MUNICIPAL ENGINEERING FOUNDATION VICTORIA

2005 AMERICAN STUDY TOUR

INTEGRATING WATER SENSITIVE URBAN DESIGN INTO NEW SUBDIVISIONS

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- City of Seattle
- City of Bellview
- City of Atlanta
- City of Griffin
- The Low Impact Development Centre
- Baltimore County
- Ramsey – Washington Metro Watershed District
- Metropolitan Water Reclamation District of Greater Chicago
- American Public Works Association.

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2.0 INTRODUCTION

This paper reviews the current practice of integrating water quality management (Water Sensitive Urban Design) into residential areas in the northern states of the United States of America, in particular new residential developments.

Based on my observations on the Study tour and my local experience, the advantages, limitations and potential opportunities for integrating the treatment into new subdivisions are provided.

3.0 BACKGROUND

Historically, stormwater has been viewed as a problem for residential developments. It has been piped away and any flooding managed. In the late 20th century, the impact on the rivers and bays of litter and later sediment, phosphorous and nitrogen in stormwater was recognised and programs implemented to address these new problems.

In the 21st century, Melbourne is facing an 8% reduction in its potable water supply over the next 20 years and a 20% reduction by 2050. At the same time, over 500 billion litres of stormwater - more than Melbourne's current potable water consumption - flows into the bay each year. Stormwater can no longer be considered as a disposal problem, but as a valuable resource.

Water quality management or Water Sensitive Urban Design is more than just the management of the quality of the stormwater being discharged to the waterways and bays. It involves:

- protecting and enhancing the environment of the waterways the potable water supply is drawn from and also the waterways stormwater is discharged to;
- reducing the demand on the potable water supply by the use of efficient appliances, rainwater reuse and grey water reuse;
- minimising the generation of grey water and ensuring its treatment to a standard for reuse or discharge to streams and the sea;
- treating stormwater to a standard for reuse or discharge to streams.

The challenge is to incorporate Water Sensitive Urban Design (WSUD) into new residential developments in a sustainable way, sustainable for both the communities that live with the WSUD systems and the authorities that have to manage the systems.

4.0 WYNDHAM'S EXPERIENCE WITH WSUD

The City of Wyndham is located 30 kilometres south west of Melbourne's CBD and is one of Melbourne's designated growth areas. Its current population is 118,000. This is projected to increase to 250,000 by 2030.

Between 2000 and 2004 over 3,600 new resident lots were developed each year. The lots, generally ranging from 500 to 700 square metres, were developed in the traditional method. The developer subdivides the land and provides the infrastructure (including the roads and drainage) before selling house lots to individual owners who construct the houses.

At this stage in Wyndham, true water sensitive urban design (WSUD) has only being partially implemented. Since the late 1990's, residential developments have incorporated stormwater treatments – retarding basins, wetlands and bio-retention swales. Two estates are now being developed with a "third pipe system" to supply treated sewage effluent to replace the use of potable water on gardens, open space and for toilet flushing.

4.1 Retarding Basins and Wetlands

In the 1990's, retarding basins and wetlands were constructed to retard creek flows to "pre development conditions" and to reduce sediment, phosphorous and nitrogen in the stormwater flows. The retarding basin and wetland occupy approximately 1 to 2 percent of the area of the subdivision. As the area is subject to inundation, it is considered encumbered land and is in addition to the 5 percent public open space required by Council under the Subdivision Act.

Wetland at River Sanctuary Estate Werribee

There have not been any significant problems with the operation and maintenance of the retarding basins and wetlands. However, one wetland has had weed infestation problems. There are also concerns regarding the likely frequency and cost of the on going maintenance of the wetlands, in particular the removal of sediment and subsequent replanting.

There has been no monitoring on the effectiveness of the wetlands in improving the local water quality.

4.2 Bio-retention Swales

Since 2000, four estates have been developed using bio-retention swales along the road reserves as an alternative to wetlands.

Bio-retention swale at Wyndham Waters Truganina – highlighting non - maintainable batters.

The bio-retention swale system both treats and conveys the stormwater. The system comprises a 3 metre wide swale either grassed or planted with sedges and an agricultural drain located in filter material approximately 400mm below the invert of the swale. The grass or sedges in the swale removes sediments and phosphorous while the filter material removes nitrogen. The swale is designed to hold the three month flow while it is being filtered and to convey flows greater than the three month flow.

The use of the bio-retention swale system in the road reserve has reduced the cost of the drainage system in new subdivisions. The swale has reduced both the extent of the underground pipe system and the size of the pipes required. The bio-retention swale system in the road reserve has replaced the need for wetlands and avoided the cost of the land required for the wetlands.

While Wyndham has only been limited experience with bio-retention swales, they are already proving problematic. There is concern about the life, maintainability and general community acceptance of the swale system. The problems experienced include:

- root infiltration into the agricultural pipe;
- insufficient road reserve width to accommodate the swale;
- loss of naturestrip carparking;
- steep, unmaintainable batters;
- maintenance of the planting
- damage by service authorities;
- damage by builders;
- sediment blocking the agricultural pipe;
- sediment blocking the surface of the filter material.

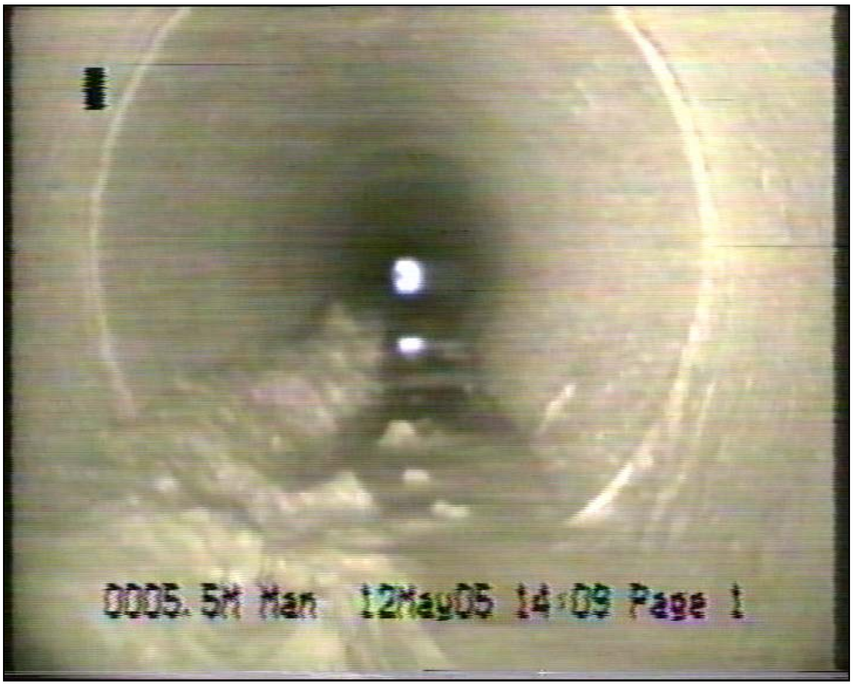
Roots shown entering the 100mm dia. Agricultural Pipe in the Bio-retention System within 12 months of construction

Melbourne Water and Wyndham City Council are developing road reserve cross sections needed to accommodate the bio-retention swale. On average, the road reserve needs to be 3 metres wider to effectively accommodate the bio-retention swale while providing space for the road pavement, carparking, trees and underground services.

4.3 Sedimentation and Erosion Controls

Unlike New South Wales, in Victoria there is little regulation or enforcement of controls to reduce erosion or sediment in stormwater runoff from construction and building sites.

The magnitude of sediment in the stormwater runoff from subdivision construction sites can be gauged by the amount of sediment that is deposited in the stormwater pipe system during construction. In Wyndham it is not unusual for contractors to have to flush 50 and 100 mm (depth) of sediment from the pipe system on completion of construction. This sediment is generally flushed downstream!



Sediment in a 300 mm dia. pipe <u>after</u> the pipe had been flushed on completion of the construction of the subdivision.

5.0 THE STUDY TOUR

The study tour sought to investigation the American experience in incorporating Water Sensitive Urban Design into new residential developments.

The tour focused on the northern part of the country and included:

Seattle	-	City of Seattle
	-	City of Bellview
Minneapolis	-	Ramsey – Washington Metro Watershed District
	-	Maplewood Mall area
Chicago	-	Metropolitan Water Reclamation District of Greater Chicago
Atlanta	-	City of Atlanta
	-	City of Griffin
Baltimore	-	Low Impact Development Centre
	-	Baltimore County

The study tour was limited to the northern states of the United States and it is acknowledged that other practices and treatments may be used in other areas.

Across the northern states there is not a consistent approach to managing the quality and quantity of stormwater and little evidence of Water Sensitive Urban Design.

The City of Bellview, in Washington State, had been implementing programs to control both water quality and quantity since the mid 1970's. At the other end of the spectrum, the City of Atlanta had no water quality program and appeared to show little interest in improving the quality of stormwater. The examples of water quality treatments in Atlanta had been constructed either as a demonstration project by a private conservation body or were initiatives by individual organisations.

The reasons for the inconsistent approach to WSUD are:

- The Clean Water Act;
- A perception of an unlimited supply of potable water;
- The structure of the water supply and drainage authorities.

The Clean Water Act

The Clean Water Act – Phase II, introduced in 1999 is the driving force in improving the Quality of stormwater. The Clean Water Act introduced in 1972, seeking to address the decline in the quality of the waterways and bays focused on the discharge of sewerage plants and industry into waterways.

Phase II of the Act, while seeking to address the quality of storm water discharged to waterways does not set standards for the quality of the stormwater discharged. Phase II only requires the drainage authorities to manage the quantity and improve the quality of the stormwater runoff to the maximum extent possible. As a result of a lack of measurable and hence enforceable standards there is a significant variation in the effort being applied by the various drainage authorities to improve the quality of stormwater.

The Clean Water Act does not encourage the conservation of water.

A perception of an unlimited supply of potable water

Across the northern states of America there is a lack of awareness of the need to conserve water. This is despite the area generally having similar annual rainfalls to south eastern Australia.

The structure of the water supply and drainage authorities

Generally water supply reticulation and stormwater drainage is provided by the same authority. At the present time the major source of revenue for the authorities is generated by water supply charges and there is no incentive for them to encourage the use of stormwater to replace potable water.

6.0 STORMWATER REUSE INITATIVES

The only example of stormwater reuse observed was the use of “rain barrels”. These are 600 litre drums placed at the bottom of roof downpipes. The water collected in the barrels is used only to water gardens. The rain barrels were initially introduced by an entrepreneur seeking a market for a surplus of used wine barrels and not as a water conservation initiative.

Rain Barrel - Atlanta

ADVANTAGES:

- **Attenuates stormwater flows**
- **Allows for the reuse of stormwater at the “source”**
- **Captures the highly contaminated “first flush”**
- **Reduces dependence on high quality potable water supplies**

LIMITATIONS:

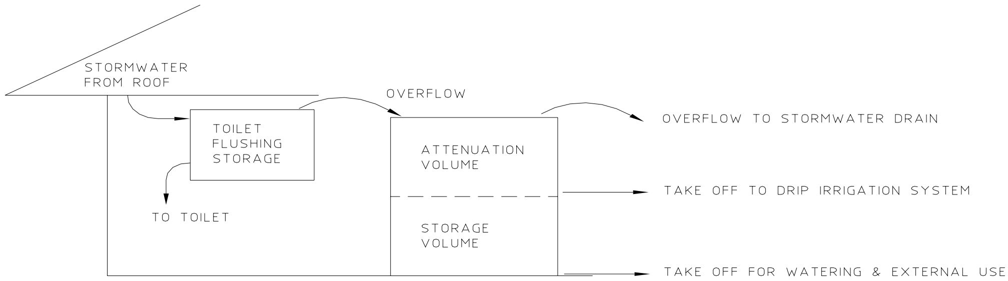
- **Occupies space on residential lots**
- **Relies on maintenance by the resident**
- **Is dependent on regular rainfalls.**

POTENTIAL OPPORTUNITIES FOR INTEGRATION INTO NEW SUBDIVISIONS:

Rain tanks should be mandatory on all buildings. Tanks can significantly reduce the demand on potable water supplies, attenuate peak storm flows and aid in the infiltration of stormwater into the groundwater table.

Stormwater stored in the tank can replace the use of potable water for the flushing of toilets and the watering of gardens.

Stormwater flows could be attenuated by temporarily storing some stormwater in the tank and discharging it by a drip feed pipe system allowing it to infiltrate into the soil and recharge the groundwater supplies mimicking the natural pre development system.



Potential Reuse and Attenuation of Stormwater

7.0 STORMWATER QUALITY INITATIVES

While rain barrels were the only example of water reuse seen on the study tour, there were a number of examples of stormwater quality treatment and initiatives. These included:

- Natural Drainage Systems
- Sand Filters
- Detention Ponds
- Bio-retention Swales
- Catch Pits
- Porous Pavements
- Disconnected down pipes
- Construction Controls

While most of the stormwater treatments and initiatives have been in use for a number of years, there is limited measurement or research into the effectiveness of the individual types of treatments. The evidence presented for the effectiveness of the treatments (as a whole rather than individually) is that the quality of the water in the streams and bays had improved over the last 10 years.

This conclusion ignores that during the same period there was also significant work undertaken and improvements made in the quality of the discharges from sewerage treatment plants. The improvements observed in the quality of the streams are more likely owing to improvements to the sewerage plants discharges than the stormwater treatments.

7.1 Natural Drainage Systems

The Natural Drainage System is designed to reduce the quantity and improve the quality of stormwater runoff by detention, infiltration and filtration through grasses and plant material.

The system comprises a large Vee shaped swale (approximately 4 to 5 metres wide and 1 to 1.5 metres deep) along the naturestrip on one side of the road. The swale is designed to retain the stormwater runoff, provide filtration and allow infiltration into the groundwater. The sides and bottom of the swale comprise a gravel filter layer and a bio-retention layer (sandy loam) and are heavily landscaped

The City of Seattle is constructing “natural drainage systems” in existing residential streets to address both a drainage and water quality issues. Approximately one third of the city, constructed during the 1950’s and 1960’s, has neither a formal drainage system nor kerb and channel on the roads. As the area is hilly stormwater runoff is fast and there are limited flat areas to provide conventual retarding basins and treatments ponds.

The City claims that the Natural Drainage Scheme has resulted in a significant slowing and reduction of stormwater runoff into the streams. Testing is still ongoing on the reduction in total suspended solids (TSS), petroleum hydrocarbons, dissolved metals, faecal coliform and pesticides.

All the landscaping in the swales is being maintained by the City of Seattle; however it is proposed that after three years residents will become responsible for maintaining the landscaping.

Natural Drainage System Swale – City of Seattle

Deep swale posing a potential safety hazard. Natural Drainage System – City of Seattle

In steep or unstable terrain the natural drainage system is not used as the infiltration of stormwater could cause slope instability

ADVANTAGES:

- **Attenuates peak flows by providing storage in the channel**
- **May recharge the groundwater by allowing infiltration**
- **Removes suspended sediments, phosphorous and nitrogen**
- **Can replace the need of a piped drainage system**

LIMITATIONS:

- **Requires significant land (Road reserves need to be at least 18 metres wide)**
- **Infiltration system may become blocked by sediments**
- **The landscaping requires annual maintenance**
- **The depth and steep sides slopes makes maintenance difficult, particularly for residents**
- **The depth and steep side slopes pose a major safety hazard for pedestrian and vehicles**

POTENTIAL OPPORTUNITIES FOR INTEGRATION INTO NEW SUBDIVISIONS:

The Natural Drainage System could be incorporated into public open spaces where the swale could be developed as a landscape feature and the batter slopes reduced to improve both safety and maintenance. The additional land required for the swale could also have a "community value" in enhancing the public open space.

7.2 Sand Filters

Sand filters treat stormwater by filtering the water through a layer of sand which traps sediments and removes nutrients.

Two types of sand filters were observed – a large above ground sand filter (City of Bellveiw) and a small underground sand filter (Baltimore County).

The City of Belview had extensive experience in the use of sand filters and considered above ground sand filters very effective. Initially it was considered that the sand filters would have a life of approximately 5 years before requiring major reconstruction and replacement of the sand filter. However, a number have lasted in excess of 10 years.

The aboveground sand filter inspected at the City of Bellview, was approximately the size of a soccer pitch. The stormwater is passed through large sedimentation and oil separation tanks prior to being discharged to the sand filter. Despite the pre treatment of the stormwater, the top layer of sand in the filter is removed and replaced annually as it blocks with sediment.

Sand Filter – City of Bellview

At the time of the inspection the vegetation on the sand filter was dead and detracted from the appearance of the area.

The Baltimore County uses sand filters, constructed in large underground pits, when retro fitting treatments in small developed areas. Underground sand filters are also used on new small subdivisions (10 to 12 lots) where land is not available or the terrain not suitable for a pond. The filters require regular inspection and maintenance to ensure the filter material is not blocked and the filter holding water. The upper layer of the filter sand is also removed and replaced annually.

Below ground sand filter- Baltimore County

ADVANTAGES:

- **May require less open space than other treatment controls**
- **Underground sand filters can be retro fitted to existing developments**
- **High removal efficiency for phosphorous**

LIMITATIONS:

- **Stormwater requires pre-treatment to removed sediments to extend the life of the sand filter,**
- **Requires regular maintenance,**
- **Requires 1 to 1.5 metre difference between the inlet and outlet levels,**
- **Not suitable in areas where a heavy sediment load is expected owing to the likelihood of the sediment blocking the sand filter,**
- **Neither attenuates peak flows nor allows infiltration.**

POTENTIAL LOCATION FOR USE:

Owing to the high cost of construction and maintenance, sand filters should only be considered in retro fitting developed areas where it is not possible to use an alternative treatment.

7.3 12-Hour Detention Pond

The 12 Hour Detention Pond is the predominant form of water quality treatment used by the municipalities visited owing to the pond providing both flow retardation and water quality.

The ponds can either be dry ponds, designed to empty between rainfall events, or wet ponds, designed to retain some water between events to maintain a small marsh area.

The ponds are generally steep sided and vary in depth between one and five metres. They are fenced and not opened to the public owing to concerns about the potential for children to drown in the ponds or fall through an “iced over” surface during winter. The ponds are either landscaped with plants tolerant to wet and dry conditions or left to revegetate naturally.

There are two types of outlet systems used in the design of the ponds. The simplest outlet system discharges the water through a small pipe outlet. The alternative outlet system uses a network of agricultural drainage pipes under the pond to discharge the detained water.

The stormwater is treated by detention for 24 to 48 hour, allowing the larger sediment to settle. Nutrients are removed through biological contact with the plants in the pond. In ponds with an agricultural drain outlet nutrients are also removed by biological contact with the sand filter around the agricultural drains.

The ponds require minimal maintenance. Baltimore County has 700 ponds maintained by six employees. Maintenance involves annual slashing of the grass and thinning of the under growth. Ponds with the agricultural drainage system may require the agricultural pipe system flushed or the filter material scarified or replaced if the pond hold water for longer than intended.

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Detention Pond – City of Griffin - showing risers for flushing of the Agricultural drains

ADVANTAGES:

- **Controls both the quantity and quality of the stormwater**
- **Low construction and maintenance costs**
- **Can be retro fitted into existing retarding basins**
- **Efficient at removing sediments – the longer the detention time the greater efficiency**
- **Can be incorporated into public open space**

LIMITATIONS:

- **Only moderately effective in removing phosphorous and nitrogens,**
- **Requires a relatively large area of land**
- **Sediments can become re - suspended after large storms,**
- **Can contribute to the breeding of mosquitoes.**

POTENTIAL OPPORTUNITIES FOR INTEGRATION INTO NEW SUBDIVISIONS

Owing to the pond being only moderately efficient in the removal of phosphorous and nitrogen, its use is not recommended unless used in conjunction with grass swales or other forms of water quality treatment.

7.4 Bio - Retention Swales

The bio-retention swale operates by detaining the stormwater allowing sediments to settle. Nutrients are removed through biological contact with either the plants in the swale or the filter material around an agricultural drain under the swale.

Three bio-retention swale systems were inspected - Belly Creek Highway, a residential subdivision in Baltimore County and Maryland University.

The Belly Creek Highway bio-retention swale was constructed in 1999-2000 to serve a catchment of 120 acres of highway. The swale is approximately 15 to 20 metres wide; several hundred metres long and two to three metres deep. It is located along the side of a state highway.

The swale failed within a few months of construction owing to sediment blocking the filter material. At the time of inspection the swale was being reconstructed with a larger diameter agricultural pipe system, a 1.5 metre wide sand filter strip over the agricultural pipes and landscaped with swamp plants.

Large Swale – Belly Creek Highway

Baltimore County trialled bio-retention swales in residential areas and reported that the swales were not successful. In addition to the swales being prone to freezing, they were not accepted by residents. One bio-retention swale in a new housing estate was abandoned and filled in shortly after it was completed owing to resident opposition. County officers did not support the use of swales and considered that if swales are used they should be placed in easements within properties.

The third bio-retention swale inspected is in a car parking area at Maryland University. The swale is approximately 2 to 3 metres wide and one metre deep. It is located within the islands separating the car parking areas and along one side of the car park. While no detail could be provided on either its construction or maintenance it appears to be functioning and maintained with minimal effort. The natural appearance of the swale complemented the natural bush landscaping around the University.

Bio-retention swale in car park at Maryland University - Baltimore

ADVANTAGES:

- **Highly efficient in removing suspended solids, phosphorous and nitrogens**
- **Can be incorporated into landscape features in car parks and open spaces**
- **The swale can replace the conventional stormwater pipe drainage system in the upper catchment**
- **Attenuates the peak flows by providing storage in the swale and slowing runoff.**

LIMITATIONS:

- **Where used in the road reserve requires the road reserve to be increased in width by 3 to 4 metres to accommodate the swale**
- **The life of the filter material and Ag system (before becoming blocked) is unknown**
- **The swale, filter and Ag system is prone to damage by off street car parking and building activity**
- **Higher maintenance costs compared to kerb and channel and centralised treatments**
- **When used in nature strips responsibility between the resident and council for its maintenance is unclear**

POTENTIAL OPPORTUNITIES FOR INTEGRATION INTO NEW SUBDIVISIONS:

Bio-swale systems could be used in public open spaces (reserves, parks, golf courses, car parks etc) where the swale could form part of the landscape feature, maintained by council and be protected from damage. In these locations, the additional land required for the swale could be of value to the community and help offset the additional maintenance costs.

Owing to the need to increase the width of the road reserve by 3 to 4 metres to accommodate the swale, the potential for damage to the swale by cars parked off the road and high maintenance costs it is not recommended that the swale be used in the road reserve except in small localised areas.

7.5 Catch Basins

The City of Bellivew uses a 300mm deep sump in its side entry pits to trap sediment and street litter in minor stormwater flows. The City considers that the sumps are more effective than street sweeping in removing sediments and litter from stormwater and the street sweeping plant more effectively used cleaning sumps annually. It is acknowledged that holding water in the sumps does cause some complaints from residents about stagnant water and mosquito breeding.

ADVANTAGES:

- **Traps some suspended solids and litter**
- **Low cost to construct**

LIMITATIONS:

- **High maintenance costs owing to the need to regularly clean a large number of sumps**
- **Trapped material may become resuspended during high intensity storms or if not regularly cleaned**
- **Water and material trapped in the sump may become putrid and contribute to the breeding of mosquitoes.**

POTENTIAL OPPORTUNITIES FOR INTEGRATION INTO NEW SUBDIVISIONS:

The use of sumps is not recommended owing to the high maintenance cost in regularly cleaning a large number of sumps and their limited effectiveness.

Strategically located gross pollution traps (GPTs) are more effective in trapping suspended solids and litter. The cost of maintaining a few strategically located GPTs is significantly less than regularly cleaning a large number of sumps.

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7.6 Permeable and Porous Pavements

Permeable and porous pavements are being trialled in a number of locations to allow the stormwater to infiltrate into the groundwater or to filter stormwater prior to its collection by a conventional drainage system.

Permeable pavements are constructed using concrete blocks with either holes through the blocks or gaps between blocks. These voids are filled with a filter material which allows water to pass through to drainage and filter layer. The water is then either held in the drainage layer and allowed to infiltrate into the groundwater or drained to a collection point.

The permeable pavement inspected in Maplewood was three weeks old. It is in a court bowl in an existing residential subdivision and was constructed by removing the upper layers of an existing pavement and replacing them with the concrete blocks on a drainage layer. The voids between the concrete blocks are filled with a 5 mm screenings.

Permeable Pavement – City of Maplewood

Close up view of the permeable pavement

Porous pavements are constructed with "open graded "material which allows the water to pass through the pavement either to infiltrate into the ground or drain to a collection point.

Porous pavements were inspected in Atlanta. One is in a car park and the other a residential driveway. Both pavements are constructed with an open graded (no fines) concrete surface layer over a filter and drainage layer.

Car park with a porous pavement – City of Atlanta

Close up view of porous concrete pavement

ADVANTAGES:

- **Utilises existing pavement area for water quality**
- **Attenuates minor flows**
- **Allows infiltration to sandy soils**
- **Removes sediments**

LIMITATIONS:

- **Prone to clogging with sediments. The City of Bellview trialled porous pavements in the 1990's, however they were easily blocked with silts and oils.**
- **Not suitable for use on expansive soils**
- **Not suitable for use in areas under construction where mud could be deposited on the pavement and block the "opens"**
- **The pavement is not as strong as a conventional concrete or interlocking block pavement**
- **The permeable or porous pavement surface (interlocking blocks or porous concrete) is not as strong as the conventional pavement surfaces and does not add to the strength of the pavement.**

POTENTIAL OPPORTUNITIES FOR INTEGRATION INTO NEW SUBDIVISIONS:

Permeable and Porous pavements could be used in residential driveways. Porous concrete pavements could also be used for residential paths and public footpaths where high pavement strength is not required and in car parks provided the pavement base is designed to be free draining and with sufficient strength to support a non-structural surface.

Where either a permeable or porous pavement is used, consideration should be given to deferring its construction until all other building activity is completed in the area to minimise the risk of mud and silt from the construction activity clogging the pavement.

7.7 Disconnected Downpipes

On a number of residential developments, the down pipes from the house roof gutters are not connected into an underground drainage system and instead discharged onto garden or lawn areas. The City of Bellview also encourages residents to disconnect down pipes on existing buildings from the underground drainage system.

Disconnecting down pipes from the underground drainage system reduces runoff, sediment and nutrients, allows infiltration, and retards the stormwater discharge.

On the housing estate where disconnected down pipes were observed, the houses had been constructed as part of the medium density multi-house development (similar to town house developments in Australia). The discharge from the down pipes is controlled by grading the land away from the buildings and allowing the stormwater to flow to cross garden and grass areas towards a common driveway.

If large single house lots cannot be graded to the street, shallow swales are graded along the rear or sides of the lots to control the flow of stormwater from one property to the next property. (This treatment was not seen.)

Example of a disconnected down pipe

ADVANTAGES:

- **Attenuates peak stormwater flows**
- **Allows infiltration**
- **Removes sediments if the stormwater is discharged onto a grassed area**
- **Proves water for landscaped areas**
- **Reduces the extent of the underground drainage system**

LIMITATIONS:

- **Requires detailed control of the grading of the site to control the overland flow of stormwater and placement of downpipes on buildings to avoid nuisance flooding problems**

POTENTIAL OPPORTUNITIES FOR INTEGRATION INTO NEW SUBDIVISIONS:

Disconnected downpipes could be used on multi unit development and residential subdivisions where the building and landscaping are planned and constructed at the same time.

Disconnected down pipes would not be appropriate on the conventional type of subdivision where the subdivision of the land and the construction of the houses are done independently of each other.

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7.8 Construction Controls

A number of States have controls to stop or at least limit the amount of sediments in the stormwater run off from construction sites.

In the State of Maryland, a grading permit is required for any grading activity exposing more than 5000 square feet or excavation of more than 100 cubic yards of soil. The permit requires a plan detailing the sequence of works and controls to limit erosion and sediment leaving the site.

The construction controls used include

- Minimising the area being cleared
- Protecting trees
- Temporary Sedimentation ponds
- Silt fencing
- Diverting water away from cleared areas
- Silt traps on drainage pits
- Hydro seeding of disturbed areas left stripped for more than 21 days and
- Truck tyre cleaning areas at the exit of the site

In addition the person in charge of the site must have undertaken a half day training program in erosion and sediment control.

The subdivision construction site inspected in Baltimore County used extensive silt fences, temporary silt traps on the side entry pits. All runoff from the site was also directed through a temporary sedimentation pond.

ADVANTAGES:

- **Reduces the amount of sediment and silt produced by construction activities**
- **Reduces the sediment load and maintenance on downstream water quality treatment facilities**

LIMITATIONS:

- **The construction controls need to be maintained during both the land development and building construction phases**

POTENTIAL OPPORTUNITIES FOR INTEGRATION INTO NEW SUBDIVISIONS:

Construction controls to limit the generation and transportation of sediment should be mandatory on all construction sites where more than 300 square metres of vegetation is removed or 100 cubic metres of excavation occurs.

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8.0 RECOMMENDATIONS FOR INCORPORATING WATER SENSITIVE URBAN DESIGN INTO NEW DEVELOPMENTS.

Based on both the study tour and my experience as a municipal engineer involved in subdivision development the following are my recommendations for incorporating WSUD into new subdivisions.

- All new subdivisions should be designed to reduce their reliance on the potable water supply and to control and treat the stormwater to the appropriate standards for discharge to the rivers and bay. Water Management (Conservation) Plans should be mandatory as part of the design of new subdivisions. The plan should cover
    - Measures to minimise the use of potable water;
    - Reuse of stormwater and treated sewerage effluent;
    - Landscaping to minimise the use of water;
    - Stormwater quality treatments.

- Stormwater Management Plans should be mandatory for the construction phase of all subdivisions. The plan should cover both the initial construction (construction of the roads, drains and services) and a period of two years while the houses and landscaping is developed.

- A training course similar to the Maryland's erosion and sediment control course should be developed by the Environment Protection Authority, Melbourne Water or the construction industry and it should be mandatory for the person in charge of the subdivision construction site to have undertaken the course.

- Integrated developments, similar to multi-unit developments, where the subdivision and the houses are planned and preferably constructed together, should be strongly encouraged. This would allow
    - the disconnection of house roof down pipes from underground drainage systems without causing flooding issues;
    - deferring the construction of WSUD treatments, which can be damaged during the house construction phase until the houses are completed;
    - maximising the options to incorporate WSUD into the design of both private and public spaces.

- Rainwater tanks should be mandatory on all new houses and sized to retain all runoff from the house roof. The tank should supply water to the toilet cisterns and gardens and discharge to a drip irrigation system. This would reduce consumption of potable water, attenuate peak stormwater flows, irrigate gardens and allow infiltration.

- Owing to the difficulties in maintaining and ensuring the long term operation, swales and rain gardens should not be used in residential streets unless incorporated into landscaping features to provide water. Examples of these treatments are a rain garden replacing a potable water irrigation system or “kerb cuts” opposite naturestrip trees to provide water to the trees.

- Stormwater quality treatments should preferably be placed in public open space. This would allow easier maintenance, monitoring and protection of the treatments. It would also allow better utilisation of the land required for water treatment facilities than the widening of road reserves for swales. Treatment options could include swales, ponds and wetlands.

9.0 CONCLUSION

In the 1980’s and 1990’s WSUD was about protecting waterways down stream from urban development through improving the quality of stormwater discharged from the developed areas. Today WSUD also includes protecting the waterways upstream of urban development by minimising the demand for potable water.

Based on my observations on the study tour, WSUD has only been partially implemented in the United States. In a number of cities there is significant effort and progress in treating and improving the quality of stormwater discharged to waterways from urban areas - mainly through the use of ponds. However, there is little effort and progress in using stormwater to reduce the use of potable water and hence minimise the impact of urban development on the streams which supply potable water.

I consider that Melbourne surpasses the cities visited in the United States in implementing WSUD on new residential subdivisions. The standard and quality of the stormwater treatments being used in Melbourne is at least equal to those used in the United States. In addition Melbourne is seeking to reduce its usage of potable water by encouraging the installation of rainwater tanks to use stormwater for watering of gardens and flushing of toilets.