NJCAT TECHNOLOGY VERIFICATION

StormTrap StormSettler® Hydrodynamic Separator

StormTrap LLC

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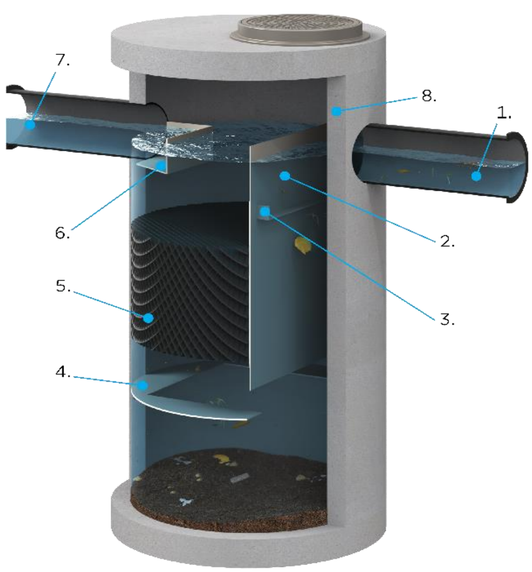
1. Description of Technology

The StormSettler® is a patent pending manufactured treatment device, specifically a hydrodynamic separator (HDS), developed by StormTrap. The StormSettler is designed to remove sediment from runoff using inclined tube settling technology. An inclined tube settler enhances settling by providing many small channels that reduce the settling distance, and therefore the settling time required for a particle to be captured. The settling pack in each StormSettler model occupies 75% of the cross-sectional area of the separator, while the dimensions of the settling tubes remain constant. The number of settling tubes and the settling area of the settling pack scales linearly with pack area, ensuring identical settling times in all models. If floatables capture is required, the system can be fitted with a net or basket in consultation with StormTrap. This configuration was not tested; hence, no performance claim is made.

In addition to the inclined tube settler, also called an enhanced settling pack, the StormSettler employs several flow modifiers to control the flow and optimize performance. The flow modifiers were designed using computational fluid dynamics (CFD) to create an optimal flow distribution that increases removal while decreasing scour potential. The internal components are typically fabricated using plastic parts however in some applications the components may be metal. StormSettler is typically housed within a concrete structure.

Figure 1 shows the StormSettler in a low flow condition and **Figure 2** shows the StormSettler in a high flow condition (See also **Figure 3**). The view is reversed from **Figure 1** to **Figure 2** to show the internal components more clearly.



1. Inlet
2. Vertical baffle
3. Vortex disruptor
4. Flow modifiers
5. Enhanced Settling pack
6. Outlet control diverter
7. Outlet
8. Tank wall

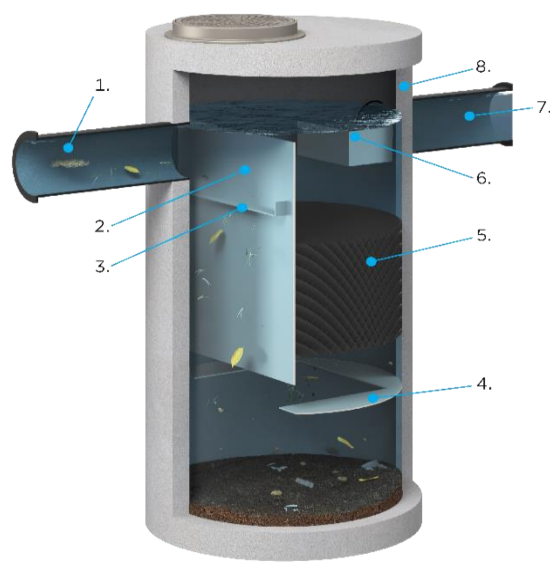


Figure 1 StormSettler Low Flow Operation

Figure 2 StormSettler High Flow Operation

During normal operations, where the vertical baffle forces all the flow under it, stormwater enters the inlet side of the StormSettler HDS through an inlet pipe (1), where it is immediately directed downward by the vertical baffle (2). A vortex disruptor (3) on the baffle helps prevent high velocity vortices on the inlet side. Water then flows under the vertical baffle where additional flow modifiers (4) help distribute the flow more evenly in the outlet chamber prior to the flow entering the enhanced settling pack (5).

The enhanced settling pack (5) consists of a large number of narrow channels which provide an effective settling area much greater than the system footprint. Upon exiting the enhanced settling device, the water is directed through an outlet diverter (6) to prevent any short circuiting and then to the outlet pipe (7).

During high flow events the vertical baffle acts as an internal bypass. All excess flow is directed over the baffle and the top of the outlet diverter. The remaining flow follows the low flow path and is fully treated. The internals are affixed to the tank wall (8). Maintenance is performed by accessing the tank floor from the inlet side.

Figure 3 shows the elevations of the various components in a 4' unit, which was the size tested.

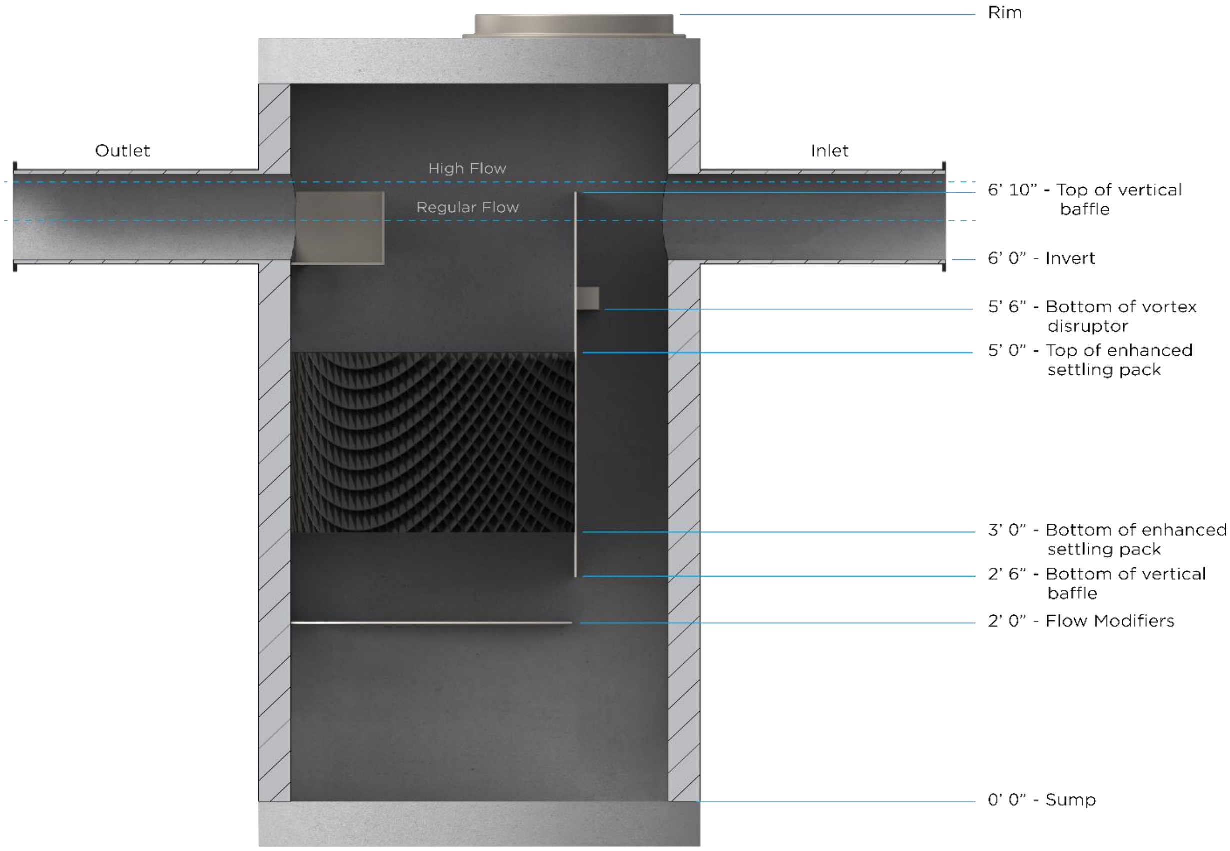


Figure 3 4-Foot System with Component Elevations

2. Laboratory Testing

The test program was conducted by Good Harbour Laboratories, an independent water technology testing lab, at their site in Mississauga, Ontario, Canada. The StormSettler was evaluated for sediment removal efficiency and scour in accordance with *the New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 1, 2021).* Prior to starting the performance testing program, a quality assurance project plan (QAPP) was submitted to and approved by the New Jersey Corporation for Advanced Technology (NJCAT).

The device tested was a prototype of a commercially available 4-foot diameter StormSettler unit consisting of internal components housed in a metal manhole prototype. In commercial systems, the internal components are typically housed in a concrete manhole. The metal prototype of the test unit was equivalent to commercial concrete manholes in all key dimensions. The use of a metal prototype was proposed due to the difficulties associated with transporting and physically supporting the weight of a concrete unit. Using metal in lieu of concrete did not have any impact on system performance. The test unit was equipped with a 24-inch diameter access port with an invert 12 inches above the floor to access the sump to allow for easy recovery of captured sediment. The port contained a plug to maintain a smooth inner wall. The prototype utilized in testing is in conformance with the test protocol.

The laboratory test set-up was a water flow loop, capable of moving water at a rate of up to 3 cfs. The test loop, illustrated in **Figure 4**, is comprised of a series of water reservoirs, pumps, sediment filter, receiving tank and flow meters.

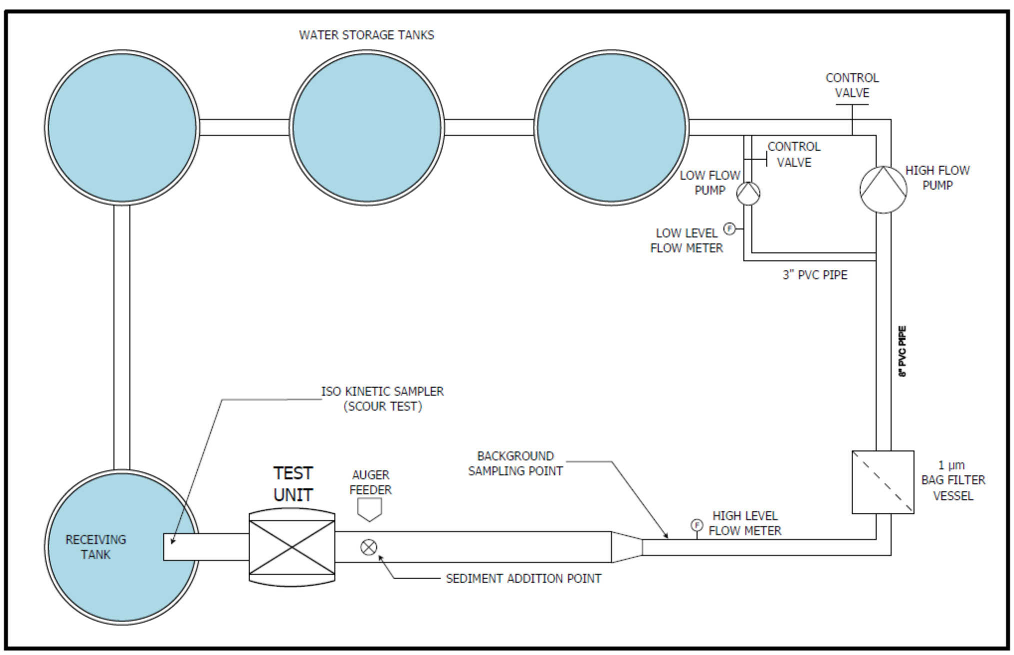


Figure 4 Laboratory Test Setup

2.1 Test Setup

The treatment device tested was a full-scale StormSettler unit (StormSettler-4); dimensional details are provided in **Table 1**. Both the inlet and outlet pipes were 12" in diameter. This unit had a total sump area of 12.6 ft^2 and a ***target*** maximum treatment flow rate (MTFR) of 1.15 cfs (516 gpm). For the sake of consistency with other reports the Effective Treatment Area is the cross-sectional area of the system.

Table 1 StormSettler-4 Dimensions

MTFR (target)		Diameter (ft)	Sump Area (ft^2)	Sediment Storage (ft^3)	Maximum Sediment Storage Depth (in)	Effective Treatment Area (ft^2)	Target Loading Rate (gpm/ft^2)
(cfs)	(gpm)						
1.15	516	4	12.6	14.7	14	12.6	40.9

Water Flow and Measurement

From the water supply tanks, water was pumped using either a WEG Model FC00312 (1 - 200 gpm) or an Armstrong Model 8X8X10 4380 (100 – 1300 gpm) centrifugal pump. Flow measurement was done using either a 3" Toshiba Model GF630 electromagnetic type flow meter with an accuracy of ± 0.2% of reading (1 - 200 gpm) or a MJK Magflux Type 7200 flow meter Model 297237 with an accuracy of ± 0.25% of reading (100 - 1300 gpm). All flow meters were installed away from flow disturbances in accordance with the manufacturer's recommendation. The data logger used was a MadgeTech Process 101A data logger, configured to record a flow measurement once every 30 seconds.

The water in the flow loop was circulated through a filter housing containing high-efficiency pleated bag filters with 0.5 µm or 1.0 µm absolute rating for removal efficiency testing and 1 µm nominal rating for scour testing. The influent pipe was 12 inches in diameter, 84 inches long and installed with a 1% slope. Sediment addition was done through a port on the crown of the influent pipe, 24 inches upstream of the StormSettler. The sediment feeder was an Auger Feeders Model VF-1 volumetric screw feeder with vibratory hopper. The feeder had a 10-gallon hopper above the auger screw to provide a constant supply of sediment.

Water flow exited the StormSettler through a 47-inch length of effluent pipe, 12-inch diameter, also installed with a 1% slope, and terminated with a free-fall into the receiving tank to complete the flow loop.

Sample Collection

Background water samples were taken by grab sampling. A 1L, wide-mouth, sample jar was filled using a ¾-inch, full-port (**Figure 5**), sampling ball valve located downstream of the sediment bag filter and upstream of the sediment addition point.

Removal efficiency was determined by mass recovery; no effluent samples were collected for removal efficiency analysis. Both the sediment mass recovered in the manufactured treatment device (MTD) and the inlet pipe were quantified and reported separately.

For the scour test, effluent samples were taken by hand. The effluent pipe drained freely into the receiving tank. The end of the effluent pipe was fitted with a 3-tube isokinetic sampler **(Figure 6**) and the effluent sample was taken at that point. The sampling technique was to hold a 1 L wide-mouth jar underneath the stream of effluent flow from the isokinetic sampler such that all three tubes drained completely into the jar.

Duplicate samples were collected for background and scour effluent samples. The primary set was analyzed and reported while the second set was held under refrigerated conditions in case there was a need for investigation of any aberrant results. The duplicate samples were not used.

Figure 5 Background Sampling Point

Figure 6 Scour Effluent Sampling Point

Sediment calibration samples were taken at the end of the auger feeder's spout attachment (**Figure 7**) by holding a 500 mL jar just under the opening. The test sediment was sampled six times per run to confirm the sediment feed rate. Each sediment feed rate sample was collected over an interval timed to the nearest second. Samples were weighed to the nearest 0.01 g.

Figure 7 Sediment Auger Feeder

Other Instrumentation and Measurement

Water temperature was measured and recorded using a MadgeTech MicroTemp data logger that was suspended inside the StormSettler next to the inlet pipe. The MicroTemp was configured to take a temperature reading once every minute.

Run and sampling times were measured using a NIST traceable stopwatch, Control Company Model 62379-460.

The sediment feed samples that were taken during the run were collected in 500 mL jars and weighed on a top loading balance (Mettler Toledo, PB 4002-S/FACT) with a precision of 0.01 g.

The sediment that was added to the auger feeder, and the sediment recovered following each run, was weighed on an industrial balance (Mettler Toledo, BBA 231-3BB35A/S) with a precision of 5 grams.

2.2 Test Sediment

Removal Efficiency Test Sediment

The test sediment used for the removal efficiency study (1-1000 µm) was a custom blend of commercially available silica sediments blended by GHL. This particular batch was GHL lot # A031-119. The blend ratio was determined such that the particle size distribution (PSD) of the resulting blended sediment would meet the specification for the test protocol. The sediment was sampled in multiple locations throughout the blending process; three composite samples were created for PSD analysis. The final blended sediment was stored in 12 sealed buckets until needed.

Each of the three composite samples was reduced in size using a riffle splitter. The three samples were analyzed for PSD by a qualified 3rd party analytical laboratory (Bureau Veritas in Mississauga) in accordance with ASTM D6913-17, “Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis” and ASTM D7928-17 “Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis”. The moisture content of the test sediment was determined using the test method in the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act, as required by Ontario Regulation 153/04. It differs from ASTM Method D2216-19, “Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass”, only in that the drying temperature is 105 ^{o}C instead of 110 ±5^{o}C. The test results are summarized in **Table 2** and shown graphically in **Figure 8.**

Table 2 Particle Size Distribution of 1- 1000 µm Test Sediment

Particle Size (µm)	Test Sediment Particle size (%passing)◊				NJDEP Specification (minimum % passing)*
	Sample 1	Sample 2	Sample 3	Average	
1000	100	100	100	100	100
500	96	96	96	96	95
250	89	89	90	89	90
150	79	79	81	80	75
100	58	58	63	60	60
75	51	53	59	54	50
50	45	45	47	46	45
20	39	39	39	39	35
8	28	25	27	27	20
5	22	20	22	21	10
2	11	12	11	11	5

◊Where required, particle size data has been interpolated to allow for comparison to the required particle size specification.

*A measured value may be lower than a target minimum % less than value by up to two percentage points, (e.g., at least 3% of the particles must be less than 2 microns in size [target is 5%]), provided the measured d50 value does not exceed 75 microns for TSS test removal efficiency PSD.

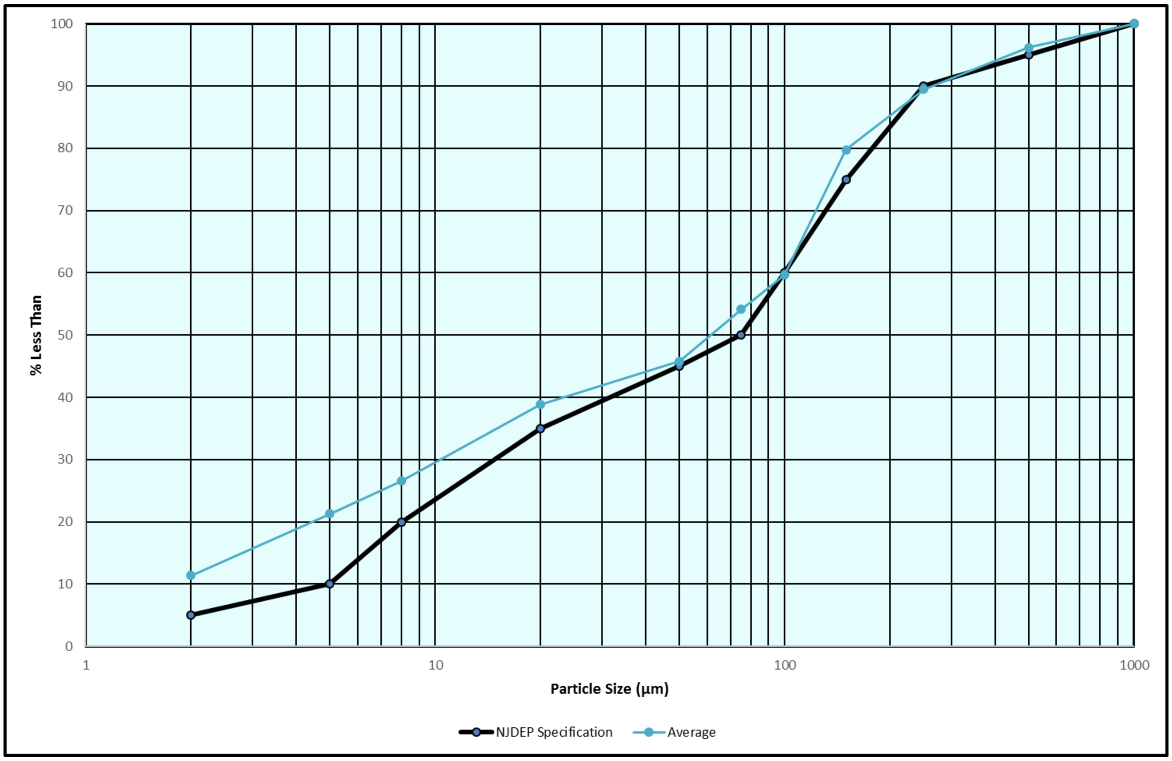


Figure 8 Average Particle Size Distribution of 1-1000 µm Test Sediment

In addition to particle size distribution, Bureau Veritas also performed a moisture analysis of the test sediment and determined the water content to be < 0.30%, the method detection limit. This amount of moisture is not considered significant and therefore no correction for the amount of moisture in the sediment mass was made.

The blended test sediment was found to meet the NJDEP particle size specification and was acceptable for use. With a median (d_{50}) of 65µm, the test sediment was finer than the sediment required by the NJDEP test protocol.

Scour Test Sediment

The test sediment used for the scour study was also a custom blend of commercially available silica sediments blended by GHL. This particular batch was GHL lot # A034-081. The blend ratio was determined such that the particle size distribution of the resulting blended sediment would meet the specification for the test protocol. The blended scour test sediment was stored in 9 five-gallon buckets. Three separate composite samples were created by sampling all of the five-gallon buckets used to load the StormSettler for the scour test. Each bucket was sampled in three locations: top third, middle third and bottom third. The composite samples were well blended and reduced in size using a sediment riffle splitter.

The three samples were analyzed for PSD by a qualified 3rd party analytical laboratory (GeoTesting Express in Massachusetts) in accordance with ASTM D6913-17, "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis" and ASTM

D7928-17 “Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis”. The moisture content of the test sediment was also determined in accordance with ASTM Method D2216-19, “Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.” The test results are summarized in

Table 3 and shown graphically in **Figure 9**. The scour test sediment was finer than the sediment required by the NJDEP test protocol and therefore was acceptable for use. The moisture content was reported as 0.0%.

Table 3 Particle Size Distribution of Scour Test Sediment

Particle Size (μm)	Test Sediment Particle size (%passing) ◊				NJDEP Specification (minimum % Passing)*
	Sample 1	Sample 2	Sample 3	Average	
1000	100	100	100	100	100
500	93	94	94	94	90
250	57	61	58	59	55
150	44	48	45	46	40
100	25	29	23	26	25
75	8	11	5	8	10

◊Where required, particle size data has been interpolated to allow for comparison to the required particle size specification.

*A measured value may be lower than a target minimum % less than value by up to two percentage points, (e.g., at least 8% of the particles must be less than 75 microns in size [target is 10%]).

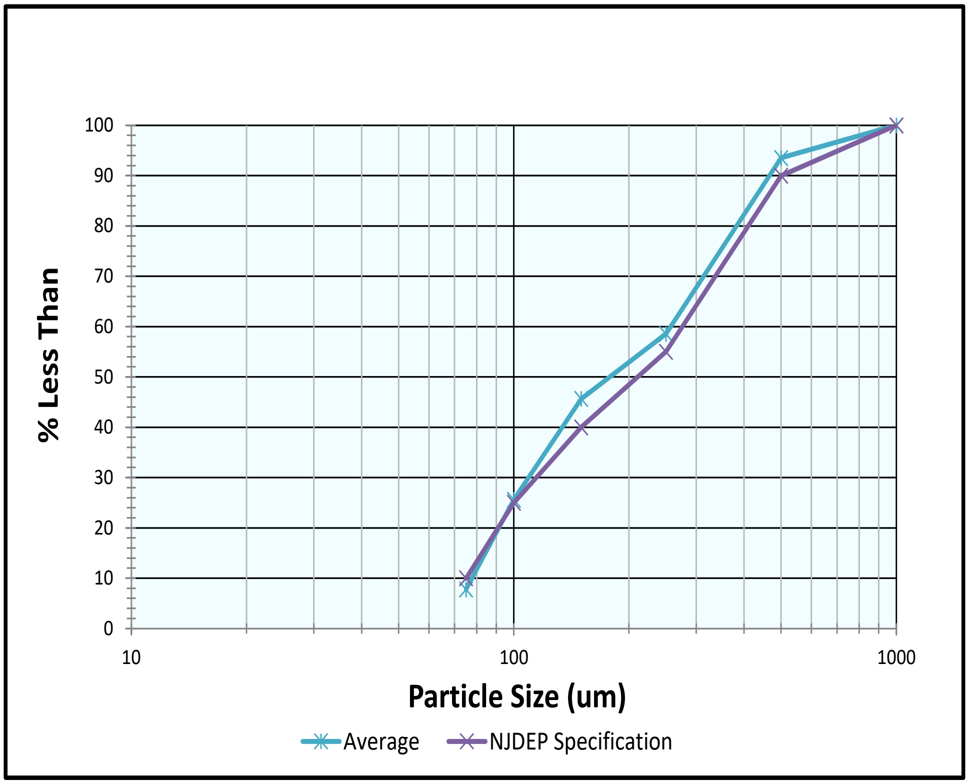


Figure 9 Average Particle Size Distribution of Scour Test Sediment

2.3 Hydraulic Testing

Prior to the start of testing with sediment, water flow and the corresponding water levels in the inlet and outlet pipes were measured and recorded to establish the head loss across the device, in accordance with Section 4.B.6 of the NJDEP Laboratory Protocol for Hydrodynamic Sedimentation MTDs. The head loss measurements were taken approximately one pipe-diameter upstream and downstream of the test unit. The measurements covered the span of 10% to 200% of the target MTFR and included the point when bypass occurred. The false floor was installed at the 50% level for the hydraulic test. Testing results are given in section 4.3.

2.4 Removal Efficiency Testing

Removal efficiency testing was conducted in accordance with Section 4 of the NJDEP Laboratory Protocol for Hydrodynamic Sedimentation MTDs. Testing was completed at flow rates of 10%, 25%, 50%, 75%, 100%, 125% and 150% of the target MTFR (0.12 cfs - 1.73 cfs) and at a target influent sediment concentration of 200 mg/L. A false floor was installed at an elevation of 7 inches in the sump, equivalent to 50% of the maximum sediment storage depth.

The test sediment was sampled 6 times per run, using 500 mL jars, to confirm the sediment feed rate. Each sediment feed rate sample was a minimum of 100 mL, or the amount collected over a 1-minute period, whichever came first.

Each run continued until at least 25 lbs of sediment had been added to the MTD. Eight background water samples were taken at evenly-spaced intervals during each test run.

At the end of each run, water flow continued for one detention time after sediment feed was stopped to allow for sediment that would not normally be captured to pass through the MTD. The sediment added during a run was determined by weighing the hopper feed sediment before and after each run and correcting for the six feed sediment calibration samples that were taken.

At the end of the test program the results were fit to a curve, in accordance with the NJDEP HDS protocol, and the result determined that the MTFR is 1.41 cfs. With an MTFR at 1.41 cfs, then the 125% flow rate, which is the highest flow used in the net annual removal calculation, would be 1.76 cfs. The implications of this were discussed with Dr. Richard Magee and the following decision was reached: Since the original test program only went to 1.73 cfs, it was necessary to do an additional run at or greater than 1.76 cfs in order that none of the data in the net annual removal calculations was extrapolated. This 8th run was completed at 1.76 cfs and included with the previous data.

2.5 Scour Testing

Prior to the start of testing, sediment was loaded into the sump of the StormSettler and leveled at a depth of 4 inches above the false floor, for a total depth of 7 inches. The final height of the sediment was at an elevation equivalent to 50% of the maximum sediment storage capacity of the MTD. After loading of the sediment, the unit was gradually filled with clear water, so as not to disturb the sediment, to the invert of the inlet pipe. The filled unit was allowed to sit for approximately 95 hours before starting the scour test.

When the removal efficiency testing indicated that an MTFR of 1.41 cfs could be claimed, the scour test was repeated with a target flow rate of 2.83 cfs (1270 gpm), a little more than 200% of the selected MTFR. During the scour test, the water flow rate was recorded once every 30 seconds and the temperature was recorded once every minute. Testing commenced by gradually increasing the water flow into the system until the target flow rate was achieved (within 3 minutes of commencing the test). Background and effluent sampling began 1 minute after starting the flow. An effluent grab sample was taken once every two minutes, until a total of 15 effluent samples were taken. The first effluent sample, at t = 1 min, was taken by sweeping a jar through the effluent flow because the isokinetic sampler tubes were not yet flowing full. All subsequent samples were taken from the isokinetic sampling tubes. A total of eight background water samples were collected (taken with every odd-numbered effluent sample).

It should be noted that the initial scour test was conducted at a target flow rate of 2.3 cfs (1030 gpm). A second scour test was conducted at a target flow rate of 2.80 cfs (1257 gpm). The system passed both the scour tests, but the results are not reported since they were superseded by the higher flow test reported here.

2.6 Laboratory Proficiency Testing

Prior to the start of testing, six spiked blind Total Suspended Solids (SSC) samples, three at a concentration of around 20 mg/L and the other three at a concentration of around 50 mg/L were prepared by GHL using the same test sediment as for the removal performance testing. These samples were submitted to OSHTECH Inc, an ISO 17025 accredited laboratory in Etobicoke, Ontario. Samples were analyzed by OSHTECH for sediment concentration (SSC) in accordance with ASTM Method D 3977-97 “Standard Test Methods for Determining Sediment

Concentrations in Water Samples". The results of the proficiency testing are summarized in **Table 4** below.

Table 4 Laboratory Proficiency Testing Results

Sample ID	Sample Concentration (mg/L)	Reported SSC (mg/L)	% Recovery
Control #1	20.6	18.6	90.3
Control #4	22.7	21.5	94.7
Control #5	21.3	20.2	94.8
		Average	**93.3**
Control #2	52.4	47.9	91.4
Control #3	50.0	49.3	98.6
Control #6	49.4	46.3	93.7
		Average	**94.6**

The average recovery percentage of the spiked SSC samples was 93.3% at 20 mg/L and 94.6% at 50 mg/L, meeting the requirement of 85 – 115%. The lab, OSHTECH Laboratory, passed the Laboratory Proficiency Testing for SSC analysis.

3. Performance Claims

Per the NJDEP verification procedure, the following are the performance claims made by StormTrap LLC and/or established via the laboratory testing conducted for the StormSettler Hydrodynamic Separator.

Total Suspended Solids (TSS) Removal Rate

The TSS removal rate of the StormSettler was calculated using the annualized weighted method required by the NJDEP mass capture HDS MTD protocol. Based on a MTFR of 1.41 cfs (633 gpm), the StormSettler achieved an annualized weighted TSS removal rate of 50.4%.

Maximum Treatment Flow Rate (MTFR)

The tested StormSettler unit had a surface area of 12.6 ft^2 and a maximum treatment flow rate (MTFR) of 1.41 cfs (633 gpm). This equates to a hydraulic loading rate of 50.2 gpm/ft^2.

Maximum Sediment Storage Depth and Volume

The maximum sediment storage depth is 14 inches which equates to 14.7 ft^3 of sediment storage volume.

Effective Treatment/Sedimentation Area

The effective treatment area and effective sedimentation area are 12.6 ft^2.

Detention Time and Wet Volume

The detention time at 100% MTFR of the test unit is 61 seconds. The wet volume of the test unit was 86 ft^3, calculated based on the water level at 100% MTFR.

Online Installation

Based on the laboratory scour testing, the StormSettler qualifies for online installation.

4. Supporting Documentation

The NJDEP Procedure (NJDEP, 2021) for obtaining verification of a stormwater manufactured treatment device (MTD) from the New Jersey Corporation for Advanced Technology (NJCAT) requires that "copies of the laboratory test reports, including all collected and measured data; all data from performance evaluation test runs; spreadsheets containing original data from all performance test runs; all pertinent calculations; etc." be included in this section. This was discussed with NJDEP, and it was agreed that as long as such documentation could be made available by NJCAT upon request that it would not be prudent or necessary to include all this information in this verification report. All supporting documentation will be retained securely by GHL to be provided to NJCAT or NJDEP upon request.

4.1 Removal Efficiency Testing

A total of 7 removal efficiency test runs were completed in accordance with the NJDEP HDS protocol. The target flow rate ranged from 10 - 150% of the target MTFR and the target influent sediment concentration was 200 mg/L. A false floor was set at 7”, which is 50% of the storage depth. The results from all 7 runs were used to calculate the overall removal efficiency of the StormSettler. Sediment removal efficiencies were plotted vs. flow rate to generate a removal efficiency curve from which the MTFR was selected, and an annual weighted removal efficiency was calculated.

The total water volume and average flow rate per run were calculated from the data collected by the flow data logger, one reading every 30 seconds. The average influent sediment concentration for each test flow was determined by mass balance. The amount of sediment fed into the auger feeder during dosing, and the amount remaining at the end of a run, was used to determine the amount of sediment fed during a run. The sediment mass was corrected for the mass of the six feed rate samples taken during the run. The mass of the sediment fed was divided by the volume of water that flowed through the MTD during dosing to determine the average influent sediment concentration for each run.

Six feed rate samples were collected at evenly spaced intervals during the run to ensure the rate was stable. The COV of the samples had to be ≤ 0.10 per the NJDEP protocol.

Following each run, the captured sediment in the StormSettler was allowed to settle overnight before draining. Once drained, all of the captured sediment was removed from the unit’s sump. The sediment that was retained in the inlet pipe was collected separately from the sediment collected in the sump. Any trace amount of sediment that was left behind was flushed with water and suctioned with a wet/dry vacuum. The contents of the vacuum were transferred to a 100 L container and allowed to settle for at least 2 hours before decanting the water. The settled sediment in the container was collected and added to the sediment collected from the sump. All collected sediment was placed in glass trays and dried in a convection oven, that was set to 110 ^{0}C, until a constant weight was obtained when cooled to room temperature, as determined by two successive measurements taken no less than two hours apart which show no more than a 0.1% difference in measured mass weighed to a precision of 10 grams. Any sediment that was recovered from the inlet pipe was dried and weighed separately from the sediment that was recovered from the unit’s sump. There was no sediment accumulation in the effluent pipe for any of the seven runs.

The data collected for each sediment removal efficiency run is presented below:

10% MTFR

Table 5 Sampling Schedule - 10% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	Background
0.0	1	1
44.3		2
62.0	2	
88.6		3
124.0	3	
132.9		4
177.1		5
186.0	4	
221.4		6
248.0	5	
265.7		7
310.0	6	8
320.0	End of Testing	
MTD Detention Time = 9.9 minutes Sediment Sampling Time = 1 minute		

Table 6 Water Flow and Temperature - 10% MTFR

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	51.5	51.5	0.1%	0.005	68.5
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

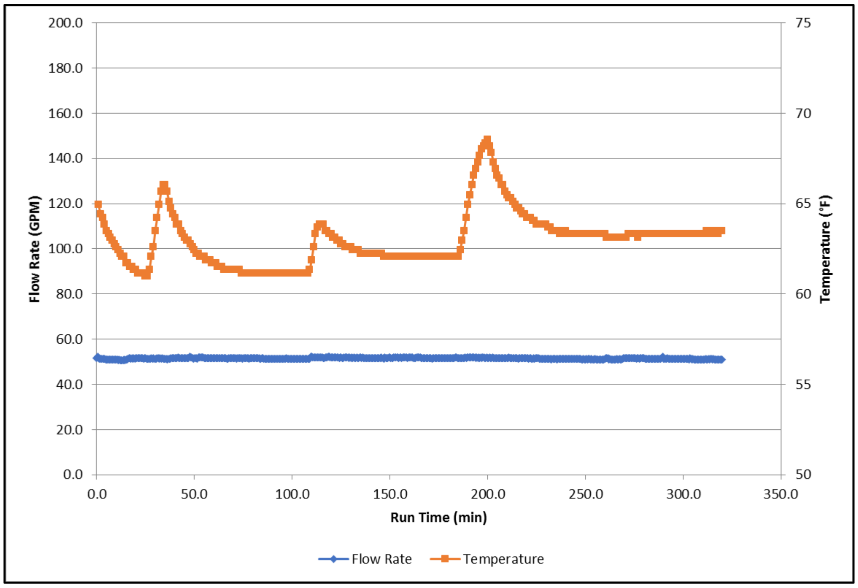


Figure 10 Water Flow and Temperature - 10% MTFR

*Temperature fluctuations are due to GHL filling the reservoir tanks.

Table 7 Sediment Feed Rate Summary – 10% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	40.03	Starting Weight of Sediment (lbs.)	72.54
2	38.99		
3	37.28	Recovered Weight of Sediment (lbs.)	45.45
4	39.02		
5	39.28	Mass of Sediment Used (lbs.)	27.09
6	38.39	Volume of Water Through MTD During Dosing (gal)	15,716
Average	38.83		
COV	0.024	Average Influent Sediment Concentration (mg/L)	202.7*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 8 Background SSC - 10% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	3.1	1.4	1.1	2.2	3.1	2.8	3.7	3.3	≤ 20 mg/L PASS

25% MTFR

Table 9 Sampling Schedule - 25% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	Background
0.0	1	1
17.9		2
25.1	2	
35.9		3
50.2	3	
53.8		4
71.7		5
75.3	4	
89.6		6
100.4	5	
107.6		7
125.5	6	8
129.5	End of Testing	
MTD Detention Time = 4.0 minutes Sediment Sampling Time = 1 minute		

Table 10 Water Flow and Temperature - 25% MTFR

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	128.8	130.4	1.2%	0.012	66.7
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

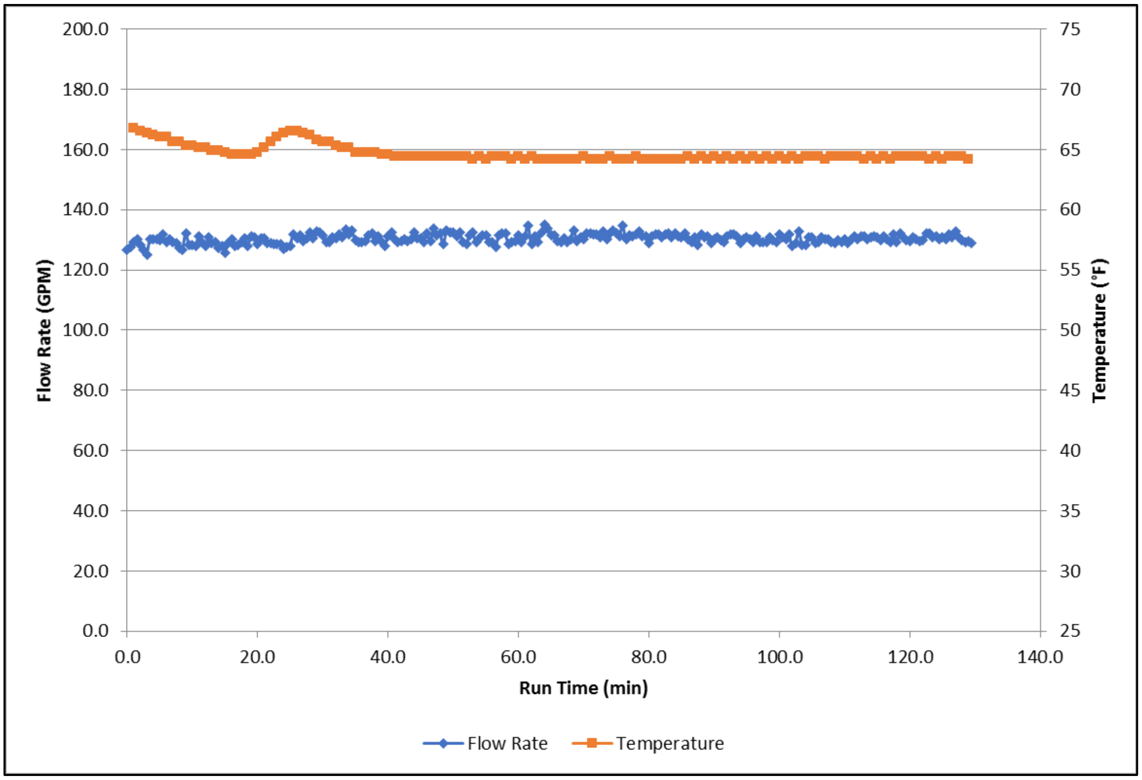


Figure 11 Water Flow and Temperature - 25% MTFR

Table 11 Sediment Feed Rate Summary – 25% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	103.73	Starting Weight of Sediment (lbs.)	73.03
2	103.78		
3	103.89	Recovered Weight of Sediment (lbs.)	43.24
4	109.84		
5	108.67	Mass of Sediment Used (lbs.)	29.78
6	102.14	Volume of Water Through MTD During Dosing (gal)	15,715
Average	105.34		
COV	0.030	Average Influent Sediment Concentration (mg/L)	216.5*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 12 Background SSC - 25% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	1.3	1.2	1.1	ND	2.5	1.7	2.4	1.9	≤ 20 mg/L PASS

ND = below method detection limit of 1.0 mg/L

50% MTFR

Table 13 Sampling Schedule - 50% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
9.4		2
13.1	2	
18.7		3
26.2	3	
28.1		4
37.4		5
39.3	4	
46.8		6
52.4	5	
56.1		7
65.5	6	8
67.5	End of Testing	
MTD Detention Time = 2.0 minutes Sediment Sampling Time = 1 minute		

Table 14 Water Flow and Temperature - 50% MTFR

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	257.5	256.9	-0.2%	0.008	65.7
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

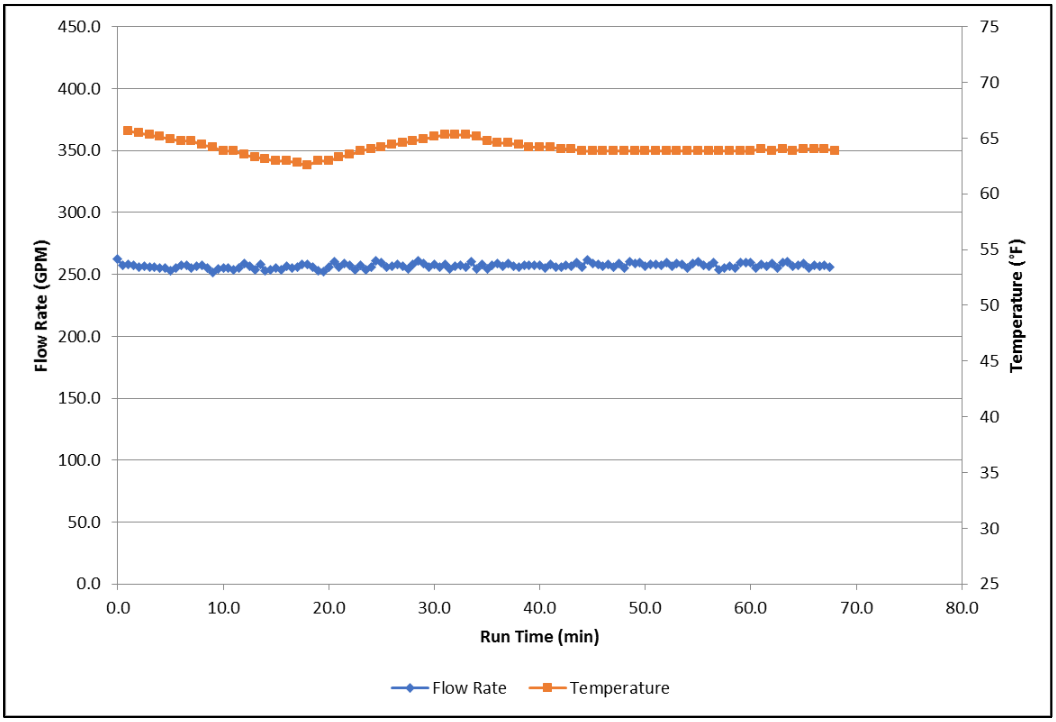


Figure 12 Water Flow and Temperature - 50% MTFR

Table 15 Sediment Feed Rate Summary – 50% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	194.12	Starting Weight of Sediment (lbs.)	71.78
2	192.23		
3	197.60	Recovered Weight of Sediment (lbs.)	43.17
4	189.96		
5	191.17	Mass of Sediment Used (lbs.)	28.62
6	199.81	Volume of Water Through MTD During Dosing (gal)	15,612
Average	194.15		
COV	0.020	Average Influent Sediment Concentration (mg/L)	200.0*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 16 Background SSC - 50% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	1.0	1.2	1.4	1.0	1.7	1.0	≤ 20 mg/L PASS

ND = below method detection limit of 1.0 mg/L

75% MTFR

Table 17 Sampling Schedule - 75% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
6.2		2
8.7	2	
12.4		3
17.4	3	
18.6		4
24.9		5
26.1	4	
31.1		6
34.8	5	
37.3		7
43.5	6	8
45.0	End of Testing	
MTD Detention Time = 1.3 minutes Sediment Sampling Time = 30 seconds		

Table 18 Water Flow and Temperature - 75% MTFR

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	386.3	385.9	-0.1%	0.006	65.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

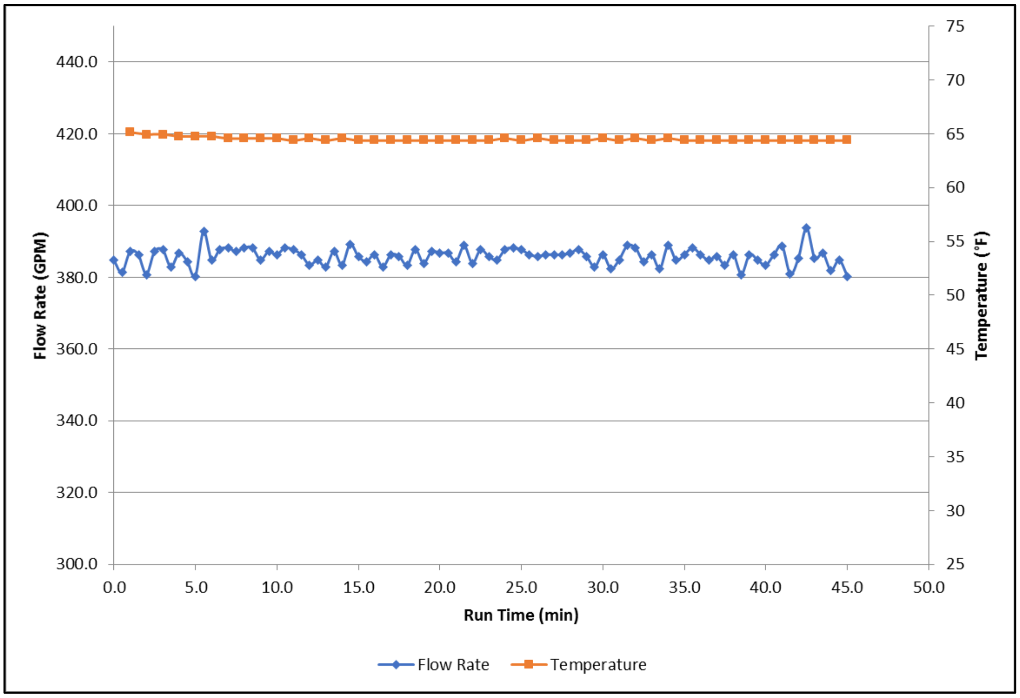


Figure 13 Water Flow and Temperature - 75% MTFR

Table 19 Sediment Feed Rate Summary – 75% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	288.22	Starting Weight of Sediment (lbs.)	70.82
2	312.73		
3	296.09	Recovered Weight of Sediment (lbs.)	41.77
4	298.87		
5	294.95	Mass of Sediment Used (lbs.)	29.06
6	303.19	Volume of Water Through MTD During Dosing (gal)	15,823
Average	299.01		
COV	0.028	Average Influent Sediment Concentration (mg/L)	205.1*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 20 Background SSC - 75% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	1.2	1.7	2.7	4.6	6.4	6.9	6.2	2.4	≤ 20 mg/L PASS

100% MTFR

Table 21 Sampling Schedule - 100% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	Background
0.0	1	1
4.7		2
6.6	2	
9.4		3
13.2	3	
14.1		4
18.9		5
19.8	4	
23.6		6
26.4	5	
28.3		7
33.0	6	8
34.0	End of Testing	
MTD Detention Time = 1.0 minutes Sediment Sampling Time = 30 seconds		

Table 22 Water Flow and Temperature - 100% MTFR

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	515.0	514.6	-0.1	0.006	57.6
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

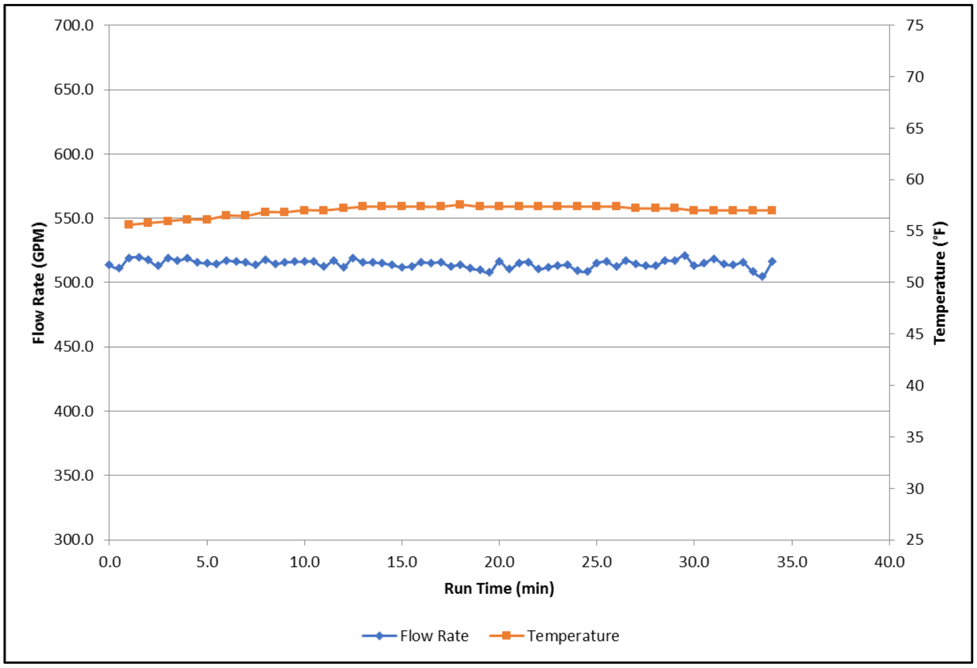


Figure 14 Water Flow and Temperature - 100% MTFR

Table 23 Sediment Feed Rate Summary – 100% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	385.32	Starting Weight of Sediment (lbs.)	75.50
2	390.97		
3	380.19	Recovered Weight of Sediment (lbs.)	47.13
4	390.20		
5	386.73	Mass of Sediment Used (lbs.)	28.36
6	405.29	Volume of Water Through MTD During Dosing (gal)	15,702
Average	389.78		
COV	0.022	Average Influent Sediment Concentration (mg/L)	196.9*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 24 Background SSC - 100% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	1.3	3.2	2.2	≤ 20 mg/L PASS

ND = below method detection limit of 1.0 mg/L

125% MTFR

Table 25 Sampling Schedule - 125% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	Background
0.0	1	1
3.7		2
5.2	2	
7.4		3
10.3	3	
11.0		4
14.7		5
15.4	4	
18.4		6
20.6	5	
22.1		7
25.7	6	8
26.5	End of Testing	
MTD Detention Time = 0.8 minutes Sediment Sampling Time = 20 seconds		

Table 26 Water Flow and Temperature - 125% MTFR

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	643.8	645.1	0.2%	0.008	59.4
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

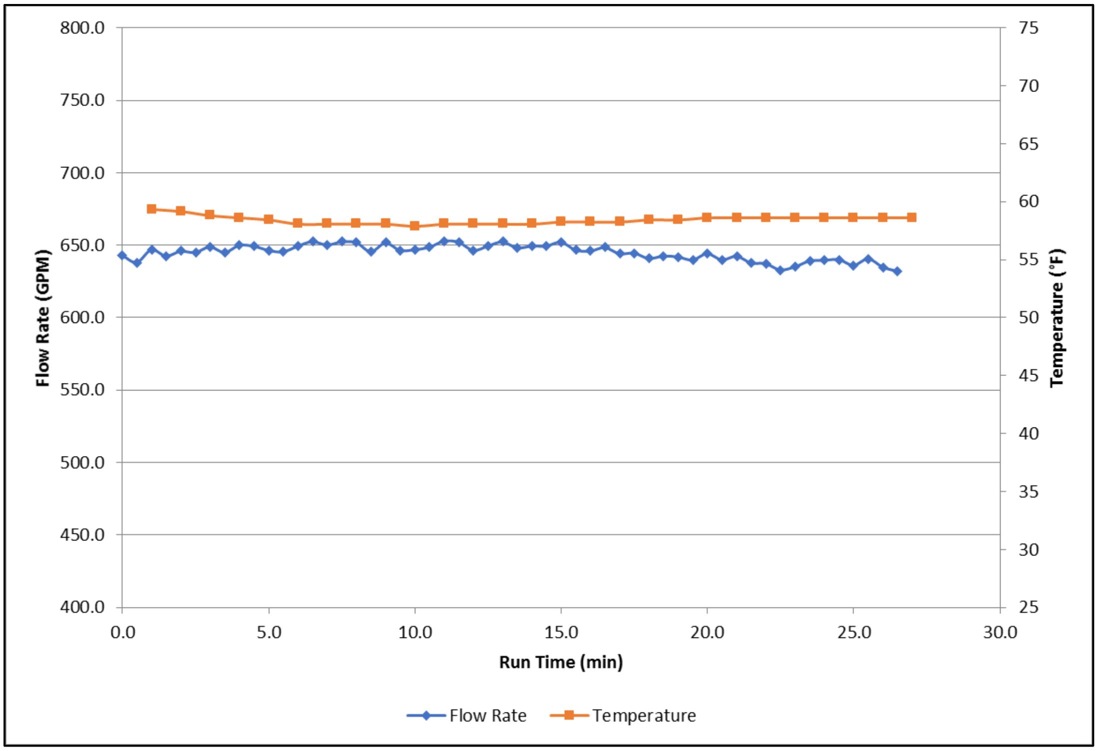


Figure 15 Water Flow and Temperature - 125% MTFR

Table 27 Sediment Feed Rate Summary – 125% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	477.28	Starting Weight of Sediment (lbs.)	73.67
2	534.32		
3	495.16	Recovered Weight of Sediment (lbs.)	45.18
4	488.29		
5	514.02	Mass of Sediment Used (lbs.)	28.48
6	516.01	Volume of Water Through MTD During Dosing (gal)	15,528
Average	504.18		
COV	0.042	Average Influent Sediment Concentration (mg/L)	202.7*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 28 Background SSC - 125% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	1.5	3.0	4.1	5.6	≤ 20 mg/L PASS

ND = below method detection limit of 1.0 mg/L

150% MTFR

Table 29 Sampling Schedule - 150% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
3.2		2
4.5	2	
6.4		3
8.9	3	
9.6		4
12.8		5
13.4	4	
16.0		6
17.9	5	
19.1		7
22.3	6	8
23.0	End of Testing	
MTD Detention Time = 0.7 minutes Sediment Sampling Time = 18 seconds		

Table 30 Water Flow and Temperature - 150% MTFR

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	772.5	755.4	-2.2%	0.007	60.4
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

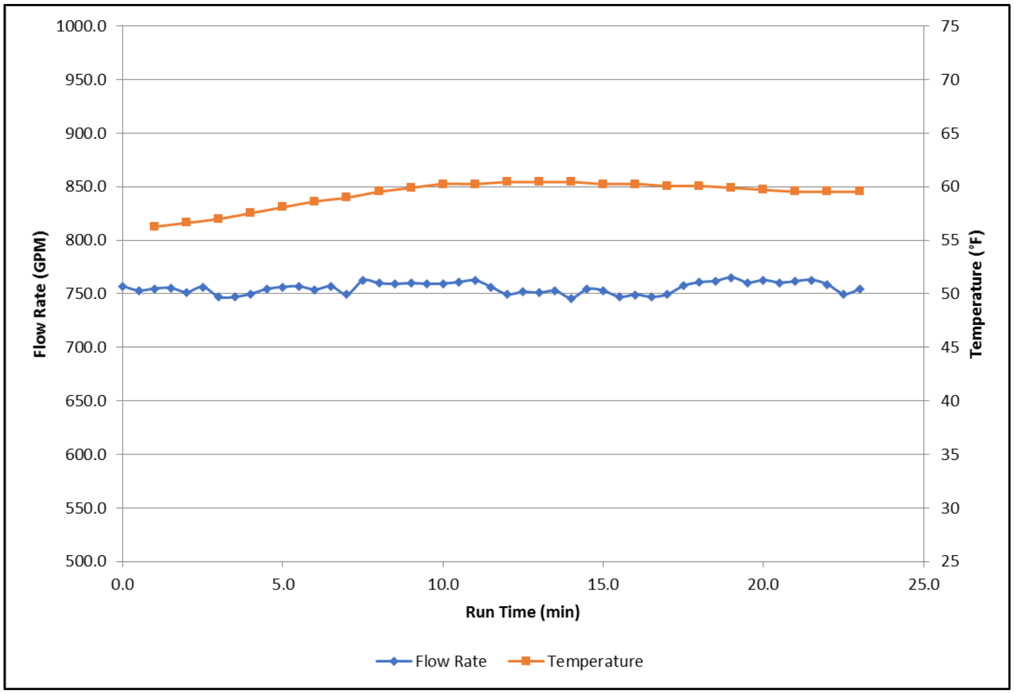


Figure 16 Water Flow and Temperature - 150% MTFR

Table 31 Sediment Feed Rate Summary – 150% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	572.90	Starting Weight of Sediment (lbs.)	72.17
2	594.64		
3	569.95	Recovered Weight of Sediment (lbs.)	44.28
4	581.73		
5	581.14	Mass of Sediment Used (lbs.)	27.89
6	574.95	Volume of Water Through MTD During Dosing (gal)	15,739
Average	579.22		
COV	0.015	Average Influent Sediment Concentration (mg/L)	194.8*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 32 Background SSC - 150% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	1.0	1.9	3.3	4.1	≤ 20 mg/L PASS

ND = below method detection limit of 1.0 mg/L

All the recovered sediment was dried in glass trays using a convection oven. The sediment was dried until a constant weight was achieved. The recovered sediment mass and removal efficiency for each run are summarized below:

Table 33 Sediment Removal Efficiency Based on Captured Sediment

% MTFR	10	25	50	75	100	125	150
Total Mass Added (lb)	26.58	28.39	26.06	27.08	25.80	26.26	25.59
Total Mass Retained in Inlet Pipe + MTD (lb)	18.24	18.89	16.19	14.91	10.77	8.63	6.31
Sediment Retained in Inlet Pipe (lb)	0.14	1.05	0.00	0.00	0.00	0.00	0.00
Sediment Captured in MTD (lb)	18.10	17.85	16.19	14.91	10.77	8.63	6.31
Removal Efficiency* (%)	68.1	62.9	62.1	55.1	41.7	32.9	24.6
% of Retained Sediment in Inlet Pipe	0.8	5.5	0.0	0.0	0.0	0.0	0.0

* Sediment retained in the inlet pipe is excluded from the removal efficiency calculation.

Analysis of the initial 7 runs showed that the fitted MTFR for the tested StormSettler could be as high as 1.41 cfs (633 gpm). Claiming a higher MTFR would mean that 125% MTFR is 1.76 cfs (791 gpm). This exceeds any of the previous seven runs so an 8th run was completed at 1.76 cfs and removal was recalculated with this 8th point. To be consistent with the first seven runs the 8th run is labeled as 154% of the ***target*** MTFR.

The rationale for this is that none of the 5 points used in the Annual Removal calculation can be extrapolated. Using a new MTFR also required a new, higher flow scour test, so that was done in addition to the 8th performance run. Details of the scour test are in section 4.2.

154% MTFR

Table 34 Sampling Schedule - 154% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	Background
0.0	1	1
3.0		2
4.3	2	
6.1		3
8.5	3	
9.1		4
12.1		5
12.8	4	
15.2		6
17.0	5	
18.2		7
21.3	6	8
22.0	End of Testing	
MTD Detention Time = 0.6 minutes Sediment Sampling Time = 15 seconds		

Table 35 Water Flow and Temperature - 154% MTFR

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	791.0	791.9	0.1%	0.006	70.7
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

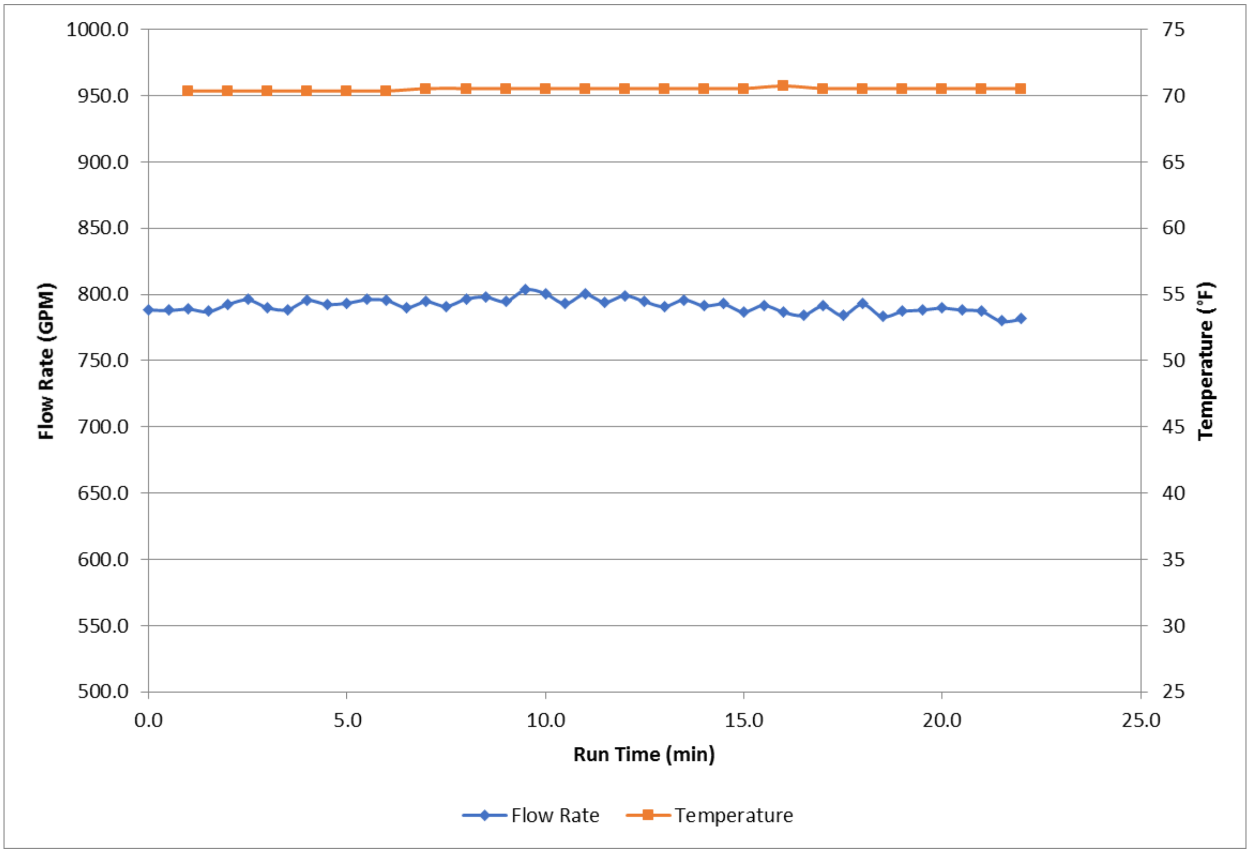


Figure 17 Water Flow and Temperature - 154% MTFR

Table 36 Sediment Feed Rate Summary – 154% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	589.49	Starting Weight of Sediment (lbs.)	72.50
2	640.01		
3	605.45	Recovered Weight of Sediment (lbs.)	43.40
4	627.30		
5	611.14	Mass of Sediment Used (lbs.)	29.10
6	615.65	Volume of Water Through MTD During Dosing (gal)	15827
Average	614.84		
COV	0.028	Average Influent Sediment Concentration (mg/L)	204.8*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 37 Background SSC - 154% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	1.1	1.0	1.2	ND	1.4	3.1	3.7	≤ 20 mg/L PASS

ND = below method detection limit of 1.0 mg/L

Table 38 Sediment Removal Efficiency at 154% MTFR (791 gpm)

% MTFR	**154**
Total Mass Added (lb)	27.05
Total Mass Retained in Inlet Pipe + MTD (lb)	6.71
Sediment Retained in Inlet Pipe (lb)	0.00
Sediment Captured in MTD (lb)	6.71
Removal Efficiency (%)	24.8

Annualized Weighted Removal Efficiency

A plot was made of the removal efficiency vs. flow rate data (**Figure 18**) for all eight runs and a curve of best fit was obtained using a 3rd order polynomial (r^2 = 0.990). The curve was used to determine the StormSettler MTFR and the annualized weighted removal efficiency for sediment in stormwater has been calculated using the rainfall weighting factors provided in the NJDEP laboratory test protocol. For a MTFR of 1.41 cfs (633 gpm), the annual weighted removal is 50.4%, as shown in **Table 39**.

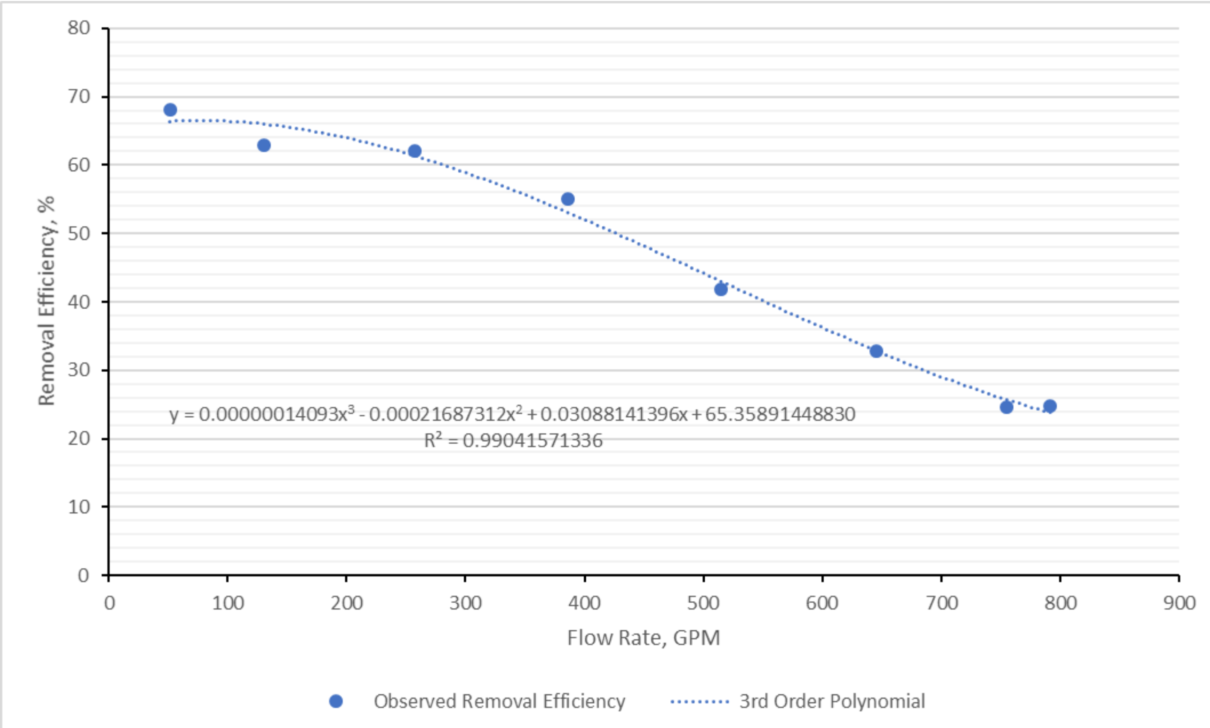


Figure 18 StormSettler® Removal Efficiency Curve

Table 39: Annualized Weighted Removal Efficiency for StormSettler®

%MTFR	Flow Rate (gpm)	Removal Efficiency (%)	Annual Weighting Factor	Weighted Removal Efficiency (%)
25	158	65.4	0.25	16.3
50	316	57.9	0.30	17.4
75	475	46.2	0.20	9.2
100	633	33.8	0.15	5.1
125	791	23.8	0.10	2.4
Annualized Weighted Removal Efficiency				**50.4%**

4.2 Scour Testing

Scour testing was conducted in accordance with Section 5 of the NJDEP Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation MTD. Testing was initially conducted at a target flow rate of 2.3 cfs (1030 gpm), 200% of the target MTFR. Due to the change in MTFR based on the sediment removal performance results, it was repeated at 2.80 cfs (1257 gpm), which was slightly below 200% of the desired MTFR due to a miscalculation. A last test was conducted at 2.83 cfs (1270 gpm) slightly more than 200% of the maximum treatment flow rate (MTFR). All three scour tests passed the scour criteria for online installation but only the last scour test results at 2.83 cfs are reported.

In preparation for the scour test, the false floor inside the unit sump was lowered to 4 inches below the 50% maximum sediment storage volume. The sump was then loaded with scour test sediment. When levelled, the sediment formed a layer 4 inches thick, so the top of the sediment was 7 inches above the sump floor. After sediment loading, the sump was filled with water. The water was added in such a way as to avoid disturbing the sediment bed. The StormSettler was allowed to sit for 95 hours before commencing the scour test.

Scour testing began by gradually increasing the flow rate to the target flow within a 3-minute period. The sampling frequency for background and effluent samples is summarized in **Table 40**. Run time 0 min. is when the pump was started.

Table 40 Scour Test Sampling Frequency

Sample/ Measurement Taken	Run Time (min.)														
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
Effluent	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Background	X		X		X		X		X		X		X		X

Table 41 Water Flow and Temperature - Scour Test

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	1270	1270	-0.001%	0.004	64.6
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

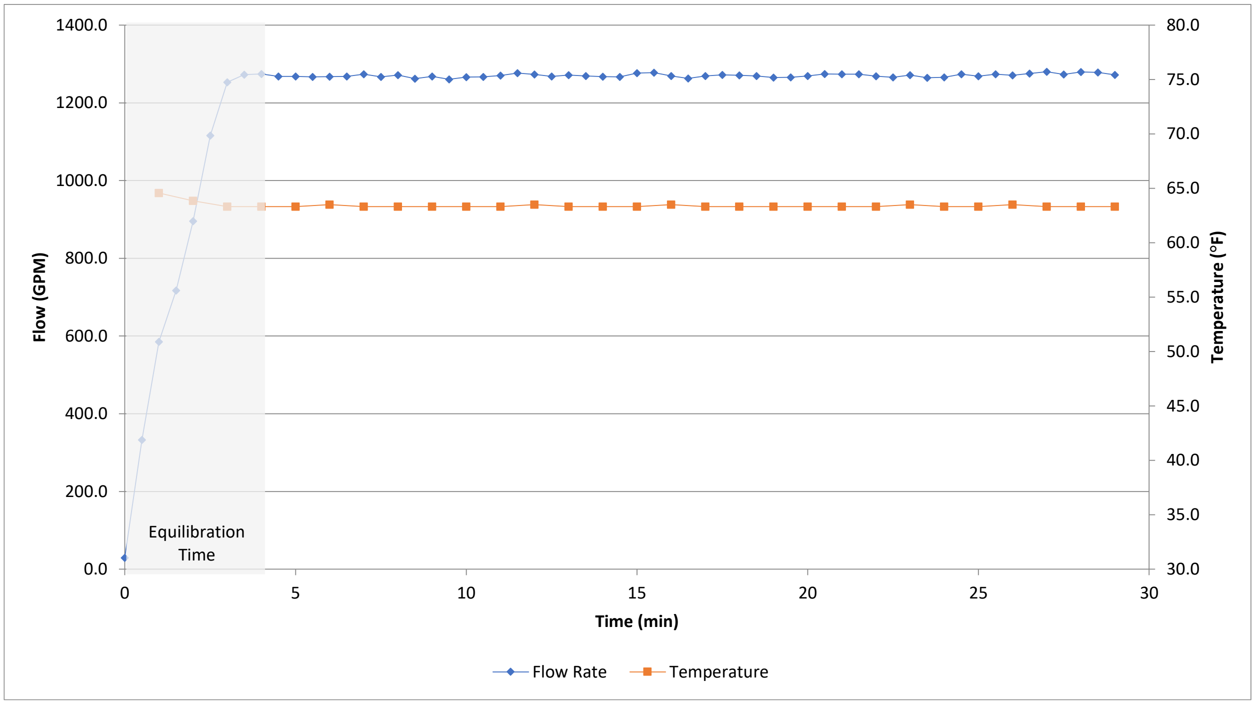


Figure 19 Water Flow and Temperature - Scour Test

The effluent and background SSC results are reported in **Table 42**. For instances where the reported SSC concentration was below 1.0 mg/L, the method detection limit, a value of 0.5 mg/L was used for calculation purposes. The adjusted effluent concentration was calculated as:

$$Adjusted\ Effluent\ Concentration\ \left(\frac{mg}{L}\right) = Initial\ Concentration - Background\ Concentration$$

For effluent samples that did not have a corresponding background sample, the background value was interpolated from the previous and subsequent samples. The average adjusted effluent concentration was 6.8 mg/L at >200% of the MTFR, therefore, the StormSettler meets the criteria for online use.

Table 42 Suspended Sediment Concentrations for Scour Test

	Scour Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	0.5	1.3	6.8	8.9	10.2	11.6	8.4	11	11	6.5	8.2	7.9	8.7	6.8	3.7
Background	1.1		0.5		0.5		0.5		1.1		0.5		0.5		0.5
Adjusted Effluent	0	0.5	6.3	8.4	9.7	11.1	7.9	10.2	9.9	5.7	7.7	7.4	8.2	6.3	3.2
Average Adjusted Effluent Concentration							6.8 mg/L								

4.3 Hydraulic Testing

Prior to performance testing, the head loss across the StormSettler was determined by measuring and comparing the difference between the water level at the influent side of the MTD and the effluent side, defined as the difference in water elevation, or Δh. Measurements were made on a clean unit, without sediment, using a manometer equipped with a meter stick graduated in 1 mm increments.

For the head loss measurements, the false floor was set in the sump at 7", which is 50% of the maximum rated sediment storage depth. Measured flows spanned the range of 10% - 200% MTFR. The head loss data are presented in **Table 43.**

Bypass occurred at ~450 gpm, as indicated by the plateau in the headloss curve at that point. Using the results in **Table 43** the headloss coefficient, k, was calculated to be 1.25.

Table 43 StormSettler Head Loss

Flow Rate		Water Elevation (cm)		Δh	
cfs	**gpm**	**Influent**	**Effluent**	**cm**	**inches**
0.03	12.3	2.7	1.4	1.3	0.5
0.06	24.7	3.7	2.0	1.7	0.7
0.11	51.5	6.0	3.1	2.9	1.1
0.14	61.7	6.9	3.5	3.4	1.3
0.27	121	10.4	5.0	5.4	2.1
0.29	129	10.9	5.3	5.6	2.2
0.41	184	13.9	6.9	7.0	2.8
0.55	249	17.6	8.7	8.9	3.5

0.57	258	18.0	9.0	9.0	3.5
0.68	307	20.4	9.8	10.6	4.2
0.86	384	23.9	10.8	13.1	5.2
0.96	431	25.6	11.3	14.3	5.6
1.03	462	27.0	12.9	14.1	5.6
1.15	515	27.7	13.2	14.5	5.7
1.37	617	28.9	13.6	15.3	6.0
1.43	643	29.3	13.9	15.4	6.1
1.72	774	31.5	14.5	17.0	6.7
1.79	803	32.0	14.7	17.3	6.8
2.30	1033	36.2	16.5	19.7	7.8
2.67	1200	40.0	16.7	23.3	9.2
2.85	1278	42.1	16.8	25.3	10.0

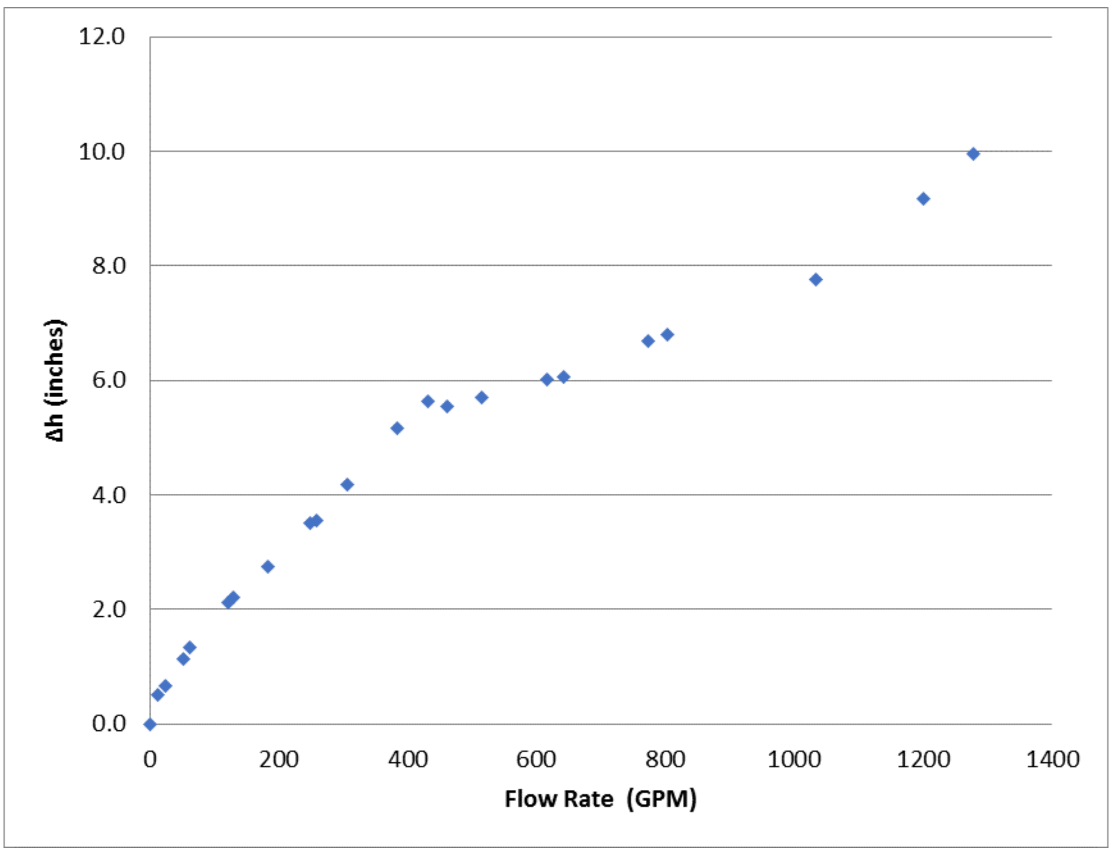


Figure 20 StormSettler Head Loss

4.4 Excluded Results

The NJDEP Verification Procedure requires disclosure and a discussion of any data excluded from analysis. Shortly after the start of testing at 125 % MTFR on February 7, 2022, it was discovered that there was a communication error between the flow meter data logger and the data acquisition laptop. This meant that none of the flow rate data was recorded so the run was halted with no results. The test unit was emptied and cleaned thoroughly and testing at 125% MTFR was restarted and completed successfully.

Data for a scour test at 1030 gpm was omitted since it was replaced by a higher flow scour test. Data for a scour test at 1257 gpm was also omitted since it too was replaced by a higher flow test. The unit passed both these earlier conducted scour tests.

5. Design Limitations

The StormTrap StormSettler is an engineered system designed to meet site-specific requirements. Design parameters and limitations are listed below.

Soil Characteristics

StormSettler is an enclosed, flow-through system that can be installed and function as intended in all soil types. StormSettler units are installed in accordance with ASTM C-891 “Standard Practice for Installation of Underground Precast Concrete Utility Structures”.

Slope of Drainage Pipe

The system was verified with an inlet pipe slope of 1%, in accordance with the protocol, but there are no specific drainage pipe slope limitations provided that both the inlet and outlet pipe elevations are identical.

Maximum Treatment Flow Rate

The maximum treatment flow rate (MTFR) for StormTrap StormSettler models is based upon the diameter of the system as shown in **Table A-1**. Systems are sized to a hydraulic loading rate of 50.4 gpm/ft^2 of effective treatment area.

Maintenance Requirements

StormSettler systems should be inspected and maintained following the recommendations and guidelines included in the StormSettler Manufacturer’s Instruction Manual available at:

https://stormtrap.com/products/stormsettler/stormsettler-maintenance-manual/

Section 6 of this report includes a detailed description of inspection and maintenance requirements.

Driving Head

StormSettler driving head requirements can be found in **Table 43** and **Figure 20**. The system headloss coefficient, k=1.25.

Installation Limitations

StormTrap provides contractors with detailed installation and assembly instructions as well as specific pick weights prior to delivery.

Configurations

StormSettler has an internal bypass and can be installed online or offline. The NJCAT/NJDEP verified/certified configuration is a single inlet and outlet at 180 degrees, but other configurations are possible.

Structural Load Limitations

StormSettler modules are typically designed for HS-20 loading. Contact StormTrap if alternate design loadings are anticipated or required for site specific conditions.

Pre-treatment Requirements

The StormSettler has no pre-treatment requirements.

Depth to Seasonal High-Water Table

StormSettler performance is independent of high groundwater conditions. Contact StormTrap if groundwater is above the system invert for site specific structural/floatation calculations.

6. Maintenance Plans

The StormSettler treatment device by StormTrap is designed to capture and store pollutants from stormwater. The unit must be inspected and maintained routinely to ensure peak removal efficiency. StormSettler maintenance frequency is site dependent and routine inspections, particularly during the first year after installation, are needed to determine the needed maintenance frequency of the unit.

Inspection

Inspections of the StormSettler are important to ensure peak performance and assess the condition of the system internals. Inspection is simple and can be performed in a short amount of time. Inspections should be performed during dry weather conditions, after the unit has had time to dewater to the usual water level.

Inspection Equipment

- StormSettler Maintenance Manual and Inspection Checklist
- Flashlight
- Manhole cover removal tools
- Proper protective equipment
- Proper traffic control signage
- Sediment probe

Inspection should begin by removing the manhole cover(s) on the unit and visually inspecting the integrity of the internal components. On larger units where two manhole covers are present, both are recommended to be removed to inspect both the inlet and outlet side of the device as effectively as possible. Visually ensure that the baffle is intact and seated properly, that the vortex disruptor is in place and undamaged, that the tube pack is free from obstructions, and the outlet diverter is seated properly and in good condition.

Sediment depth should then be determined. NJDEP requires sediment removal when sediment has reached 50% of the unit's storage depth. The 50% sediment storage depth for StormSettler NJDEP models is 7-in. Sediment depth can be determined either by using a sediment probe or by taking a measurement to the top of the sediment in relation to a fixed object in the system.

Maintenance

StormTrap recommends that a Vactor truck or similar type of vacuum equipment be used to remove sediment from the StormSettler unit. Access to the bottom of the unit is on the inlet side of the baffle.

If a pressure washer is used to assist with dislodging any debris within the system, special care must be taken when spraying the enhanced settling pack. Use a wide spray nozzle on or around the pack to avoid altering the tubes within the enhanced settling pack.

Maintenance Procedure

1. Remove manhole cover(s) to expose the inlet side of the StormSettler.
2. A Vactor truck or similar type of equipment should be used to remove all water and sediment from the system. The rodding hose of the Vactor truck should be used to remove any sediment that is stuck. Maintenance crews should be careful not to damage the internal components.
3. Refill the StormSettler unit to the normal water level.
4. Replace the manhole cover(s).
5. Dispose of any waste according to local regulations.

Dispose of all waste during maintenance per local, state, and federal guidelines and regulations.

If, during maintenance or inspection, any parts of the StormSettler are determined to be damaged, contact StormTrap to order replacements.

7. Statements

The following attached pages are signed statements from the manufacturer (StormTrap LLC), the independent test lab (Good Harbour Labs), and NJCAT. These statements are a requirement of the verification process.

In addition, it should be noted that this report has been subjected to public review (e.g., stormwater industry) and all comments and concerns have been satisfactorily addressed.

StormTrap

December 14, 2022

To: Dr. Richard Magee, Sc.D., P.E. BCEE
Executive Director
New Jersey Corporation for Advanced Technology
c/o Center for Environmental Systems
Stevens Institute of Technology
One Castle Point on Hudson
Hoboken, NJ 07030

Subject: StormSettler Laboratory Verification Report – Manufacturer's Statement of Compliance

Dr. Magee,

StormTrap has completed verification testing for the StormSettler Hydrodynamic Separator in accordance with the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device", dated January 1, 2021.

As required by the "NJDEP Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology (NJCAT)", dated August 4, 2021, this letter serves as StormTrap's statement that all procedures and requirements identified in the aforementioned protocol and process document were met or exceeded.

If you have any questions or comments regarding this verification, please do not hesitate to contact me.

Sincerely,

Greg Williams

Greg Williams, PhD., P. Eng.
Director of Water Quality Technology

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EMAIL info@stormtrap.com
1287 Windham Parkway
Romeoville, Illinois 60446

December 13, 2022

Dr. Richard Magee, ScD., P.E., BCEE
Executive Director
New Jersey Corporation for Advanced Technology (NJCAT)

Re: Performance Verification of the StormTrap StormSettler® System

Dear Dr. Magee,

Good Harbour Laboratories was contracted by StormTrap LLC to conduct performance testing of their StormSettler® hydrodynamic separator in accordance with the New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 1, 2021).

Good Harbour Laboratories is an independent hydraulic test facility located in Mississauga, Ontario Canada. I certify that we evaluated the StormSettler from January - October 2022, according to the aforementioned test protocol. The results presented in the NJCAT Verification Report dated December 2022 are accurate and all procedures and requirements stated in the test protocol were met or exceeded. I confirm that all test data that was collected is included or referenced in the report.

GHL provides testing and verification services for numerous water treatment technologies including stormwater treatment devices. GHL has had several different stormwater equipment manufacturers as clients and we have accumulated considerable experience in testing these devices. In order to be able to make this experience available to as many potential clients as possible, GHL is careful to maintain its position as an independent service provider.

With the above in mind I, the undersigned, on behalf of GHL, confirm:

- that I do not have any conflict of interest in connection to the contracted testing;

- that I will inform NJCAT, without delay, of any situation constituting a conflict of interest or potentially giving rise to a conflict of interest;

Good Harbour Laboratories
T: 905.696.7276 | F: 905.696.7279
A: 2596 Dunwin Drive, Mississauga, ON L5L 1J5
www.goodharbourlabs.com

- that I have not granted, sought, attempted to obtain or accepted and will not grant, seek, attempt to obtain, or accept any advantage, financial or in kind, to or from any party whatsoever, constituting an illegal or corrupt practice, either directly or indirectly, as an incentive or reward relating to the outcome of the testing.

Sincerely, Date

Roland G. DuBois

December 13, 2022

Roland DuBois, P.Eng.
Managing Director
Good Harbour Laboratories

CC: Dan Fajman, StormTrap LLC
Greg Williams, StormTrap LLC

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www.goodharbourlabs.com

Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030-0000

December 15, 2022

Gabriel Mahon, Chief
NJDEP
Bureau of Non-Point Pollution Control
Bureau of Water Quality
401 E. State Street
Mail Code 401-02B, PO Box 420
Trenton, NJ 08625-0420

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing conducted on a full-scale, commercially available StormTrap StormSettler® Hydrodynamic Separator (StormSettler-4) by Good Harbour Laboratories (GHL), an independent water technology testing lab, at their site in Mississauga, Ontario, Canada, the test protocol requirements contained in the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" (NJDEP HDS Protocol, January 1, 2021) were met or exceeded consistent with the NJDEP Approval Process. Specifically:

Removal Efficiency Test Sediment

The test sediment used for the removal efficiency study (1-1000 µm) was a custom blend of commercially available silica sediments blended by GHL. This particular batch was GHL lot # A031-119. The blend ratio was determined such that the particle size distribution of the resulting blended sediment would meet the specification for the test protocol. The sediment was sampled in multiple locations throughout the blending process; three composite samples were created for PSD analysis. The final blended sediment was stored in 12 sealed buckets until needed.

Each of the three composite samples was reduced in size using a riffle splitter. The three samples were analyzed for PSD by a qualified 3rd party analytical laboratory (Bureau Veritas in Mississauga) in a manner consistent with ASTM D6913-17, "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis" and ASTM D7928-17 "Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis". The sediment exceeded the protocol specifications (d_{50} 65 microns). The moisture content of the test sediment was also determined in accordance with ASTM Method D2216-19, “Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.” Moisture content was < 0.30%.

Scour Test Sediment

The test sediment used for the scour study was also a custom blend of commercially available silica sediments; this particular batch was GHL lot # A034-081. The blend ratio was determined such that the particle size distribution of the resulting blended sediment would meet the specification for the test protocol. The blended scour test sediment was stored in 9 five-gallon buckets. Three separate composite samples were created by sampling all of the five-gallon buckets used to load the StormSettler for the scour test. Each bucket was sampled in three locations: top third, middle third and bottom third. The composite samples were well blended and reduced in size using a sediment riffle splitter.

The three samples were analyzed for PSD by a qualified 3rd party analytical laboratory (GeoTesting Express in Massachusetts) in accordance with ASTM D6913-17, “Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis” and ASTM D7928-17 “Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis”. The moisture content of the test sediment was also determined in accordance with ASTM Method D2216-19, “Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.” The scour test sediment was finer than the sediment required by the test protocol and therefore was acceptable for use.

Removal Efficiency Testing

Removal efficiency testing followed the mass capture test method outlined in Section 4.C of the NJDEP HDS Protocol. The sediment removal efficiency of the StormSettler-4 at an MTFR of 1.41 cfs was 50.4%.

Scour Testing

Scour testing of the StormSettler-4 was conducted in accordance with Section 5 of the NJDEP HDS Protocol at a target flow rate slightly greater than 200% of the MTFR to qualify the MTD for online conveyance installation. The average adjusted effluent concentration was 6.8 mg/L at 200% of the MTFR, therefore, the StormSettler meets the criteria for online use.

Sincerely,

Richard S. Magee, Sc.D., P.E., BCEE

8. References

1. Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology. August 4, 2021, 2013.
2. New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device. January 1, 2021.

VERIFICATION APPENDIX

Introduction

- Manufacturer – StormTrap LLC, 1287 Windham Parkway, Romeoville, IL 60446
  Website: www.stormtrap.com General Phone: (815) 941-4663

- MTD: StormTrap StormSettler Hydrodynamic Separator. Verified StormSettler models are shown in **Table A-1**.

- TSS Removal Rate: 50%

- Offline or Online Installation

Detailed Specification

- NJDEP sizing and dimensional table is attached as **Table A-1**.

- New Jersey requires that the peak flow rate of the New Jersey Water Quality Design Storm (NJWQDS), 1.25 inches of rainfall in a 2-hour duration, shall be used to determine the appropriate size for the MTD. The StormSettler-4 has a maximum treated flow (MTFR) of 1.41 cfs (633 gpm), which corresponds to a hydraulic loading rate of 50.2 gpm/ft^2 of effective treatment area.

- Pick weights and installation procedures vary with model size. StormTrap provides contractors with project-specific unit pick weights and installation instructions prior to delivery.

- Maximum sediment depth for all units is 14 inches. StormTrap recommends that the units be cleaned when sediment depth reaches 7 inches, representing 50% sediment storage capacity.

- An Inspection and Maintenance Manual is provided for each project installation and available at:
  https://stormtrap.com/products/stormsettler/stormsettler-maintenance-manual/

- According to N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the StormTrap StormSettler to be used in series with another hydrodynamic separator to achieve an enhanced TSS removal rate.

Table A-1 StormSettler MTFRs, Sediment Removal Intervals, and Standard Dimensions

Model	Manhole Diameter (ft)	NJDEP 50% TSS Maximum Treatment Flow Rate (MTFR) (cfs)	Effective Treatment Area (ft^2)	Hydraulic Loading Rate[1] (gpm/ft^2)	Effective Sedimentation Area (ft^2)	50% Maximum Sediment Storage (ft^3)	Sediment Removal Interval[2] (years/months)	Chamber Depth[3] (ft)	Effective Treatment Depth[4] (ft)	Aspect Ratio Treatment Depth:Diameter[5]
StormSettler-3	3	0.79	7.1	50.2	7.1	4.1	3.1 / 37	5	4.42	1.47
StormSettler-4	4	1.41	12.6	50.2	12.6	7.3	3.1 / 37	6	5.42	1.35
StormSettler-5	5	2.19	19.6	50.2	19.6	11.5	3.1 / 37	6	5.42	1.08
StormSettler-6	6	3.17	28.3	50.2	28.3	16.5	3.1 / 37	6	5.42	0.90
StormSettler-7	7	4.30	38.5	50.2	38.5	22.4	3.1 / 37	9	8.42	1.20
StormSettler-8	8	5.63	50.3	50.2	50.3	29.3	3.1 / 37	10	9.42	1.18
StormSettler-10	10	8.78	78.5	50.2	78.5	45.8	3.1 / 37	12.5	11.92	1.19
StormSettler-12	12	12.7	113.1	50.2	113.1	66.0	3.1 / 37	14.5	13.92	1.16

[1] Hydraulic loading rate is defined as the ratio of MTFR to effective treatment area.

[2] Sediment removal interval is calculated using the equation presented in Appendix A, Section B of the NJDEP Protocol.

[3] Chamber depth is defined as depth from effluent invert to sump floor.

[4] Effective treatment depth is defined as depth from effluent invert to 50% of the sediment storage depth.

[5] Aspect ratio is defined as the ratio of effective treatment depth to manhole diameter. The aspect ratio for the tested unit is 1.35. Larger models (>250% MTFR of the unit tested, >3.5 cfs) must be geometrically proportional to the tested unit within the allowable ±15% tolerance.