AUCKLAND CITY'S FIELD AND LABORATORY TESTING OF STORMWATER CATCHPIT FILTERS

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ABSTRACT

The paper documents the results from a field and laboratory testing programme undertaken by Auckland City Council to compare the performance of commercial Catchpit Filter Systems (CFS). A catchpit filter takes the form of a fine-mesh filter bag that is inserted inside a standard catchpit. The need for the testing arose from the City's plans to install several hundred CFS units if they met satisfactory field and laboratory performance targets for capturing sediment washed off roads and paved surfaces.

Four suppliers volunteered CFS units for the field testing programme. 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.

Laboratory testing was carried out on CFS units from two suppliers. The testing, carried out at the University of Auckland, sought to quantify sediment capture performance. It also sought to determine the head loss characteristics of the filter fabric to establish its potential to limit the hydraulic capacity and cause flow to bypass the CFS unit. In addition, a catchpit without the CFS unit was tested. Testing was carried out for a range of flow rates and sediment concentrations.

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.

KEYWORDS

catchpit filter systems, filter bag/fabric, performance, field observations, operation and maintenance, laboratory testing, sediment capture, head loss.

1 INTRODUCTION

Auckland City lies on the isthmus between the Waitemata and Manukau harbours. The harbours and surrounding waters are used extensively for trade and recreation, and contain a number of delicate ecosystems. The treatment of stormwater runoff is essential if the harbour and its surrounding waters are to be preserved.

Studies have shown that by removing the sediment contained in stormwater, a large amount of the pollutants will be removed (Dept. of Land and Water Conservation NSW). It is found that pollutants attach to the sediments contained in stormwater. Traditional methods of stormwater treatment, such as sediment retention ponds, swales, and infiltration trenches, work by removing the sediment from the stormwater runoff. They often require large areas of land to function effectively. Because of the limited availability and high cost of land in the more developed parts of the city, retrofitting these large stormwater treatment devices is extremely difficult.

Catchpit Filter Systems (CFS) are essentially fine mesh bags that are inserted into street catchpits to capture sediments washed off the road in wet weather. The use of CFS as a means of stormwater treatment does not require the purchase of additional land, or the use of recreational reserves that the council may already control. The City is considering the use of CFS devices to treat road runoff primarily in the central business district having high traffic volumes and limited space to employ other treatment devices.

CFS units are a relatively new method of stormwater treatment aimed at capturing stormwater pollutants close to their source. Being a relatively new treatment method, limited information was available on the operation and sediment removal performance of CFS. Previous performance investigations on some products has shown it is very difficult to carry out conclusive field testing. The City sought to identify CFS products that met their performance targets before progressing to large scale installation of CFS.

A study was carried out to compare the performance and the effectiveness of four different CFS. The four suppliers of the four different CFS all took part in the study on a voluntary basis.

The study consisted of

- A Field Trial
- Laboratory Testing

2 FIELD TRIAL

The aim of the field trial was to compare the operational performance of the four different CFS by observing their installation, operational performance and maintenance requirements.

The field trial was a comparative investigation of the four CFS based on qualitative observations of their operational performance under similar weather conditions. The individual catchpits or contributing catchments were not identical, requiring observations to take account of the differing characteristics. The field trial looked at the qualitative performance of the CFS under conditions that the laboratory testing could not simulate.

The field trial was undertaken by Tonkin & Taylor (T&T) in the Newmarket/Grafton area of Auckland city from 21 March to 20 August 2002.

2.1 FIELD TRIAL METHODOLOGY

CFS product suppliers were invited to install two CFS units in two trial catchpits identified by Auckland City. Prior to the installation of CFS, all catchpits were cleaned and downstream pipes were checked for blockages.

During the trial period, suppliers were responsible for deciding when any maintenance (including cleaning) of the CFS was required. Suppliers were also requested to meet with Auckland City's maintenance contractor, to discuss suppliers' maintenance/cleaning requirements. Suppliers were encouraged to be present during all maintenance operations so they could direct the maintenance contractors.

Operational performance observations for each CFS product were undertaken every fortnight and during and after significant rain events. Inspections were carried out by the same two T&T staff members throughout the trial to ensure consistency of observations and records.

The performance of each of the CFS was compared on a number of attributes, as described below.

(a) Ability of the CFS to capture and retain sediment
(b) CFS maintenance characteristics
(c) CFS physical fit within the catchpits
(d) Rigidity and strength of CFS
(e) CFS ability to catch road runoff
(f) Effect of litter and organics on the CFS performance

The information from the field observations was then used to summarise the operational performance of CFS for each of the above performance criteria. These results were then used to focus selection for further laboratory testing of the CFS products.

2.2 FIELD TRIAL RESULTS

Of the four CFS observed in the field trials, Auckland City determined that two CFS products met operational performance requirements for their project, and these were selected for further laboratory testing.

The two selected CFS performed favourably on all six performance attributes listed in 2.1 above. The comparative operational performance of the two CFS was very similar.

Some interesting issues encountered with some of the CFS in the field trials were:

- Unnecessary use of the CFS overflow mechanism, resulting in untreated flows.
- Mechanical overflow mechanisms such as flaps were prone to failure by blockage.
- Flows bypassing the filter bags due to gaps in the seal between the CFS and the catchpit wall. These gaps were a result of poor installation of the CFS.
- A small sediment storage capacity, which would result in a high cleaning frequency or loss of captured sediments during high flows.
- One of the CFS did not have an overflow mechanism to bypass the filter bag under high flows. This resulted in localised ponding/flooding around the catchpit when flows exceeded the filter bags capacity.
- One filter bag was seen to invert causing the sediment that had been captured to wash down the overflow mechanism and out of the outlet pipe.
- The filter bag from one of the CFS was sucked down the catchpit outlet pipe, creating a blockage and decreasing the capacity of the outlet.

2.3 FIELD TRIAL OUTCOMES

The two main outcomes of the field trial were

1. A CFS ability to function well is very dependant on how well it is installed. Careful specification of contract requirements and installation monitoring is required to ensure good quality control of CFS installation.
2. It is essential that CFS have an efficient and reliable overflow mechanism. Mechanical flaps observed in the field trial generally were unsuccessful.

3 LABORATORY TESTING

The laboratory study was conducted by Auckland Uniservices, in the School of Engineering at the University of Auckland.

The laboratory tests were used to quantify the effectiveness of the CFS under different flow rates and with different sediment particle sizes and concentrations. This provided a simplified and controlled representation of field conditions to test the relative performance of the CFS. The laboratory data also enables the performance of these products to be predicted from a measured sediment particle distribution. Laboratory tests were also carried out to determine the head loss across the two synthetic filter fabrics to establish the potential for limiting catchpit hydraulic capacity and relative overflow potential between different CFS.

3.1 LABORATORY TESTING METHODOLOGY

The laboratory setup consisting of a rectangular channel, wooden apron, hopper, and catchpit containing the CFS is shown schematically in Figure 2. The laboratory catchpit was constructed of plexiglas to dimensions similar to units in the field (catchpit dimensions are presented in Figure 3). The catchpit received water from a skewed apron (sloped in the longitudinal and transverse directions at 10^o and 6^o, respectively, to the horizontal plane) so that flow occurred primarily along the lower edge of the wooden apron.

The test procedure involved feeding synthetic road sediment, derived by adding specified amounts of sized sediments to running water, to the catchpit at various flow rates. Tests were performed for five flow rates (0.5 l/s, 1 l/s, 4 l/s, 12 l/s, 20 l/s), four sediment concentrations (50 mg/l, 150 mg/l, 250 mg/l, 400 mg/l) and four particle sizes (<100 μ, 100-500 μ, 500-1000 μ, 1000-10000 μ), yielding a total of 80 tests for each of the following three cases

- Catchpit without a CFS (base case)
- Catchpit with an Enviropod CFS
- Catchpit with a Flogard CFS.

Constant inflows of synthetic runoff to the CFS were maintained for a minimum of four hydraulic retention times, corresponding to approximately six minutes for 20 l/s and 30 minutes for 0.5 l/s. The overall CFS performance was based on the efficiency of sediment capture under specified flow rates, particle sizes, and sediment concentrations.

In addition, each of the three cases were tested using street sediments to simulate particle entrapment in the field. The street sediments were obtained by vacuuming a number of streets in Mt Roskill within the Oakley Creek catchment. The CFS tests with street sediments were conducted for flows of 4 l/s, 12 l/s and 20 l/s, with an influent sediment concentration of 250 mg/l.

Head loss tests were performed on the filter fabric by passing various flowrates across the filter fabric, and measuring the head on either side of the filter fabric using a peizometer. Figure 1 below shows a schematic of the laboratory set up.

Figure 1: Laboratory Setup for Headloss Measurements

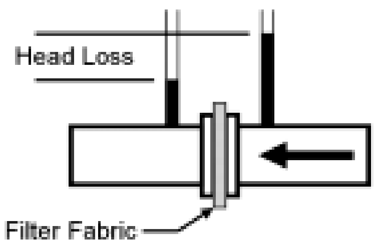


Figure 2. Experimental setup of Catchpit

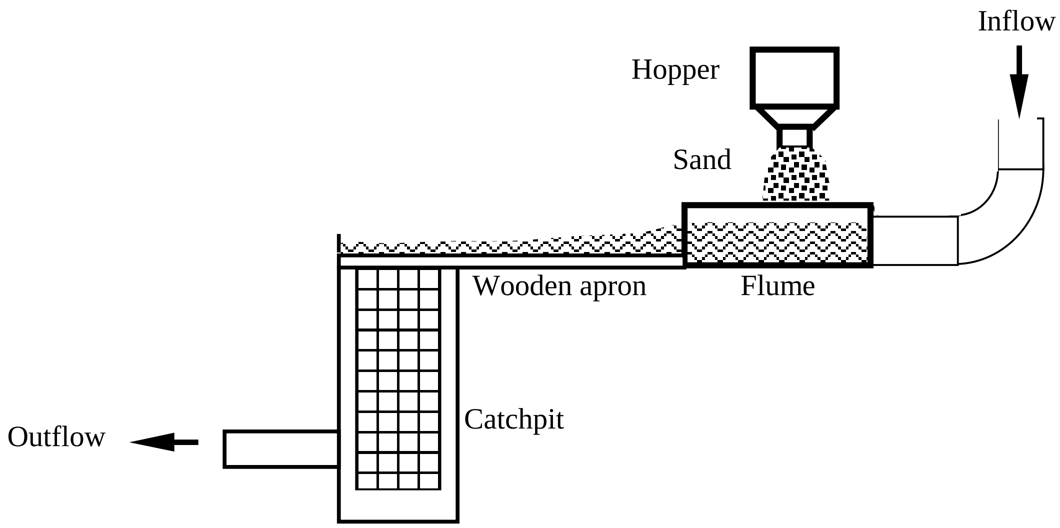
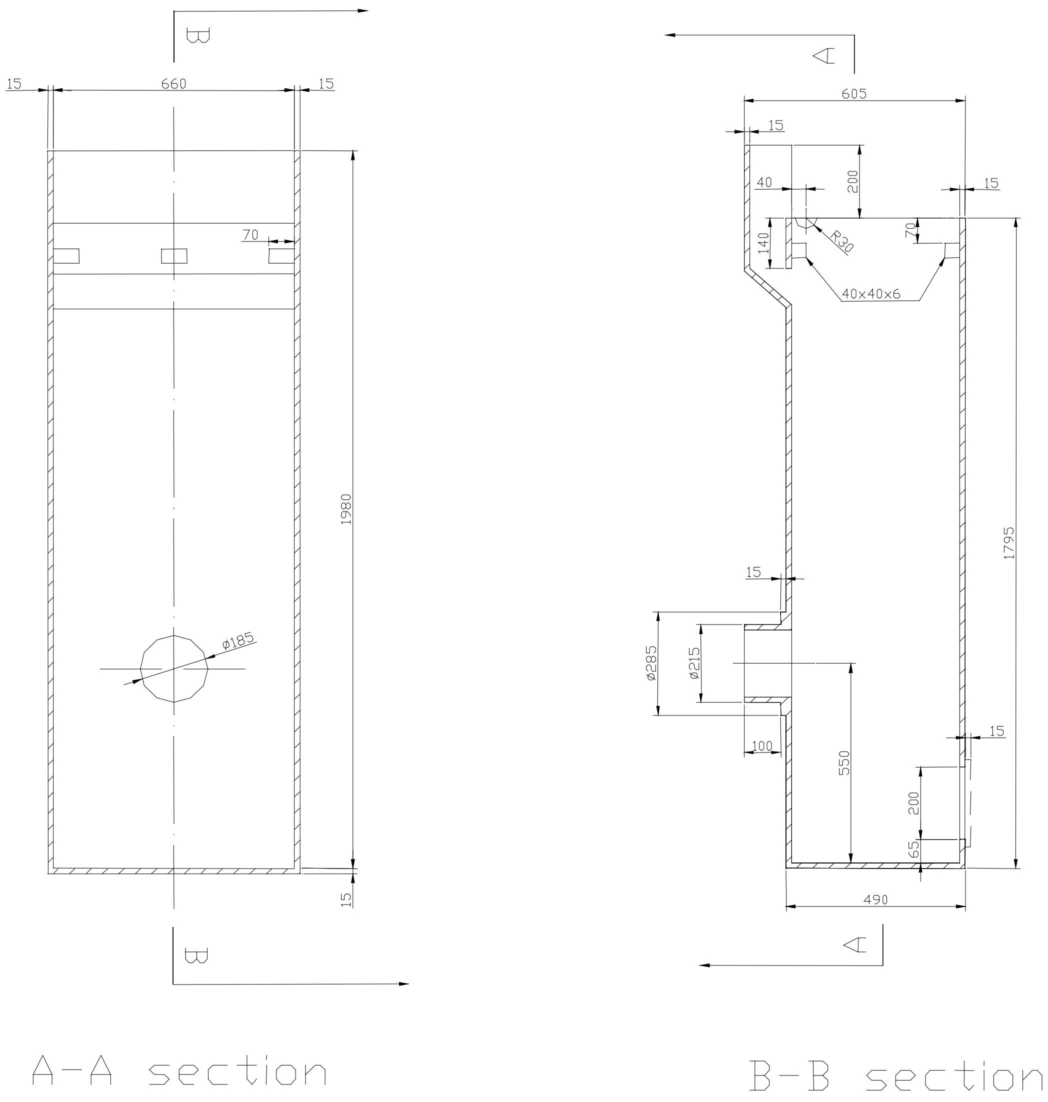


Figure 3: Catchpit Dimensions



3.2 LABORATORY TEST RESULTS

Test results for sediment removal for the three cases is presented in Figures 4, 5 and 6.

Figure 4 - Sediment Removal for the Base Case Catchpit With No CFS

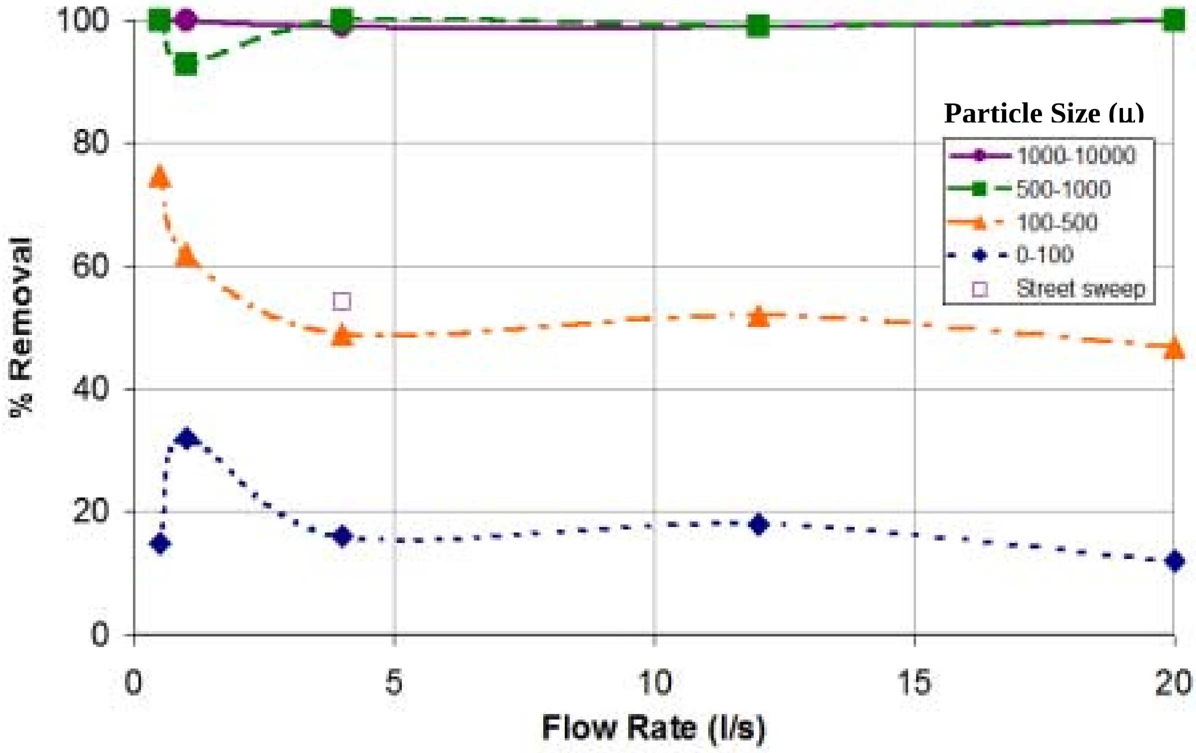


Figure 5 - Sediment Removal by the Catchpit Containing an Enviropod CFS with a 200 μm mesh

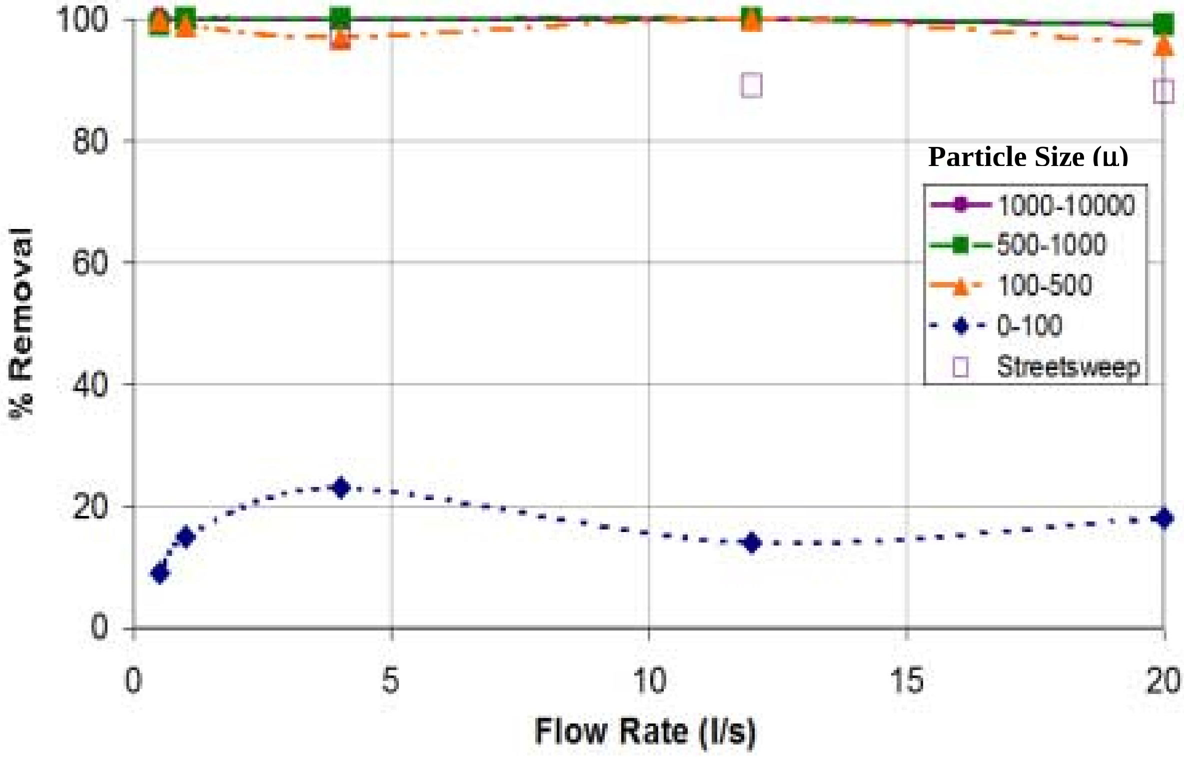


Figure 6 - Sediment Removal by the Catchpit Containing a Flogard CFS with a 400 μm mesh

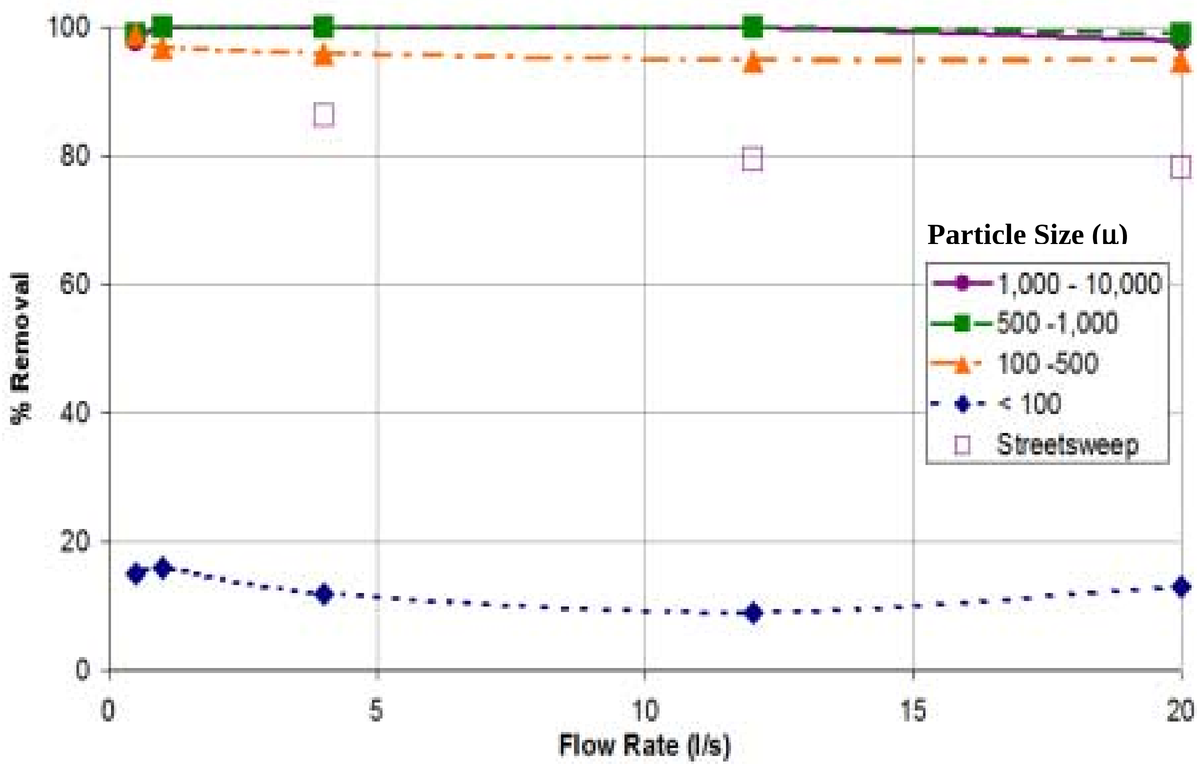


Figure 4 above shows the results in the standard catchpit without a CFS installed. Sediments larger than 500μ were completely removed for flows up to 20 l/s. The removal of 100-500μ particles decreases from 75% to 47% by increasing the flow from 0.5 l/s to 20 l/s, and only 18% of particles smaller than 100μ are trapped by the catchpit. Approximately 58% of the sediment collected from street sweepings were removed at 4 l/s.

Figures 5 and 6 show the laboratory performances of the Enviropod CFS and a Flogard CFS. The performance of both CFS was quite similar. The Enviropod CFS sediment removal efficiency was slightly greater than the Flogard for the finer sediment. These CFS remove essentially all the sediments >100μ, while the removal of sediments <100μ is similar to the standard catchpit with no CFS. The sediment removal efficiencies of the street sweep sediments at 4, 12 and 20 l/s are 97%, 89% and 88% respectively for the Envirpod CFS, and 86%, 79% and 78% respectively for the Flogard CFS. For the street sweep sediments the Enviropod CFS gave approximately 10% greater removal than the Flogard CFS due to more abundant fine sediments present in the street sweep sediments.

4 DISCUSSION

4.1 EFFECTIVENESS OF CATCHPITS

The laboratory results indicate that catchpits without CFS installed are effective at removing coarser sediments. Results show they have the potential to remove nearly 100 percent of sediments greater than 500 microns in size. Tests undertaken with road sediments collected from the Oakley Creek catchment demonstrated this related to a sediment capture efficiency of 58%. It would be expected that these efficiencies would reduce as greater volumes of sediment accumulate within the catchpit and washout of the sediment occurs due to disturbance under high flows. Similarly, efficiencies could be maintained with regular cleaning of the catchpits.

At present catchpits in Auckland City are cleaned three times per year. A more regular cleaning frequency or targeted cleaning of catchpits receiving high sediment loads may increase annual sediment capture volumes of existing catchpits. Alternatively, for new catchpits, changing the design of catchpits to increase sediment storage volume could increase sediment capture volumes. Clearly, the addition of CFS within catchpits provide a level of protection to accumulated sediments not provided in a standard catchpit.

4.2 ADDITIONAL BENEFIT OF CFS IN CATCHPITS

The test results show that CFS can increase sediment removal above that expected from a standard catchpit. The additional benefit of these devices is primarily in the 500-100 micron particle range. The increase in the percent removal efficiency by removing this particle range will vary depending on the constituents of the stormwater runoff. In the tests using street sediments from the Oakley Creek catchment, the addition of a CFS to the catchpit increased the overall sediment removal efficiency from 58% to almost 90%.

The removal of additional sediment may not be entirely due to sediment becoming trapped by the CFS filter material. Neither of the CFS tested had pore sizes as small as 100 microns yet both products still managed to remove particles below this size. Field trial observations found that the use of CFS resulted in less turbulence within the catchpit. The reduced turbulence may provide more favourable conditions for sedimentation and hence the removal of particles smaller than the filter bag perforations. Alternatively the particles may be adhering to the filter bag. As discussed above a valuable outcome of the installation of CFS would be the protection of accumulated sediment from washout during higher flows.

4.3 LABORATORY VS FIELD EFFICIENCY

It is worth noting that the above CFS sediment removal efficiencies are based on laboratory conditions. These are the sediment removal efficiencies from stormwater runoff that the CFS unit receives. In a field situation not all stormwater runoff is received by the CFS. This is due to many factors including

- Poor installation resulting in stormwater bypassing the CFS and entering the catchpit directly.
- High flows bypassing the filter bag via the engineered overflow.
- Reduced filter capacity due to filling with sediment, increasing the incidence of engineered overflow.

4.4 FINDINGS

- Modified catchpits or catchpits with CFS could be a practical and economical form of sediment capture in retrofit situations such as heavily built up urban areas.
- Existing standard catchpits are capable of high annual rates of sediment capture. Logically, the more frequently they are cleaned, the greater the annual volume of sediment capture.
- At the time of this study, some CFS products compromised the hydraulic capacity of the catchpit. Clearly, any CFS system must not in any way compromise the hydraulic design capacity of an existing catchpit.
- Most current off the shelf CFS units are designed to be gross pollutant traps and/or fuel oil traps which trap only the coarser sediment particles. It appeared that most CFS products would be able to be modified to focus on sediment capture.
- The field installation of CFS products needs to carefully specified and be well supervised, especially for new entrants to the CFS market.

5 ENVIRONMENTAL BENEFITS

There are many stormwater treatment systems that provide various single or combined levels of environmental benefit. These systems include coarse litter traps, fuel oil removal systems, chemical traps, nutrient removal systems, sediment traps and the like.

This study has focused on the sediment capture efficiency of CFS products. Test results have shown that an appropriately maintained standard catchpit can remove the majority of sediment down to 500 microns in size.

Test results show that with the addition of CFS, the majority of sediment down to 100 microns in size can be removed.

If the removal of particles greater than 500 micron provides an opportunity to halt degradation or improve the quality of the Auckland environment then a focus on standard catchpits would be a step in the right direction. If the requirements are to remove down to 100 microns then the addition of a suitable CFS would equally be a step in the right direction.

Identification of the relationship between sediment particle size removed and the volume of various pollutants removed has not been part of this study.

DISCLAIMER

The intent of this paper has not been to proclaim any particular CFS brand name or supplier as being “better” than another. The authors acknowledge that suppliers may have changed the character or form of CFS products since this study was carried out, and this paper should not be used as a basis for users to select one product over another.

REFERENCES

DLWC (1998) ‘The Constructed Wetlands Manual’ Department of Land and Water Conservation, New south Wales, Volume 2.

ABBREVIATIONS

CFS Catchpit Filter Systems
T&T Tonkin & Taylor Environmental & Engineering Consultants Ltd