water by design
an initiative of
Healthy land & water

Low Impact Design

DISCUSSION PAPER

LOW IMPACT DESIGN
Version 1.1 - Draft 5.07.2021

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About this document

Traditional Owner Acknowledgement

We acknowledge that the place we now live in has been nurtured by Australia's First Peoples for tens of thousands of years. We believe the spiritual, cultural and physical consciousness gained through this custodianship is vital to maintaining the future of our region.

Funding Acknowledgement
The Urban Stormwater and Erosion and Sediment Control Capacity Building program is funded through the Queensland Government's Investing in Our Environment for the Future Program and delivered by the Department of Environment and Science (DES).

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INTRODUCTION

INTRODUCTION

This paper was sponsored by the Queensland Government Department of Environment and Science (DES) and is for discussion purposes only. The paper builds on successive research into waterway science and practice. It expands on strategies for achieving holistic waterway health outcomes that align with community values and expectations. This paper provides key discussion points on the implementation of Low Impact Design (LID) and adoption of water sensitive approaches within the lot and streetscape.

Minimising the environmental footprint of suburban housing

Since the introduction of stormwater pollution controls within the State Planning Policy (SPP), there has been significant investment in end-of-line stormwater management devices, such as bioretention basins and Gross Pollutant Traps (GPTs). While progress has been made to treat pollution there is still much to do, and new approaches are needed to reduce pollution at its source.

Under the current state planning policy, developers have clear objectives and expectations around stormwater quality. However, the average Queensland household has very limited responsibility to minimise pollution outputs. As one of the most effective measures to control waterway threats is to eliminate them at their source, this represents a significant gap in the management of waterway hazards.

The following paper discusses ways to incentivise and promote Low Impact Design (LID), both within the streetscape and on housing lots. The paper outlines two key LID technologies: rainwater tanks and Water Wise Street Trees. These devices assist in mitigating stormwater impacts on local waterways and provide a range of co-benefits to the surrounding community and environment.

Low Impact Design can bring the benefits of Water Sensitive Urban Design back to street level.

ISSUE	SOLUTION
Water security	Rainwater reuse/grey water reuse/ water wise fixtures/low water landscapes
Pollution control	Rainwater reuse/rain gardens/ water wise street trees
Local flooding	Rainwater harvesting and reuse/ improving stormwater infiltration
Improve urban habitat	Healthy blue-green corridors/ water wise street trees/green roofs
Urban liveability	Cool green irrigated landscapes/ water wise street trees/green roofs
Replenish groundwater	Minimise impervious surfaces/ maximise landscaped areas and permeable paving

TABLE 1 LOW IMPACT DESIGN SOLUTIONS CAN IMPROVE MANY ASPECTS OF WATER MANAGEMENT

WHAT IS LOW IMPACT DESIGN?

Low Impact Design (LID) is an approach to manage stormwater runoff at its source. LID emphasises conservation and use of on-site natural features at the lot and street scale to protect water quality. This approach aims to replicate the pre-development hydrologic regime of catchments through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. At the lot scale, low impact design can include shade trees, rainwater tanks, raingardens, maximising opportunities for pervious infiltration areas and greywater reuse. While there are many technologies that can be implemented at the lot-scale (Refer Appendix C) the remainder of this report focuses on rainwater tanks and Water Wise Street Trees.

The WaterWise House

Click for factsheet

https://waterbydesign.com.au/download/waterwise-house

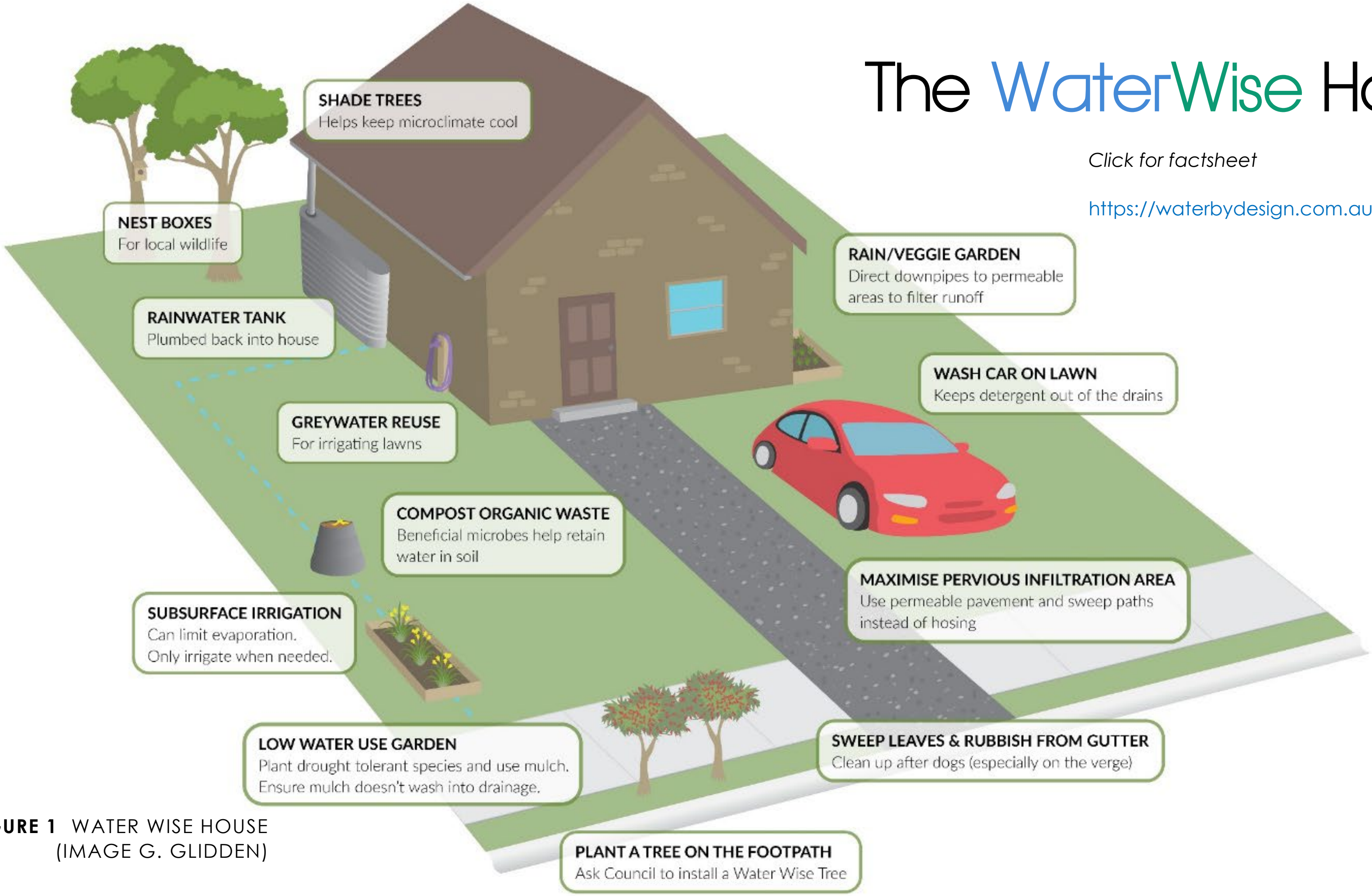
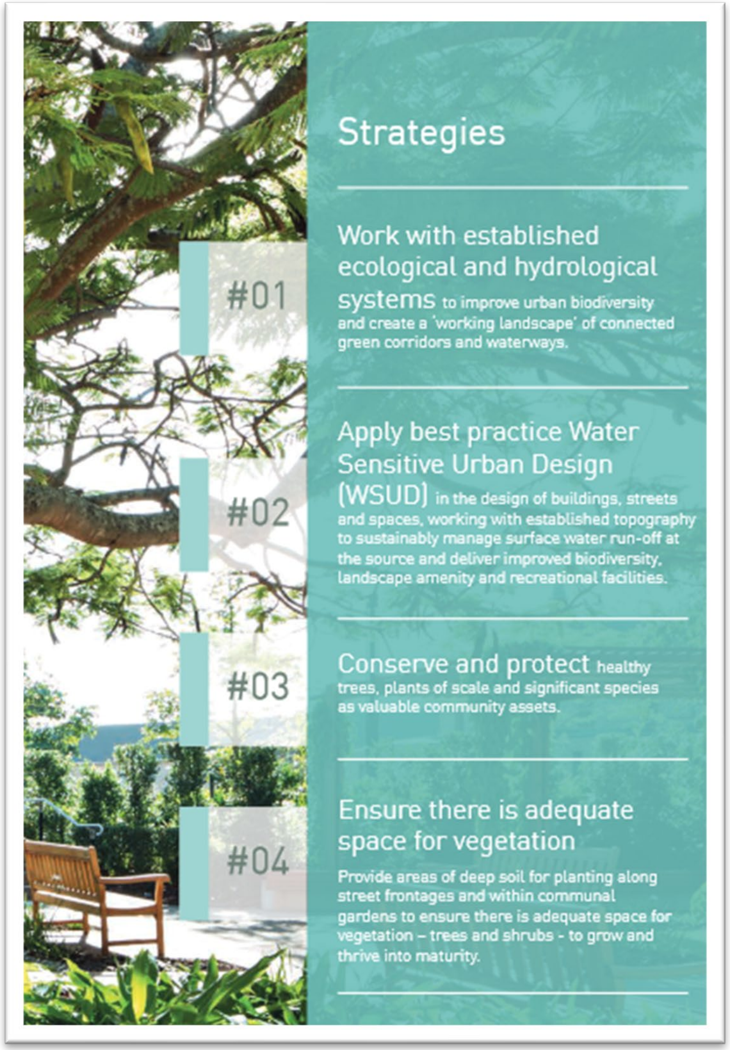


FIGURE 1 WATER WISE HOUSE (IMAGE G. GLIDDEN)

THE VISION FOR QUEENSLAND BUILDINGS

The Queensland Government's *QDesign Manual* establishes nine priority principles for successful urban design. The manual aims to guide the design and development of Queensland's streets, places and buildings, and puts a strong emphasis on ecological considerations, as outlined in Principle 03 below (Extract 1). The technologies and research set out in this discussion paper bolsters the strategies set out by the Queensland Government with a view to lessening the burden on our waterways and creating more liveable communities.

> **PRINCIPLE 03:** WORK WITH AND ENHANCE NATURAL SYSTEMS, LANDSCAPE CHARACTER AND BIODIVERSITY
>
> The health of our urban environments and our personal health are interlinked. Well planned and maintained green spaces and waterways have been shown to improve community health and wellbeing, and significantly improve the liveability of places. Their inclusion supports biodiversity, delivers opportunities for sustainable water management, contributes to better air quality, mitigates noise, moderates temperature, provides enhanced recreational opportunities and comfort through shade.


Strategies

#01 Work with established ecological and hydrological systems to improve urban biodiversity and create a 'working landscape' of connected green corridors and waterways.

#02 Apply best practice Water Sensitive Urban Design (WSUD) in the design of buildings, streets and spaces, working with established topography to sustainably manage surface water run-off at the source and deliver improved biodiversity, landscape amenity and recreational facilities.

#03 Conserve and protect healthy trees, plants of scale and significant species as valuable community assets.

#04 Ensure there is adequate space for vegetation Provide areas of deep soil for planting along street frontages and within communal gardens to ensure there is adequate space for vegetation – trees and shrubs - to grow and thrive into maturity.

Click for full document

EXTRACT 1 PRINCIPAL 03 STRATEGIES (QDESIGN MANUAL)

RAINWATER HARVESTING

RAINWATER HARVESTING

Rainwater harvesting is the process of collecting rainwater from an impervious surface and directing it to a location where it can be used or stored for later use. Identified within the Blueprint for Improving Waterway Management (refer Appendix A, WbD, 2020), rainwater harvesting is a key strategy for improving waterway outcomes. Rainwater tanks (Figure 2) are an efficient means of collecting and storing rainwater for later use within the household. Rainwater reuse should be fit-for-purpose and can include uses for irrigation, toilet flushing and laundry use.

HISTORY

- Mandatory tanks were legislated under *Queensland Development Code* Part 4B for new housing projects (2009).
- Critique of the policy based on perceived high cost to benefit ratio.
- Change of government resulted in the repeal of the legislation (2013).
- Local governments are now required to present a Cost Benefit Analysis in order to opt in to *Queensland Development Code* legislation.
- In QLD Toowoomba Regional Council is the only LGA currently who has opted in, mandating tanks on new builds.
- Analysis (Coombes 2016 and 2018) has shown that the Cost Benefit Analysis for water savings infrastructure is improved significantly if co-benefits are considered.

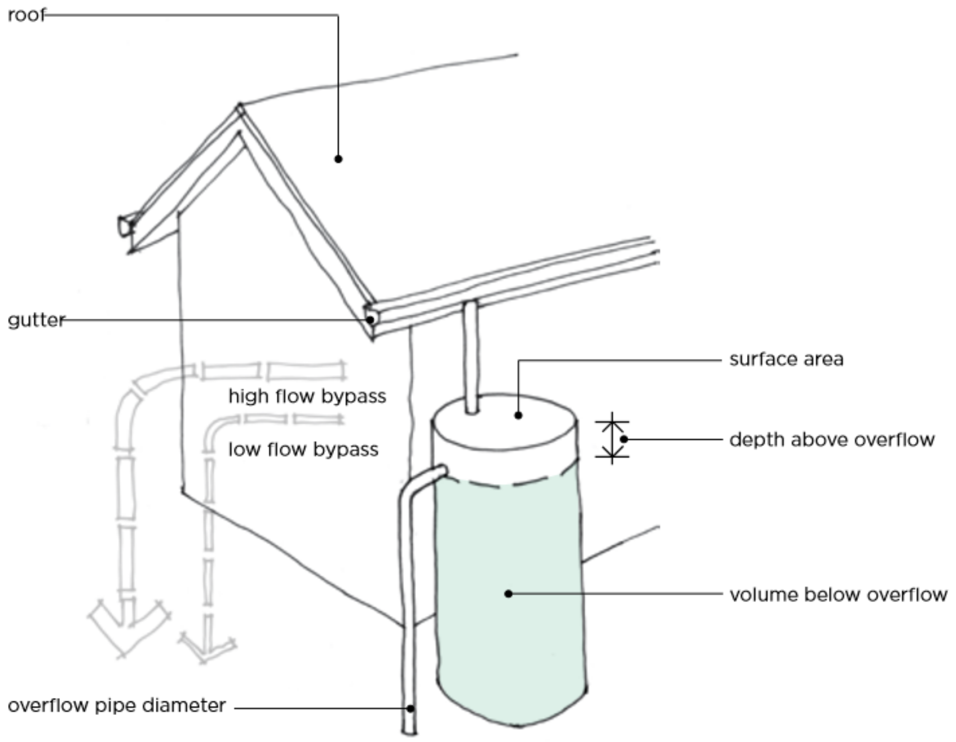


FIGURE 2 RAINWATER TANKS (IMAGE J.GALL)

KEY BENEFITS

- REDUCE DEMANDS ON DRINKING WATER SUPPLIES
- IMPROVE WATER SECURITY IN RESPONSE TO DROUGHT
- DIVERSIFY WATER SUPPLY SOURCES
- BENEFICIAL RAINWATER REUSE WITHIN THE HOME
- WATERWAY HEALTH

Rainwater tanks have many benefits. They can help reduce demands on drinking water supply, can improve water security in response to drought, diversify water supply sources and enable beneficial rainwater reuse where it would have been wasted otherwise. When rainwater tanks are used in combination with irrigation, this can help to recreate natural hydrology and reduce pollution flowing to local waterways.

Resilience to other events

Water utilities generally take measures to prevent dam water dropping to critical levels. However, there are other rare but potentially catastrophic events that can restrict water supply. Recent examples where water systems have had near misses or have been threatened by other means include:

- 2020 **Bushfires** - Stanthorpe
- 2020 **Cyanobacteria** - Murray Darling
- 2017 **Cyclones** - Whitsundays
- 2014 **Lead poisoning** - Flint (USA)
- 2011 **Floods** (increased sediment) - Brisbane
- 2008 **Weed infestation** - Brisbane
- 1998 **Waterborne parasites** - Sydney

A decentralised network of rainwater tanks can provide a short-term, supplemental water supply for residents until local supply is restored, adding to overall water security and system resilience.

Benefits to the economy/community

- A meta-analysis study of ‘willingness to pay’ research projects documented the ‘freedom from water restrictions benefit‘ and found it varies from $3 a month to $33.50 a month per household (Houtven *et al*. 2017).
- Zhang *et al*. (2015) used the ‘willingness to pay’ method to report that a rainwater tank has a one-off value of $18,000 per property.
- A South Australian study (RHA, 2020) found that removal of requirements supporting rainwater harvesting could decrease the value of the state’s economy by $1 billion.

Benefits to the resident

- Cost savings on water rates.
- Additional source of water available for washing cars, watering gardens, pools etc.
- Additional value to the home.
- A reduction in stormwater runoff from the roof.
- A contribution to a more sustainable community.
  Source: ***Toowoomba Region website***

RECENT ADVOCACY FOR RAINWATER TANKS

In 2020, Stormwater Queensland published a **position statement** on rainwater tanks. The statement outlines the further benefits rainwater tanks provide to local waterways (Table 2) and recommends re-inclusion in the *Queensland Development Code* pending further investigation into the cost and benefits of rainwater tanks.

TABLE 2 RAINWATER TANK BENEFITS (STORMWATER QUEENSLAND 2020)

Communities across Queensland currently experience the following effects:	Rainwater tanks can:
Ongoing damage to our waterways (creeks, rivers, bays and the reef).	Reduce both water quality and hydrological impacts of urbanisation on receiving waterways.
No reduction in nuisance flooding.	Aid flood mitigation thereby protecting local homes, business, services and infrastructure.
Higher demand on reticulated water supply and associated existing infrastructure.	Provide an alternative water source.
Higher demand for new water supply infrastructure.	Offset the demand for new infrastructure and reduce the scale/costs of future infrastructure.
Limited water security options for individual households.	Increase resilience to climate change pressures including drought.

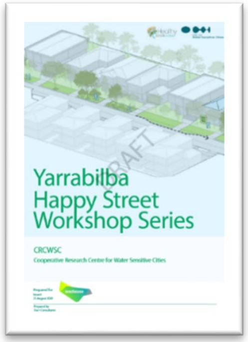
BARRIERS TO IMPLEMENTATION

LOCAL PLANNING

- Many local governments have encountered barriers in approving rainwater tanks in new development applications due to uncertainties around tank condition and upkeep (e.g. disconnections, lack of maintenance). This issue could be resolved via the reintroduction of a head of power or mandate through the *Queensland Development Code*.
- Priority Development Areas (PDAs) are implemented by Economic Development Queensland (EDQ), limiting the influence of local governments over the development process.

HOUSING ESTATES

- Generally, investors do not consider running costs or sustainability outcomes.
- The price point for housing is often determined by mortgage repayment affordability.
- Infrastructure such as tanks are often the first items to be excluded to reduce initial price points, despite the long-term savings they provide.



Document available soon

To overcome these barriers, Healthy Land and Water and the Cooperative Research Centre for Water Sensitive Cities held a seminar series called 'Water as an Enabler' which explored several Low Impact Design alternatives at Yarrabilba.

TECHNOLOGY CONSIDERATIONS

The Urban Water Security Research Alliance (UWSRA) undertook extensive research into rainwater tank technology (2007-2012). The key risks identified are summarised below:

a) **Health risks**: Diseases associated with mosquito breeding due to poor maintenance or removal of mosquito screens, algae and pathogen growth due to lack of cleaning or removal of covers, plumbing mistakes such as cross-connections.
b) **Undetected technical failure**: Poor design or wear and tear of system components, such as top-up systems or screens, can lead to increased use of mains water or impact water quality.
c) **Tank structural failure**: Poor manufacture, poor installation or blockage of overflows can result in leaks or by-pass, erosion of tank footing or damage to infrastructure.
d) **Aesthetics**: Discoloration of water due to lack of cleaning/removal of leaves from gutters and tank openings.
e) **Environmental impacts**: Negative impacts associated with reduced savings of mains water or high energy use of rainwater supply, often as a consequence of (b) and (c).
f) **Social**: Loss of confidence in rainwater tanks due to poor performance, public opinion backlash as a consequence of previous failings.
g) **Economic**: Loss of capital invested in rainwater infrastructure, unrealised water and infrastructure savings.

These risks could be managed through established protocols as outlined below.

RISK MITIGATION

Health risks: Health risks can be minimised by limiting human contact and exposure to untreated water. Tank water should be used in fit-for-purpose applications such as irrigation of lawns and gardens or non-contact internal uses (e.g. flushing toilet, laundry).

Licenced plumber: If mandated under the *Queensland Development Code*, local government can enforce the installation of rainwater tanks by a licenced plumber (as per Toowoomba Regional Council regulations). This will reduce the occurrence of faulty connections.

Maintenance: Without regular maintenance of tanks and roofs, there are risks that the water quality in the tanks will deteriorate. Advice and education programs can help inform residents of rainwater tank upkeep needs.

OPPORTUNITIES

Ownership: In some housing estates, water utilities own and maintain the rainwater tanks (e.g. **Aquarevo - South East Water**). This strategy helps to manage the uncontrolled environment that exists within housing lots and reduces ongoing risks.

Flood mitigation: With smart technology (e.g. automated valves), water can be pre-emptively released from the tank prior to heavy rainfall to reduce local flood peaks.

Improving waterway health: Rainwater tanks can be configured to help improve the quality and quantity of stormwater flowing to the receiving environment reducing the need for end-of line treatment systems.

DRIVING UPTAKE OF RAINWATER TANKS

The following options are available to public and private industry to improve the uptake of rainwater tanks:

- **Incentives** – Use voluntary accreditation programs such as **Greenstar**. Greenstar currently covers four categories (communities, buildings, interiors, design, and as built).
- **Rebates** – Toowoomba Regional Council offers a rebate for residents to install rainwater tanks. This water security initiative provides rebates of $300 for a 5,000L tank or $500 for tanks that are 10,000L or larger (**Read more here**). As 5000L tanks generally retail for less than $1000, this can be a significant saving for homeowners.
- **Establish a rain bank** – Stormwater offsets revenue can be used to subsidise the retrofitting of rainwater tanks. Local governments could investigate this as an option as part of an offsets program.
- **Permit a Total Annual Load (TAL) approach** to calculate pollutant load reductions and State Planning Policy compliance. This approach is designed to incentivise increases in pervious area within lots and create a higher demand for irrigation and rainwater tanks. Refer to Page 23 for more information on this approach.

RAINWATER TANK REQUIREMENTS UNDER THE *QUEENSLAND DEVELOPMENT CODE*

There remains the opportunity for individual councils to opt into mandatory rainwater tanks. Below are the regulations used by Toowoomba Region Council under *Queensland Development Code* 4.2 applicable to any new class 1(a)(i) buildings (single detached dwellings) on blocks greater than 250m^2. Dwellings on blocks less than 250m^2 are exempt. Requirements applying to a new house:

- **Roof collection area** - collect water from at least 50% of the roof area or 100m^2 (whichever is lesser).
- **Plumbed to service** - toilets, washing machine, at least one outdoor tap.
- **Minimum capacity** - 5,000 litres (where the site has an area or 250m^2 or more) and 45,000 litres (in a rural residential zone and only where no reticulated water is available).

Queensland Development Code 4.3 is applicable for any new commercial buildings (class 5 to 9). Please note that units are exempt. Requirements applying to class 5-9 buildings:

- **Roof collection area** - collect water from at least 50m^2 of the roof area.
- **Plumbed to service** - toilets (50m^2 per pedestal) and outdoor taps.
- **Minimum capacity** - 1,500 litres per required pedestal - refer to *Queensland Development Code* Mandatory Part 4.3.

The approval of mandatory rainwater tanks is issued as part of the overall plumbing approval for any new residential or non-residential building(s).

WATER WISE STREET TREES

WATER WISE STREET TREES

Water Wise Street Trees (Figure 3) are a low cost, high impact technology that can improve the vitality of the streetscape through passive irrigation (refer Appendix B for more details on the benefits of passive irrigation). The technology works by allowing stormwater from the kerb and channel to enter the verge via an inlet and passively irrigate a street tree when it rains helping to filter and treat stormwater. Drainage configurations can be very simple or complex depending on the application.

HISTORY

2009	The Water Sensitive Urban Design Concept Design Guideline (Water by Design, 2009) recommends a streetscape-style bioretention system for flat sites.
2014 - 2018	Healthy Land and Water worked with Brisbane City Council to install over 150 basic WWST as part of the Australian Government Caring for Our Country initiative (2014 - 2018).
2018	Healthy Land and Water releases Water Wise Street Tree **Sizing Guide** (2018) to optimise catchments for tree health (WbD, 2018).
2019	Queensland Government provides grants to several councils for **pilot installations** (Water by Design, 2019).
2019	Queensland Government provides grant for Water Wise Street Tree - **Concept Design Catalogue** and three **video** case studies (Water by Design, 2019).
2020	Cooperative Research Centre for Water Sensitive Cities releases Designing for a Cool City **Guideline** (CRCWSC, 2020).
2021	Water Wise Street Tree **online training course** launched (Healthy Land and Water, 2021).

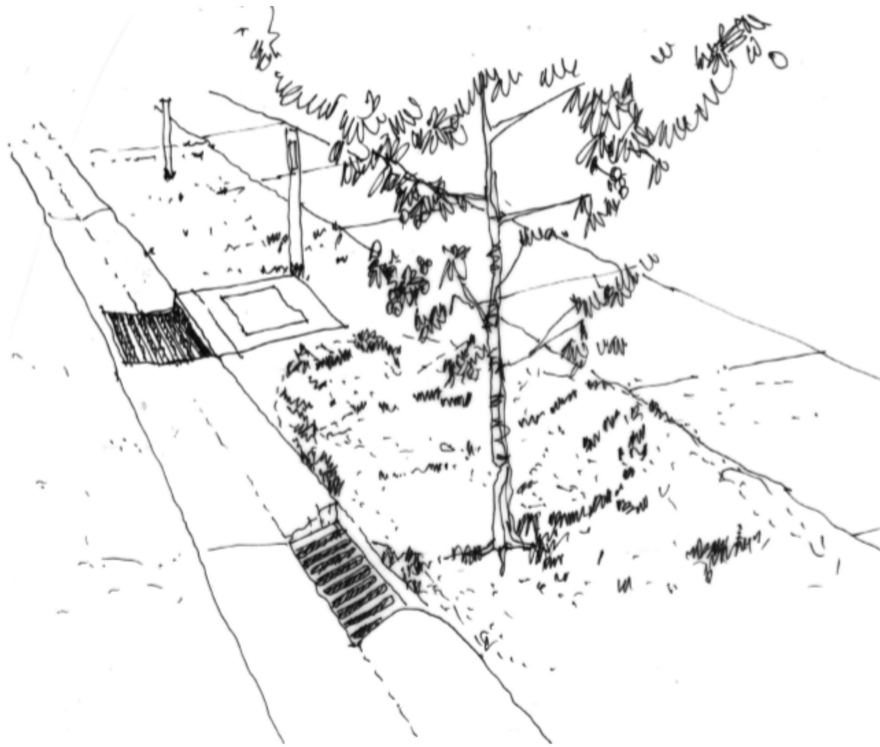


FIGURE 3 WATER WISE STREET TREES (IMAGE J. GALL)

KEY BENEFITS

WATER CONSERVATION & DROUGHT RESILIENCE | **STREET TREE LIFECYCLE COST REDUCTION** | **BETTER STREET TREE HEALTH AND VITALITY** | **IMPROVED SHADE & LIVEABILITY** | **REDUCED URBAN HEAT ISLAND EFFECT** | **WATERWAY HEALTH**

Identified within the Blueprint for Improving Waterway Management (refer Appendix A, WbD, 2020), Water Wise Street Trees are a key strategy for improving waterway outcomes. As outlined below, Water Wise Street Trees provide many local benefits to the economy, community, local environment and waterway (WbD 2019). Further details of these benefits are provided in Appendix B.

- Reduced irrigation need ➔ Reduced potable water consumption
- Increased stormwater infiltration ➔ Nutrient recycling
- Stormwater filtration and treatment ➔ Improved waterway health
- Improved tree vitality ➔ Extended tree lifespan
- Broader canopy ➔ more shade, cooler microclimate
- Improved urban greening ➔ positive mental health benefits
- Improved urban greening ➔ house values increase
- Improved urban habitat ➔ improved biodiversity
- Less root intrusion ➔ Lower footpath maintenance costs

RECENT PROJECTS IN QUEENSLAND

The momentum for the adoption of this technology is building. Water Wise Street Trees and passive irrigation are becoming increasingly mainstream.

TOWNSVILLE STANLEY STREET (IMAGE J. JOHNSTONE)

LIVINGSTONE WHITMAN STREET (IMAGE A. CROCETTI)

WHITSUNDAY FUNNEL BAY BEACH (IMAGE A. CROCETTI)

MACKAY MAUD ST, MIRIANI (IMAGE L. GALEA)

A LOW-RISK TECHNOLOGY

Since the *Water Sensitive Urban Design Concept Design Guidelines* were released in 2009, Water Wise Street Trees and streetscape bioretention have been promoted as an alternative approach to end-of-pipe treatment of stormwater runoff (Figure 4). This brings the benefits of a Water Sensitive Urban Design approach back to the street.

The guideline recommends that "adopting an at-surface approach on flat sites has the potential to significantly reduce the overall capital costs of stormwater infrastructure and improve visual integration of stormwater within the urban fabric."

Water Wise Street Tree technology has been established in Australia for over 10 years.

FIGURE 4 STREETSCAPE WATER SENSITIVE URBAN DESIGN TREE PITS (WATER BY DESIGN, 2009)

TECHNOLOGY CONSIDERATIONS

RISK MITIGATION

Maintenance: Regular maintenance programs are needed to maintain free flowing inlets and prevent blocking.

Vandalism: Normal precautions against tree vandalism should be installed, including appropriate tree size species selection, tree grates and cages.

Potential risks associated with Water Wise Street Trees are manageable and, in many cases, WWST technology improves ecological resilience.

Anchoring: Additional ground anchoring may be necessary to secure trees where they may be subject to cyclonic winds, especially in combination with wetter soil media.

OPPORTUNITIES

Drought tolerance: Improves survival rates of street trees during drought conditions. Supplemental irrigation (with recycled water) may be warranted in high visibility areas during prolonged dry periods.

Biodiversity: Provides opportunities to work with ecologists to improve the habitat potential of urban forests. A Central Queensland council is investigating this as part of a road upgrade program.

Climate resilience: In anticipation of a changing climate, a growing range of street tree species can be adjusted to better tolerate hotter temperatures and altered rainfall patterns.

DRIVING UPTAKE OF WATER WISE STREET TREES

There are a variety of options available to governments and developers to drive uptake of Water Wise Street Trees in Queensland, including:

DEVELOPERS

- **Incentives** through voluntary schemes such as the Greenstar rating system. This scheme is already in place in Queensland but requires refinement to further promote Water Wise Street Trees and water quality issues.
- Develop **house and land packages** that include Low Impact Design options, such as Water Wise Street Trees and stormwater disconnections, as these devices are cheaper to install into greenfield sites. This approach requires engagement with the building industry.

LOCAL GOVERNMENTS

- **Opportunistic** installation of Water Wise Street Trees to coincide with planned road upgrades.
- Retrofit programs funded with **stormwater offsets**. A South East Queensland council has been investigating this approach in conjunction with an offset scheme.
- Link Water Wise Street Trees with protection of our existing urban forest and Urban Heat Island mitigation.
- Introduction of **shade targets** to help encourage installation of Water Wise Street Trees**.** Brisbane City Council (BCC) have a policy of 50% shade coverage of verge by 2031.

STATE GOVERNMENT

- For **subthreshold** lots (< 2500m^2 and 6 lots) where there is no Water Sensitive Urban Design provided, a new 'deemed to comply' category could be created that mandates the use of basic Water Wise Street Trees.
- Permit a **Total Annual Load** (TAL) approach to calculate pollutant load reductions via MUSIC modelling and incentivise low impact design.

PROTECTING OUR EXISTING URBAN FORESTS

With the prospect of increasing heatwave duration and frequency due to climate change, there is a need to establish adequate tree canopy coverage of our streets to mitigate the "Urban Heat Island Effect" and improve liveability. Water Wise Street Trees (WWSTs) have the potential to help fortify and enhance our urban forests.

Maintaining tree canopy cover has become an area of concern for urban planners and needs to be considered in conjunction with LID policy.

In 2020 Greener Spaces Better Places released a report into the state of urban forestry across Australia. The Logan City Council case study (Extract 2) provides important examples of successful urban forestry management programs in South East Queensland.

Click for full document

WHAT DOES LOGAN CITY COUNCIL DO WELL?

Purchase to protect:

In 2019, Logan City Council used Environmental Levy funds to purchase a 47 hectare parcel of land called Bahrs Scrub for conservation and regeneration.

The purchase of this land contributes significantly to the council's green infrastructure network. Given the type of land within the City of Logan, there is a lot of emphasis on the preservation of wildlife and habitat corridors and Voluntary Conservation Covenants on land.

Recognising the value of green infrastructure:

The environmental levy is spent on initiatives such as waterway enhancement and recovery, ecosystem protection and the Conservation Incentive Program, as well as inspiring the community to connect with nature through the Environmental Events and Activities program. In Financial Year 19/20, $9.2 million was levied through rates and $823,444 was collected through Environmental Land Sales and Other Income. Of this, $821,700 was spent on environmental park infrastructure enhancements, $3.4 million on bushland maintenance and bush care and $2.7 million spent on connecting landscapes, river recovery and nature conservation.

Tree giveaway:

Tree giveaways to residents and community groups is a successful way in which the Council continues to encourage urban greening on private land. During FY19/20, 12,910 free native plants were provided to the community through various conservation programs.

Register to protect significant trees:

Council has a registry of significant trees that are afforded greater protection under planning laws. Members of the community are encouraged to nominate trees that they think are significant to the registry.

EXTRACT 2 LOGAN CITY COUNCIL CASE STUDY (GREEN SPACES BETTER PLACES)

LOW IMPACT DESIGN RESOURCES

AVAILABLE GUIDELINES

Healthy Land and Water's Water by Design Program has created a series of factsheets and guidelines to assist practitioners with Water Wise Street Tree design (Figure 6 and 7). Additional resources include the Bioretention Technical Design Guideline and the MUSIC Modelling Guideline.

The Cooperative Research Centre for Water Sensitive Cities has also released a new guideline called Designing For a Cool City (Figure 10), which provides details on street tree systems and other passive irrigation systems such as wicking beds.

Improving the capacity of local government will help to reduce risks and improve the quality of Water Sensitive Urban Design Guideline technology delivered throughout the state.

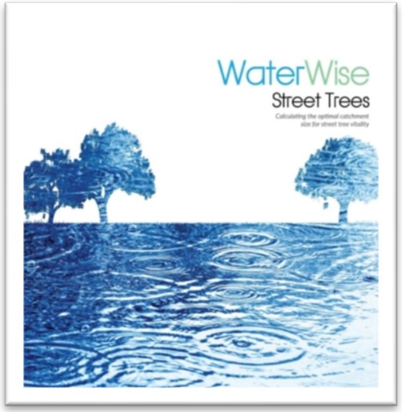


FIGURE 6 WATER WISE STREET TREE SIZING GUIDE FOR OPTIMISING CATCHMENTS

FIGURE 7 WATER WISE STREET TREE CONCEPT DESIGN CATALOGUE

Click for full documents

FIGURE 8 CRCWSC DESIGNING FOR A COOL CITY GUIDELINE

ONLINE TRAINING

Water Wise Street Trees course

Healthy Land and Water have released a new online training course for Water Wise Street Trees. The course is available through an online learning portal and covers benefits, design, modelling, case studies, maintenance, resources and other opportunities. This course is freely available to all participating Local Government Authorities across Queensland and can be accessed via the following link: **https://training.waterbydesign.com.au**

COOPERATIVE RESEARCH CENTRE FOR WATER SENSITIVE CITIES

The Cooperative Research Centre for Water Sensitive Cities has been investigating Low Impact Design for many years and has developed a set of tools and resources (Figure 12) to assist local governments in undertaking Low Impact Design planning.

Click for full document

The **Typologies Catalogue** (2020) detailing design options for water sensitive housing to better inform residential infill practice. This document helps set benchmarks for pervious area of various built forms and compliments a Total Annual Load modelling approach.

The Water Sensitive Cities **Scenario Tool** is a planning-support tool that enables users to assess the evolution of urban infrastructure, water networks and population demographics over time.

Understanding and managing water sensitive performance requires quantifying the water flows associated with an urban area. The **Site-scale Urban Water Mass Balance Assessment (SUWMBA) Tool** achieves this by performing an urban water mass balance, a comprehensive account of all water flows in both the natural and anthropogenic water cycles.

The Water Sensitive Cities case study showcases **Josh's House.** It is an innovative, housing-scale, sustainable design and construction project based in Hilton (Western Australia) and led by environmental scientist and national media personality Dr Josh Byrne. Alternative supplies plus efficiency measures reduced mains water use by 92% compared with the average Perth home.

FIGURE 5 TOOLS AND RESOURCES (Cooperative Research Centre for Water Sensitive Cities)

MAKING IT HAPPEN

TOTAL ANNUAL LOADS

The current Stormwater Management Design Objectives (SMDOs) within the State Planning Policy (SPP) have driven significant investment into Water Sensitive Urban Design infrastructure throughout Queensland and have helped to reduce pollutant loads entering the waterway. However, there is opportunity to further refine the metrics behind these objectives.

Currently, a site with a high percentage of impervious area (and more pollution runoff) can have a similar bioretention footprint requirement to a site with extensive permeable area (and less pollution). This is because the objectives are based on a percentage reduction of pollution, as opposed to considering the total amount of pollution discharging from a site. Adopting a Total Annual Load (TAL) approach can create incentives for Low Impact Design and help reduce the overall volume of pollution being discharged (Refer WbD 2021). TAL could be configured to sit alongside the existing Stormwater Management Design objectives in the State Planning Policy.

THE TOTAL ANNUAL LOADS APPROACH

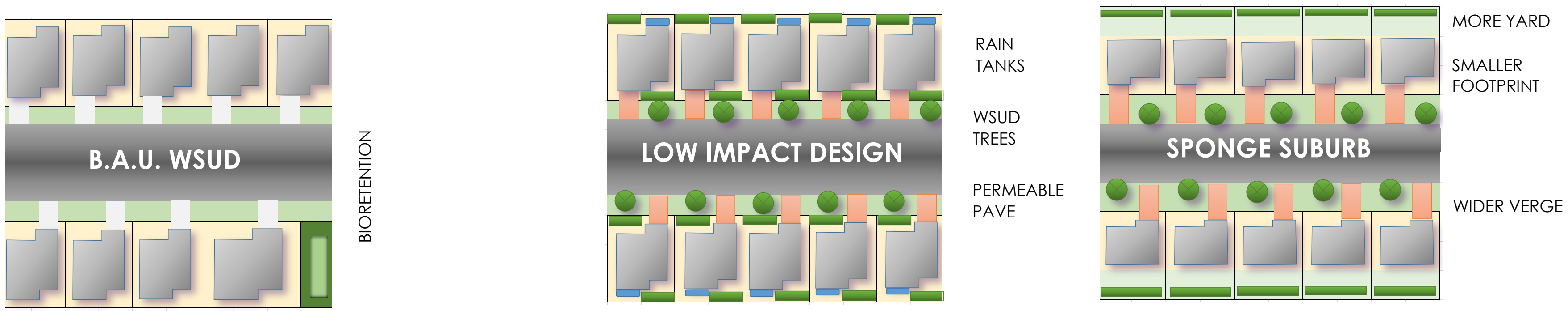
New developments assess Total Annual Loads (TAL) using MUSIC modelling software

Where a LID solution results in a lower TAL than the current approach, it should be prioritised over SMDOs

Lowers pollutant load entering waterway and drives uptake of LID solutions

TRADITIONAL APPROACH

ALTERNATIVE TYPOLOGIES



80/60/45 LOADS

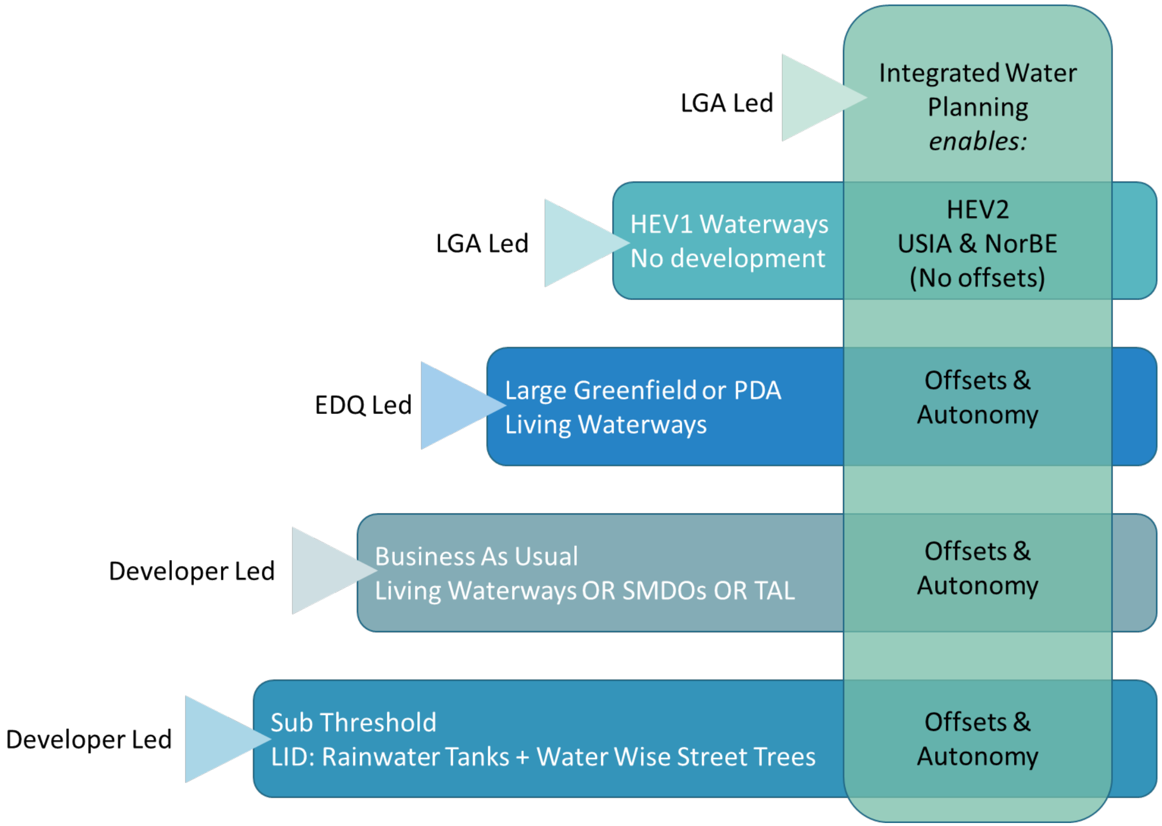
EQUIVALENT TOTAL LOADS
HIGHER LOT YIELD
OWNER BENEFITS

REDUCED TOTAL FLOW
HIGHER LOT YIELD

FIGURE 9 TOTAL ANNUAL LOADS APPROACH

LEVERAGING INTEGRATED WATER PLANNING

To improve the efficacy of Low Impact Design measures, Healthy Land and Water recommends that local governments undertake Integrated Water Planning (IWP) throughout their catchment (refer *Integrated Water Planning Synthesis Report*, Healthy Land and Water, 2021). Integrated Water Planning helps determine what approach (i.e. regional or local) will be most beneficial based on location. Figure 10 depicts a flexible framework for Water Sensitive Urban Design that combines an Integrated Water Planning, Low Impact Design, offsets, business as usual and Total Annual Load approach.



EDQ	Economic Development Queensland
LGA	Local Government Area
LID	Low Impact Design
HEV	High Ecological Value
NorBE	Neutral or Beneficial Effect
PDA	Priority Development Area
SMDOs	Stormwater Management Design Objectives
TAL	Total Annual Load
USIA	Urban Stream Impact Assessment

FIGURE 10 USING INTEGRATED WATER PLANNING TO MAXIMISE THE EFFECTIVENESS OF LOW IMPACT DESIGN

SUMMARY

This paper discussed Low Impact Design (LID) through the adoption of several water sensitive approaches at the lot and street scale.

Rainwater tanks and Water Wise Street Trees are low-risk, low-cost, high-benefit technologies that can improve waterway condition and residential liveability across Queensland.

Driving uptake of these technologies should be a high priority for water managers and may be achieved through a combination of local, state and voluntary actions. For example new incentives could be created for LID by adopting a Total Annual Loads approach within the State Planning Policy (SPP). For developments below the SPP threshold that currently do not mitigate stormwater pollution, there exists an opportunity to link to new LID requirements.

There are many guidelines, factsheets and decision support tools available to aid practitioners in designing and implementing Low Impact Design solutions. The momentum for the adoption of this technology is building and the time is right for change.

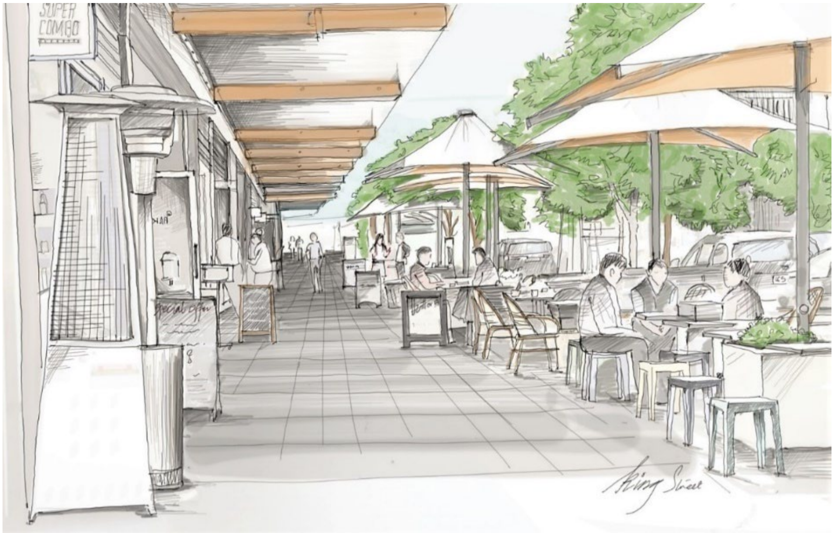


FIGURE 11 KING STREET, BRISBANE INCLUDES MULTIPLE WATER WISE STREET TREES (ARTIST P. PERIWAL)

NEXT STEPS

Healthy Land and Water is committed to improving the ability of the industry to deliver Low Impact Design solutions such as rainwater tanks and Water Wise Street Trees. Outlined below are recommended key steps for each technology.

- Investigate the business case for Low Impact Design as a means to promote triple bottom line benefits and facilitate broader uptake.
- Publish Low Impact Design Case Studies to drive broader industry uptake and promote industry discussion.
- Promote Water Wise Home factsheet to enable uptake and promote industry discussion.
- Create a simple rainwater tank online training course (include water uses, sizing, risks and maintenance) to build industry capacity.
- Update Water by Design guidelines for the Total Annual Load approach to incentavise low impact design approaches.
- Rollout of Water Wise Street Trees Online Training Course to build capacity to deliver this technology.
- Develop detailed design Water Wise Street Trees standard drawings to ensure a consistent and rigorous approach.

REFERENCES

- Stormwater Queensland Position Paper
  http://stormwaterqueensland.asn.au/wp-content/uploads/2020/03/Rainwater-Tanks-Position-Statement-FINAL-20191114.pdf
- Cooperative Research Centre for Water Sensitive Cities (2020), Designing for a Cool City
  https://watersensitivecities.org.au/content/designing-for-a-cool-city-guidelines-for-passively-irrigated-landscapes/
- Cooperative Research Centre for Water Sensitive Cities (2020), Scenario Tool
  https://watersensitivecities.org.au/solutions/water-sensitive-cities-scenario-tool/
- Cooperative Research Centre for Water Sensitive Cities (2020), SUWMBA
  https://watersensitivecities.org.au/content/user-manual-for-site-scale-urban-water-mass-balance-assessment-suwmba-tool-v2/
- Cooperative Research Centre for Water Sensitive Cities (2021), Typologies Catalogue
  https://watersensitivecities.org.au/content/infill-typologies-catalogue/
- Cooperative Research Centre for Water Sensitive Cities (2018), Josh's House
  https://watersensitivecities.org.au/solutions/case-studies/joshs-house/
- Greener Spaces Better Places (2020), Where will all the trees be?
  https://www.greenerspacesbetterplaces.com.au/media/163315/where-will-all-the-trees-be-benchmarking-report-2020.pdf
- Peter J Coombes, Michael Smit & Garth MacDonald (2016): Resolving boundary conditions in economic analysis of distributed solutions for water cycle management, Australian Journal of Water Resources.
- Rainwater Harvesting Australia (RHA) et al, (2020), Submission to Department of Planning, Transport and Infrastructure - Draft Planning and Design Code for South Australia.
- Peter J Coombes (2018) Effectiveness of rainwater harvesting for management of the urban water cycle in South East Queensland.
  https://rainwaterharvesting.org.au/wp-content/uploads/2018/01/Joint-ARMA-and-RHAA-Effectivenss-of-rainwater-harvesting.pdf
- Urban Water Security Research Alliance **http://www.urbanwateralliance.org.au/**
- Queensland Department of Housing and Public Works (2020), The QDesign Manual
  https://www.hpw.qld.gov.au/__data/assets/pdf_file/0022/4837/qdesignmanual.pdf
- Water by Design (2009), WSUD Concept Design Guideline
- Water by Design (2009), Stormwater Harvesting Guidelines
  https://waterbydesign.com.au/download/stormwater-harvesting-guidelines
- Water by Design (2014), Water Sensitive Designs
  https://waterbydesign.com.au/download/water-sensitive-designs-sketchbook
- Water by Design (2017), Water Wise Street Tree Sizing Guide for Optimising Catchments
  https://waterbydesign.com.au/download/water-wise-street-tree-booklet
- Water by Design (2019), Water Wise Street Tree Concept Design Catalogue
  https://waterbydesign.com.au/download/water-wise-street-tree-booklet
- Water by Design (2020), Blueprint for Improving Waterway Management
  https://waterbydesign.com.au/download/spp-review-blueprint-for-improving-waterway-management
- Water by Design (2020), Water Wise Street Tree Online Training Course
  https://training.waterbydesign.com.au

APPENDICES

APPENDIX A

WATER BY DESIGN - BLUEPRINT FOR IMPROVING WATERWAY MANAGEMENT (EXTRACT)

Strategy 4 – 'At Source' WSUD

Target pollution 'at source' by improving the urban development template with underlying WSUD principles

ISSUE 4A – REDUCING POLLUTION 'AT SOURCE'

MUSIC modelling does not favour or incentivise low impact solutions including hazard minimisation, green catchments, and at source treatment. Bring WSUD benefits back to street level via 'at source' treatment.

SOLUTION

SPP Change: document to permit an alternative compliance pathway. Engineers to calculate Total Annual Load (TAL). If a 'low impact' solution achieves less TAL than a standard approach (i.e. 80/60/45), then proceed with low impact approach and ignore 80/60/45.

OUTCOMES

Developers could achieve a smaller TAL compared to Business As Usual (B.A.U) and smaller WSUD footprint using rainwater tanks, WSUD street trees and catchment permeability
(See Figure 4).

ISSUE 4B – REDUCE EXCESS FLOW 'AT SOURCE'

Reduce the detrimental impacts of flow increase on our waterways and improve groundwater infiltration
(See also Issue 3b).

SOLUTION

- Enable permeable catchments and groundwater replenishment
- Research cost / benefit of at source WSUD products
- Find ways to incentivise use (see Greenstar and Basix)

OUTCOMES

Increase catchment permeability through implementation of infiltration, WSUD street trees, rainwater tanks and irrigation etc.

ALTERNATIVE SOLUTIONS

Stormwater connections to be licenced in order to discharge (as per sewer).

Private Stormwater Quality Improvement Devices (SQUIDs) to require registration licencing and servicing as per septic tanks.

DEEMED TO COMPLY (DTC)SOLUTIONS

Sub-threshold* house lots need to install either:

- Water Wise Street Trees
- Rainwater Tank management
- Permeable driveway
- Two story home with garden space
- Stormwater disconnection
- Raingarden

Flexibility to choose what suits best. Enforced through the QDC.

*SPP threshold <2500m2 + 6Lots

CASE STUDIES

- Currumbin Ecovillage
- Noosa Flexi Learning Centre
- Greenstar
- Basix

JUSTIFICATION

A study looking at the relationship between urban greenery and mental health found those participants that perceived they had a green neighbourhood, had a 40 to 60% chance of better physical and mental health outcomes, compared to those participants that perceived they did not have a green neighbourhood (Sugiyama et al, 2008).

Cooperative Research Centre (CRC) for Water Sensitive Cities examined property sales in Sydney between Jan 2008 and Sep 2014 and found houses sold for at least $50,000 more when a rain garden was less than 50 metres away.

ACTIONS

- Low impact templates to be refined in MUSIC and road tested
- Link to Cooperative Research Centre for Water Sensitive Cities (CRCWSC) infill templates
- Link to CRCWSC economic benefits tool
- Establish business case for low impact solutions

Strategy 11 – Water for Cooling

Utilise water as a tool to cool our suburbs

ISSUE 11A – NEED MORE SHADE

High summer temperatures can make it uncomfortable and unsafe to walk on streets which can lead to higher energy and health costs. Heatwaves are also a silent killer; reducing maximum temperatures in our suburbs by even a few degrees can potentially save lives (see Loughnan et al, Monash).

SOLUTION

Passively irrigated street trees can greatly influence the microclimate of our streets and need to be encouraged.

SPP Change: Introduce a tree canopy shade target (e.g. 50% of road corridor area - BCC 2031 Target).

Option for the SPP to set a temperature reduction target which can be assessed with CRCWSC Scenario Tool.

Urban Design Guidelines: To make basic passive irrigation for street trees mandatory.

OUTCOMES

Cooler, greener suburbs with improved liveability

ISSUE 11B – NEED TO ENCOURAGE COOLING

Barren and dry landscapes can be just as hot as concrete (CRCWSC, 2020). Retaining water in the landscape can reduce the Urban Heat Island effect and help alleviate additional heat stresses induced by climate change *(Figure 11).*

SOLUTION

By retaining water in the neighbourhood, we can mitigate some of the harmful impacts of heatwaves and improve health and liveability.

- Living Waterways: Strengthen element LE5
- MUSIC Guideline: Incentivise urban wetlands through affirmative action (i.e. kC* improvements)
- Retain flow paths and 1st order streams

OUTCOMES

Cooler, greener suburbs with improved liveability

JUSTIFICATION

A study found a 10% increase in tree canopy in the street was associated with an increase in property sale prices of $18,707 (Netusil et al., 2014).

A study in Perth found that a 10% increase in canopy cover adjacent to public open space was worth $17,264 per property (Pandit, 2013).

Scenario Modelling at Yarrabilba shows the potential to counteract a Heat Island effect by up to 5 degrees on maximum temperature days by using a Water Sensitive Cities approach (Tanner, 2020)

CASE STUDIES

- Greater Sydney Tree Canopy Targets
- Ripley Valley cool roofs policy
- Cool City Guideline – CRCWSC
- Queensland Walking Strategy
- Loughnan et al, Monash
- Netusil et al., 2014
- Pandit, 2013
- Tanner, 2020
- CRCWSC Scenario Tool.

ACTIONS

- Link to CRCWSC Scenario Tool
- Link with Health and Heat Flagship (DES)
- Define a Water Wise Street Tree solution in Living Waterways
- Temperature Mapping and prioritisation project for urban areas

Strategy 12 – Water Reuse

Enable fit-for-purpose reuse of stormwater

ISSUE 12A – IMPROVE WATER SUPPLY SECURITY

Water resources can be susceptible to drought. Improve the diversity and resilience of our water supply.

Encourage and implement fit-for-purpose stormwater reuse.

Reduce irrigation costs and allow for irrigation during water restrictions.

SOLUTION

QDC
Rainwater tanks and a basic inexpensive form of passive irrigation for street trees to be made mandatory.

EPP
Total Water Cycle Management Plans (TWCMP) to be reintroduced.

Investigate ways to fund stormwater harvesting schemes (e.g. market incentives, stormwater connection fees, impervious area tax, portion of offsets funding).

OUTCOMES

Expand cost effective and resilient non-potable water supply network via rainwater tanks and stormwater harvesting.

JUSTIFICATION

A meta study of various willingness to fund research projects documented the freedom from water restrictions benefit and found it varies from $3 a month to $33.50 a month per household (Houtven et al., 2017).

Zhang et al. (2015) used this method in reporting that a rainwater tank has a one-off value of $18,000 per property.

Undertaking the TWCMP allowed MBRC to reduce waterway associated costs from approximately $4M to $800K.

CASE STUDIES

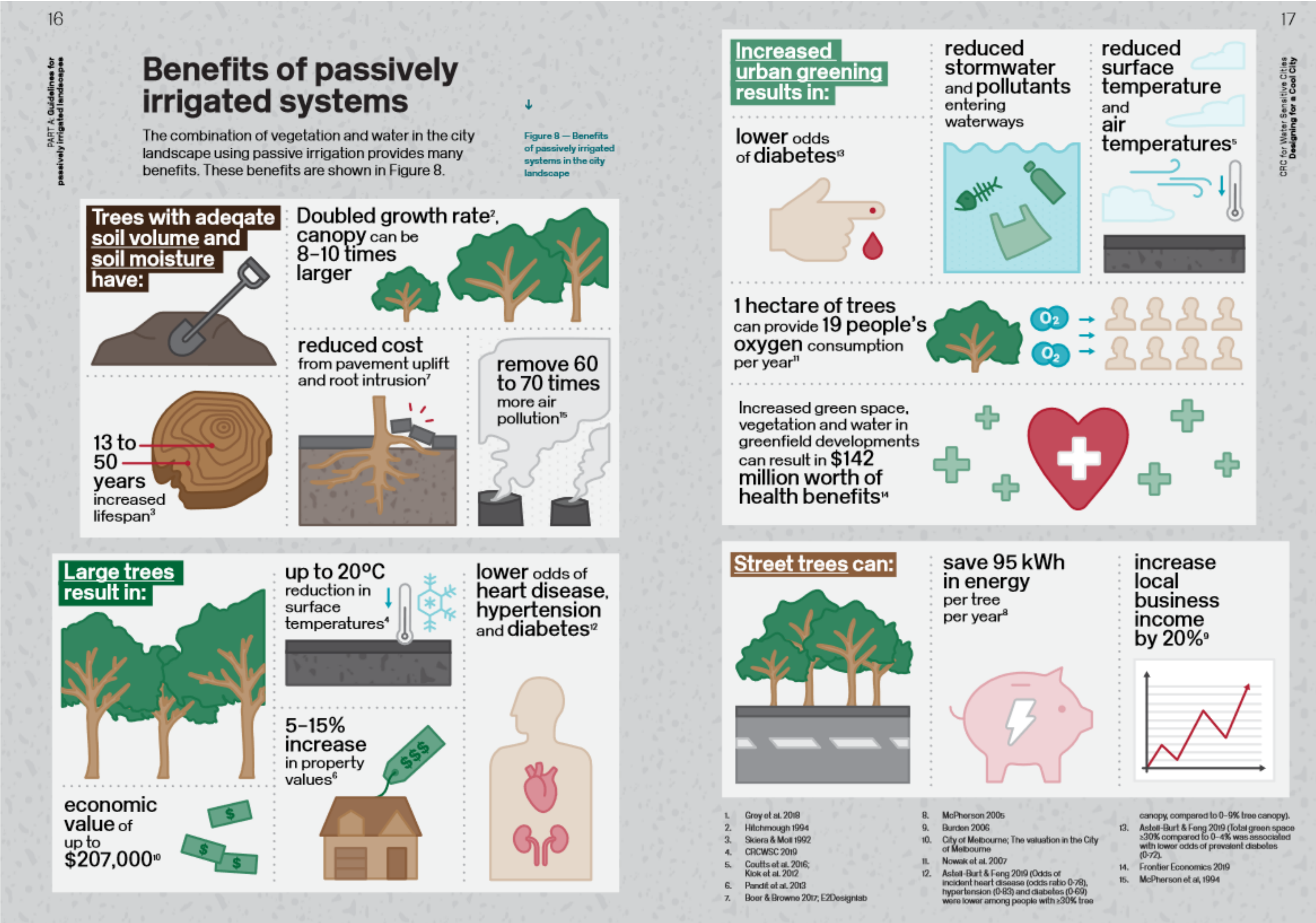
- Moreton Bay Regional Council TWCMP *(Figure 12)*
- Fitzgibbon Chase PotaROO
- Southbank Rain Bank

ACTIONS

- Liaise with QDC regarding tanks
- Insert TWCMP into the EPP
- Update Water by Design (WbD) Stormwater Harvesting Guidelines

APPENDIX B

COOPERATIVE RESEARCH CENTRE FOR WATER SENSITIVE CITIES – DESIGNING FOR A COOL CITY GUIDELINES (EXTRACT)



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PART A: Guidelines for passively irrigated landscapes

Benefits of passively irrigated systems

The combination of vegetation and water in the city landscape using passive irrigation provides many benefits. These benefits are shown in Figure 8.

Figure 8 — Benefits of passively irrigated systems in the city landscape

Trees with adeqate soil volume and soil moisture have:

Doubled growth rate[2], canopy can be 8–10 times larger

reduced cost from pavement uplift and root intrusion[7]

remove 60 to 70 times more air pollution[15]

13 to 50 years increased lifespan[3]

Large trees result in:

up to 20°C reduction in surface temperatures[4]

lower odds of heart disease, hypertension and diabetes[12]

5–15% increase in property values[6]

economic value of up to $207,000[10]

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CRC for Water Sensitive Cities Designing for a Cool City

Increased urban greening results in:

lower odds of diabetes[13]

reduced stormwater and pollutants entering waterways

reduced surface temperature and air temperatures[5]

1 hectare of trees can provide 19 people's oxygen consumption per year[11]

Increased green space, vegetation and water in greenfield developments can result in $142 million worth of health benefits[14]

Street trees can:

save 95 kWh in energy per tree per year[8]

increase local business income by 20%[9]

1. Grey et al. 2018
2. Hitchmough 1994
3. Skiera & Moll 1992
4. CRCWSC 2019
5. Coutts et al. 2016; Klok et al. 2012
6. Pandit et al. 2013
7. Boer & Browne 2017; E2Designlab
8. McPherson 2005
9. Burden 2006
10. City of Melbourne; The valuation in the City of Melbourne
11. Nowak et al. 2007
12. Astell-Burt & Feng 2019 (Odds of incident heart disease (odds ratio 0·78), hypertension (0·83) and diabetes (0·69) were lower among people with ≥30% tree canopy, compared to 0–9% tree canopy).
13. Astell-Burt & Feng 2019 (Total green space ≥30% compared to 0–4% was associated with lower odds of prevalent diabetes (0·72).
14. Frontier Economics 2019
15. McPherson et al, 1994

APPENDIX C
FLEXIBLE ON-SITE OPTIONS FOR MEETING STORMWATER QUALITY DESIGN OBJECTIVES (EXTRACT - WATER BY DESIGN, 2015)

On-site technologies

There are a range of design approaches and technologies which can be adopted within developments that will contribute towards the achievement of the stormwater quality design objectives on-site. These can be categorised as either *avoidance* or *mitigation* techniques, which are described as follows:

- Avoidance techniques – These techniques prevent the creation of polluted runoff by either capturing or infiltrating rainfall. Examples include low impact design and rainwater tanks.
- Mitigation techniques - The aim for mitigation strategies is to treat stormwater before it leaves the development site (mitigating polluted stormwater runoff). These techniques focus on the removal of pollutants from runoff, rather than preventing the generation of polluted runoff.

In general, avoidance techniques have greater on-site benefits in addition to the water quality benefit provided, compared to mitigation techniques. However, the performance of avoidance techniques is more difficult to quantify using either compliance methodologies (1) or (2) and hence have traditionally been poorly adopted compared to the mitigation techniques which fit well with these compliance methodologies. The Living Waterways framework (compliance methodology (3)) recognises and credits the multiple-benefits often associated with avoidance techniques and hence is an important methodology for promoting adoption of these techniques. A description and discussion of common avoidance and mitigation techniques is provided below.

Common avoidance strategies

The following strategies for avoidance may be considered acceptable, however, their efficacy and cost effectiveness will vary depending on the location of the treatment measure.

Rainwater harvesting

Roof water harvesting involves the collection of rainwater from roofs and podiums within above or below ground storage systems for reuse. Rainwater contains substances such as nitrogen that can be harmful to bays and inlets. Roof water harvesting contributes to both water conservation and stormwater management outcomes (Water by Design, 2009).

Porous pavements

Porous pavements are an alternative to typical, impermeable pavements and consist of modular block pavements or permeable pavements overlaying a shallow storage layer of aggregate material. Porous pavements provide some removal of sediments and attached pollutants by infiltration through an underlying sand or gravel media layer. However, their main purpose is to reduce runoff volume by infiltration into the sub-soils and delaying runoff peaks by providing retention storage capacity and reducing flow velocities. Porous pavements serve as source-control stormwater treatment devices as they minimise the volume of stormwater entering downstream systems and provide primary level treatment through the removal of particulate pollutants (Water by Design, 2009). The maintenance requirements for porous pavements involve the settling of paving after construction and ongoing care to avoid clogging of the pavement by weeds and sediment (Auckland Council, 2014).

The following are the routine maintenance requirements for porous pavements (City of Gold Coast, 2007):

- Routine inspection to identify any surface clogging/blockage of the underlying aggregate or filter layers.
- Routine inspection of inlet points to identify any areas of scour, litter build up, sediment accumulation or blockages.
- Routine inspection of pavement for holes and cracks.

- Routine inspection to ensure contributing catchment area is stabilised and not a significant source of sediment.
- Routine inspection of pre-treatment to ensure it is working effectively.
- Periodic inspection to ensure system dewaters following storm events.
- Removal of accumulated sediment and clearing of blockages to inlets.
- Regular vacuum sweeping and/or high pressure hosing to free pores in the top layer from clogging; periodic replacement of aggregate layer (about every 20 years).
- Replacement of geotextile fabric.
- Maintaining the surface vegetation (if present).

Vegetated roof systems

A green roof is a roof surface, flat or pitched, that is planted partially or completely with vegetation and a growing medium over a waterproof membrane (Commonwealth of Australia, 2013). Vegetation on green roofs is planted in a growing substrate that may range in depth from 50mm to more than a metre, depending on the weight capacity of the building's roof and the aims of the design. Green roofs absorb and retain rainwater and can be used to manage stormwater runoff in urban environments by retaining rainwater and slowing rainfall runoff (Commonwealth of Australia, 2013). They can also filter particulates and pollutants (DEPI, 2014). Stormwater runoff can be reduced or slowed because it is stored in the substrate, used by or stored in the foliage, stems and roots of plants and also evaporates directly from the substrate. Additional water storage capacity can be provided through incorporation of a water retentive layer or drainage layer at the base of the green roof (DEPI, 2014). Research at the University of Queensland has shown runoff reductions of up to 42% achieved with only 100mm of soil planted with moderate growth turf; as the soil depth and vegetation water use is increased, so does retention capacity (Commonwealth of Australia, 2013). For green roofs, it is desirable to maximise water retention in the system for as long as possible, and to send reduced volumes of high quality (low nutrient) run-off off the roof (DEPI, 2014). Green roofs do require fertiliser application which may cause nutrient to leach via roof runoff, however, green roof runoff could be used for irrigation and other non-potable uses (DEPI, 2014). However, a greater surface area for potential capture and storage of contaminants on a green roof decreases nutrient loading entering stormwater runoff (DEPI, 2014).

Design considerations should include weight loading, existing structure and size, drainage, climate, and the local environment.

An extensive vegetated roof cover is a veneer of vegetation that is grown on and covers an otherwise conventional flat or pitched roof, endowing the roof with hydrologic characteristics that more closely match surface vegetation than the roof (Cahill, 2012). The overall thickness of an extensive vegetated roof may range from 2 to 6 inches (revise) and may contain multiple layers, including waterproofing, synthetic insulation, non-soil-engineered growth media, fabrics and other synthetic components. Vegetated roof covers can be optimised to achieve water quantity and water quality benefits. Through the appropriate selection of materials, even thin vegetated covers can provide significant rainfall retention and detention functions. To make vegetated roofs practical for installation on conventional roof structures, lightweight materials are used in preparation of most engineered media. The following design elements of a vegetated roof system are required: (Cahill, 2012, page 155).

Other strategies for reducing the generation of stormwater pollutant runoff include change to the streetscape layout; implementing driveway standards that minimise impervious surfaces; implementing narrower roads; and utilising micro depression landscaping.

Low Impact Design - Housing layout

A water sensitive housing layout integrates residential blocks with the surrounding drainage function and public open space. Such layouts often include a more compact form of development, which reduces impervious surfaces and helps protect the water quality and health of urban waterways (CSIRO, 2006 - figure 5.2 page 53)

There are a number of key measures involved in this design choice including:

- Increase public open space: encourages a reduction of private open space and an increase in public open spaces.
- Setbacks: setbacks from waterways should be determined according to topography, waterway flooding characteristics, vegetation and visual quality.
- Buffer zones: incorporate buffer zones beside creeks and retain existing remant vegetation.
- Orientation: orientate residential living areas to public open space.

- Reduced paving: minimise the extent of paving and impervious surfaces by introducing shorter residential driveways.
- Lot geometry: introduce a flexible lot minimum size.
- Housing runoff: where possible, direct run-off from housing to a treatment point within the development site. (CSIRO, 2006)

Road layout

A water sensitive road layout incorporates the natural features and topography of the site. It implements the practice of locating roads beside public open spaces wherever possible – this enhances visual and recreational amenity, temporary storage, infiltration at or close to source, and water quality. It also aims to minimise the extent of impervious road surfaces (CSIRO, 2006).

There are a number of key measures involved in this design choice including:

- Road alignment: ensure that local collector roads run parallel to contours.
- Access places and ways: ensure short access places and access ways are perpendicular to the contours. Design access places and road cross falls to direct run-off to local collection/detention measures.
- Reduce impervious surfaces: reduce the area of impervious surfaces through.
- Decreasing the length and width of low traffic local roads.
- Designing a shorter road network.
- Using cul-de-sacs with reduced road surface areas (smaller radius, T-shaped).
- Roadside detention: design roadways and parking to incorporate detention basins and filtering by vegetation. Provide areas for stormwater detention and filtration along road verges where direct vehicular access is restricted or limited. Locate small detention basins, leach drains and swales in 'pockets' created by curved alignments.
- Road location: locate public open spaces on local collectors at the head or base of cul-de-sac to accommodate local run-off overflow.
- Minor and major flows: incorporate swales to carry minor flows along collector roads, while roads carry major storm event flows (CSIRO, 2006).

Common mitigation strategies

Bioretention basins

Bioretention systems operate by filtering stormwater runoff through densely planted surface vegetation and then percolating runoff through a prescribed filter media. Bioretention systems serve as tertiary stormwater treatment devices and they target fine sediments, metals, particulates and dissolved nutrients. Bioretention systems deliver significant stormwater quality management outcomes through the reduction in pollutant concentrations and loads. They also contribute to hydrology management by slowing the rate of discharge of stormwater to the receiving environment and reduce volume through evapotranspiration (Water by Design, 2009).

Constructed wetlands

Constructed wetlands are densely vegetated water bodies that use enhanced sedimentation, fine filtration, adhesion and biological uptake, and transformation processes to remove pollutants from stormwater. They serve as tertiary stormwater treatment devices and target fine sediments, metals and particulates and dissolved nutrients. Constructed wetlands deliver significant stormwater quality management outcomes through a reduction in pollutant concentrations and loads. They also contribute to hydrology management by slowing the rate of discharge of stormwater to the receiving environment and volume reduction through evapo-transpiration (Water by Design, 2009).

Grass or vegetated swales

Swales are shallow, open, vegetated channels that serve as secondary stormwater treatment devices in stormwater treatment trains. The vegetation in the swales can range from mown turf to sedges and rushes. Grass or vegetated swales contribute to stormwater quality management outcomes by removing coarse sediments and some nutrient and heavy metals. They also contribute to water conservation through passive irrigation of these landscape elements from stormwater, thus reducing demand on alternative water sources for irrigation (Water by Design, 2009).

Passively irrigated street trees

Passive watering involves the redirection of 'low flow' road stormwater to water street trees while allowing any greater flows to be collected in the stormwater collection system (Landcom, 2008). Passive irrigation can provide water quality and quantity management benefits. Water Sensitive

Designs (WbD, 2014) provides a number of examples for the use of passively irrigated street trees through the use of low technology measures.

Rainwater harvesting

Roof water harvesting involves the collection of rainwater from roofs and podiums within above or below ground storage systems for reuse. Rainwater contains substances such as nitrogen that can be harmful to bays and inlets. Roof water harvesting contributes to both water conservation and stormwater management outcomes (Water by Design, 2009).

Stormwater harvesting

Stormwater harvesting captures stormwater flows from ground surfaces such as roads, car parks, and pedestrian areas. Stormwater harvesting systems provide water quality and quantity management benefits. Re-use of harvested stormwater reduces the volume of stormwater runoff entering urban streams and associated stormwater pollutant loads. Capturing and re-using the first 15 to 20mm of runoff from impervious surfaces can assist in protecting and restoring the pre-developed natural hydrologic conditions of an urban waterway (Water by Design, 2009).

Porous pavements

Porous pavements can also be used to mitigate the impacts of stormwater as described above in the 'avoid' section.

Vegetated and non-vegetated infiltration systems

Infiltration measures consist of a 'detention volume' located either above or below ground, designed to capture runoff and 'infiltration areas' or 'surface' through which the captured stormwater is subsequently infiltrated into the surrounding soils and underlying groundwater. Infiltration systems can operate at a variety of scales and there are four basic types: leaky wells, infiltration trenches, infiltration soak-aways, and infiltration basins. Infiltration measures contribute to stormwater quantity management as they minimise the volume of stormwater entering downstream environments (Water by Design, 2009).

Raingardens

Raingardens are garden beds which use native plants and free draining soils to capture, filter and treat pollutants typically found in stormwater that runs from impermeable surfaces such as roofs, paving and driveways. Treatment occurs through a combination of natural physical and chemical processes associated with the type of soil and plants used (Water by Design, 2009). Treated stormwater is then fed back into the drainage system or left to infiltrate into the ground below (Clearwater, 2012). Raingardens improve water quality by removing suspended solids, nitrogen and phosphates whilst providing a source of water for the plants.

Litter Baskets

These devices are solely targeted towards the removal of gross pollutants such as litter and leaves. They are a mesh insert placed within a stormwater gully pit to achieve this purpose. The advantage over traditional gross pollutant traps is that the mesh allows the pollutants to be stored in a dry state which prevents breakdown of the trapped organic material and release of soluble nutrients.

Cartridge Filters

These devices are a manufactured stormwater treatment product which uses fine filtration and activated media to remove particulate and soluble pollutants. There are a number of manufacturers producing products in this category which are marketed in Queensland and which have significant differences in their lifecycle costs. Treatment performance of these devices is highly dependent on ongoing maintenance and routine replacement of cartridges.

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