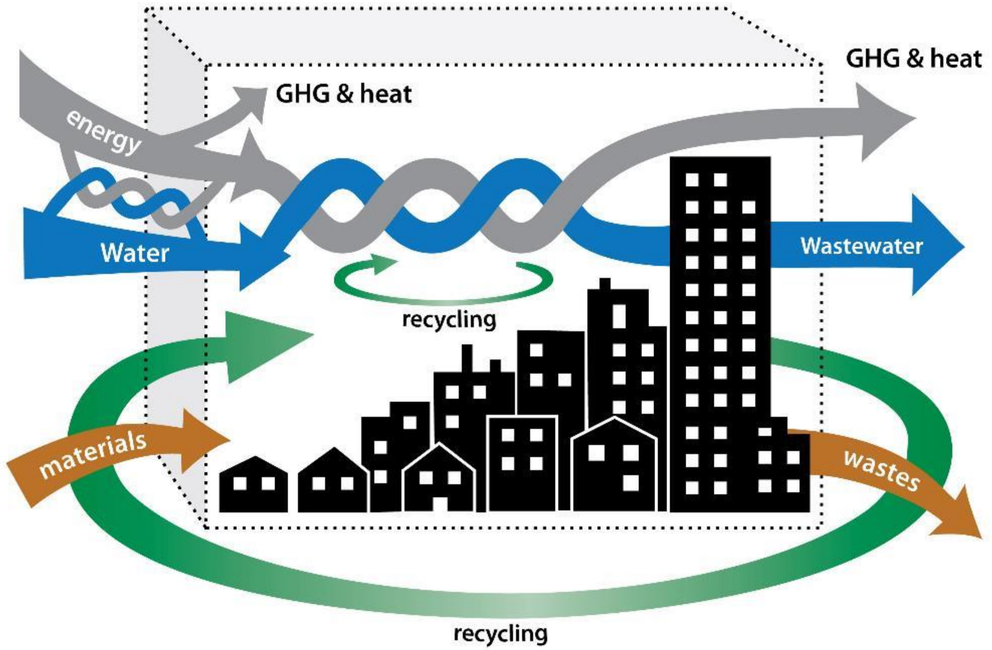
(recycle water ~20 times at different qualities)

Transforming cities and measuring the improvement



Performance

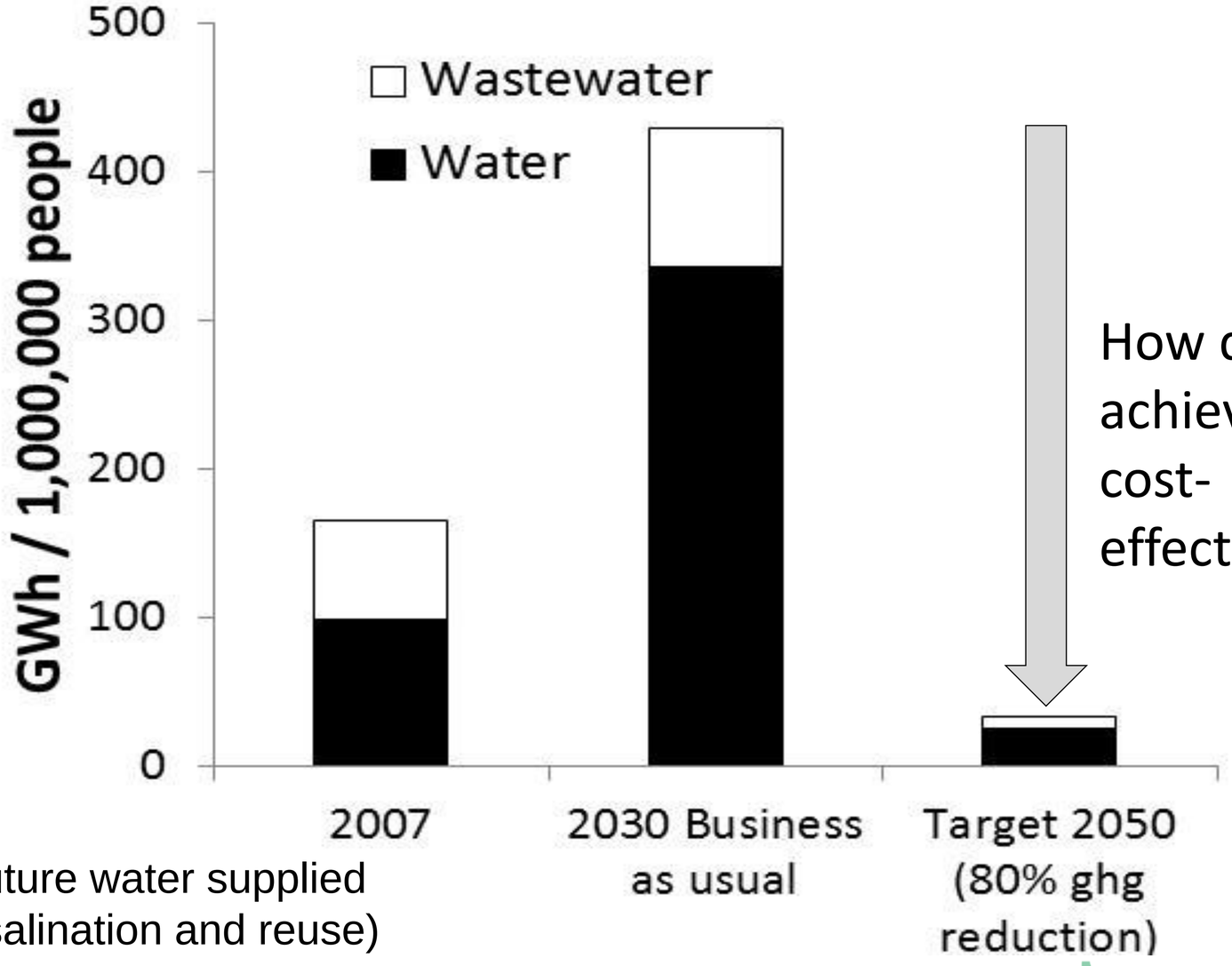
- B — Ecosystem health
- A — Human well-being
- C — Energy, ghg and heat
- B — Water
- B — Materials and waste



Performance

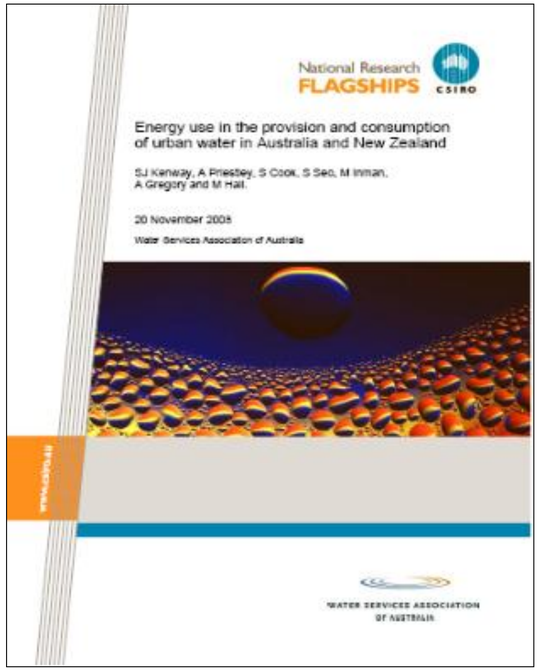
- B — Ecosystem health
- A — Human well-being
- A — Energy, ghg and heat
- A — Water
- A — Materials and waste

A challenge for Australia (and elsewhere)….rising energy use in urban water, rising energy costs, and National greenhouse gas targets



How do we achieve this cost-effectively?

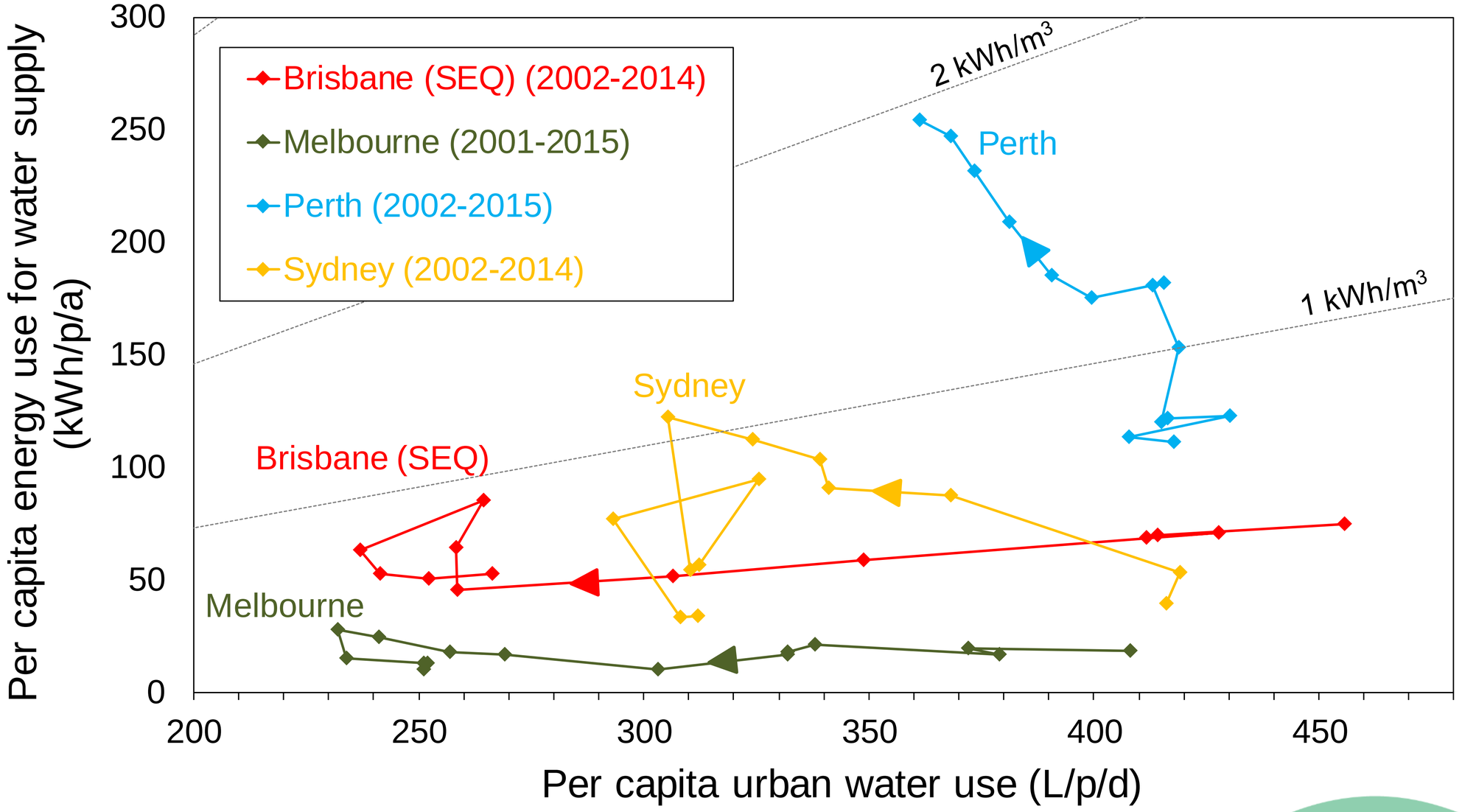
(Most future water supplied from desalination and reuse)



Kenway et al (2008), and Cook et al 2012

assumes 225 L/p.d residential consumption and that climate change will not adversely affect existing water yields.

Water-energy trajectories - Australian cities



Lam, K.L., Kenway, S.J and Lant, P.A. (2016) Energy use for water provision in cities.

Lam, K.L., Lant, P.A., O'Brien, K.R. and Kenway, S.J. (2016) Comparison of water-energy trajectories of two major regions experiencing water shortage. *Journal of Environmental Management* 181, 403-412.

Energy influenced by urban water SEQ 2011-12

	Supply	Residential (water-related energy)	Industrial & Commercial (water-related energy)	Wastewater treatment
Energy (GWh)	150	3,200*	2,300*	250*
Energy ($ million)	20	800*	300*	25*

(93%)

Collectively accounts for:

- *13% of all electricity use in South East Queensland*
- *18% of all natural gas use, + 4% all other energy use*

Kenway, S., et al. (2015). *Environmental Modelling and Software*

How will new water technology (and solutions) influence water-related energy?

Household scale

Recirculating showers

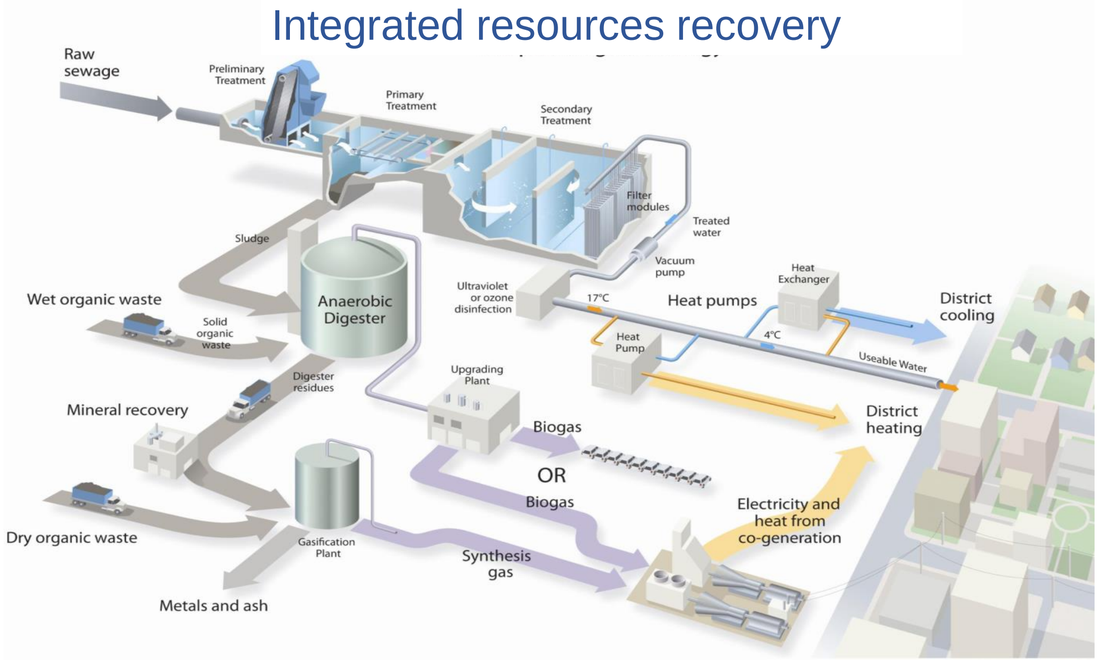
Waterless clothes- and dish-washers

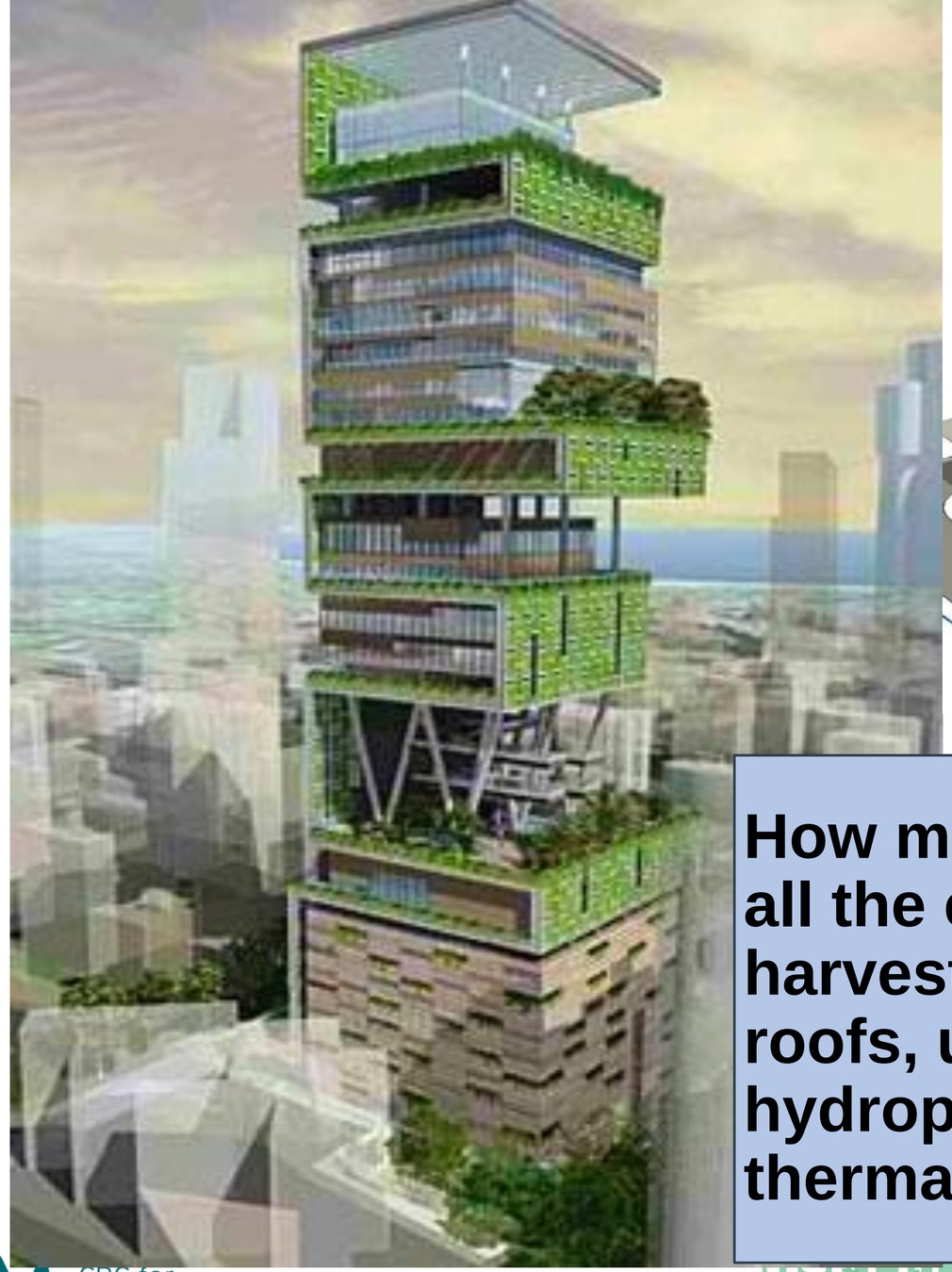
Not a product endorsement

City Scale

WSC solutions

Integrated resources recovery





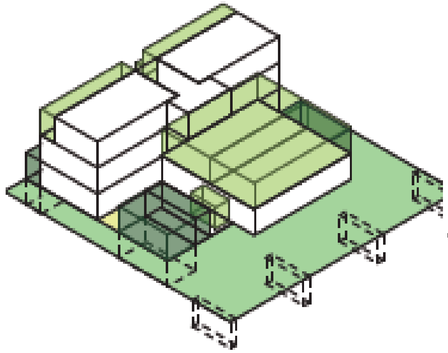
GRAPHIC BY MKA MAGNUSON KLEMENCIC

How much energy could we save if all the elements of rainwater harvesting, water reuse, green roofs, urban agriculture, hydropower, evaporative cooling & thermal storage are used?

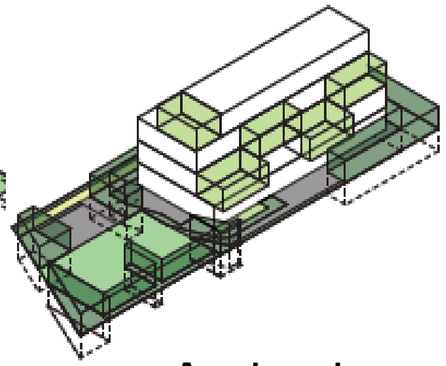
Source: Steve Moddemeyer 2009

IRP4 Water sensitive outcomes for infill PRODUCTS / OUTPUTS

Designs of urban typologies
(drawings and plans)



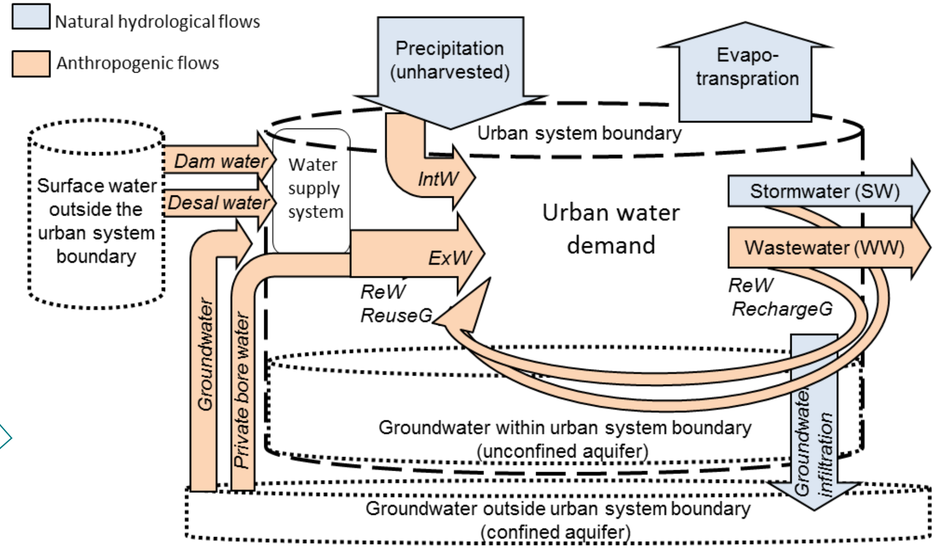
Dwellings



Apartments

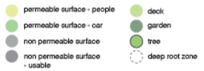
Streets

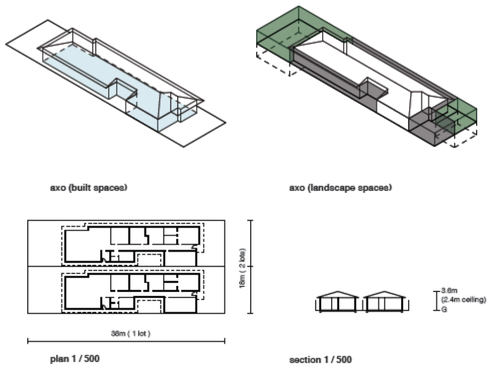
Performance framework and water mass balance



Category A: Suburban Lot Subdivision
Standard Industry Practice
Two Unit Occupancy - Single Lot
Salisbury SA

Category D: Suburban Precinct
Redcliffe Connect
Monash Architecture Studio
2012 - 2017





1. Catalogue of infill typologies design and performance information
2. Case studies of typologies embed in urban precincts
3. Evaluation framework and mass balance tool.

Dwelling Data			
Bedrooms:	4 (per dwelling)	Garden Area:	91 m2 (per dwelling)
Occupants:	4-6 (per dwelling)	Roof Surface Area:	209 m2 (per dwelling)
Cars:	2 (per dwelling)	Roof Surface Type:	?
Building Storeys:	1	Volume:	418 m3
Building Site Area:	684 m2	Area of roof area connected to rainwater storage:	?%
Building Footprint:	168 m2 (per dwelling)	Rainwater Storage Capacity:	2000 litres (approx) (per dwelling)
Floor Area (building):	168 m2 (per dwelling)	Household water appliances: (per dwelling)	2 x shower, basin, wc, 1 x bath, kitch sink, laun tub, wm.
Floor Area (deck):	83 m2 (per dwelling)	Building material:	brick veneer

Site Data			
Site Area:	? m2	Vegetated Surface (garden/ trees)	? m2
Number of Lots:	?	Deep Root Zones:	?
Number of Dwellings:	?	Canopy Trees	?
Density:	? dwellings per hectre	Other on-site rainwater water storage capacity (stormwater):	?
Open Space:	? m2	Expected irrigation pattern for planned garden area:	?
Site Coverage:	%	Vegetation characteristics (i.e., vegetation type, leaf area):	?
Permeable Hard Surface (car, people):	? m2	Soil characteristics (i.e., soil type, top soil depth)	?

Workshop Thursday morning

CRC for Water Sensitive Cities

watersensitivecities.org.au

Thanks to! ……IRP4 Research team

Steven Kenway
Project Leader, UQ

Nigel Bertram
Research Lead, Monash

Geoffrey London
Research Lead, UWA

Marguerite Renouf
Research Lead, UQ

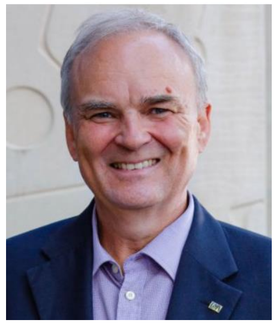
Oscar Sainsbury
Building design typologies, Monash

Beata Sochacka
Water demand, project management, UQ

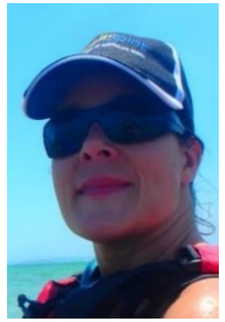
Tatjana Todorovic
Design typologies, UWA

Kerry Nice
Urban heat, Monash

Bosco Chow
Technology, UQ



Jurg Keller
Project Guidance

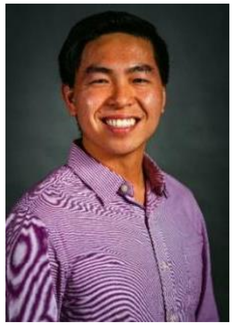


Marie-Laure Pype
Technology suitability, UQ

Daniel Martin
Principles for infill, UWA

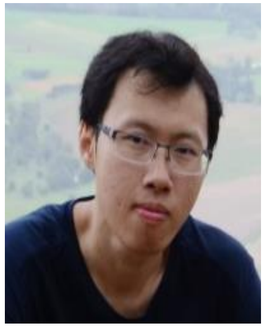
Owen Hoar
Performance framework and groundwater, UQ

Xuli Meng
Hydrological performance, UQ



Kyle Wang
Water data value, Monash

Mojtaba Moravej
Hydrology, UQ



Ka Leung Lam
Water mass balance and framework, UQ

Niloo Tara
Water performance, UQ

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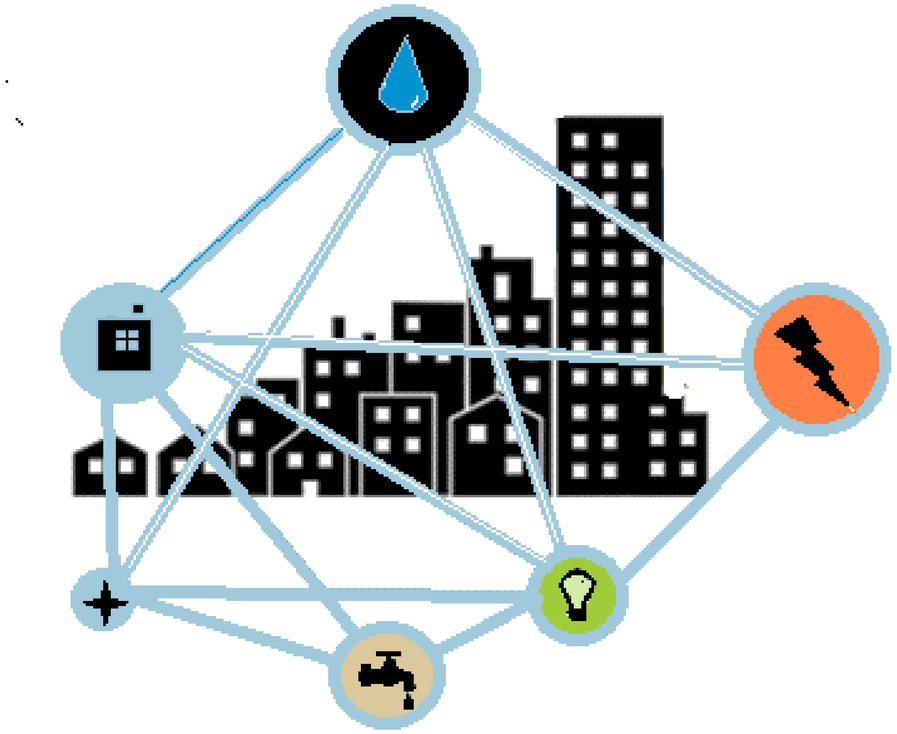
WATER AND ENERGY DESIGN CHALLENGE WINTER SCHOOL

24-28 June 2019

https://www.stickytickets.com.au/84511



- **Build cross-disciple links and industry connections.**
- **Network with mentors, judges, presenters.**
- **Build applied knowledge for a critical issue.**
- **Compete for cash (1500$ team) and other prizes.**
- **Have fun!**

ERGON ENERGY NETWORK

Energy Queensland

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INTERNATIONAL WATERCENTRE

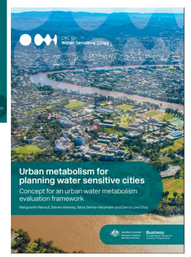
URBANENQUIRY Research + Practice

CRC for Water Sensitive Cities

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Water-Energy-Carbon Research Group

Publications / selected reading



Marguerite R, Sochacka, B, Kenway, S Lam, K-L, Neumann, S, Morgan, E and Choy D. (2017). Urban metabolism for planning water sensitive city-regions Proof of concept for an urban water metabolism evaluation framework B1.2 **Report**. https://watersensitivecities.org.au/wp-content/uploads/2017/12/Milestone-Report-Urban-metabolism_FINAL-1.pdf

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