PERFORMANCE TESTING OF A

LITTATRAP CATCH BASIN FILTER

Prepared by:

Joe Costa, B.Sc.

Senior Scientist

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Prepared for:

Mike Hannah

Managing Director

Stormwater360

7C Piermark Drive

Rosedale 0632, New Zealand

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Revision Table

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Approvals

Author(s) Review: I confirm that the information in this technical report is accurate, appropriately referenced, and scientifically sound

Joe Costa
Senior Scientist

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Date

Technical Review: I confirm that sufficient information and detail have been reported in this technical report, that it is scientifically sound, and that appropriate conclusions have been included.

De Wu Zhang
Research Scientist

Mar 08, 2018
Date

Stormwater360:

Mike Hannah
Managing Director

Date

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Abbreviations and Definitions

Abbreviation/Term	Definition
COV	Coefficient of Variation
ETV	Environmental Technology Verification Program
LOQ	Limit of Quantitation
NJDEP	New Jersey Department of Environmental Protection
PSD	Particle Size Distribution
SLR	Surface Loading Rate
SSC	Suspended Sediment Concentration

References

[1] GHL Report TR-JC20171025-01

[2] GHL Notebooks A019, pg. 88-89, 131-133 and 152-160; A018, pg. 1-46.

[3] Proposal PN 17-007

[4] Canadian Environmental Technology Verification Program (CETV) *Procedure for Laboratory Testing of Oil-Grit Separators*, June 6, 2014 – Version 3.0

[5] ASTM D3977-97 (2013), Standard Test Methods for Determining Sediment Concentration in Water Samples.

[6] ASTM D422-63, Standard Test Method for Particle-Size Analysis of Soils; Reapproved 2007.

[7] NJDEP 2013, *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device*; January 25, 2013.

[8] California Department of Transportation District 7 Litter Management Pilot Study, CALTRANS Document No. CT-SW-RT-00-013; June 26, 2000. http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-00-013.pdf

[9] WWW.envriopod.com

1. Introduction

The purpose of this study was to evaluate the performance of the LittaTrap™ catch basin insert. The insert was evaluated on three performance criteria: (i) Removal Efficiency testing to determine the amount of sediment that could be removed from stormwater run-off, (ii) Scour Testing to measure the amount of re-suspension and washout of previously captured sediment within the catch basin, and (iii) Gross Pollutant testing to measure the insert's ability to capture Gross Pollutant.

The Removal Efficiency and Scour tests were based on the Canadian Environmental Technology Verification Program (ETV) and the New Jersey Department of Environmental Protection (NJDEP) test protocols while the Gross Pollutant testing was based on a protocol currently under development by the Stormwater Equipment Manufacturers' Asscoaition (SWEMA). The SWEMA protocol is based on a series of studies conducted by the California Department of Transportation (CALTRANS) in the early 2000s.

2. Experimental

2.1 Sediment Removal Efficiency Test

The performance of the LittaTrap™ catch basin insert was assessed by determining the removal efficiency of suspended sediment in the influent water. The insert was tested both with and without a liner. The test apparatus consisted of a simulated catch basin that was constructed out of wood. The catch basin was 600 mm X 600 mm and was 1.8 m deep with a false floor installed 254 mm (10 inches) below the invert of the effluent pipe to simulate a catch basin that contained sediment. The catch basin is illustrated in Figure 1.

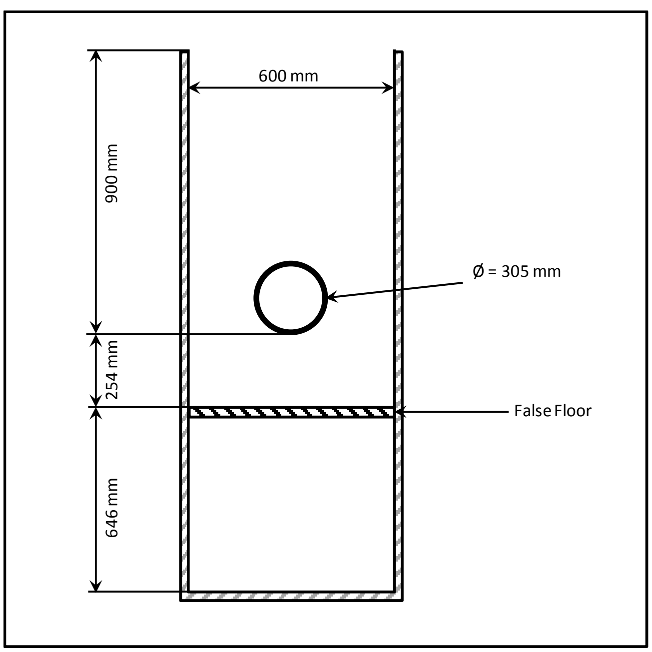
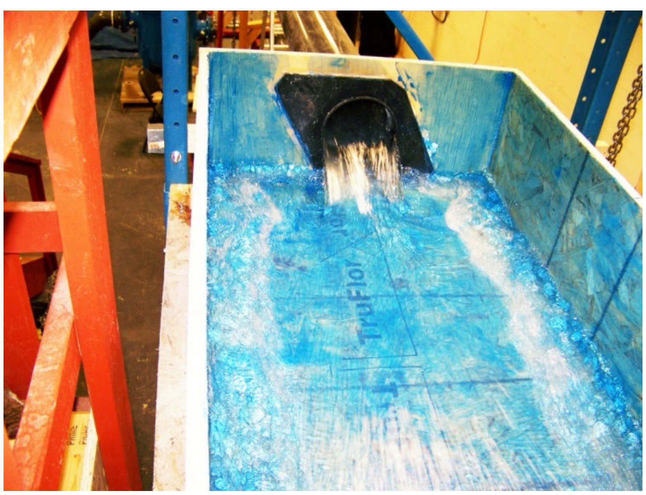


Figure 1: Simulated Catch Basin Dimensions

To simulate the sheet flow of water observed as stormwater runoff enters a catch basin, this study pumped water on to a simulated “streetscape”, a plywood sheet 2.4 m long and 0.6 m wide, that directed the water flow to the catch basin grate. The streetscape was sloped towards the catch basin with a 1.5% slope. The test sediment was dropped onto the streetscape by means of an auger feeder (Auger Feeders Model VF-1 volumetric screw feeder). The setup is illustrated in Figure 2. The streetscape was painted with a waterproofing resin to prevent water leaks. To ensure that any sediment added onto the streetscape flowed into the catch basin, the floor of the streetscape underneath the sediment addition point was lined with a smooth polyethylene sheet.

The sediment removal performance testing was based on a Technology Specific Test Plan (TSTP) that combined elements of the Canadian ETV and NJDEP test protocols. Water was introduced onto the catch basin with a target influent sediment concentration of 200 mg/L. Removal efficiency was determined by measuring the suspended sediment concentration (SSC) of the effluent and calculating the amount captured by the insert and catch basin. Testing was completed at four different target flow rates, 1, 4, 8 and 12 L/s. To better approximate the typical operating conditions, the LittaTrap™ was loaded to 20% capacity with gross solids (leaves) prior to starting the performance testing (Figure 3).



Inlet End of Streetscape

Catch Basin End of Streetscape

Figure 2: Catch Basin Streetscape

Figure 3: LittaTrap™ Pre-loaded with Leaves

Flow measurement was done using a mag-type flow meter and a MadgeTech Process 101A data logger. The data logger was configured to record a flow measurement once every 30 s. The duration of each test run was 15 minutes, with sampling occurring as specified in Table 1. For the 1 L/s run however, the run time was increased to 25 minutes to ensure a minimum of 3 detention times elapsed between the start of sediment addition and the taking of effluent grab samples. For the 1 L/s run, sampling occurred at 00:00, 06:00, 12:00, 18:00, 24:00 and 25:00 minutes. The average influent suspended sediment concentration for the run was determined using the amount of water that flowed through the catch basin during the test and the average sediment feed rate. The feed water for the test was filtered using a Fil-Trek model ELPA30-1012-8F-150 filter, where it passed through 0.5 µm (absolute) pleated bag filters to remove background particulate. Past experience with this system has shown that the background particulate concentration using this filtration system is typically below the SSC method limit of quantitation (LOQ) of 2.3 mg/L and therefore the contribution of SSC from the feed water was omitted for this study.

Replicate effluent grab samples were taken at the catch basin effluent pipe stub which drained freely into a receiving tank. When possible, the entire effluent flow stream was sampled, otherwise, the effluent sample was taken by sweeping a 1L wide-mouth jar through the entire effluent flow stream such that the sample jar was full after a single pass.

Table 1: Removal Efficiency Sampling Schedule

Run Time (min:sec)	Effluent Sample	Sediment Calibration Sample
00:00		X
05:00	X	X
08:00	X	X
11:00	X	X
14:00	X	X
15:00	END OF TESTING	

2.2 Scour Test

The objective of this test was to quantify and characterize the amount of previously captured sediment that was re-suspended and washed out during periods of high flow. Sediment scour and re-suspension was assessed at five separate SLRs, as specified in Table 2. Replicate effluent grab samples for the Scour Test were again taken at the catch basin effluent pipe stub; the sampling frequency is detailed in Table 3. As with the removal efficiency testing, no background water samples we taken.

Table 2: Scour Test Surface Loading Rates

Surface Loading Rate (LPS/m^2)	Test Flow Rate (LPS)	Run Time (Minutes)
3.3	1.2	5
13	4.8	5
23	8.4	5
33	12.0	5
43	15.6	5

Table 3: Scour Testing Effluent Sampling Frequency

Run Time (min.)												
0	**1**	**2**	**3**	**4**	**5**	**6**	**7***	**8**	**9**	**10**	**11**	**12**
Set Flow		X		X		X		X		X		X
13*	**14**	**15**	**16**	**17**	**18**	**19***	**20**	**21**	**22**	**23**	**24**	**25***
	X		X		X		X		X		X	
26	**27**	**28**	**29**	**30**								
X		X		X								

* Increase in system flow

In preparation for the scour testing, the false floor remained set at an elevation of 254 mm below the invert of the effluent pipe and the sump of the catch basin was pre-loaded with the same test sediment used for the Removal Efficiency testing. When levelled, the sediment formed a layer 102 mm thick (Figure 4). After sediment pre-loading, the catch basin was reassembled and filled with water. The water was added in such a way as to avoid disturbing the sediment bed. The test setup was allowed to sit for approximately 16 hours before commencing the Scour Test.

The ETV protocols allows for the test device to sit for up to 96 hours following the loading to allow for all the of the test sediment to settle before the test. Since this scour test was run only 16 hours after loading, some particles were still in suspension.

Figure 4: Sediment Pre-loading of Sump

To better approximate the typical operating conditions, the LittaTrap™ was loaded to 20% capacity with Gross Pollutant prior to starting the Scour test (Figure 5).

Figure 5: LittaTrap™ Scour Test Preload

2.3 Test Sediment

The test sediment used for Removal Efficiency and Scour testing was a silica blend supplied by AGSCO Corporation, lot # 040617. The sediment particle size distribution (PSD) was determined by GHL using the methodology of ASTM method D422-63 (2007) e1, *Standard Test Method for Particle-Size Analysis of Soils*. The test results are summarized in Table 4 and shown graphically in Figure 6.

Table 4: PSD of Silica Test Sediment

ETV Specification		LOT # 040617	Deviation from Specification	Allowed ETV Deviation
Particle Size, µm	% Passing	%Passing	% (absolute)	
1000	100	100	0	± 6%
500	95	95	0	
250	90	89	-1	
150	75	74	-1	
100	60	54	-6	
75	50	50	0	
50	45	41	-4	
20	35	29	-6	
8	20	15	-5	
5	10	10	-0	
2	5	4	-1	
d_{50}, um	75	75		

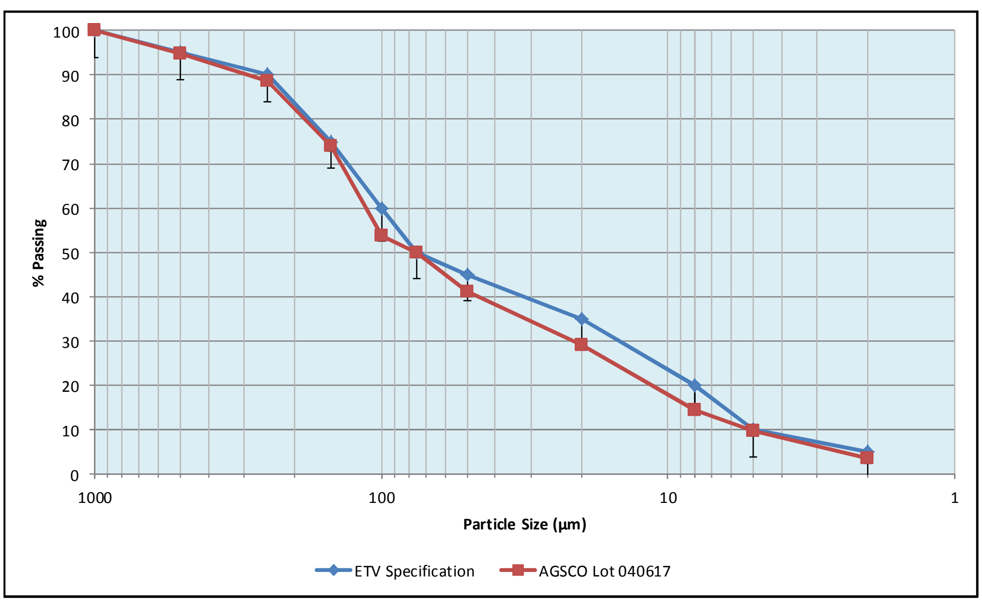


Figure 6: PSD of Silica Test Sediment

2.4 Gross Pollutant Test

This performance test assessed the LittaTrap's™ ability to remove gross pollutants from stormwater runoff and was based on work reported in the Caltrans document "*Laboratory Testing of Gross Solids Removal Devices*" - CTSW-RT-05-73-18.1. The composition of the Gross Pollutant used is summarized in

Table 5. The Gross Pollutant test was conducted at 3 flow rates, 5, 10 and 15 L/s. To better assesses the performance of the LittaTrap™, a control run was performed on the catch basin alone at 5 and 15 L/s.

For this test, 10 L (approximately 193 g) of gross solids were added at the target flow rate over a 5 minute period. This was completed manually by dropping a handful of solids onto the "Streetscape" and allowing the solids to be washed into the catch basin. To ensure that the Gross Pollutants were washed into the catch basin, the grate was removed from the opening (Figure 7). Following the Gross Pollutant addition, the grate was replaced and water was allowed to flow into the catch basin at the target flow rate for at least an additional 10 minutes. In the case of the 15 L/s run, the water flow rate was sustained for an additional 55 minutes following the solids addition.

For the control test, 256 g of solids was added to the catch basin over a 5 minute period. The grate was replaced on top of the catch basin and the water flow continued for an additional 10 minutes. The flow was then increased to 15 L/s and held for an additional 15 minutes (no further trash addition at the higher flow). Since it was observed that most of the solids had escaped from the catch basin, there was no need to maintain the flow any longer than 15 minutes.

Table 5: Gross Pollutant Composition

Component	Description	Dimensions	% by Mass
Cigarette Filter	OCB regular cigarette filters 9.15 g/100 filters Bulk density = 900 filters/1L	7 mm diameter x 15 mm	14
Newspaper	Standard news print sheet cut in strips	28 cm x 5 cm	17
Wood	Popsicle sticks	11 cm x 0.95 cm x 0.2 cm	11
Plastic-Moldable	10 oz. PETE plastic cup cut in strips	9 cm x 2.5 cm	23
Plastic-Film	Plastic shopping bag split in half and cut in strips	40 cm x 8 cm	8
Cardboard/Chipboard	Cardboard box cut in strips	23 cm x 2.5 cm	10
Cloth	Cotton linen fabric cut in strips	35 cm x 5 cm	6
Metal – Foil, Molded	Aluminum drink can cut in strips	10 cm x 2.5 cm	7
Styrofoam	Standard "S"-shaped peanut packing material	3 mm x 3.5 mm x 1.5 mm	4

Figure 7: Gross Pollutant Addition to Streetscape

3. Results & Discussion

3.1 Sediment Removal Efficiency

For each removal efficiency test run, the average influent sediment concentration was determined from the average sediment feed rate, determined from the five sediment feed calibration samples, and the average flow rate for the run. The water and sediment feed rates have been summarized in Table 6 and the calculated removal efficiencies in Table 7.

Removal efficiency was determined by comparing the average effluent concentration of the grab samples to the average influent sediment concentration during the run:

$$Removal\ Efficiency\ (\%) = \frac{SSC_I - SSC_E}{SSC_I} \times 100\%$$

where:

SSC_I = the average influent sediment concentration for the run

SSC_E = the average sediment concentration of the effluent grab samples

Table 6: Flow Rate and Sediment Concentration

Run Number	Average Sediment Feed Rate (g/min)	Average Run Flow Rate (L/s)	Influent Sediment Concentration (mg/L)
1	13.84	0.98	236.4
2	47.20	3.99	197.0
3	104.3	7.98	217.8
4	143.5	11.99	199.5

Table 7: LittaTrap™ Removal Efficiency

Run Number	Influent Sediment Concentration (mg/L)	Effluent Concentration (mg/L)	Removal Efficiency (%)
1	236.4	90.0	61.9
2	197.0	94.9	51.8
3	217.8	139.8	35.8
4	199.5	132.0	33.8

As expected, as flow rate increases the removal efficiency decreases. The LittaTrap™ performance is summarized in Figure 8. The data has been fitted with a logarithmic function to allow for comparison to competitors' products.

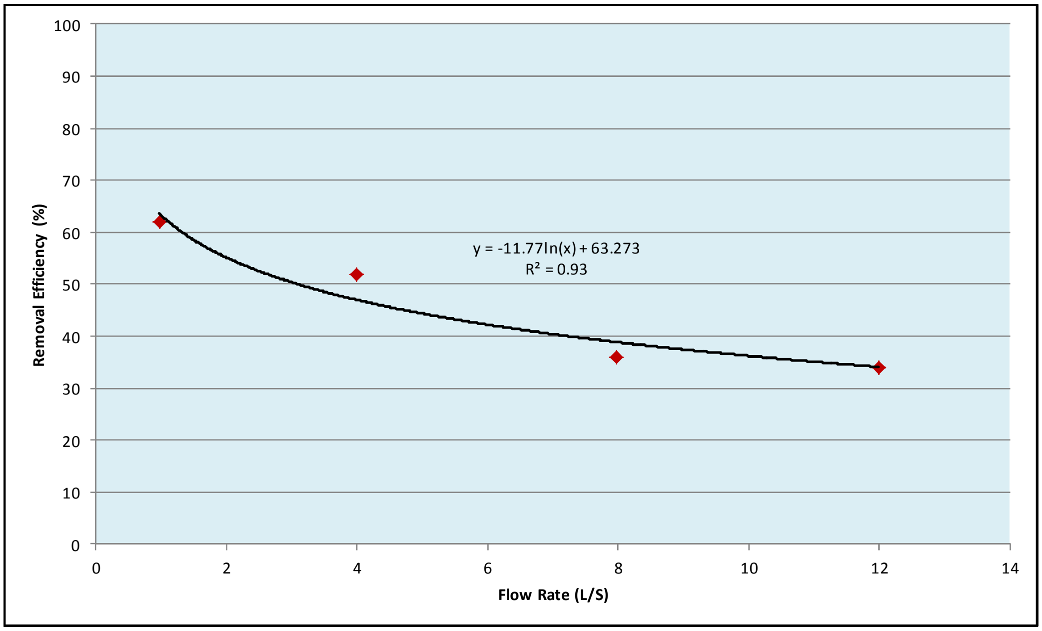


Figure 8: LittaTrap™ Removal Efficiency vs. Flow Rate

3.2 Scour Test

For the Scour test, a single pump was used for the first four flow rates, however for the final flow rate, a switch was made to a larger pump to be able to accommodate the higher flow. The change-over from one pump to the next was managed without stopping water flow to the system and was completed within 60 seconds. The flow rates for SLRs 1-4 were recorded using a data logger, while SLR # 5 was recorded manually, directly from the flow meter. For all runs the recording interval was 30 seconds. The flow data is summarized in Table 8.

Table 8: Scour Testing Water Flow Rates

Surface Loading Rate	Target Flow Rate	Flow (gpm)			COV
LPS/m^2	Lpm	Min	Max	Average	
3	1.2	1.19	1.22	1.20	0.009
13	4.8	4.78	4.88	4.80	0.005
23	8.4	8.35	8.44	8.39	0.003
33	12.0	11.84	12.01	11.96	0.004
43	15.6	15.17	15.99	15.55	0.017

The coefficient of variation (COV) for all SLRs was below 0.04, the specification for the ETV test protocol. The test results are summarized in Table 9. In cases where the SSC result was below the analytical method LOQ of 2.3 mg/L, a result of 2 mg/L was reported for calculation purposes.

Table 9: Scour Test Results

Target Flow Rate (L/S)	Sample Run Time (min)	Suspended Sediment Concentration (mg/L)	
		Effluent Sample	Cumulative Average
1.2	2	41.5	-
	4	4.9	23
	6	2*	16
4.8	8	7.2	14
	10	3.6	12
	12	2*	10
8.4	14	3.7	9.3
	16	5.7	8.8
	18	8.2	8.8
12.0	20	9.8	8.9
	22	3.4	8.4
	24	6.5	8.2
15.6	26	6.8	8.1
	28	4.9	7.9
	30	6.8	7.8

*Result < LOQ

The overall average SSC concentration for the scour test was 7.8 mg/L. Since the catch basin only sat for 16 hours following the sediment preload, it is possible that the average SSC result for the scour test could have been even lower if it sat for the full allowable 96 hours, particularly for the first sample taken at 2 minutes. It should be noted that since the suspended sediment concentration of the test influent water was not measured, the Scour test results are uncorrected for background concentration. Typically for a scour test the background SSC is subtracted from the effluent SSC value, so if anything these values are higher than actual.

Some regulatory agencies, the New Jersey Department of Environmental Protection (NJDEP) for example, have a maximum limit on average SSC of 20 mg/L for their scour test that involves a similar methodology.

3.3 Gross Pollutant Removal

The solids for the Gross Pollutant test were divided into four batches, one for each run (Figure 9). During the tests, any solids that escaped the catch basin were captured in a net, air-dried and weighed. The test results have been tabulated in Table 10 and Table 11.

Figure 9: Gross Pollutant Test Solids

Table 10: LittaTrap Gross Pollutant Test Results

Test Item	Flow Rate (LPS)	Mass of Escaped Solids (g)	Description of Escaped Solids	Estimated Gross Solids Capture Efficiency (%)
LittaTrap™	5	0.0275	Newspaper (fragments), fabric (fragments)	100 [1]
LittaTrap™	10	0.1546	Newspaper (fragments), fabric (fragments)	99.9 [1]
LittaTrap™	15 [2]	1.47	Styrofoam pieces, Newspaper (fragments)	99.2 [1]

[1] Based on an added mass of 193 g

[2] Flow held for 55 min. following the addition of solids

Table 11: Catch Basin (control) Gross Pollutant Test Results

Test Item	Flow Rate (LPS)	Mass of Escaped Solids (g)	Description of Escaped Solids	Estimated Gross Solids Capture Efficiency (%)
Catch Basin (Control)	5	221.99	All components	13.4 [1]
Catch Basin (Control)	15	234.97 [2]	Popsicle sticks, metal strips, plastic strips	8.3 [1]

[1] Based on an added mass of 256 g

[2] Includes the mas of escaped solids at 5 LPS (above)

A small volume of fragmented newspaper and fabric where observed to bypass through the LittaTrap™ basket during the 5 and 10 L/s test runs. These articles where smaller than the screen size of the trap and where a result of the paper and fabric strips breaking down during the test.

At 15 L/s the water level inside the LittaTrap™ basket was at the crest of the internal bypass, causing some bypass. During the 55 minute sustained flow some Styrofoam pieces where lost though the bypass channel. At the end of the test the LittaTrap™ was approximately 2/3 full of captured wet gross solids (Figure 11). It total, only 0.8% (mass basis) of the solids escaped the LittaTrap™ during the test at 15 L/s.

Figure 10: Escaped Solids – LittaTrap™ at 15 L/s

Figure 11: Retained Solids – LittaTrap™ at 15 L/s

For the Catch Basin, 87% of the solids escaped at 5 L/s and 92% escaped once the flow was increased to 15 L/s (Figure 12and Figure 13).

Figure 12: Escaped Solids – Control at 15 L/s

5 L/s **15 L/s**

Figure 13: Retained Solids – Control at 5 and 15 L/S

3.4 Experimental Design Errors

For this study, the catch basin, grating and streetscape were fabricated from plywood as it was impractical to use concrete in a laboratory setting. To prevent leaks and stop the wood from absorbing water, surfaces were painted with a rubberized coating. It was discovered that from the continual lifting and dropping of the grate on the catch basin, some of the coating was removed and showed up in the effluent in the form of small fibers. A micrograph of some of the larger fibers is shown in Figure 14.

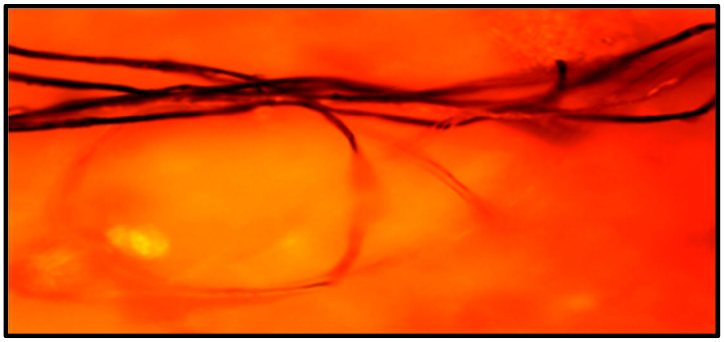


Figure 14: Rubber Coating Fibers

To estimate the impact these fibers had on the data, the fibers were removed from one of the recovered sediment sample dishes and the sample was reweighed. The mass of the fibers was found to be only 0.2 mg. Therefore, it is unlikely that the presence of the fibers had a significant impact on the results. In any future testing, the grating, and any surface it sits on at the top of the catch basin, should be replaced or lined with PVC, polyethylene or other similar material.