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Integrating Stormwater Practices into Sustainable Green Spaces

Runoff in Public Spaces

Text and images by William Hunt and Benjamin Loh
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1. In Raleigh, a wet pond system is surrounded by multiple terraces that act as cleansing filters.

2. A constructed stormwater wetland runs alongside the Los Angeles River, to which a fraction of the river's flow is diverted.

3. An example of a biotope used to clean a large lake in Singapore's Kallang River-Bishan Park.

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As cities "go green" and seek to create more green places for their citizenry to recreate and relax, they are concurrently being required to treat runoff from impermeable and compacted surfaces that tend to dominate cities. Excessive stormwater runoff has been linked to flooding, stream erosion, overwhelming combined sewer systems, and impairments to lakes and estuaries, causing fill kills and unsafe seafood consumption. In response, national and state governments from Australasia to Europe to North America are promulgating regulations designed to capture and treat runoff from the most frequent events (such as those less than 25 or 30 millimetres). Because of the lack of space available in cities, local governments are turning to areas where modest amounts of space are available, including parks and other green spaces. Green spaces are "natural" homes for stormwater practices because they are usually owned by the municipality and space is available. If installed on municipal land, the likelihood of appropriate care (inspection, operation, and maintenance) increases. This approach has been taken in several high profile projects, in cities including Brisbane, Australia; Los Angeles, USA; Portland, USA; Singapore; and Wellington, New Zealand. However, as stormwater treatment infrastructure is rather expensive, particularly those installed as retrofits, community leaders often need to justify the public investment in stormwater infrastructure.

When viewing the values, or services, associated with stormwater practices in a holistic manner, it is much easier to argue their value. This article discusses the types of stormwater practices that are being installed in green spaces and then provide a brief review of the many ecosystem services that each provides.

Stormwater practices have a variety of nomenclature that is not consistent worldwide. Some of the current terms used for systems that treat stormwater runoff include: ABC Water Features (in Singapore), Low Impact Design or Low Impact Development (LID) (in USA and New Zealand), Stormwater Control Measures (SCM) (in USA), Sustainable Urban Drainage Systems (SUDS) (in UK), and Water Sensitive Urban Design (WSUD) (in Australia). While some of these terms are more philosophies of stormwater treatment and others more specific installations, all of them address human-influenced stormwater management, which entails the planning, design, construction, and maintenance of facilities intended to treat runoff. For the purpose of this article, the term "Stormwater Control Measure" (or "SCM") will be employed. SCMs of most applicability in green spaces are those that are vegetated themselves and have the potential to blend into the landscape. These include bioretention cells, constructed stormwater wetlands, green roofs, rain- and stormwater harvesting, swales, vegetated filter strips, and wet ponds with vegetated shelves. The exact selection is dependent upon several factors, with one of the most important being the aesthetic of the green space in which they are being incorporated.

In larger park settings, normally those not in a city centre, large-scale SCMs can be employed. These include constructed stormwater

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wetlands and wet ponds with wetland features. Examples include a wet pond system surrounded by multiple terraces that act as cleansing filters (Raleigh, North Carolina, USA), a biotope to clean a large lake, which again employs multiple terraces (Singapore), and a 0.5-kilometre-long constructed stormwater wetland that runs alongside the Los Angeles River, to which a fraction of the river's flow is diverted (Los Angeles, California, USA) (Figs. 1 – 3).Ponds and wetlands are designed to capture and temporarily store runoff. This water is discharged through an outlet structure to ensure that water is retained with the SCM for a specified length of time (often a 48-hour minimum). The most obvious difference between wetlands and ponds with wetland fringes is the fraction of vegetative cover. The vegetation-soil-water-microbe interface present in wetlands and wetland fringes is critical for these two SCMs to provide many ecosystem services. In the Raleigh and Singapore examples, these SCMs are integral to the landscape and are designed to integrate people into their space (Fig. 4). An important pair of ecosystem services (recreation and education) is therefore demonstrated.

The most successful larger practices involve a team of designers including biologists, engineers, landscape architects, and parks and recreational professionals. Intricate paths can be laid out, which draw people into the heart of the green space and SCM (Fig. 5). For these larger SCMs to work, they need large catchment areas, often in tens of to a hundred hectares. This is potentially ideal for those seeking to meet stormwater management goals, as treating a large catchment will lead to a larger volume of pollutants treated. Moreover, long-term maintenance on a large facility, while greater individually than that for a small practice, when normalised by the catchment area is much less expensive. Larger SCMs are often a focal point of a park or urban green space, such as in Wellington, New Zealand (Fig. 6).

Smaller green spaces typically cannot support large SCMs for many reasons, including a lack of space. However many other green practices can be easily integrated into more restrictive green spaces. Most popular among these SCMs are bioretention, swales and vegetative filter strips, and bio-swales. Each of these can be landscaped and integrated into a manicured garden, a turf grass lawn, or a more natural setting. Plant selection and maintenance for each is also dictated by safety needs. Often SCMs are specifically designed with low-lying shrubs and other vegetation to meet safety obligations.

Bioretention is designed to filter water, and in many cases infiltrate runoff. Swales and vegetated filter strips are conveyances of runoff, exposing water to vegetation. Bioswales are a combination of the two. Bioretention can be used to create lush areas in otherwise sterile landscapes, such as in the Kapiti Coast of New Zealand (north of Wellington) (Fig. 7). Bioretention has gained special popularity. Often called a “rain garden” in the landscape community, this clever term has helped to foster its acceptance by the public at large. Portland, Oregon, USA, uses these rain gardens in streets to help calm traffic, while simultaneously reducing the risk of accidents and increasing the green space along the residential street (Fig. 8). Of all SCMs

4. As a stormwater control measure, this biotope in Kallang River-Bishan Park is integral to the landscape and further designed to integrate people into its space.

5. Intricate paths can draw people into the heart of the green space, as pictured at the North Carolina Museum of Art in Raleigh.

6. Large-scale stormwater control measures can emerge a focal point of a park or urban green space, such as in Wellington, New Zealand (Photo: Simon Devitt).

7. In the Kapiti Coast of New Zealand (north of Wellington), bioretention is used to create lush areas in otherwise sterile landscapes, as pictured.

8. A residential area in Portland, USA, uses bioretention rain gardens in streets to help calm traffic and increase the green space found there.

studied worldwide, there is general agreement that bioretention is the most efficient cleanser of water, due to all the pollutant mechanisms present in this device (including sedimentation, filtration, nitrification-denitrification, and other biological, chemical, and thermodynamic mechanisms). Swales, while not as efficient at pollution removal, serve a key role in the landscape: conveying runoff. As such, they can be designed as cascade systems (Fig. 9) or serve other aesthetic purposes (Fig. 10). They do expose water to vegetation and some of the associated pollutant removal processes associated with the soil-water-plant interface. Some swales also provide infiltration. Because neither bioretention nor swales has particularly deep ponding water, except in times of extreme rainfall, they are generally regarded as safe against drowning.

Park structures can "go green" as well, by incorporating SCMs like rainwater (or stormwater) harvesting and green roofs. While the harvesting system does not directly employ vegetation, it is environmentally friendly and serves as great demonstration sites that homeowners can emulate on their personal property. Park headquarters have placed rainwater harvesting systems in extremely visible locations to foster adoption, such as in Hemlock Bluffs Park of the town Cary in North Carolina (Fig. 11). Larger stormwater harvesting systems, such as the Stormwater Harvesting And Reuse Centre (SHARC) in Brisbane, Australia, can capture runoff from ultra-urban catchments, so the water can be treated then conveyed a few metres to supply green space needs. In the case of SHARC, this means supplying water for the South Beach (really an urban, beach-like pool) constructed south of the Brisbane River—an extremely popular green space in Queensland's capital city (Fig. 12). Water diverted from a receiving channel helps reduce bank erosion, another key ecosystem service provided by SCMs. Many public gardens, such as the colonial gardens of Tryon Palace in New Bern, North Carolina, now utilise rainwater harvesting systems as their "first choice" for irrigation (Fig. 13). Park designers are frequently turning to eco-roofs, or popularly known as green roofs—where vegetation and substrates are placed onto rooftops to mitigate temperatures, runoff volumes, and metals in stormwater while subsequently providing habitat and a recreation amenity in an otherwise most sterile of locations (the rooftop). Many communities have launched aggressive green roof programmes, such as Berlin and Stuttgart, in Germany; Chicago and Portland, in USA; and Singapore. As of June 2012, Singapore had nearly 450 green roofs within its jurisdiction. Park headquarters or shelters are prime locations for green roofs, as pictured in Auckland, New Zealand (Fig. 14), and Singapore (Fig. 15). Moreover, moving beyond parks downtown or into the City Centre, often the *only possible* green space is a green roof. In the USA, Chicago and Portland are leaders in creating downtown green roofs to promote healthy living and decrease the heat island effect (Fig. 16).

9. Swales may be designed as cascade systems, as has been done in Maryland, USA (Photo: Adrienne Cizek).

10. Swales can also be designed to serve other aesthetic purposes, such as for landscaping, here in Kallang River-Bishan Park.

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11. Rainwater harvesting systems are a prominent feature of Hemlock Bluffs Park's headquarters, encouraging their adoption (Photo: Mitchell Woodward).

12. The Stormwater Harvesting And Reuse Centre (SHARC) in Brisbane, Australia, successfully supplies water to the very urban South Beach.

13. The colonial gardens of Tryon Palace in New Bern, North Carolina, has chosen rainwater harvesting systems for irrigation.

14, 15. Green roofs installed in park headquarters in Auckland (Fig. 14) and Singapore (Fig. 15).

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Each of these SCMs is designed and installed by municipal leaders to reduce the runoff volume entering streams or other conveyances. While this and water quality improvement are considered to be the most popular and recognised benefits that SCMs provide, there is a host of other ecosystem services associated with these practices. Other benefits include air quality improvement, biodiversity (flora and fauna), carbon sequestration, education, food and other supply provision, and recreation. While the fact that SCMs do provide these ecosystem services is generally accepted, their true value has often not been quantified yet. Efforts are underway by researchers to begin accounting for these other ecosystem services. SCMs do not provide these services equally. Some supply services more readily than swales, like constructed stormwater wetlands. As these differences become more thoroughly quantified, stormwater planners will be better able to guide green spaces to adopt particular "more holistic" SCMs.

One final point that planners will need to understand while considering the sustainability of SCMs in green spaces is the amount of operation and maintenance inputs each practice requires. In general, the more complicated a practice is in its operation, the more expensive it will be. Similarly, the more manicured a practice must appear, the more money (namely labour) will be invested in that system. While practices may be appear beautiful, they will also be expensive and maybe not "sustainable". While high operation costs are not a reason to forgo the selection of an individual practice, it must be accounted for at the very beginning of the design process, as decision makers must acknowledge this expense. In many ways, more natural-looking practices that rely on passive operation may prove to be the most sustainable SCMs, as long as the local public is accepting.

Stormwater control measures are "naturally" married to green spaces in cities. Governments are mandating that stormwater runoff be treated. By virtue of their incorporating vegetation and proximity to built-up areas that shed runoff, SCMs are a neat fit in urban green spaces, particularly parks. The challenge to designers in the future will be to choose and design practices that meet water quality and hydrologic requirements, while also optimising the suite of additional ecosystem services provided and minimising the long-term operation and maintenance costs. Only by doing so can SCMs in green spaces truly be sustainable.

16. Chicago and Portland are leaders in creating downtown green roofs to promote healthy living and decrease the urban heat island effect.

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