Experiences with Stormwater Pit Pollutant Traps:

The Upper Parramatta River Stormwater Source Control Project

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abstract

Stormwater Pit Pollutant Traps are a relatively new technology that has not been comprehensively evaluated in Australia. This discussion paper summarises four integrated projects in the Upper Parramatta River Catchment, west of Sydney, that demonstrate and evaluate stormwater pit pollutant traps sourced from Australia, NZ and USA. Results from a pollutant retention monitoring program are presented, highlighting the effectiveness of the devices to retain high proportions of litter and sediment. Design issues for each pollutant trap are summarised in Appendix 2 and highlight the need for modification of all devices under trial. Recommendations for the selection of stormwater pit pollutant traps and for further monitoring are made.

keywords

Exerts, Pit Inserts, Pollutant traps, Source Control, Stormwater.

introduction

Throughout a number of developed countries, studies have determined that urban runoff and combined sewer overflows represent potentially the most serious water quality problem (US EPA, 1983; Ellis, 1986; Marsalek, 1986). The problem is no less significant in Australia, and for the last 15 years has amassed interest evidenced by the increasing number of technical papers and conferences on the subject.

The management of stormwater quality globally is still at an infant stage, with the continuation of trials of various structural and non-structural techniques. These ‘Best Management Practices’ (BMPs) for stormwater are constantly evolving and being refined, causing stormwater BMP manuals to be out of date within 5 years of publication.

In the US and Australia, the majority of systems installed to date are ‘in-line’ and ‘end-of-pipe’ technologies (Watershed Management Institute, 1997; Environment Protection Authority, 1997a; Victorian Stormwater Committee, 1998). The NSW Stormwater Trust Grants for 1998 (Stage 1) gave evidence of this focus, with a minority of projects concentrating on community education. However, the NSW Environment Protection Authority (1997b) endorsed a ‘stormwater management hierarchy’ that is shown in Figure 1.

*if degraded

Figure 1 – Stormwater Management Hierarchy (from EPA 1997b)

Maxted and Shaver (1996) and Shaver *et al* (1996) provided evidence that managing stormwater quality using a simple “quick fix” or “best management practice” approach is not sufficient to mitigate the impacts of urbanisation in a catchment. To this end, stormwater managers need to consider a number of aspects such as;

- Pollutant loads from diverse land uses q The response of water bodies to these pollutant loads

q The response of aquatic ecosystems to altered flow, water quality and other impacts

q The effectiveness of stormwater best management practices

q Altered geomorphology due to changed flow regimes

q The value and accuracy of water quality and hydrological modeling.

The purpose of this paper is to consider managing the diversity of issues related to stormwater using source control principles, namely at-source structural controls.

stormwater issues in the upper parramatta river catchment

The Upper Parramatta River Stormwater Management Plan (1999) identified a gamut of water quality and stormwater issues in the catchment. Of these issues, a number of pollutant issues were highlighted as critical:

w High levels of total suspended solids in the river and tributaries

w Significant litter loads from major commercial precincts

w Frequent and detrimental toxicant spill events from industrial estates

w Unknown quantities of oils and grease from commercial and industrial areas.

More specifically the following areas were identified as “hot spots” in the Stormwater Management Plan:

- Castle Hill Commercial Precinct

- Girraween Industrial Estate

- Parramatta CBD (Church Street to Darcy Street)

- The Blacktown “Mega-Centa” and St Martins Shopping Village, cnr. Blacktown and Bungarribee Roads, Blacktown.

These “hot spots” were identified as a result of consultation with local Streamwatch school groups and Council and Trust staff. Each site possesses individual pollution problems. The “hot spots” are the locations in the catchment that are impacting substantially on the aquatic ecosystem, or are indicators of ecosystem decline. Examples of “hot spots” may include particular industrial estates or premises, commercial precincts, sewer overflow points, parks approved for animal recreation, and heavily trafficked motor transport nodes (e.g. Pitt and Bozeman, 1982; Bannerman *et al* 1993; Shaheen 1975).

Castle Hill is a heavily trafficked (37 500 AADT cnr. Showground & Old Northern Roads) shopping centre that occurs at the highest elevation (180m) in the Catchment, producing a variety of oils, litter, contaminated sediments and heavy metals that flow almost the complete length of Darling Mills Creek. The pollutants impact on this creek with obvious indicators of sediment deposition, noxious and environmental weed proliferation, and reduced species richness of indicator macro-invertebrates.

Girraween Industrial Estate is an 86ha subdivision that represents 228 businesses ranging from small automotive industries through to large multi-national manufacturing companies. The site lies adjacent to Toongabbie Road and discharges directly to Greystanes Creek. Heavy vehicles, including hazardous materials transporters, represent a significant portion of the daily traffic along Toongabbie Road and pose the potential for a serious pollution event. The Industrial Estate has been subject to a number of residential complaints for illegal discharges of fuels and sudsy solutions. Girraween High School's Streamwatch group regularly monitors water quality at Greystanes Creek and is currently involved in a catchment audit and business drain-stencilling program.

The "Main Street Clean Street" project at Parramatta involves the treatment of pollutants flowing from one of the most popular regional centres in Australia. In 1997, the CBD attracted 68 000 pedestrians daily, including 23 000 in the hour between 12 and 1pm (Parramatta City Council, 1998). The site contains 98% of impervious surfaces. Litter, combined with automotive emissions such as brake dusts and oils, are the main pollutants of concern. Issues such as access to stormwater drainage systems and the age of the infrastructure create unique challenges for the project.

The St Martins Mega-Centa and Shopping Village project addresses stormwater pollution from a retail bulky goods and fast food complex on the corner of Blacktown and Bungarribee Roads, Blacktown. The site predominantly consists of hard surfaces (87%), and is swept and maintained by on-site staff seven days a week. Litter from consumers, oils from itinerant vehicles and leachate from waste receptacles are the pollutants of concern, as identified by the Mitchell High School Streamwatch group. The site provides an ideal opportunity for demonstrating various source control methods, with excellent accessibility and a relatively recent pre-cast stormwater drainage system. Although the site is relatively new (Village 1988, Mega-Centa 1994), the installation of the pavement was not carried out satisfactorily, causing numerous stormwater inlet pits to be offset.

project origins

In response to the issues identified in the Stormwater Management Plan, the steering committee resolved to apply for Stormwater Trust funding for four projects demonstrating stormwater source control principles and representing the four local government areas of Baulkham Hills, Blacktown, Holroyd and Parramatta within the Upper Parramatta River Catchment. A consultant was engaged by the Upper Parramatta River Catchment Trust to identify potential source control methods and write the Stormwater Trust Stage 2 Grant Applications on each Council's behalf. The "hot spot" areas identified above were determined as pertinent sites for such demonstrative projects. The following objectives were formulated for the combined projects:

← Improve the practice of trapping stormwater pollutants and reducing pollutant loads at the source

← Promote understanding and acceptance of pollution problems and the liabilities and support from business and industry

← Enhance communication and relationships with stakeholders and the councils

← Initiate changes in work practices to reduce the environmental impacts of the industrial and business operations

← Act as a demonstration project for best practice standards

← Support the protection of the environment by reduction in litter, hydrocarbon and sediments contamination

← Feedback the results and performance of the projects to polluters

← Monitor the effectiveness of the project and justify the benefits for ongoing implementation

← Establish self-sustaining projects for local communities and business

Design and Installation of At-Source Controls

Each project site with its own specific problems required careful assessment of drainage networks, major pollutant sources, the target group and consideration of access for maintenance. Every stormwater pit was identified and photographed with accompanying data on observed pollutants, potential catchment pollutant sources, pit dimensions, obstructions, linkages in the stormwater network, direction of flow and access maintenance. The extensive investigation took two months to complete, but provided a wealth of information to the Grants Project Team, suppliers of stormwater treatment devices and the education and promotion consultants. Based on the investigation and comprehensive literature review, the following performance objectives for at-source structural treatments were realised:

1. Total suspended solids, oil and grease and rubbish (anthropogenic litter) are the target pollutants. Suspended solids, including sediments, are particularly important because a large fraction of the heavy metals in stormwater are adsorbed to their surfaces (Revitt *et al*, 1981), with the degree of contamination related to the type of land use (Xanthopoulos and Augustin, 1990). Birch *et al* (1999) found that dust from a selection of roads in the Iron Cove catchment was a significant source of heavy metals. Nutrients are largely associated with finely graded organic particles (<125µm) (Lloyd and Wong, 1999), and oil and PAHs can be associated with organic solids (Colwill *et al*, 1984).

Hydrocarbons are primarily contributed from vehicles and in large quantities, having damaging effects on humans and environmental health (Bomboi and Hernández, 1991; Eganhouse *et al*, 1981; Farrington and Tripp, 1977; Zürcher *et al*, 1978). Rubbish, although ecologically less significant than the former pollutants, is considered a serious issue for the maintenance of aesthetic quality in the waterways and is considered by the study area communities as undesirable (Molino Stewart, 1999).

2. Toxicants, assumed to be more likely from Girraween, would vary in type and quantity based on the industry type and the likelihood, frequency and magnitude of pollutant discharges. This agrees with research conducted by Line *et al* (1996).

3. Structural treatments should not increase the risk of flooding and should not significantly alter stormwater flows.

4. The treatments should be low-cost in terms of both capital and operation/maintenance and equivalent in terms of cost-benefit to in-line and end-of-pipe treatments.

5. A practical approach is necessary, based primarily on observation and anecdotal information, as funding for monitoring is limited. Considerations such as occupational safety and ease of installation and cleaning are considered paramount to the evaluation.

In view of the performance objectives, the Grants Project Team considered stormwater pit pollutant traps or inserts as most appropriate for the Castle Hill, Parramatta and Blacktown sites. The main attractions of this treatment technique were that the pollutant traps had not been investigated in the catchment beforehand and only in a few cases within Australia, and the visibility of trapped pollutants in the pits and maintenance procedures could be integrated into an education campaign. Given the lack of interest expressed by landowners and occupiers to participate in a trial, and the diversity of industries, drainage systems and configurations discovered in a catchment audit, it was determined that stormwater pit inserts would not be appropriate in the Girraween Industrial Estate. As a result, alternative solutions were considered.

An extensive literature review of stormwater pit inserts was conducted using on-line serial and Internet search engines. A number of pertinent US studies highlighted the opportunities and constraints of the devices, ie. Alsaigh *et al* (1999), Ambient Engineering (1998), Interagency Catch Basin Insert Committee (1995), Leif (1998), Pitt and Field (1998), Stenstrom and Lau (1999), URS Greiner Woodward Clyde (1999). Furthermore, the results of field trials of side entry pit litter traps in Coburg, Victoria (Allison *et al*, 1997) and a laboratory-tested prototype side entry pit insert in South Australia (Nilson *et al*, 1995) were considered.

Expressions of Interest advertisements were placed in the free e-mail list 'LAWNADS' and the Weekend Australian. A shortlist of suitable suppliers of stormwater pit inserts was created and quotations from those suppliers were obtained for supply and installation. Furthermore, a New Zealand company, Enviropod NZ Ltd, was contacted to provide a quotation for supply and installation.

A consultant assisted the Project Team in identifying appropriate US stormwater pit pollutant traps, of which a total of 12 designs from 3 companies were selected. The companies were contacted by e-mail and facsimile to obtain quotations for supply of pit pollutant traps to Sydney airport. A local contractor was selected to install the inserts.

Copies of relevant material of the approved stormwater pit pollutant traps are provided in **Appendix 1**. The total cost to supply and install 165 stormwater pit pollutant traps was $91,290, including importation and customs clearance expenses.

Prior to installation of the pollutant traps, another assessment of pollutant sources was undertaken at the sites. Three target pollutants were considered – sediment, oils and litter. Nutrients were not considered a target pollutant due the small proportion of landscaped areas at all three sites. Heavy metals were considered important, but it was assumed those captured by the traps would be bound to sediment particles. Each pit was assigned a primary and secondary target pollutant in order of priority. The devices were chosen based on the manufacturers' claims to efficiently remove one or more of the target pollutants.

Evaluation of Stormwater Pit Pollutant Traps

Design of Monitoring Program

Quotations for the maintenance and monitoring of the stormwater pit pollutant traps were obtained. The brief required the contractor to undertake a minimum of 5 maintenance and monitoring procedures. Monitoring of the devices included the following aspects:

- Providing a photographic record of each installed stormwater pit treatment device. Digital records are preferable.

- Documenting any visual defects in each treatment device, eg:

  - torn, cracked, corroded or broken material of the device

  - clogged filters

  - faulty mechanisms

  - evidence of scouring or re-suspension of captured pollutants

Ø evidence of pollutants bypassing device

Ø blockage of pipes and potential flooding

Ø poor sealing of device against pit walls, allowing pollutants to escape through cracks

v Documenting whether the pollutants in the device are kept out of standing water

v Undertaking additional inspections after rainfall events equal or greater than 10 mm

v Separating pollutants found in each stormwater treatment device into the following categories:

Ø Domestic Plastics

Ø Industrial Plastics

Ø PET Bottles

Ø Metals

Ø Oil and grease (including cooking oils, hydraulic fluids, motor oil, distillate and petroleum)

Ø Paper

Ø Sediment

Ø Organic Matter

v Documenting the proportion the pollutants captured as % volume of the total load

- Collecting, on a minimum monthly basis, all pollutants captured by each stormwater pit treatment device in standard bags of known volume that are removed, dried and weighed

- Documenting the dry weight of pollutants captured for each treatment device

- Commenting on the relative ease of cleaning for each type of treatment device based on cleaning method recommended by device supplier

Summary of Monitoring Results

Table 1 summarises the dry weights and cleaning times collected monthly by the monitoring and maintenance contractor, Stormwater Systems, over the five-month period (February - June 2000). **Figures 1-3** show the average proportion of pollutants retained within each device. The results do not portray efficiencies of the inserts, rather they indicate the pollutant or pollutants favoured by each device. The results indicate that the Dencal 'L-shaped frame' and Wire Baskets favour coarse litter, the Pit Bull exert effectively retains sediment, and the Enviropod and Ecosol devices provide overall pollutant retention capabilities. The figures indicate differences in the ambient pollutant loads; Parramatta and Castle Hill harbouring significant quantities of leaf litter (organic matter), whilst St Martins appears to be more a source of small anthropogenic litter such as cigarette butts. This may be attributed to the daily cleaning and maintenance of the shopping centre removing a large proportion of the larger size rubbish and debris. In terms of cleaning time, the Dencal is the most efficient of the devices, and the Pit Bull the least efficient. This relates to the method of cleaning, Pit Bull requiring removal of the unit from under the grate as opposed to direct vacuuming of the material in the Dencal, Ecosol and Enviropod devices.

Ecosol

Enviropod

Dencal

Pit Bull

Total No. Units

21

29

42

18

Average Dry Weight (kg) all sites

6.47

6.12

3.88

3.43

Average Dry Weight (kg) Parramatta

6.01

5.91

5.11

4.65

Average Dry Weight (kg) Castle Hill

6.92

7.88

4.33

3.83

Average Dry Weight (kg) St Martins

NA

4.58

2.21

1.82

Average time to Clean/month (min)

7.70

7.76

6.24

9.00

Table 1 - Average Dry Weight and Cleaning Times for Selected Stormwater Pit Pollutant Traps based on five samples at one-month intervals (February – June 2000)

Figure 2 – Mean Proportions of Pollutants Retained in Stormwater Pit Pollutant Traps at Parramatta

Unfortunately the installations of US devices were delayed due to shipment delays and difficulties in obtaining the services of a contractor. The installations occurred on 28 April 2000. Current data is insufficient for analysis. The devices will require further monitoring to determine their pollutant retention capabilities.

Oil sorbents will be removed during July for analysis. According to a literature review of stormwater pit insert devices (URC Greiner Woodward Clyde, 1999) and findings of Stenstrom and Lau (1999), the inserts show promise for significant retention of petroleum hydrocarbons.

Figure 3 – Mean Proportions of Pollutants Retained in Stormwater Pit Pollutant Traps at Castle Hill

Figure 4 – Mean Proportions of Pollutants Retained in Stormwater Pit Pollutant Traps at St Martins, Blacktown

According to information supplied by Stormwater Systems, a total of 400-600 kg of material has been removed from each site on a monthly basis. The Blacktown site on average produces 300 kg of material, which relates to the smaller catchment size (6.5 ha) and daily sweeping. Parramatta CBD, although swept daily, is the largest catchment (23 ha) with a high visitation rate and 98% impervious. Castle Hill is swept 3 times a week and is approximately 16 hectares in area.

The results in Table 1 concord with the findings of field trials in the US, notably:

〈 Rubbish, debris and sediments were the main pollutants retained by the inserts (Interagency Catch Basin Committee, 1995; Ambient Engineering, 1998; Alsaigh *et al*, 1999). Although a particle size analysis has not been undertaken on the collected materials, the observed sediments appear to favour the sand fraction. This agrees with Leif (1998), who found medium sand to be most readily collected by the units.

〈 The average time to clean each stormwater pit insert is 5 minutes (Interagency Catch Basin Insert Committee, 1995). However, manual cleaning methods may extend the interval to 30 minutes, as quoted in Alsaigh *et al* (1999).

Observations by Maintenance/Monitoring Contractor

A summary of the observations made by the contractor that are of value to stormwater practitioners are provided below:

← All stormwater pit pollutant traps on trial are functioning. However, the Pit Bull device requires modifications to reduce the potential for flooding and to prevent bypass of pollutants as a result of dislodgment by vehicular traffic.

← A two-person team is the minimum requirement for maintenance of the units and a three-person team is optimal to effect an efficient and safe operation. The removal of the cast iron pit grates requires two persons, however, installation and removal of the inserts and exerts can be effectively undertaken by one person. This agrees with the findings of the Interagency Catch Basin Insert Committee (1995).

← Decanting of liquids from the inserts and exerts was not required at any time during trial since the units other than the Aquanet Gullywasher Oil/Water Separator drained completely between rain events.

← A six-inch, custom-designed hose was installed on the eductor truck with enough flexibility to enable adequate movement around stationary vehicles but maintaining a certain rigidity to extract bulky and sharp materials.

← The Enviropod and Ecosol units included a large sump capacity to trap pollutants. As a result, a larger proportion of pollutants was recorded in these units. However, these units can not retrofit pits with shallow obvert depths in contrast with the Pit Bull, Dencal and Suntree Curb Inlet Protector.

← The stormwater pit pollutant traps employing flexible gaskets to seal around the perimeter of the units were found to be more effective in retrofitting pits, particularly where a large proportion of pits were offset. The findings of the Interagency Catch Basin Insert Committee (1995) of Washington State US were similar, highlighting that some configurations of inserts can allow stormwater to enter the stormwater pit between the pavement and the outer edge of the grate frame, passing beneath the frame of the insert.

← Cleaning of the inserts, particularly during summer, needs to be reduced from a monthly to fortnightly basis. This agrees with the recommendations of Ambient Engineering (1997) in a study of catch basin inserts at Whitmans Pond, Weymouth, Massachusetts USA.

← Hypodermic syringes were observed in pits at all three demonstration sites and between 5 and 6 items were removed during each cleanout. Considering stormwater waste should not include sharps, this poses a significant challenge to cleaning contractors.

← Sediments were more prominent in inserts and surrounding exerts at Castle Hill and Parramatta than Blacktown. This has been attributed to thorough pavement cleaning on a daily basis at the Blacktown site.

← Major sources of litter were found within the Church Street Mall, Parramatta and the Terminus Street car park, Castle Hill. The high level of pedestrian movements is attributed to the former, however, poor litter management is considered the greatest problem at the latter site.

← Comparing in-line and end-of-pipe technologies with stormwater pit pollutant traps and exerts, the lightweight organic materials were observed to be more readily retained by the insert and exert systems. In-line systems generally contain very small proportions of lightweight organic matter.

Design Considerations

Appendix 2 includes a table summarising the designs of each device considered in the study. The table includes criteria summarising the observed design issues based upon a desktop study and field investigation. These issues have been ratified by the overseeing committee, the Grants Project Team. A salient feature of this overview is the obvious correlation between capital cost and sump capacity of the devices. The most expensive devices available locally have more intricate features and are typically designed to retain finer materials such as sediments and oils. The cost of the devices depends upon the target pollutants and the materials. In the present study, the capital cost of individual units varied from $130 to $826 for local (Australian and New Zealand) devices and $193 to $1320 (USA), excluding customs clearance and freight. Please note that at the time of ordering, the US dollar was $0.63 AUD. As shown in the table in Appendix 2, it is obvious that all devices require modification, although these are generally minor.

Findings of Value Management Study

A Value Management Study facilitated and reported by Tooher Gale and Associates (2000) involved key stakeholders in the trial of stormwater pit pollutant traps. The report identified the following issues related to the use of the devices:

〈 Sediment is a serious pollutant and should be targeted

〈 Cigarette butts, containers and plastic bags are significant pollutants.

〈 Different devices are designed and used for different locations/conditions.

〈 Maintenance and cleaning plant should be used for awareness/education/sponsors by displaying project signs and advertising.

〈 Disposal of sharps is a significant issue, considering the requirements for disposal of stormwater waste. This concords with the observations of the maintenance/monitoring contractor.

〈 Recycling of pollutants is not economically feasible, as the cost of separation is too expensive.

〈 Good drainage diagrams are essential for efficient trap installation. Parramatta City Council's drainage diagram for the Church Street study area was poorly reproduced and difficult to interpret.

〈 All traps are to be fitted tightly against the pits to prevent pollutants passing through the gaps. Further discussions with suppliers need to occur to overcome this problem.

〈 Access to pits is important. Location of the pits should allow reasonable access for maintenance and operation. Difficulties such as parked vehicles and access to restricted areas such as the Church Street Mall need to be considered early in the design.

〈 Traps should be cleaned at least once per month for maintenance of operation efficiency. This concords with the findings of the maintenance/monitoring contractor.

〈 From observations over the trial period, all traps are working well with little maintenance[1].

〈 Manual cleaning is cost-prohibitive. The uses of an eductor truck or vacuum unit on street cleaning plant are recommended as the most efficient options.

〈 The cost of cleaning is critical to the further implementation of stormwater pit inserts and exerts.

Based on the above observations, the Value Management workshop team decided to adopt the generic classification approach and agreed to classify the pollutant traps in the following groupings:

- Oil Inserts

- Litter Inserts

- Litter and sediment inserts

- Exerts (devices that sit outside of the pit, generally attached to the lintel of a side entry pit)

In summary, the overall performance of stormwater pit pollutant traps is considered satisfactory to meet the technical and functional requirements. However, the selection of traps needs to be carefully considered to maximise the performance of the traps according to the location and operating environment. Rather than evaluating the individual technical performance of the traps, the team has developed and agreed with a best practice process for planning and selection of traps suitable for a specific site.

The planning process for selection of suitable stormwater pit pollutant traps at a specific location and environment isidentified and set out in Figure 5.

Source Control Device Type   Location and Environment
Proprietary Models

〈 Commercial

- Shops (litter)
- Pedestrian (litter)
- Car Parks (oil, litter, sediment)
- Landscape (sediment)

2,3

2

1,3

4

(Medium/large capacity)

(Medium/large capacity)

〈 Industrial

- Auto repairs (oil)
- Transport (oil / sediment)

- Other (litter)

1

1,3

2

〈 Transport (litter)

Corridors (oil /sediment)

1,3

4

(No low point, street sweeping)

(Stop/start)

〈 Areas not in study

- Parks, beaches, recreational (litter)
- Construction (sediment)
- Concrete batching (sediment)

2

3,4

4

Where 1 = oil inserts, 2 = litter inserts, 3 = litter and sediment inserts, 4 = exerts.

Figure 5 – Selection Guideline for Stormwater Pit Devices

Benefits and Constraints of Stormwater Pit Devices

Benefits

- Stormwater pit inserts and exerts are relatively simple and cheap to install compared with current in-line and end-of-pipe technologies.

- It is evident that, provided councils operate eductor trucks or sweeping plant with vacuum units, the maintenance of the stormwater pit inserts can be annexed to existing operations. Compared with the cleaning of end-of-pipe devices that typically require specialised equipment, and combined with the added educational benefits, the maintenance of stormwater pit inserts is cost-effective. This finding agrees with EPA (1998, p.3) that "most source control techniques can be implemented quickly and are often a refinement or extension of activities already undertaken within council".

- Educational benefits can be gained by including the devices in an overall campaign. Exerts are particularly useful for attracting attention to the retained pollutants on the pavement or along the kerbside of a street used heavily by pedestrians.

- The responsibility for the installation and maintenance of stormwater pit inserts and exerts may lie with private landowners, compared with regional facilities that impose on municipal maintenance budgets.

- Particular pollutants can be targeted by the various stormwater pit devices currently available. For example, there is great potential for stormwater pit inserts to be a last resort sediment trap adjacent to building sites.

- The devices may be used as an investigative tool for regulation and compliance as retained pollutants are relatively easy to observe at any time of day.

- Considering most stormwater pit pollutant traps remain dry between storm events and do not hold materials in solution for extended periods, the costs of disposal are more competitive than for sump systems. Furthermore, the potential for anaerobic decomposition of sediments and debris is minimised. During runoff events, the stormwater entering a sump may cause changes in pH, ionic strength, dissolved organic carbon and suspended solids concentrations (Morrison, 1985) and alterations in these ambient levels will affect the availability and speciation of metals (Morrison, *et al*, 1984).

- Stormwater pit pollutant traps are installed in urban environments and as result, are less likely to impact on aquatic habitat and natural systems than regional facilities as identified by Sharpin and Morison (1995).

- There is great potential to design and prototype stormwater pit inserts that will differentiate or segment pollutants within the device to assist with recycling and reduced solid waste disposal costs. For example, a pit insert may separate sediments from litter and oils, providing an opportunity to dispose of the partitioned pollutants at different times and to different waste management recipients.

- Inserts and exerts can be installed and removed generally from the street or ground level avoiding the problem of confined spaces.

- Stormwater pit pollutant traps can be removed and re-installed at another site where similar pit configurations exist. This provides the added benefit of monitoring illegal discharges and treating itinerant pollutant loads. There is great potential to utilise such facilities for special events including festivals and promotional events that attract large transient populations.

Disadvantages

- The units require frequent cleaning, generally on a monthly basis.

- Older stormwater pits with cast iron grates pose occupational safety risks due to the weight of the grates and the awkwardness of their removal. A two-person team is necessary for their removal.

- In popular precincts, stationary vehicles may restrict access to the pit inserts during business hours and in some cases for 24 hour periods.

- Stormwater pit inserts may not properly seal in offset and obstructed pits causing bypass of low flows and a significant portion of the "first flush".

- There is potential for the blinding or blockage of oil sorbents. These may need to be isolated from the "first flush" of particulates. This notion is currently under investigation by one of the suppliers of stormwater pit inserts.

- A number of stormwater pit inserts such as the fibreglass Suntree "Skimmer Tray" raise the grate above the surrounding ground level causing a potential safety and public liability issue. Not only could passing vehicles dislodge the unstable grate, the insert may be deformed or damaged by the weight of the vehicles.

- The oil sorbents used in a number of trialed devices do not retain emulsified oils, according to Stenstrom and Lau (1999). However neither do in-line treatment devices. Oil sorbents, according to the Interagency Catch Basin Insert Committee (1995), need to be in contact with stormwater for a short period to efficiently absorb oils. The "single-pass" systems demonstrated in this trial would not achieve this objective. However Stenstrom and Lau (1999) recorded significant efficiencies for oil sorbents in these systems (up to 91%, dependent upon flow and influent concentration).

Recommendations for future activities

The program stakeholders consider the results from this demonstrative trial of stormwater pit pollutant traps and at-source technologies a success. A number of suggestions are made for the refinement of successive programs:

- A thorough drainage investigation should be carried out, including pit configurations, drainage networks, pollutant sources and loads.

- Site meetings with suppliers of stormwater pit pollutant traps assist in determining the practical requirements and reducing the potential for misunderstandings and variable cost estimates.

← Drainage diagrams and maps need to be accurate and simple to interpret by all parties. The quality of the diagrams will influence the quality and efficiency of design, installation and cleaning and maintenance of stormwater pit systems.

← Replacement costs of oil sorbents and other disposable media needs to factored into stormwater pit devices. Alsaigh *et al* (1999) recommended the replacement of oil sorbents in the “Gullywasher” and Suntree “Skimmer Box” every 3 months. Costs vary depending upon the type of sorbent and the supplier.

← A comprehensive economic analysis needs to be carried out to include factors such as economies of scale and determine the minimum number of devices that is cost-beneficial compared to regional facilities.

← Post-graduate research project are recommended to undertake: an hydraulic analysis; particle size analysis of sediments; determination of attached and disassociated heavy metals, nutrients and oils; analysis of oil sorbents; the comparative analysis of in-line with at-source systems under similar catchment conditions; and the establishment of protocols for future investigation and analysis of at-source treatment systems.

← Further inspections, particularly during and after storms are necessary to determine the durability and efficiency of the devices.

← Stormwater pit inserts must be designed to remain outside the periphery of the pit outlet pipe to limit hydraulic constraints and the potential for minor flooding.

← It is imperative that at-source structural treatments are not used as an excuse or a replacement for true source controls such as education, cleaner production and regulation. It is also recommended that these systems remain as part of an overall treatment train (Watershed Management Institute, 1997; Victorian Stormwater Committee, 1998).

conclusion

It has been proven that stormwater source control is highly effective and saves money (Lehner *et al* 1999). The gamut of stormwater pollution prevention measures dramatically and cost-effectively reduces the quantity and concentration of pollutants ending up in waterways (Aponte Clarke *et al* 1999).

The Upper Parramatta River Stormwater Source Control Projects have provided excellent opportunities to demonstrate innovative at-source structural treatments. It is expected that the results of this trial will be valuable for stormwater managers grappling with a multiplicity of pollution issues and limited capital and maintenance budgets.

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Appendix 1

Product Information for Stormwater Pit Pollutant Traps under Trial

Appendix 2

Summary of Stormwater Pit Pollutant Trap Designs

[2]

[3]

[4]

[5]

[6]

Dencal 'Litterguard' dual 25 mm wire baskets

M

H

18 days (pits measured and pitted with props, baskets then manufactured in Vic & transported to site)

Drop Inlet Pits preferred, customised for each pit

Byp (10-15 mm gap between pit walls and wire)

M or A

L (12.7 mm aperture for perforated metal; 25 mm aperture for wire mesh)

Dencal 'Litterguard' L-shaped frames

L

H

-14 days (made up and fitted on site)

Side Entry Pits preferred, customised for each pit

Byp (up to 10 mm gap between frame and pit wall on sides)

M or A

L (25 mm aperture)

Ecosol RSF 100/GSP

M

M

35 & 75 days (custom fitted on site, partial installation due to mistake by sub-contract supplier)

Kerbside Entry Pits with grates; min. obvert depth = 450 mm

Byp (materials can jam overflow bypass flaps; gaps in off-set pits), Dur (bypass flaps alloy with springs)

M or A

L (÷1.5 mm)

Ecosol RSF GSP

M

M

35 & 75 days (custom fitted on site, partial installation due to mistake by sub-contract supplier)

Drop Inlets; min. obvert depth = 450 mm

Byp (materials can jam overflow bypass flaps; gaps in off-set pits), Dur (bypass flaps alloy with springs)

M or A

L (÷1.5 mm)

Enviropod (NZ)

H

H

32 days (measured by supplier, fabricated in NZ, custom fitted by supplier)

Kerbside Entry Pits or Drop Inlets; 620 x 620 mm & 930 x 960 mm units supplied; min. 225 mm ϕ outlet with 1 m obvert depth; offset pits unacceptable

Flam (nylon bags), Byp (on large cantilevers, rubber flaps can be pushed inwards), Cln (mesh bag is flexible preventing efficient cleaning)

A

L, S (÷200μm based on aperture of mesh)

Pit Bull Custom Lintel Skirt & Grate Covers

L

H

23 & 35 days (measured by supplier, fabricated off site, custom fitted by supplier)

Kerbside Entry Pits for lintel skirt and grate cover; Drop Inlet Pits for grate cover only

Hyd (potential blockage & minor flooding); dur (plastic ties); cln (filter insert difficult to remove without losing some pollutants)

A

L, S (coarse fraction)

StreamGuard ‘Oil & Grease Catch Basin Insert’

L

H

*

Drop inlets; one size cut to fit grate dimensions

Dur (designed to be replaced when saturated; generally 3-6 months)

D

O

StreamGuard ‘Sediment Only Catch Basin Insert’

L

H

*

Drop inlets; one size cut to fit grate dimensions

Dur (designed to be replaced when saturated; generally 3-6 months)

D

S

StreamGuard Passive Skimmer

L

H

*

Sump pits; attaches and hangs from grate

Dur (to be replaced when saturated)

D

O

StreamGuard Black Box II

M (580x580); H (900x900)

M

*

Kerbside Entry Pits or Drop Inlets

An (no free-draining)

A

O, S

StreamGuard Black Box III

M (580x580); H (900x900)

M

*

Kerbside Entry Pits or Drop Inlets

A

L, O, S

Fossil Filter “Drop In” Catch Basin Insert

H (US)

L

149 days (Supply & Install); 46 days (supply)

Drop Inlet Pits

Hyd (unit relies on low flows for treatment)

M

O

Fossil Filter “Combination Curb/Gutter Grate Inlet”

H (US)

L

149 days (Supply & Install); 46 days (supply)

Kerbside Entry Pits with grate

Hyd (low flows treated)

M

O

Fossil Filter “Flo-Guard”

H (US)

L

149 days (Supply & Install); 46 days (supply)

Drop Inlet Pits

Hyd (unit relies on low flows for treatment)

M

O

Gullywasher “Geotextile Catch Basin Insert” (Oil and Sediment Model)

H (US)

L

149 days (Supply & Install); 24 days (supply)

Drop Inlet Pits

Hyd (may clog with sediment)

M

O, S

Gullywasher “Sediment Trap/Oil-Water Separator with Floating Poly Boom & Absorbent Filter Pillow”

H (US)

L

149 days (Supply & Install); 24 days (supply)

Drop Inlet Pits

An (sump in base)

M

S, O

Gullywasher “Debris & Oil Control Insert” (central catchment and perimeter bypass)

H (US)

L

149 days (Supply & Install); 24 days (supply)

Drop Inlet Pits

Hyd (low flows treated; potential clogging of absorbent)

M

S, O

Gullywasher “Debris & Oil Control Insert” (perimeter catchment and central bypass)

H (US)

L

149 days (Supply & Install); 24 days (supply)

Drop Inlet Pits

Hyd (low flows treated; potential clogging of absorbent)

M

S, O

Suntree Technologies “Grate Inlet Skimmer Box”

H (US)

L

149 days (Supply & Install); 63 days (supply)

Drop Inlet

Hyd (potential clogging of filters)

M

S, O, L

Suntree Technologies “Adjustable Skimmer Tray”

H (US)

L

149 days (Supply & Install); 63 days (supply)

Drop Inlet

Hyd (low flows treated; potential clogging of filters); Pl (grate is pushed above surface level); Dur (fibreglass cracking under pressure)

M

O

Suntree Technologies “Curb Inlet Protector”

H (US)

L

*

Kerbside Entry Pits (fits across side entry without grate inlet)

Hyd (potential minor flooding due to blockage)

A

S, L

Suntree Technologies “Grate Protector 2000”

H (US)

L

*

Drop Inlet Pits

Hyd (potential minor flooding due to blockage)

M (claims to be self-cleaning)

S, L

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[1] Maintenance refers to the repair or replacement of the units in contrast to the cleaning of individual units.

[2] Costs: L = $0-250; M = $251-500; H = $500+

[3] Retrofitting Ability: L = 0-33% pits; M = 33-66% pits; H = 66-100% pits

[4] Observed Design Issues: hyd = hydraulic restraints, e.g. low capacity, potential blockages; dur = materials may not be durable; flam = materials potentially flammable; byp = flows and pollutants may bypass in low flows; an = anaerobic decomposition and mosquito breeding habitat; cln = cleaning restraints; pl = public liability

[5] Maintenance Methods: M = manual (e.g. by hand), A = automated (e.g. by eductor truck), D = disposal & replacement with new device

[6] Pollutants: S = sediment; L = litter; O = oils