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Te Kaunihera o Tāmaki Makaurau

Gross Pollutant Traps as a Stormwater Management Practice

Literature Review

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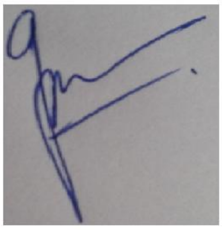	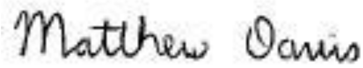
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Executive Summary

Despite ongoing education, awareness and street cleaning programmes, large amounts of gross pollutants (litter, debris and sediment greater than 5 mm in size) are reaching stormwater systems and degrading receiving water environments. All forms of development and land use generate gross pollutants which are a threat to wildlife and aquatic habitats. These pollutants are also aesthetically unpleasant, may cause odour problems and may attract vermin.

There are numerous techniques available for removing gross pollutants from the receiving environment. The most effective strategies involve a combination of non-structural measures (e.g. education and waste management programmes, and source controls) and structural treatments (installation of Gross Pollutant Traps).

While not widely implemented in New Zealand to date, Gross Pollutant Traps (GPTs) have been used internationally to improve water quality. They are generally used as primary treatment to assist and improve the function of other treatment devices designed to remove finer fraction contaminants. Sometimes, where gross pollutants themselves are perceived as unacceptable, GPTs may be installed in isolation.

Provided appropriate GPT selection, design and maintenance regimes are implemented, there are applications within the wider Auckland area where GPTs would be beneficial. However, due to a lack of selection criteria, design guidance and practical local examples there has been limited uptake by developers and local councils.

Currently the Proposed Auckland Regional Council: Air, Land and Water Plan (PARC-ALW Plan) requires the removal of 75% of total suspended solids from new impervious surfaces on a long term average basis. ARC's TP10 best practice document, *Stormwater Management Devices: Design Guidelines Manual* details a number of techniques for achieving the ALW Plan objective. Both documents presume that the removal of sediment will also inherently remove some of the other contaminants of concern, including particulate trace metals, particulate nutrients, oil and grease on sediments and bacteria on sediments.

Stand-alone GPTs are considered most appropriate for use in retro-fit situations as a primary treatment device to target gross pollutants. GPTs must only be used in conjunction with appropriate maintenance regimes to ensure that the treatment performance of the GPT is maintained.

The whole of life cost for each GPT is critical, with maintenance costs often being overlooked or dramatically underestimated, and the development of a catchment-specific maintenance programme over time to optimise overall efficiency is highly recommended.

Disposal costs are also a key maintenance element that is often not given enough consideration during the design phase.

This literature review of national and international resources indicates that the following key aspects should be considered critical with regard to the use of GPTs in the Auckland region:

- Site specific characteristics
- Treatment objectives
- Device selection
- Design features
- Maintenance and operational requirements

GPTs available on the market vary greatly in their treatment mechanism, effectiveness, efficiency, proven life performance, operational monitoring and maintenance requirements and cost. No devices available on the market are identical; therefore careful consideration is needed to ensure appropriate devices are considered for site-specific conditions.

Many GPT performance claims are made by manufacturers based on limited test data, using test methods that may lack scientific rigour. Stormwater designers are recommended to critically check the claimed performance efficiency results of specific devices, examine the conditions the results were obtained under, and ensure testing is independent.

1 Introduction

1.1 Project Scope and Purpose

The current design guidelines (TP10) provide limited information with regard to the definition of gross pollutants and Gross Pollutant Traps (GPTs), therefore the scope of this project has been to bridge these knowledge gaps and address the following:

- Identify the various types of devices currently available, with performance achievements, benefits and limitations outlined
- Carry out a literature review of design factors, methodologies low flow and high flow bypass systems for various devices
- Confirm key device selection considerations and criteria
- Outline specific maintenance requirements for the Auckland region

By examining local and international research and design guidelines to establish best practice, this report aims to develop improved selection criteria for GPTs in the Auckland region. This report presents aspects of GPT implementation including appropriate selection and design considerations, construction, maintenance and operation.

This report does not attempt to set an Auckland region wide gross pollutant treatment objective. Therefore the implementation of GPTs will continue to occur in selected catchments on a site specific basis. Requirements need to be considered on a catchment by catchment basis, and this report details key selection, design, construction and operational monitoring and maintenance aspects to consider once the need for a GPT has been established.

This report discusses the GPT types available on the market, along with their benefits and limitations. Whilst this report may name companies and/or products, the Auckland Council does not endorse any particular product or company. The naming of a product or company is purely to discuss the current methods available in the market for GPTs. It is acknowledged that other products may be available (or have become available since the time of writing).

1.2 Acronym List

For the purposes of this report, the following acronyms apply:

ARC – Auckland Regional Council

CFS – Catchpit Filter System

FDT – Floating Debris Trap

GPT – Gross Pollutant Trap

HDS – Hydrodynamic Deflective Separation

LCD - Litter Control Device

PARC-ALWP – Proposed Auckland Regional Council Air, Land and Water Plan

SEPT – Side Entry Pit Trap

TP – Technical Publication

TSS – Total Suspended Solids

WQV – Water Quality Volume

2 Purpose of a Gross Pollutant Trap

Gross Pollutant Traps (GPTs) are devices used for water quality control that remove solids typically greater than five millimetres conveyed by stormwater runoff.

The term "gross pollutant" when used in connection with stormwater drainage systems can include litter, debris and coarse sediments. Litter is defined as human-derived material including paper, plastics, metals, glass and cloth. Debris is defined as any organic material transported by stormwater (such as leaves, twigs and grass clippings). Sediments are defined as inorganic particulates. While all gross pollutants are not 100% human derived, human activities are likely responsible for an exponential increase in pollutants over predevelopment conditions.

The primary purpose of GPTs is to remove gross pollutants (>5 mm) washed into the stormwater system before the stormwater enters the receiving waters. They generally collect larger items from the water, such as containers, leaves, bottles and plastic bags. Smaller pollutants, such as dirt, chemicals, heavy metals and bacteria are not collected directly by the GPTs; however, some small particles are caught up in the larger items removed, and thus prevented from reaching the receiving water.

There are two primary characteristics that determine the long term effectiveness and performance 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 high proportion of the gross pollutants transported by the stormwater are passing through the trap and reaching downstream waters (Allison, et al., 1998).

The typical application for GPTs is within a residential suburb, commercial or industrial area, highway or on a catchment-wide scale. A localised residential or commercial system might involve smaller traps in side inlet catchpit systems that filter runoff from a smaller sub-catchment area. A catchment-wide system may include racks and booms across rivers, streams and major stormwater channels, or at the base of the catchment. Racks typically catch debris far greater in size than 5 mm, while booms generally capture floating pollutants (and contaminants attached to the floating pollutants).

GPTs can operate in isolation to reduce pollutant effects within immediate downstream receiving waters, or as part of a more comprehensive treatment train system to prevent overload of downstream infrastructure or treatment devices.

GPTs do not contribute to flood control. If not maintained GPTs can contribute to an increase in flooding by generating additional backwater effects, therefore careful selection and design is required.

2.1 Definition of Gross Pollutants

Based on international standards, gross pollutants are generally defined as material that would be retained by a five millimetre mesh screen. Therefore it can be assumed that only sediments that are attached to litter and debris would be captured as a gross pollutant. Figures 1 and 2 below show the general makeup of gross pollutants and litter by mass within an urban area based on field studies (Allison et al., 1997).

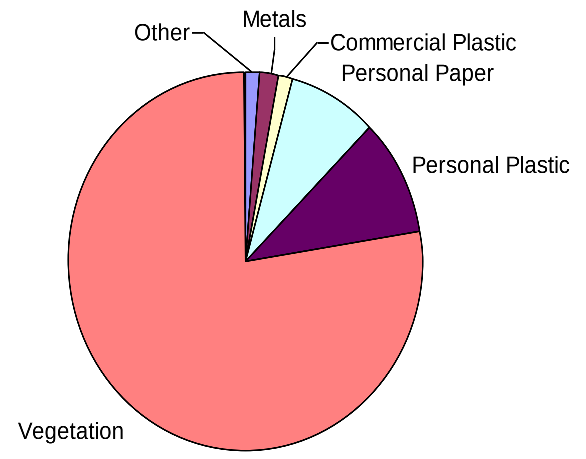

Figure 1: Composition of urban gross pollutants by mass (Allison et al., 1997)

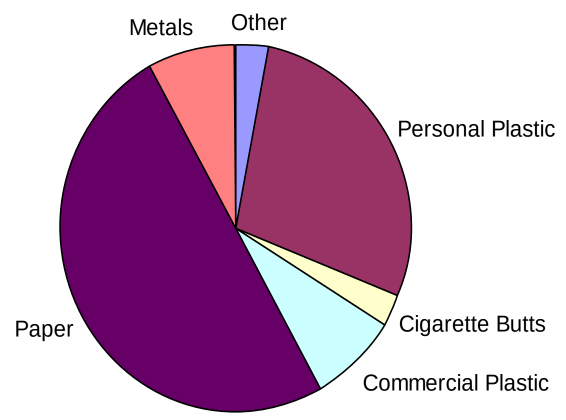

Figure 2: Composition of urban litter by mass (Allison et al., 1997)

Several studies have been completed internationally to assess the makeup of gross pollutants in the field, including well known studies by Allison et al. (1997, 1998a, 1998b) for the Coburg catchment. This catchment, 8 km north of central Melbourne, is considered a typical inner city suburban catchment.

It should be noted that catchment specifics such as rainfall/runoff patterns, infiltration rates and the connectivity of stormwater systems will alter the extent and type of gross pollutants able to be captured within any catchment. However, as a broad general comparison, the likely makeup of gross pollutants within urban Auckland could be considered comparable to those found in the Coburg catchment analysis. A separate Auckland analysis for key gross pollutant areas could be carried out as a comparison; however findings are likely to be catchment-specific.

Some key findings in Allison's Coburg field study that help define "Gross Pollutants" include (Allison, et al., 1998):

- The nominal annual gross pollutant load estimates (for material greater than 5 mm in size) was approximately 90 kg ha^{-1} yr^{-1} (wet weight).
- Typical pollutant density (wet) is approximately 250 kg m^{-3} and the wet to dry mass ratio is approximately 3.3 to 1. This gives the expected volume of total gross pollutant load as approximately 0.4 m^3 ha^{-1} yr^{-1}.
- A high proportion of the total gross pollutant load consists of vegetation (i.e. leaves), although this will fluctuate seasonally.
- Urban derived litter, food and drink refuse (from fast food consumers) and cigarette refuse, constitutes approximately 30% of the total gross pollutant load. These items entered the drainage network primarily from commercial areas.
- Data indicates that approximately 10% of gross pollution remains buoyant for a significant length of time.
- The study by Allison et al. (1997) found that gross pollutant concentrations are highest during the early stages of runoff; however most of the load is transported during periods of high discharge.

3 Types of Gross Pollutant Traps

3.1 GPTs as Part of a Treatment Train

When two or more treatment devices are linked together in series, this is referred to as a treatment train. The receiving environment often requires a treatment train approach to meet water quality objectives. A treatment train may be comprised of a GPT together with other non-GPT devices, particularly those targeting finer pollutants. GPT devices are generally the first device within a treatment train.

The treatment train approach is particularly important when a treatment device requires pre-treatment to remove pollutants that may affect the performance of the treatment device. For example, wetland systems are often employed to protect receiving environments from the impact of excessive nutrients and heavy metals. However, wetlands perform poorly if gross pollutants and coarse sediments are not removed prior. It is therefore important to select and order treatment devices appropriately to ensure treatment objectives are achieved.

The 'treatment train approach' increases the likelihood of meeting Water Quality Objectives.

Figure 3 below illustrates the relationship between pollutant type and treatment process, and a GPT device are generally classified as primary treatment devices, with particle capture greater than 5000 μm (5 mm) in size.

There is a clear relationship between contaminant size and the appropriate process that can be employed to retain/remove the pollutant. By knowing the target pollutants, appropriate treatment measures within the treatment train can be selected and properly ordered. The figure also illustrates the approximate hydraulic loading rate for effective operation of the various treatment measures. The hydraulic loading rate is a function of the treatment process (screening, sedimentation, enhanced sedimentation, filtration or biological uptake) and can be used to approximate the area required to install a device given the design flow. This is useful to assess the space requirements for the various treatments (CSIRO, 2006).

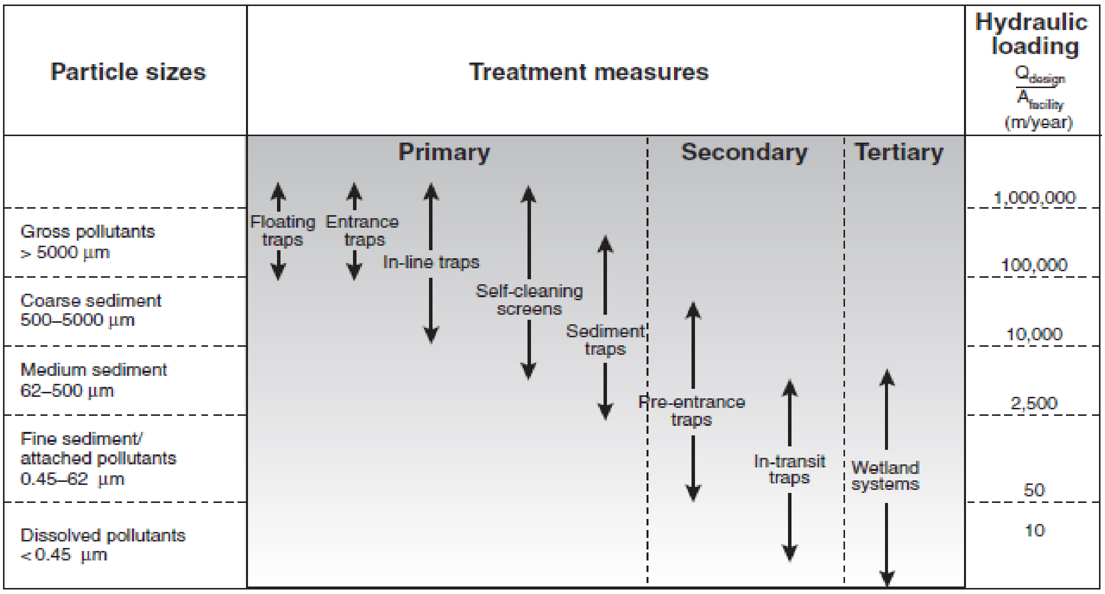

Figure **3:** Desirable design ranges for treatment measures and pollutant sizes (CSIRO, 1999)

GPTs can operate in isolation or be used to reduce gross pollutants within immediate downstream receiving waters or as part of a more comprehensive treatment train system. When acting in isolation they are used primarily for aesthetic reasons to reduce impacts on downstream waters from litter, debris and coarse sediment. It is the larger, often floating contaminants that are most visible and unaesthetically pleasing within the waterways.

In integrated treatment systems (or treatment trains), they are often the most upstream measure and are important to protect the integrity of downstream treatments (such as wetlands, soakage disposal systems, and sand filters) by removing the coarsest fraction of contaminants. Alternatively, a GPT such as a floating boom may be placed further downstream within a catchment within a slow moving body of water to capture floating gross pollutants.

A poorly performing GPT (due to poor design, improper installation or inadequate maintenance) can result in litter, debris and coarse sediments fouling downstream treatment devices and impacting on their operation (for example, smothering vegetation in a macrophyte system). In addition, litter can detract from attractive stormwater treatment devices such as wetlands and reflect poorly on the overall treatment system.

The location of a GPT within a stormwater management system and type of GPT must be carefully considered when determining how to meet water quality objectives.

For these reasons the selection, sizing, siting, installation, and maintenance of GPTs are critical components to increase the effectiveness of an overall stormwater management system.

There are also numerous stormwater treatment devices that incorporate their own GPT as an initial treatment stage for many of the beneficial reasons outlined within this report. However this report does not attempt to cover multi-stage devices.

3.2 General Limitations of GPTs

GPTs as a structural primary treatment device offer many environmental and aesthetic benefits to downstream waterways provided they are correctly designed, installed, and maintained. However, despite their benefits there remain several limitations which need to be carefully considered before GPT's are selected and installed. Specific limitations applicable to the individual type of GPT are described in more detail later in this section. Also the Device Selection Matrix included in Appendix 1 outlines some key limitations and features associated with each device. GPT limitations are also determined by how a GPT is used within a catchment (i.e. as a stand-alone treatment device or as a primary treatment within a treatment train process).

General limitations with GPTs include:

- Limited (if any) removal of fine sediments less than 5 mm.
- Lack of maintenance significantly reduces efficiency and performance.
- Difficult and expensive maintenance procedures (primarily cleaning operations) can lead to a decline in the trap's maintenance frequency. A poorly maintained trap will reduce its pollutant trapping efficiency and also may potentially become a source of pollutants as collected material break-down.
- When trash racks reach maximum capacity debris can be remobilised.
- Potential to create or increase upstream flooding if the trash rack becomes blocked by debris and litter.
- Can be visually unattractive.
- Potential odours if maintenance is not regular.
- Potential health risks to workers when handling pollutants.
- Can be a barrier to fauna migration.
- GPT performance is site specific and affected by rainfall, runoff and wind – eg higher infiltration rates reduce surface water discharge and hence the potential for gross pollutant transport. Wind and litter drop by people also affect the extent of accumulated pollutants.
- GPT performance is directly related to the connectivity runoff pathways of the stormwater systems entering the GPT.

- There is little information collected confirming the performance of most trapping systems in the field. Removal efficiencies to date are often based on tests of scaled models in the laboratory (often with "synthetic litter") or limited field testing. In addition, most gross pollutants cannot be sampled by traditional automatic samplers and have not been included in studies evaluating the impact of stormwater runoff on receiving waters.

3.3 Structural and Non-Structural Methods

Methods for reducing gross pollutants in urban waterways can be grouped into two categories (Cooperative Research Centre for Catchment Hydrology, Stormwater Gross Pollutants 1997):

- **Structural methods** are traps placed in catchpits and 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) through education, and waste management programmes.

This chapter describes the structural methods commonly used for reducing gross pollutants, known as Gross Pollutant Traps (GPTs).

3.4 GPT Treatment Mechanisms and Types

There are a wide variety of GPTs available, with varying treatment mechanisms, size, operational requirements, cost, and trapping performance. Due to the range of techniques available, there are no standard treatment parameters that all GPTs meet.

The extent of pollutants retained by a five millimetre mesh screen (typically used for gross pollutant capture) can vary considerably as the set mesh size clogs and catches smaller particles. In addition to this, sediments attached to litter and debris may also be captured as a gross pollutant.

There are a large number of proprietary GPT devices available on the market, and this report does not cover every variant, but instead addresses GPTs generically and provides suitable selection criteria so that individual devices can be evaluated. Also, many drainage inlets (e.g. catchpits and pipe entry screens) have some gross pollutant capture ability but these are not specifically considered here. In many cases their gross pollutant capture is aimed at avoidance of downstream system blockage rather than achieving optimal gross pollutant removal.

GPTs are continuously being developed and modified as suppliers research the operation of their traps and respond to treatment requirements. There is generally a shortage of field data relating to the actual trapping performance of the various methods, making the accuracy of treatment comparisons difficult.

For all types of GPTs, a poorly maintained device can hold gross pollutants for some time, during which some types of GPTs can transform collected contaminants into more bio-available forms. Small flows through the collected pollutants can then leach transformed pollutants downstream, where they can be detrimental, in some cases causing more problems than if a GPT was not installed.

Figure 4 below shows diagrammatically how these various pollutant removal processes are used to target specific particle sizes.

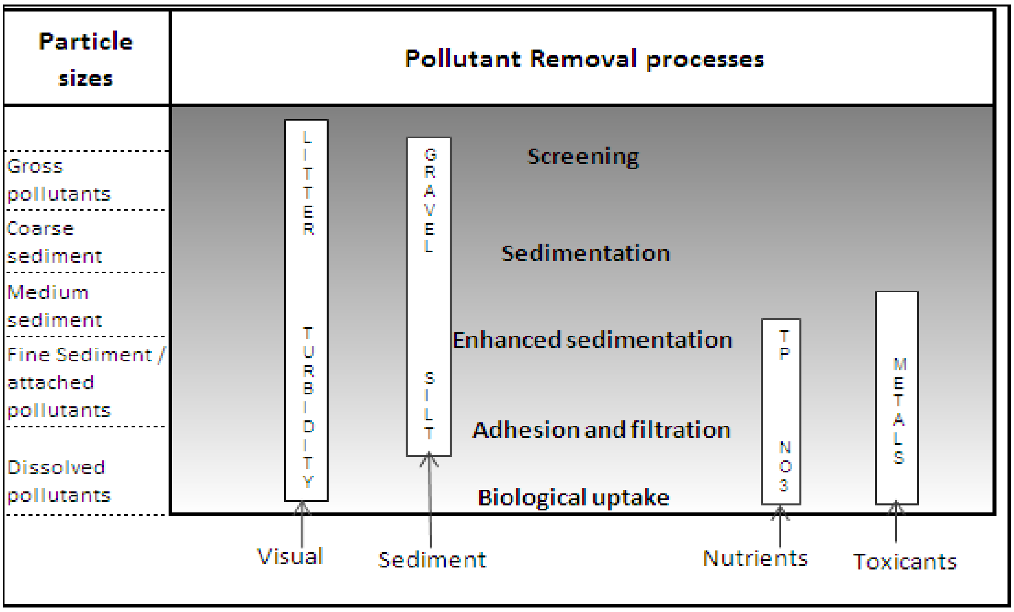

Figure 4: Typical pollutants and treatment processes (CSIRO, 1999)

The different types of GPTs available generally fall under one of the following four categories (CSIRO Urban Stormwater 2006):

- Drainage entrance treatments: grate entrance systems, side entry catchpit traps and gully pit traps
- Direct screening devices: litter collection baskets, release nets, trash racks, return flow litter baskets, and channel nets
- Floating traps: flexible floating booms, floating debris traps
- Non-clogging screens: circular and downwardly inclined screens
- Sediment traps: sediment settling basins and ponds, circular settling tanks, hydrodynamic separators.

Commonly used gross pollutant trap systems which are currently available for Auckland region applications, range from at-source treatment for the upper reaches of the catchment (e.g. side entry pit traps) to those intended for slow-moving waterways further down the catchment (e.g. litter booms).

It should be noted that several of the devices detailed in this section have not yet been installed in the Auckland region but have been used extensively overseas, significantly in Australia.

Each device described includes an Estimated Treatment Performance Summary as a table which considers various performances, maintenance and design considerations based on a negligible, low, moderate, high or very high rating system. Definitions of these ratings are included in Appendix 1 within the Device Selection Matrix.

The maintenance frequencies outlined below for each device are indicative only and based on typical international experiences. It is recommended that each device installed within the Auckland area be monitored and maintained initially in this manner for a period of approximately one year to allow for site specific characteristics to be assessed. Different land uses may require different maintenance regimes so initial monitoring and experience will help determine an appropriate ongoing maintenance frequency which can then be developed for the catchment to optimise maintenance efficiency. The whole of life value for each device is critical with maintenance costs often being dramatically underestimated, so a catchment-specific maintenance programme to optimise overall efficiency is highly recommended.

Disclaimer

The sections below discuss the GPT types available on the market, along with their benefits and limitations. Whilst this report may name companies and/or products, the Auckland Council does not endorse any particular product or company. The naming of a product or company is purely to discuss the current methods available in the market for GPTs. It is acknowledged that other products may be available (or have become available since the time of writing).

3.5 Catchpit Grates and Entrance Screens

Type: Drainage Entrance Treatment

Application: Catchpit grates and entrance screens are generally the first point of interception between road runoff and the reticulated stormwater system.

Catchpit grates and entrance screens are particularly suited to trapping large litter items, grate and entrance screens are typically used to prevent drain blockages. Entrance grates should be located in areas that are prone to pipe blockages or are known to contribute large amounts of gross pollutants. These include shopping centres and other busy commercial areas.

Function: Grate and entrance screens consist of sturdy metal screens that cover the inlet to the drainage network. Water passes between the screen bars, while gross pollutants are prevented from entering. The grates are usually used on conjunction with a debris sump.

Trapping Performance: The key function of entrance screens is to prevent pipe blockages by excluding gross pollutants from the drainage network. Their performance efficiency depends heavily on effective street cleaning practices—infrequent street cleaning can lead to dispersion of trapped pollutants by either wind or traffic. In addition to this, cesspit/catchpit filter bags can be used as a variation of this technique, and they can be further enhanced by inclusion of a half-siphon outlet. These generally have reasonable sediment capture but require a high level of maintenance. Moderate sediment washout occurs due to turbulence during high flows. Litter trapping is reduced when an open "back-entry" is present.

Estimated treatment performance summary					
Gross pollutants	L	Coarse sediment	N	Medium sediments	N
Fine sediments		Attached sediment	N	Dissolved	N
Installation costs	L	Maintenance costs	L/M	Head requirements	L
N = negligible, L= low, M=moderate, H=high, VH=very high					

Reference: CSIRO, 2006

Catchpit grates and entry screens are a commonly accepted practice, and their use should be encouraged. However as a stand-alone GPT device they perform relatively poorly, unless their performance is enhanced by filter bags.

Maintenance:

Inspections for blocked screens may be necessary if flooding is a potential problem. Installation costs of entrance grate and screens are low. If cleaning can be incorporated into regular street cleaning, no additional maintenance cost need apply.

Advantages

- Inexpensive and easy to install
- Accepted practice
- Prevent drain blockages
- Suitable for targeting specific problem areas
- Can be enhanced with a filter bag to increase trapping performance
- Can be enhanced with a half siphon pipe arrangement to limit carry-over of floatables and avoid pipe blockages

- Can be enhanced with a screen (eg Tetra-Trap) to increase performance

Limitations

- Only separates out larger gross pollutants
- Relies on effective street cleaning for effective pollutant removal
- Localised flooding can occur if blocked
- Seasonal issues such as leaf accumulation can cause blockage
- Potential for litter and solids wash-out
- Smaller gross pollutants may be pushed through the grate by stormwater flow or traffic.

In addition to the standard catchpit grates and screens available, there is a standard Auckland City Council (ACC) device that uses a half siphon and has the added advantage of being able to block and spill over rather than transmit trapped litter, thus drawing attention to the device which is in need of maintenance. These offer some grit and litter removal ability (enhanced by the half-siphon) but they exist primarily to create a hydraulically efficient pipe entry and to avoid pipe blockage. This device is shown in Figure 5 below.

The Tetra-Trap shown in Figure 6 is an entrance screening device which is also currently used within Auckland City.

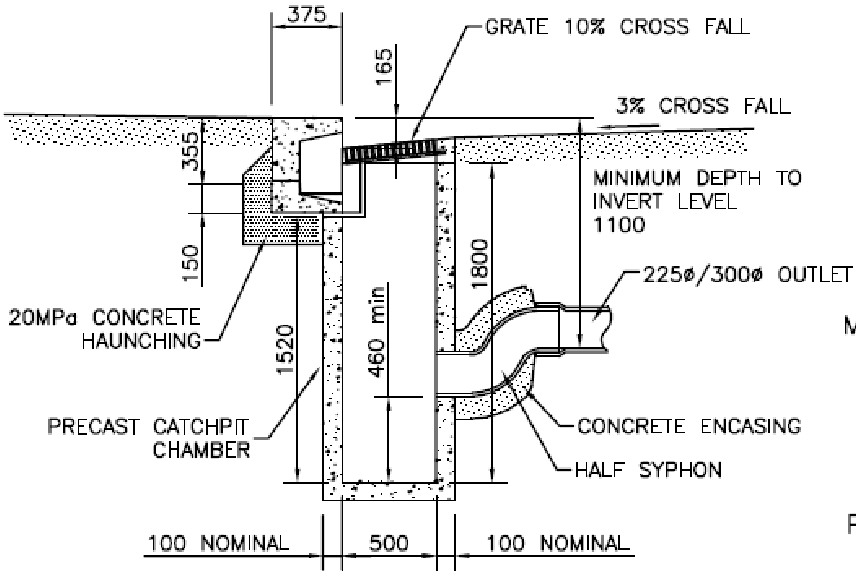

Figure 5: Standard Auckland City Council street catchpit, (ACC, 2009)

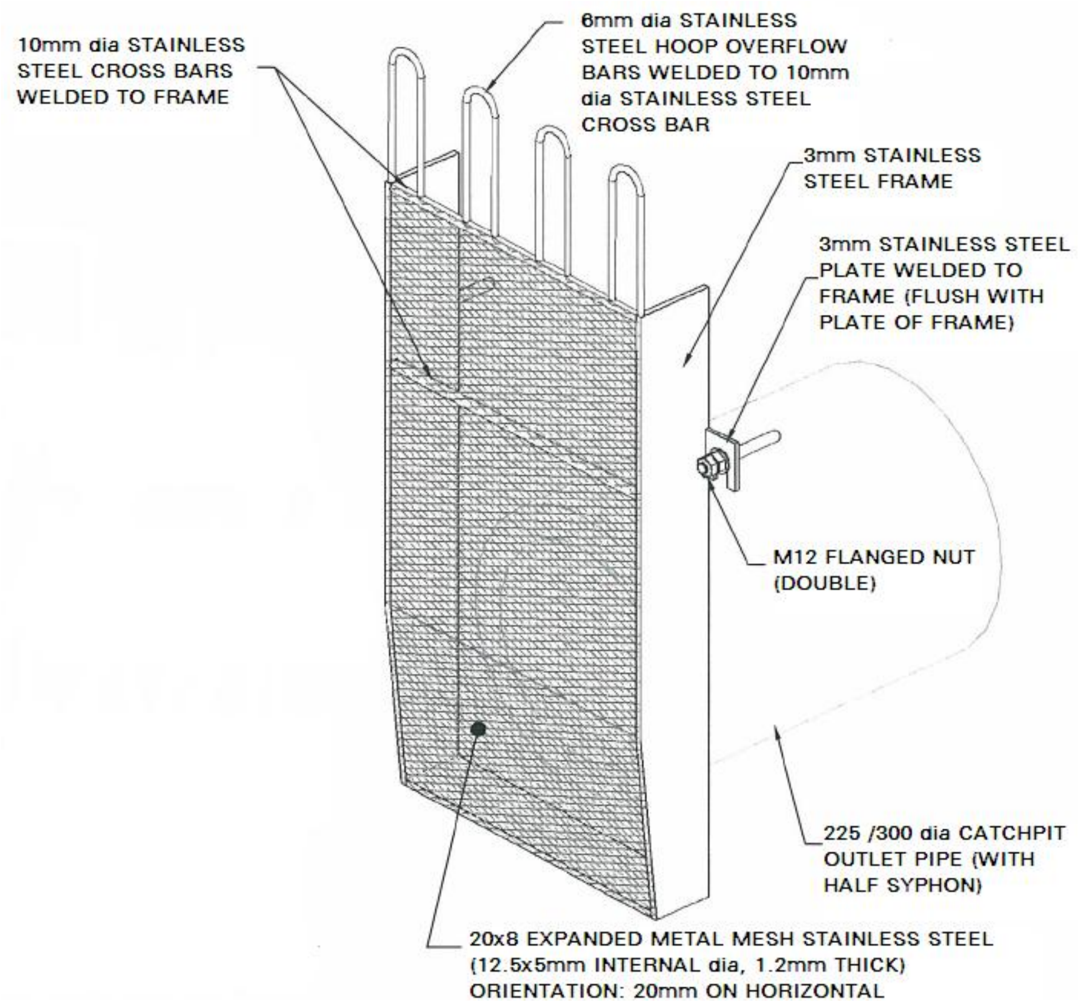

Figure 6: Tetra-Trap Stormwater Catchpit Device (Auckland City Transport)

3.6 Side Entry Pit Trap (SEPT)

Type: Drainage Entrance Treatment

Application: Side Entry Pit Traps (SEPTs) are used within a stormwater network where kerb and channel and gutters exist. SEPTs may also be referred to in New Zealand as a Catchpit Filter System (CFS) which takes the form of a fine-mesh filter bag that is inserted inside a standard catchpit. They are often used at target areas such as shopping malls, schools and car parks. Contributing catchments are generally less than 1 hectare.

Function: Side Entry Pit Traps (SEPTs) are baskets within a pit (much like a catchpit arrangement) that are placed in the entrance to stormwater pipes from the roadside kerb and channel. The baskets are fitted below the invert of the kerb and channel, inside catchpits. Stormwater passes through the baskets to the stormwater pipe and material larger than the basket mesh size (5-20 mm) is retained. 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.

Trapping Performance: The trapping performance of SEPTs is unknown but is considered reasonably high (up to 85% of litter load and up to 75% of gross pollutant load if they have been installed on all public entrances to the stormwater system) (Allison et al.,1997). SEPTs' high maintenance requirements usually set a practical upper limit to the extent of SEPT application within a catchment. It is therefore imperative to choose the drain entrances that contribute the greatest gross pollutant loads when locating the SEPTs. Monitoring by Allison et al. (1997) revealed that by careful selection of SEPT locations it is possible to capture 65% of litter and 50% of total gross pollutants by locating SEPTs at only 40-50% of drain entrances within a catchment. Therefore the overall trapping efficiency within an area is influenced by individual trap efficiencies, along with the amount of pollutants that successfully by-passes the SEPT network. Potential bypass paths include direct roof runoff from buildings and drainage through grates located in private carparks or grassed areas.

The nature of material that is caught by SEPTs influences the degree of basket blockage. Once the pores in the basket 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.

Estimated treatment performance summary					
Gross pollutants	M/H	Coarse sediment	L	Medium sediments	N
Fine sediments	N	Attached sediment	N	Dissolved	N
Installation costs	L/M	Maintenance costs	M/H	Head requirements	L
N = negligible, L= low, M=moderate, H=high, VH=very high					

Reference: CSIRO, 2006

A paper presented at the May 2004 Stormwater Conference titled *Auckland City's Field and Laboratory Testing of Stormwater Catchpit Filters* documents the results from a field and laboratory testing programme undertaken by Auckland City to access the performance of a range of commercial Catchpit Filter Systems (CFS). Four manufacturers submitted CFS units for the field testing programme and each was installed in a city street and observations made over a five month period covering: ease of fitting, sediment retention, maintenance needs, rigidity/strength, ability to catch flows and the effects of litter/organics. On the basis of the field results, CFS units from two manufacturers were judged as warranting laboratory testing. This testing carried out by Auckland University, sought to quantify the sediment capture performance. Testing methods and observations are documented within the paper. In summary, for a composite 'street sweep sediment sample', the CFS units were found to capture between 78% to 97% of the sediments entering the catchpit (Butler et al., 2004)

Maintenance: Material remains in the basket until maintenance is carried out either manually or using a large diameter vacuum device. The traps are intended to be cleaned every four to six weeks. Typically a team of two operators and one truck can clean up to 50 SEPTs a day (CSIRO, 2006).

Advantages

- Prevents drain blockages
- Suitable for targeting specific problem areas
- Can be retrofitted into existing drainage systems
- Can be used as a pre treatment for other measures
- Low head requirements thus are suitable for many low lying situations
- Minimal visual impact as SEPTs are installed underground
- Relatively cheap and easy to install compared to some alternative options

Limitations

- Distributed SEPTS make maintenance intensive
- Requires regular maintenance due to the limited holding capacity
- A vacuum device may not unclog pores in the basket. Back flushing would be needed to do this.
- Previously caught material may be re-suspended if overtopping occurs
- Only suitable for road entrant/kerb and channel installations
- Frequently requires traffic control during maintenance
- Provides a beneficial function but are generally not sufficient as a standalone device

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 a lesser tendency to entangle with mesh but they require vacuum plant rather than manual labour for cleaning because they are fixed inside the pits (CSIRO, 2006).

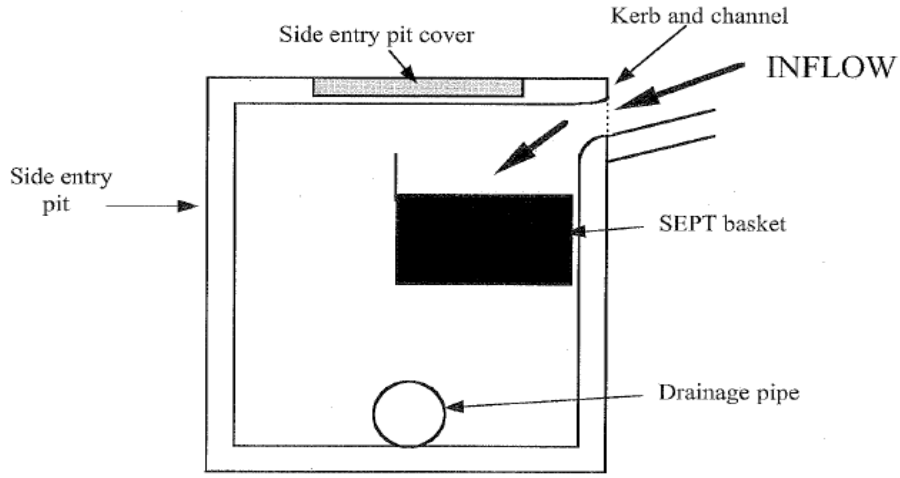

Figure 7: Side Entry Pit Trap – side elevation (CSIRO, 2006)

3.7 Baffled Pits (Trapped Street Gullies)

Type: Drainage Entrance Treatment

Application: Installations to date have been limited and they were originally designed for providing odour control for combined sewers but have more recently been recognised for their pollutant retention capabilities. They generally are used in catchments 0.1 – 2 hectares.

Function: Baffled Pits (or Trapped Street Gullies) are modified stormwater pits (with baffles installed) used to retain sediments and floating material from road runoff. Baffle plates fitted in the drainage pits are used to facilitate the settlement of heavy sediments and containment of floating debris in the pit. Designs have been modified after hydraulic modelling to improve the retention capabilities by minimising velocities.

Maintenance: An appropriate access chamber for inspection and cleaning is needed for this device. The contents of the pit are removed with a large diameter vacuum device during maintenance which is recommended every three weeks.

Trapping Performance: Baffled pits are best suited to trapping highly buoyant contaminants or heavy, fast settling solids. Conventional baffled pits often have limited sediment retention capacity due to the turbulence associated with inflows. Desorption of pollutants under anaerobic conditions has also been reported. As a consequence, conventional baffled pits can discharge pollutants during and following large storm events, particularly if maintenance is poor. Recent design developments are starting to address some of these concerns. On average, the estimated efficiency for gross pollutant removal is considered low to moderate.

Estimated treatment performance summary					
Gross pollutants	L	Coarse sediment	M	Medium sediments	L/M
Fine sediments	L	Attached sediment	N	Dissolved	N
Installation costs	L/M	Maintenance costs	L/M	Head requirements	L
N = negligible, L= low, M=moderate, H=high, VH=very high					

Reference: CSIRO, 2006

Advantages

- Can be used as a pre-treatment for other measures
- Can be retrofitted into existing drainage systems, particularly on roads with high traffic volumes
- Minimal visual impact as they are installed underground
- Can prevent odours exiting the drain
- Low head requirements make Baffled Pits good for many low lying situations

Limitations

- Some designs have a potential to re-suspend sediments
- Potential release of nutrients and heavy metals from sediments
- Potential for scouring of collected pollutants during high flows
- Requires regular maintenance due to the trap’s limited holding capacity
- Poor retention of material that is entrained in the flow
- Reduces or eliminates air supply to the drainage network downstream of the pit
- Large retention pit capacity is required for effective pollutant removal

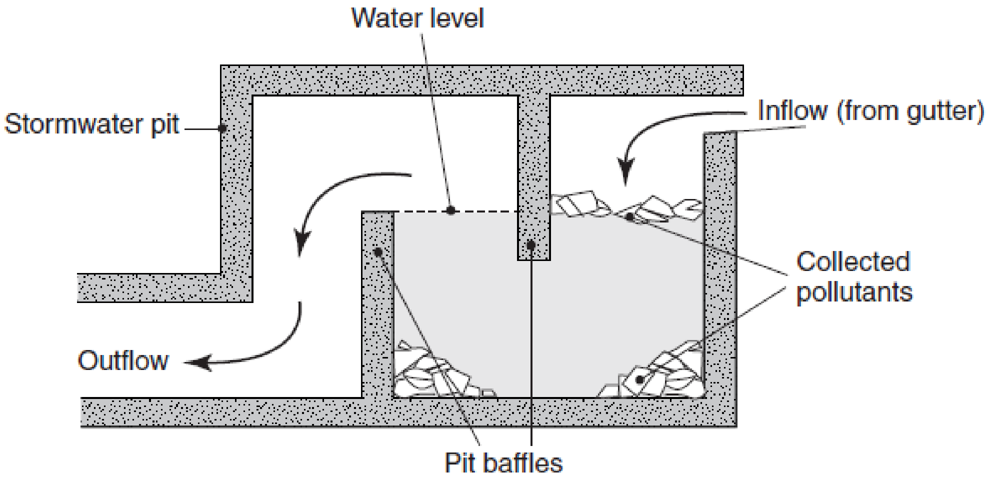

Figure 8: Section view of a baffled pit (CSIRO, 2006)

3.8 Trash Racks

Type: Direct Screening Device

Application: Trash racks are generally installed in stormwater open channels for catchments 20 - 500 hectares in size and can be either inline or offline.

Function: Trash Racks intercept floating (such as bottles/cans) 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 pass through and material larger than the bar spacing is retained. As material builds up behind the trash rack finer material also accumulates.

Maintenance: 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. Maintenance of trash racks is generally done manually on an as needed basis. Monthly is recommended.

Trapping Performance: The estimated efficiency for gross pollutant removal is considered low to moderate. Limited performance data suggests trapping efficiencies between 5 – 14% for floating items. The main disadvantage of a trash rack is its inability to self cleanse. Although trash racks are designed to continue operating while partially blocked, trash rack overtopping is common. There have been numerous attempts to develop a self cleansing trash rack including widening the bar spacing and angling the screen to the flow, angling the rack across the channel bed, using horizontal bars along the rack, and vibrating the trash racks. Designs have also pushed gross pollutants along the racks to a collection point. All results have shown minor, if any improvements in the field.

Estimated treatment performance summary					
Gross pollutants	L	Coarse sediment	L/N	Medium sediments	L/N
Fine sediments	N	Attached sediment	N	Dissolved	N
Installation costs	L	Maintenance costs	L/M	Head requirements	L/M
N = negligible, L= low, M=moderate, H=high, VH=very high					

Reference: CSIRO, 2006

Advantages

- May be used to trap litter upstream of other treatment measures or waterways
- Can be retrofitted into existing drainage systems
- Collects litter at a single location rather than over a large area
- Simple to construct

Limitations

- The backwater behind a blocked trash rack can cause upstream flooding, reduce flow velocities near the rack and allow sediments to settle which further contributes to blocking.
- Previously caught material may be released if overtopping occurs
- Difficult to maintain and requires manual maintenance
- Appearance of the rack and trapped litter can be obtrusive
- Material may be re-suspended due to tidal effects in tidal channels
- Moderate to high head requirements limit the use of Trash Racks for some applications.

3.9 Litter Control Devices (LCD)

Type: Direct Screening Device

Application: Litter Control Devices are generally located in pits within the piped drainage network where the catchment area ranges from 2 to 150 ha.

Function: LCDs consist of steel frames that support metal baskets which are approximately 1 m^3 in size. 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 allowing smaller material to be caught.

Maintenance: Regular (weekly) cleaning is recommended. Maintenance involves lifting the LCD directly onto disposal vehicles with modified 5 tonne cranes. Alternatively the baskets may be emptied with a vacuum plant. To clean one trap it generally takes 20-40 minutes.

Trapping Performance: LCDs have been reported to have varying effectiveness for trapping gross pollutants, but have been reported on average with moderate to high efficiencies of 80 – 85%, but as low as 35% for larger storm events. Effectiveness is highly dependent on cleaning frequency. Problems with floating materials in tidal areas and high discharges are cited as possible reasons for material passing the traps. Inclined trash racks have also been used at the downstream end of particular LCDs to collect material scoured from baskets.

Estimated treatment performance summary					
Gross pollutants	M/H	Coarse sediment	L/N	Medium sediments	N
Fine sediments	N	Attached sediment	N	Dissolved	N
Installation costs	M/H	Maintenance costs	M/H	Head requirements	M/H
N = negligible, L= low, M=moderate, H=high, VH=very high					

Reference: CSIRO, 2006

Advantages

- Can be retrofitted into existing drainage systems
- Potentially useful in areas with high litter loads
- Easy to maintain
- Can be used as pre treatment for other measures
- Minimal visual impact as installed underground

Limitations

- The traps require approximately 1m drop in the channel bed from the inlet to outlet to accommodate the basket. This limits their applicability in low lying areas, and in retrofit situations.
- Can cause upstream flooding if blocked
- Hydraulic head loss occurs particularly for baskets installed in the base of pits
- Presents a possible source of odours and health risk to cleaning crews

- Previously caught material may be re-suspended if overtopping occurs
- Problems with floating materials in tidal areas and high discharges are cited as possible reasons for material passing the traps
- Some tests show that only a small quantity of gross pollutants remain after large flow events

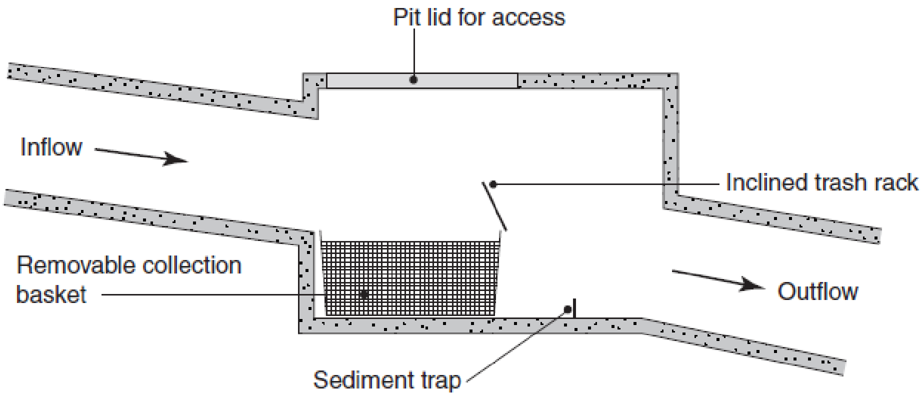

Figure 9: Litter collection device (CSIRO, 2006)

3.10 Fixed Trash Traps

Type: Direct Screening Device

NOTE: This device is referred as Gross Pollutant Trap in CSIRO, 2006.

Application: Fixed trash traps are generally installed within a stormwater channel or waterway for catchments 5 – 5,000 hectares in size. Fixed trash traps are of considerable size and consequently are best suited to developing areas where land can be set aside for construction which is generally on the edges of urban areas.

Function: Fixed trash traps are in-transit pollution traps intended to remove litter, debris and coarse sediments. Fixed trash traps have evolved from sedimentation basins, and generally consist of a large concrete-lined wet basin upstream of a weir and trash rack. The philosophy behind fixed trash traps 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 trap 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.

Two types of fixed trash traps have evolved – major and minor traps. Major fixed trash traps are open and intended to be located in large floodway’s and treat medium to large flows. Minor fixed trash traps are closed and intended to be placed at features within the drainage system (heads of floodway’s, junctions of stormwater pipes and major water bodies) but the principles of operation are the same for both traps. Design criteria for the sizing of the sediment basin in a fixed trash traps have been set according to the potential impact that sediments pose on downstream water bodies.

Maintenance: Manual litter removal is generally carried out monthly. Additional maintenance involves dewatering the wet basin and using a backhoe to remove sediments. This is generally carried out six monthly.

Trapping Performance: Although similar in principle, gross pollutant traps have some operational advantages over conventional trash racks. Entrance channels to the fixed trash trap are widened to match the width of the sedimentation basin. This ensures the trash rack located on the downstream end of the basin provides more trash rack area for a given stormwater channel width than conventional trash racks. This presumably results in improved performance and fewer blockages. Fixed trash traps are primarily sized according to sediment retention capacity. Better performance for coarse rather than fine sediments is reported, however only a few studies have investigated their trapping efficiencies.

The overall estimated efficiency for gross pollutant removal is considered low to moderate.

Estimated treatment performance summary					
Gross pollutants	L/M	Coarse sediment	M/H	Medium sediments	M
Fine sediments	L	Attached sediment	N	Dissolved	N
Installation costs	H	Maintenance costs	M/H	Head requirements	H
N = negligible, L= low, M=moderate, H=high, VH=very high					

Reference: CSIRO, 2006

Advantages

- Can provide coarse sediment and gross pollutant pre-treatment for other stormwater devices
- Small traps can be located underground, minimising visual impacts
- Offers a larger rack area than conventional trash racks, thereby improving removal rate
- Lower overtopping potential of flow if rack becomes partially blocked compared to conventional trash racks

Limitations

- The trash rack can suffer blockages
- High construction costs

- Difficult and expensive to clean
- Hydraulic head loss occurs through the trash rack
- Can cause upstream flooding during trash rack blockages
- The appearance of the rack and trapped litter can be aesthetically displeasing
- Potential breakdown of collected pollutants in wet sump (basin)
- Retrofitting can be difficult due to land and topographic requirements
- Previously caught material may be re-suspended if overtopping occurs
- A moderate to high amount of head is also required which limits their use for some applications.

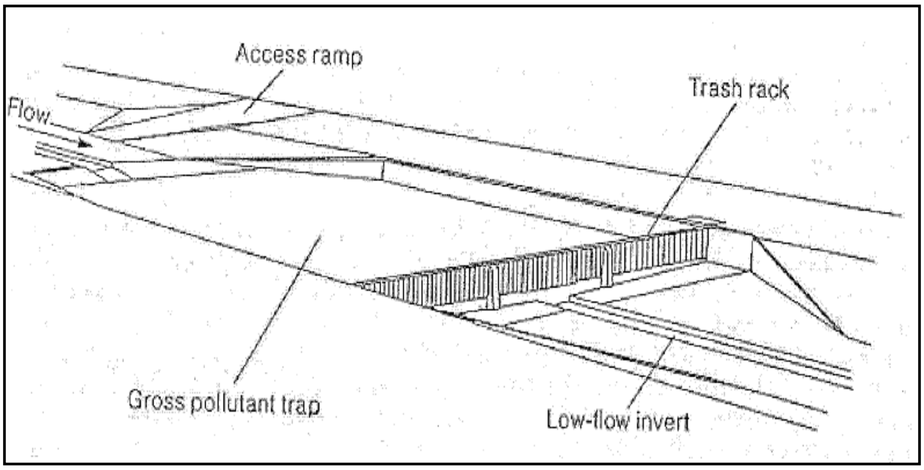

Figure 10: Fixed Trash Trap (CSIRO, 2006)

3.11 Booms and Floating Traps

Type: Floating Traps

Application: Litter booms and floating traps are best suited for very slow moving waters and perform best with floating objects such as plastic bottles and polystyrene. Catchment areas are generally greater than 250 ha.

Function: Litter booms are constructed by stringing partly submerged floating booms across waterways. The boom intercepts and collects floating objects. The performance of any boom is greatly influenced by the flow conditions of the waterway.

More recently Floating Debris Traps (FDTs) have evolved from booms and have 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. 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 grate is raised during cleaning; material flows out of the trap and into a collection basket that is located downstream of the trap.

Maintenance: Litter booms generally require manual cleaning, performed by retrieving collected trash from within the boom with a trench digger or by using boat and pitch forks. To improve this operation for small booms, they can be pulled to one bank and material can 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. Cleaning is usually on demand, but fortnightly – monthly is recommended.

Trapping Performance: During high flows the trapping efficiency of litter booms is greatly reduced because material is forced over and under the boom, or the boom may break from the banks. The litter retention properties of booms can be enhanced by angling booms across to the current away from high velocity areas and by using mesh skirts. However high flow problems still persist.

The floating boom is only effective in retaining gross pollutants that float. This represents less than 20% of litter and 10% of vegetation which suggests a limited performance for floating boom applications. However, despite the inefficiencies with booms (during high flows and for submerged material) they have been reported to trap large quantities of gross pollutants, particularly the large highly-visible litter component that the general public tend to be most aware of.

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).

Estimated treatment performance summary					
Gross pollutants	L	Coarse sediment	N	Medium sediments	N
Fine sediments	N	Attached sediment	N	Dissolved	N
Installation costs	L	Maintenance costs	M	Head requirements	L
N = negligible, L= low, M=moderate, H=high, VH=very high					

Reference: CSIRO, 2006

Advantages

- Enhances aesthetics and recreational potential of downstream waterways
- Mobile and may be appropriate for retrofitting into existing areas
- Collects litter at a single location rather than numerous sites over a large area
- Able to rise and fall with changes in flow or tide

Limitations

- Gross pollutants may be swept past the boom by tide movement, wind or high flows. Knowledge of wind directions and flow paths for a reach of waterway is recommended prior to installation.
- Booms can only capture floating pollutant load
- Maintenance is difficult, with most boom assemblies cleaned by boat
- Spanning of the entire waterway width may be difficult because of size and/or waterway traffic
- Booms may break away from the banks during high flows
- The appearance of the boom and trapped litter can be aesthetically displeasing

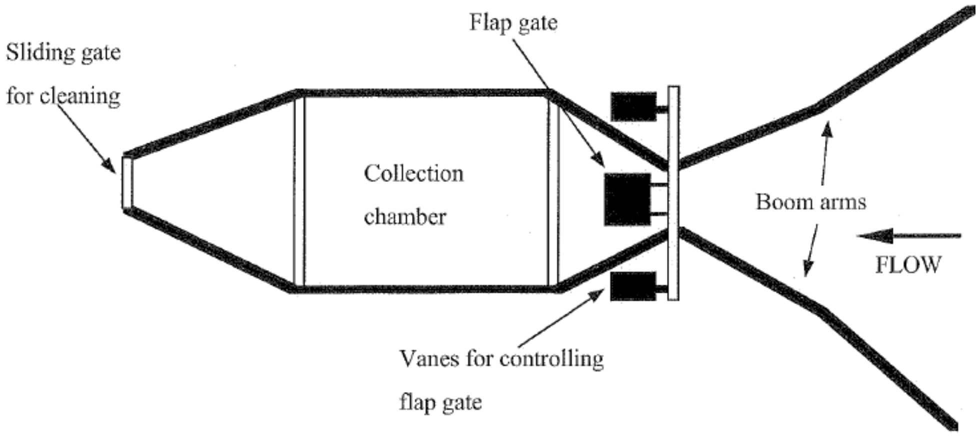

Figure 11: Plan view of Bandalong floating debris trap (CSIRO, 2006)

3.12 Circular Screen / Hydrodynamic Deflective Separation (HDS) Devices

Type: Non Clogging Screen / Sediment traps

Application: HDS Devices are generally installed within a stormwater pipe network or open channel for catchments 20 - 500 hectares in size. The compact design is well suited for space constrained sites.

Function: The HDS 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. 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.

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 water will be forced outwards and be pressed against the outer boundary of the chamber (the perforated screen). Also objects near the screen will be influenced by the drag forces associated with the flow component through the perforated mesh, however these are considered negligible compared to the centrifugal forces.

A diversion structure upstream of the HDS unit acts as a bypass weir and is constructed so that during periods of above design conditions, excess stormwater can bypass the HDS unit. The selection of the height of the weir determines the frequency of stormwater bypass. 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.

Maintenance: Material that collect 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 removed with a powerful vacuum pump. A two to three monthly cleaning frequency is recommended.

Trapping Performance: High trapping efficiencies have been recorded. During twelve months of monitoring, practically all gross pollutants transported by the stormwater system were trapped by the HDS unit (Allison et al. 1996). Longer term trapping rates will be determined by the height of the bypass weir. Typical installations accommodate at least a one in six month storm prior to overflow. This would ensure at least 95% of annual discharge is treated, with a similar proportion of gross pollutants captured. Some monitoring suggests a significant quantity of sediment is retained. 90% of the sediment recovered from the collection sump was smaller than the screen mesh size. In addition, 70% retention of suspended sediment by the device was reported during the early flows of a runoff event (Walker et al. 1999).

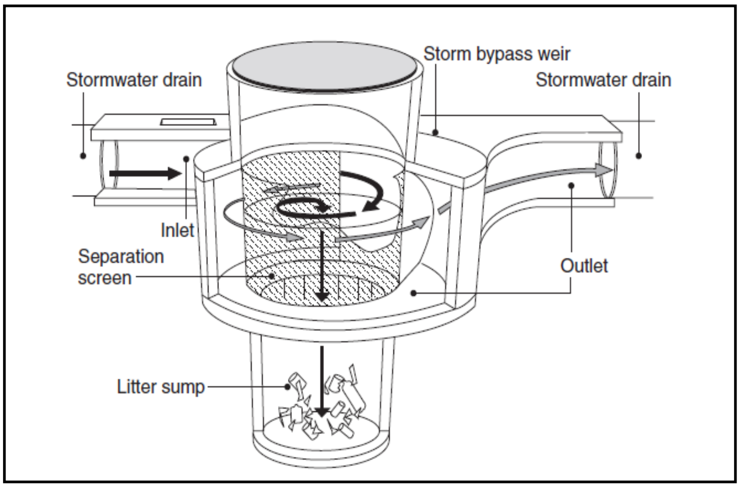

Figure 12: Continuous deflective separation trapping system (CSIRO, 2006)

Estimated treatment performance summary					
Gross pollutants	V/H	Coarse sediment	H	Medium sediments	M
Fine sediments	L/M	Attached sediment	L	Dissolved	N
Installation costs	H	Maintenance costs	M	Head requirements	L
N = negligible, L= low, M=moderate, H=high, VH=very high					

Reference: CSIRO, 2006

It should be noted that there are several similar proprietary versions of the HDS unit available with various features.

Advantages

- Very high removal rate for gross pollutants
- Low head requirements
- Can be retrofitted into existing drainage systems
- Minimal visual impact as typically installed underground
- Traps coarse sediment, with limited fine sediment retention
- Units with submerged screens also retain oils
- Minimal maintenance requirements

Limitations

- HDS units require a greater capital investment but are considered to provide easier maintenance than other trapping systems.

- Potentially large structure requires substantial area and depth
- Potential breakdown of collected pollutants in wet sump
- Potential re-suspension of sediments if design flows are exceeded

4 Considerations when selecting a GPT

4.1 Pre-requirements

Prior to the selection of an appropriate Gross Pollutant Device, the following key questions need to be considered:

1. Is full PARC-ALW (Proposed Auckland Regional Council Air, Land and Water Plan) compliance required and appropriate for the site?
2. Is the installation of a GPT justified at the site?

For many newly developed sites or infrastructure full ALW compliance would be required and appropriate. Therefore the installation of a GPT in this situation would be considered a useful primary treatment device. A GPT would be installed in conjunction with other necessary treatment measures required to meet full ALW compliance.

For many retrofit sites, full ALW compliance may not be required. Where this is the case, a GPT may still be justified.

It is critical to carefully consider the appropriateness of a GPT installation as a useful installation within the treatment train of the wider catchment. In many situations GPTs may not align well with a catchment's specific characteristics, pollutant types, existing treatment devices and likely maintenance regimes.

Once the need for a GPT has been established, the key considerations outlined below can be used to help ensure the correct GPT is selected.

4.2 Treatment Performance Objectives

It is important to determine appropriate *catchment-specific* treatment performance objectives for a GPT, whilst considering existing treatment devices within the wider catchment area. It is essential that these objectives are established as part of the conceptual design process and discussed with the client prior to commencing.

Treatment devices are generally assessed according to their trapping efficiency for each pollutant category, so designers need to ensure each device considered is specific to the pollutant profile of the catchment. Some GPT devices will claim to target smaller sediment and pollutants, however designers are recommended to confirm the proven performance of each device considered. Gross pollutant capture generally includes trash, litter and vegetation larger than 5 mm.

4.3 Design Flows

Catchment specifics such as size, rainfall/runoff patterns, infiltration rates and the connectivity of stormwater systems will alter the extent and type of gross pollutants able to be captured within any catchment. These factors will also affect the design flow selection for a particular catchment. The design flow is maximum flow rate at which a treatment device is designed to operate effectively.

A whole of life assessment must be carried out to evaluate the merits of increasing the volume of runoff treated by the device (design flow), whilst considering environmental and aesthetic benefits to receiving waters and additional capital and operational costs. Determining the design flow is generally a trade-off between cost and space requirements of the device and the volume of water that could potentially bypass the treatment device and avoid treatment.

4.4 Flood Capacity

A high flow bypass is generally designed into treatment devices for protection from large flood flows that could damage the device or scour and transport previously collected pollutants downstream. Again, a close look at the proven performance of high flow bypasses in the various devices considered is recommended.

A study previously completed (Wong et al. 1999) using Melbourne rainfall data is plotted in Figure 13 below. This compares the volume of mean annual run-off that would be treated at or below the design flow rate for a range of design standards for several hypothetical catchments with different times of concentration. The plot shows that the curves are relatively independent of the time of concentration of the catchment and also that the incremental benefit of increasing the treated volume of run-off diminishes beyond a design flow rate of the 2 year ARI. The plot also suggests that generally the optimum operating range falls within a design flow rate of between 0.25 and 1.0 year ARI discharges.

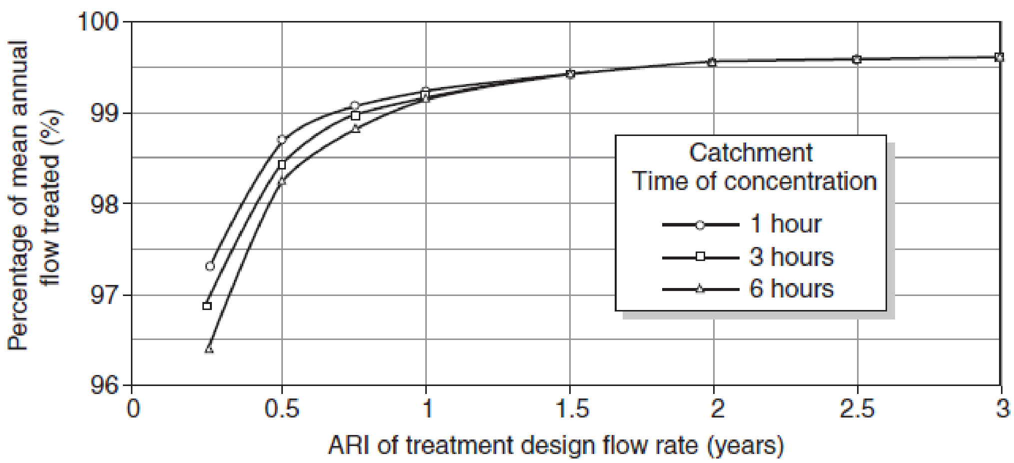

Figure 13: Treatment design flows plotted against the percentage of mean annual flow treated for the Melbourne region (Wong 1999)

4.5 Trapped Pollutant Storage

Trapped pollutants are held in a wet sump, in baskets, nets or behind screens that are free draining. The GPT needs to be designed so that it prevents re-suspension of captured contaminants during flows in excess of the design ARI. The most efficient GPTs are configured so that pollutants accumulate in a location that is not affected by high flows.

The continuous wet conditions in a pollutant containment sump and possibly limited turn over, mixing or aeration can lead to organic material decomposition, with depleted oxygen levels creating severe reducing conditions. Under these conditions, collected pollutants can be transformed from a relatively innocuous state to highly bio-available forms that are then released to downstream waters with any through-flow.

Therefore, when installing as a stand-alone GPT (i.e. without downstream treatment measures) the impact on downstream waterways from the release of potential pollutants from wet sumps should be considered. If necessary, GPT type or configuration needs to be reviewed.

4.6 Maintenance Requirements

The main environmental issues with GPTs are associated with:

- Long-term storage of pollutants that may be remobilised or cause odour;
- Limitations on the disposal of the trapped material.

A poorly maintained treatment device may not only perform badly, it may become a flood hazard or a source of pollution itself. Maintenance is the most commonly overlooked aspect of GPT selection, yet it is one of the most important for gross pollutant reduction.

GPT operation and maintenance requirements vary widely and the following issues with regard to maintainability and operability should be considered when selecting design objectives and targets:

- Access to the treatment site (i.e. by vehicle);
- Ease and frequency of maintenance;
- Availability of spare parts and service;
- Disposal of waste.

The ease of maintenance relates to the systems and equipment required to clean a GPT. Cleaning systems range from:

- Manual handling of collected pollutants;

- Vacuuming collected pollutants;
- Using a crane to retrieve collected pollutants from a basket or net; or
- Using large excavators to remove pollutants.

The design of any removable sump or basket collection system must ensure that floatable contaminants do not overspill the basket during lifting or clean out operations.

It is important that an assessment of the catchment pollutant load be undertaken in winter months to determine the likely pollutant 'wash off' and collection load. This load can be used to determine the holding capacity (or pollutant storage volume) required of the GPT for the catchment. This knowledge can also be applied in combination with winter climatic conditions to determine the frequency of clean out procedures required to ensure the trap is working efficiently.

4.7 Site Suitability Assessment

The choice of GPT location has a big influence on cost, treatment effectiveness, maintainability and overall device sustainability.

All potential sites for a GPT installation within the catchment need to be identified, whilst considering the specific characteristics and constraints of each location.

GPT location is affected by many factors. Initially the adoption of an 'outlet' or 'distributed' approach needs to be determined. The traditional outlet approach involves constructing a single large treatment device at the catchment's outlet.

This single site approach offers obvious maintenance advantages; it has the disadvantage of needing to treat larger volumes of water at a location often a considerable distance from the pollutant's source.

An alternative is the *distributed approach* where a number of smaller and potentially different GPT treatments are installed throughout the catchment. This offers many advantages including:

- **Improved protection:** water quality protection may be distributed along a greater length of waterway
- **Localised treatment:** particular treatments may be specifically targeted at highly polluted sites
- **Improved removal efficiencies:** distributed treatments are typically located in areas of lower flow. Lower flow velocities and volumes and high pollutant concentrations in stormwater at these sites lead to higher operating efficiencies
- **Staged implementation:** individual sites may be brought into operation at different stages

The characteristics of a particular site can limit the choice of treatment measures suited to the area. Two broad site constraint categories exist - physical and social.

Physical site constraints can make construction difficult or impossible and maintenance expensive, for example:

- Topography: eg steep slopes
- Soils and geology: eg erosivity, porosity, depth to bedrock or instability
- Groundwater: eg geochemistry and water table depth
- Space: limited open space, proximity to underground services, traffic
- Nature of drainage system: open channel or piped.

Social constraints include issues of health and safety, aesthetics, and impacts on recreational facilities, for example:

- Odour problems
- Visual impacts
- Noise
- Physical injury: eg due to unauthorised access to structures
- Contamination: eg infection, poisoning or injury caused by trapped pollutants
- Vermin: eg mosquitoes, rats

Many safety issues can be addressed at the treatment design stage, for example developing specific health and safety procedures for construction and maintenance staff, installation of warning signs, and fencing the site (CSIRO, 2006).

4.8 Cost Considerations when selecting a GPT

The costs of GPTs vary significantly based on the required size and application. This is very much dependant on the total catchment area from which the GPT is receiving stormwater, and the extent of gross pollutants within that catchment.

Factors which should be considered when determining installation, maintenance and disposal costs are detailed below.

4.8.1 Installation Costs

Installation costs include the cost of supply and installation of a GPT. Variables related to ground conditions (such as rock or groundwater conditions) or access issues may vary construction costs significantly. Some GPT sites are inherently more simple and cost effective than others.

To estimate the installation costs there are a number of localised issues that will need to be considered, including:

- Design flow rate and available hydraulic head;
- Size and configuration of the trap (with regard to site constraints);
- Safety and other construction issues.

If any of the above factors cannot be adequately satisfied by a particular trap it should be deemed as potentially inappropriate for that location.

4.8.2 Maintenance Costs

Monitoring and maintenance costs can be more difficult to estimate than the installation costs; however these are often the most critical variable. This is due to variances of the techniques used, the amount of material removed and the unknown nature of the pollutants exported from a catchment. In many cases maintenance costs are the most significant cost of a treatment measure. It is therefore imperative to carefully consider the maintenance requirements and estimated whole of life costs when selecting a GPT. Allowance for any associated transport costs needs to be included, along with the time and resources needed for data capture and storage.

One important step is to check previous installations by contacting current owners of GPTs and asking about their annual costs. Also, product suppliers can usually supply contact and cost information. Many vendors can also be contracted to maintain their devices which can ensure that the maintenance costs (excluding inflation) can be determined prior to device installation.

4.8.3 Disposal Costs

Disposal costs will vary depending on whether the collected material is retained in a wet or dry state (i.e. either under water or left so it can drain). Handling of wet material is more expensive and will require sealed handling vehicles.

Generally, all GPT sediment waste is considered contaminated, and gross litter requires disposal to landfill.

Addressing the following questions will assist in determining disposal costs:

- Is the material in a wet or dry state and what cost implications are there?
- Are there particular hazardous materials that may be collected and will they require special disposal requirements (e.g. contaminated waste)? If so, what cost implications are there?
- What is the expected load of material and what are the likely disposal costs?

In the event that there is no other data, the values in Table 1 below could be considered.

Table 1: Approximate Litter and Gross Pollutant Loading Rates used for Melbourne (IE Aust, 2006)

Land use Type	Litter Volume	Litter Mass	Gross Pollutants Volume	Gross Pollutants Mass
	(L ha^{-1} yr^{-1}	(kg ha^{-1} yr^{-1})	(L ha^{-1} yr^{-1})	(kg ha^{-1} yr^{-1})
Commercial	210	56	530	135
Residential	50	13	280	71
Light Industrial	100	25	150	39

4.8.4 Wet versus Dry Loads

From a disposal cost sense, GPTs are grouped into two main categories according to whether a dry or wet load is stored. This means that collected items are either stored above (dry) or below (wet) standing water levels.

Traps that store trapped material in a dry state are generally cheaper to operate as the collected material can be delivered to local landfill facilities without any issue.

Wet load traps are more complicated and thus more expensive to operate. They require suction equipment for cleaning and the liquid portion is classified as toxic liquids. Disposal is to a hazardous waste facility under often strict guidelines.

4.8.5 Whole-of-Life Costs

Whole-of-life costs are a combination of the installation and operational costs and provide an indication of the true long-term cost of the infrastructure. It is particularly important to consider whole-of-life costs for GPTs because maintenance costs can be significant compared with the capital cost of installation. Consideration of asset removal and decommissioning costs also need to be allowed for when assessing whole-of-life costs.

To determine life cycle costs, an estimated life span of the device needs to be assumed (e.g. 20 or 25 years), or if the trap is to control pollutants during the development phase only, it may be three to 10 years. Defining costs in terms of their Net Present Value (NPV) is a convenient way of describing whole-of-life costs.

4.9 Device Selection Matrix

"Device Selection Matrix" (Appendix 1) summarises common Primary Treatment Devices and their attributes identified in Section 3 to assist designers with appropriate device selection.

This Device Selection Matrix includes the selection parameters discussed in Section 4. The following parameters are included to the matrix:

- efficiency (very high – negligible)
- head requirements (high-low)
- construction costs (high-low)
- maintenance costs (high-low)
- particle size (gross pollutants, coarse, medium or fine sediments, and attached pollutants)

The Device Selection Matrix can be used to help select appropriate GPT treatments based on pollutant retention efficiencies, design construction and operational considerations and costs.

Device Selection Matrix helps the designer to quickly reject the GPT techniques that have little impact on target contaminants and specific catchment characteristics.

Having established a short list, the treatment measures should be reviewed in detail to determine the best options. All aspects should be considered and compared including maintainability and operability, pollutant retention, head requirements, cost and secondary benefits. Certain treatment measures provide incidental benefits beyond the primary goal of removing the target pollutants. Some treatment measures demonstrate the potential to remove pollutants other than the primary targets. Some treatment types may provide added benefits such as aiding flood control, ecological enhancement or provision of an educational resource. Designers should, however, be careful to check proven performance and the conditions a device was tested under when considering performance claims over and above the primary targets.

5 Operation and Maintenance

5.1 Why Regular Maintenance is Critical

Gross Pollutant Traps require a considerable amount of maintenance to ensure that they continue to operate at the design level of performance.

A poorly performing GPT (due to poor design or inadequate maintenance) can result in overloaded treatment devices releasing trapped gross pollutants (litter, debris and coarse sediments) which in turn smother downstream treatments and impact on their operation. This is especially a risk during larger storm events. In addition, litter can detract from attractive stormwater treatments such as wetlands and reflect poorly on the overall treatment system.

A poorly maintained GPT can hold gross pollutants for some time, during which some types of GPTs can transform collected contaminants into more bio-available forms. Small flows through the collected pollutants can then leach transformed pollutants downstream, where they can be detrimental, in some cases causing more problems than if a GPT was not installed.

5.2 Developing a Monitoring and Maintenance Plan

It is critical that the performance and service of each GPT installed has a Monitoring and Maintenance Plan that has been developed during the design process. This plan can be used as an effective means of ensuring long term owners of each device have sufficient information to carry out ongoing maintenance effectively and safely.

This plan should include the following information:

1 **Device Details**

- The location and type of device
- Ownership details and who will incur the costs of maintenance and disposal

2 **Inspection/Monitoring/Reporting**

- Who is going to perform the routine maintenance
- Monitoring, measurement, recording and reporting of system condition and performance.

3 Maintenance Requirements

- What parts of the device are to be cleaned and how
- Maintenance systems and equipment required
- Type of maintenance and likely frequency
- What, if any, machinery is required to maintain the device
- What consumables/spare parts are required
- Expected maintenance and inspection frequency
- Expected maintenance costs or other resource requirements
- Method of disposal and anticipated costs for the likely pollutant to be encountered
- Access issues such as locked gates, entry through private property etc including contact telephone numbers
- Any environmental safeguards required during cleaning (eg hay bales required to filter stormwater drained from device)
- Occupational Health and Safety issues (eg is confined spaces accreditation required to clean the device?)
- Alternatives to proposed cleaning method (ie device may be cleaned by lifting out baskets by crane or by vacuum truck)
- Any other information that is important to the routine maintenance of the device

4 Contingency Plans

- Details on any general and site specific contingency and emergency procedures
- Details on maintenance procedures during high flow events if device is impacting detrimentally on adjoining areas

5 Appendices

- As-built plans
- Manufacturers information
- Resource consents
- Standard forms and checklists

Maintenance personnel and asset managers should use the maintenance plan to ensure the GPT continues to function as designed. Ongoing assessment of the condition of each device during periods of monitoring or maintenance will allow appropriate depreciation of the asset to be determined. An example operation and maintenance inspection form is included in Appendix 2 of this report. These forms should be developed on a site-specific basis as the nature and configuration of GPTs varies significantly.

5.3 Maintenance Operations

Frequency of Cleaning

The minimum level of maintenance and cleanout required to ensure the GPT system operates as designed to maximise pollutant capture without causing adverse environmental or hydraulic impacts, should be specified. The maintenance of GPT systems must be able to demonstrate that captured contaminants can be stored so as not to cause significant adverse environmental impact or nuisance (e.g. odours and putrefaction, or flooding). The maintenance program should allow for the costs of collection, transport and delivery of captured gross pollutants to an appropriate waste disposal facility.

The maintenance frequencies outlined for each type of device in Section 4 of this report are indicative only based on typical international experiences. It is recommended that each device installed within the Auckland area be monitored and maintained initially in this manner for a period of approximately one year to allow for site specific characteristics to be assessed. An appropriate ongoing monitoring and maintenance frequency can then be developed for the catchment to optimise maintenance efficiency.

Timing of Cleaning

It is considered acceptable practice to disregard the need to include a flow isolation option in the design and installation of these GPTs. All GPTs are generally cleaned during periods of dry weather.

Method of Cleaning

Cleaning systems range from:

- Manual handling of collected pollutants;
- Vacuuming collected pollutants;
- Using a crane to retrieve collected pollutants from a basket or net; or
- Using large excavators to remove pollutants.

The maintenance/cleanout procedure to be adopted for the GPT device should utilise plant and equipment readily available or currently in use by the maintenance contractor if possible.

The design of any removable sump or basket collection system must ensure that floatable contaminates do not overspill the basket during lifting or clean out operations.

Disposal of Gross Pollutants

The cost of disposal is a key maintenance consideration which is often overlooked or underestimated. Method of disposal will depend on the pollutants and level of contamination encountered. Silts and sediment may be considered contaminated whereas floatable litter may be appropriately disposed of at a landfill. Disposal requirements and costs should be confirmed and included within the Maintenance and Monitoring Plan.

All maintenance activities should be developed to ensure they require no manual handling of collected pollutants because of safety concerns with hazardous material.

Monitoring of Gross Pollutants Collected

Where monitoring of the GPT cleanout is required, allowance should be provided in the maintenance programme to undertake the necessary on-site or laboratory processing to separate the contaminants into the following pollutant categories (CSIRO Urban Stormwater 2006):

- Gross pollutants: trash, litter and vegetation larger than 5 mm
- Coarse sediment: contaminant particles between 5 and 0.5 mm
- Medium sediment: contaminant particles between 0.5 and 0.062 mm
- Fine sediment: contaminant particles smaller than 0.062 mm
- Attached pollutants: those that are attached to fine sediments – specifically nutrients, heavy metals, toxicants and hydrocarbons
- Dissolved pollutants: typically nutrients, metals and salts

5.4 Check Lists

Aspects to be covered in the Construction and Maintenance Plan are described in Section 5.2 and 5.3. Appendix 2 includes checklists that can be used for selecting a GPT, design calculation, maintenance inspection and cost association.

During the design stage the design objectives and key targets need to be achieved and assessed and were included to the check list.

During the construction and maintenance inspections on site to ensure key aspects are assessed and included to the check list.

Appropriate installation is critical and is often overlooked. Installations should be checked to ensure correct construction drawings have been followed with an independent third party inspection carried out.

Photo 1: Maintenance of a litter and sediment trap by vacuum (Department of Water 2006)

Photo 2: Maintenance using a truck mounted crane to lift sediment baskets (www.nettech.com.au)

6 Summary

Gross Pollutant Traps (GPTs) are devices used for water quality control with the primary purpose of removing gross pollutants greater than 5 mm. Some GPT's are designed for "Gross Pollutants" such as containers, leaves, bottles and plastic bags. However, gross pollutant also includes large particles such as gravel and particles greater than 5 mm and GPTs may be designed to remove these eg catchpit. Smaller pollutants, such as dirt, chemicals, heavy metals and bacteria are not collected directly by the GPTs; however, some small particles are caught up in the larger items removed, and thus prevented from reaching the waterway.

The receiving environment often dictates a treatment train approach comprising a GPT together with other non-GPT components, particularly those targeting finer pollutants. GPT devices are generally the first device within a treatment train.

There is a wide variety of GPTs available, with widely varying treatment mechanism, size, operational needs, cost and trapping performance. With such a range of techniques available, there are no consistent treatment parameters that all GPTs follow.

GPTs generally operate by screening, stilling or slowing the flow of water, flow separation, sedimentation, flotation, or filtration or a combination of these treatment mechanisms.

This literature review has investigated available GPT techniques and identified a series of design considerations including treatment performance objectives, design flows, flood capacity, trapped pollutant storage, maintenance requirements, and whole of life costs. Where practicable these considerations have been summarised in a Device Selection Matrix (appended) which compares the benefits and limitations of each type of GPT currently available.

Maintenance is the most commonly overlooked aspect of GPT selection, yet it is one of the most important for gross pollutant reduction. A poorly maintained treatment measure may not only perform badly, it may become a flood hazard or a source of pollution itself. A GPT should not be installed unless there is a corresponding commitment to long term monitoring and maintenance.

There are a large number of proprietary GPT devices available on the market, and this report has not covered every variant, but has addressed GPTs generically, thus providing a useful basis for the assessment of individual devices.

GPTs are continuously being developed and modified as suppliers research the operation of their traps and respond to treatment requirements. There is generally a shortage of field data relating to the actual trapping performance of the various methods, making the accuracy of treatment comparisons difficult. Stormwater designers are recommended to critically check the claimed performance efficiency results of specific devices, examine the conditions the results were obtained under, and ensure testing is independent.

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9 APPENDIX 1: Device Selection Matrix

DEVICE SELECTION MATRIX FOR PRIMARY TREATMENTS

Coresponding Section in Report	Type of GPT	Mechanism	Removal Efficiency					Design Considerations			Construction		Operation and Maintenance				
			Gross Pollutants Efficiency	Coarse Sediments Efficiency	Medium Sediments Efficiency	Fine Sediment Efficiency	Attached Pollutants Efficiency	Catchment Area Range (ha)	Ability to Incorporate High Flow Bypass (Y/N)	Head Requirements	Visible or Underground	Installation Costs	Maintenance Costs	Pollutant Storage Online/Offline	Pollutant Storage Imersed/Drained	Can Pollutants become Resuspended? (Y/N)	Cleaning Frequency
3.5	Grate and entrance screens	Drainage Entrance Treatment	L	N	N	N	N	0.1-1	N	L	Visible	L	L/M	Offline	Drained	Y	weekly
3.6	Side entry pit traps	Drainage Entrance Treatment	M/H	L	N	N	N	0.1-1	N	L	Underground	L/M	M/H	Offline	Drained	Y	monthly
3.7	Baffled pits	Drainage Entrance Treatment	L	M	L/M	L	N	0.1-2	N	L	Underground	L/M	L/M	Offline	Imersed	Y	monthly
3.8	Trash racks	Direct Screening Device	L	N/L	N/L	N	N	20-500	N	L/M	Visible	M	L/M	Online	Imersed	Y	monthly
3.9	Litter control devices	Direct Screening Device	M/H	L/M	N	N	N	2-150	Y	M/H	Underground	M/H	M/H	Online	Imersed	Y	weekly/monthly
3.10	Gross pollutant traps	Direct Screening Device	L/M	M/H	M	L	N	5-5000	N	H	Visible	H	M/H	Online	Imersed	Y	monthly/quarterly
3.11	Boom diversion systems	Direct Screening Device	M	L/M	N/L	N	N	10-40	Y	L	Underground	M	M/H	Offline	Imersed	Y	monthly
3.11	Flexible floating booms	Floating Trap	N/L	N	N	N	N	>100	N	L	Visible	L	M	Online	Imersed	Y	weekly/monthly
3.11	Floating debris traps	Floating Trap	L	N	N	N	N	>100	N	L	Visible	L	M	Online	Imersed	Y	weekly/monthly
3.12	Hydrodynamic seperation	Sediment Trap / non clogging s	L/M	M/H	M	M	L/M	5-100	Y	L	Underground	H	L/M	Offline	Imersed	Y	monthly
	Release nets	Direct Screening Device	M/H	N/L	N	N	N	1-50	Y	L	Visible	L	L/M	Online	Drained	N	weekly/monthly
	Return flow litter baskets	Direct Screening Device	M/H	M	L	N	N	20-100	Y	L	Underground	M/H	L/M	Online	Imersed	N	monthly
	Hydraulically operated trash racks	Direct Screening Device	H/VH	L/M	N	N	N	>10	Y	L	Visible	L/M	M/H	Online	Imersed	N	weekly
	Circular screens	Non-Clogging Screen	VH	H	M	L/M	L	5-150	Y	L	Underground	H	M	Online	Imersed	N	quarterly
	Downwardly inclined screens	Non-Clogging Screen	H/VH	N	N	N	N	5-500	Y	H	Visible	M/H	L/M	Offline	Drained	N	monthly/quarterly
	Sediment settling basins	Sediment Trap	N/L	M/H	M	L	N/L	10-500	N	L	Visible	L/M	L/M	Online	Imersed	Y	half-yearly
	Circular settling tanks	Sediment Trap	L/M	H	M/H	M	L/M	1-20	Y	L	Underground	H	M	Offline	Imersed	N	monthly

Information has been sought from *CSIRO Urban Stormwater: Best Practice Environmental Management Guidelines, 2006* to develop this table.

Ongoing product advancements mean the information contained within this table will need updating as new technologies are developed.

The information contained within this table is based on the likely performance of each type of GPT assuming appropriate siting, device and bypass installation, and maintenance are carried out. It is also assumed that devices are designed appropriately based on site secific flows and maximum design flows are not exceeded. If any of these criteria are not met/exceeded, then performance of all devices are subject to critical failure.

Some of the main GPT devices listed above are cross referenced back to a coresponding section within our report '*Literature Review: Gross Pollutant Traps as a Stormwater Management Practice* (February 2011)'. It should be noted that several of the devices detailed in this matrix have not yet been installed in the Auckland region but have been used extensively overseas, significantly in Australia.

POLLUTANT CATEGORY:

Note: the primary function of GPTs is to retain gross pollutants larger than 5mm in size. Smaller pollutants captured should be considered an additional benefit.
Gross Pollutants: trash, litter and vegetation larger than 5 millimetres
Coarse Sediment: contaminant particles between 5 and 0.5 millimetres
Medium Sediment: contaminant particles between 0.5 and 0.062 millimetres
Fine Sediments: contaminant particles smaller than 0.062 millimetres
Attached Pollutants: those that are attached to fine sediments—specifically, nutrients, heavy metals, toxicants and

REMOVAL EFFICIENCY:

N= negligible, L= low, M= moderate, H= High, VH= very high
Pollutant retention efficiency grading is as follows:
Very High (VH): 80 to 100 per cent of total pollutant load retained
High (H): 60 to 80 per cent of total pollutant load retained
Moderate (M): 40 to 60 per cent of total pollutant load retained
Low (L): 10 to 40 per cent of total pollutant load retained
Negligible (N): less than 10 per cent of total pollutant load retained

HEAD REQUIREMENTS:

High: more than 1 metre
Moderate: between 0.5 and 1 metre
Low: less than 0.5 metre

CONSTRUCTION COSTS (based on overseas findings):

These indicative rankings for capital cost are based on the treatment's total installed cost per hectare of catchment.
These costs should be used as a broad approximation as costs will vary according to catchment characteristics and rainfall.
High (H): greater than $1500 per hectare of catchment
Moderate (M): between $500 and $1500 per hectare of catchment
Low (L): less than $500 per hectare of catchment.

MAINTENANCE COSTS (based on overseas findings):

Maintenance costs are based on the cost per hectare per annum of the particular treatment type.
Maintenance costs generally include inspections, routine maintenance and cleaning operations.
Disposal costs for the pollutants is excluded.
Broad estimates are categorised as:
High (H): greater than $250 per hectare of catchment per annum;
Moderate (M): between $100 and $250 per hectare of catchment per annum
Low (L): less than $100 per hectare of catchment per annum

RESUSPENSION OF POLLUTANTS:

It should be noted that although some GPTs are more prone to the resuspension of pollutants as shown in the table, in general when design flows are exceeded most GPTs will be capable of resuspending caught pollutants.

MAINTENANCE FREQUENCY (based on overseas findings):

The frequency shown in the table above is **indicative only** based on overseas experiences. As deailed within the report text, a site specific maintenance frequency should be developed over time based on catchment specifics and actual loads encountered.

10 APPENDIX 2: Checklists

10.1 Selecting a GPT Checklist

General	Y	N
Space available for the device (i.e. required footprint, access routes, services)		
Location suit the catchment treatment objectives (e.g. position in a treatment train)		
Holding chamber suitable (wet or dry retention)		
Sufficient safety precautions (i.e. preventing entry, access for cleaning)		
Visual impact (and odour potential) satisfactory		
Treatment flow sufficient to meet treatment objectives		
Flooding impact satisfactorily addressed		
Sufficient consultation taken place with operational staff and the local community		
Expected pollutant removal rate sufficient to meet treatment objectives		
Installation	**Y**	**N**
Price includes installation		
Sufficient contingencies for ground conditions (e.g. rock, shallow water table, soft soils etc)		
Allowance for relocation of services		
Sufficient access or traffic management systems proposed as part of construction		
Maintenance	**Y**	**N**
Method of cleaning applicable to local conditions (e.g. OH&S issues, isolation of the unit from inflows etc)		
Maintenance (cleaning) techniques suitable for the organisation responsible (i.e. required equipment, space requirements, access, pollutant draining facilities		
Size of the holding chamber sufficient (for a maximum of 12 cleans per year)		
Disposal costs been accounted for		

10.2 Design Calculation Checklist

Asset ID:			
GPT Location:			
Hydraulics:	Design operational flow (m3/s):		
	Above design flow (m3/s):		
Area:	Catchment area (ha):		
Treatment		Y	N
1. Treatment performance verified			
GPT Component		Y	N
2. Appropriate hydraulic calculations used			
3. GPT capacity sufficient for maintenance period			
4. Maintenance access provided			
5. Public access to system prevented			
6. Drainage facilities/dewatering provide for cleanout			
7. Overall flow conveyance sufficient for design flood event			
8. No head loss in drainage system			
9. No surcharge upstream			
10. Bypass sufficient for conveyance of design event			
11. Tidal influence assessment undertaken (if appropriate)			
Comments			

10.3 Maintenance Inspection Checklist

Asset ID:		Date of Visit:	
Location:			
Description:			
Site Visit By:			
Purpose of Site Visit:	Routine Inspection:		
	Routine Clean Out of Trash Rack and Baskets:		
	Annual Inspection:		

Inspection	
1. Percentage of GPT covered by debris (%)	
2. GPT clean out required if above >50% (Y/N)	
3. Any visible damage to GPT (if yes, complete section on condition) (Y/N)	
Cleanout of GPT	
4. Volume of debris removed (m3)	
5. Visible damage to GPT (if yes, complete section on condition) (Y/N)	

Component Condition	Checked?		Condition OK?		Remarks
	Y	N	Y	N	
6. Concrete walls					
7. Trash rack					
8. Baskets					
9. Access ladders					
10. GPT inlet					

11. GPT outlet					
12. Lids					
Comments on Inspection					
Actions Required					
1					
2					
3					
4					
5					
Inspector's Signature:					

10.4 Life Cycle Costs Checklist

Installation	Y/N
1. Does the trap satisfy:	
(i) the design flow rate	
(ii) the available space constraints	
(iii) hydraulic and flooding issues	
(iv) other concerns (e.g. safety and aesthetics)	
If no to any of the above, then go no further	
2. Trap cost	
3. Installation cost	
4. Other costs (rock excavation, lid loading, access road for maintenance etc.)	
Maintenance	
5. Annual maintenance costs	
6. Cost of any special maintenance equipment	
7. Expected costs of disposal	
Life Cycle Cost	
8. Estimated project duration (in years)	
9. Life cycle costs = (Installation costs + (n x maintenance costs)) divided by n	
where n = project duration (years)	