Veeriah Jegatheesan (Jega), RMIT
Ashantha Goonetilleke, QUT
John van Leewen, UniSA
Jaya Kanadasamy, UTS
Doug Warner, University of Hertfordshire, UK
Baden Myers, UniSA

Stormwater Management for Improved Stream Health via Integrated Water Management

2019 Stormwater Victoria Conference
4-5 June, Marysville

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4 June 2019

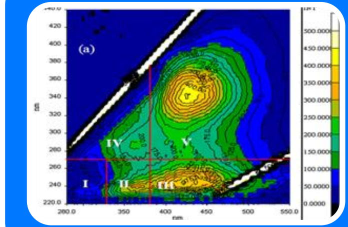
Water Effective Technologies & Tools (WETT) Research Centre

- Members : 28
- Strength: Engineering, environmental chemistry and microbiology, ecotoxicology, biology, modelling and renewable energy

Director
Professor Veeriah Jegatheesan

Deputy Director
Assoc. Professor Oliver Jones

Strategic Advisor
Emeritus Professor Felicity Roddick



Assist practitioners to provide secure, sustainable supply of safe clean water with minimal impact on the environment and so build resilient communities

in 2017:

>100 Projects

150 journal publications (94 in top quartile)

21 HDR completions

ERA 2015: ranked

5 for 0502 environmental science and management and 0912 materials engineering

If one single man suffers from starvation, we will destroy the entire world – Subramania Bharati, 1882-1921

WETT's Research Contributions towards SDGs

Let the sky fall, when it crumbles, we will stand tall and face it all together – Theme song of 23rd James Bond Movie, "Sky Fall"

WETT Focus

Quality and Quantity of Water

Research covers the entire water cycle, 3 major themes

Water Resources and Management

Water sensitive urban design, systems for management of quality and quantity of all water types (potable, storm, waste, ground)

Water and Wastewater Treatment, Reclamation

Treatment of potable, industrial, wastewater and water reclamation, desalination, generation and utilisation of renewable energy

Biosolids and Bioenergy

Health, safety and utilisation of biosolids from wastewater treatment processes, sustainable production of energy via bioenergy systems

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Research Partners

Melbourne Water

South East Water

City West Water™

GOULBURN VALLEY WATER

Barwon Water

Smart Water Fund

City of Casey

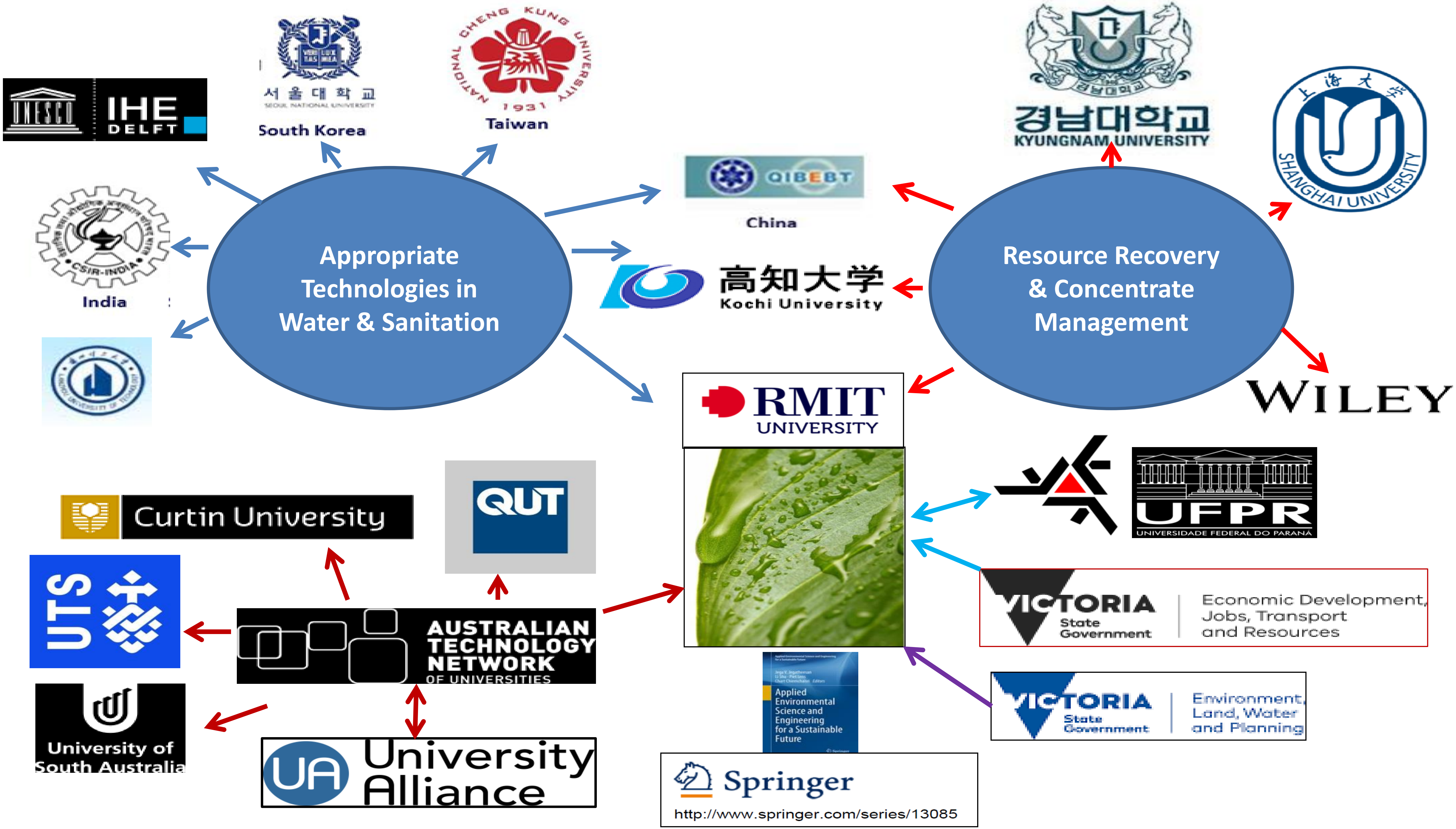
Australian Water Recycling Centre of Excellence

Cranfield University

Water Research Australia

seqwater WATER FOR LIFE

VICTORIA State Government | Environment, Land, Water and Planning


UNESCO IHE DELFT
서울대학교
South Korea
NATIONAL CHENG KUNG UNIVERSITY 1931
Taiwan
경남대학교
KYUNGNAM UNIVERSITY
SHANGHAI UNIVERSITY
QIBEBT
China
CSIR-INDIA
India
Appropriate Technologies in Water & Sanitation
高知大学
Kochi University
Resource Recovery & Concentrate Management
RMIT UNIVERSITY
WILEY
UFPR
UNIVERSIDADE FEDERAL DO PARANÁ
Curtin University
QUT
UTS
AUSTRALIAN TECHNOLOGY NETWORK OF UNIVERSITIES
VICTORIA State Government
Economic Development, Jobs, Transport and Resources
Applied Environmental Science and Engineering for a Sustainable Future
VICTORIA State Government
Environment, Land, Water and Planning
University of South Australia
UA University Alliance
Springer
http://www.springer.com/series/13085

Stormwater - Overview

- One of the major polluters of rivers

- Carries 14,000 tonnes of sediment, 650 tonnes of nutrients such as nitrogen from fertiliser, litter, heavy metals and bacteria into the Yarra River each year

- Around 540 billion cubic meter of stormwater flows into Port Phillip Bay annually

- Flooding causes
  - Shock loading of pollutants to the rivers
  - Structural damages due to changes in the hydraulics of the river

- Major Stormwater management and flood mitigation initiatives
  - Water Sensitive Urban Design (WUSD)
  - Sponge City Program (SCP)
  - Sustainable Urban Drainage Systems (SuDS)
  - Low Impact Development (LID)

https://yarraandbay.vic.gov.au/issues/stormwater

Stormwater - Overview

- Issues with the implementation of such strategies
  - Localized
  - Integration with the wider geophysical and social characteristics of the broader surrounding region

- Varied approaches towards stormwater harvesting
  - Simple rainfall capture from roofs
  - Advanced systems such as aquifer storage, transfer and recovery

Stormwater – Discussion Topics

Australia and the United Kingdom

- Impacts of stormwater and flooding
  - Transport of nutrients

- Emerging and recently identified problems
  - Transport of key synthetic organic pollutants e.g. PFAS
  - Presence of antibiotic resistant bacteria and genes

- Effectiveness of current management practices of stormwater and flooding

Stormwater Discussion Topics

- Current and likely challenges in stormwater management that may occur in the future
  - increased risks to water quality
  - environmental impacts

- Use of stormwater as a resource for human and environmental needs

- Social acceptance

- Current regulations relating to stormwater capture and reuse

- Future impacts of growing urbanisation on flood risks

Surface water quality in the UK

- Surface waters negligible improvement since 2008

  According to the Joint Nature Conservancy Council (JNCC) Indicator B7: Surface Water Status (2018) UK

- 35% of UK surface waters classed as ‘high’ or ‘good’ ecological status

  in 2018 under the EU Water Framework Directive (2006/60/EC)

- Europe average 43% of surface waters good ecological status or above in 2009 and reaching 53% (estimated) in 2015

- Restore a minimum of 75% of UK surface waters to one of high ecological status

  (recently published ‘25 Year Environment Plan’ by the UK govenment)

Impacts of Flooding - UK

- UK Government investing £2.6 billion on flood defence work until 2021
- Floods in England 2015 - 2016 cost an estimated £1.6 billion
- At present 2.7 million UK homes at risk from surface level flooding
- UK water management focuses on flood mitigation from rivers and in coastal areas

https://www.bbc.co.uk/news/uk-england-london-36471889

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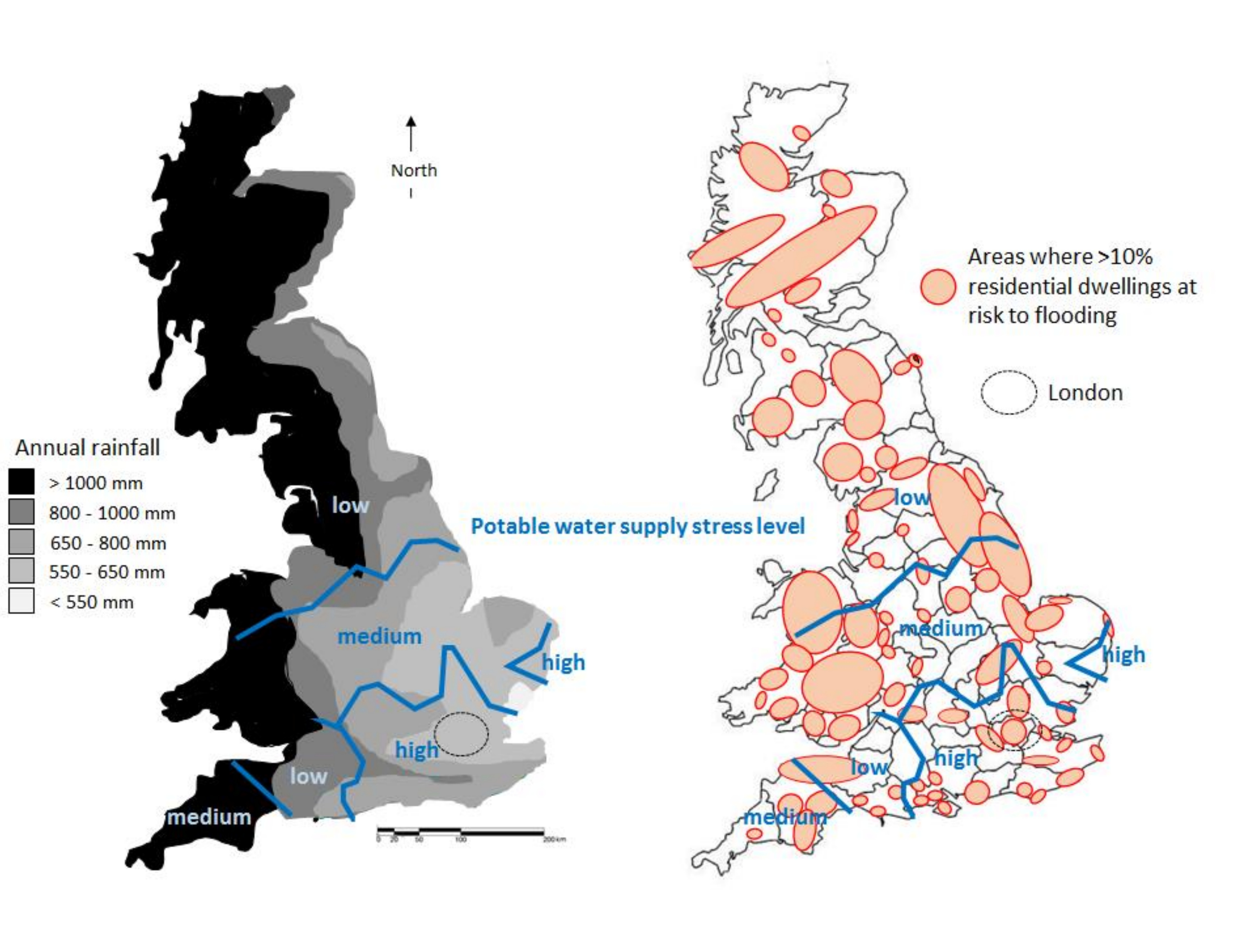
UK flood risk



Rainfall in the East is less than the annual average rainfall in Melbourne, Sydney and Brisbane

Despite our assumption that it rains all the time in the UK

Environment Agency (2015)

Impacts of stormwater and flooding - Australia

Public urged not to swim at Adelaide beaches as polluted stormwater spews into the sea

October 6, 2016 6:05pm

Jade Gailberger

The Advertiser, 6 Oct 2016

The Environment Protection Authority is warning swimmers to stay out of the water at Glenelg, Henley Beach, Hallett Cove, Christies Beach and Moana after the storms last week. Picture: Tricia Watkinson

The Popeye makes it way through the green slime on the River Torrens.

SA News

Colin James: It's time to fix the River Torrens once and for all — or face more outbreaks of green slime

The Advertiser, 18 Feb 2015

Colin James, The Advertiser
February 18, 2015 12:30pm

YET again, just when we need Adelaide looking its absolute best, the River Torrens lets us down by turning into a slimy eyesore. Perhaps it's time to get rid of it once and for all. Heck, why not pave over the Torrens Lake?

Aerial view of River Torrens outlet at Henley Beach after a storm

(Image source: ABC Online, 23/12/2016)

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Pollutants in stormwater

Contaminant	Unit	Mean	Standard Deviation	Percentiles				
				5	25	50	75	95
Pathogens								
Campylobacter (bacteria)	/100 ml	3.31	1.97	1.00	1.93	2.89	4.21	7.02
Cryptosporidium (protozoa)	/10 L	176	211	12	52	112	222	546
Giardia (protozoa)		1.81	2.08	0.12	0.55	1.17	2.29	5.55
Bacteria Indicators								
Coliforms	/100 ml	97665	170197	3369	17668	44884	106860	355988
Clostridium perfringens		925	1016	103	315	614	1153	2748
E coli		59339	71939	3835	17203	37511	74564	184382
Enterococci		13792	10928	1621	6043	11229	18586	34465
Faecal coliforms		96429	82740	4694	20440	44168	87235	215568
Faecal streptococci		29771	21717	3829	13991	25212	40317	70894
Somatic coliphages		17530	20917	1154	5088	11115	22083	54704

- ✓ 59 samples
- ✓ 4 Sydney sites
- ✓ Sewered residential areas
- ✓ 3 sites with high sewer overflows
- ✓ 11 dry weather samples
- ✓ 48 wet weather samples
- ✓ 4 storm events
- ✓ Sampling during the early, mid and late hydrograph stages

Data considered to be representative of stormwater quality through the range of conditions within which water would be harvested

Australian Guidelines for Water Recycling: Stormwater Harvesting and Reuse (2009)

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Pollutants in stormwater

Contaminant	Unit	Mean	Standard Deviation	Percentiles				
				5	25	50	75	95
Heavy Metals								
Aluminium	mg/L	0.19	0.60	0.49	0.78	1.07	1.47	2.29
Arsenic		0.009	0.001	0.006	0.008	0.009	0.009	0.011
Barium		0.028	0.005	0.021	0.025	0.028	0.031	0.038
Cadmium		0.0198	0.0242	0.0015	0.0061	0.0127	0.0248	0.0606
Chromium		0.009	0.005	0.002	0.005	0.008	0.011	0.017
Copper		0.055	0.047	0.012	0.025	0.041	0.068	0.141
Iron		2.842	1.246	1.126	1.956	2.674	3.540	5.100
Lead		0.073	0.048	0.017	0.040	0.063	0.095	0.162
Manganese		0.111	0.046	0.054	0.079	0.103	0.134	0.197
Mercury		0.218	0.105	0.080	0.143	0.201	0.273	0.411
Nickel		0.009	0.004	0.004	0.007	0.009	0.011	0.017
Zinc		0.293	0.153	0.080	0.183	0.272	0.379	0.570

Australian Guidelines for Water Recycling: Stormwater Harvesting and Reuse (2009)

Pollutants in stormwater

Contaminant	Unit	Mean	Standard Deviation	Percentiles				
				5	25	50	75	95
Nutrients								
Oxidised nitrogen	mg/L	0.680	0.446	0.132	0.361	0.592	0.900	1.523
Total dissolved nitrogen		3.28	2.61	0.68	1.55	2.59	4.19	8.22
Total Kjeldahl nitrogen		2.84	4.14	0.60	0.95	1.59	3.04	8.82
Total organic nitrogen		0.623	0.828	0.160	0.233	0.367	0.669	1.874
Total nitrogen		3.09	2.33	0.62	1.52	2.51	4.00	7.46
Filtered reactive phosphorous		0.664	0.762	0.050	0.204	0.430	0.839	2.037
Total phosphorous		0.480	0.413	0.075	0.207	0.367	0.620	1.261
Hydrocarbons								
Polycyclic Aromatic Hydrocarbons	µg/L	0.262	0.306	0.017	0.078	0.168	0.331	0.811
Physico-chemical Indicators								
Ammonia	mg/L	1.135	1.187	0.102	0.394	0.793	1.464	3.281
Bicarbonate alkalinity as $CaCO_3$		35.21	3.36	29.99	32.887	35.04	37.37	40.97
Biochemical Oxygen Demand		54.28	45.58	6.56	22.87	42.53	72.03	140.77
Chemical Oxygen Demand		57.67	17.22	32.90	45.41	55.75	67.85	88.72

Australian Guidelines for Water Recycling: Stormwater Harvesting and Reuse (2009)

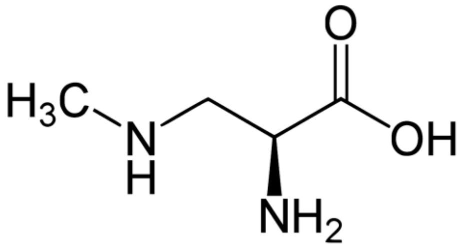
Pollutants in stormwater

Contaminant	Unit	Mean	Standard Deviation	Percentiles				
				5	25	50	75	95
Chloride	mg/L	11.40	1.05	9.75	10.67	11.35	12.08	13.20
Oil and grease	mg/L	13.13	8.11	3.43	7.45	11.47	16.93	28.25
Sodium	mg/L	10.63	2.82	6.58	8.62	10.31	12.29	15.72
Suspended solids	mg/L	99.73	83.60	19.01	45.41	77.24	127.19	254.47
Total dissolved solids	mg/L	139.60	17.30	112.89	127.44	138.54	150.58	169.60
Total organic carbon	mg/L	16.90	3.33	11.99	14.54	16.60	18.92	22.80
Turbidity	NTU	50.93	40.46	7.98	23.21	40.74	66.78	127.79
pH	-	6.35	0.54	5.50	5.98	6.33	6.70	7.27

Impacts of stormwater and flooding

Blue-Green Algae and motor neuron disease

Blue-Green Algae and Alzheimer's disease



THE CONVERSATION

Academic rigour, journalistic flair

Toxic load: blue-green algae's role in motor neuron disease

September 26, 2013 7.01am AEST

Pretty but deadly: researchers now understand how blue-green algae is linked to neurodegenerative diseases. Mark Sadowski

Author

Rachael Dunlop

Post-doctoral fellow, University of Technology Sydney

Need management of nutrient cycles

THE CONVERSATION

Academic rigour, journalistic flair

Exposure to algae toxin increases the risk of Alzheimer's-like illnesses

January 20, 2016 11.43am AEDT

Blue-green algae blooms are increasing in size and frequency as global temperatures rise.

- Algal toxin BMAA (β-Methylamino-L-alanine) mimics an amino acid, that our bodies naturally use to make proteins, called L-Serine
- Mistaking the toxin for the amino acid, the body incorporates into human proteins
- Rendering them harmful

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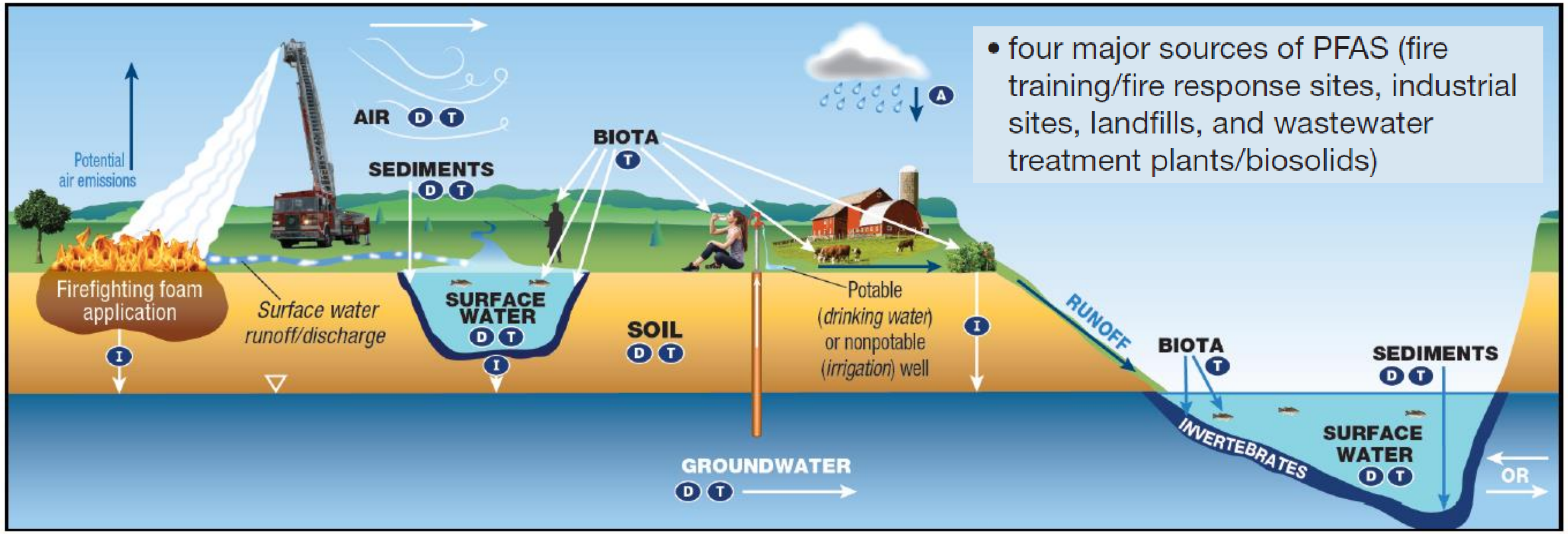
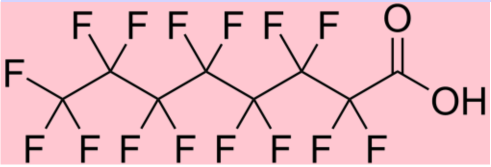
Impacts: Per- and polyfluoroalkyl substance (PFAS) in Stormwater

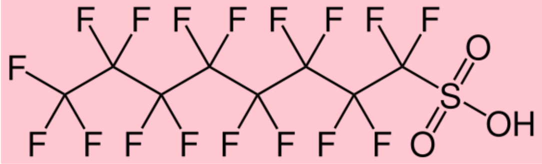


KEY A Atmospheric Deposition D Diffusion/Dispersion/Advection I Infiltration T Transformation of precursors (abiotic/biotic)

Perfluorooctanoic acid (PFOA)



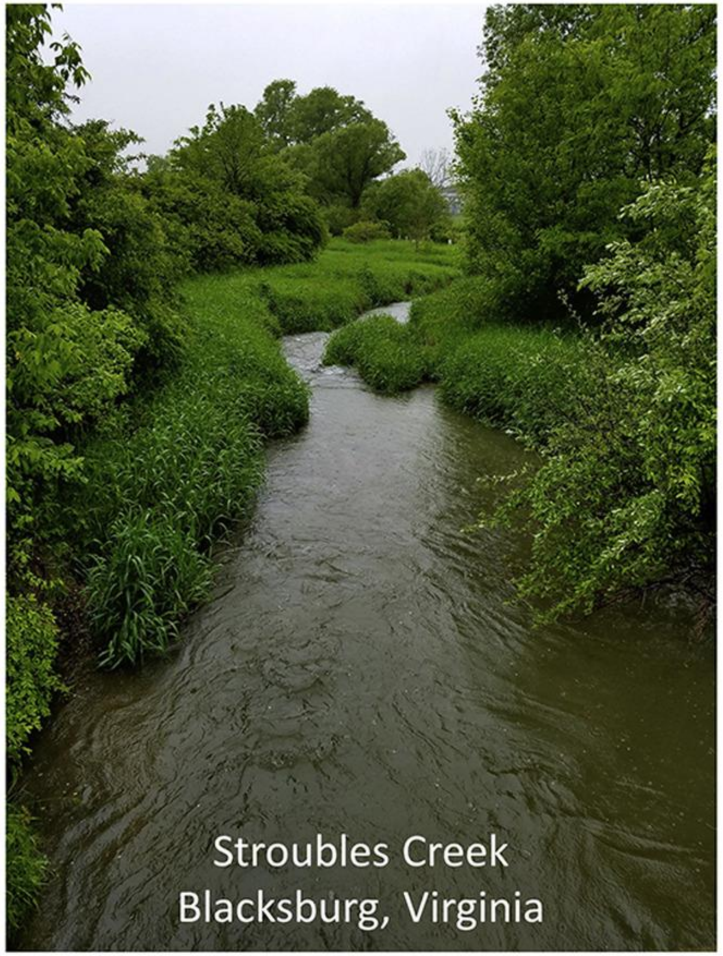
Perfluorooctanesulfonic acid (PFOS)

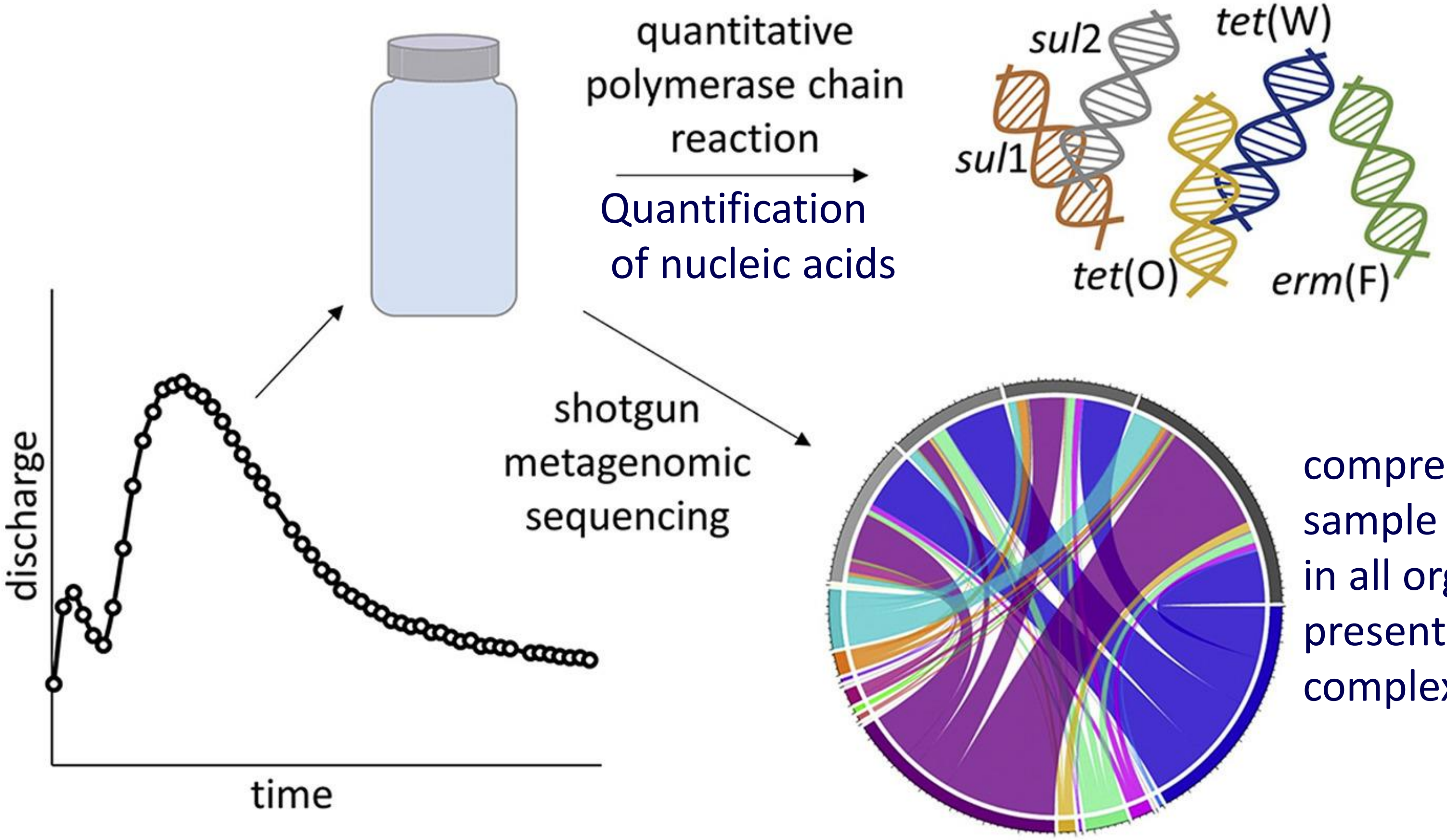


- Used in non stick coatings, textiles, paper products, fire fighting foams and other products
- Repel oil and water, resist temperature extremes, reduce friction
- Have multiples structures and functional groups

Interstate Technology Regulatory Council, 2018

Impacts: Antibiotic Resistance Genes (ARGs)



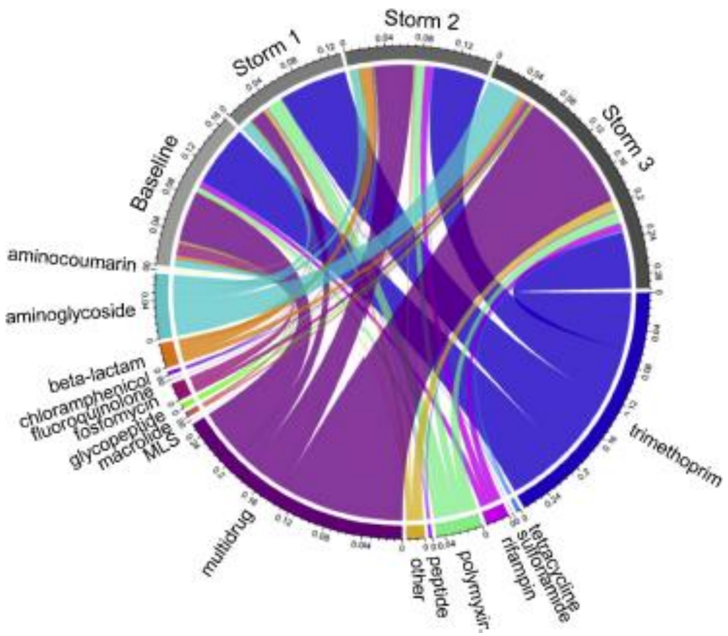


comprehensively sample all genes in all organisms present in a given complex sample

E. Garner et al. / Water Research 123 (2017) 144-152

Impacts: Antibiotic Resistance Genes (ARGs)

Drainage area	14.4 km^2
Urban/residential land use	84%
Agricultural land use	13%
Forested land	3%
Storm event 1	6 mm, 8,100 m^3
Storm event 2	17 mm. 37,000 m^3
Storm event 3	12 mm, 70,000 m^3



Abundance of five ARGs (sulfonamide, tetracycline and Macrolide) in an inland urban stream (Virginia, USA)

Spearman's rank correlation coefficients indicating correlations between ARGs, fecal indicator bacteria, and physicochemical water quality parameters. Statistically significant correlations ($\alpha = 0.05$) indicated in bold and with an asterisk.

	E. coli	enterococci	temperature	turbidity	dissolved oxygen	conductivity	pH
*sul*1	0.123	0.167	**0.279***	**0.392***	−0.188	−0.206	**−0.285***
*sul*2	0.165	**0.244***	**0.327***	**0.467***	−0.221	−0.165	**−0.251***
tet(O)	**0.363***	**0.522***	**0.446***	**0.753***	**−0.397***	**0.316***	−0.063
tet(W)	**0.330***	**0.321***	**0.312***	**0.542***	**−0.266***	−0.138	**−0.274***
erm(F)	0.150	**0.314***	**0.324***	**0.619***	**−0.508***	**0.271***	**−0.339***

E. Garner et al. / Water Research 123 (2017) 144-152

Impacts: Antibiotic Resistance Genes (ARGs)

- Significant loading of ARGs due to storm-driven transport
- Varying loadings of different ARGs
- Tetracycline resistance genes correlated with *E. coli*
- Transfer of ARBs downstream

E. Garner et al. / Water Research 123 (2017) 144-152

Key issues for surface water quality in the UK

- Surface run-off from agricultural land – nitrogen (as nitrate NO_3^-), phosphate (P_2O_5) and soil particulates (sedimentation)

- Biocides – metaldehyde (molluscicide), highly persistent, may accumulate within water bodies, classed as an emerging contaminant in UK water supplies

- Oil from vehicles and herbicides applied to control weeds on pavements in urban areas

- Risk of the above entering surface waters increased by extreme weather events e.g. heavy rainfall, or by flooding

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Objectives of recent advances in stormwater management

- Water resource preservation
- Passive water treatment systems
- Minimizing urban flooding
  - stormwater detention, infiltration and controlled release
- Minimizing storm water infrastructure upgrade and maintenance

Current and likely challenges in stormwater management that may occur in the future

Treatment Measures

- Impacts of infiltration, incl. wetlands, bioretention on groundwater
- Treatment of emerging contaminants
- Treatment of pathogens – long term (reliability for risk management)
- Long term pollutant accumulation and rehabilitation – metals, oils.
- Optimisation of filter media

Decision Support

- Performance and economic cost/benefit critical for decision making in stormwater management
- Databases for performance and costings of WSUD are limited

Current and likely challenges in stormwater management that may occur in the future

Runoff Quality Processes

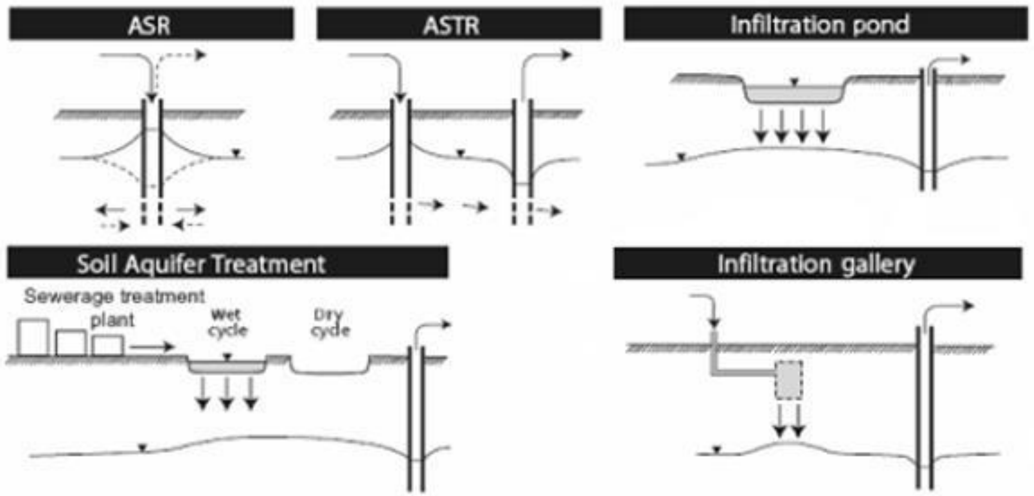
- Build-up and wash off models are physically based, but modelling tools use simple power functions to simulate this
- Interactions between particles and particle bound pollutants are not fully understood – e.g. adsorption and desorption

Stormwater Modelling

- There is a need for tools that can be used to assess modelling uncertainty
- The use of stochastic modelling in lieu of deterministic modelling may reduce uncertainty for ungauged catchments

Use of stormwater as a resource for human and environmental needs – *Integrated Water Management*

Managed Aquifer Recharge and Recycling Options (MARRO)



http://www.clw.csiro.au/publications/waterforahealthycountry/2010/wfhc-MAR-case-study-risk-assessments.pdf

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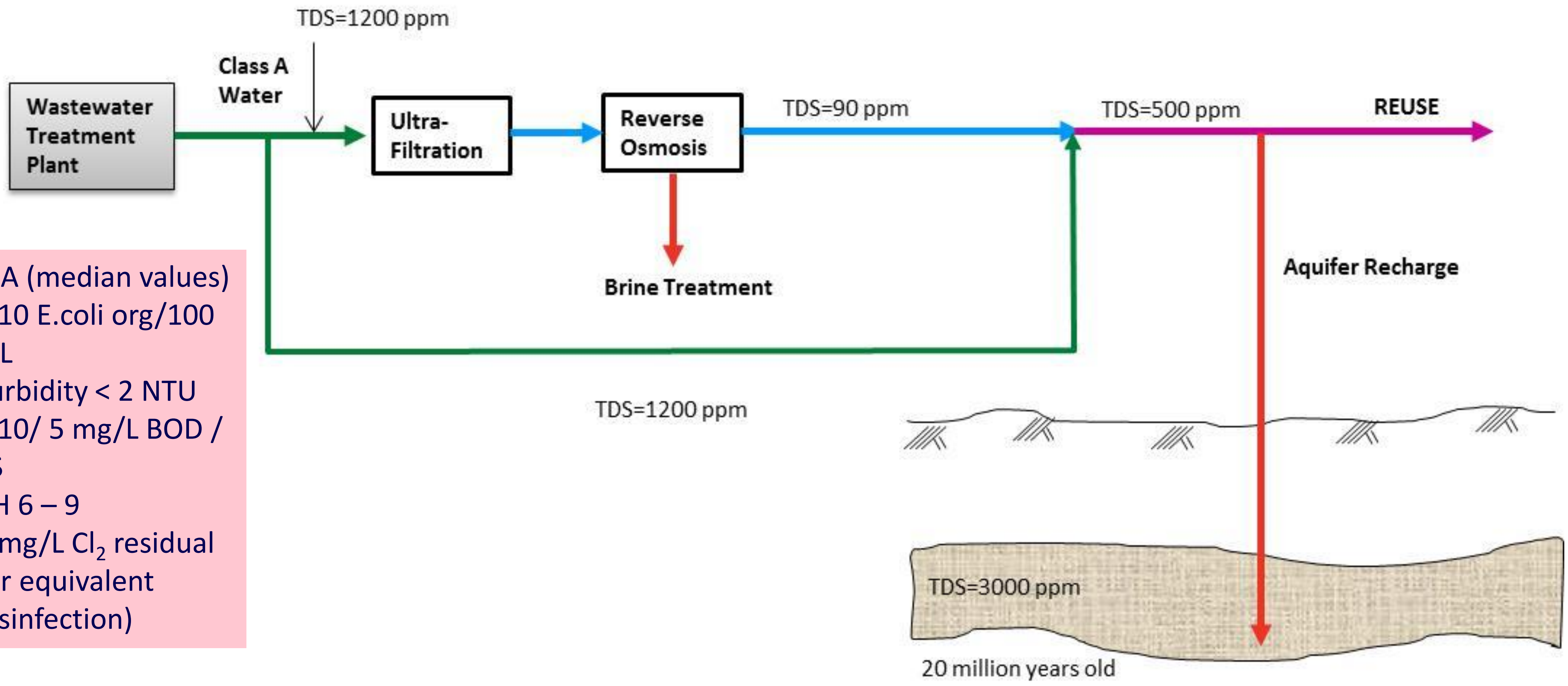
Use of stormwater as a resource for human and environmental needs – *Integrated Water Management*

Example - Werribee MAR Scheme by City West Water



Class A (median values)
- ✓ < 10 E.coli org/100 mL
- ✓ Turbidity < 2 NTU
- ✓ < 10/ 5 mg/L BOD / SS
- ✓ pH 6 – 9
- ✓ 1 mg/L Cl_2 residual (or equivalent disinfection)

Matthew Hudson, Senior Hydrogeologist, City West Water

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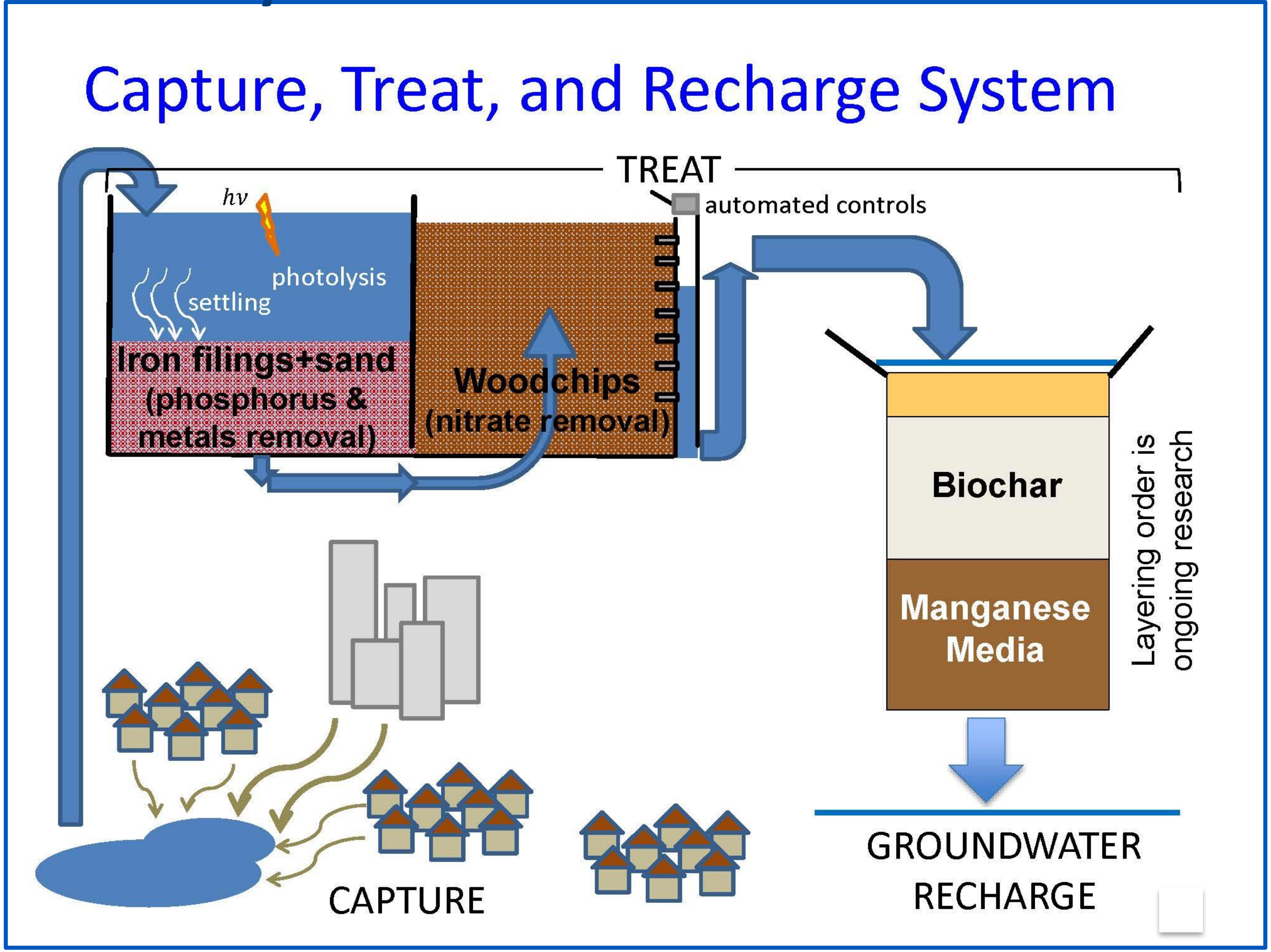
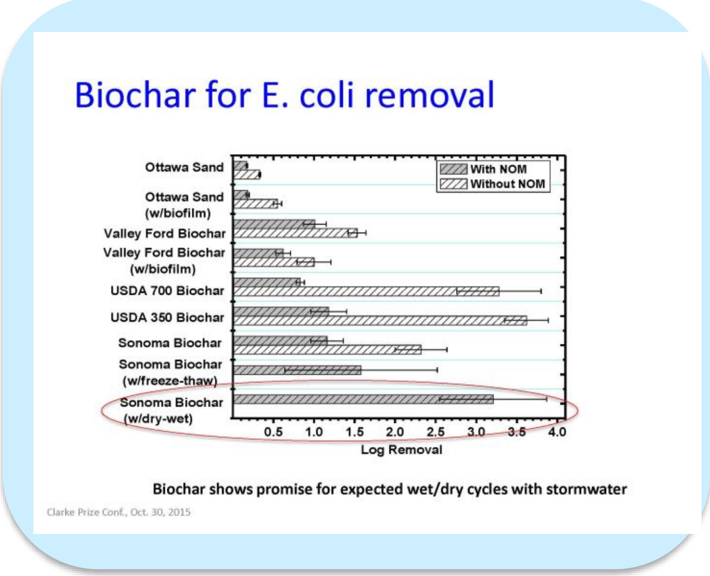
Case Study in the US

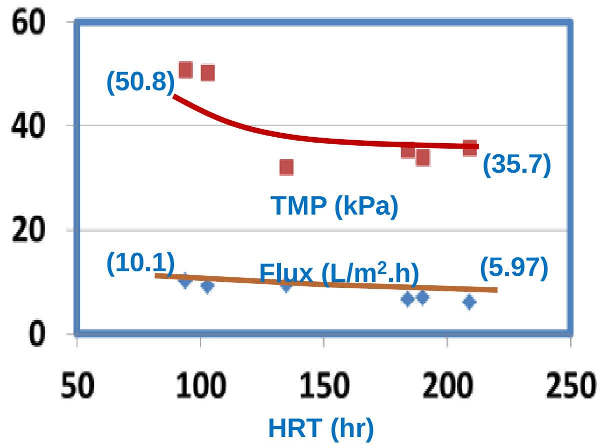




- Tests are being carried out with these systems in the field with a project with Sonoma County Water Agency
- Another similar system in Southern California

https://mavensnotebook.com/2016/08/18/stormwater-capture-treatment-and-recharge-for-urban-water-supply/

Protecting Our Waterways & Producing Fit-for-Purpose Water



- COD = 191 – 548 mg/L
- SS = 275 – 1200 mg/L
- TN = 3 – 19.5 mg/L
- TP = 0.32 – 22.4 mg/L
- Zn = 0.2 – 6.8 mg/L
- Cu = 0.2 – 2.1 mg/L
- *E.Coli* = 4900 orgs/100 mL
- MBAS = 83 mg/L
- Oil & Grease = 25 mg/L
- 50% of particles ~ 54.8 μm

- COD = 0.5 – 10.2 mg/L
- Turbidity = 0.18 – 0.83 NTU
- Particles/mL = 0
- E.Coli/100 mL = 0
- MBAS < 0.05 mg/L
- Oil & Grease < 5 mg/L

Fouled Membrane

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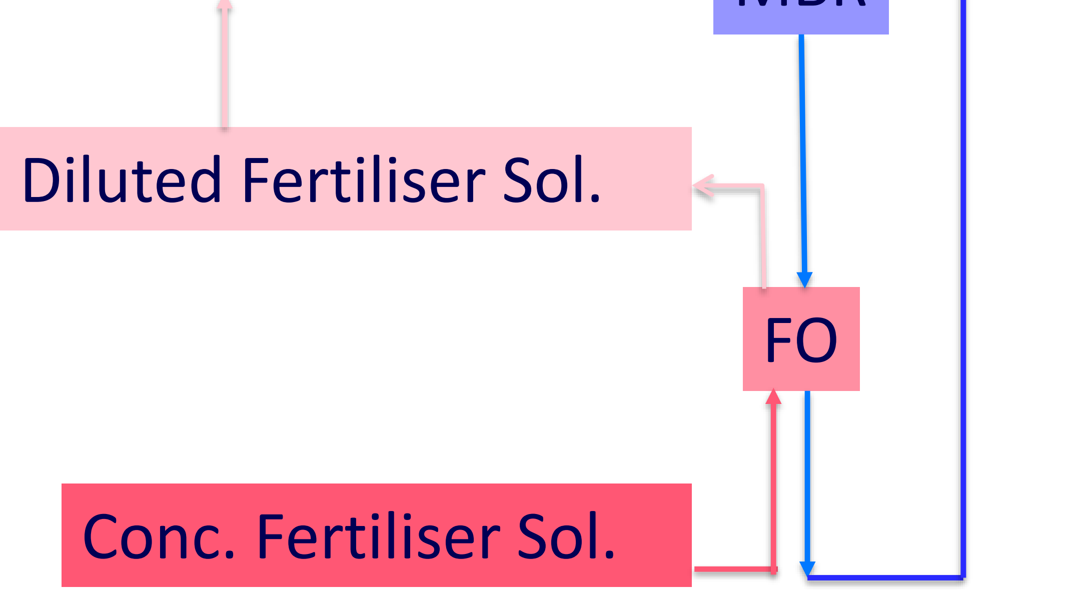
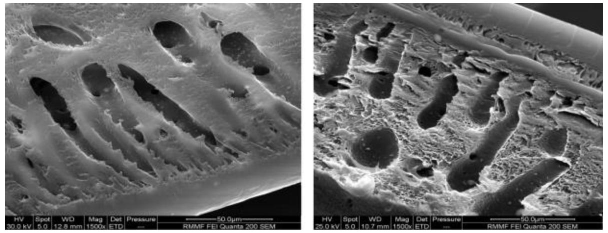
Protecting Our Waterways & Producing Fit-for-Purpose Water





Membrane
- ✓ Preparation
- ✓ Characterisation
- ✓ Application
- ✓ Modelling the Fouling & Performance

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Use of stormwater as a resource for human and environmental needs – *Integrated Water Management*

- The longest serving MAR - infiltration basins to recharge up to 45GL/yr on the Burdekin Delta, Queensland
- Adelaide - to supply approximately 20 GL/yr currently, with potential to increase toward a target of 60 GL/yr by 2050
- Perth - a 14 GL/yr groundwater replenishment scheme is operational since 2017
- Cloudbreak iron ore mine in the Pilbara, Western Australia uses reinjection to manage at least 20 GL/yr of brackish and saline water
- Where urban aquifers have been mapped in Perth, Adelaide and Melbourne, there are known prospects for managing the storage of more than 460 GL/yr urban supplies
- Large areas of Australia are likely to have aquifers suited to MAR, but the storage potential has not yet been mapped

https://research.csiro.au/mar/using-managed-aquifer-recharge/

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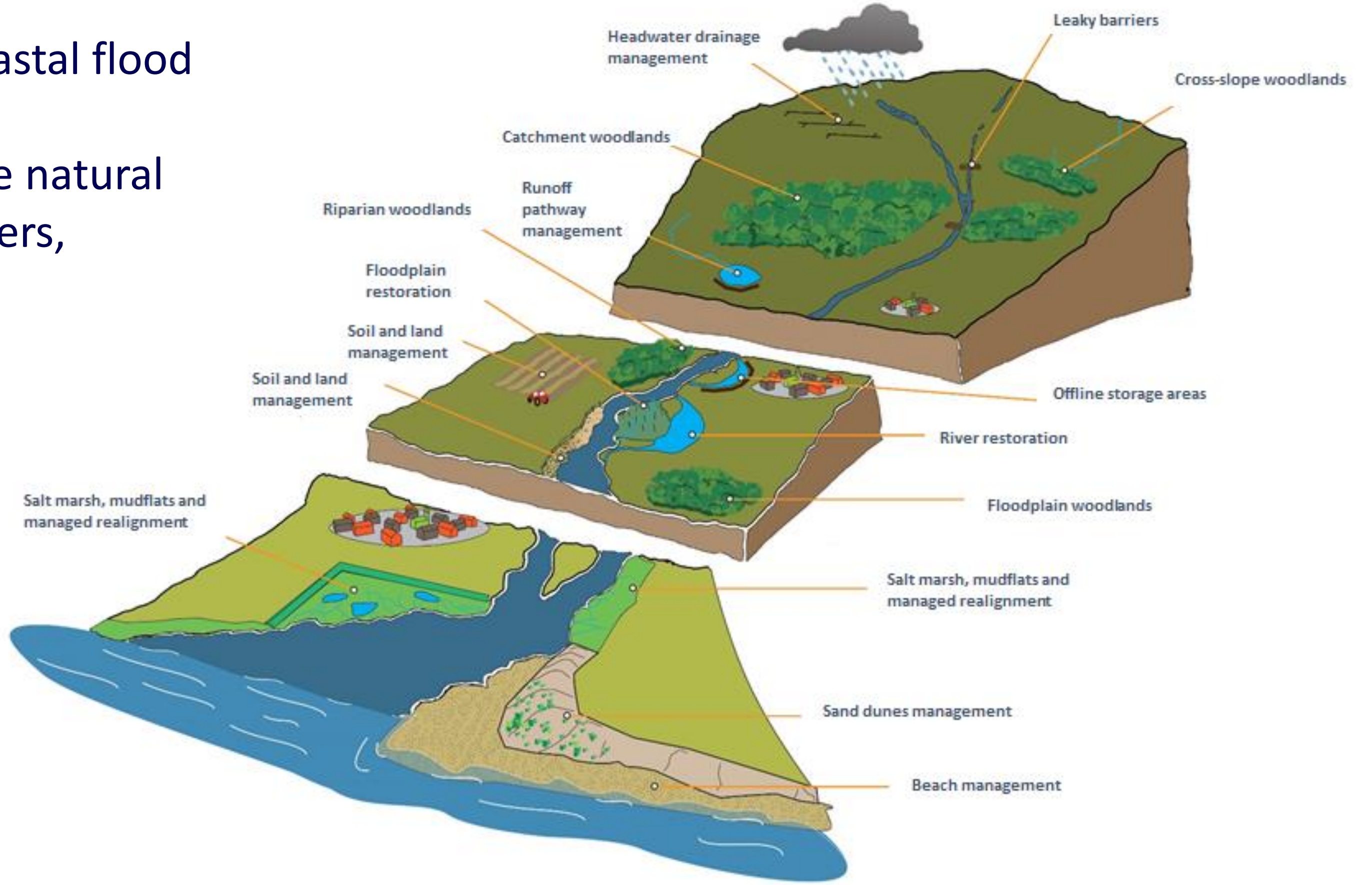
Protecting surface waters – Working with Natural Processes (WWNP) approach in the UK

- Taking action to manage fluvial and coastal flood and coastal erosion risk
- Protecting, restoring and emulating the natural regulating functions of catchments, rivers, floodplains and coasts
- (EA, 2012)

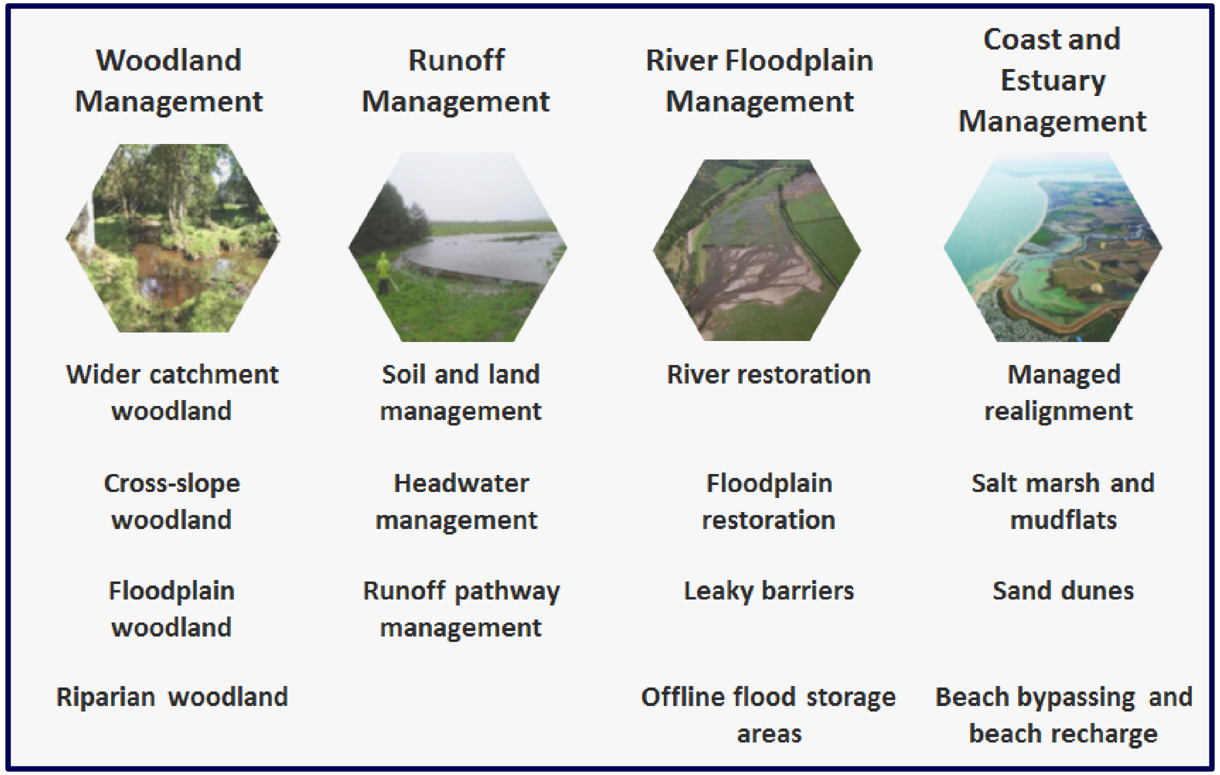


- ✓ Reducing the use of materials (concrete) by using SuDS in urban areas
- ✓ Restoring floodplains to store more water in rural areas
- ✓ Creating managed flood storage areas along rivers, estuaries and coasts

Environment Agency (2017)

Protecting surface waters – rural areas (UK)

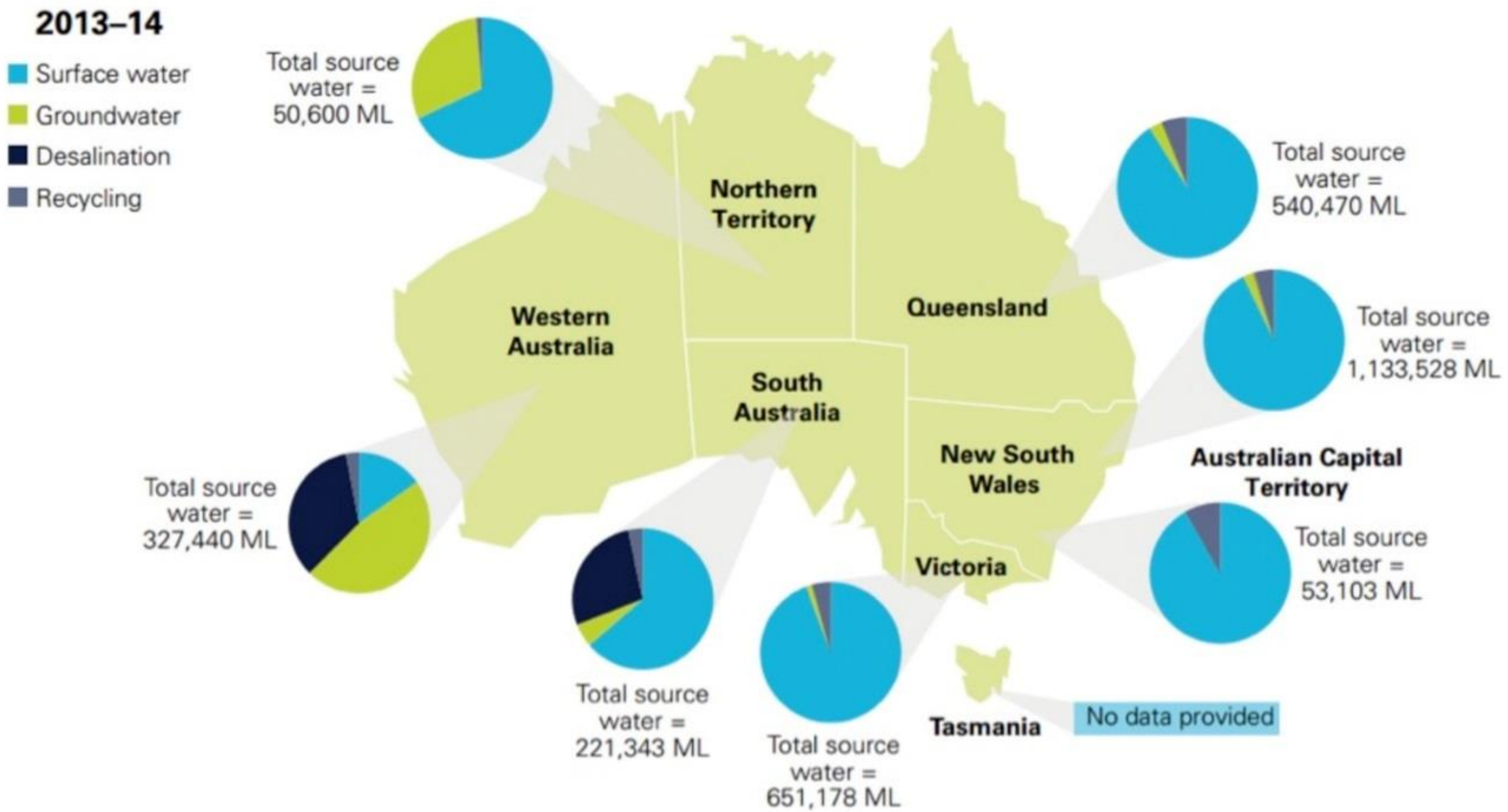
- UK plans to expand implementation of ‘natural flood management solutions’
- Strategic placement of woodlands, improved soil management practices on agricultural land to reduce surface run-off
- Complements the Working with Natural Processes (WWNP) approach of the Environment Agency (2017)



Environment Agency (2017)

Social acceptance

Where does Australia's water come from?



- 92 desalination plants (seawater, groundwater and others)
- 268 recycled plants (wastewater, groundwater and others)

http://www.bom.gov.au/water/crews/; http://theconversation.com/the-role-of-water-in-australias-uncertain-future-45366

Social acceptance – case study (Adelaide)

- Acceptance to use stormwater for non-potable applications is higher than for potable uses
- Both uses are considered acceptable
- Trust is important to acceptance of managed aquifer recharge of stormwater
- Message on safety may not be necessary for stormwater use
- Extensive community education is not required
- Communication and community engagement activities are more important
- Develop policy to address trust, fairness and effectiveness

Mankad, A., and A. Walton (2015), Accepting managed aquifer recharge of urban storm water reuse: The role of policy-related factors, *Water Resour. Res.*, *51*, 9696–9707, doi:10.1002/2015WR017633.

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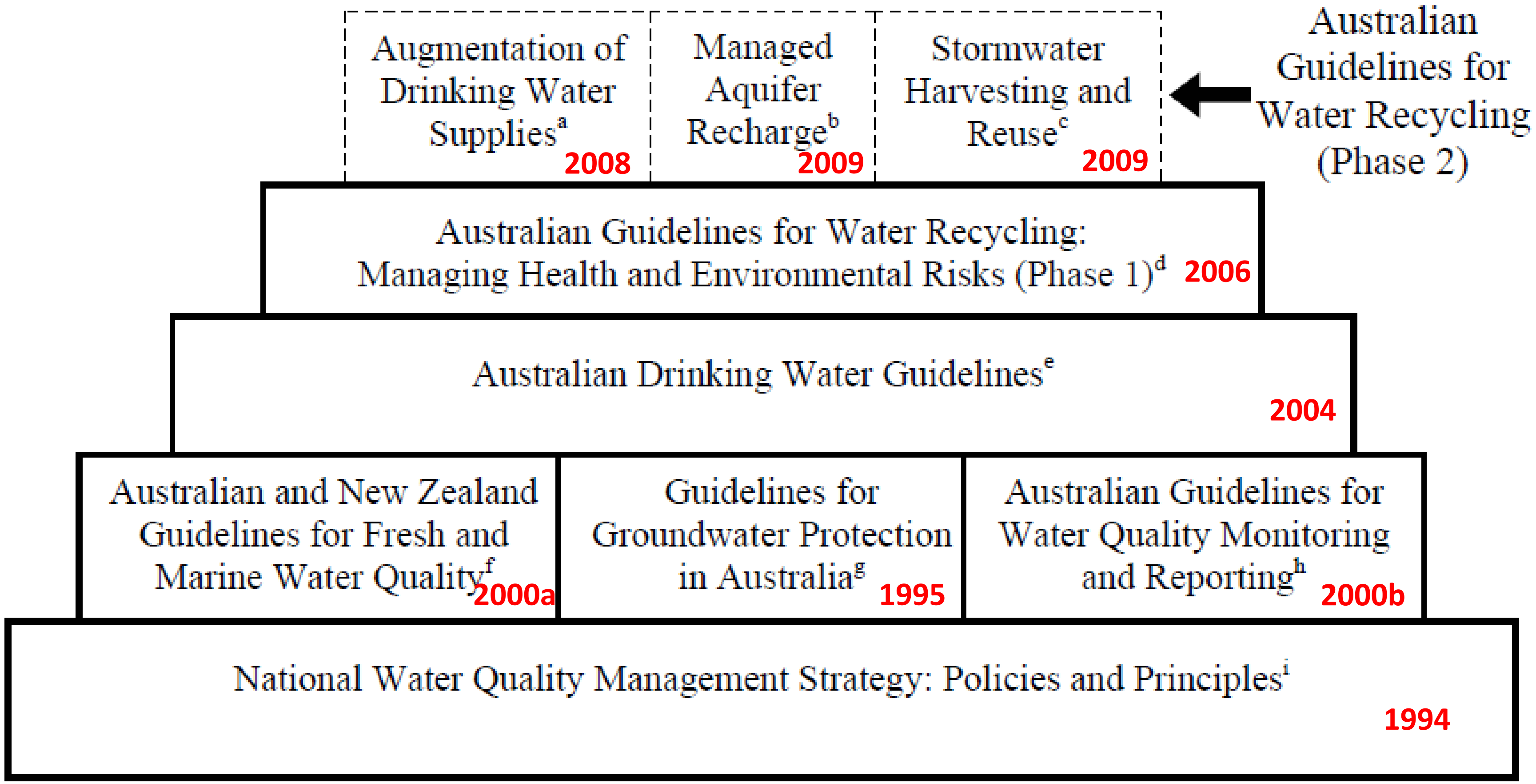
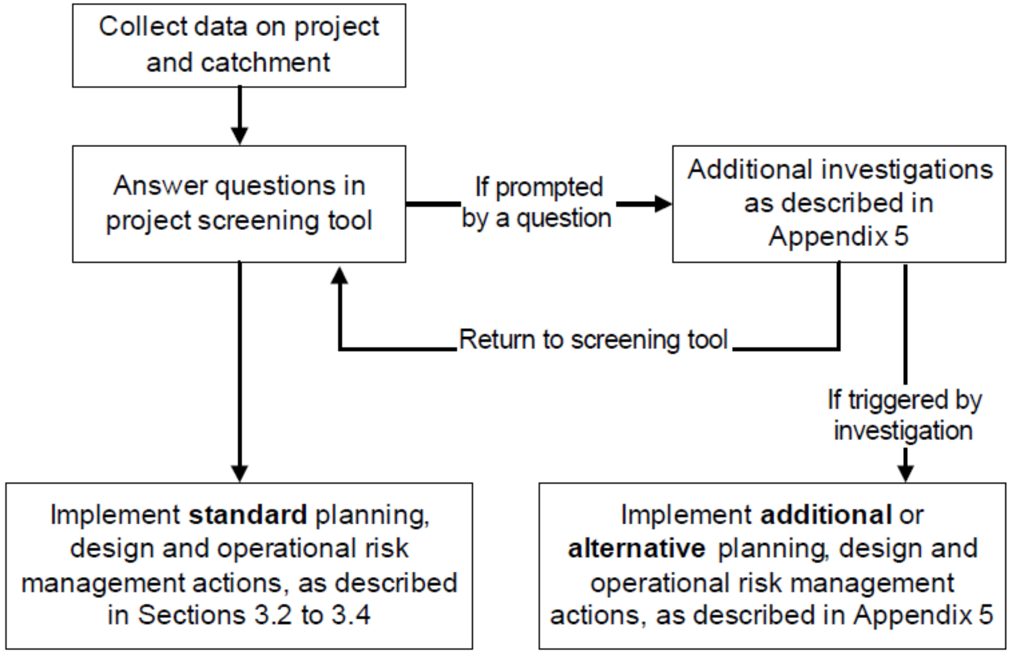
National Water Quality Management Guidelines and Documents



a NRMMC–EPHC–NHMRC (2008)
b Current document
c NRMMC–EPHC–NHMRC (2009)
d NRMMC–EPHC–AHMC (2006)
e NHMRC–NRMMC (2004)
f ANZECC–ARMCANZ (2000a)
g ARMCANZ–ANZECC (1995)
h ANZECC–ARMCANZ (2000b)
i ARMCANZ–ANZECC (1994).

Current regulations relating to stormwater capture and reuse

Project Screening Tool



https://www.clearwatervic.com.au/user-data/resource-files/WQ_AGWR_GL__Stormwater_Harvesting_and_Reuse_Final_200907[1].pdf

Current regulations relating to stormwater capture and reuse

Operational Risks

Table 3.2 Indicative stormwater treatment criteria for public, open-space irrigation — managing operational risks

Parameter	Stormwater treatment criteria	
	Design life up to 20 years	**Design life up to 100 years**
Suspended solids	<50 mg/L	<30 mg/L
Coarse particles	<2 mm diameter	<1 mm diameter
Iron (total)[a]	<10 mg/L	<0.2 mg/L
Phosphorus (total)[a]	<0.8 mg/L	<0.05 mg/L
Hardness ($CaCO_3$)[a]	<350 mg/L	<350 mg/L

a Derived from ANZECC–ARMCANZ (2000a).

https://www.clearwatervic.com.au/user-data/resource-files/WQ_AGWR_GL__Stormwater_Harvesting_and_Reuse_Final_200907[1].pdf

Current regulations relating to stormwater capture and reuse

Health Risks

Table 3.3 Stormwater treatment criteria for public, open-space irrigation (no access control) — managing health risks

Parameter	Stormwater treatment criteria
Disinfection	• >1.5 $\log_{10}$ (96%) reduction[a] of viruses and bacteria • >0.8 $\log_{10}$ (82%) reduction[a] of protozoan parasites • *E. coli* <10 colony forming units (CFU)/100 mL (median)
Turbidity	• <25 nephelometric turbidity units (NTU) (median) • 100 NTU (95th percentile) provided the disinfection system is designed for such water quality and that, during operation, the disinfection system can maintain an effective dose by using up all disinfectant demand and providing free disinfectant residual and/or provides adequate UV dose even in the presence of elevated turbidity and UV absorbing materials
Iron	• <9.6 mg/L[b] (median)

a Refer to the Glossary for information on log reductions.
b This is the impact threshold concentration for ferrous iron from US EPA (2006) — total iron in urban stormwater is expected to be ferrous iron, because stormwater is normally well oxygenated.

$x \log_{10} = [100 - 10^{(2-x)}]\ \%$

https://www.clearwatervic.com.au/user-data/resource-files/WQ_AGWR_GL__Stormwater_Harvesting_and_Reuse_Final_200907[1].pdf

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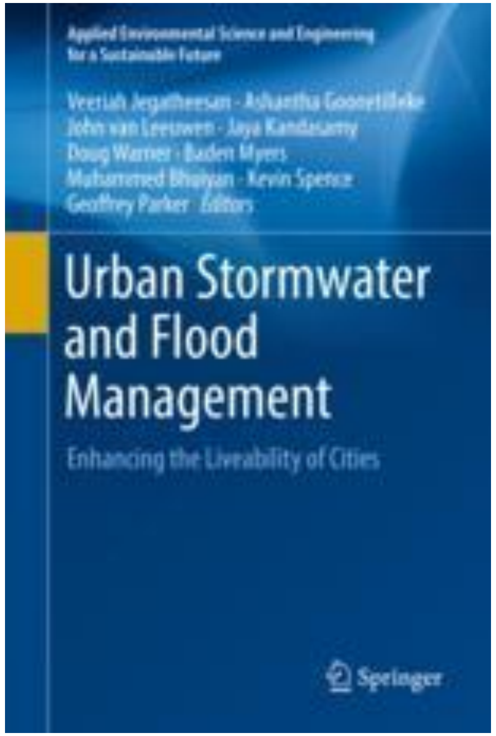
Conclusions

- Population growth and urbanisation are going to increase the impact of stormwater and flooding
- Work with natural processes to improve the ecology of water bodies
- Develop treatment techniques to remove emerging pollutants
- Improve the performance of wetlands
- Develop policies to encourage public engagement
- Revisit existing regulations



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