Rain Gardens - A Local Government Perspective

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Abstract

Local governments across Australia are approving increasing numbers of ‘rain gardens’ (also known as bio-retention systems) within residential streetscapes – either as part of new developments or integrated into their own capital works program. The environmental benefits of rain gardens are rarely questioned, however Council officers are now asking themselves about the longer-term practical implications; how much will they cost and how do we manage these assets effectively?

In my role as Team Leader of the Design Department at the City of Kingston (in Melbourne’s southern suburbs), I’ve been involved in the planning, design, construction and maintenance of around 100 rain gardens over the last 7 years. I’ve generally found that whilst most industry ‘advice’ is based on sound water quality objectives and design principles, few water quality ‘experts’ appear to have a full appreciation of the practical issues faced by Local Government. Examples include community expectations, public safety concerns, asset management strategies, parking needs, maintenance practices and budgetary constraints.

To further advance our understanding, Kingston Council recently teamed up with Melbourne Water and ‘Land & Water Construction’ to review the performance of 22 rain garden projects across Melbourne. The main objective of the review was to investigate the quality of vegetation and filter media in order to identify the design, construction and maintenance factors that contribute to (or impede) successful outcomes. Based on my experience and the results of this study, I would recommend the following initiatives to enhance the likelihood of implementing sustainable rain garden projects:

- Encourage all Council departments responsible for planning, design, construction and maintenance activities to be actively involved from the beginning of each project.
- Each Council to develop their own ‘design standards’ to address the issues relevant to their local area in a practical manner.
- Specify the soil filter media very clearly and test its hydraulic conductivity during construction. The review identified a high percentage of ‘failures’ are due to the use of filter media containing topsoil with very low infiltration rates.
- Ensure that all of your in-house departments clearly understand their roles and responsibilities. Treat your rain gardens as another asset that needs to be recorded and managed effectively.
- Ensure that your Council understands and allocates appropriate funding for ongoing monitoring and maintenance activities.
- Develop ‘information brochures’ to assist with ongoing community education and awareness.

I would encourage all Councils to get involved, experiment and develop systems and standards that are appropriate for your Council operations and your local needs. The good news is that rain gardens can be very effective and should be encouraged. The bad news is that they also require a lot of time and effort to ensure successful long-term outcomes.

1. Introduction

Local governments across Australia are approving increasing numbers of ‘rain gardens’ (also known as bio-retention systems) within residential streetscapes – either as part of new developments or integrated into their own capital works program.

I’ve generally found that whilst most industry ‘advice’ is based on sound water quality objectives and design principles, few water quality ‘experts’ appear to have a full appreciation of the practical issues faced by Local Government. Examples include community expectations, public safety concerns, asset management strategies, parking needs, maintenance practices and budgetary constraints.
This report summarises my findings based on:

- Lessons learned from the design, construction and maintenance of rain gardens within the City of Kingston;
- An independent inspection and testing of rain gardens by Land and Water Construction during 2006 entitled ‘Review of Street Scale WSUD in Melbourne’ and;
- My experience as a Council design engineer including a Municipal Engineering Foundation funded study tour of ‘Water Sensitive Urban Design’ projects in USA during October 2005.

2. Background
In my role as Team Leader of the Design Department at the City of Kingston (in Melbourne’s southern suburbs) I’ve been involved in the planning, design, construction and maintenance of around 100 rain gardens over the last 7 years. Kingston’s integration of rain gardens into streetscape designs are often showcased nationally and are the subject of numerous site inspections and guided tours.

To further advance our understanding, Kingston Council recently teamed up with Melbourne Water and ‘Land & Water Construction’ to review the performance of 22 rain garden projects across Melbourne. The main objective of this review was to investigate the quality of vegetation and filter media in order to identify the factors that contribute to (or impede) successful outcomes.

![Figure 1 & 2. Rain Gardens in Stawell St, Mentone](image)

3. What is a Rain Garden?
‘Rain Garden’ is the term commonly used to describe a vegetated area that removes pollutants from storm water runoff. Rain water flows into a Garden bed and filters through a layer of engineered soil. The clean water is collected by slotted pipes and directed back into Council’s drainage system.

The surface traps litter, leaves and sediment whilst the soil (in combination with the plants root system) helps to filter and breakdown microscopic pollutants such as nutrients, heavy metals and hydrocarbons.

Rain gardens are designed to filter pollutants from frequent low intensity showers (catering for 95% of all storm water runoff). The traditional drainage system (pits and pipes) are still required to cater for larger infrequent storm events to prevent flooding.
4. History of Rain Gardens in Melbourne

Interest in ‘Water Sensitive Urban Design’ started to gain momentum during the 1990’s with Melbourne Water taking a lead role with publications such as Urban Stormwater: Best Practice Environmental Management Guidelines providing a framework for the development of Stormwater Management Plans by local councils. More recently, the release of Melbourne 2030 (Department of Infrastructure, 2002) clearly articulates the role of sustainable stormwater management strategies such as rain gardens.

The catalyst for the City of Kingston’s involvement with Rain gardens commenced as a result of funding from the Victorian Stormwater Action Program in 1999/2000 to construct a trial project. Following detailed consultation with world-renowned expert Tony Wong (Director of Ecological Engineering), Kingston constructed our first Rain garden in Riviera St during 2001.

Over the last six years, Council’s engineers have consulted with residents, investigated alternative designs and constructed a broad range of Rain garden projects as summarised in the following table:

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Suburb</th>
<th>Type</th>
<th>Constructed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Riviera St</td>
<td>Mentone</td>
<td>17 Rain gardens in wide nature strip</td>
<td>2001</td>
</tr>
<tr>
<td>2</td>
<td>Albenca St</td>
<td>Mentone</td>
<td>4 Rain gardens in wide nature strip</td>
<td>2001</td>
</tr>
<tr>
<td>3</td>
<td>Railway Walk Carpark</td>
<td>Cheltenham</td>
<td>3 Rain gardens in traffic islands</td>
<td>2001</td>
</tr>
<tr>
<td>4</td>
<td>Fowler St</td>
<td>Bonbeach</td>
<td>13 Rain gardens in narrow nature strip</td>
<td>2002</td>
</tr>
<tr>
<td>5</td>
<td>Stawell St</td>
<td>Mentone</td>
<td>10 Rain gardens</td>
<td>2003</td>
</tr>
<tr>
<td>#</td>
<td>Location</td>
<td>Borough</td>
<td>Description</td>
<td>Year</td>
</tr>
<tr>
<td>---</td>
<td>---------------------</td>
<td>-----------</td>
<td>------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>6</td>
<td>Wells Rd- Stage 2</td>
<td>Patterson Lakes</td>
<td>5 Rain gardens along arterial road</td>
<td>2004</td>
</tr>
<tr>
<td>7</td>
<td>Brisbane Tce</td>
<td>Parkdale</td>
<td>6 Rain gardens in road narrowings</td>
<td>2004</td>
</tr>
<tr>
<td>8</td>
<td>Peter Scullin Carpark</td>
<td>Mordialloc</td>
<td>8 Rain gardens in traffic islands</td>
<td>2004</td>
</tr>
<tr>
<td>9</td>
<td>Alleyene Ave</td>
<td>Chelsea</td>
<td>9 Rain gardens along curvilinear road</td>
<td>2003</td>
</tr>
<tr>
<td>10</td>
<td>Volti St</td>
<td>Cheltenham</td>
<td>1 Rain garden in landscaped area</td>
<td>2005</td>
</tr>
<tr>
<td>11</td>
<td>Third St</td>
<td>Clayton South</td>
<td>8 Rain gardens in road narrowings</td>
<td>2005</td>
</tr>
<tr>
<td>12</td>
<td>Bradshaw St</td>
<td>Mordialloc</td>
<td>3 Rain gardens in nature strip</td>
<td>2005</td>
</tr>
<tr>
<td>13</td>
<td>The Esplanade</td>
<td>Edithvale</td>
<td>1 Large Rain garden at foreshore outlet</td>
<td>2006</td>
</tr>
<tr>
<td>14</td>
<td>Bear St</td>
<td>Mordialloc</td>
<td>5 Rain gardens along curvilinear road</td>
<td>2006</td>
</tr>
<tr>
<td>15</td>
<td>Sherwood Ave</td>
<td>Chelsea</td>
<td>8 Rain gardens along curvilinear road</td>
<td>2007</td>
</tr>
<tr>
<td>16</td>
<td>Warren Rd</td>
<td>Parkdale</td>
<td>6 grassed bio-retention swales in kerb extensions</td>
<td>2007</td>
</tr>
</tbody>
</table>

5. **Financial Analysis**

The following costings are based on the Rain gardens constructed in Stawell St and are considered representative of Kingston’s current projects.

**Capital Investment**

Each rain garden costs (on average) around $5,000 to $7,000 to implement. This figure allows for the cost of investigation, public consultation, detail design, construction and planting. This equates to a cost (on average) of between $25,000 to $35,000 for every 100m of local road.

**Rehabilitation Costs**

Over time, the soil within each Rain garden will begin to ‘clog up’ and become less effective. At some point in time, each Rain garden will need to be excavated and replaced (it is anticipated that around 40% of the original infrastructure will remain).

The ‘life’ of each rain garden is dependent on numerous variables and is therefore difficult to quantify (e.g the volume of pollutants and sediments at each site, the quality of soil and the performance of plants which help to break down pollutants).

The following ‘Whole of Life’ model is based on the following scenarios:

(i) Rain gardens rehabilitated every 20 years (i.e in years 20, 40 and 60) and;
(ii) Rain gardens rehabilitated every 40 years (i.e in year 40 only)

**Annual Recurring Costs**
Maintenance activities involve a general inspection, weeding and litter removal on a regular cycle. Maintenance also includes pruning plants, replacing dead plants and topping up mulch each year during the annual planting season.

The total cost of maintaining Rain gardens is dependent on a combination of community expectations and (eventually, following an ongoing education program) the level of community involvement with basic weeding and litter collection.

(i) The cost of providing a high level of maintenance (3 week cycle) with no public assistance would cost around $1,900 per 100m of local road per annum.

(ii) The cost of providing a medium level of maintenance (13 week cycle) in combination with public assistance would cost around $1,000 per 100m of local road per annum.

**Whole of Life Costs**

The opportunity to construct Rain gardens is typically evaluated when the road is due to be reconstructed (i.e Rain gardens require the kerb and channel and drainage system to be significantly reconfigured). It is therefore considered reasonable to calculate the whole of life cost of a Rain garden over the life span of the road asset - specifically the life span of the concrete kerb, which for the purposes of this model is assumed to be 80 years.

The ‘whole of life’ cost consists of the following components (per 100m of local road):

- **(i)** Capital Investment: Once off initial cost of $25,000 to $35,000
- **(ii)** Rehabilitation Costs: Ranges from $18,000 to $54,000 over 80 years
- **(iii)** Annual Maintenance: Ranges from $1,000 p.a to $1,900 p.a over 80 years

Based on the above figures, the total ‘whole of life’ cost is summarized in the following table:

<table>
<thead>
<tr>
<th>Level of Maintenance Provided</th>
<th>Whole of Life Cost per 100m of road over 80 years</th>
<th>Total Annualised Cost per 100m of road</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Level</td>
<td>$195,000 to $240,000</td>
<td>$2,440 to $3,000 p.a</td>
</tr>
<tr>
<td>Medium Level plus public assistance *</td>
<td>$125,000 to $170,000</td>
<td>$1,560 to $2,120 p.a</td>
</tr>
</tbody>
</table>

* A medium level of maintenance assumes that residents will ultimately assist with litter collection and basic weeding which will allow Council’s regular maintenance to drop from a 3 week inspection cycle to a 13 week cycle after the initial establishment period. This option would require a prolonged public education campaign similar to the ‘adopted a street tree’ campaign.

**Cost to remove Pollutants**

Modeling undertaken by Melbourne Water (based on the Stawell St project) indicate the following volumes of pollutants generated from a typical residential area. Using this data we can calculate the cost to remove 1 kg of each type of key pollutant per year based on Kingston’s whole of life costings for Rain gardens:

6. **Key Learnings**

There has been substantial worldwide research that highlights the merits of constructing Rain gardens as the preferred method of treating storm water runoff. The important question is how to incorporate Rain gardens into road works projects in a safe, affordable and long term sustainable manner.
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total Suspended Solids</th>
<th>Total Phosphorus</th>
<th>Total Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kg per year of pollutants generated per 100m of road</td>
<td>660 kg / yr</td>
<td>1.4 kg / yr</td>
<td>10.6 kg yr</td>
</tr>
<tr>
<td>% of pollutants removed by Rain gardens</td>
<td>93 %</td>
<td>76 %</td>
<td>49 %</td>
</tr>
<tr>
<td>Kg per year of pollutants removed per 100m of road</td>
<td>614 kg / yr</td>
<td>1.1 kg / yr</td>
<td>5.2 kg yr</td>
</tr>
<tr>
<td>Cost to remove 1 kg per year based on a high level of maintenance</td>
<td>$4.00 to $4.90</td>
<td>$2,260 to $2,780</td>
<td>$470 to $580</td>
</tr>
<tr>
<td>Cost to remove 1 kg per year based on a medium level of maintenance plus public assistance *</td>
<td>$2.50 to $3.50</td>
<td>$1,450 to $1,950</td>
<td>$300 to $410</td>
</tr>
</tbody>
</table>

Based on the work undertaken within the City of Kingston, I would strongly recommend that municipal council’s (who are planning to undertake similar projects), take into consideration the following recommendations:

**Recommended Projects .....(the ones that work !)**

The following types of projects are more likely to incur lower maintenance costs and endure less public criticism. Generally all of these types of projects (space permitting) can be designed to incorporate rain gardens where practical:

- landscaping buffers and islands within car parks.
- traffic treatments including slow points and kerb outstands.
- parks and retarding basins.

These assets usually include landscaped areas that can readily be modified and require little or no public support or additional maintenance. From the public perspective they represent only a subtle change from the traditional approach to landscaping.

The construction of rain gardens within residential nature strips are achievable, however they typically pose additional challenges such as:

- insufficient nature strip width to achieve gentle batters (particular where adjacent footpaths are more than 100mm above existing to of kerb levels).
- achieving clearances to underground services and tree roots.
- choosing attractive and appropriate vegetation that can survive the harsh environment.
- comprehensive public consultations before, during and after construction.

**Co-ordinating Council Departments ..... (is everyone on board?)**

Successful projects require commitment from a range of Council departments including those responsible for planning, design, construction and maintenance. Most Councils are likely to have experienced maintenance staff who may question the practicality of implementing rain gardens. It is essential that these staff attend training sessions, be involved in the design and implementation phases and encouraged to develop informed views. Once experienced Council staff become informed, they can then debate the merits of individual projects based on facts using real examples. The design, construction and monitoring of trial projects is an excellent strategy for building local knowledge.
Involving a broad cross section of staff will also assist with developing an integrated approach to stormwater management and funding decisions that appropriately address flood mitigation objectives, pipe maintenance, water conservation as well as stormwater quality and reuse. Too often these initiatives are considered in isolation and opportunities forgone.

*Asset Management ..... (who’s asset is it ?)*
Ensure that all Council departments clearly understand their roles and responsibilities including regular maintenance programs, performance inspections, GIS mapping and budgeting. Rain gardens need to be treated as another important infrastructure asset that needs to be recorded, assessed and managed effectively.

*Design Standards ..... (how to minimise future complaints !)*
Each Council needs to develop their own ‘design standards’ to address the issues relevant to their local area in a practical manner (including the minimisation of public liability risks). Good designs achieve water quality objectives, but not at the expense of competing objectives such as pedestrian safety, garbage collection and maintenance considerations. The following is a sample of design standards currently used by the City of Kingston:

- The side batters of a rain gardens shall not be steeper than:
  - 1 in 8 for grassed surfaces that require mowing;
  - 1 in 5 for planted surfaces and;
  - 150mm (maximum) terraced steps in lieu of retaining walls.
- Where rain gardens abut footpaths, pram crossings and vehicle crossings, the design shall appropriately cater for pedestrian safety. This should desirably be achieved by providing a 600mm (minimum) wide ‘flat’ strip beside the pedestrian path.
- Where vehicles can legally park beside a rain garden, provision shall be made for passengers to alight from the vehicle onto a stable surface. This should desirably be achieved by providing a 600mm (minimum) wide stable surface (informal path) parallel to the kerb line where appropriate.

*Filter Media ..... (the soil has to be right !)*
The recent Land & Water Construction review of 22 rain garden projects (entitled ‘Review of Street Scale WSUD in Melbourne’) identified a high percentage of ‘failures’ are due to the use of filter media containing ‘fines’ with very low infiltration rates. Of the locations tested, more than 50% had hydraulic conductivity results that were lower than 40mm/hr (compared to an optimum range of 100 to 200mm/hr). As a result of this review, the majority of rain gardens constructed within the City of Kingston will be reconstructed during 2007/08.

It is therefore very important that the soil filter media be:
- very clearly specified on the design plans and within tender documents;
- tested on-site during construction to determine its hydraulic conductivity and particle size distribution and;
- that the filter media have appropriate additives ‘mixed in’ to promote healthy plant growth.

To achieve optimum pollutant removal effectiveness, filter media is often specified with hydraulic conductivity in the range of 100 to 200 mm/hr. From a practical perspective, I would recommend a range of 200 to 300 mm/hr to ‘build in’ a factor of safety and reduce the risk of premature clogging.

*Funding ..... (show me the money !)*
It is crucial that Councils allocate appropriate funding for ongoing monitoring and maintenance activities. Whilst our maintenance costs are typically around $17 per sqm per annum, it is important to prepare future budgets based on each individual Council’s own projects, resources and community expectations.

Council staff need to be fully aware of the long-term asset management demands of each type of project. If a Council cannot commit to a project’s long term financial and resource demands, then it may be more cost effective (from a ‘big picture’ water quality improvement prospective) to adopt lower risk alternatives that are more affordable and achievable. Typically most Councils will need to increase their maintenance budgets and develop monitoring procedures to enable them to effectively asset manage water quality improvement projects (including new subdivisions and capital works projects).

Further Information…..
The report by Land and Water Construction during 2006 entitled ‘Review of Street Scale WSUD in Melbourne’ provides interesting reading and discusses a number of associated topics including:

- plant and mulch selection;
- suggested maintenance regimes and;
- a detailed specification on filter media

7. Conclusions
Based on my experience and the results of this study, I would recommend the following initiatives to enhance the likelihood of implementing sustainable rain garden projects:

- Encourage all Council departments responsible for planning, design, construction and maintenance activities are actively involved from the beginning of each project.
- Councils to develop their own ‘design standards’ to address the issues relevant to their local area in a practical manner (including the minimisation of public liability risks).
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