University of Southern Queensland

Faculty of Engineering and Surveying

Feasibility study: Into the design, effectiveness & limitations of installing raingardens within an inner urban environment.

A dissertation submission by
Mr Paul Michael Vincec

Courses ENG4111 and ENG4112 Research Project

In fulfillment of the requirements of
Bachelor of Engineering – Civil

November 2008

Certification

I certify that the ideas, designs and experimental work, results, analysis and conclusions set out in the dissertation are entirely my own efforts, except where otherwise indicated and acknowledged

I further certify that the works is original and has not been previously submitted for assessment in any other course or institution, expect where specifically stated.

Paul Michael Vincec

Student Number: 00050042248

______________________________ Signature

______________________________ Date

ACKNOWLEDGEMENTS

This Research was carried out under the principal of:

1. Mark Sturge, Team Leader – Design, City of Stonnington
2. Mark Porter – USQ

Appreciation is also due to:

1. Sarah Buckley, Environmental Officer – City of Stonnington
2. John Gowan, Asset Engineer - City of Stonnington
3. Megan Jones , Landscape Coordinator – City of Stonnington
4. Steve Watt, Arborist – City of Stonnington

University of Southern Queensland

Faculty of Engineering and Surveying

ENG4111 & ENG4112 Research Project

Limitations of Use

The Council of the University of Southern Queensland, its Faculty of Engineering and Surveying, and the staff of the University of Southern Queensland, does not accept any responsibility for the truth, accuracy or completeness of material contained within or associated with this dissertation.

Persons using all or part of this material do so at there own risk, and not at the risk of the Council of the University of Southern Queensland, it's Faculty of Engineering and Surveying or the staff f the University of Southern Queensland.

This dissertation reports an education exercise and has no purpose or validity beyond this exercise. The sole purpose of the course pair entitled "research Project" is to contribute to the overall education within the student's chosen degree program. This document, the associated hardware, software, drawings, and other material set out in the associated appendices should not be used for any other purpose: if they are so used, it is entirely at the risk of the user.

Prof Frank Bullen
Dean
Faculty of Engineering and Surveying

Aim

This study focuses on the inner urban area within the City of Stonnington, a Council approx 5 km South East from Melbourne CBD, the aim of this study is to not only to investigate how bioretention systems (raingardens) can be implemented into the densely populated areas within Council, however the study also to give guidance to Council Engineers in forward thinking in how to design and implement bioretention systems within inner urban areas of Council, especially within the suburbs of South Yarra, Prahran and Windsor.

This study is to give an insight in what needs to be taken into consideration during the design stages of any civil construction project to ensure that any bioretention systems to be introduced can perform just as effectively as any other bioretention system that would be implemented in outer suburban areas and ensure that pollutant reduction targets are met without compromising on the performance the effectiveness of stormwater treatment due to current constraints within the local environment.

To achieve reduction targets and ensure the effectiveness of pollutant reduction within inner urban areas, this study, is to outline current design principals used for bioretention systems and identify constraints within inner urban areas and how can these constraints be overcome by outlining a set of designs, recommendations and a checklist that can be utalised by Council Engineers to assist in successfully implementing bioretention systems within inner urban areas of Stonnington.

Even though this study will focus on inner urban areas the general designs and concepts explained in this study can be extended to other urbanised areas of Council.

Study objectives

The main objective of this study is how bioretention systems (Raingardens) can be successfully designed and implemented within inner urban areas of Stonnington, ensuring that the overall design of the raingarden performs its main function of effectively capturing, retaining and filtrating as much stormwater as possible and reducing the amount of untreated runoff flowing into existing underground stormwater systems within an area where there is limited available space and other constraint factors involved as part of inner urban sprawls.

To achieve this main objective the following areas are investigated in this study to assist in the design of raingardens into inner urban areas.

Identify why there is a push for bioretention systems to be installed not only within Stonnington but with other inner urban councils around Melbourne, who is pushing such devices and the problem faced when trying to implement raingardens within densely developed areas within Stonnington.

Investigate how other implemented raingarden designs performed identify what's been learnt and the considerations needed by Council Engineers during conceptual stage of any civil project if bioretention systems are to be introduced, reducing the likelihood of any construction or long term performance problems during the life cycle of the asset.

Investigate the current design principals, requirements, recommendations of existing installation of raingardens and how do these reflect on the effectiveness of treating incoming stormwater flows and how can these design principals be mirrored to reflected the most efficient design for inner urban areas of Stonnington.

Create a set of preliminary raingarden designs, based upon MUSIC modeling application and current design principals. The overall design is to entail all components of the raingarden and can be used to assist in early development of the ideal design, location and to determine the effectiveness of a raingarden, ensuring that any proposed design can be retrofitted within inner urban areas.

Problem this study will address.

This study is to investigate how the City of Stonnington, bioretention systems (raingardens) within inner urban, densely populated areas of Council, without creating additional impacts already faced on a restricted yet sprawling environment.

The study will also address, the uncertainties raised by Council Engineers with the design of raingardens to ensure that there are reduced effects on the construction and long term performance of the raingarden when once completed.

The final set of recommendations in this study are not restricted to inner urban areas of Stonnington and the same designs and findings can be implemented into other low to medium developed areas where the impervious percentage is lower than 60%, *it is assumed* that suburban areas were there is no restricted room the implementation of raingarden designs presented in this study would exceed the minimum reduction target set by Melbourne Water.

Need for this study.

This study has been developed to assist Council Engineers to gain a better understanding in the design of raingardens without resorting to the need of external consultants; this study also gives the opportunity for staff *to think outside the square* when it comes to stormwater management techniques especially when implementing raingardens within the inner urban areas of Council.

Even though this study refers to inner urban areas, any effective design that can be achieved to treat high impervious areas with minimal space, the same design can be implemented in any area of Council where the impervious runoff percentage is lower than which is identified in this study, resulting in the designed raingarden meeting all pollutant reduction targets.

Word definition

To minimise confusion the following words will undertake the following meanings through out this study.

"Council" This is referring to the City of Stonnington and no other Council, if reference is made to another Council then the full name of that council will be used in this report.

"Stonnington" This is referring to an abbreviation to the word *City of Stonnington* and will mean the same thing in this report.

"Bioretention System" This is referring to the concept of a Raingarden and no other type of Bioretention system or Water Sensitive Urban Design device.

"Raingarden" This term will replace the word *Tree Plots or any other small treatment devices* that performs the same function of detaining and filtrating of stormwater.

Raingarden implementation

Sizing

The first step with preparing the design for raingardens is to verify the size of the treatment. This is undertaken by using software designed for measuring pollutant reduction, one such application is MUSIC (Modeling for Urban Stormwater Improvement Conceptualisation.)

Limitations within inner urban areas, due to reduced road reserve, narrow carriageways and high volume of vehicle and pedestrian traffic and underground services can have impact on meeting overall targets; smart planning during the conceptual design stage of a proposed road project can overcome this.

The objective of the size is to ensure that pollutant reduction targets are met.

Table XX: Melbourne Water pollutant removal target by percentage.

Pollutant	Reduction target (%)
Total Suspended solids (TSS)	80%
Total Phosphorus (TP)	45%
Total Nitrogen (TN)	45%
Litter	80%

(Ref)

Pretreatment

Ideally with the introduction of any Raingarden (Bioretention system), it is recommended that pretreatment measures are put in place to ensure the long term sustainability and functionality of the raingarden.

Pretreatment systems such as swales and grass buffer strips assist in the primary removal of course sediment and litter that is transported with moving stormwater before it enters into the Bioretention system.

Pretreatment also assists in dissipating sheet flow, reduce velocity of incoming stormwater and greatly assist in retaining containments, gross pollutants and litter, these systems require long length of space to ensure that flows into the Bioretention system are suited and prolong the life and effectiveness of the device.

Within inner urban environments, this space is limited and such primary treatment may not be the most suited option in heavy trafficable areas.

To overcome this, the use of dissipation ponds can be used which can assist in slowing down upstream velocities and removed coarse sediment of 1mm or greater, minamising large amounts of silt entering into the raingarden and smothering vegetation with silt.

Dissipation ponds

As mentioned, they are designed to slow down and break up flow paths of incoming stormwater, this is done by utilising a random arrangement of stones, with varying sizes just like a natural creek bed, which allows low volumes of stormwater to dissipate into different directions around main stones, (commonly called key stones) and over smaller stones that are embedded into the ground, this breaks up the concentrated flow path resulting in reducing the velocity of stormwater.

Ideal stone sizes and areas for dissipation rocks are shown in the table and figure below.

(Ref)

The use of Dissipation as a primary treatment option is ideal for areas within inner urban environments where space is limited as area required is less than of other primary treatments such as swales.

Dissipation system is commonly located in areas where channel would previously be and be located close to road base. The use of geo-textile under stones is not recommended especially within built up areas or where soil conditions are not ideal (i.e. Sandy Clays) as seepage could undermine the road base resulting in other maintenance issues such as pot hole repair.

(Dissipation design drawing)

The use of week concrete slurry to position rocks will ensure that the stones remain and are not subjected to disturbance or to vandalism as they can be picked up and removed and seepage into the surrounding soils is minimal.

Table XX: flow velocities that should be entering into a Bioretention system.

Annual Rainfall Interval	Flow velocity (m/s)
2 years to 10 years	0.5 m/s
50 years to 100 years	1.0 m/s

(Ref)

Positioning raingardens

Roads
Within in inner urban environments one of the main constraints is the lack of road reserve, many roads within inner urbanised area of Stonnington are between 6 to 6.6m from invert to invert, this is sufficient for a single lane traffic to pass a parked vehicle safely at low speeds, many of these streets have been converted to one way streets, restricting parking on one side of the road.

Identifying potential spots where raingardens can be installed can be undertaken during the early stages of design, within inner urban areas, ideal location to implement raingardens are around no stopping zones of intersections, converting existing planter boxes, traffic treatment devices and utilise areas deemed to considered as substandard parking bays.

Location of any raingarden needs to ensure that it does not become an obstruction to passing traffic and that sufficient lane widths are maintained.

Trafficable lane widths

Absolute minimum	2700mm
Desired minimum	3000mm
Preferred	3500mm

(Ref)

Intersections
Within an intersection, raingardens can be considered proving that there is no impact to traffic movements in and around the intersection.

Within narrow intersections, turning movements needs to be considered, by implementing something that protrudes into the intersection, this may restrict maneuvering or lager service vehicles i.e. garbage truck or ambulance.

Review no stopping zones to ensure that these spots are not used to allow traffic to pass one another especially within narrow roads where the lane width is insufficient for two vehicles to pass side by side.

Parking
Many inner urban areas have issues with the restriction of parking on the street, whilst some inner suburban properties may for off street parking facilities; many do not, with the common type of parking within the street being parallel parking.

Where raingardens are going to be considered the positioning of these devices needs to ensure that there is no net loss of parking spaces nor a property disadvantaged as parking has been removed, ideally raingardens needs to be installed either between properties or within in areas where there is insufficient room for a vehicle to park safely, generally speaking any parking bay less than 5400mm.

Parking requirements taken into consideration are as follows:

(Diagram)

Bicycles

Consideration for bicycles will need to be taken into consideration if the desired road is a common bicycle route or that the number of vehicles is exceeding 3000 cars per day (c.d) **(Ref)** where designated bicycle lanes should be installed.

Streets with low speed limits and low traffic volumes will not warrant a bicycle lane being installed, introduction of any raingarden should be confined within the area of the parking bay and the use of reflectors should be used as a buffer and a deterrent for bicycles riding through or over a grated raingarden.

Road sight distance:

Narrow and bind intersections are often found in well developed and inner urban areas, many early established properties are built right on property line and right at the intersection, resulting in a dramatic reduction of sight distance.

Careful design and correct landscaping techniques needs to be taken into account when placing raingardens within an intersection, it is important that there is no impact to the sight distance for terminating vehicles to ensure safe access into the continuing street.

Sight distance requirements are shown below.

(Diagram)

Ideally, any vegetation to be considered at an intersection needs to be either low cover foliage that spreads along the surface of the raingarden or grass/plantation that will not exceed driver's eye height of 1100mm, trees are not recommended in areas where sight distance is already impacted due to other contributing factors, i.e. dense development, vertical curves, hills.

Pedestrians

Pedestrian access is also limited within inner urban areas, preferred footpath width within Stonnington is 1500mm, which complies with the minimum width for Australian Standards AS1428.2 1992 to allow for people with disabilities and wheel chairs to pass safely-

One main problem with raingardens that have abutted or are with the vicinity of pedestrian movements is the vertical drops. The drop is required to ensure that there is sufficient ponding depth within the system, within many inner urban areas, where there are restrictive and large pedestrian movements, there needs to be some delineation between pedestrians walking and potential hazard to passer by.

The use of buffer strip between pedestrian footpath and raingarden, gives the sense of safety to pedestrians, if ever there was an obstacle blocking the footpath near a raingarden. A Buffer strip allows a define edge to be determined between pedestrian movement and drop off into the ponding depth ideally being 300mm wide **(Ref)** this can only be adopted if the total footpath width from is greater than 1500mm, however if a footpath is 1500mmwide, a buffer zone of 300mm can still be implement proving that the resulting footpath behind the raingarden is no less than greater that 1200mm and only for a short distance, in accordance to the Australian Standards.

A defined planter strip can be used to complement surround plants within the raingarden, however any shrubbery planted within the buffer strip will need to comply with heights to ensure that they do not become a an issue with sight distance and that they are visible to passing pedestrians and do not become a trip hazard.

1: Slopping batter
2: Hard vertical edges and fences
3: Grates

1: slopping batter
This is considered as the most gentile approach when transitioning between surface level and mulch layer within the raingarden, slopping batters require larges spaces to allow for a safe transition where a batter slope of 1:4 (1 Vertical to 4 horizontal) **(REF).** Within inner urban areas this is not considered feasible use of space for a stormwater treatment measure. Studies have found that batters greater than 1:4 can be considered as a tripping hazard and become difficult to maintain. **(REF).**

2: Hard vertical edges & fences
Hard vertical edges can be used to delineate between the footpath and ponding areas of a raingarden, hard vertical edges can be used where the area for a sloping batter is restricted and that a shear drop is required at the back of the buffer strip.

Hard vertical edges are ideal where a buffer strip of 300mm can not be achieved, the use of a visible hard edge can comprise of bluestone, concrete beams or even timber retaining wall providing that the edge will not constitute a tripping or a restrictive hazard with pedestrian movements within the vicinity of the raingarden. **(REF)**

Fences can be considered where there is insufficient room to provide a buffer strip, however studies have found that they do become prone to vandalism **(REF)** and become an additional maintenance cost for Council.

3 Grates:
The provision of grates assist in two ways, one it acts as a litter trap, capturing larger items of litter washed down by stormwater preventing it entering and potentially clogging up the raingarden and allows for vegetation to protrude upwards and out of the grate, secondly grates can effectively hide a raingarden within restricted areas without having impact on pedestrian or through traffic.

When implementing grates standards do apply, the grate needs to ensure it complies with Australian Standard requirements for positioning grates within a carriageway and that it is a suitable heavy duty grate used, manufactures will advise of such a grate proving they have been advised the purpose of use.

The selection of the grate needs to ensure that the grate does not become a hazard for both cyclists and pedestrians who transverse over the grate as is plush within the road pavement.

Drainage:

Where surrounding in-situ soils prohibit the filtration of treated stormwater water though to ground water beneath, ie clays, the use of an under drain is required to remove treated water back into the Councils stormwater drainage system.

The pipe itself can comprise of either a flexible Aggie drain or perforated PVC pipe with the outlet being located at the far lowest point of the raingarden, a minimum grade of 0.5% is recommended though the system. **(REF)**

Recommend under drain pipe sizes:

Area for raingarden	Pipe size
Up to 10m^2	100 diam. pipe
10 to 20m^2	150 diam. pipe

(REF)

Spaces of 1500mm centre to centre should be considered; this minimises the horizontal distance for treated stormwater to travel and does not hinder the drainage of filter media **(REF)**

I.O inspection openings are required to assist maintenance crews when flushing the system, angled (slightly) pipes **(REF)** or otherwise vertical system can be adopted should comprise of a solid PVC pipe with no perforated holes, preventing any short circuiting of the raingarden when stormwater is being treated through the filter layer, **(REF)** the top of the I.O should protrude above the mulch layer with a sealed cap.

A slightly angled IO connection will allow easier access by maintenance and can allow for water-jetting to be used to flush out the system easy. **(REF)**

If a fine filter media is being and that the particle size is less than 1.5mm (perforated slot size), then design should consider a transitional layer to be introduced, even if sand is used as a drainage layer. **(REF)**

The type of perforated pipe should not restrict in the particle size of filter media that can be used resulting in a system that may be considered sub-standard to meeting reduction targets, providing that there is sufficient filter media depth for effective filtration to occur, the use of a transitional layer is ideal.

Geo-liner

Many aggie drains works comprise of placing a sock over the pipe to prevent the loss of sediment into the underground drain. Studies have found that by placing a sock over the aggie pipe it is more prone for fines to clog the sock resulting in a decline in effectiveness of the system, **(REF)** hence placing a sock/geo-liner over the drainage pipe is not recommended.

If there is a likelihood that fines are going to easily enter into the aggie pipe after the filtration of stormwater through the filter, then the use of a transitional layer of coarse sand should be considered.

Infiltration Capacity

To ensure the long term treatment effectiveness of a raingarden it is important that adequate infiltration capacity is maintained **(Ref)** to achieve this, three design elements need to be met, they are.

1. Extended detention depth (Ponding depth)
2. Filter surface area
3. Filter media conductivity.

1. Extended filtration depth (Ponding depth)

2. Filter surface area.

3. Filter media conductivity.

In-situ soils

The objective of any raingarden system is retain, filtrate and improve the quality of incoming stormwater, however if surrounding soils are x10 magnitude greater than the conductivity of the filter media then there is a likelihood that the system will short circuit as water will filtrate directly into the surrounding soils rather than filtrate downwards through the filter media. **(Ref)**

Consideration of impervious liner should be considered if the surrounding soils are x10 magnitude, however if areas are directly near road sub grade or any type of structure which is preventing water from being absorbed, ideally a impermeable liner should be used.

The following classifications of soils identified throughout Stonnington are:

(Soil data here) (Ref)

(Refer to appendix C for further map and soil details)

If surrounding soils are less than x10 magnitude that the likelihood of an impermeable liner is not required **(Ref)**

The following Australian standard XX outlines general soil condtions/hydro-conductivity.

(Aust. Std. data here) (Ref)

Impermeable liners:

Types of impermeable liners can either be permeate or flexible, depending on the surround environment, if the area is quite built up and that the soil conditions are known and are not ideal for infiltration, hence a permeate reinforced concrete wall would be ideal, however flexible liners LPDE can be used.

References:

AUSTROADS, 1999, *Guide to Traffic Engineering Practice, Part 7 - Parking,* AUSTROADS Publication, Sydney, Australia.

AUSTROADS, 1999, *Guide to Traffic Engineering Practice, Part 11 - Pedestrians,* AUSTROADS Publication, Sydney, Australia.

AUSTROADS, 1999, *Guide to Traffic Engineering Practice, Part 14 - Bicycles,* AUSTROADS Publication, Sydney, Australia.

Breen, Denman, Leister & May, 2004, *Street trees as Stormwater treatment measures*, University of Melbourne, Burnley, Victoria.

Breen, Lloyd, Wong, 2000, *Water Sensitive Road Design - Design options for improving Stormwater of Road Runoff,* CRC for Catchment Hydrology, Monash University, Melbourne.

Brisbane City Council, 2005, *Draft Water Sensitive Urban Design Engineering Guidelines, Bioretention Basins*, BCC, Brisbane.

Brisbane City Council, 2005, *Draft Water Sensitive Urban Design Engineering Guidelines, Hydrology*, BCC, Brisbane.

Brisbane City Council, 2005, *Draft Water Sensitive Urban Design Engineering Guidelines, Plant selection for WSUD devices*, BCC, Brisbane.

Chesterfield, Christopher, Lloyd, Wong, 2001, *Opportunities and Impediments to Water Sensitive Urban Design in Australia,* CRC for Catchment Hydrology, Monash University, Melbourne.

Clearwater, 2007, *Clearwater MUSIC & STORM training course notes - July 2007*, Melbourne Water, Melbourne.

CSIRO, Northcote, *Atlas of Australian Soils Melbourne-Tasman Area, Sheet 2,* Melbourne Uni Press, Melbourne.

Department of Natural Resources, 2002, Port Phillip Bay Environmental Management Plan, Natural Resources and Environment, East Melbourne, Victoria.

Duncan, 1999, *Urban Stormwater Quality: A Statical overview,* CRC for Catchment Hydrology, Monash University, Melbourne.

EGIS Consulting Australia, 1999, *Stonnington City Council - Flood Plan Mapping 98/99 final report*, EGIS, Melbourne.

EPA Victoria, 2008, *Maintaining Water Sensitive Urban Design elements,* EPA Victoria, Melbourne.

Erickson, Gulliver, Weiss, 2005, *Cost and effectiveness of stormwater management practices,* Minnesota Department of Transport, St Paul, MN, USA.

FAWB, 2008, *Guidelines for Soil filter media in Bioretention systems (Ver. 2.01),* FAWB, Melbourne.

Gold Coast City Council, 2005, L*and development guidelines* - *Section 13,* GCC, Queensland.

Kingston City Council & Better Bays & Waterways, *Review of Street Scale WSUD in Melbourne - Study findings*, Land water Constructions, Melbourne.

Longmore, 2008, *Port Phillip Bay environmental management plan: Monitoring the state of the Bay nitrogen cycling (2006-2007)*, Department of Primary Resources, East Melbourne, Victoria.

Melbourne Water, 2004, MUSIC input parameters, Melbourne.

Melbourne Water, *Water Sensitive Urban Design - WSUD Key principals*, Melbourne.

North Shore City Council, Stormwater management practices Note NSE23: Bioretention, NSCC, Sydney.

Stonnington City Council, 1997, *Engineering Design Guidelines*, SCC, Prahran, Melbourne.

Tuckee Meadows Regional Stormwater quality management program, 2005, *Draft low impact development handbook - Bioretention*, USA.

URS Australia Pty Ltd, 2004, T*echnical guidelines for Western Sydney*, Sydney.

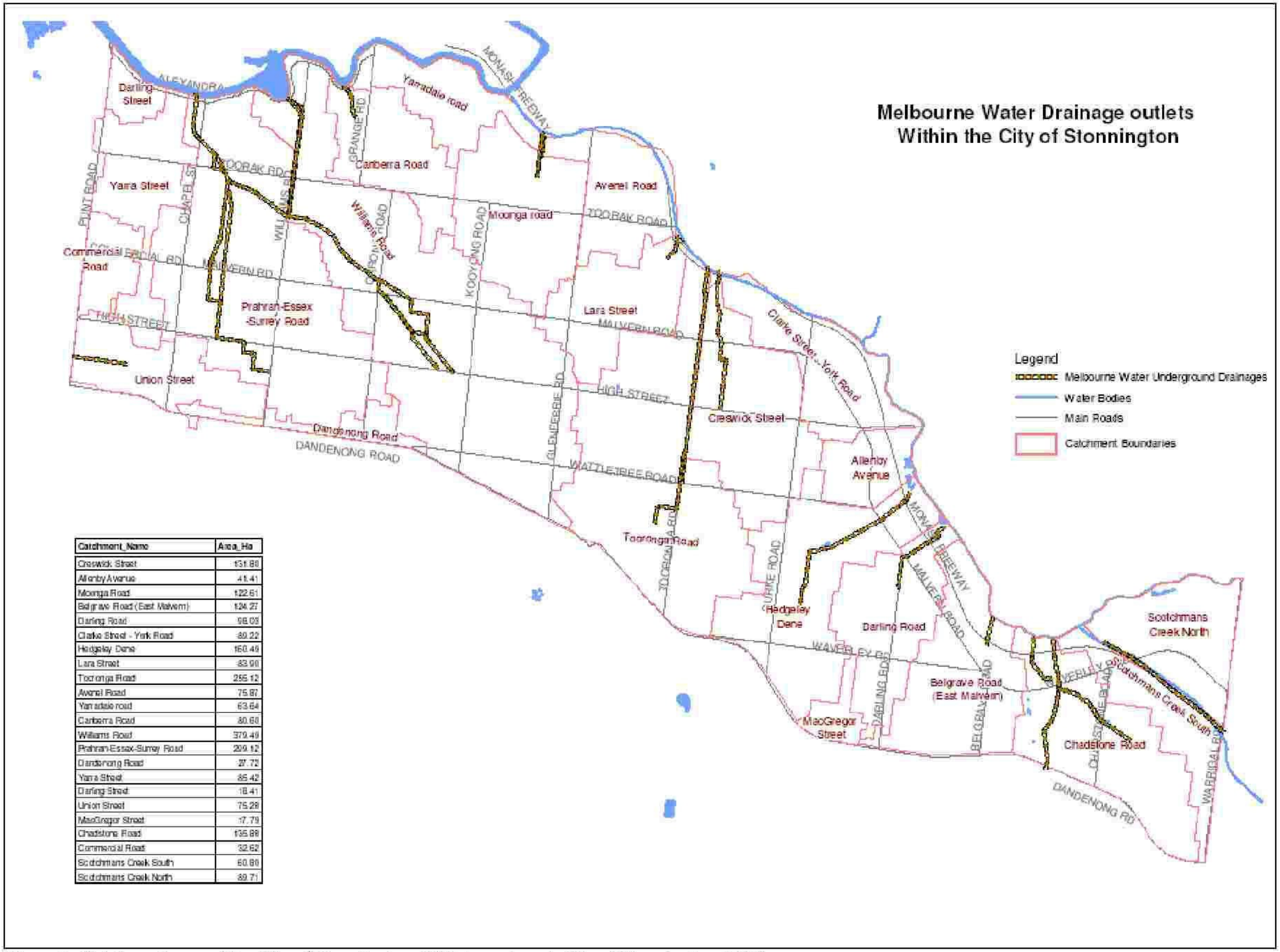
Van de Graaff, Wootton, 1996, *Landcare Notes - Melbourne Soils, Department of Natural Resources*, Victoria.

VICRoads, 1999, *Traffic Engineering Manual Volume 1 - Traffic Management*, VIC Roads Printing services, Kew, Victoria.

West, 2005, *Water sensitive Road projects, A snapshot of projects within the City of Kingston*, Victoria.

Yarra City Council, *WSUD Case Study, Napier Street & Kerr Street, Fitzroy - Streetscape Renewal*, Yarra City Council, Melbourne.

Appendix A:
Hydrological data for Stonnington



Catchment_Name	Area_Ha
Creswick Street	131.89
Allenby Avenue	41.41
Moonga Road	122.61
Belgrave Road (East Malvern)	124.27
Darling Road	98.03
Clarke Street - York Road	89.22
Hedgeley Dene	160.49
Lara Street	83.90
Tooronga Road	255.12
Averel Road	75.87
Yarradale road	63.64
Canberra Road	80.60
Williams Road	379.49
Prahran-Essex-Surrey Road	209.12
Dandenong Road	27.72
Yarra Street	85.42
Darling Street	18.41
Union Street	75.28
MacGregor Street	17.79
Chadstone Road	135.88
Commercial Road	32.62
Scotchmans Creek South	60.80
Scotchmans Creek North	89.71

Figure 1: Catchment map of the City of Stonnington, (GIS department, City of Stonnington, 2008)

Catchment Summary Statistics - Stonnington									
Catchment Reference	Total Area (Ha)	Reserves (Ha)	Schools (Ha)	Commerical (Ha)	Industrial (Ha)	Residential (Ha)	% Impervious	Catchment Number	Avg % Impv for catchment
2101	1.99	0.00	1.46	0.00	0.00	0.52	46.3%	1	50.6%
2102	9.63	0.00	0.00	0.00	0.00	9.63	50.0%	1	
2104	7.91	0.11	0.00	0.09	0.00	7.71	49.8%	1	
2201	8.57	0.35	0.00	0.00	0.41	7.81	68.0%	1	
2202	10.17	2.98	0.00	0.00	0.28	6.91	39.1%	1	
2006	44.62	0.00	0.00	25.89	0.91	17.82	70.9%	2	70.9%
2001	54.65	0.00	0.00	0.00	4.30	50.36	52.3%	3	52.3%
1801	51.10	0.00	1.09	1.80	2.67	45.53	53.2%	4	53.2%
1901	14.17	0.00	0.00	0.00	1.00	13.18	52.1%	5	52.1%
1701	16.79	4.43	0.00	0.00	0.64	11.72	40.6%	6	46.3%
1702	70.10	2.93	0.00	2.96	5.07	59.14	52.0%	6	
1601	25.18	0.00	0.00	0.00	1.19	23.99	51.4%	7	51.4%
1501	2.53	0.00	0.00	0.00	0.00	2.53	60.0%	8	61.2%
1502	17.30	0.00	0.00	0.00	2.00	15.30	62.3%	8	
1401	60.72	1.96	0.00	0.92	3.77	54.07	60.0%	9	60.0%
1403	5.80	0.00	0.00	0.00	0.00	5.80	60.0%	9	
1301	28.83	0.00	0.00	0.89	2.44	25.50	62.5%	10	59.9%
1302	53.15	4.94	1.89	1.28	2.43	42.61	56.3%	10	
1402	179.71	1.10	1.20	2.71	7.99	166.71	60.9%	10	
1201	44.89	0.00	2.99	0.73	3.01	38.16	61.7%	11	61.9%
1202	1.90	0.00	0.00	0.00	0.00	1.90	60.0%	11	
1205	7.08	0.00	0.00	0.00	1.39	5.89	63.9%	11	
1103	11.89	0.00	0.00	0.00	0.90	10.99	70.8%	12	70.8%
1001	46.70	0.00	0.00	0.00	1.95	40.76	60.8%	13	60.2%
1002	43.38	0.00	0.00	0.00	2.76	40.62	61.3%	13	
1003	1.73	0.00	0.00	0.00	0.00	1.73	60.0%	13	
1005	8.16	0.40	0.00	0.35	0.01	7.41	58.7%	13	
901	1.18	0.00	0.00	0.00	0.09	1.09	61.5%	15	64.3%
902	1.39	0.00	0.00	0.00	0.01	1.38	60.1%	15	
903	2.75	0.00	0.00	0.00	0.00	2.75	70.0%	15	
904	5.28	0.00	0.00	0.00	0.00	5.28	60.0%	15	
906	0.93	0.00	0.00	0.00	0.00	0.93	70.0%	15	
712	3.23	0.00	0.00	0.00	0.00	3.23	70.0%	16	70.4%
801	49.05	0.00	0.00	0.00	0.00	46.53	70.5%	16	
802	16.67	0.00	0.30	1.17	0.02	15.18	70.6%	16	
701	56.32	1.63	1.90	11.36	3.36	38.27	67.6%	17	70.0%
702	367.69	0.36	0.00	0.00	2.61	34.72	70.1%	17	
703	33.71	0.31	1.09	3.67	2.66	25.97	71.0%	17	
704	12.66	0.00	0.00	0.00	0.12	12.55	70.1%	17	
705	4.41	0.00	0.00	0.00	0.39	4.02	70.9%	17	
706	12.68	0.00	0.50	2.43	1.13	9.07	70.0%	17	
711	1.95	0.00	0.00	0.00	0.00	1.70	70.1%	17	
713	0.95	0.00	0.00	0.00	0.00	0.95	70.1%	17	
714	1.17	0.00	0.00	0.00	0.00	1.17	70.0%	17	
601	8.37	0.00	0.00	0.00	0.44	7.93	51.6%	18	51.6%
501	48.71	0.00	0.14	4.11	3.94	40.52	76.2%	19	66.3%
503	1.92	0.00	0.00	0.00	0.14	1.77	75.4%	19	
511	16.46	0.94	0.00	0.30	1.05	14.16	71.8%	19	
512	46.21	1.92	5.47	22.23	85.55	10.02	77.3%	19	
514	0.25	0.00	0.00	0.25	0.00	0.00	85.0%	19	
517	47.38	0.80	0.00	0.77	1.98	43.84	74.3%	19	
716	3.92	1.84	1.09	0.00	0.38	0.98	34.8%	19	
717	4.15	2.45	0.17	0.23	2.85	0.93	35.5%	19	
102	4.97	0.00	0.00	0.00	0.63	4.34	80.0%	20	80.0%
103	0.62	0.00	0.00	0.00	0.00	0.62	80.0%	20	
201	38.32	0.55	0.04	3.69	3.11	30.93	76.9%	21	81.8%
203	2.60	0.00	0.00	1.61	0.28	0.51	83.5%	21	
205	1.50	0.00	0.00	1.50	0.00	0.00	85.0%	21	
301	31.63	0.10	0.00	0.50	4.47	26.52	79.8%	22	79.8%
401	66.55	0.86	3.71	6.96	7.45	47.69	79.2%	23	79.2%

Table 1: Catchment Summary Statistics for the City of Stonnington, (EGIS Consulting, 1999)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	na	na	na	na	na	64%	64%	64%	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
2	80%	82%	82%	66%	70%	70%	64%	64%	60%	60%	71%	71%	na	na	na	na	na	na	na	na	na	na	na	na	na
3	82%	82%	82%	66%	66%	70%	70%	70%	60%	60%	71%	71%	na	na	na	na	na	na	na	na	na	na	na	na	na
4	82%	82%	82%	66%	66%	66%	70%	70%	60%	60%	71%	62%	62%	na	na	na	na	na	na	na	na	na	na	na	na
5	82%	82%	82%	66%	66%	66%	70%	70%	70%	60%	62%	62%	62%	60%	60%	61%	na	na	na	na	na	na	na	na	na
6	82%	82%	66%	66%	66%	66%	70%	70%	70%	70%	62%	60%	60%	60%	60%	61%	na	na	na	na	na	na	na	na	na
7	80%	82%	66%	66%	66%	66%	66%	70%	70%	70%	70%	60%	60%	60%	60%	61%	61%	61%	na	na	na	na	na	na	na
8	80%	82%	80%	79%	66%	66%	66%	70%	70%	70%	70%	60%	60%	60%	60%	60%	51%	51%	na	na	na	na	na	na	na
9	79%	79%	79%	79%	66%	52%	52%	70%	70%	70%	70%	60%	60%	60%	60%	60%	46%	46%	na	na	na	na	na	na	na
10	na	na	na	na	na	na	na	na	na	70%	70%	60%	60%	60%	60%	46%	46%	46%	53%	53%	na	na	51%	51%	51%
11	na	na	na	na	na	na	na	na	na	na	na	60%	60%	60%	60%	46%	46%	46%	53%	53%	52%	71%	51%	51%	51%
12	na	na	na	na	na	na	na	na	na	na	na	na	60%	60%	60%	46%	46%	46%	53%	52%	52%	71%	71%	51%	51%
13	na	na	na	na	na	na	na	na	na	na	na	na	na	60%	46%	46%	46%	46%	53%	52%	52%	71%	71%	71%	51%
14	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	46%	46%	46%	53%	52%	52%	71%	71%	71%	71%
15	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	71%	71%
			Chapel Street		Willams Road		Orrong Road		Kooyong Road		Glenferrie Road			Tooronga Road		Bourke Road		Darling Road		Belgrave Road		Chadstone Road			Warrigal Road

Key:

(blue)	Up to 49% Impervious runoff
(yellow)	50 to 59% Impervious runoff
(yellow)	60 to 69% Impervious runoff
(orange)	70 to 79% Impervious runoff
(red)	< 80% Impervious runoff
na	Cell not within Stonnington Boundary

Table 2: Impervious runoff Chart based upon average impervious fractions from EGIS consulting, (Vincec, 2008)

Appendix B:
MUSIC data findings

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.2	Ha	
Impervious % runoff:	60	%	
Filter Area:	6.3	m^2	(2.5m x 2.2m)
Ponding Area:	7.5	m^2	(2.5m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Redu
(Filter Depth 1.0m)												
Flow (ML/yr)	0.673	0.675	-0.3	0.673	0.675	-0.3	0.673	0.675	-0.3			
Total Suspended Solids (kg/yr)	135	15.6	88.4	135	16.2	87.9	140	17.8	8.73E+01			
Total Phosphorus (kg/yr)	0.28	6.54E-02	76.7	0.28	6.94E-02	75.2	0.284	7.35E-02	74.1	Reduction targets failed		
Total Nitrogen (kg/yr)	1.94	0.979	49.5	1.94	1.02	47.1	1.9	1.02	46.4			
Gross Pollutants (kg/yr)	29	0	100	29	0	100	29	0	100			
(Filter Depth 0.8m)												
Flow (ML/yr)	0.673	0.675	-0.3	0.673	0.675	-0.3						
Total Suspended Solids (kg/yr)	135	16.1	88	135	16.8	87.5						
Total Phosphorus (kg/yr)	0.28	6.77E-02	75.8	0.28	7.20E-02	74.3	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.94	1.01	47.9	1.94	1.06	45.4						
Gross Pollutants (kg/yr)	29	0	100	29	0	100						
(Filter Depth 0.6m)												
Flow (ML/yr)	0.673	0.675	-0.2									
Total Suspended Solids (kg/yr)	135	16.4	87.8									
Total Phosphorus (kg/yr)	0.28	6.96E-02	75.2	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.94	1.04	46.3									
Gross Pollutants (kg/yr)	29	0	100									

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.15	Ha	
Impervious % runoff:	60	%	
Filter Area:	5.5	m^2	(2.5m x 2.2m)
Ponding Area:	6.6	m^2	(2.5m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.505	0.507	-0.4	0.505	0.507	-0.4	0.505	0.507	-0.4	0.505	0.507	-0.4
Total Suspended Solids (kg/yr)	104	9.37	91	104	9.87	90.5	104	10.3	90.1	104	10.5	89.9
Total Phosphorus (kg/yr)	0.209	4.30E-02	79.4	0.209	4.62E-02	77.9	0.209	4.84E-02	76.9	0.209	4.98E-02	76.2
Total Nitrogen (kg/yr)	1.45	0.684	52.9	1.45	0.719	50.5	1.45	0.743	48.9	1.45	0.757	47.9
Gross Pollutants (kg/yr)	21.7	0	100	21.7	0	100	21.7	0	100	21.7	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.505	0.506	-0.3	0.505	0.506	-0.3	0.505	0.506	-0.3	0.505	0.506	-0.3
Total Suspended Solids (kg/yr)	100	10.4	89.6	104	10.4	90	100	11.5	88.6	100	11.8	88.3
Total Phosphorus (kg/yr)	0.204	4.64E-02	77.2	0.209	4.81E-02	77	0.204	5.22E-02	74.4	0.204	5.37E-02	73.7
Total Nitrogen (kg/yr)	1.45	0.715	50.6	1.45	0.753	48.2	1.45	0.778	46.3	1.45	0.792	45.3
Gross Pollutants (kg/yr)	21.7	0	100	21.7	0	100	21.7	0	100	21.7	0	100
(Filter Depth 0.6m)												
Flow (ML/yr)	0.505	0.506	-0.3	0.505	0.506	-0.3						
Total Suspended Solids (kg/yr)	100	10.8	89.3	100	11.4	88.6						
Total Phosphorus (kg/yr)	0.204	4.82E-02	76.3	0.204	5.19E-02	74.5	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.45	0.743	48.7	1.45	0.783	45.9						
Gross Pollutants (kg/yr)	21.7	0	100	21.7	0	100						

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.1	Ha	
Impervious % runoff:	60	%	
Filter Area:	3.3	m^2	(1.5m x 2.2m)
Ponding Area:	3.8	m^2	(1.5m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.337	0.338	-0.3	0.337	0.338	-0.3	0.337	0.338	-0.3			
Total Suspended Solids (kg/yr)	68.8	8.38	87.8	68.8	8.69	87.4	68.8	8.95	87			
Total Phosphorus (kg/yr)	0.137	3.21E-02	76.5	0.137	3.41E-02	75	0.137	3.56E-02	74			
Total Nitrogen (kg/yr)	0.972	0.489	49.6	0.972	0.512	47.3	0.972	0.528	45.7	Reduction targets failed		
Gross Pollutants (kg/yr)	14.5	0	100	14.5	0	100	14.5	0	100			
(Filter Depth 0.8m)												
Flow (ML/yr)	0.337	0.337	-0.3	0.337	0.337	-0.3						
Total Suspended Solids (kg/yr)	65.5	7.7	88.2	65.5	8.05	87.7						
Total Phosphorus (kg/yr)	0.134	3.28E-02	75.4	0.134	3.49E-02	73.8	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	0.962	0.499	48.1	0.962	0.523	45.6						
Gross Pollutants (kg/yr)	14.5	0	100	14.5	0	100						
(Filter Depth 0.6m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.1	Ha	
Impervious % runoff:	60	%	
Filter Area:	5.5	m^2	(2.5m x 2.2m)
Ponding Area:	6.6	m^2	(2.5m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.337	0.338	-0.5	0.337	0.338	-0.5	0.337	0.338	-0.5	0.337	0.338	-0.5
Total Suspended Solids (kg/yr)	69	2.91	95.8	69	3.33	95.2	69	3.68	94.7	69	3.68	94.7
Total Phosphorus (kg/yr)	0.138	2.09E-02	84.9	0.138	2.34E-02	83.1	0.138	2.53E-02	81.8	0.138	2.53E-02	81.8
Total Nitrogen (kg/yr)	0.981	0.383	60.9	0.981	0.411	58.1	0.981	0.43	56.2	0.981	0.43	56.2
Gross Pollutants (kg/yr)	14.5	0	100	14.5	0	100	14.5	0	100	14.5	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.337	0.338	-0.4	0.337	0.338	-0.4	0.337	0.338	-0.4	0.337	0.338	-0.4
Total Suspended Solids (kg/yr)	69	3.18	95.4	69	3.65	94.7	69	4.04	94.1	69	4.29	93.8
Total Phosphorus (kg/yr)	0.138	2.22E-02	84	0.138	2.49E-02	82	0.138	2.68E-02	80.6	0.138	2.80E-02	79.8
Total Nitrogen (kg/yr)	0.981	0.405	58.8	0.981	0.434	55.8	0.981	0.453	53.8	0.981	0.465	52.6
Gross Pollutants (kg/yr)	14.5	0	100	14.5	0	100	14.5	0	100	14.5	0	100
(Filter Depth 0.6m)												
Flow (ML/yr)	0.337	0.338	-0.3	0.337	0.338	-0.3	0.337	0.338	-0.3	0.337	0.338	-0.3
Total Suspended Solids (kg/yr)	69	3.98	94.2	69	3.98	94.2	69	4.41	93.6	69	4.7	93.2
Total Phosphorus (kg/yr)	0.138	2.66E-02	80.8	0.138	2.66E-02	80.8	0.138	2.86E-02	79.3	0.138	2.99E-02	78.4
Total Nitrogen (kg/yr)	0.981	0.46	53.1	0.981	0.46	53.1	0.981	0.481	51	0.981	0.493	49.7
Gross Pollutants (kg/yr)	14.5	0	100	14.5	0	100	14.5	0	100	14.5	0	100

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.2	Ha	
Impervious % runoff:	70	%	
Filter Area:	8.8	m^2	(4.0m x 2.2m)
Ponding Area:	10.9	m^2	(4.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.882	0.885	-0.3	0.882	0.885	-0.3	0.777	0.78	-0.4	0.777	0.78	-0.4
Total Suspended Solids (kg/yr)	186	20.2	89.1	186	21.1	88.7	159	15.2	90.4	159	15.6	90.1
Total Phosphorus (kg/yr)	0.368	8.26E-02	77.6	0.368	8.78E-02	76.1	0.33	7.56E-02	77.1	0.33	7.78E-02	76.4
Total Nitrogen (kg/yr)	2.6	1.28	50.7	2.6	1.34	48.4	2.2	1.11	49.3	2.2	1.13	48.3
Gross Pollutants (kg/yr)	34.6	0	100	34.6	0	100	32	0	100	32	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.882	0.884	-0.2	0.882	0.884	-0.2	0.882	0.884	-0.2			
Total Suspended Solids (kg/yr)	186	21	88.7	186	21.9	88.2	186	22.7	87.8			
Total Phosphorus (kg/yr)	0.368	8.56E-02	76.7	0.368	9.12E-02	75.2	0.368	9.52E-02	74.1	Reduction targets failed		
Total Nitrogen (kg/yr)	2.6	1.33	49	2.6	1.39	46.5	2.6	1.43	44.8			
Gross Pollutants (kg/yr)	34.6	0	100	34.6	0	100	34.6	0	100			
(Filter Depth 0.6m)												
Flow (ML/yr)	0.777	0.779	-0.3	0.777	0.779	-0.3						
Total Suspended Solids (kg/yr)	155	14	91	155	15	90.4						
Total Phosphorus (kg/yr)	0.322	7.02E-02	78.2	0.322	7.59E-02	76.4	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	2.23	1.14	48.9	2.23	1.21	46						
Gross Pollutants (kg/yr)	32	0	100	32	0	100						

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.2	Ha	
Impervious % runoff:	70	%	
Filter Area:	6.6	m^2	(3.0m x 2.2m)
Ponding Area:	7.5	m^2	(3.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.777	0.78	-0.3	0.777	0.779	-0.2						
Total Suspended Solids (kg/yr)	159	23.1	85.5	159	23.6	85.2						
Total Phosphorus (kg/yr)	0.319	8.40E-02	73.7	0.319	8.61E-02	73.1	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	2.22	1.19	46.6	2.22	1.22	45.3						
Gross Pollutants (kg/yr)	32	0	100	32	0	100						
(Filter Depth 0.8m)												
Flow (ML/yr)	0.777	0.779	-0.2									
Total Suspended Solids (kg/yr)	159	24.4	84.7									
Total Phosphorus (kg/yr)	0.319	9.07E-02	71.6	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	2.22	1.27	43									
Gross Pollutants (kg/yr)	32	0	100									
(Filter Depth 0.6m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.2	Ha	
Impervious % runoff:	70	%	
Filter Area:	6.2	m^2	(2.8m x 2.2m)
Ponding Area:	7	m^2	(2.8m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.777	0.779	-0.3									
Total Suspended Solids (kg/yr)	159	25.1	84.2									
Total Phosphorus (kg/yr)	0.319	8.83E-02	72.3	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	2.22	1.21	45.4									
Gross Pollutants (kg/yr)	32	0	100									
(Filter Depth 0.8m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												
(Filter Depth 0.6m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.1	Ha	
Impervious % runoff:	70	%	
Filter Area:	4.4	m^2	(2.2m x 2.2m)
Ponding Area:	5.5	m^2	(2.2m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.389	0.39	-0.3	0.389	0.39	-0.3						
Total Suspended Solids (kg/yr)	80.2	11	86.3	80.2	11.4	85.8						
Total Phosphorus (kg/yr)	0.163	4.27E-02	73.8	0.163	4.49E-02	72.5	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.11	0.585	47.2	1.11	0.609	45						
Gross Pollutants (kg/yr)	16	0	100	16	0	100						
(Filter Depth 0.8m)												
Flow (ML/yr)	0.389	0.39	-0.2									
Total Suspended Solids (kg/yr)	80.2	11.2	86									
Total Phosphorus (kg/yr)	0.163	4.37E-02	73.2	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.11	0.6	45.8									
Gross Pollutants (kg/yr)	16	0	100									
(Filter Depth 0.6m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.2	Ha	
Impervious % runoff:	70	%	
Filter Area:	6.2	m^2	(2.8m x 2.2m)
Ponding Area:	7	m^2	(2.8m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.389	0.39	-0.4	0.389	0.39	-0.4	0.389	0.39	-0.4	0.389	0.39	-0.4
Total Suspended Solids (kg/yr)	80.2	6.67	91.7	80.2	6.67	91.7	80.2	7.38	90.8	80.2	7.59	90.5
Total Phosphorus (kg/yr)	0.163	3.25E-02	80.1	0.163	3.25E-02	80.1	0.163	3.67E-02	77.5	0.163	3.78E-02	76.8
Total Nitrogen (kg/yr)	1.11	0.51	53.9	1.11	0.51	53.9	1.11	0.556	49.8	1.11	0.567	48.8
Gross Pollutants (kg/yr)	16	0	100	16	0	100	16	0	100	16	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.389	0.39	-0.3	0.389	0.39	-0.3	0.389	0.39	-0.3			
Total Suspended Solids (kg/yr)	80.2	7.14	91.1	80.2	7.64	90.5	80.2	8.06	90			
Total Phosphorus (kg/yr)	0.163	3.52E-02	78.4	0.163	3.81E-02	76.7	0.163	4.01E-02	75.4	Reduction targets failed		
Total Nitrogen (kg/yr)	1.11	0.551	50.3	1.11	0.582	47.5	1.11	0.603	45.6			
Gross Pollutants (kg/yr)	16	0	100	16	0	100	16	0	100			
(Filter Depth 0.6m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.15	Ha	
Impervious % runoff:	70	%	
Filter Area:	6.6	m^2	(3.0m x 2.2m)
Ponding Area:	7.8	m^2	(3.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.661	0.663	-0.2	0.583	0.585	-0.4	0.583	0.585	-0.4	0.583	0.585	-0.4
Total Suspended Solids (kg/yr)	143	16.6	88.4	117	11.3	90.3	117	11.8	89.9	117	12.1	89.6
Total Phosphorus (kg/yr)	0.286	6.81E-02	76.2	0.24	5.34E-02	77.8	0.24	5.60E-02	76.7	0.24	5.76E-02	76
Total Nitrogen (kg/yr)	1.92	1.02	47	1.67	0.826	50.6	1.67	0.854	48.9	1.67	0.871	47.9
Gross Pollutants (kg/yr)	26	0	100	24	0	100	24	0	100	24	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.583	0.584	-0.2									
Total Suspended Solids (kg/yr)	116	14.3	87.6									
Total Phosphorus (kg/yr)	0.231	5.88E-02	74.6	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.72	0.91	47.1									
Gross Pollutants (kg/yr)	24	0	100									
(Filter Depth 0.6m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.2	Ha	
Impervious % runoff:	80	%	
Filter Area:	8.8	m^2	(4.0m x 2.2m)
Ponding Area:	10.9	m^2	(4.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.882	0.885	-0.3	0.882	0.885	-0.3	0.882	0.885	-0.3	0.882	0.885	-0.3
Total Suspended Solids (kg/yr)	186	20.2	89.1	186	21.1	88.7	186	21.7	88.3	186	22.2	88.1
Total Phosphorus (kg/yr)	0.368	8.26E-02	77.6	0.368	8.78E-02	76.1	0.368	9.16E-02	75.1	0.368	9.39E-02	74.5
Total Nitrogen (kg/yr)	2.6	1.28	50.7	2.6	1.34	48.4	2.6	1.38	46.8	2.6	1.41	45.9
Gross Pollutants (kg/yr)	34.6	0	100	34.6	0	100	34.6	0	100	34.6	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.882	0.884	-0.2	0.882	0.884	-0.2	0.882	0.884	-0.2			
Total Suspended Solids (kg/yr)	186	21	88.7	186	21.9	88.2	186	22.7	87.8			
Total Phosphorus (kg/yr)	0.368	8.56E-02	76.7	0.368	9.12E-02	75.2	0.368	9.52E-02	74.1	Reduction targets failed		
Total Nitrogen (kg/yr)	2.6	1.33	49	2.6	1.39	46.5	2.6	1.43	44.8			
Gross Pollutants (kg/yr)	34.6	0	100	34.6	0	100	34.6	0	100			
(Filter Depth 0.6m)												
Flow (ML/yr)	0.882	0.884	-0.2									
Total Suspended Solids (kg/yr)	186	21.4	88.5									
Total Phosphorus (kg/yr)	0.368	8.80E-02	76.1	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	2.6	1.37	47.2									
Gross Pollutants (kg/yr)	34.6	0	100									

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.15	Ha	
Impervious % runoff:	80	%	
Filter Area:	6.6	m^2	(3.0m x 2.2m)
Ponding Area:	7.8	m^2	(3.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.661	0.663	-0.3	0.661	0.663	-0.3	0.661	0.663	-0.3	0.661	0.663	-0.3
Total Suspended Solids (kg/yr)	143	15.7	89	143	16.3	88.6	143	16.8	88.2	143	17.2	88
Total Phosphorus (kg/yr)	0.286	6.38E-02	77.7	0.286	6.78E-02	76.3	0.286	7.07E-02	75.3	0.286	7.24E-02	74.7
Total Nitrogen (kg/yr)	1.92	0.947	50.6	1.92	0.99	48.3	1.92	1.02	46.8	1.92	1.04	45.9
Gross Pollutants (kg/yr)	26	0	100	26	0	100	26	0	100	26	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.661	0.663	-0.2	0.661	0.663	-0.2	0.661	0.663	-0.2			
Total Suspended Solids (kg/yr)	143	16.2	88.6	143	16.9	88.1	143	17.5	87.7			
Total Phosphorus (kg/yr)	0.286	6.61E-02	76.9	0.286	7.04E-02	75.4	0.286	7.35E-02	74.3	Reduction targets failed		
Total Nitrogen (kg/yr)	1.92	0.982	48.7	1.92	1.03	46.3	1.92	1.06	44.7			
Gross Pollutants (kg/yr)	26	0	100	26	0	100	26	0	100			
(Filter Depth 0.6m)												
Flow (ML/yr)	0.661	0.663	-0.2									
Total Suspended Solids (kg/yr)	143	16.6	88.4									
Total Phosphorus (kg/yr)	0.286	6.81E-02	76.2	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.92	1.02	47									
Gross Pollutants (kg/yr)	26	0	100									

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.1	Ha	
Impervious % runoff:	80	%	
Filter Area:	6.6	m^2	(3.0m x 2.2m)
Ponding Area:	7.8	m^2	(3.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.441	0.443	-0.5	0.441	0.443	-0.5	0.441	0.443	-0.5	0.441	0.443	-0.5
Total Suspended Solids (kg/yr)	88.4	4.69	94.7	88.4	5.2	94.1	88.4	5.62	93.6	88.4	5.9	93.3
Total Phosphorus (kg/yr)	0.181	2.94E-02	83.8	0.181	3.25E-02	82.1	0.181	3.47E-02	80.8	0.181	3.61E-02	80.1
Total Nitrogen (kg/yr)	1.27	0.524	58.8	1.27	0.558	56.1	1.27	0.581	54.3	1.27	0.595	53.2
Gross Pollutants (kg/yr)	17.3	0	100	17.3	0	100	17.3	0	100	17.3	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.441	0.442	-0.3	0.441	0.442	-0.3	0.441	0.442	-0.3	0.441	0.442	-0.3
Total Suspended Solids (kg/yr)	88.4	4.95	94.4	88.4	5.51	93.8	88.4	5.97	93.2	88.4	6.28	92.9
Total Phosphorus (kg/yr)	0.181	3.08E-02	83	0.181	3.41E-02	81.2	0.181	3.64E-02	79.9	0.181	3.79E-02	79.1
Total Nitrogen (kg/yr)	1.27	0.547	57	1.27	0.583	54.2	1.27	0.607	52.3	1.27	0.622	51.1
Gross Pollutants (kg/yr)	17.3	0	100	17.3	0	100	17.3	0	100	17.3	0	100
(Filter Depth 0.6m)												
Flow (ML/yr)	0.441	0.442	-0.3	0.441	0.442	-0.3	0.441	0.442	-0.3	0.441	0.442	-0.3
Total Suspended Solids (kg/yr)	88.4	5.19	94.1	88.4	5.83	93.4	88.4	6.35	92.8	88.4	6.7	92.4
Total Phosphorus (kg/yr)	0.181	3.24E-02	82.1	0.181	3.59E-02	80.2	0.181	3.85E-02	78.7	0.181	4.00E-02	77.9
Total Nitrogen (kg/yr)	1.27	0.572	55.1	1.27	0.611	52	1.27	0.637	50	1.27	0.652	48.7
Gross Pollutants (kg/yr)	17.3	0	100	17.3	0	100	17.3	0	100	17.3	0	100

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.1	Ha	
Impervious % runoff:	80	%	
Filter Area:	4.4	m^2	(2.2m x 2.2m)
Ponding Area:	5.5	m^2	(2.2m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.441	0.442	-0.3	0.441	0.442	-0.3	0.441	0.442	-0.3	0.441	0.442	-0.3
Total Suspended Solids (kg/yr)	88.4	9.4	89.4	88.4	9.81	88.9	88.4	10.1	88.5	88.4	10.4	88.3
Total Phosphorus (kg/yr)	0.181	4.06E-02	77.6	0.181	4.32E-02	76.2	0.181	4.50E-02	75.1	0.181	4.61E-02	74.5
Total Nitrogen (kg/yr)	1.27	0.626	50.8	1.27	0.655	48.5	1.27	0.676	46.9	1.27	0.687	46
Gross Pollutants (kg/yr)	17.3	0	100	17.3	0	100	17.3	0	100	17.3	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.441	0.442	-0.3	0.441	0.442	-0.3	0.441	0.442	-0.3			
Total Suspended Solids (kg/yr)	88.4	9.72	89	88.4	10.2	88.5	88.4	10.5	88.1			
Total Phosphorus (kg/yr)	0.181	4.21E-02	76.8	0.181	4.48E-02	75.2	0.181	4.68E-02	74.1		Reduction targets failed	
Total Nitrogen (kg/yr)	1.27	0.649	49	1.27	0.68	46.6	1.27	0.701	44.9			
Gross Pollutants (kg/yr)	17.3	0	100	17.3	0	100	17.3	0	100			
(Filter Depth 0.6m)												
Flow (ML/yr)	0.441	0.442	-0.2									
Total Suspended Solids (kg/yr)	88.4	9.89	88.8									
Total Phosphorus (kg/yr)	0.181	4.33E-02	76.1		Reduction targets failed			Reduction targets failed			Reduction targets failed	
Total Nitrogen (kg/yr)	1.27	0.669	47.4									
Gross Pollutants (kg/yr)	17.3	0	100									

Input data:

Catchment size:	0.2	Ha	
Impervious % runoff:	85	%	
Filter Area:	8.8	m^2	(4.0m x 2.2m)
Ponding Area:	10.9	m^2	(4.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.934	0.937	-0.3	0.934	0.937	-0.3	0.934	0.937	-0.3			
Total Suspended Solids (kg/yr)	188	20.1	89.3	188	21	88.9	188	21.7	88.5	Reduction targets failed		
Total Phosphorus (kg/yr)	0.383	8.93E-02	76.7	0.383	9.47E-02	75.3	0.383	9.85E-02	74.3			
Total Nitrogen (kg/yr)	2.65	1.34	49.4	2.65	1.4	47.1	2.65	1.44	45.5			
Gross Pollutants (kg/yr)	35.9	0	100	35.9	0	100	35.9	0	100			
(Filter Depth 0.8m)												
Flow (ML/yr)	0.934	0.936	-0.2	0.934	0.936	-0.2						
Total Suspended Solids (kg/yr)	188	20.8	89	188	21.7	88.5						
Total Phosphorus (kg/yr)	0.383	9.25E-02	75.8	0.383	9.82E-02	74.3	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	2.65	1.39	47.6	2.65	1.45	45.2						
Gross Pollutants (kg/yr)	35.9	0	100	35.9	0	100						
(Filter Depth 0.6m)												
Flow (ML/yr)	0.934	0.936	-0.2									
Total Suspended Solids (kg/yr)	188	21.2	88.8									
Total Phosphorus (kg/yr)	0.383	9.51E-02	75.2	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	2.65	1.43	46									
Gross Pollutants (kg/yr)	35.9	0	100									

Input data:

Catchment size:	0.2	Ha	
Impervious % runoff:	85	%	
Filter Area:	7.7	m^2	(3.5m x 2.2m)
Ponding Area:	8.8	m^2	(3.5m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.934	0.936	-0.3									
Total Suspended Solids (kg/yr)	195	29.3	85	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Phosphorus (kg/yr)	0.384	0.104	72.9									
Total Nitrogen (kg/yr)	2.7	1.45	46.3									
Gross Pollutants (kg/yr)	35.9	0	100									
(Filter Depth 0.8m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												
(Filter Depth 0.6m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)	Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.15	Ha	
Impervious % runoff:	85	%	
Filter Area:	8.8	m^2	(4.0m x 2.2m)
Ponding Area:	10.9	m^2	(4.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.701	0.703	-0.4	0.701	0.703	-0.4	0.701	0.703	-0.4	0.701	0.703	-0.4
Total Suspended Solids (kg/yr)	142	9.43	93.4	142	10.2	92.8	142	10.8	92.4	142	11.2	92.1
Total Phosphorus (kg/yr)	0.289	5.25E-02	81.8	0.289	5.71E-02	80.2	0.289	6.03E-02	79.1	0.289	6.23E-02	78.4
Total Nitrogen (kg/yr)	1.96	0.868	55.8	1.96	0.917	53.3	1.96	0.951	51.6	1.96	0.971	50.6
Gross Pollutants (kg/yr)	26.9	0	100	26.9	0	100	26.9	0	100	26.9	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.701	0.703	-0.3	0.701	0.703	-0.3	0.701	0.703	-0.3	0.701	0.703	-0.3
Total Suspended Solids (kg/yr)	142	9.87	93	142	10.7	92.5	142	11.4	92	142	11.8	91.7
Total Phosphorus (kg/yr)	0.289	5.48E-02	81	0.289	5.97E-02	79.3	0.289	6.31E-02	78.1	0.289	6.53E-02	77.4
Total Nitrogen (kg/yr)	1.96	0.909	53.8	1.96	0.961	51.1	1.96	0.997	49.3	1.96	1.02	48.2
Gross Pollutants (kg/yr)	26.9	0	100	26.9	0	100	26.9	0	100	26.9	0	100
(Filter Depth 0.6m)												
Flow (ML/yr)	0.701	0.702	-0.3	0.701	0.702	-0.3	0.701	0.702	-0.3	0.701	0.702	-0.3
Total Suspended Solids (kg/yr)	142	10.2	92.8	142	11.1	92.1	142	11.9	91.6	142	12.4	91.2
Total Phosphorus (kg/yr)	0.289	5.72E-02	80.2	0.289	6.25E-02	78.3	0.289	6.63E-02	77	0.289	6.86E-02	76.2
Total Nitrogen (kg/yr)	1.96	0.95	51.6	1.96	1.01	48.8	1.96	1.05	46.8	1.96	1.07	45.6
Gross Pollutants (kg/yr)	26.9	0	100	26.9	0	100	26.9	0	100	26.9	0	100

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.15	Ha	
Impervious % runoff:	85	%	
Filter Area:	6.6	m^2	(3.0m x 2.2m)
Ponding Area:	7.8	m^2	(3.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.701	0.703	-0.3	0.701	0.703	-0.3						
Total Suspended Solids (kg/yr)	142	15.9	88.8	142	16.6	88.3						
Total Phosphorus (kg/yr)	0.289	6.87E-02	76.2	0.289	7.27E-02	74.8	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.96	1.01	48.8	1.96	1.05	46.6						
Gross Pollutants (kg/yr)	26.9	0	100	26.9	0	100						
(Filter Depth 0.8m)												
Flow (ML/yr)	0.701	0.702	-0.2	0.701	0.702	-0.2						
Total Suspended Solids (kg/yr)	142	16.3	88.5	142	17	88	Reduction targets failed			Reduction targets failed		
Total Phosphorus (kg/yr)	0.289	7.08E-02	75.5	0.289	7.51E-02	74						
Total Nitrogen (kg/yr)	1.96	1.04	47.1	1.96	1.09	44.7						
Gross Pollutants (kg/yr)	26.9	0	100	26.9	0	100						
(Filter Depth 0.6m)												
Flow (ML/yr)	0.701	0.702	-0.2									
Total Suspended Solids (kg/yr)	142	16.5	88.4									
Total Phosphorus (kg/yr)	0.289	7.25E-02	74.9	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.96	1.07	45.5									
Gross Pollutants (kg/yr)	26.9	0	100									

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.1	Ha	
Impervious % runoff:	85	%	
Filter Area:	6.6	m^2	(3.0m x 2.2m)
Ponding Area:	7.8	m^2	(3.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.467	0.469	-0.5	0.467	0.469	-0.5	0.467	0.469	-0.5	0.467	0.469	-0.5
Total Suspended Solids (kg/yr)	97.1	6.16	93.7	97.1	6.7	93.1	97.1	7.14	92.6	97.1	7.43	92.3
Total Phosphorus (kg/yr)	0.193	3.36E-02	82.6	0.193	3.68E-02	80.9	0.193	3.91E-02	79.7	0.193	4.05E-02	79
Total Nitrogen (kg/yr)	1.31	0.554	57.8	1.31	0.589	55.2	1.31	0.612	53.4	1.31	0.626	52.4
Gross Pollutants (kg/yr)	17.9	0	100	17.9	0	100	17.9	0	100	17.9	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.467	0.469	-0.3	0.467	0.469	-0.3	0.467	0.469	-0.3	0.467	0.469	-0.3
Total Suspended Solids (kg/yr)	97.1	6.49	93.3	97.1	7.09	92.7	97.1	7.57	92.2	97.1	7.89	91.9
Total Phosphorus (kg/yr)	0.193	3.52E-02	81.8	0.193	3.86E-02	80	0.193	4.10E-02	78.8	0.193	4.25E-02	78
Total Nitrogen (kg/yr)	1.31	0.578	56	1.31	0.614	53.2	1.31	0.639	51.4	1.31	0.654	50.2
Gross Pollutants (kg/yr)	17.9	0	100	17.9	0	100	17.9	0	100	17.9	0	100
(Filter Depth 0.6m)												
Flow (ML/yr)	0.467	0.468	-0.3	0.467	0.468	-0.3	0.467	0.468	-0.3	0.467	0.469	-0.4
Total Suspended Solids (kg/yr)	97.1	6.75E+00	93	97.1	7.43E+00	92.3	97.1	7.98E+00	91.8	97.1	8.83E+00	90.9
Total Phosphorus (kg/yr)	0.193	3.68E-02	80.9	0.193	4.05E-02	79	0.193	4.32E-02	77.6	0.193	3.99E-02	79.4
Total Nitrogen (kg/yr)	1.31	0.607	53.8	1.31	0.646	50.8	1.31	0.673	48.8	1.31	0.607	53.8
Gross Pollutants (kg/yr)	17.9	0	100	17.9	0	100	17.9	0	100	17.9	0	100

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.1	Ha	
Impervious % runoff:	85	%	
Filter Area:	5.5	m^2	(2.5m x 2.2m)
Ponding Area:	6.3	m^2	(2.5m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.467	0.469	-0.4	0.467	0.469	-0.4	0.467	0.469	-0.4	0.467	0.469	-0.4
Total Suspended Solids (kg/yr)	95.4	9.05	90.5	97.1	9.32E+00	90.4	97.1	9.73E+00	90	97.1	9.99E+00	89.7
Total Phosphorus (kg/yr)	0.191	3.94E-02	79.4	0.193	4.29E-02	77.8	0.193	4.50E-02	76.7	0.193	4.63E-02	76
Total Nitrogen (kg/yr)	1.35	0.613	54.6	1.31	0.639	51.4	1.31	0.661	49.7	1.31	0.674	48.7
Gross Pollutants (kg/yr)	17.9	0	100	17.9	0	100	17.9	0	100	17.9	0	100
(Filter Depth 0.8m)												
Flow (ML/yr)	0.467	0.469	-0.3	0.467	0.469	-0.3	0.467	0.469	-0.3	0.467	0.469	-0.3
Total Suspended Solids (kg/yr)	97.1	9.19	90.5	97.1	9.74	90	97.1	10.2	89.5	97.1	10.5	89.2
Total Phosphorus (kg/yr)	0.193	4.15E-02	78.5	0.193	4.47E-02	76.9	0.193	4.70E-02	75.7	0.193	4.84E-02	75
Total Nitrogen (kg/yr)	1.31	0.63	52	1.31	0.664	49.4	1.31	0.687	47.7	1.31	0.701	46.6
Gross Pollutants (kg/yr)	17.9	0	100	17.9	0	100	17.9	0	100	17.9	0	100
(Filter Depth 0.6m)												
Flow (ML/yr)	0.467	0.468	-0.3	0.467	0.468	-0.3	0.467	0.468	-0.3			
Total Suspended Solids (kg/yr)	97.1	9.47	90.2	97.1	10.1	89.6	97.1	10.6	89.1			
Total Phosphorus (kg/yr)	0.193	4.32E-02	77.6	0.193	4.67E-02	75.8	0.193	4.92E-02	74.5			
Total Nitrogen (kg/yr)	1.31	0.661	49.7	1.31	0.698	46.9	1.31	0.723	45			
Gross Pollutants (kg/yr)	17.9	0.00E+00	100	17.9	0.00E+00	100	17.9	0	100			

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.1	Ha	
Impervious % runoff:	85	%	
Filter Area:	4.4	m^2	(2.2m x 2.2m)
Ponding Area:	5.5	m^2	(2.2m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	0.467	0.468	-0.3	0.467	0.468	-0.3						
Total Suspended Solids (kg/yr)	97.1	11.6	88	97.1	12.1	87.6						
Total Phosphorus (kg/yr)	0.193	4.63E-02	76	0.193	4.90E-02	74.7	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.31	0.667	49.2	1.31	0.697	47						
Gross Pollutants (kg/yr)	17.9	0	100	17.9	0	100						
(Filter Depth 0.8m)												
Flow (ML/yr)	0.467	0.468	-0.3	0.467	0.468	-0.2						
Total Suspended Solids (kg/yr)	97.1	12.4	87.2	97.1	12.5	87.1						
Total Phosphorus (kg/yr)	0.193	5.09E-02	73.7	0.193	5.08E-02	73.7	Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.31	0.717	45.4	1.31	0.717	45.4						
Gross Pollutants (kg/yr)	17.9	0	100	17.9	0	100						
(Filter Depth 0.6m)												
Flow (ML/yr)	0.467	0.468	-0.2									
Total Suspended Solids (kg/yr)	97.1	12.2	87.4									
Total Phosphorus (kg/yr)	0.193	4.92E-02	74.5	Reduction targets failed			Reduction targets failed			Reduction targets failed		
Total Nitrogen (kg/yr)	1.31	0.706	46.2									
Gross Pollutants (kg/yr)	17.9	0	100									

MUSIC Data : Bioretention System - Raingarden

Input data:

Catchment size:	0.25	Ha	
Impervious % runoff:	85	%	
Filter Area:	8.8	m^2	(4.0m x 2.2m)
Ponding Area:	10.9	m^2	(4.0m x 2.5m)
Ponding Depth:	0.3	m	

	0.20mm screenings			0.45mm screenings			0.75mm screenings			1mm screenings		
	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction	Source	Residual load	% Reduction
(Filter Depth 1.0m)												
Flow (ML/yr)	1.17	1.17	-0.2									
Total Suspended Solids (kg/yr)	239	39.7	83.4		Reduction targets failed			Reduction targets failed			Reduction targets failed	
Total Phosphorus (kg/yr)	0.471	0.135	71.4									
Total Nitrogen (kg/yr)	3.31	1.82	45.1									
Gross Pollutants (kg/yr)	44.8	0	100									
(Filter Depth 0.8m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)		Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed	
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												
(Filter Depth 0.6m)												
Flow (ML/yr)												
Total Suspended Solids (kg/yr)												
Total Phosphorus (kg/yr)		Reduction targets failed			Reduction targets failed			Reduction targets failed			Reduction targets failed	
Total Nitrogen (kg/yr)												
Gross Pollutants (kg/yr)												

Appendix C:
Soil Conditions of Melbourne

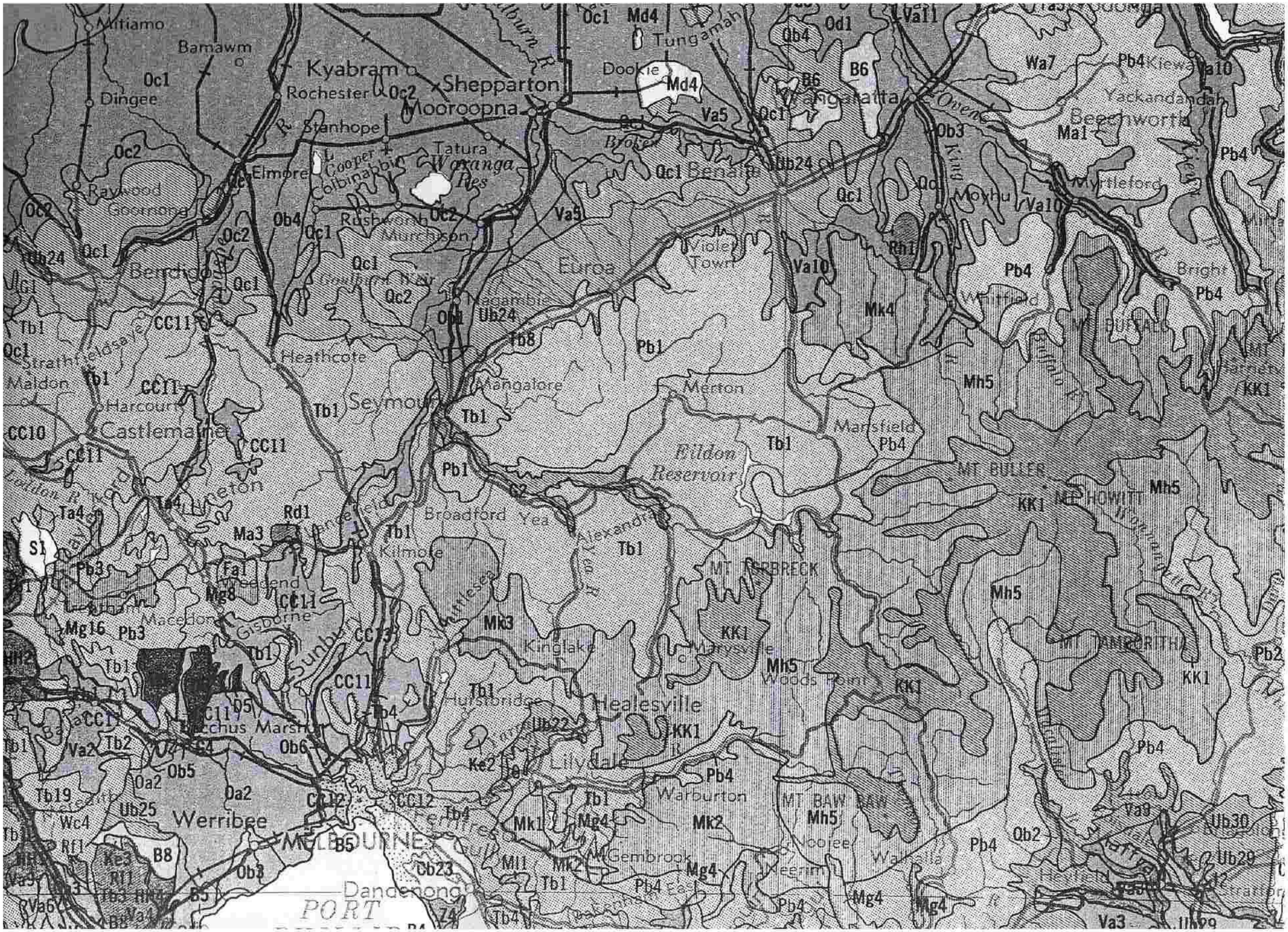


Figure 2: Soil types around Melbourne (Victoria-Tasmania Area), (CSIRO, Northcote, n.d)