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THE BUSINESS CASE FOR WATER SENSITIVE URBAN DESIGN: AN ASSESSMENT OF THE COSTS AND BENEFITS

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Abstract

Many economic, ecological and social values can be seriously affected by a decrease in waterway health. One of the main impacts on waterway health in urban areas is stormwater runoff. Given population and urban development forecasts, a business-as-usual approach to development will accelerate a decline in the health of waterways. Managing the negative impacts of urban development, such as increased stormwater flows, and the sediment and nutrient loads associated with these flows, is a priority to ensure the continued health of waterways and their services. These negative impacts can be managed through the adoption of water sensitive urban design (WSUD).

Market receptivity is one of eight factors that are required to enable the mainstreaming of WSUD (Brown and Clarke, 2007). However, market receptivity in Australia is generally low. Research indicates that urban water professionals, including land developers and policy officers, perceive the capital and maintenance costs to be a barrier that prevents the uptake of water sensitive urban design (Brown *et al*, 2007).

To build the receptivity of state government, local councils and the development industry, a business case for WSUD was prepared. This involved undertaking a cost–benefit assessment to determine if the benefits of applying WSUD practices to typical low density residential, medium to high density residential, and commercial and industrial developments are likely to outweigh the costs. Data was gathered through:

- a literature review and semi-structured interviews with industry stakeholders
- case study assessments of six different development types across four climatic regions.

The completed cost-benefit frameworks bring together both quantitative and qualitative values of likely social, environmental and financial benefits and costs to assist in approximating the net benefit. The benefits are broad and difficult to quantify. The benefits which were quantified for the cost-benefit frameworks include potential property premiums associated with the application of WSUD, avoided infrastructure costs on flat sites (i.e. <5% grade), stormwater pollutant load reductions and potentially avoided waterway rectification and maintenance costs.

This paper presents the business case for WSUD, including the range of costs and benefits of WSUD. In addition, a number of other key findings will be presented such as how WSUD can be delivered cost effectively, how it may affect lot prices and yields, and sales advantages.

Background

Many economic, ecological and social values can be seriously affected by a decrease in waterway health. One of the main impacts on waterway health in urban areas is stormwater runoff. Given population and urban development forecasts, a business-as-usual approach to development will accelerate a decline in the health of Queensland's waterways. Figure 1 illustrates that stormwater runoff from urban diffuse sources will represent the largest percentage growth in pollutant loads in South East Queensland waterways over the coming years, considering future population growth and urban growth estimates.

Managing the negative impacts of urban development, such as increased stormwater flows, and the sediment and nutrient loads associated with these flows, is a priority to ensure the continued health of waterways and their services. However, the market receptivity to managing stormwater is generally low. Research indicates that urban water professionals, including land developers and policy officers, perceive the capital and maintenance costs to be a barrier that prevents the uptake of water sensitive urban design (Brown *et al*, 2007).

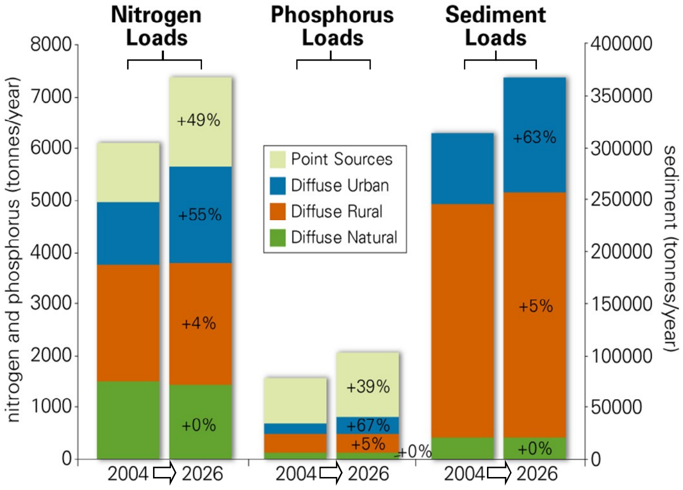

Figure 1 Changes in the annual load of pollutants entering South East Queensland waterways if no additional measures are undertaken (Source: South East Queensland Healthy Waterways Strategy 2007–2012).

The draft *State Planning Policy for Healthy Waters* (the draft policy) (Queensland Government, 2009) has been developed to ensure best practice stormwater management is applied to development across Queensland to protect the environmental values of waterways. A key mechanism of the policy is setting design objectives for managing stormwater quality, waterway stability and frequent flows (Table 1). In South East Queensland (SEQ), these objectives are already mandated by the *South East Queensland Regional Plan 2009-2031 Implementation Guideline No. 7: Water Sensitive Urban Design*. The objectives apply to new developments greater than six lots or 2500 m^2.

The design objectives can be achieved by adopting Water Sensitive Urban Design (WSUD). WSUD is planning and design approach that aims to ensure urban development is sensitive to natural hydrological and ecological cycles through the integration of water and stormwater management solutions into the engineering, landscape and architectural design of urban areas.

Table 1 Stormwater management design objectives for Queensland as proposed by the draft *State Planning Policy for Healthy Waters 2009* and the *South East Queensland Regional Plan 2009–2031: Implementation Guideline No. 7*

Policy objective	Intent	Performance targets
Stormwater quality	To protect receiving water quality by limiting the quantity of discharged stormwater pollutants. Applicable to all urban developments, excluding developments that are less than 25% impervious and that comply with the frequent flow objective.	Treat in accordance with best practice for each climatic region. Minimum required reductions in total pollutant loads, compared to untreated stormwater runoff from developments, are defined for: Total Suspended Solids (TSS), Total Phosphorus (TP), Total Nitrogen (TN) and gross pollutants. The minimum reduction varies between regions in Queensland.
Waterway stability	To prevent exacerbated in-stream erosion downstream of urban areas by controlling the magnitude and duration of sediment-transporting stormwater flows.[i]	Limit the post-development peak one-year Average Recurrence Interval (ARI) event within the receiving waterway to the pre-development peak one-year ARI event discharge.
Frequent flow	To protect in-stream ecosystems from the significant effects of increased runoff frequency by ensuring the frequency of hydraulic disturbance to in-stream ecosystems in developed catchments is similar to pre-development conditions.[ii]	Capture and manage the design runoff capture depth (mm/day) from all impervious areas so that the frequency of surface runoff is the same as pre-development conditions: - developments with a total fraction impervious <40%: design runoff capture depth = 10mm/day - developments with a total fraction impervious >40%: design runoff capture depth = 15mm/day. Note: Runoff capture capacity needs to be replenished within 24 hours of the runoff event.

Purpose

In order to build the receptivity of the development industry, and support the adoption of the State Planning Policy so that the binding and measurable targets are put in force, a business case was prepared. The business case determines if the benefits of applying WSUD practices to achieve best practice stormwater management are likely to outweigh the costs for typical development types. This paper presents a summary of the method and results. Full details are presented in *A Business Case for Best Practice Urban Stormwater Management* (Water by Design, 2010a) and the associated *Case Study Report* Water by Design (2010b), accessible from www.waterbydesign.com.au.

Method

A cost–benefit framework was developed (Table 2) that brings together quantitative and qualitative values of benefits and costs associated with applying WSUD to achieve best practice stormwater management for typical low-density residential, medium- to high-density residential, and commercial and industrial developments. The purpose of the frameworks is to allow:

- broad assessment of whether the benefits are likely to outweigh the costs
- stakeholders to easily evaluate the best available data to draw their own conclusions.

Table 2 Cost and benefit framework

Likely costs for typical developments	Likely benefits for typical developments
Major quantifiable costs (estimates)	**Major quantifiable potential benefits (estimates)**
• Acquisition (capital + design costs) • Annual maintenance costs • Life cycle costs • Annualised life cycle costs	• Value of the reduction in TN loads in stormwater • Potentially avoided costs associated with downstream waterway rehabilitation and maintenance • Potential increase in property values • Potential development costs that are avoided (applicable only on flat sites i.e. <5%) **Major unquantifiable potential benefits (estimates)** Example: • Protection of the numerous values associated with healthy downstream waterways
Minor potential costs	**Minor potential benefits**
Example: • Additional development assessment, compliance checking and enforcement costs associated with WSUD assets	Example: • Increased rate of sales associated with developments with landscaped WSUD features
Conclusions regarding the relative magnitude of likely costs and benefits: Assessment of whether the benefits are likely to outweigh the costs.	

The following tasks were undertaken to gather information to populate the frameworks:

- literature review and interviews with industry stakeholders to identify a list of all the potential costs and benefits of implementing stormwater management using WSUD practices, and to gain quantitative and qualitative data relating to costs and benefits
- case study assessment of six different development types in four different climatic regions (Brisbane, Mackay, Townsville and Cairns) to test the practicality of WSUD practices for meeting the proposed stormwater management design objectives and to identify the associated costs to achieve the design objectives.

The case study developments represent examples of 'greenfield' and 'infill' development that would be captured by the State's Integrated Development Assessment System, the draft *State Planning Policy for Healthy*

Waters and the *South East Queensland Regional Plan 2009–2031: Implementation Guideline No. 7*. The case studies are summarised below:

- Case study 1: Residential greenfield development on a sloping site (gradient of 5% or greater). The case study site covers an area of 76 ha within an overall subdivision of approximately 1,000 ha. There are 951 detached houses, with a typical lot size of between 400–700 m^2.
- Case study 2: Residential greenfield development on flat topography. The case study site covers an area of 6.4 ha within an overall subdivision of approximately 100 ha. There are 84 detached houses within the site, with typical lot sizes between 400–500 m2.
- Case study 3: Residential townhouse development. The case study site comprises 25 two-storey townhouses plus the site has landscaped areas, an internal road network, visitor parking spaces and a loading bay.
- Case study 4: Urban renewal development (high-density development). The case study is a large-scale urban renewal project involving conversion of an industrial area into a high-density residential development. The development includes 7 ha of high-rise residential towers and 5 ha with five-storey residential apartment buildings. There are 25 separate buildings within the site.
- Case study 5: Commercial development. The case study is a small-scale commercial development comprising a neighbourhood shopping centre with 15–20 ground-level shops on a 0.42 ha site. A central arcade separates two buildings.
- Case study 6: Industrial development. The case study is a medium-scale industrial development comprising a factory and warehouse on a 1 ha site. The single building is surrounded by an internal driveway and car park with approximately 100 car parking spaces.

Each case study is a real development that has either been designed or built somewhere in Queensland, with or without WSUD practices. Choosing case studies based on real developments ensures the developments' characteristics are generally consistent with current town planning scheme provisions and reflect current stakeholder and market expectations in Queensland.

To determine what additional costs, if any, are added to developments as a result of best practice stormwater management using WSUD practices, for each case study a 'WSUD case' scenario (where the stormwater management design objectives are met) was compared to a 'base case' scenario. The base case reflects a development that complies with existing mandatory State Government policy.

Therefore, the base case scenarios assume:

- conventional stormwater drainage management
- flood management (flood detention storage)
- rainwater tanks sized in accordance with the Queensland Development Code (except for case study 4 which the alternative water source requirement does not apply).

For each WSUD case study scenario, additional WSUD practices were required, above and beyond the base case, to meet the stormwater management design objectives defined by the draft State Planning Policy for Healthy Waters. Therefore the WSUD case scenarios assume:

- all the base case practices
- bioretention systems for compliance with the stormwater quality and frequent flow objectives
- detention storage for compliance with the waterway stability objective.

Selection and optimisation of the WSUD solution is site and development specific and therefore dependent on topography, receiving drainage and waterway levels, land availability and landscape intent. The WSUD practices were identified for each of the case studies using the approaches outlined in the *Concept Design Guidelines for WSUD* (Water by Design, 2009) and *Deemed to Comply Solutions – Stormwater Quality* (Water by Design, 2010c).

The performance of each scenario was calculated using desktop and modelling analysis. The cost information (unit rates) used is based on a review of recent reference material, advice from suppliers (e.g. rainwater tank suppliers), actual costs incurred in recent projects and on data from related research projects.

Results

The majority of benefits are non-market benefits and estimations of their economic worth are limited. This meant that it was not possible to conduct a solely quantitative cost–benefit analysis. However, the completed frameworks bring together both quantitative and qualitative financial, environmental and social values of likely benefits and costs to assist in approximating the net benefit of applying WSUD.

Literature review

The literature review identified that meeting the stormwater management objectives using typical WSUD practices requires capital, design, site acquisition, and approval and regulatory costs. Ongoing operation and maintenance costs are also required. In addition to the easily identifiable financial (direct) costs, implementing WSUD involves an opportunity (indirect) cost as some practices may exclude the use of land for an alternative purpose such as buildings, landscaping or open space. There are also other costs, such as environmental costs associated with obtaining raw materials.

On the other hand, the key benefits of best practice urban stormwater management are likely to include:

- reduced pollutants loads discharged to waterways relative to unmitigated urban development, which is estimated to be a potential annual saving of $515 per kilogram of TN removed
- reduced need for rehabilitation and maintenance of downstream waterway environments, which can range from $200–$3000 per metre of stream per annum
- premiums on land values due to enhanced amenity values and local and regional water quality, which have been estimated to range from 0.25 to 1.0% percent
- educational benefits.

There are also many important unquantifiable benefits of best practice urban stormwater management, such as the contribution towards maintaining the health of aquatic ecosystems and the services they provide. It will assist to preserve and enhance waterway-based recreation, current commercial values of waterways such as tourism and commercial fishing, and important non-market values such as the intrinsic value of aquatic ecosystems.

Case study assessment

The case study assessment provided a quantitative understanding of the cost to achieve the design objectives and calculation of the mean annual loads of pollutants removed from stormwater via WSUD practices for each case study.

The acquisition, annual maintenance and lifecycle costs of achieving the stormwater management design objectives are presented in detail (including on a dollar per lot and dollar per hectare basis) in the *Business Case for Best Practice Urban Stormwater Management* (water by Design, 2010a) and the accompanying *Case Study Report* (Water by Design, 2010b).

Key findings regarding acquisition costs are:

- Implementing the stormwater management components of WSUD is **typically less than 1% of the total cost of establishing a new dwelling**.
- The acquisition costs of implementing WSUD elements range from approximately $400 per dwelling for units in large complexes to around $4,000 for more complex WSUD elements for detached houses in case study 2 in Cairns.
- As housing density increases, the acquisition cost decreases. In a detached dwelling development, acquisition costs of the WSUD solution are approximately $1,600–$4,000 per household. In a townhouse development, this reduces to $800–$1,200 per dwelling, and for units it reduces to about $400 per dwelling. The same can be said for total life cycle costs. In a detached dwelling development, total life cycle costs of the WSUD solution are approximately $4,000–$5,000 per household. In a townhouse development this reduces to $1,000–$1,500 per dwelling, and for units it reduces to about $500 per dwelling.

The key finding regarding ongoing costs are that operating and maintenance costs per annum for WSUD elements to meet the stormwater management objectives range from less than $5 a year per dwelling for units to around $50 a year per dwelling for detached houses in areas such as Cairns.
The case studies quantified the benefits associated with stormwater pollutant load reductions, potentially avoided waterway rectification and maintenance costs, potential property premiums associated with the application of WSUD, and avoided infrastructure costs on flat sites (i.e. <5% grade) (see next section on cost-benefit frameworks for more information).

The case study assessments also found that:

- When implemented well (such as being considered appropriately at the material change of use or reconfiguration of a lot stage of development), WSUD practices can be accommodated within developments without loss of developable land.
- Geographic location influences the size of the WSUD treatment systems required and therefore the cost. Where rainfall is higher, treatment systems generally need to be slightly larger to achieve the stormwater quality objective when rainwater tanks are included in the treatment train. For example, the size of a bioretention filter area in an urban renewal development is 1.1% of the total catchment area in Brisbane, but 1.6% is required in Cairns.
- The stormwater management design objectives can be practically achieved through implementing WSUD practices.
- WSUD has sufficient flexibility to comply with the current town planning provisions of local governments' while meeting the broader requirements of the draft policy.

Cost-benefit frameworks

The results of the literature review and case study assessments were used to populate the cost-benefit frameworks. Refer to Water by Design (2010a) for the completed frameworks.

The frameworks demonstrate that the benefits of using WSUD practices to achieve best practice urban stormwater management on typical residential, commercial and industrial developments in Queensland are likely to exceed the costs. **The potential quantifiable benefits alone are likely to outweigh the costs.** For example:

- the value of pollution reduction (i.e. total nitrogen only) is estimated to be worth more than the life cycle cost of WSUD assets
- the potential avoided waterway rehabilitation life cycle costs are estimated to be worth around 70% of the life cycle cost of WSUD assets
- the potential property premiums are estimated to be around 90% of the capital cost of WSUD assets
- conservatively, the avoided capital cost on flat sites is likely to be in the order of $36,000 per hectare, or $34,123 in terms of a life cycle cost.

The actual avoided capital cost will vary considerably depending on site conditions and experience in developments such as Bellvista and North Shore show that the avoided costs are considerably higher than the WSUD costs.

In addition to presenting the likely net benefit of best practice urban stormwater management, a number of key points were also determined regarding the distribution of costs and benefits:

- The cost of applying WSUD practices to achieve best practice stormwater management should not significantly impact on the profitability of residential, commercial and industrial developments. For example, the acquisition (capital and design) costs of establishing WSUD to meet the stormwater management design objectives for residential developments are typically less than 1% of the cost of a new dwelling. The capital cost of WSUD is of a similar magnitude to the potential property premium attributable to improved water quality in local waterways.
- For residential developments, WSUD-related costs are likely to be indirectly borne by local householders via land costs and local government rates or body corporate fees. The distribution of these costs between households will be influenced by commercial decisions of developers and by planning decisions and rate determinations of local governments.
- For commercial or industrial developments, the costs may either be borne by the tenants (reflected in marginally higher rents) or the owners (reflected in marginally higher capital or purchase costs).
- The ongoing costs of maintaining WSUD assets in public areas will initially be met by local governments and may be partially offset by reductions in other council costs such as waterway rehabilitation. Local government would likely recover the increase in costs through rates revenues as it would be inefficient to establish more sophisticated administrative ways to recover the costs (e.g. charging a specific levy in areas where WSUD has been established). The impost on council budgets is likely to be negligible. For example, the annual growth in WSUD management costs in Brisbane would require an increase in total revue of approximately 0.005%.
- For residential rental properties, owners will likely pass on costs in full via rents. For commercial or industrial developments, sharing of costs between owners and lessees would be determined by prevailing market circumstances (e.g. vacancy rates, ability of tenants to pass on costs to their customers, or conditions of existing lease agreements).
- The ongoing costs for WSUD assets on private land may be covered by a body corporate, for example, and will again eventually be passed onto households.
- The benefits are distributed over a wide range of geographic, social and temporal scales, with the majority of the benefits accruing to a wide section of current and future community members via a mix of lower

costs, an enhanced environment, and benefits such as improved recreational opportunities, and stronger tourism industries.

Conclusion

The business case assessment illustrates that by adopting WSUD practices for best practice stormwater management, the stormwater management design objectives established by the draft State Planning Policy for Healthy Waters can be practically achieved for typical urban developments. In addition to being practical, the assessment suggests that the widespread application of best practice stormwater management using WSUD practices to new development in Queensland should produce a net benefit to society.

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[i] The waterway stability objective only applies to developments that drain to un-lined, non-tidal waterways and wetlands or if the local council intends to decommission a lined waterway and re-instate a natural channel.

[ii] The frequent flow objective only applies in catchments that pass through or drain to unlined non-tidal waterways and wetlands that are not degraded or classified as being of High Environmental Value (HEV), or slightly disturbed streams (as described in Environmental Planning Policy (Water) 2009) where the local council intends to rehabilitate.