FROM ROADS TO RIVERS

GROSS POLLUTANT REMOVAL FROM URBAN WATERWAYS

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PREFACE

This is one of three reports that describe the gross pollutant research study undertaken by the Cooperative Research Centre for Catchment Hydrology. The study is part of Project C2 (Design and Management Procedures for Urban Waterways and Detention Basins) in the CRC's Urban Hydrology Program.

The objectives of the study are to understand the quantities and characteristics of gross pollutants moving through the stormwater system, and to review and assess gross pollutant trapping techniques. A feature of this study is the extensive field monitoring which involved a range of parties, including federal, state and local agencies, community groups and two private companies.

An industry report which provides a general description of gross pollutant characteristics and trapping devices has been published. This technical report describes the study in much more detail. The third report describes a decision support system that can be used to compare different approaches for trapping gross pollutants.

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ABSTRACT

There is increasing public concern about the large amount of gross pollutants, such as litter and debris, observed in urban waterways and receiving waters. These pollutants are unattractive, disturb the physical habitat, degrade the waters, are linked to marine animal deaths and reduce amenity values.

A number of approaches are used to reduce the problem: public awareness and education programs, penalties for littering, the provision of collection bins and extensive street cleaning. Despite these efforts it is clear that significant amounts of material continue to enter the urban drainage system. Traps can be installed to collect gross pollutants and can be located at street channel entry pits, within main drains and in slow moving receiving waters. However, it is rarely feasible to provide sufficient trapping to collect all the pollutants in the urban drainage system, but a proportion can be trapped economically.

This report describes a field monitoring program used to measure gross pollutant loads and flows associated with rainfall events and to assess the performance of two gross pollutant trapping systems. The results suggest that, although large amounts of gross pollutants are transported from urban catchments to receiving waters via the stormwater system, technologies are available to capture these pollutants from within the drainage network. However, trapping gross pollutants from within urban waterways can be expensive. With the large areas associated with urban centres in Australia, it is unlikely that gross pollutant traps will be located on all urban catchments. Waterway managers must therefore decide what are the appropriate trapping techniques and where best to locate traps within a particular drainage network.

ABBREVIATIONS

CDS	- Continuous deflective separation
FDT	- Floating debris trap
GPT	- Gross pollutant trap
LCD	- Litter control device
MMBW	- Melbourne and Metropolitan Board of Works
SEPT	- Side entry pit trap
SPCC	- State Pollution Control Commission, NSW
TN	- Total nitrogen
TP	- Total phosphorus
TSS	- Total suspended solids

TABLE OF CONTENTS

1. INTRODUCTION

Gross pollutants (litter and debris) in urban waterways are unattractive, disturb the physical habitat, degrade the water, attract pests and vermin, can cause marine animal deaths, can promote littering and reduce amenity values. Although these impacts are receiving increasing attention, little research has been done in this area.

This report firstly provides a background to the problems caused by gross pollutants followed by a review of methods for reducing gross pollutants from reaching receiving waters. Results from monitoring the loads of gross pollutants during the early part of the study are then presented. These results improve our understanding of the movement of gross pollutants during runoff events and the amount of gross pollutants transported from different land-use catchments.

The performance of two gross pollutant trapping systems were then tested in a 50 hectare inner-Melbourne catchment and the results are presented. One trap proved to have a very high capture rate and therefore provided an excellent monitoring device to investigate the material emanating from the catchment from storm events. A detailed analysis of the trapped material allowed conclusions to be made about the quantities and origins of gross pollutants reaching the drainage network.

The report intends to provide:

- an improved understanding of the types, quantities and origins of urban gross pollutants;
- a description of the movement of gross pollutants during runoff events; and
- performance data for two devices used to remove gross pollutants from within the urban drainage network.

This report is the third of three reports describing the gross pollutant research undertaken by the CRC for Catchment Hydrology. The first report is a CRC Industry Report which provides a general description of gross pollutant charcteristics and trapping devices. The second report describes the development of a decision-support-system that is based on the results of this report. The decision-support-system provides a method of comparing different approaches for trapping gross pollutants. All of these reports are available from the Centre office by contacting Virginia on (03) 9905 2704 or facs. (03) 9905 5033.

1.1 DEFINITION OF GROSS POLLUTANTS

The term “gross pollutant” is variously defined in the literature, but when used in connection with stormwater drainage systems can include litter, debris and sediments (Willing and Partners, 1992; and Essery, 1994). Litter is defined as human-derived material including paper, plastics, metals, glass and cloth (as defined in the Litter Act, 1987). Debris is defined as any organic material transported by stormwater (such as leaves, twigs and grass clippings) as defined by DLWC (1996). Sediments are defined as inorganic particulates.

There is little reference in the literature to the minimum size material which is considered a gross pollutant. For the purposes of this study **gross pollutants are defined as material that would be retained by a five millimetre mesh screen**. This means that in the present study only sediments that are attached to litter and debris will be included in this definition. This definition is used for two reasons: firstly, the emphasis of this study is on the impacts of litter and debris (as opposed to sediments) on receiving waters and secondly, the aperture size of the samplers developed by Essery (1994) that are used to measure gross pollutant loads is five millimetres. This definition is also consistent with the five millimetre screen size of a gross pollutant trap tested as part of this study.

2. BACKGROUND

There is increasing public concern about the large amount of gross pollutants, such as litter and debris, observed in urban waterways and receiving waters. This was illustrated in a survey that revealed the public perceive gross pollutants as the greatest threat to waterway health (TQA, 1993).

The environmental problems associated with the large quantities of gross pollutants present in urban waterways have been widely recognised (Molinari & Carleton, 1987; MMBW et al., 1989; Senior, 1992; O'Callaghan, 1993; and Cornelius et al., 1994). However, there has been little research into gross pollutant movement and loads reported, particularly in Australia, where stormwater and wastewater collect in separate systems (Molinari & Carleton, 1987; and Essery, 1994). In addition, there has been only limited investigation into the deployment and performance of devices designed to trap gross pollutants in urban stormwater drainage systems. Studies tend to report the quantities of material retained by trapping devices but not the amounts of gross pollutants by-passing the devices (Molinari & Carleton, 1987; Nielsen & Carleton, 1989; Sim & Webster, 1992; and Gamtron, 1992).

Litter can be unsightly, environmentally damaging and impede the hydraulic performance of drainage systems (by causing blockages). Paper and plastics accumulate along stream beds reducing the aesthetic appeal of the waterway as well as increasing the possible spread of disease (McKay & Marshall, 1993). Plastics in particular can also cause death to aquatic life and birds as plastic products are sometimes mistaken for food (O'Callaghan, 1993; and Wace, 1996). Litter can also be carried through the drainage system and into receiving coastal waters, to be further spread along the coast where it does not break down readily (Senior, 1992; and McKay & Marshall, 1993). The problem with plastics is their durability. Generally they do not decompose over time frames of less than 100 years (Cottingham, 1988) and hence are transported to receiving waters intact. The bulk of marine litter comes from land-based sources via stormwater (O'Callaghan, 1993; Sydney Harbour Task Force, 1991; Collett, 1992; and ANZECC, 1996).

Marine litter and debris can cause a significant economic impact. Gross pollutants can foul the engines of small to medium size craft and cause significant costs (O'Callaghan, 1993; and Gamtron, 1992). The Maritime Service Board (NSW) spend $1.3m per year on harbour cleaning of gross pollutants (Sydney Harbour Task Force, 1991), and each year Melbourne Water allocates $1 million to litter management and reduction (Collett et al., 1993).

Litter is often seen as a sign of poor water quality by the public (TQA, 1993). Flies and vermin that are attracted to the litter further reduce the environmental and recreational amenity value of the waterway (Gamtron, 1992; O'Loughlin et al., 1993; and Collett et al., 1993). The presence of litter often promotes further littering (Senior, 1992) which compounds the problem. Glass and metal items can be dangerous to humans and are another problem caused by the presence of gross pollutants.

The lack of quantitative information concerning gross pollutants and their trapping has created problems for authorities responsible for the health of urban waterways. This provided the impetus for the present study.

2.1 PREVIOUS GROSS POLLUTANT RESEARCH

Nielsen & Carleton (1989) were the first in Australia to quantify accurately the composition of gross pollutants in stormwater. They collected samples from trapping devices located in concrete lined channels in Sydney over a four month period from the end of winter into spring. They used a volumetric measure to quantify the collected material, shown in Table 2.1. They reported that garden refuse (organic material) and plastic material constituted the bulk of the gross pollutants with high amounts of paper also present.

Table 2.1 Major categories of trash - collected at two booms and a trash rack (average % volume) (after Nielsen & Carleton, 1989)

Categories	Muddy Creek boom	Cup & Saucer Creek boom	Marrickville trash rack
No. of samples	5	3	4
Glass	0.5	0.7	0.6
Cans	2.6	1.7	0.3
Plastic	22.9	31.6	45.8
Paper	8.8	19.9	24.3
Garden Refuse	50.2	40.6	21.7
Deliberately dumped	7.8	3.2	7
Miscellaneous	7.2	2.3	0.3

Gamtron (1992) collected gross pollutants from four floating booms in the Sydney region and found similar proportions of components. On a volume basis organic material (garden refuse and vegetation) averaged 71% of the total, plastics 13% of the volume with paper (7%), glass (2%) and metal (1%) making up the remainder. Other research reports similar components of gross pollutants in stormwater (eg. Sim & Webster, 1992).

MMBW et al. (1992) used simple devices to capture gross pollutants from within concrete lined stormwater channels in Coburg, Victoria and used an item count to classify the litter (ie. not including garden refuse). The results show high proportions of plastics and paper in the litter and small amounts of cans and glass with 11% of the sample miscellaneous (Figure 2.1). In total 2231 items of litter were collected in the study. The size, mass or density of the material was not reported which limits comparisons with other work.

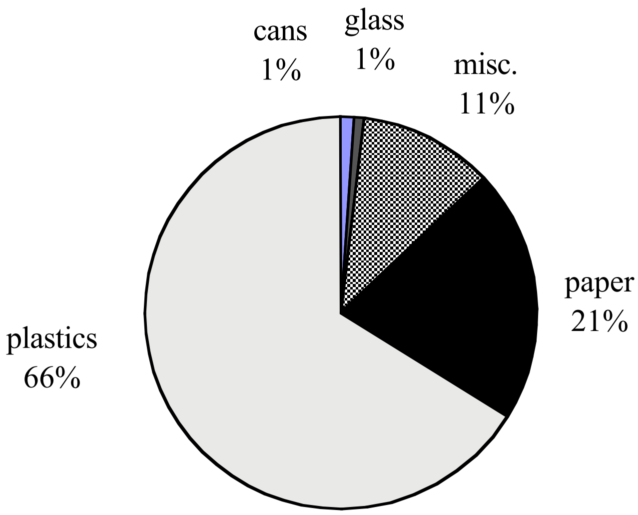


Figure 2.1 Composition of stormwater litter items collected (after MMBW et al., 1992)

From an extensive tagged-litter study conducted in Melbourne, McKay and Marshall (1993) estimate Melbourne's waterways to transport 4 to 5 million items of floatable litter each year (ie. not including suspended material). The study used efficiency ratings of floating booms and the volumes collected by the booms for their estimates.

There are limitations in comparing results that are reported in different ways, for example, volume analysis in Nielsen & Carleton (1989), item counts in McKay & Marshall (1993) or mass analysis in Sim & Webster (1992). Although there is limited information about the magnitude of gross pollutant loads there appears to be consistency about the composition of gross pollutants caught in traps. At least two thirds are organic (mainly leaves and twigs) and the remainder consists mainly of plastics and paper, but also can contain metal, glass, cloth and unidentifiable items. An improved consistency of reporting gross pollutant loads would enable more meaningful comparisons between different studies to be made.

Essery (1994) describes a range of assessment techniques for gross pollutant impacts in urban waterways. Techniques include public surveys, visual monitoring, trap cleaning assessments and a more rigorous gross pollutants sampling program (which was adopted as part of this study, see Chapter 4). Essery's study was the first to investigate the concentrations or loads of gross pollutants in Australian stormwater during runoff events. Essery (1994) presents one plot of gross pollutant concentrations and loads with values up to 0.3 grams per litre and 18 grams per second respectively.

All other Australian data relating to gross pollutants in stormwater identified for this report present the quantity of material caught by particular traps but not how much material escaped the traps. The trapped loads are useful for comparing different trapping techniques but do not allow estimates of the total loads of gross pollutants travelling through stormwater systems (because it is unknown how much material passes the traps). However, these studies are useful for indicating the scale of gross pollutant problems. For example, approximately 2000 tonnes of litter are removed each year from Sydney's street gullies in the central business district alone (Gibson & Evernden, 1992). Robyn Sim (pers. comm., 1995) collected as much as 250 kg/ha.year at one gross pollutant trap in Sydney.

Most international literature reviewed for this study that discusses gross pollutants is concerned with combined sewerage systems and in particular combined sewer overflows (eg. Pisano, 1988; Clifforde et al., 1990; and Cootes, 1990). These systems have limited relevance to Australian separate stormwater systems because they are primarily concerned with sewerage items (such as sanitary napkins) which are generally not present in separate stormwater systems and therefore cannot be compared with Australian data. More recent research in New Zealand and South Africa has more relevance to Australian conditions because they also have separate stormwater and wastewater systems.

In New Zealand, it is estimated that approximately ten million items of *debris* (not defined but appears to be only human derived items, ie. litter) emanate from Auckland's drainage system annually (Cornelius et al., 1994; and Arnold et al., 1994). Cornelius et al. (1994) monitored gross pollutants with 19 mm square mesh bags fitted to the ends of drain outlets and report large variations in loads from residential, industrial and commercial catchments and at different times of the year. Loads of between 0.5 and 1.4 kilograms per hectare per year are reported (assumed wet and not including organic material). This appears to be lower, but of the same order, as loads monitored as part of this study (see Chapter 6). Large amounts of hard plastic are reported from industrial catchments, while commercial runoff consisted mainly of paper and residential areas had a high proportion of plastic sheeting and paper.

From results of the Auckland study, Cornelius et al. (1994) observed that rainfall had no effect on gross pollutant loads, except to convey a first flush. This appears to be in direct contrast to 1994 Sydney study observations of Essery, who concluded that because subsequent storms in the same day produced similar concentrations and loads of gross pollutants as the storms earlier in the day, gross pollutants were not all 'flushed' from the catchment surface following a single rainfall event and consequently loads are highly dependent on rainfall.

South African research into gross pollutant traps is progressing rapidly with the development of several promising traps. An overview of South African research will be presented by Armitage et al. (1997) in a pending report which describes the evolving traps and other gross pollutant monitoring.

2.2 CONCLUSIONS

From the material reviewed here it can be seen that gross pollutants present major problems to urban waterway managers. The problems are compounded by the limited amount of useful information available concerning pollutant loads. It is difficult to determine optimal reduction programs without a better understanding of what types and quantities of gross pollutants are derived from different catchments and what are the driving forces behind their movement. A review of gross pollutant reduction strategies is presented in the next chapter then the remainder of the report describes a monitoring program designed to improve our understanding of gross pollutant transport in urban drainage systems and to provide performance data for gross pollutant trapping systems.

3. REDUCING GROSS POLLUTANTS

Reduction campaigns for gross pollutants can be broken into two categories, non-structural and structural. Non-structural measures are means of reducing the quantity of pollutants available for wash-off, primarily by changing the attitudes (and actions) of the community, and structural measures are constructed in-transit treatments that separate and contain pollutants. Despite the presence of existing non-structural programs, significant quantities of gross pollutants reach receiving waters and either improved or alternative approaches for reducing their impacts are required. Trapping systems provide a structural method for reducing the quantities of gross pollutants that reach receiving waters and are the focus of this study. Although little information is available concerning their performance, trapping strategies are becoming increasingly used in Australia.

A wide range of traps are available for catching gross pollutants transported by stormwater, varying in size, cost and trapping efficiency by orders of magnitude. This section describes a selection of techniques currently used to remove gross pollutants (and sometimes other pollutants) from urban waterways. Trapping concepts and processes are described and the trapping effectiveness is discussed, some costs are presented which unless otherwise stated are in 1997 Australian dollars.

3.1 INTRODUCTION

An integrated approach to stormwater pollution encompassing non-structural and structural measures is seen as an effective means of pollution control (Graham, 1991). In summary, there are a number of elements for reducing gross pollutant impacts (Melbourne Water, 1995a), including:

- preventative measures (education and awareness);
- containment of gross pollutants on land (street cleaning);
- capture of gross pollutants in the drainage system prior to release into receiving waters (trapping systems); and
- remedial clean-up methods (eg. clean-up days).

The public contribute significantly to pollutant loads through misguided actions, such as littering (Senior, 1992; Aitken, 1995; and Clean & Green Victoria, 1995). Education and awareness campaigns are intended to change public attitude towards the drainage system and hence reduce the amount of litter and other pollutants deposited across urban catchments. In addition to media advertising, drain labelling is a means of increasing awareness of stormwater systems and hence behaviour that affects stormwater quality (Aitken, 1995; and Davies, 1995). Drains are usually labelled with a logo and a brief message (eg. Photograph 3.1).

Community involvement and education about stormwater systems can potentially reduce the impacts of stormwater pollutants on receiving waters (Lees et al., 1992; Seymour, 1993; and DLWC, 1996), however, improvements from these programs take place over long time periods and are difficult to quantify.

It is widely recognised that manufacturers play a part in the general litter problem through packaging and advertising (Molloy, 1989). Manufacturers are keen to reduce the number of items becoming litter as it can leave a reputation as an environmentally unfriendly company. Improved consultation with manufacturers and the research and development of environmentally-friendly substitutes are possible ways of reducing litter in urban catchments (Seymour, 1993).

Photograph 3.1 Drain labelling is a means of educating people about the link between roads and rivers

Councils could be educated and encouraged (through guidelines) to use improved management techniques for their catchments. Improved street cleaning methods and garbage and recycling collections (to incorporate more efficient spillage control during collection) would decrease pollutants reaching receiving waters (Golder, 1995). Some of these programs have been implemented (Golder, 1995); however, the effectiveness is difficult to measure because improvements generally occur over long time periods.

Community clean-up days involve gathering volunteers and manually removing litter and debris from urban areas (KAB, 1994). These efforts can be successful in improving the appearance of waterways in the short term. Large numbers of people are involved and collect large quantities of material. Although they do not address the source of the contaminants, they do provide good media coverage and hence play an important educational role by raising the profile of the degradation of receiving waters.

The focus of the rest of this chapter is on trapping techniques for gross pollutants (capture prior to release into receiving waters), although a section on street cleaning is included for completeness. Trapping systems play an important role in the success of any gross pollutant reduction strategy.

3.2 TRAPPING GROSS POLLUTANTS

There are two primary characteristics that determine the log term effectiveness of a gross pollutant trapping system: the gross pollutant trapping efficiency and the maintenance requirements. The trapping efficiency of a device is defined as the proportion of the total mass of gross pollutants transported by stormwater that is retained by the trap. A trap with a low trapping efficiency means that a higher proportion of the gross pollutants transported by the stormwater is passing the trap and reaching downstream waters. Difficult or expensive maintenance procedures (mostly cleaning operations) can lead to a decline in the trap's cleaning frequency. A poorly maintained trap will reduce its pollutant trapping efficiency and also may potentially become a source of pollutants as collected materials break-down.

Approaches for trapping gross pollutants vary considerably across Australia. The first gross pollutant traps were built in the late 1970s and were very simple designs. More recently technologies have developed with clever trapping concepts and *high-tech* construction requirements. Despite increasing expenditure on trapping systems for gross pollutants in stormwater, little information has been collected on the performance of most systems.

The most common types of debris traps used in Australia are trash racks, floating booms and Gross Pollutant Traps (GPT). Booms generally are designed to remove floating items, trash racks floating and submerged material and GPTs are designed to collect these as well as sediments. Emerging techniques include: Side Entry Pit Traps (SEPT) positioned at inlets to the drainage system; Continuous Deflective

Separation (CDS) devices, Litter Control Devices (LCD) and improved trash racks installed in pipes and channels; and modified floating booms installed in slow moving water bodies.

The trapping systems discussed in the following sections are loosely ordered from those intended for the headwater parts of catchments down to traps intended for slow moving water bodies.

3.2.1 Street cleaning

A regulated street cleaning regime can potentially reduce large amounts of litter from road surfaces (Gibson & Evernden, 1992). Street sweeping (brushes that sweep pollutants into a collection chamber) is the primary method of street cleaning in Australia, although street vacuuming (brushes move pollutants into the path of a large vacuum) has a better pollutant capture rate (O'Loughlin et al., 1992) and is being adopted by some local governments (Golder, 1995).

Most local government authorities in Australia do some sort of street cleaning such as street sweeping and most reduce the input of gross pollutants to the stormwater system. However, some practices (especially street flushing) may have a detrimental effect (Seymour, 1993) because of the pollutants they deliver to urban waterways. Senior (1992) reported that 67% of councils use street flushing to some extent. Street flushing involves using either hydrants or large water trucks to wash streets free of debris with the hydrant water. The water (and collected pollutants) then travels into the stormwater system leaving the streets free of gross pollutants. In some instances chemicals are added to the flushing water to improve the smell of the streets.

Despite acknowledging limitations such as needing to flush hydrants and obstructions from parked cars, street cleaning guidelines now recommend against street flushing and encourage street sweeping and vacuuming (IMEA, 1996) so that pollutants are prevented from entering the drainage network.

Photograph 3.2 Parked cars are a problem during typical street sweeping in Australia

There is a lack of data on the effectiveness of street cleaning for stormwater pollution control in Australia. North American experience (Athayde et al., 1983; Sartor & Gaboury, 1984; and Prych & Ebbert, 1987) found that sweeping had little effect on finer water quality parameter concentrations (such as TP, TN and metals) in stormwater. However, Sartor & Gaboury (1984) claim nearly 80% capture for materials larger than two millimetres when sweeping was performed under ideal conditions (ie. sweeping more frequently than rainfall and effective use of parking restrictions). This work suggests that street cleaning is potentially an effective means of reducing gross pollutants from reaching stormwater systems given suitable conditions. It also identified some important factors governing the performance of street cleaning operations. These include the street surface (type and condition), type of cleaners (broom and vacuum type, operators skills and operation speed) and the type of work program (frequency, number of passes and the use of effective parking restrictions).

It is unlikely that ideal conditions are met during typical operations in Australia. Obstacles such as wind, limited resources (therefore limited cleaning frequency), obstructions on roads (such as parked cars) and the thoroughness of the operators are all limitations to effective street cleaning for stormwater quality protection. More research is required to quantify the effectiveness of street cleaning in Australia for stormwater pollution control. Photograph 3.2 shows typical street sweeping in Melbourne with parked cars preventing the machines from reaching the gutter and wind blowing pollutants away from the sweeper.

3.2.2 Side Entry Pit Trap (SEPT)

SEPTs are baskets that are placed in the entrance to drains from road gutters. The baskets are fitted below the invert of the gutter, inside drainage pits (Figure 3.1 and Photographs 3.3 a&b). Stormwater passes through the baskets to the drain and material larger than the basket mesh size (5-20 mm) is retained. Material remains in the basket until a maintenance crew removes the material either manually (Pitclear Industries, 1994; and Dencal Industries, 1995) or using a large diameter vacuum device (ie. an eductor, Banyule City Council, 1996; Photograph 3.3b). The traps are intended to be cleaned every four to six weeks.

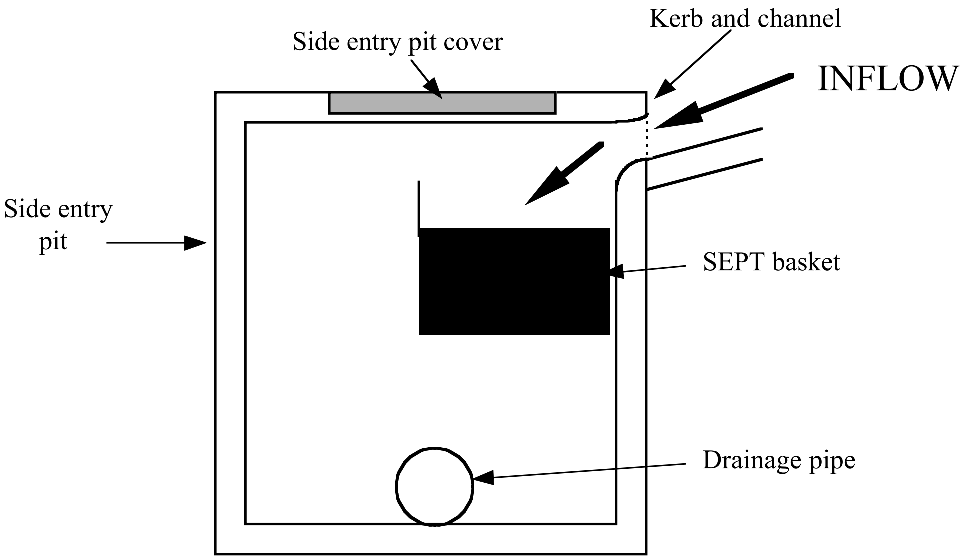
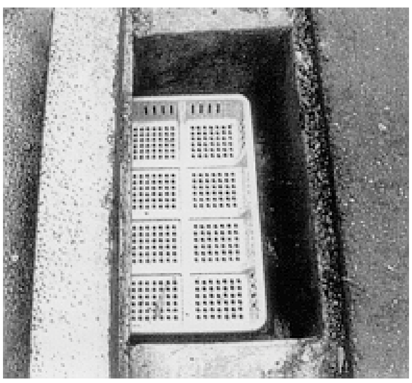
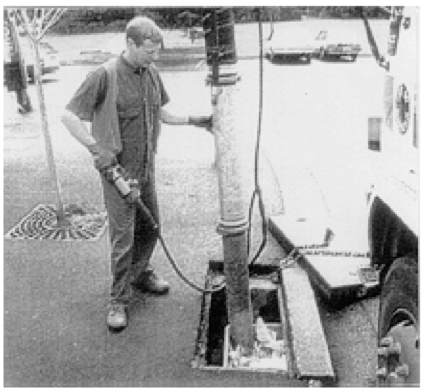


Figure 3.1 Side Entry Pit Trap - side elevation (after Davies, 1995)



Photograph 3.3a Side Entry Pit Trap (Banyule C.C. style)



Photograph 3.3b Contents of SEPT being educted

The traps are installed with a space at the rear of the pit to provide a flow path for high flows. When the basket pores are blocked or during high flows, water is discharged over the rear of the basket. Items smaller than the mesh size can also be retained due to the collected material partly blocking the basket.

The trapping performance of SEPTs is unknown. The overall trapping efficiency for an area is influenced by individual trap efficiencies as well as any material that finds its way into the stormwater system through entrances other than side entry pits (eg. direct roof runoff from commercial buildings or through grates that are strategically located to remove drainage water from private car parks or grassed areas etc.). The proportion of stormwater that enters the drainage network through entrances that can have SEPTs fitted is estimated to be 80% from the author's observations (in the study area for this project, see Section 5.4). However, the proportion of gross pollutants that finds their way into the drainage system by other means than side entry pits is unknown.

The nature of material that is caught by SEPTs influences the degree of basket blockage. Once the pores in the baskets are blocked, water ponds in the basket and then spills over the rear of the basket. Trapping efficiencies are expected to reduce significantly once overflow occurs.

SEPTs require maintenance at many locations in a catchment. Currently, traps can only be installed in targeted areas (such as commercial and industrial areas) because of the large maintenance requirements.

In Victoria SEPTs are supplied by three companies. Different designs include steel and plastic baskets, pore size and cleaning technique (manual or automated). Plastic baskets have the advantage of easier cleaning as material has less tendency to entangle with mesh but they require vacuum plant rather than manual labour for cleaning because they are fixed inside the pits.

SEPTs are cheap and easy to install compared to other stormwater debris traps. The costs are estimated to be $60-150 installed for each pit and maintenance of $5-10 per pit per clean-out (Colin Rose, pers. comm., Banyule City Council, Victoria). In addition to preventing large amounts of material from entering urban waterways, another benefit of SEPTs is that they reduce the frequency of pipe blockages by preventing gross pollutants from entering drains (Davies, 1995) and therefore avoid costly blockages at inaccessible locations in the drainage network.

With approximately 250,000 side entry pits in Melbourne (using an average of four pits per hectare from observations in Coburg, see Chapter 5) the key to SEPT's success is being able to target the entry pits that contribute the largest loads of pollutants. The maintenance requirements of traps precludes the use of SEPTs on all entrances. An improved understanding of what types of entrances in what types of areas contribute the most loads is needed.

The lack of trapping efficiency information for SEPTs and a need to be able to target specific locations for SEPTs, led to field experiments to address these issues. Chapters 5 and 8 discuss performance monitoring of SEPTs and their applicability to urban systems.

3.2.3 Baffled Pits (Trapped Street Gullies)

Baffled pits (or Trapped Street Gullies) are modified stormwater pits (with baffles installed) used to retain sediments and floating material from road runoff. Installations are limited to Sydney City Council where they have been used for over 100 years. They were originally designed for providing odour control for combined sewers but have more recently been recognised for their pollutant retention capabilities (Gibson & Evernden, 1992).

Baffle plates fitted in the drainage pits are used to facilitate the settlement of heavy sediments and containment of floating debris in the pit (Gibson & Evernden, 1992). Designs have been modified after hydraulic modelling to improve the retention capabilities by minimising velocities (MHL, 1994). A sketch of the layout of a modified pit is shown in Figure 3.2.

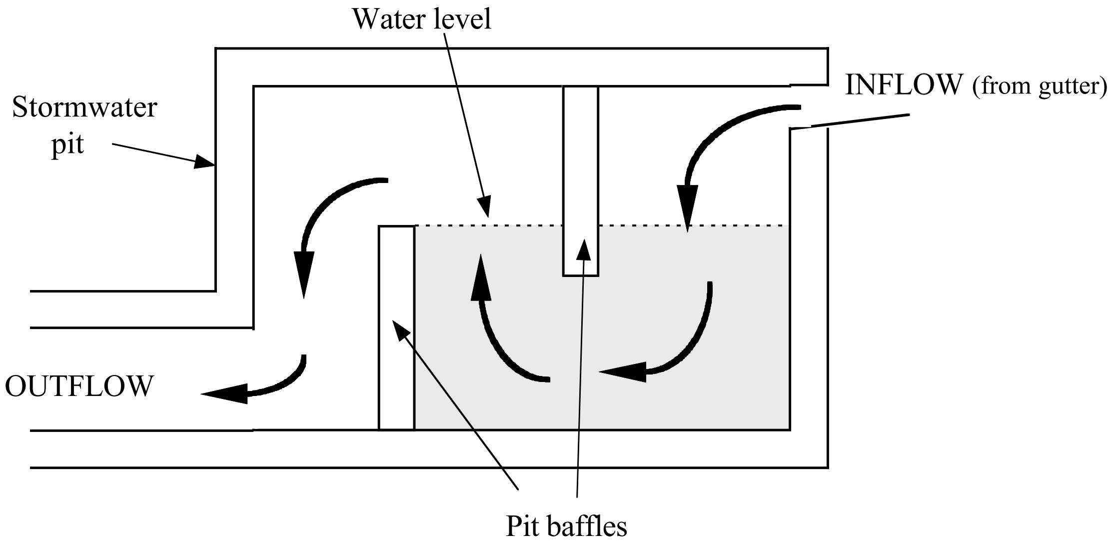


Figure 3.2 Idealised section view of a baffled-pit

The contents of the pits are educted (removed with a large diameter vacuum device) during maintenance which is performed every three weeks. Gibson & Evernden (1992) report approximately 2000 tonnes of silt and debris are cleaned from Sydney City Council pits per year. Although this is a large quantity of material, it is unlikely that a large proportion of the material entrained in the flow will be retained.

Modified gully pits cost between \$3,000 and \$4,000 to install (Haradasa et al., 1995). This may appear relatively cheap; however, a large number of distributed traps are required for an area and these require a large maintenance commitment because of the limited holding capacity and hence frequent cleaning cycle. Sydney City Council uses three educting machines, running two shifts a day, six days a week for cleaning pits. Gibson & Evernden (1992) describe a problem with the traps in 'flushing' collected pollutants through the traps during high flows. Although no data were presented by Gibson & Evernden (1992), they question the suspended material retention capabilities of this system.

There is research currently underway in Australia attempting to improve the baffled pit trap design for improved pollutant retention properties, however, no results are available yet (Sydney Coastal Councils, 1996).

A device that uses similar principles to the baffled pits is the "Stormceptor" device. It has a circular cross section and features a high flow diversion to prevent collected material from being scoured (Weatherbe et al., 1995) and is designed for sediment and oil capture (ie. not gross pollutants, Figure 3.3). The high flow diversion is a vital element in maintaining the integrity of the trap to prevent resuspention of collected material. Bryant et al. (1995) have monitored the trap for its sediment retention capabilities and appears to work well.

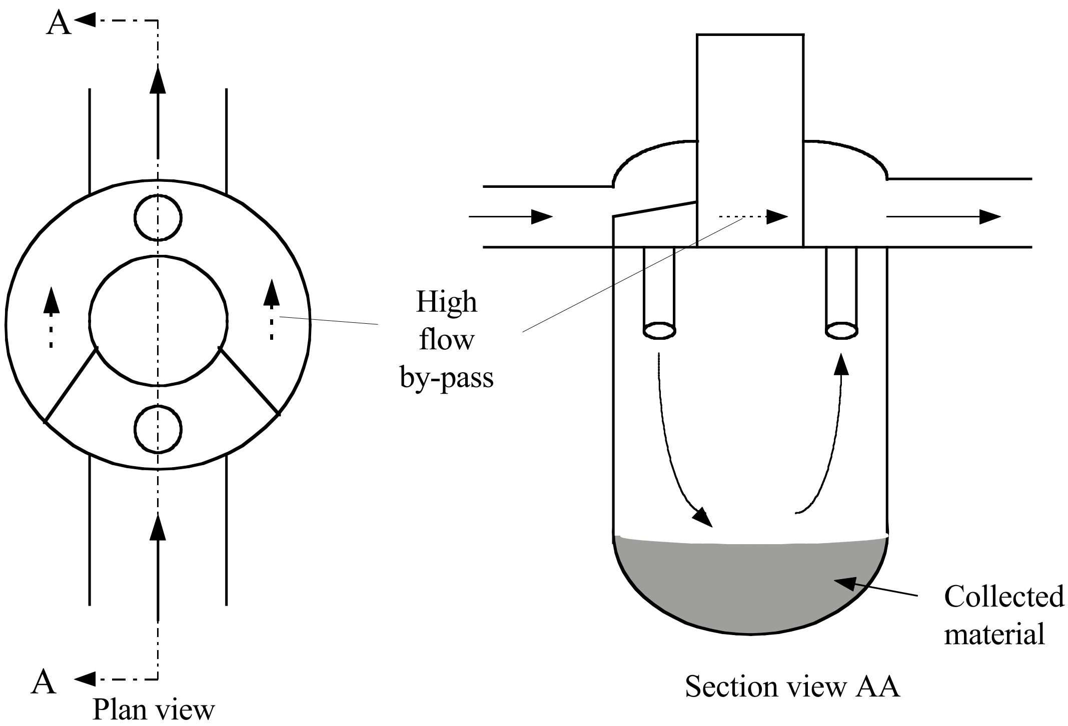


Figure 3.3 Stormceptor trap (after Weatherbe et al., 1995)

3.2.4 Trash Racks

Trash racks are installed in storm drainage channels to intercept floating and submerged objects (such as plastic bags). They generally consist of vertical steel bars (typically spaced 40-100 mm apart) and are manually cleaned. Trash racks provide a physical barrier that water must past though and material larger than the bar spacing is retained. As material builds up behind the trash rack finer material also accumulates (Nielsen & Carleton, 1989).

Photograph 3.4 Trash racks on Cup & Saucer Creek (Sydney)

The main disadvantage of trash racks is their inability to self cleanse (Nielsen & Carleton, 1989; Beecham & Sablatnig, 1994; and DLWC, 1996). Even though trash racks are designed to cope with discharges while partially blocked (SPCC, 1989) overtopping of a trash rack is common (Carleton, 1990; McKay & Marshall, 1993; and Melbourne Water, 1995a). As more material is retained behind the bars less water can penetrate the bars and the water level behind the trash rack rises until the bars are overtopped. When water flows over the top of the rack it carries not only incoming gross pollutants but also material (especially floating material) that has accumulated behind the screen. The backwaters behind a blocked trash rack can cause upstream flooding, reduce flow velocities near the rack and allow sediments to settle which further contribute to blocking.

It is impractical and unsafe to clean trash racks during storms, therefore it is imperative for trash racks to be self cleansing for at least the duration of a storm or sufficiently sized to accommodate the expected load in a typical storm event. A self cleaning trap would allow the flow-path of the water to remain free from collected debris. Some research into self cleaning racks involved angled screens that encourage trash to move up the rack and allow water to flow underneath the collected material. Although angling the trash rack to the flow did not produce a self cleansing trap, the self cleansing ability was seen to increase as the angle of the rack to the water decreased (Nielsen & Carleton, 1989).

Nielsen & Carleton (1989) also found that by increasing the size of the openings between the bars a higher self cleaning ability was achieved, although this would suggest that more material passes through the trap. They also suggested angling the racks downwards in the direction of the flow as a possible improvement and this has been more recently developed by Baramy Engineering (1996; see Section 3.1.9) and Nel (1996) in South Africa.

Other attempts to design a self-cleaning rack include angling the rack across the channel bed, using horizontal bars along the rack and a combination of the two (Krejci, 1989; Sim & Webster, 1992; and Beecham & Sablatnig, 1994). Vibrating the trash racks has also been tested (Nguyen, 1991). It was hoped that the improvements would allow for gross pollutants to be pushed along the racks by the flow to a collection point. Results have shown that despite minor improvements (for some configurations) the racks block, in much the same way as a vertical bar rack.

Trash racks have been installed in almost all major cities in Australia. Limited data regarding trapping performance suggest trapping efficiencies between 5-14% for floating items (McKay & Marshall, 1993). Beecham & Sablatnig (1994) gave qualitative descriptions of trapping efficiency for various configurations of trash racks but no removal efficiencies were quoted.

The maintenance regime for trash racks is either on demand (most installations) or cleaned during programmed works. Manual cleaning of trash racks is expensive, time consuming and potentially dangerous work, but no automated techniques have been developed. Four trash racks in Sydney cost between \$40 and \$500 per hectare per year to maintain (Robyn Sim, pers. comm., Sydney Water).

3.2.5 Litter Control Devices (LCD)

North Sydney City Council developed a stormwater litter trap in response to publicity surrounding a clean-up campaign (Cooper, 1992) and by 1995 they had constructed nine devices (Brownlee, 1995). The traps are located in pits in the drainage network (catchment areas range from 2 to 145 hectares) and consist of steel frames that support metal baskets (approximately one cubic metre), see Figure 3.4.

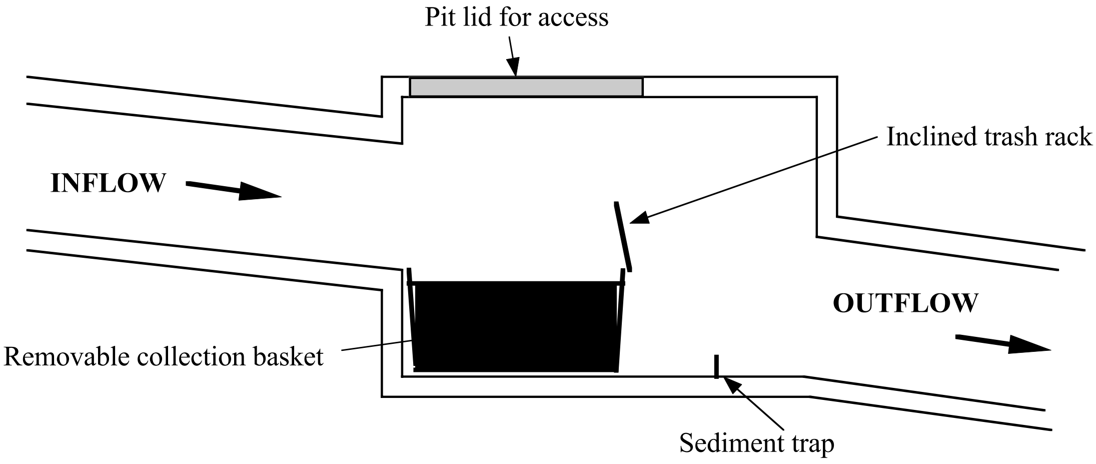


Figure 3.4 Litter control device (after Brownlee, 1995)

The baskets sit below the invert of the inlet pipe and water drops into the baskets (that have 30 mm diameter pressed holes in the sides) and flows out through the holes in the baskets. Large material (greater than 30 mm pore size) is retained in the basket and, as it builds up, it reduces the pore sizes offered to the incoming flow (Hocking, 1996) allowing smaller material to be caught. The traps require approximately one metre drop in the channel bed from inlet to outlet to accommodate the basket (Hocking, 1996). This limits their applicability in low lying areas.

LCDs have been reported to have varying effectiveness for trapping gross pollutants (Brownlee, 1995 and Hocking, 1996). Problems with floating materials in tidal areas and high discharges are cited as possible reasons for material passing the traps. An inclined trash rack was installed at the downstream end of one trap to reduce quantities of material being scoured from within the baskets (see Figure 3.4).

Trapping efficiencies of 80 to 85% are quoted for a LCD during a series of monitored storm events (Hocking, 1996) with the range of efficiencies between events from 35 to 98%. During the experiment the flows around the basket were altered considerably (due to the monitoring equipment) and this may have affected results. Monitoring screens with 10 millimetre apertures were placed across the outlet pipe downstream from the LCD. Material that collected on the monitoring screens quickly blocked the screen and retarded outflow, thus causing ponding upstream of the monitoring screen and flooding of the LCD collection basket.

The changed flow conditions during the monitoring period limits the reliability of the efficiency data from the study. Hocking (1996) also notes that only a small amount of material was found in the baskets after large rainfall events. Monitoring (described in Chapter 4), as part of the present study, indicated that large events transport large quantities of gross pollutants. This would suggest that material escaped the LCD during high flows, and consequently, only small quantities of gross pollutants remained after large flow events.

Monitoring of the LCD on a weekly cleaning frequency yielded approximately three times more gross pollutants than previous monitoring (of the same trap) using a monthly cleaning frequency (Hocking, 1996). This suggests that pollutants may escape LCD if not maintained regularly (weekly) and that the monitoring overestimated the pollutant capture for the device compared to normal operational conditions (in which it is cleaned monthly).

LCDs retain some sediments once the pores in the baskets become blinded with material (Brownlee, 1995). Hocking (1996) suggests the sediment retention capabilities of the devices account for some improvement of water quality parameter concentrations (measured upstream and downstream of the trap). However, changed flow conditions during the monitoring period would enable more solids to settle from the flow than in typical installations.

The nine installations of LCDs by the North Sydney City Council have cost between $900 and $29,000 per hectare (1.7 to 144 hectares) and maintenance is estimated at $33 per hectare per year (Brownlee, 1995). Maintenance involves lifting the collection baskets out of the LCD directly onto disposal vehicles with modified five tonne cranes. To clean one trap the operation (one truck and two people) takes 20 to 40 minutes (Brownlee, 1995).

There have been devices with similar trapping concepts installed in Melbourne. The difference in the Melbourne traps is the use of nylon mesh for the basket material. The mesh basket proved to be a limitation when cleaning as material would entangle with the mesh making it extremely slow to clean and fast to block during flow events. No performance data were collected.

3.2.6 Continuous Deflective Separation (CDS) devices

The CDS mechanism of solid separation is by diverting the incoming flow and associated pollutants away from the main flow stream of the pipe or waterway into a pollutant separation and containment chamber. Solids within the separation chamber are kept in continuous motion and are prevented from "blocking" the screen (Figure 3.5). This is achieved by a hydraulic design that ensures the tangential force exerted on an object by the circular flow action is significantly higher than the friction caused by the centrifugal force associated with the rotating flow in the circular chamber. Floating objects are kept in continuous motion on the water surface while the heavier pollutants settle into a containment sump.

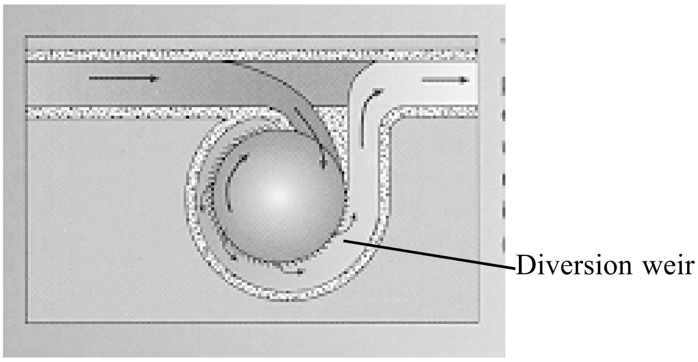


Figure 3.5 Schematic diagram of the CDS trapping system

The flow conditions within the swirling chamber are extremely complex and a detailed analyses of their behaviour is beyond the scope of this thesis. However, some comments can be made based on relatively simplistic physical considerations. Measurements of surface velocities in the swirling chamber were made by Wong & Wootton (1995) on a scale model of the CDS unit. Their measurements indicate that the circumferential velocities increase with the radial distance from the centre of the chamber (Figure 3.6). Therefore, the main flow in the chamber behaves in the manner of solid body rotation (forced vortex) and consequently, any object in the flow, with a density greater than that of water, will be forced outwards and be pressed against the outer boundary of the chamber (the perforated screen). In addition, objects near the screen will be influenced by the drag forces associated with the flow component through the perforated mesh, however, these are considered to be negligible compared to the centrifugal forces.

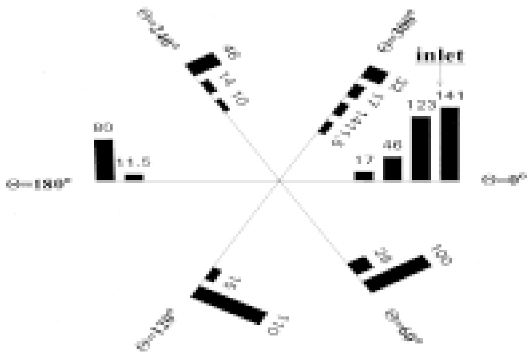


Figure 3.6 Surface velocity distribution within the separation chamber of a CDS unit (after Wong & Wootton, 1995)

To illustrate the non-blocking principle, consider a particle on the surface of the screen in Figure 3.7. The particle is influenced by the circular motion of the water inside the chamber forcing the particle outwards, but is prevented from moving to outside the chamber by the perforated screen. The rotating motion of the flow inside the chamber results in a centrifugal force acting on the particle (F_b), which acts to block the screen. This force is resisted by an equal but opposite force exerted by the screen (F_s, the centripetal force). The particle also experiences a tangential drag force caused by the tangential flow around the chamber (F_t). This force is resisted by a friction force (F_f) caused by the centrifugal force into the screen (F_b).

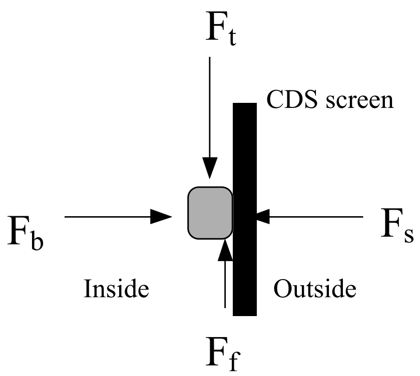


Figure 3.7 Schematic drawing of the forces on an object near the CDS screen

The particle is kept in motion because the tangential drag force (F_t) is larger than the friction force (F_f). The dimensions of the chamber ensure that the ratio between F_t and F_f is always in favour of F_t, regardless of the position of the object around the chamber screen.

A diversion structure upstream of the CDS unit acts as a by-pass weir and is constructed so that during periods of above design conditions, excess stormwater can by-pass the CDS unit. The selection of the height of the weir determines the frequency of stormwater by-pass. The height of the weir is dependent on a number of factors including the topography of the site, depth of cover of the existing pipe and the discharge capacity of the stormwater system. The diversion weir is typically designed to divert at least 95% of annual discharge through the separation chamber (Wong et al., 1996).

A feature of the CDS system is that it requires only small amounts of hydraulic head to operate (Wong & Wootton, 1995). This allows the trap to be potentially installed at many locations in the drainage network including low lying areas (Melbourne Water, 1995a).

Material that collects in the separation chamber can be removed in two ways. The sump can be fitted with a large basket that collects sinking material and can be lifted with a crane onto a removal truck. Alternatively the contents of the sump can be educted with a powerful vacuum pump A two to three monthly cleaning frequency is recommended although there is limited experience with cleaning CDS units.

CDS units require substantial capital investment but are intended to provide easier maintenance than other trapping systems. High trapping efficiencies are reported from laboratory tests (Wong et al., 1996) but no field data regarding the field trapping efficiency existed prior to the present study. Performance monitoring of a CDS unit was undertaken as part of this study. Chapter 5 describes how the project was initiated, the construction of the device and procedures for collecting performance data. Chapter 6 and 7 discuss the monitoring results and implications.

3.2.7 Gross Pollutants Traps (GPT)

GPTs are in-transit pollution traps intended to remove litter, debris and coarse sediments. GPTs have evolved from sedimentation basins (see Perrens, 1992; and Queck et al., 1991 for descriptions of sedimentation basins). They generally consist of a large concrete lined wet basin upstream of a weir and a trash rack is located above the weir (Willing and Partners, 1992; and see Figure 3.8). Maintenance involves dewatering the wet basin and using a backhoe to remove sediments (Willing and Partners, 1992). GPTs are primarily designed for trapping coarse sediments from stormwater. These criteria have governed their shape and size (Willing and Partners, 1992).

The philosophy behind GPTs is to decrease flow velocities sufficiently, so that coarse sediments settle to the bottom. This is achieved by increasing the width and depth of the channel in the GPT basin. The trash rack on the downstream end of the basin (usually constructed of vertical steel bars) is intended to collect floating and submerged debris in the same way as conventional trash racks (see Section 3.1.4).

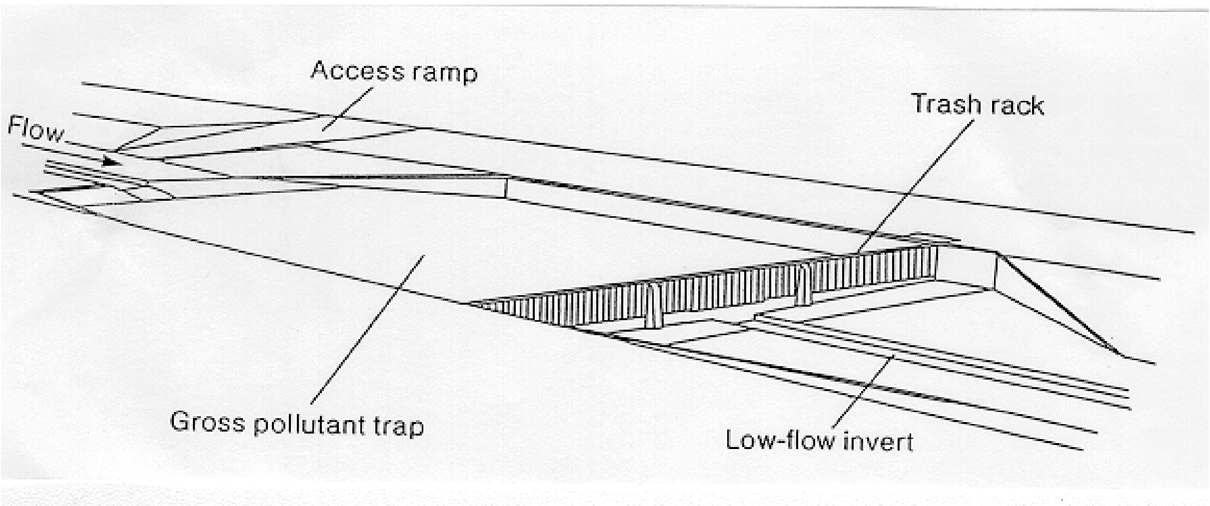
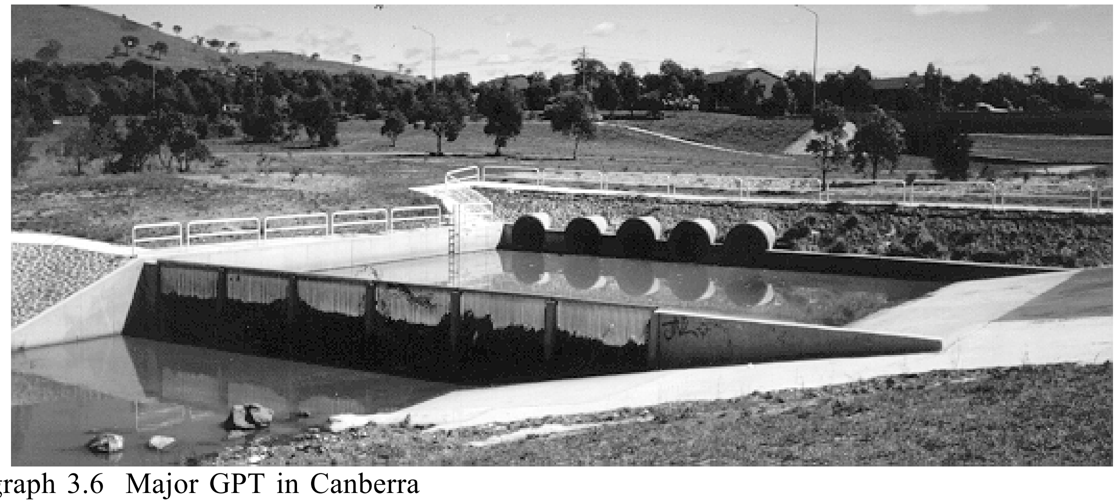


Figure 3.8 Gross Pollutant Trap (after SPCC, 1989)

Two types of GPTs have evolved - major and minor traps (Phillips et al., 1988). Major GPTs are open and are intended to be located in large floodways and treat medium to large flows (Photograph 3.5). Minor GPTs are closed and intended to be placed at features in the drainage system (heads of floodways, junctions of stormwater pipes and major water bodies, Photograph 3.6), but the principles of operation are the same for both traps.


Photograph 3.5 Minor GPT in Canberra


Photograph 3.6 Major GPT in Canberra

GPTs are used primarily in the ACT where approximately 60 traps are installed (Kloos, 1995). In Sydney there are six GPTs and they appear to trap large quantities of gross pollutants (10 to 100 kilograms per hectare per year; Robyn Sim, pers. comm., Sydney Water) although there has been very little monitoring of their trapping efficiency for litter or debris (Webster et. al 1992; and Sim & Webster, 1992).

GPTs are of considerable size and consequently are best suited to developing areas where land can be set aside for construction (Phillips, 1992) which is generally on the edges of the urban area. Retrofitting is seen to be difficult due to the land and topographic requirements (Zaman & Kandasmy, 1996). Approximate construction costs in New South Wales are between $700 and $17,000 per hectare of catchment and annual maintenance between $20 and $900 per hectare (Robyn Sim, pers. comm., Sydney Water). Canberra data show that GPTs are cheaper to maintain than in Sydney and also that major GPTs are cheaper ($3-14 per hectare per year) than minor GPTs ($10 - 120 per hectare per year) to maintain, however, construction costs of the Canberra traps are unknown (Carl Kloos, pers. comm., ACT Department of Urban Services).

A large proportion of the building costs for major and minor GPTs can relate to subsidiary costs such as access roads for maintenance (Phillips, 1992). These high subsidiary costs have meant minor GPTs cost more per hectare than larger GPTs. Consequently, more major GPTs have been built resulting in large structures that can be obtrusive in an otherwise tranquil setting.

Design criteria for the sizing the sediment basin in a GPT have been set according to the potential impact that sediments pose on downstream water bodies. As GPTs are often located just upstream of wetlands, the guidelines have been set so the effluent from a GPT does not retard macrophyte growth in the pond (Willing and Partners, 1992). Monitoring of the sediment trapping performance of a GPT suggested that it did not meet design criteria of the expected sediment retention (Southcott, 1995) There appears to be no efficiency monitoring for litter and debris available in the literature.

GPTs have several disadvantages: high construction and maintenance costs, large visual impact on usually a recreational area and their frequency of trash rack blocking and subsequent overflowing, in addition to a costly maintenance program. The trash racks installed in GPTs encounter the same problems as conventional trash racks (see Section 3.1) but may perform slightly better because of the increased proportion of trash rack area available to the flow (DLWC, 1996).

3.2.8 Booms and floating traps

Litter booms are constructed by stringing partly submerged floating booms across waterways (Photograph 3.7). The boom (originally designed as an oil slick retention device) collects floating objects as they collide with it (MMBW et al., 1989). The performance of any boom is greatly influenced by the flow conditions of the waterway (McKay & Marshall, 1993; Melbourne Water, 1995a; and DLWC, 1996). Litter booms are best suited for very slow moving waters and perform best with floating objects such as plastic bottles and polystyrene (SPCC, 1989).


Photograph 3.7 Sobar oil retention boom used as a litter retention device, Yarra River, Melbourne

Despite early claims of high trapping efficiency (Molinari & Carleton, 1987) it was later recognised that during high flows the gross pollutant retaining performance of floating booms is greatly reduced because material is forced over and under the boom (Nielsen & Carleton, 1989; Gamtron, 1992; and Horton et al., 1995), or the boom breaking from the banks (MMBW et al., 1989). The litter retention properties of booms can be enhanced by angling booms across to the current, and by using mesh skirts (Horton et al., 1995); however, high flow problems still persist.

Litter booms generally require manual cleaning, performed by retrieving collected trash from within the boom with a trench digger or by using a boat and pitch forks. Cleaning is usually on demand. To improve this operation for small booms, they can be pulled to one bank and material can then be accessed manually from land. Booms angled across the flow are intended to transfer collected material to a collection area that is accessible from land. This has been achieved for some small booms but not for most installations (Horton et al., 1995).

Despite the inefficiencies with booms (during high flows and for submerged material) they have been reported to trap large quantities of gross pollutants. It has been reported that between 100 and 370 cubic metres of gross pollutants annually have been removed from booms in Melbourne (SPCC, 1989). Gamtron (1992) quotes annual capture rates of between 24 to 71 kilograms per hectare from four booms in Sydney.

More recently, Floating Debris Traps (FDTs; Bandalong Engineering, 1995) have evolved from booms and have an enhanced retention of captured material and an improved cleaning method. The traps use floating polyethylene boom arms with fitted skirts to deflect floating debris through a flap gate into a storage compartment (Figure 3.9). The flap gate is intended to prevent collected floatables escaping with changed wind or tidal conditions. A sliding gate on the downstream end of the trap provides an improved cleaning method. As the gate is raised material flows out of the trap and into a collection basket that is located downstream of the trap during cleaning. Once full, the cleaning basket is lifted onto a specially designed barge (fitted with a crane to lift the basket).

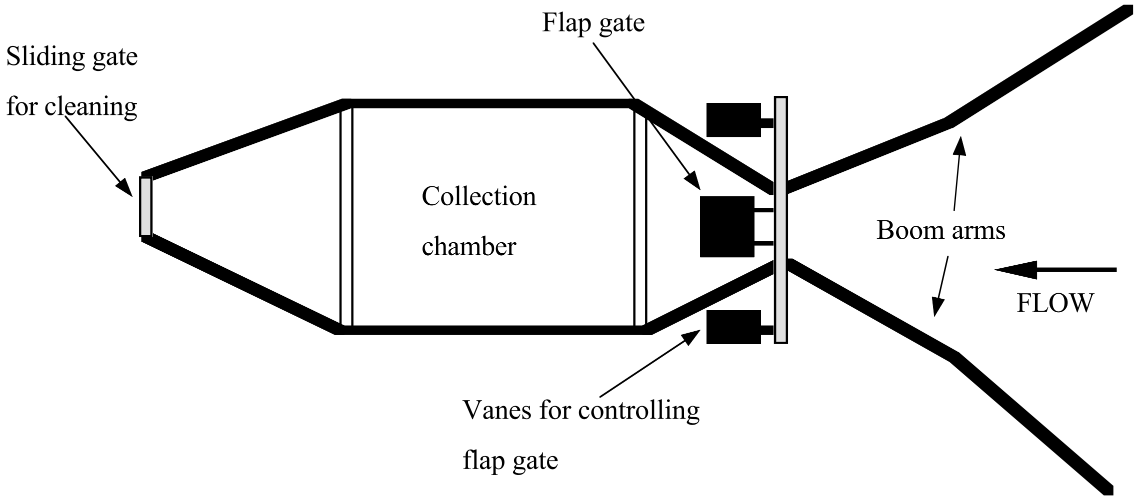


Figure 3.9 Plan view of Bandalong floating debris trap

Photograph 3.8 Bandalong floating debris trap installed on the Yarra River Melbourne

FDTs operate with the same principle as a floating boom but have improved retention of floating gross pollutants once captured, and an improved cleaning method. Although there is little data regarding the trapping efficiency of floating debris traps, it is likely that they experience similar problems to floating booms (high flow problems and wind distributing gross pollutants away from the traps).

As booms or floating debris traps can rarely span the complete width of a waterway (because of size and/or waterway traffic), the location of the trap is critical to its performance because the preferential flow paths for floating gross pollutants (governed by discharge, tide or wind depending on conditions) can either direct pollutants into or away from the traps. Knowledge of flow paths and wind directions for a reach of waterway is recommended prior to installing FDTs. Parks Victoria use a number of floating debris traps in a series along the Yarra River to maximise the overall trapping potential.

A Melbourne study used tagged litter items, released upstream of various traps to determine floating boom efficiencies (McKay & Marshall, 1993). The efficiencies reported varied from 12 to 50%, however, these efficiencies were considered preliminary because of the low number of items released in the boom catchments (McKay & Marshall, 1993). In addition, the items released in the study were highly floatable items (suitable for tagging) and do not represent the complete range of gross pollutants found in urban stormwater, (Section 6.1 describes results from monitoring in this study that shows floating items account for only 25% of the total gross pollutant load). It is therefore expected that the figures quoted by McKay & Marshall (1993) represent higher trapping efficiencies than those expected for the total gross pollutant load (ie. including submerged material).

3.2.9 Evolving stormwater debris traps

There are a range of traps becoming available that incorporate new techniques or are developments of previous devices for trapping gross pollutants. Installations are limited to a few cases and few data exist on their trapping performance. Descriptions are presented here for completeness.

3.2.9.1 Contra-sheer trash racks

The Baramy trap (Baramy, 1996; Figure 3.10) works with a *contra-sheer* concept. Stormwater is delivered from pipe outlets onto an downward inclined trash rack (inclined away from the flow as suggested by Nielsen & Carleton, 1989). Water is intended to fall between the trash rack bars and pollutants larger than the gap width slide down the rack onto a holding shelf.

The trap is constructed so that maintenance can be performed with standard plant with access down a ramp. The holding shelf allows water to drain from collected material which simplifies the cleaning process. At least one trap has been installed in Sydney (on a 900 mm diameter pipe), and at the time of writing there was no performance data available.

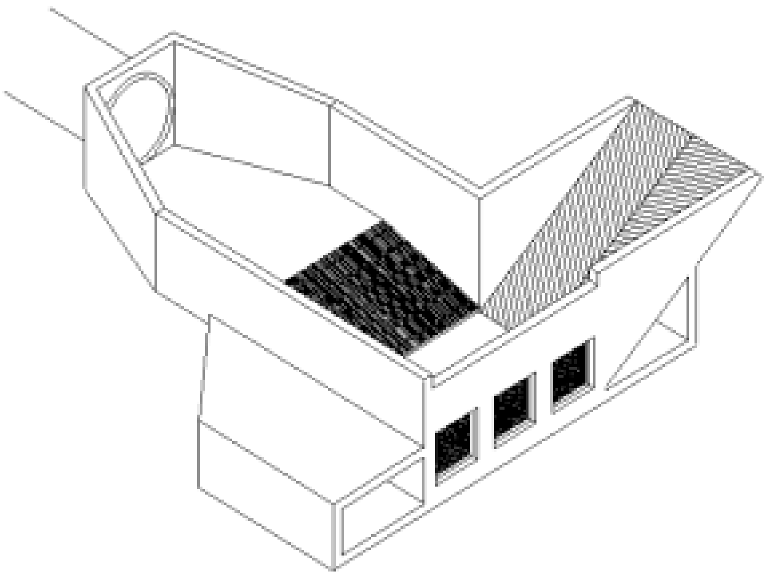


Figure 3.10 The Baramy gross pollutant trap (after Baramy, 1996)

3.2.9.2 Diston trap

The Diston litter and pollution trap uses a perforated deflection weir upstream of the main separation chamber (which is fixed to the channel bed) to divert gross pollutants and most of the water into a collection chamber (Diston, 1996; Figure 3.11). At high flows or during trap blockages water overflows the diversion weir and by-passes the unit.

When water enters the containment chamber it is forced through a nylon mesh bag(located in the basket) that is intended to capture gross pollutants. There is a second screen to further enhance the trapping performance of the unit. Submerged outlet pipes also allow oils to be retained during low flows. There are two installations in Melbourne but no performance data are available.

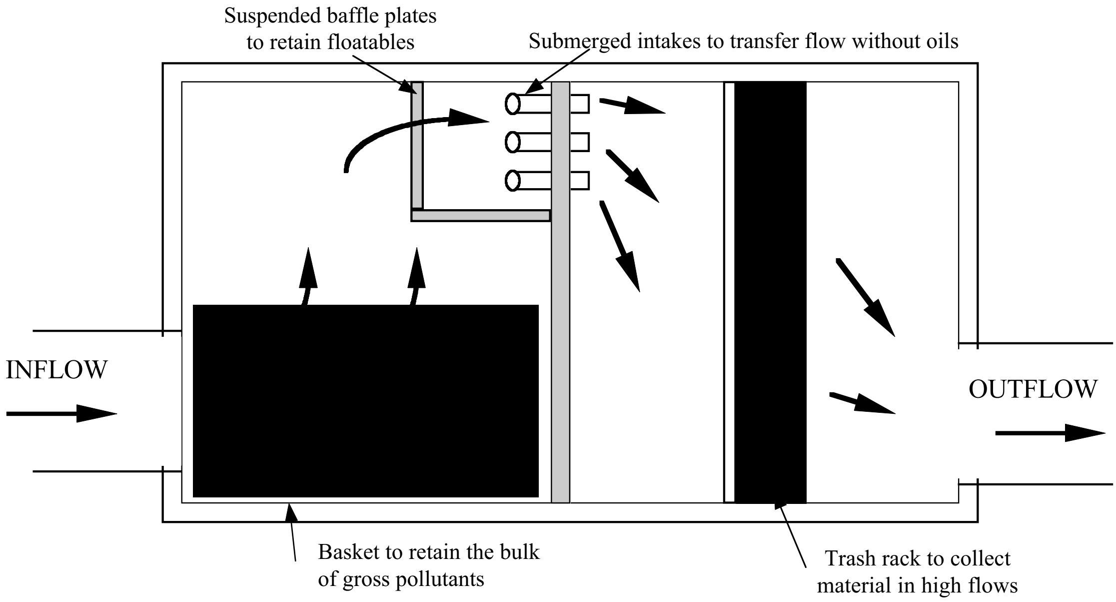


Figure 3.11 Plan view of the collection chamber of the Diston Purifications Litter Trap (after Diston, 1996)

3.2.9.3 Hinged boom

Phillips (1996) is researching and developing an in-line litter separator intended for simple installation and operation. It traps pollutants by diverting them into an off-line chamber where they are retained with the use of baffles to facilitate sedimentation and retention of floating material. As the flow depth increases, the boom, which is fixed to the side of the channel with hinges, rises and only highly buoyant items are deflected into the off-line chamber. The majority of the flow bypasses the trap under the boom during high flows.

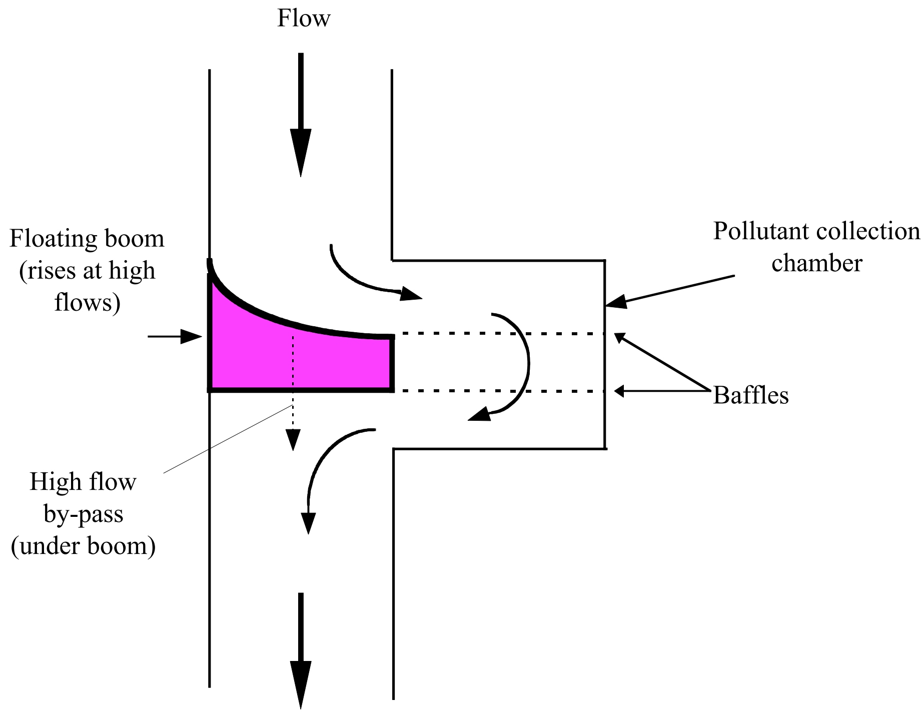


Figure 3.12 Sketch of Phillip's (1997) hinged boom pollution trap (plan view)

Maintenance is intended to be performed by vacuuming (as fitted to street a sweeping plant). Prototypes of this device are currently being tested (Figure 3.12).

3.3 OVERSEAS EXPERIENCE WITH GROSS POLLUTANT TRAPPING

Most overseas countries have combined wastewater and stormwater systems, consequently pollution problems relating to these systems (ie. combined sewer overflows, CSOs) have dominated research (Pisano, 1989; Brombach, 1990; Balmforth, 1991; and Jefferies, 1993). CSO devices have different operating conditions, but nevertheless are based on separating solids from fluids, these principles have been translated into stormwater systems with some devices (eg. CDS devices). Many CSOs rely on a return flow to the sewer for pollutant removal (and do not *trap* pollutants).

South Africa has separate stormwater systems and has conducted research into gross pollutant traps. Compion (1996) describes debris traps used in South Africa and Armiatge et al. (1997) provide an overview of South African gross pollutant research.. Traps include a system with a series of trash racks off-line to the main channel (Townshend, 1996), various angled trash racks (Compion, 1996) and a trap using a contra-sheer principle (Nel, 1996).

Townshend's (1996) method uses two sets of vertical screens on each side of a diverging channel section. The bar spacing on the screens are graded from coarsest upstream to finest on the downstream side. The trap uses a hydraulically operated sluice gate to divert the flow through the screens and encourage material to be trapped (Figure 3.13) while minimising the head required to operate the device. During high flows the water level rises and triggers the sluice gate to open and allows the flood to pass through the centre of the trap, avoiding scouring material from the screens.

This method presents a series of graded screens therefore has a larger screen area than conventional trash racks and presumably can capture more gross pollutants. Collected pollutants are also less likely to be scoured from behind the screen once the hydraulic sluice gate is activated. Early reports from South Africa suggested that cleaning could only be performed manually, however, now automated cleaning methods have been developed and therefore this system may be well suited to Australian conditions.

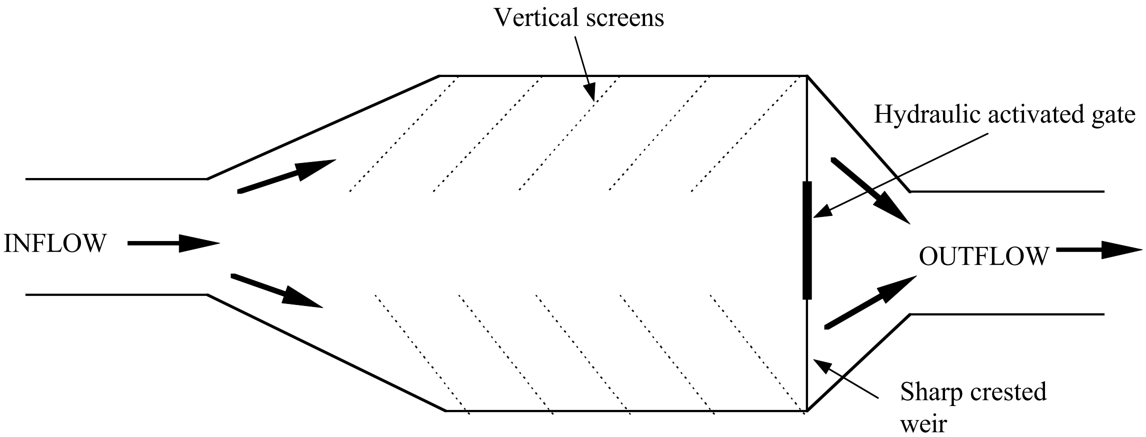


Figure 3.13 Plan view of trap by Townshend (South Africa, after Townshend, 1996)

There are also a range of standard trash racks used in South Africa (Compion, 1996) ,however, these appear to be similar to Australian trash racks and experience the same blocking problems.

The gross pollutant trap developed by Nel (1996) was constructed in Springs (South Africa) on a five metre wide open channel, Figure 3.14. The trap consists of a trash rack area adjacent to the main channel. Water is diverted by a diversion weir onto trash racks which are inclined downwards in the direction of the flow (Figure 3.15). Gross pollutants are pushed along the rack by the force of the water onto collection shelves. The water that falls through the trash racks is returned to the main channel via a drain located beneath the pollutant collection areas. During high flows water passes over the diversion weir and therefore avoids scouring collected pollutants.

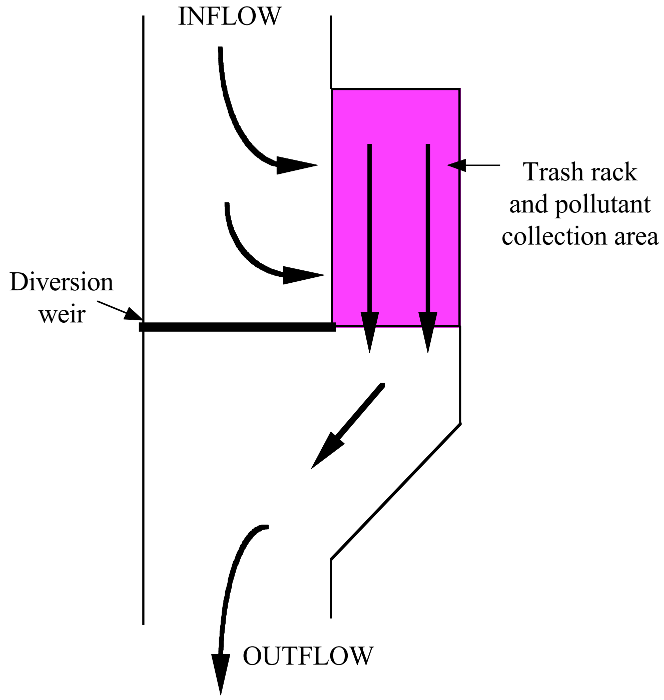


Figure 3.14 Sketch of Nel's (1996) South African pollution trap (plan view)

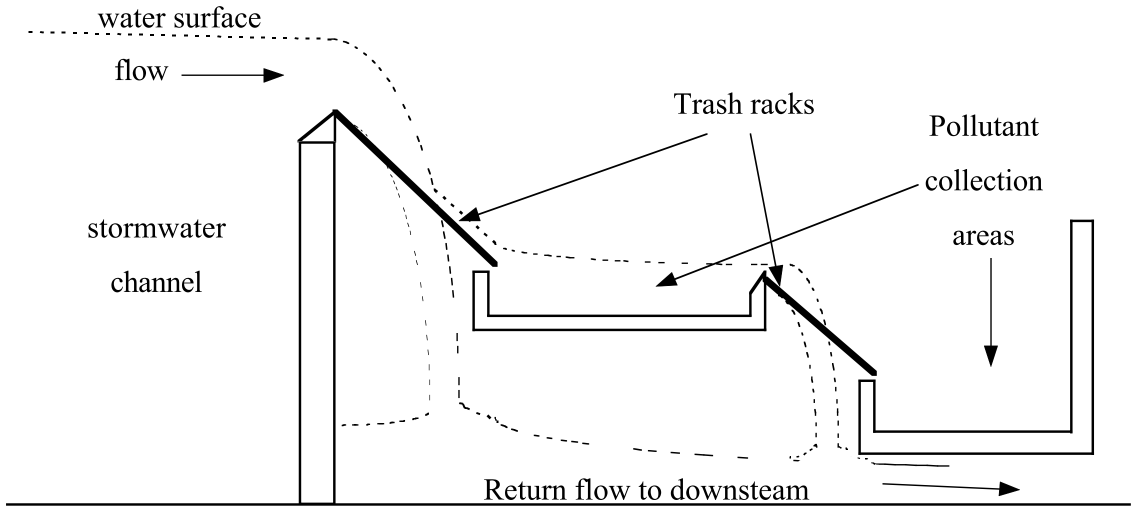


Figure 3.15 Sketch of trash rack used by Nel (1996) in South Africa (in section)

Material that collects on the holding shelves can drain and remains dry during low flows. Maintenance is performed with earth moving equipment with vehicular access along the holding shelves and material is transferred to disposal vehicles.

Nel's (1996) trap appears to perform well and is installed in a much larger catchment than the Baramy traps in Australia. Although it requires a considerable drop in the channel bed to operate (in the order of two metres) and takes up considerable space, there is no reason why this trap is not suitable for some Australian conditions.

3.4 SUMMARY OF TRAPPING TECHNIQUES

There are increasing numbers of gross pollutant traps being used in Australia with considerable investment. However, there is a shortage of data relating to the trapping performance of the various techniques and consequently, comparisons between different approaches are limited. Comparative quantitative information is essential for choosing the best techniques for trapping gross pollutants from urban stormwater systems.

Table 3.1 lists the range of traps discussed in this chapter and summarises the performance and limitations of each system. In the table each system is rated for the gross pollutant trapping efficiency, cleaning frequency and operational head requirements. According to the categories of low, medium and high. Low gross pollutant trapping efficiencies are considered to be less than 35%, moderate efficiencies from 35% to 65% and high from 65% to 90%. A low head requirement rating means the trap can usually be retrofitted into most existing drains (eg. slope of 1%), moderate head results in some disturbance to the channels or pipes and may cause upstream ponding (this restricts the locations for potential traps to reaches in the drainage network that have drops in the channel bed), and high head requirements require a substantial drop in the channel bed for the traps to operate (ie. they incorporate a drop into the design of the trap, typically at least one metre).

To address the lack of performance data, field trials were set-up to investigate the trapping performance of two promising systems (SEPTs and CDS traps) as part of this study. CDS devices appear to trap pollutants very well and do not require much head to operate. SEPTs are comparatively very cheap, easy to install and allow specific areas to be targeted, but their trapping effectiveness in the field was also unknown. The field experiments are described in Chapter 5 and results follow.