A Landscape Design Process for Bioretention Systems

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Abstract

Bioretention systems for stormwater treatment are primarily designed to meet the technical specifications of engineering design guidelines. Although these systems may perform their intended purpose of filtering stormwater runoff, they may fail to make the most of the site, limit the use of adjacent open space, compromise visual amenity or create unnecessary maintenance issues. These inadequacies could lead to poor public perception of bioretention systems and a lack of willingness to invest in these treatment systems.

This paper provides an analysis of the design process commonly employed for bioretention systems. The analysis identified limitations that constrained the input of collaborating designers such as landscape architects or other specialists, limiting the value of the landscapes that were created.

Landscape architects rely on a more open and collaborative approach to site design that depends on specialist input and feedback loops to resolve design issues. Such a design process was developed for a stormwater bioretention system located in a highly utilised park in Sydney’s inner west, with the overall objective of making the bioretention system an integrated and valuable landscape asset. This design process is outlined in this paper and developed into a framework for the design of bioretention systems in the public realm.

The recognition of the need for a multiplicity of landscape values, and the need for diverse specialists to collaborate on the design has flow on consequences that impact the way a project is executed. The expectations of a multiplicity of landscape values has the following effects: (a) Funding - this may diversify the sources of funding available for these works; (b) The brief – the expectations of multifunctional landscapes should be articulated in the brief; Project team – appropriately diverse teams can then be assembled to address the brief; Design outputs – the design led process facilitates the timely input of all specialists, and ensures consistency in outputs; and Outcomes – acknowledging the varied values of the landscape assists in determining what resources are required to best manage the asset. The community benefits through the inclusion of public domain assets that incorporate contemporary design principles for public open space. The asset owner benefits from an asset that is well used and maintained, and performs the desired functions.
Introduction

There is a problem with the design of many stormwater treatment systems

Bioretention systems and other stormwater treatment devices such as swales and constructed wetlands are often designed for the specific purpose of stormwater filtration, but may not be designed to complement the greater landscape in which they are located. These stormwater treatment systems are typically designed in accordance with engineering design guidelines such as:

- Melbourne Water (1999), Urban Storm Water: Best Practice Environmental Management Guidelines (Victorian Stormwater Committee);
- Melbourne Water (2005), WSUD Engineering Procedures: Stormwater

Such guidelines are intended for detailed design and address hydraulic, access and maintenance requirements. The engineers using these guidelines are typically not trained in site design or ecosystem functions. Consequently, bioretention systems designed to these criteria may perform their intended function of filtering stormwater and safely conveying specific design flows but they may fail to integrate with the surrounding urban form, limiting the use of adjacent open spaces, compromising visual amenity or creating unnecessary maintenance issues (an example is shown in ). These inadequacies could lead to poor public perception of bioretention systems and a lack of willingness to invest in these treatment systems, or worse the abandonment of these treatment systems in practice or in policy.
Stormwater infrastructure such as bioretention systems can offer much more value to the open spaces where these systems are typically constructed. Indeed, stormwater infrastructure is well suited to public recreational spaces when sensitively integrated, adding to the recreational journey and educational value, and creating places of interest. Landscape design guidelines are not generally available for stormwater treatment systems. Consequently, design opportunities that may be missed by engineering specifications-led design include:

- **Social** – visual amenity, enhancing the sense of place, community interaction and cohesion, education
- **Economic** – activation of space, public open space credits for new developments, flood attenuation, water supply, maintenance cost saving, promotion of asset owner’s values, efficient use of materials and passive irrigation of landscapes
- **Environmental** – habitat, carbon sequestration, resilience (drought tolerance, adaptability, resistance to disease and insects), shade and microclimate amelioration.

To maximise the value of investments in open space, the public realm should provide social, economic and environmental services, and these are compatible with designs for stormwater treatment. Some stormwater treatment systems have been well integrated into their local context with documented research showing benefits for the asset owner (such as high level of acceptance by the community, and residents voluntarily undertaking maintenance activities (Hoban and Kennedy 2012). Further, developers may be able to reap direct economic benefits if the landscape design associated with stormwater treatment systems meets landscape design standards (Leinster et al., 2010).

However, despite a general awareness of the benefits of integrated design for stormwater treatment systems it is not yet common practice. This may be a consequence of the structure of responsibility and funding within the organisations that are responsible for building and maintaining these assets, whereby only a narrow range of outcomes can be designed for and funded.

**Aim of this paper**
The purpose of this paper is to recommend a design process for stormwater treatment systems that incorporates site design and involves specialists such as landscape architects and other professionals. This approach will help to avoid the pitfalls of a narrow (engineering specifications-led) design brief and bring many other landscape values to the site. Our aspiration is that the personnel responsible for the management of stormwater treatment will be able to use this design process to support an interdisciplinary approach to funding, designing, building, and maintaining such assets.

**Description of the problem**
Technical design guidelines for bioretention systems exist but these are written only for the engineering discipline. The focus of the guidelines is usually water conveyance, ensuring no worsening of flooding, and prescribing specifications that the design should meet (e.g. SEQ guidelines, Melbourne Water Guidelines, NSW bridging guidelines).

However, these guidelines usually stress the importance of landscape design to ensuring the success of the final outcome. For example, DEWHA (2009) states:

“In the overall evaluation process, it cannot be stressed enough of the importance of a multidisciplinary approach. WSUD implementation is not just an engineering process, but one that has to take account of planning, landscape design, architecture, open space management and asset management at the minimum.”

Although landscape integration is evident in many designs across Australia (our region of experience), the construction of bioretention systems that are not well integrated into their surrounding landscapes continues. It is postulated that this occurs for several reasons:

- Technical design guidelines are not rigorously followed throughout the processes of design or evaluation
- Those commissioning the stormwater treatment systems attempt to minimise costs by requesting only the services of engineers for the design work
Those commissioning the stormwater treatment systems are not aware of the benefits of integrated design;

Lack of understanding between disciplines, and inadequate integration of these disciplines into the design process

Those with the responsibility for implementing WSUD have limited influence on the landscapes and do not coordinate design proposals with the authorities responsible for the landscapes.

The ignorance of design guidelines and financial short-cuts cannot be addressed by this paper. However, based on our experience in the landscape design industry, the value of the integration of stormwater treatment systems into landscape is often overlooked. This is partially an artifact of the engineering design process and how it differs to the landscape design process.

This paper proposes to redress this artifact by:

- Describing how different disciplines in WSUD work
- Recommending a more effective design process
- Illustrating communication tools to foster integration of design ideas across several disciplines – including the project manager
- Presenting a case study that demonstrates successful outcomes of bioretention system design.

How different disciplines work

Engineering Design Process

Typically, engineering design requirements lead the design of stormwater treatment devices. For example, the *WSUD Technical Design Guidelines for South East Queensland* (Healthy Waterways 2006) describe the design process for bioretention systems as follows (refer Figure 2):

*Then…..landscape design notes are included. Although these are comprehensive, it gives the impression that the design is mostly ‘done’ prior to the involvement of other specialists. This can result in other design requirements being ignored, not met or only partially met.*

Landscape Design Process

The landscape design process aims to create a bespoke and holistic response to a site, through deep understanding of the processes and influences on that site within the greater landscape. It aims to integrate all requirements into a cohesive design.
that functions from a social, environmental and economic perspective (refer Figure 3). Key to the landscape design process is to maximise the site function, and thus value, within the constraints of any given environment. This requires resolving priorities, integration with the surrounding landuses, and the shape of the asset.

The processes and influences that affect a site for consideration in the design response may be:

- Environmental factors, such as drainage / hydrology, existing vegetation (both natural communities and planted), soils, habitat, aspect and microclimate
- Social factors, such as land use, local community demographics and requirements, and the nature of the proposed development
- Economic factors, such as funds available for development and ongoing maintenance.

The landscape architect may not have the training to address all these functions, therefore they should be able to identify where specialist input may be required and integrate that into the design process.

**Specialist study disciplines**

Scientific or ecological information can be used to guide or support the design process. Examples include:

- Soil properties – use of site soils or dealing with acid sulphate or saline sub-soils
- Habitat creation – site specific response to topography, hydrology (aquatic habitat creation or maintenance) materials or plant selection for a specific ecological function;
- Weed suppression
- Archaeology
- Bushfire considerations
- Hydrology in response to downstream environments / aquifer recharge
- Permaculture and sustainable food production requirements.

The need for this input will vary depending on the specific site issues to which the design must respond, as well as the nature of the proposed development or product.

On its own, scientific method and response to a problem is based on a research – isolated investigation – report output. This may or may not be easily translatable into a spatial design response by the engineer or designer of the product (refer Figure 4).
**Why using separate design processes causes problems for integrated design?**

The three disciplines of engineering, landscape design and specialist environmental sciences respond to different issues, using separate processes, and aim for differing outputs or outcomes. Individually they may be successful when employed to do a certain job, but the holistic success of the product (i.e. a holistically successful landscape with functioning integrated WSUD elements) must be measured by the overall performance of the product from all three disciplines.

Figure 5 shows an example of the failure of integration where all three processes are expected to fit within one specialist design discipline’s goals and method (i.e. an engineering-led process). In this example, the design process is led by the overall aim of flood attenuation and water treatment, and as such, many design parameters are set prior to landscape architects and other specialists becoming involved. Without the opportunity to do a full site analysis and identification of any issues that may require specialist scientific study or information overlay (e.g. habitat creation or specific soil requirements) many site-wide opportunities may be overlooked and ultimately missed out. The resulting design may in fact function well in its original intention of flood attenuation and water quality treatment, but not fit into its greater landscape context or provide social and environmental outcomes.

![Diagram of design processes](image)

**Figure 5**: An example of how working to the goals of one specialist, without common design goals, results in missed opportunities.
An integrated design process
To create functional landscapes that successfully integrate human use, environmental, and engineering design requirements, a holistic design-led process is beneficial. In the development of this integrated design process, the following are important:

- There must be a holistic end product that encompasses each discipline’s individual outcomes within a greater functioning landscape
- Each discipline and the client must understand how or where their knowledge or output sits within this greater scheme, and feed into a unified response which can be presented in a manner that can be understood by all.

A design process commonly used by landscape architects can provide the structure within which the engineering and ecological / specialist input can sit, resulting in a more integrated response to site ‘problems’ or issues (refer Figure 6).

Figure 6: An example of how a design process can incorporate input from various disciplines while still working to a common goal. Any discipline can use this design process to lead the project. The client would be expected to be involved in all of the steps illustrated as manager of the priorities that make up the common goals.

Such a design process was adopted for the recently completed Stormwater Bioretention and Harvesting System within Sydney Park. This pilot project for the City of Sydney was intended to set a benchmark for
future bioretention systems within the council boundary. The overall objective was to make the bioretention system an integrated and valuable landscape asset.

In this project, the team included landscape architects; a WSUD specialist engineer, civil engineers, an ecologist, horticulturist and artist (refer Figure 7). The design process began with a detailed site analysis by the landscape architects and WSUD engineer, which identified opportunities for placement of the bioretention system. Rough calculations defined an estimated size requirement, which formed the base concept design. Landscape considerations were overlaid, which determined conceptually how the system would perform within a social and environmental function. The detailed design phase required the input of the WSUD engineer, an artist (who developed a public art piece to sit within the system), civil engineers, and ecological and horticultural input, which refined the design to enhance performance; reducing maintenance requirements and providing biodiversity through intelligent planting.

**COMMON GOAL**

The integration of human use, environmental, and engineering design requirements to create a design response that provides social, environmental and economic functions

![Diagram of the design process](image)

**Figure 7:** In this example, the design process is led by the landscape architect, and was used to integrate design input from all disciplines.

Landscape integration design provided by the landscape architect included the integration of hard infrastructure and volumetric requirements, form, edge treatments, access, aesthetics, views, habitat, local history, park use, safety and maintenance considerations. Public consultation was also evaluated
for its role in the design process and the benefits of allowing local users to take ownership of the space to facilitate the correct use and protection of the asset.

The design-led approach for Sydney Park defined the design principles used by landscape and engineering disciplines to meet the project requirements and aspirations. These principles helped retain the design intent from concept through to value engineering phases and construction. Designing together provided a democratic drawing board where no single discipline dominated over another, however, drawing co-ordination was critical. Collaboration within the project team resolved an array of issues not related to water treatment. These included: bioretention system layout and form, visual amenity impacts, infrastructure requirement (pits and water dissipation), edge form and construction, ecological requirements, creation of views, incorporation of site history.

**Design Tools and Outputs**

**Design Tools**

Ongoing communication is the key to a successful integrated design process. Communication can be verbal (contact hours throughout the design process). In the Sydney Park example, design team meetings were critical for design development. The development that took place in the meetings ensured that every discipline’s requirements were accommodated in all design responses and associated documentation.

Graphic tools can assist with internal team communication and communication to external stakeholders. An example is seen in the Sydney Park Storm Water Harvesting project, where the landscape architect determined a planting design that provided aesthetic benefits, adding to the human experience of the space. This concept was illustrated to the ecologist / horticulturist, who could overlay a planting palette that performed these aesthetic functions as well as provided for biodiversity and habitat functions, and minimised maintenance requirements (refer to Figure 8 and Figure 9). The graphic tools were also used to explain the design outcomes to the client, who used them to understand how the design goals were being met.

**Design Outputs**

A common documentation package is not necessarily required, provided that each specialist’s documentation package shares common design information and consistent design parameters.
FIGURE 8: A graphic representation of a concept can be used to explain the desired aesthetic outcome to others in the design team as well as summarise a common design vision. This image helped to convey the design intent for views and visual amenity, and provided parameters for horticultural input.

FIGURE 9: Two sections that illustrate the concept shown in Figure 8. These images helped to convey the design intent for views and visual amenity, and provided parameters for horticultural input.
Recommendations

Setting the brief for design work

An integrated project should begin with the setting of common goals that are broader than the specific stormwater treatment function of the asset. For example, consideration could be made of the contemporary design principles for public open space (Healthy Waterways, 2010). These principles include:

- Being meaningful to place and community;
- Being multi-functional and adaptable;
- Being connected to desirable routes and other nodes;
- Providing diversity;
- Encouraging social interaction;
- Promoting health and wellbeing;
- Providing equity and accessibility;
- Embodying environmental sustainability; and
- Providing connectivity within strategic open space network.

Additional principles to be incorporated into the design may include:

- To design for future urban environmental conditions; and
- To incorporate resilience to adverse conditions

The aim of achieving an integrated project benefits from sharing the vision, concept, design, and imagery. Each member of a project team should share the objective of incorporating these common goals into the design through to construction. This collaborative approach often results in innovative outcomes that provide an outcome that no individual discipline could resolve by working in isolation.

Cost expectations for those commissioning the work

The involvement of more than one discipline in design may increase the cost of the design. However, this approach should be able to provide a landscape of much greater value and lower costs in the long-term. To derive an accurate appraisal of the cost and value of the design work, project appraisals should ensure that value is placed on:

- Landscape values, ongoing maintenance implications and community acceptance
- Engineering values such as standards, and conveyance
- Science and ecology values such as ecosystem services and environmental protection
- Incorporating more diverse values may enable access to other funding sources that support the multiplicity of landscape values (i.e. park upgrades, stormwater and bushcare).

Design process

Providing the framework for a multi-disciplinary and collaborative design process is needed to realise the best opportunities of any particular site. The design process does not need to be led by any particular discipline. However, all collaborating disciplines need to understand at the outset the shared design goals and how input from each discipline will be managed.
Document Set

The Document set from each contributing discipline must share common design information and consistent design parameters. Graphic tools can assist in communicating design goals.

Conclusions

For stormwater treatment assets in the public domain to be accepted and valued by the community whom they serve, and the organisations that manage them, they must be designed to incorporate social, economic and environmental values.

Our analysis of the design process commonly employed for bioretention systems identified limitations that constrained the input of collaborating designers such as landscape architects or other specialists, limiting the value of the landscapes that were created.

To overcome this, the design process commonly used by landscape architects can be used to incorporate information from collaborating specialists to achieve an optimal outcome for the site. This process facilitates the timely input of information from collaborating specialists at the site analysis and concept design phase. The design process can be led by any discipline.

The need for a multiplicity of landscape values and diverse specialists to collaborate on design has flow-on consequences that impact the way a project is executed. The expectation of a multiplicity of landscape value has the following effects:

- Funding – the expectations of those commissioning the work influences the funds available. Expectations should be for landscapes that provide stormwater filtration in addition to a multiplicity of additional values, and this may diversify the sources of funding available for these works
- The brief – the expectations of multi-functional landscapes should be articulated in the brief
- Project team – appropriately diverse teams can then be assembled to address the brief
- Design outputs – the design-led process facilitates the timely input of all specialists, and ensures consistency in outputs
- Outcomes – acknowledging the varied values of the landscape assists in determining what resources are required to best manage the asset. The community benefits through the inclusion of public domain assets that incorporate contemporary design principles for public open space. The asset owner benefits from an asset that is well used and maintained, and performs the desired functions.

References


