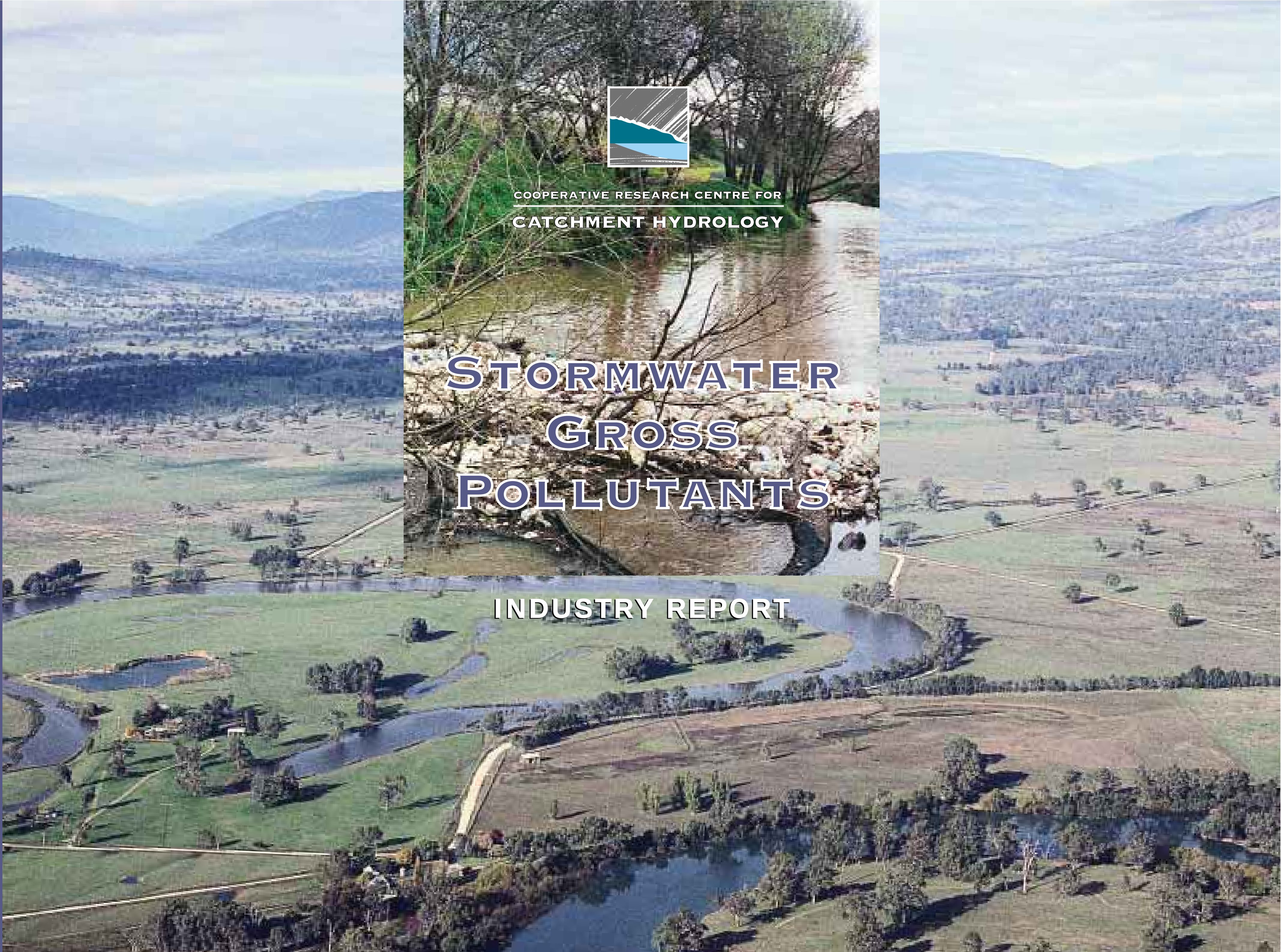
COOPERATIVE RESEARCH CENTRE FOR
CATCHMENT HYDROLOGY

Stormwater Gross Pollutants

INDUSTRY REPORT



Stormwater Gross Pollutants

by

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Background cover photo: Aerial view of Murray River billabong near Albury, NSW.

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F o r e w o r d

This industry report is one of a series prepared by the Cooperative Research Centre (CRC) for Catchment Hydrology to help provide agencies and consultants in the Australian land and water industry with improved ways of managing catchments.

Through this series of reports and other forms of technology transfer, industry is now able to benefit from the Centre's high-quality, comprehensive research on salinity, forest hydrology, waterway management, urban hydrology and flood hydrology.

This particular Report represents a major contribution from the CRC's urban hydrology program, and presents key findings from research on stormwater gross pollutants in the project entitled 'Design and management procedures for urban waterways and detention basins'. (More detailed explanations and research findings from the project can be found in the Reports and Working Documents published by the Centre.)

The CRC welcomes feedback on the work reported here, and is keen to discuss opportunities for further collaboration with industry to expedite the process of getting research into practice.

Russell Mein

Director, Cooperative Research Centre for Catchment Hydrology

P r e f a c e

This report summarises the Cooperative Research Centre (CRC) for Catchment Hydrology's research on gross pollutants in urban stormwater. This study is part of the CRC's project C2 'Design and management procedures for urban waterways and detention basins'. The following topics are covered in this report:

- the CRC's gross pollutant monitoring programs
- stormwater gross pollutant characteristics (loads and types)
- gross pollutant trapping systems
- field monitoring of two gross pollutant traps
- estimating gross pollutant loads and comparing different trapping strategies.

A feature of the project was the range of organisations it brought together, particularly in monitoring gross pollutant characteristics and evaluating two types of gross pollutant traps. The authors wish to thank all of the partners for their generous cooperation and support. The participants in the project included:

- Australian Water Technologies
- Banyule City Council
- CDS Technologies
- Environment Australia
- Melbourne Water
- Merri Creek Management Committee
- Moreland City Council
- The University of Melbourne

Contents

Gross pollutants come in all shapes and sizes

Introduction

Gross pollutants are large pieces of debris flushed through urban catchments and stormwater systems. For the purpose of this report, gross pollutants are defined as debris items larger than five millimetres. They typically include litter (mainly paper and plastics) and vegetation (leaves and twigs), which are transported by stormwater runoff into receiving waters (urban creeks, rivers and estuaries). Gross pollutants are a threat to wildlife and aquatic habitats, look unpleasant, smell and attract vermin.

Although the environmental problems associated with gross pollutants in urban waterways are recognised, there has been little research in Australia into gross pollutant characteristics and movement. There is also limited information on the performance of structural devices to trap gross pollutants. This report describes a monitoring study undertaken by the CRC for Catchment Hydrology as part of its Project C2: Design and management procedures for urban waterways and detention basins to address this knowledge gap.

Gross pollutants – an environmental hazard

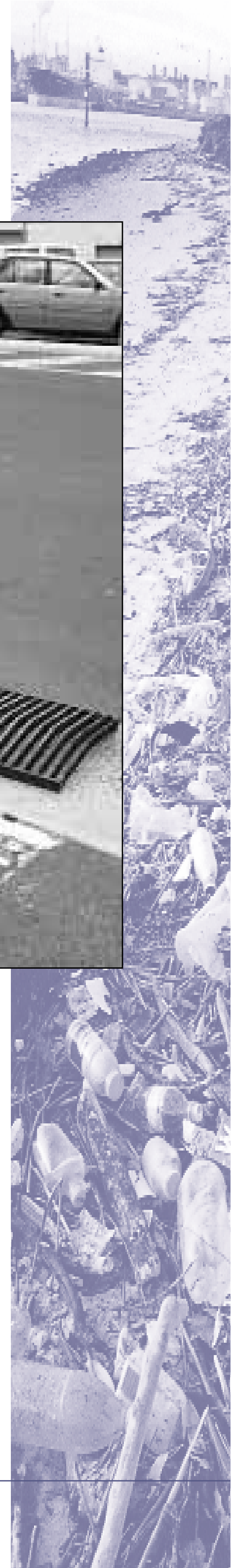
CRC Monitoring Programs

The CRC project involved two field monitoring programs in Coburg, Melbourne. The study site is 8 km north of central Melbourne and is typical of inner city suburbs in Australian capital cities. Results from this study could therefore be applied to the management of gross pollutants in other Australian cities.

CRC researcher retrieving data from a stormwater flow meter.

In the first program, CRC researchers monitored stormwater flows and gross pollutants, and manually collected water samples during storm events at several sites. These data were used to investigate the variation of gross pollutant concentrations and loads throughout a runoff event.

In the second program, the CRC investigated the performance of two promising gross pollutant trapping systems. The first device (CDS, see page 9) had a very high trapping efficiency, and thus provided excellent data on the gross pollutant characteristics for the catchment. In evaluating the second system (SEPTs, see page 8), the CRC installed traps at all 192 publicly owned road-side entrances in the catchment, providing data on the distribution of gross pollutants across the catchment.



Gross Pollutant Characteristics

GROSS POLLUTANT LOADS

Sorting gross pollutants into various classifications

Results from the CRC monitoring program suggest that urban areas contribute about 20-40 kilograms (dry mass) per hectare per year of gross pollutants to stormwater. For Melbourne, this is equivalent to approximately 60,000 tonnes or 230,000 cubic metres of gross pollutants (about 120 Olympic-sized swimming pools) and about 2 billion items of litter annually (about one item per person per day).

Collecting gross pollutants from a continuous deflective separation trap for analysis

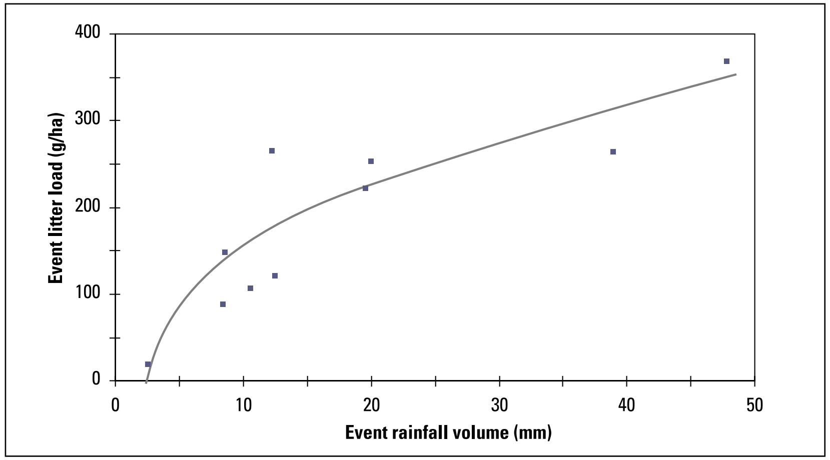


Figure 1: Dry litter loads plotted against rainfall

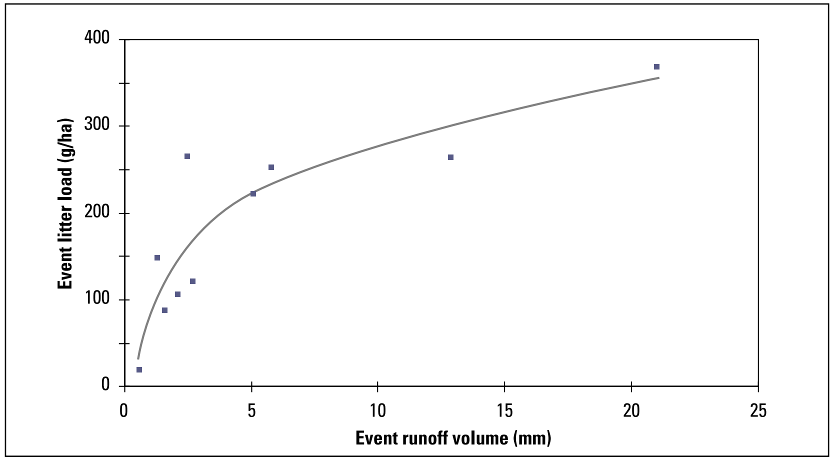


Figure 2: Dry litter loads plotted against runoff

Analyses of data collected from many storm events indicate that rainfall and runoff are the best explanatory variables for estimating gross pollutant loads. The relationships in Figures 1 and 2 are derived from the CRC monitoring data, and can be used to estimate gross pollutant loads in Melbourne and other cities with similar rainfall and runoff patterns.

GROSS POLLUTANT COMPOSITION

In the CRC studies, organic material – leaves, twigs and grass clippings – constituted the largest proportion of gross pollutant load (by mass) carried by urban stormwater (Figure 3). This was observed across all urban land-use types.

Vegetation, however, is not a major source of nutrients compared to other sources. The CRC monitoring study indicated that the potential total phosphorus and total nitrogen loads from vegetation in stormwater are about two orders of magnitude lower than the loads measured in stormwater samples. However, because of its large volume, plant matter should be taken into account in the design of gross pollutant traps, particularly where they could cause pipe blockages or habitat destruction.

Gross pollutants mainly comprise plant matter

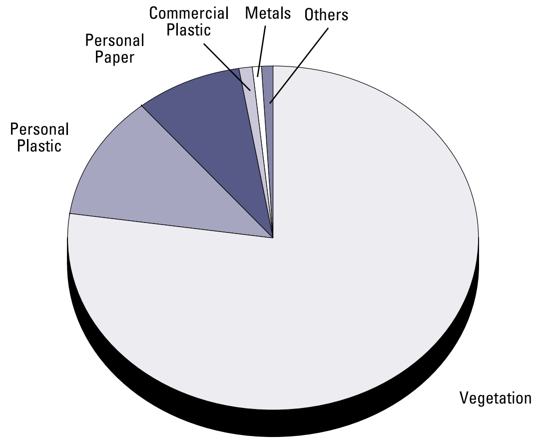


Figure 3: Composition of gross pollutants by mass

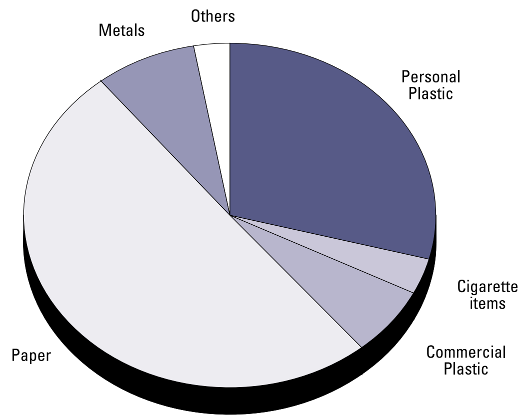


Figure 4: Composition of litter by mass

Most of the litter analysed – by mass and frequency – comprised paper and plastics. These enter the drainage network as street litter from mainly commercial areas. Large quantities of food, drink and cigarette refuse were also found during the monitoring (see Figures 4 and 5).

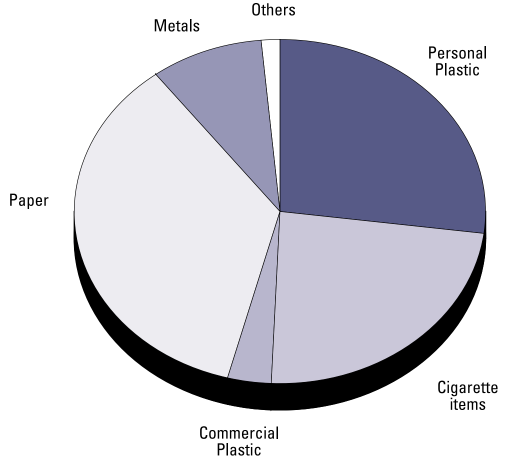


Figure 5: Composition of litter by count

These findings suggest that fast food consumers and smokers are a significant source of litter in urban streams.

Categories of gross pollutants after sorting

Floating gross pollutants collecting behind a fallen branch in the Merri Creek, Melbourne

Laboratory testing of gross pollutants showed that typically only 20 percent of the litter and less than 10 percent of the vegetation usually floats. This has implications for traps designed to catch only floating material.

GROSS POLLUTANT TRANSPORT DURING STORMS

Figure 6 shows rainfall, discharge, gross pollutant concentration and gross pollutant load rate during a typical storm event at one of the CRC monitoring sites at Coburg. These show that:

- the composition of gross pollutants during events remains relatively constant compared to the concentration and load fluctuations
- gross pollutant concentrations are highest during the early stages of runoff, but most of the load is transported during times of high discharge
- the loads and concentrations of gross pollutants generated by a storm are similar to those generated by other storms occurring earlier on the same day.

Gross pollutant samplers (developed by Dr Charles Essery, Australian Water Technologies) in action at Coburg, Melbourne

Bagging pollutants for analysis

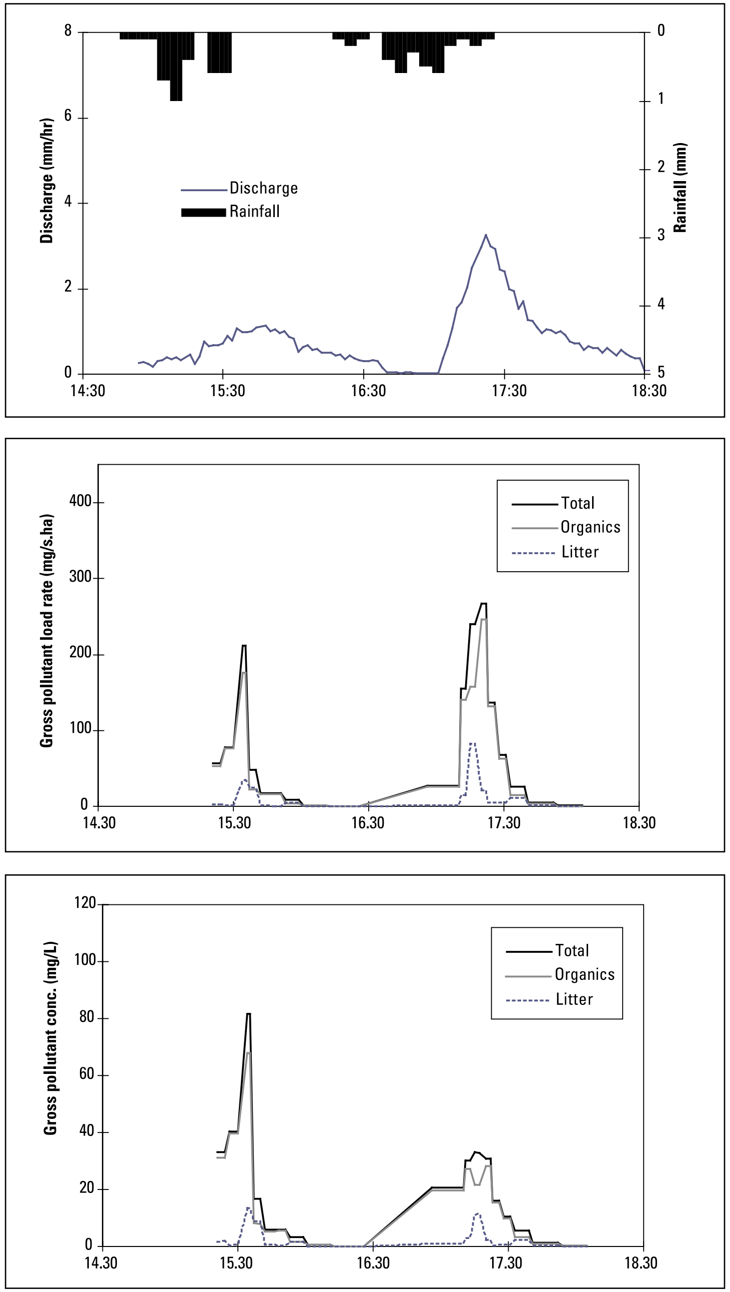


Figure 6: Rainfall, discharge and gross pollutant loads and concentrations during one storm monitored at one of the CRC's Coburg sites

Concrete-lined drains transport pollutants efficiently

Gross pollutants commonly accumulate on urban beaches

The large amount of gross pollutants observed in the CRC studies suggests that stormwater channels are effective in transporting gross pollutants from urban areas. The CRC monitoring also showed that not only do discharge and pollutant conditions in stormwater drains change and vary considerably, but so does the material carried. It may be any size, shape, density or hardness. This is the challenge that trap designers face. Trapping systems should be geared to treat the maximum possible discharge, and to cope with multiple storms in a day.

Trapping Gross Pollutants

Methods for reducing gross pollutants in urban waterways can be grouped into two categories:

- **Structural methods** are traps placed in side entry pits in gutters, or installed inside stormwater channels to separate and contain gross pollutants, and
- **Non-structural methods** involve changing the attitudes and actions of the community (including business, industry and residents).

Drain labels like this remind people of the link between street litter and waterways

Street sweeping helps reduce gross pollutants in drains

Increasing concern about the quantity of gross pollutants in urban waterways is leading to greater use of gross pollutant trapping devices. Although different types of trapping devices are now available, there is little information on their performance.

This is the focus of the CRC`s second monitoring program.

Two main characteristics determine the performance of a gross pollutant trap: trapping efficiency, and maintenance requirements. The trapping efficiency is defined as the proportion of the total mass of gross pollutants transported by stormwater that is retained by the trap. A low trapping efficiency means that gross pollutants pass through the trap and reach downstream waters. A poorly maintained trap will be inefficient at trapping pollutants, and is also a potential source of pollutants as trapped materials break down.

The first gross pollutant traps were built in the late 1970s using simple designs. More recent technologies have incorporated high-tech design and construction. Six trapping systems commonly used in Australia are described here, from those designed for the upper parts of catchments (e.g. SEPTs), to those intended for slow-moving waterways (litter booms) further down the catchment.

SIDE ENTRY PIT TRAP (SEPT)

Side entry pit trap (SEPT) in a controlled experiment

Side entry pit traps (SEPTs) are baskets fitted below the entrance to drains from road gutters. When stormwater passes through the baskets to the drain, material larger than the basket mesh size (5-20 mm) is retained. This material remains in the basket until it is removed by a maintenance crew, typically every four to six weeks. SEPTs are intended to be used at many locations throughout an urban area, and can catch up to 80 percent of the litter in a catchment.

LITTER CONTROL DEVICE (LCD)

A litter trap in Melbourne based on the litter control device (LCD) principle

North Sydney City Council developed the litter control device (LCD) in response to publicity surrounding a clean-up campaign. The baskets sit below the entry point of the inlet pipe. Water entering the baskets flows out through the holes, while debris larger than the pore size is retained. As debris builds up, it reduces the pore sizes, allowing smaller material to be caught. Trapping efficiencies of 30 to 80 percent have been reported, depending on a monthly or weekly cleaning frequency.

TRASH RACK

Trash racks consist of vertical or horizontal steel bars – typically 40-100 mm apart – fitted across stormwater channels up to 10 metres wide. They are manually cleaned, usually monthly. When water passes through the trash rack, it retains material larger than the bar spacing. As material builds up behind the trash rack, finer material is collected. However, this frequently blocks the rack, causing overflows that carry collected pollutants downstream.

Trash rack in Cup and Saucer Creek, Sydney

Continuous Deflective Separation (CDS)

The continuous deflective separation (CDS) device is installed in stormwater channels and works by diverting the incoming flow of stormwater and pollutants into a pollutant separation and containment chamber. Solids within the separation chamber are kept in continuous motion, and are prevented from ‘blocking’ the screen. Water passes through the screen and flows downstream. The non-blocking screen ensures that all gross pollutants are retained except for flows that overflow the by-pass weir during large floods. Floating objects are kept in continuous motion on the water surface, while heavier pollutants settle into a containment sump from where they can be routinely removed.

A continuous deflective separation device (CDS) in the laboratory

A major gross pollutant trap (GPT) at Tuggeranong Lake, Canberra

Gross Pollutant Trap (GPT)

Gross pollutant traps (GPTs) consist of a large concrete-lined wet basin upstream of a weir. A trash rack is located above the weir. The decreased flow velocities in the wet basin encourage coarse sediments to settle to the bottom. Gross pollutants are retained by the trash rack – usually made from vertical steel bars – at the downstream end of the basin. The trash rack collects floating and submerged debris in the same way as conventional trash racks. Major and minor GPTs have been developed to accommodate small (2–50 ha) and large (50–500 ha) catchments. Both operate with the same principles.

Floating debris trap (FDT)

Floating debris traps (FDTs), or litter booms, are made by stringing partly submerged floating booms across waterways. The booms collect floating objects as they collide with it. Newer designs use floating polyethylene boom arms with fitted skirts to deflect floating debris through a flap gate into a storage compartment. The performance of any boom is influenced by the flow conditions of the waterway – they are best suited to slow-moving waters. Because more pollutants sink than float, the traps are only useful for trapping highly buoyant materials, and thus miss most of the gross pollutant load.

Floating debris trap in the Yarra River, Melbourne

Summary of other recently developed australian gross pollutant trapping systems

While many traps have been developed in Australia over the last couple of years, information on their trapping performance is still being gathered. Table 1 lists some of the more promising traps, and provides a comment on their performance.

Device	Catchment area (hectares)	Cleaning frequency	Comments on performance
Baramy	10–100	monthly	Trash moves down an inclined screen with the force of the water, pushing pollutants onto a holding shelf to await collection. This system shows promise for economically trapping gross pollutants. Some units have been installed in NSW.
Diston	10–50	monthly	The trap uses three types of filtration to retain gross pollutants. Water firstly falls into a litter basket, then goes through a submerged outlet (to retain floatables) and then into a chamber that has a trash rack. Several units have been installed in Victoria.
Litterguard	5–50	monthly	A boom is located on the bed of a channel and it diverts flow and pollutants into a retention chamber. During high flows, the boom lifts with the flow and diverts only the floating materials. Several units have been installed in Melbourne.
Ecosol RSF4000	10–200	unknown	Stormwater and pollutants are diverted into a litter-collection basket by a hydraulically driven barrier created by the water exiting the basket. Pollutants are retained in the basket by direct filtration. Several units have been installed in South Australia.
Ski-jump	10–60	unknown	A trash rack inclined towards the flow collects pollutants during low flows. During large flows, the collected pollutants are pushed downstream into a collection chamber. Several units have been installed in NSW.

Table 1: Recent Australian gross pollutant trapping systems

Testing Gross Pollutant Traps

The CRC installed and evaluated two promising gross pollutant traps – an in-line and a source-end system – within the 50 hectare urban catchment of Coburg, Melbourne. The field work involved measurement of flows, rainfall and the quantity and composition of gross pollutants caught in the traps.

Aerial photograph of the CRC experimental site, Coburg, Melbourne.

CDS DEVICE TESTING

To assess the performance of a continuous deflective separation (CDS) device (Figure 7), flow instrumentation was installed upstream (A), downstream (C) and across the diversion weir (B) to estimate the proportion of discharge flowing through the collection chamber, and the proportion by-passing the unit over the diversion weir. The trap was cleaned as soon as possible after every storm event, and the collected material analysed in the laboratory at the University of Melbourne.

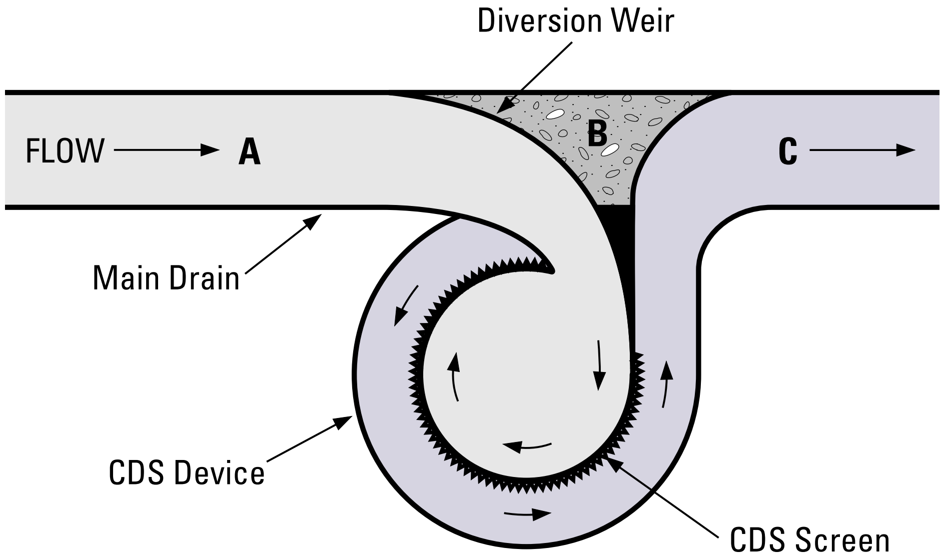
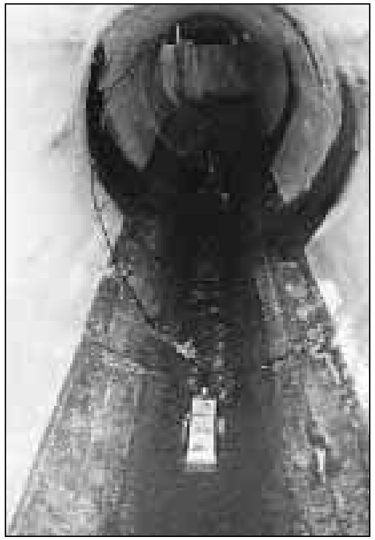


Figure 7: Diagram of CDS instrumentation layout

CDS instrumentation included depth probes (above) and flow meters (below)



The results demonstrate that CDS devices are efficient gross pollutant traps. During three months of monitoring, practically all gross pollutants transported by the stormwater were trapped by the CDS device (i.e. 100 percent removal rate). In addition, the device appears to cause minimal interference to flow in the stormwater drain, and is therefore suitable for most urban areas. However CDS devices are expensive to install and require a complex construction process. But, once constructed, they require infrequent cleaning (about once every 3 months) at one location within a catchment.

Construction of the CDS device (clockwise from top left): digging the hole for construction; walls of the collection chamber; fitting the separation screen; and the final product at road level

The CRC study included an investigation of cleaning procedures for the CDS device. After cleaning, remaining material was collected and compared to the mass removed. The study revealed that a vacuum cleaning method is best suited to the Coburg installation.

left: Cleaning the CDS unit with a sump basket

below: Cleaning the CDS with a large vacuum truck

SIDE ENTRY PIT TRAP (SEPT) TESTING

SEPTs were installed at all 192 accessible road entrances (Figure 8) in the same catchment. Because the CDS device traps practically all gross pollutants, it was used as a downstream 'control' system against which to measure the SEPTs' trapping performance.

SEPTs and the CDS device were cleaned on the same day four times over a three-month period. Data analysis indicated that SEPTs can trap significant quantities of gross pollutants. They are cheap, easy to install and, because

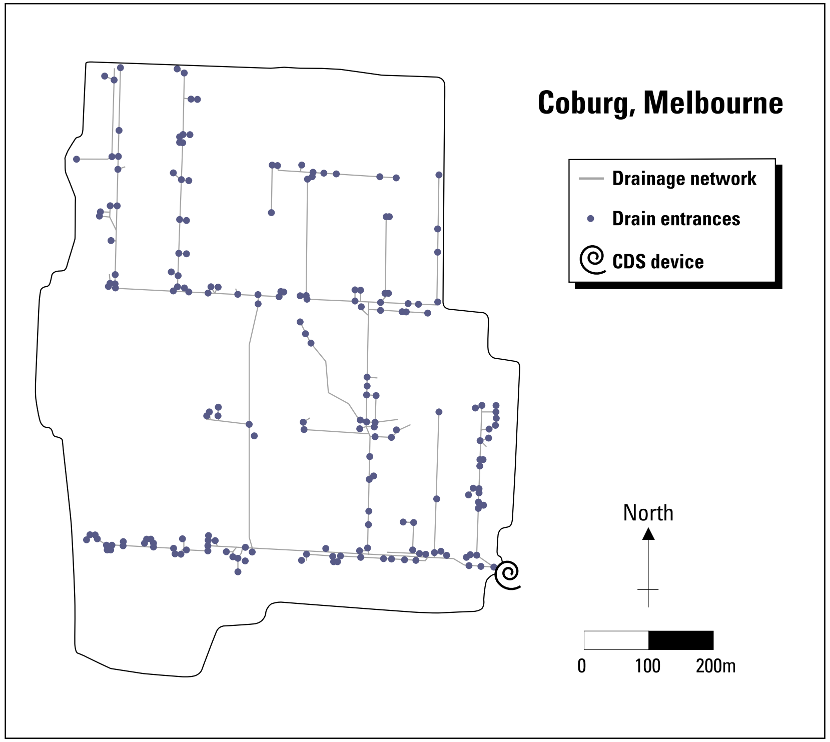


Figure 8: Coburg catchment showing drain entrances

SEPT in Coburg with trapped debris

they can be installed on individual drainage entrances, can be used in specific areas. If placed on all public roadside entry pits, they can trap up to about 80 percent of the litter load and 65 percent of the total gross pollutant load entering a catchment's drainage system.

The frequent cleaning required by SEPTs means that putting traps on all roadside entry pits is unlikely. It is possible, however, to trap two-thirds of the litter with only half of the drainage entrances fitted with SEPTs (Figure 9). CRC data analysis revealed that side entry pits deliver more gross pollutants to the drainage system than grates, and should therefore be targetted in clean-up programs.

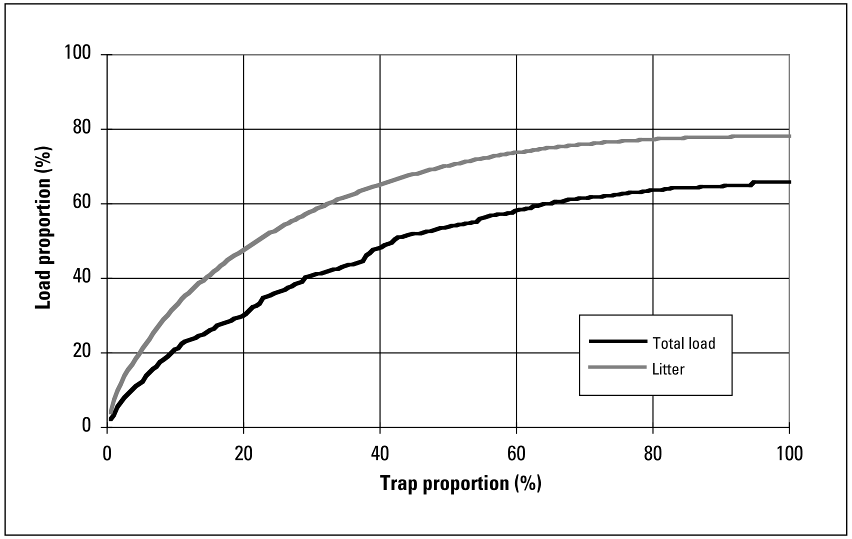


Figure 9: Plot of trapping efficiency against proportion of entrances fitted with SEPTs

Selecting Trapping Strategies

The CRC's findings demonstrate that, although large amounts of gross pollutants are carried from urban catchments via stormwater, technologies are available to trap these pollutants.

Gross pollutants in a city drain during a garbage collection strike

Trapping gross pollutants in the urban drainage system, however, can be expensive. Because of the large area occupied by towns and cities in Australia, it is unlikely that gross pollutant traps will be located on all urban catchments. Stormwater managers must therefore select appropriate trapping techniques, and decide where best to locate traps within a particular drainage network.

The results of this study have been incorporated into a decision-support-system (DSS) for managers to use in choosing from a range of gross pollutant traps described in this report (Figure 10). The DSS estimates gross pollutant loads from rainfall data and land-use type information, as well as trapping performance and costs associated with alternative trapping strategies. The DSS is a simple reference tool for urban stormwater managers to use in selecting appropriate gross pollutant reduction strategies for given resources and management needs, based on our current understanding of gross pollutant movement and trapping. For further information or queries regarding the DSS computer program and user manual please contact the CRC Catchment Hydrology centre office on (03) 9905 2704.

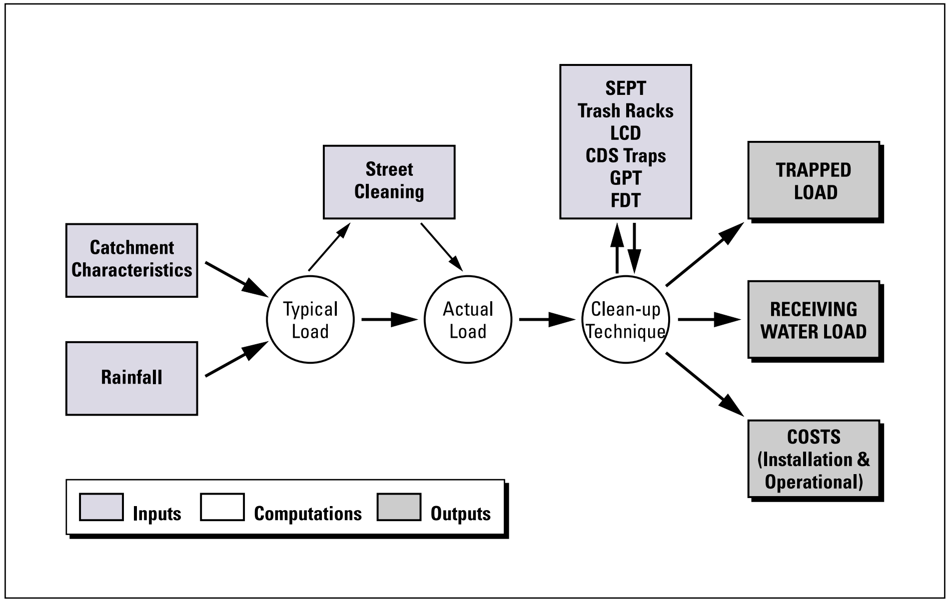


Figure 10: Structure of the CRC decision-support-system (DSS) for evaluating gross pollutant trapping strategies

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