NJCAT TECHNOLOGY VERIFICATION

SiteSaver® Stormwater Treatment Device

StormTrap, LLC

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1. Description of Technology

SiteSaver® is a manufactured treatment device, developed by StormTrap, that improves the quality of stormwater runoff. The device contains and removes suspended particulates using an insert that promotes gravity settling and is housed within a concrete vault structure. The insert is comprised of settling plates, baffles, and weirs (**Figure 1** and **Figures 2A & 2B**).

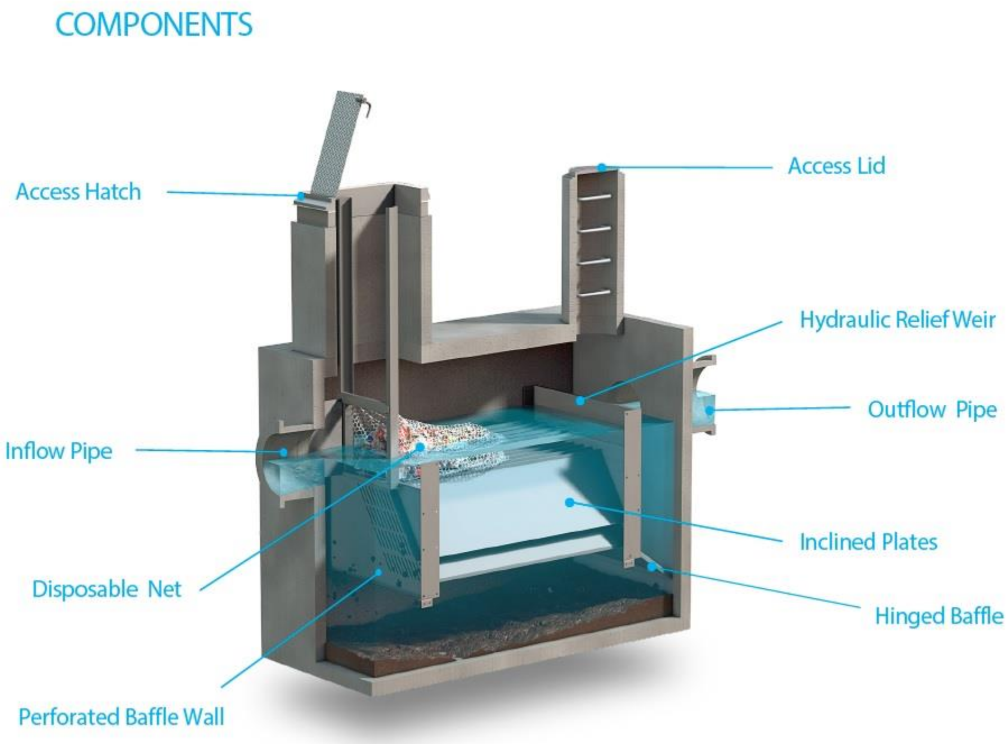

Figure 1 SiteSaver® Rendering

During normal operations, stormwater enters the device through an inflow pipe. The water then flows through the device until it reaches the inlet perforated baffle wall. Water then passes uniformly through the baffle wall into the inclined plate area via columns of four equally sized and spaced perforations. The quantity of columns is equal to the number of plates utilized. Water travels within the inclined plate area until it reaches the hydraulic relief weir. Once water reaches the hydraulic relief weir it passes through the hydraulic relief weir via columns of equally sized and spaced perforations that are identical to the perforations in the perforated baffle wall. After the water passes through the hydraulic relief weir the water then travels into the outlet pipe that is placed at the same elevation as the inflow pipe. The flow path is shown in **Figure 2A** using black and red arrows. The red arrows indicate when the water flow is within the inclined plates.

During high flow events, the hydraulic relief weir acts as an internal bypass. When flow exceeds the design capacity of the inclined plates the water's flow path still adheres to the flow described above; however, any additional flow larger than the capacity of the inclined plates is diverted above the hydraulic relief weir. The flow path of the water that exceeds the inclined plates capacity is shown in **Figure 2B** using white arrows.

The hinged baffle is connected to the hydraulic relief weir and spans the entire width of the device and the length from the hydraulic relief weir to the wall of the chamber. The hinged baffle ensures that the flow paths described are maintained in order to avoid short circuiting of the device, minimizing resuspension of captured pollutants during bypass events.

SiteSaver also contains and removes gross pollutants, such as trash, debris and rubbish, using netting components that can also be housed within the same structure as the inclined plates, baffles and weir insert. If the netting component is utilized, the floating debris is captured within the net rather than the inclined settling plates to avoid clogging the plate insert with large debris. Hydrocarbons are contained within the device throughout the entire footprint area prior to the hydraulic relief weir and to a depth from the invert of the outlet pipe to the top of the orifice openings in the perforated baffles. If oil is identified as a pollutant of concern, the SiteSaver unit can be equipped with a hydrophobic/oleophilic accessory to ensure that during a bypass event oil is not discharged.

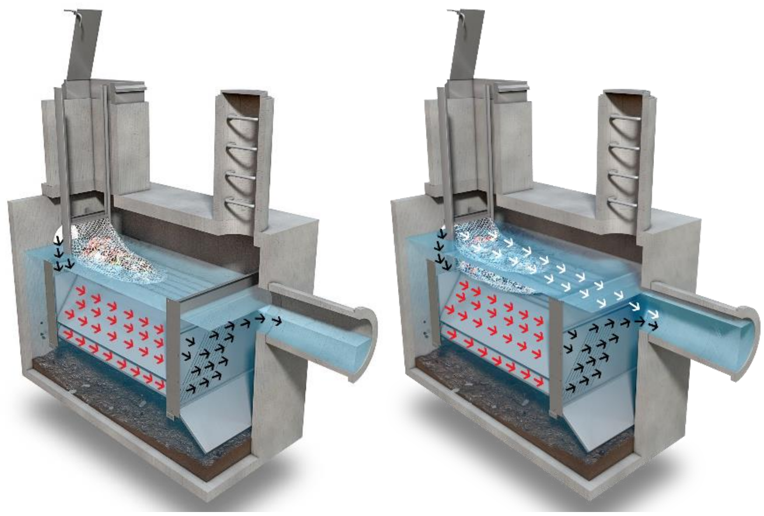

Figure 2A (Left) SiteSaver Flow Characteristics – Normal Flow Operation

Figure 2B (Right) SiteSaver Flow Characteristics – High Flow Operation

This verification report covers the StormTrap SiteSaver 1 (STSS-1) and the StormTrap SiteSaver 4 (STSS-4) hydrodynamic separators. Two model sizes were tested for sediment removal efficiency to allow for the development of a scaling methodology for other STSS hydrodynamic separators.

2. Laboratory Testing

The test program, including sediment blending, was conducted by the manufactured treatment device manufacturer, StormTrap, Inc. under the on-site supervision and direction of Good Harbour Laboratories (GHL) staff. GHL is an independent water technology testing lab based in Ontario, Canada. Sediment blending and testing took place in Morris, IL from October 2016 to April 2017 (STSS-4) and June 2018 to August 2018 (STSS-1). The models that were tested were identical to commercially available units with the exception that they did not have a concrete hatch that would be associated with a unit installed below grade. For performance testing, there was no need for the hatch and not having one in place in no way affected the test results.

Laboratory testing was done 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 2013). 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).

2.1 Test Units

The treatment devices tested were full-scale, commercially available StormTrap SiteSaver units, the STSS-1 and the STSS-4; dimensional details are provided in **Table 1**. The units both had an identical sedimentation area of 84 ft^2 and maximum treatment flow rates (MTFRs) of 1.08 cfs (485 gpm) and 4.32 cfs (1940 gpm) respectively. Physical exterior and interior dimensions are the same for all StormTrap SiteSaver models.

Table 1 SiteSaver® Dimensions of Tested Models

SiteSaver Models	MTFR (cfs)	50% Maximum Sediment Storage Volume (ft^3)	Oil Capacity (Gallons)[1]	Physical Exterior Dimensions			Physical Interior Dimensions			Effective Treatment Area[2] (ft^2)
				Length (ft)	Width (ft)	Depth (ft)	Length (ft)	Width (ft)	NWL to Floor Invert (ft)	
STSS-1	1.08	28	178	15	6.83	11.17	14	6	6.26	21
STSS-4	4.32	28	178	15	6.83	11.17	14	6	6.26	84

NWL – Normal Water Level

[1] When hydrocarbons are a pollutant of concern, it is recommended that absorptive oil booms are placed into the unit to prevent hydrocarbon wash out during high flow events in on-line installations.

[2] The effective treatment area (ETA) is the horizontally projected area of the inclined plates (21 ft^2 per plate).

Two commercially available models, with an MTFR difference of at least 250% as required by the NJDEP Protocol, were tested to determine an alternative scaling methodology. Alternative scaling is being pursued because, as noted above, the SiteSaver models all utilize the same concrete vault dimensions; therefore, geometric dimensional scaling based on vault sedimentation area, is not applicable. The flow through the STSS is controlled by perforated-openings in the outlet baffle walls. The maximum treatment flow rate (MTFR) for different models is controlled by the addition or removal of inclined plates and the correlating perforated-openings within the baffles. Each plate has a correlating column of four equally sized and spaced perforations on the inlet and outlet baffles which controls the flow rate and allows water to flow uniformly across the inclined plates. For example, a STSS-4 model will contain 4 columns of 4 perforations on the inlet and outlet baffles and a STSS-11 model will contain 11 columns of 4 perforations on the inlet and outlet baffles. Since the entire bottom of the separator is open below the inlet baffle wall, the flow is not restricted to the inlet perforations. There is a hinged baffle below the outlet baffle wall which effectively restricts the flow out of the separator to the outlet wall perforations during non-bypass conditions. In both cases the flow out of the separator is constrained by the number, and placement, of holes in the outlet baffle wall.

Since the concrete vault dimensions are constant the sedimentation storage volumes are also constant for all models; therefore, it is understood that larger models will have shorter sediment removal intervals.

2.2 Test Setup

The units were tested at different times and in different locations. The STSS-4 was tested in March 2017 in a warehouse while the STSS-1 was tested in June - August 2018 in an open field. The test setup was a single-pass system filled with potable water; the test set up is illustrated in **Figure 3**. The setup was comprised of water reservoirs, pumps, receiving tank and flow and temperature sensors, in addition to the SiteSaver® units. The maximum water capacity of the water supply tanks was 147,000 gallons.

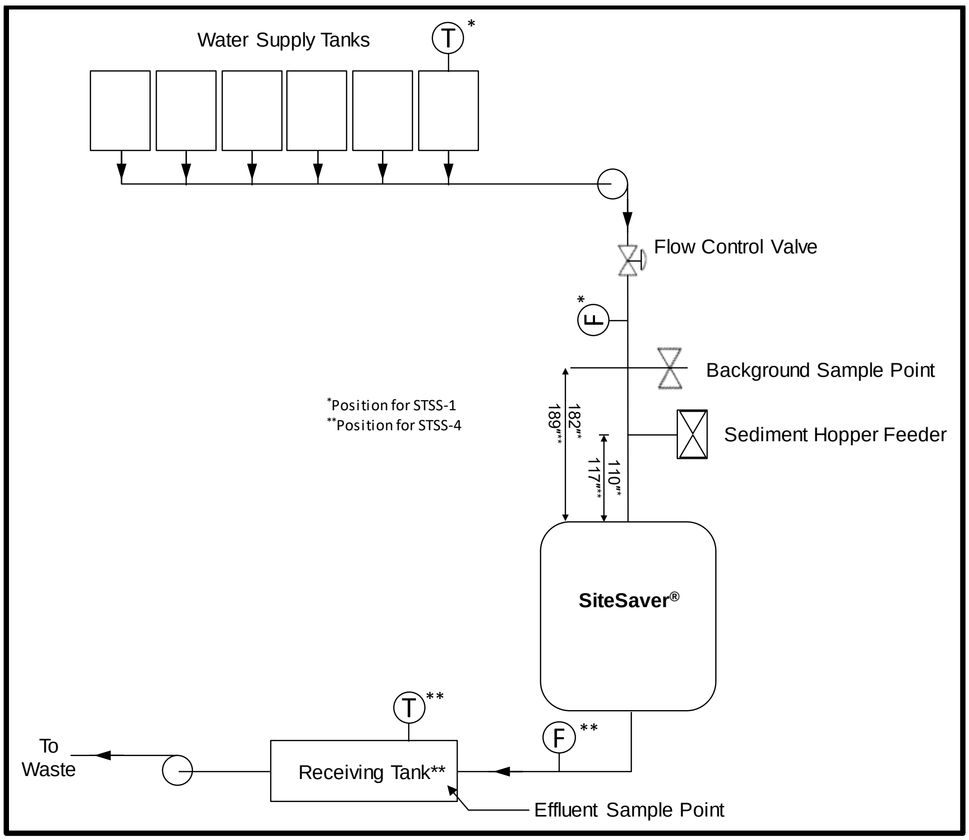

Figure 3 Test Flow Setup

Water Flow and Measurement

From the water supply tanks, water was pumped using a DV200c centrifugal pump through a 24″ SDR17 HDPE line to the SiteSaver. The flow rate was controlled using a gate valve located on the discharge side of the pump. Flow measurements for the STSS-4 unit were made with a Greyline Instruments area-volume flow meter (Model AVFM 5.0) equipped with a data logger. The flow sensor was in the 24″ effluent line of the SiteSaver and the data logger was configured to record a flow measurement once every minute. For the STSS-1, flow measurements were made in the influent line using a Greyline transit time flow meter (Model TTFM 1.0) equipped with a data logger that was configured to record a flow measurement once every minute.

The AVFM flow meter was used for the higher flow rates observed for the STSS-4 testing. During the tests, the effluent pipe had a water level sufficient enough to provide flow readings. For the STSS-1 tests however, the level in the effluent pipe was lower, therefore the switch was made to a transit time flow meter to obtain more accurate flow readings. The location of the flow meter was also changed from the effluent pipe to the influent pipe, as shown in **Figure 3**, because the TTFM only works on a full pipe. The effluent line remained unchanged.

Water flow exited the SiteSaver and terminated with a free-fall. For the STSS-4 test (completed indoors), the effluent stream emptied into the Receiving Tank and was then sent to waste while for the STSS-1 test (completed outdoors), the effluent emptied directly to waste.

Sample Collection

Background water samples were collected in clean containers from a sampling port located approximately 8 pipe diameters (182″ for the STSS-1 and 189″ for the STSS-4) upstream of the SiteSaver. The sampling port was controlled manually by a ball valve (**Figure 4**) that was opened approximately 5 seconds prior to sampling. Background as well as effluent water samples met or exceeded the minimum sample volume requirement.

Effluent samples were also grabbed by hand per section 5D of the NJDEP Protocol. The effluent pipe drained freely into the Receiving Tank or directly to waste and the effluent sample was taken at that point (**Figure 5**).

Figure 4 Background Sampling Point

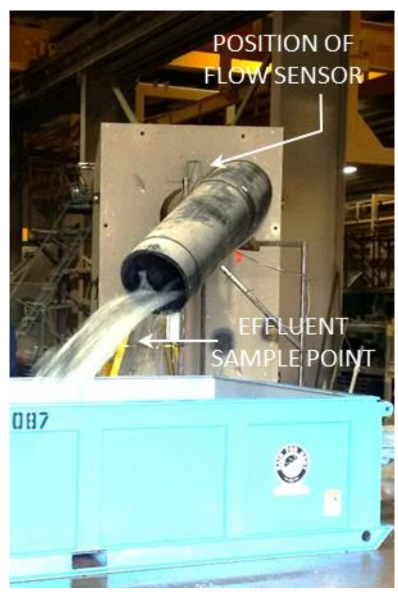

Figure 5 Effluent Sampling Point

Duplicates were taken for both background and effluent samples. The primary set was analysed and reported while the second set was held by the testing lab in case there was a need for an investigation following an aberrant result.

Other Instrumentation and Measurement

Effluent water temperature was measured using a MadgeTech temperature data logger, Model MicroTemp. The data logger was configured to record a temperature reading once every minute. For the STSS-1 test the temperature data logger was located inside one of the influent water storage tanks while for the STSS-4 test, it was located in the receiving tank. Run and sampling times were measured using a NIST traceable stopwatch, Control Company Model 1042.

Sediment addition occurred through the crown of the inlet pipe (**Figure 6**), approximately 5 pipe diameters from the SiteSaver inlet. The sediment feeder was an ACRISON Model W105Z Dry Solids Feeder with a 3-cubic foot hopper. The sediment feed samples that were taken during the run were collected in 1000-mL jars and weighed on an analytical balance (Veritas M1203i).

Figure 6 Sediment Addition Point

2.3 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. 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 blended using a cement mixer in multiple batches at the testing site. Following the blending of each batch, the sediment was sampled and the samples were placed in each of three separate buckets, the samples were taken from random positions throughout the cement mixer. This process was repeated twice, for both the STSS-1 and STSS-4 tests. The final blended sediment was stored in security sealed plastic-lined drums until needed. All seals were broken by GHL staff.

Each of the three sample buckets was mixed and then split into quarters. One of the quarters was then transferred into two separate jars, one to be sent for analysis and the other to be retained. The three sediment samples for analysis were sent to Interra in Bolingbrook, IL for particle size analysis using the methodology of ASTM method D422-63. The test results are summarized in **Table 2** and **Table 3** and shown graphically in **Figure 7** and **Figure 8.** The moisture content of all sediment samples was found to be < 0.1%.

Table 2 Particle Size Distribution of STSS-4 Test Sediment

Particle Size (µm)	Test Sediment Particle size (%passing)				NJDEP Specification* (minimum % Passing)
	Sample 1	Sample 2	Sample 3	Average	
1000	100.0	100.0	100.0	100	100
500	96.3	96.3	96.4	96	95
250	90.2	90.4	89.8	90	90
150	77.5	77.9	78.0	78	75
100	67.4	66.8	67.3	67	60
75	55.6	55.6	56.1	56	50
50	51.5	51.5	51.0	51	45
20	39.4	39.7	41.7	40	35
8	22.0	21.0	19.5	21	20
5	15.7	13.4	13.4	14	10
2	7.5	7.5	8.0	8	5
d_{50}	46	46	47	46	75

Table 3 Particle Size Distribution of STSS-1 Test Sediment

Particle Size (µm)	Test Sediment Particle size (%passing)				NJDEP Specification* (minimum % Passing)
	Sample 1	Sample 2	Sample 3	Average	
1000	100.0	100.0	100.0	100	100
500	98.9	98.7	98.6	99	95
250	88.6	88.2	87.9	88	90
150	76.0	75.0	74.4	75	75
100	62.7	61.5	60.8	62	60
75	54.8	53.4	52.8	54	50
50	52.0	50.0	48.0	50	45
20	42.5	40.6	38.4	41	35
8	20.0	20.0	19.0	20	20
5	13.0	12.9	12.8	13	10
2	5.0	5.0	5.5	5	5
d_{50}	44	50	56	50	75

* A measured value may be lower than a target minimum % less than value by up to two percentage points provided the measured d_{50} value does not exceed 75 microns.

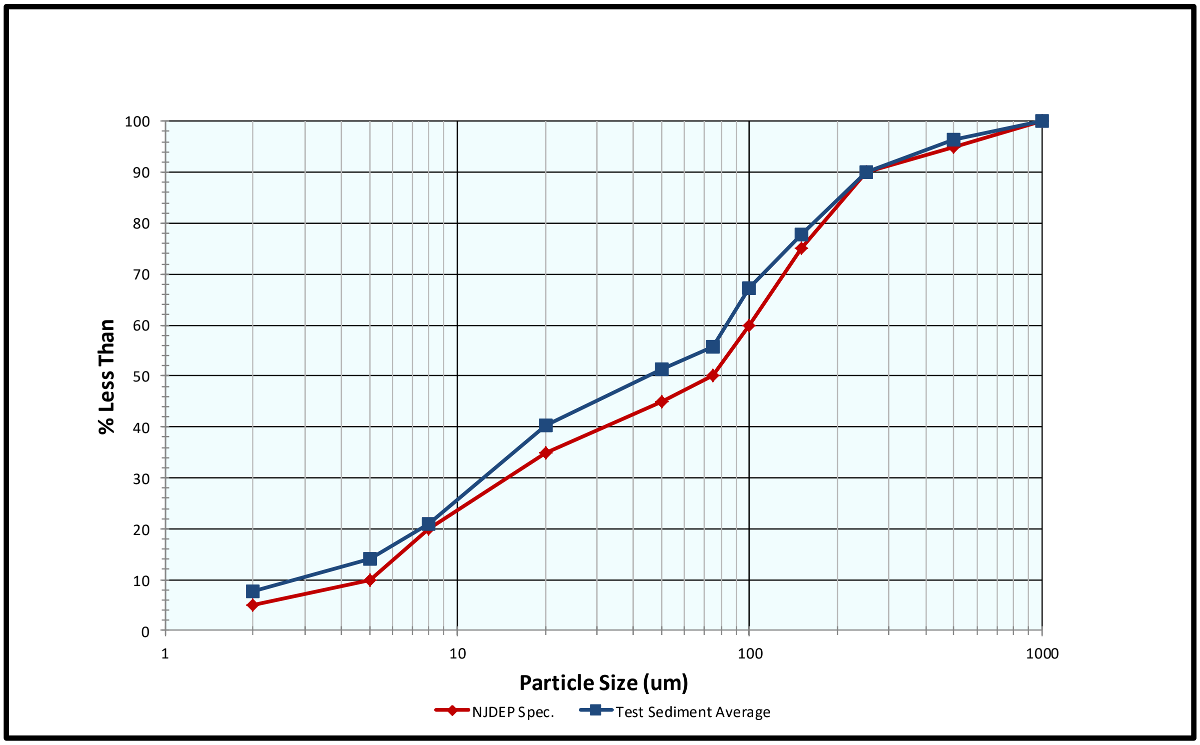

Figure 7 Average Particle Size Distribution of STSS-4 1-1000 µm Test Sediment

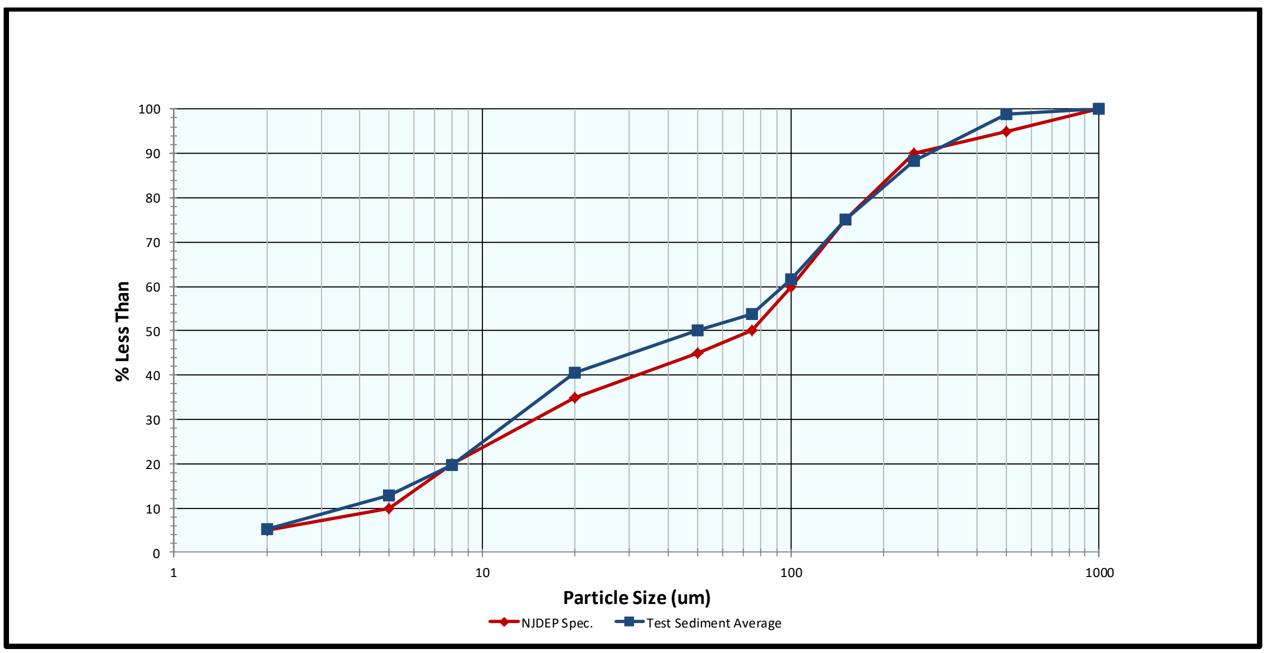

Figure 8 Average Particle Size Distribution of STSS-1 1-1000 µm Test Sediment

The 1-1000 µm test sediment was found to meet the NJDEP particle size specification and was acceptable for use. With a d_{50} of less than 75 µm, 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 (50-1000 µm) was supplied by AGSCO Corporation as a single, pre-blended batch, lot #101316 (STSS-4) and lot # 061518 (STSS-1). For the STSS-4, three separate composite samples were created by randomly sampling 50% of all the bags received. For the STSS-1, the sediment was transferred from bags into 10 buckets to facilitate the loading of the STSS sump. Each bucket was randomly sampled during the transfer to create three separate composite samples.

The composite samples were well blended and quartered. One of the quarters from each composite was split in two, half was retained and the other half was sent to Interra for particle size distribution analysis. The test results are summarized in **Table 4** and **Table 5** 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.

Table 4 Particle Size Distribution of STSS-4 Scour Test Sediment

Particle Size (µm)	Test Sediment Particle size (%passing)				NJDEP Specification (minimum % Passing)
	Sample 1	Sample 2	Sample 3	Average	
1000	100.0	100.0	100.0	100	100
500	97.7	97.8	97.4	97.6	90
250	68.2	67.9	68.9	68.3	55
150	52.0	52.1	52.8	52.3	40
100	29.5	29.4	31.3	30.1	25
75	14.8	14.9	15.5	15.1	10
50	12.0	12.0	10.1	11.4	0

Table 5 Particle Size Distribution of STSS-1 Scour Test Sediment

Particle Size (µm)	Test Sediment Particle size (%passing)				NJDEP Specification (minimum % Passing)
	Sample 1	Sample 2	Sample 3	Average	
1000	100.0	100.0	100.0	100.0	100
500	96.2	96.1	96.2	96.2	90
250	64.1	64.8	65.4	64.8	55
150	46.8	47.8	47.5	47.4	40
100	33.0	34.0	33.7	33.6	25
75	21.9	22.5	22.2	22.2	10
50	11.0	12.0	11.0	11.3	0

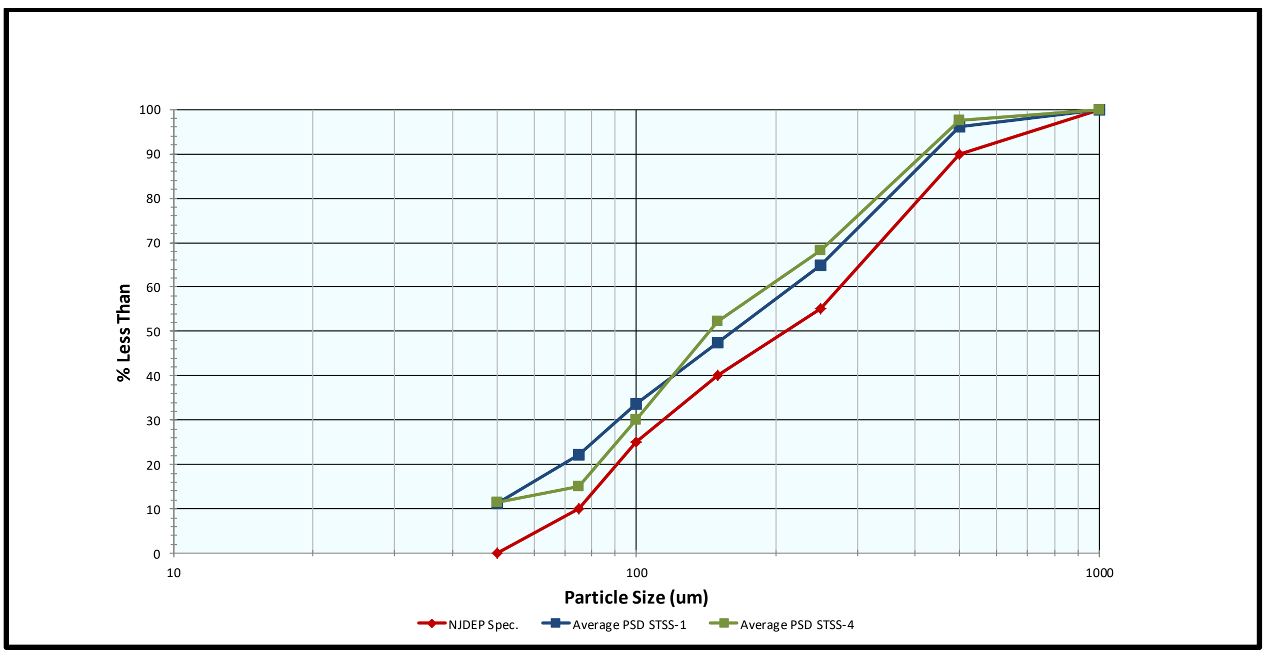

Figure 9 Average Particle Size Distribution of Scour Test Sediment

2.4 Removal Efficiency Testing

Removal Efficiency Testing was conducted in accordance with Section 5 of the NJDEP Laboratory Protocol for Hydrodynamic Sedimentation MTDs. Removal testing was conducted on a clean unit with a false floor installed at the 50% collection sump sediment storage depth of 4-inches above the device floor. Testing was completed at the flow rates specified in **Table 6** and at a target influent sediment concentration of 200 mg/L.

Table 6 Removal Efficiency Test Flow Rates

% MTFR	STSS-1 Target Flow Rates		STSS-4 Target Flow Rates	
	CFS	GPM	CFS	GPM
25	0.270	121	1.081	485
50	0.541	243	2.161	970
75	0.811	364	3.242	1455
100	1.081	485	4.322	1940
125	1.351	606	5.403	2425

The test sediment was sampled 6 times per run to confirm the sediment feed rate. Each sediment feed rate sample was a minimum of 100 mL and collected in a 1000 mL jar.

Effluent grab sampling began following three MTD detention times after the initial sediment sample. The time interval between sequential samples was 1 minute, however, when the test sediment feed was interrupted for measurement, the next effluent sample was collected following three MTD detention times from the time the sediment feed was re-established. A total of 15 effluent samples were taken during each run.

Background water samples were taken with the odd-numbered effluent samples.

As specified in the NJDEP test protocol, analysis of Total Suspended Solids (TSS) samples were done in accordance with ASTM D 3977-97 (re-approval 2007) “Standard Test Methods for Determining Sediment Concentrations in Water Samples” and reported as Suspended Sediment Concentration (SSC).

2.5 Scour Testing

For the scour tests, the false floor was removed from the sump of the test units and sediment was loaded and leveled at a depth of 4 inches. Measurements were taken at multiple locations by GHL staff to confirm the sediment depth. 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 units were gradually filled with clear water, so as not to disturb the sediment, to the invert of the inlet pipe. The filled STSS-4 unit was allowed to sit overnight before the scour test was started while the STSS-1 was allowed to sit for approximately 69 hours.

The scour test for the STSS-4 was conducted at a flow rate of 4200 gpm, over two times the MTFR. To achieve this flow, a larger pump was required. The DV200c pump was replaced with a 12″ X 12″ DV-300i centrifugal pump, rated for 6,900 gpm. Additionally, the AVFM flow sensor was relocated to the inlet pipe, through the opening used for sediment addition for the removal efficiency test (**Figure 10**). It was necessary to move the flow sensor because the very high flow rate used in the scour test created an unstable flow pattern in the outlet pipe. The scour test for the STSS-1 did not require any modification to the test flow apparatus shown in **Figure 3**.

During the scour test, the water flow rate and temperature were recorded once every minute. Testing commenced by gradually increasing the water flow into the system until the target flow rate was achieved (within 5 minutes of commencing the test). Sampling of background and effluent was completed as per the removal efficiency test.

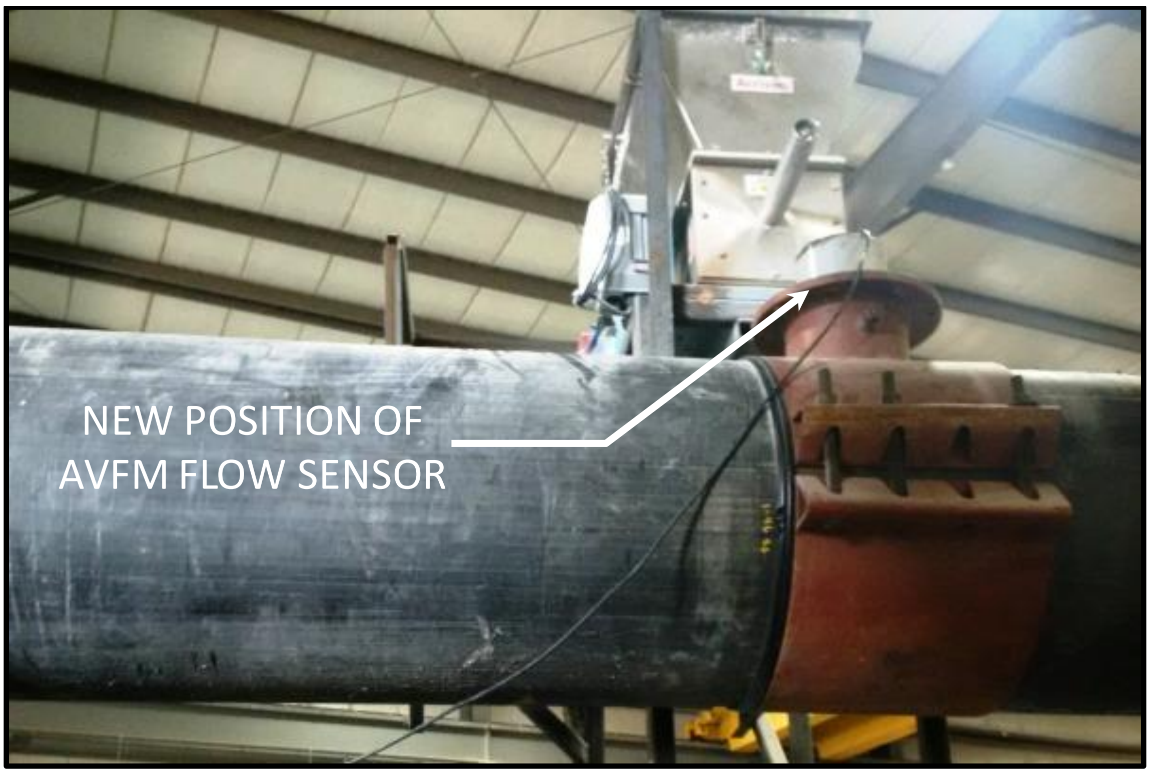

Figure 10 Position of AVFM Flow Sensor for STSS-4 Scour Test

3. Performance Claims

Per the NJDEP verification procedure, the following are the performance claims made by StormTrap and/or established via the laboratory testing conducted for the StormTrap SiteSaver®1 (STSS-1) and the StormTrap SiteSaver®4 (STSS-4) Hydrodynamic Separators.

Total Suspended Solids (TSS) Removal Rate

The TSS removal rate of the STSS-1 was calculated using the weighted method required by the NJDEP HDS MTD protocol. Based on a MTFR of 1.08 cfs (485 gpm), the STSS-1 achieved a weighted TSS removal rate of 58.1%.

The TSS removal rate of the STSS-4 was calculated using the weighted method required by the NJDEP HDS MTD protocol. Based on a MTFR of 4.32 cfs (1940 gpm), the STSS-4 achieved a weighted TSS removal rate of 54.5%.

Maximum Treatment Flow Rate (MTFR).

The STSS-1 unit had a total sedimentation area of 84 ft^2 and a maximum treatment flow rate (MTFR) of 1.08 cfs (485 gpm).

The STSS-4 unit had a total sedimentation area of 84 ft^2 and a maximum treatment flow rate (MTFR) of 4.32 cfs (1940 gpm).

Maximum Sediment Storage Depth and Volume

The maximum sediment storage depth is 8" which equates to 56 ft^3 of sediment storage volume. A sediment storage depth of 4 inches corresponds to 50% full sediment storage capacity (28 ft^3).

Sedimentation Area

The sedimentation area is 84 ft^2 for all models.

Detention Time and Wet Volume

The wet volume for the StormTrap SiteSaver® is 3,934 gallons. The detention time is dependent upon flow rate and varies for each model size.

Online Installation

Based on the laboratory scour testing, StormTrap SiteSaver® models qualify for online installation.

4. Supporting Documentation

The NJDEP Procedure (NJDEP, 2013) 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 and has been provided to NJCAT.

4.1 Removal Efficiency Testing

A total of 5 removal efficiency testing runs were completed for each test unit in accordance with the NJDEP HDS protocol. The target flow rate ranged from 25 – 125% MTFR and the target influent sediment concentration was 200 mg/L. The results from all 5 runs were used to calculate the overall removal efficiency for each unit.

The total water volume and average flow rate per run were calculated from the data collected by the flow data logger, one reading every minute. 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 each run to ensure the sediment feed rate was stable. The COV of the samples had to be < 0.10 per the NJDEP protocol. The feed rate samples were also used to calculate an influent concentration in order to double check the concentration calculated by mass balance.

The average effluent sediment concentration was adjusted for the background sediment concentration. Removal efficiency for each test run was computed as follows:

$$Removal\ Efficiency\ (\%) = \left(\frac{\begin{matrix}Average\ Influent\\ Concentration\end{matrix} - \begin{matrix}Adjusted\ Average\\ Effluent\ Concentration\end{matrix}}{\begin{matrix}Average\ Influent\\ Concentration\end{matrix}} \right) \times 100\%$$

STSS – 4 Removal Efficiency

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

25% MTFR

Table 7 Sampling Schedule - 25% MTFR STSS-4

Runtime (min)	Sampling Schedule		
	Sediment Feed	Background	Effluent
0	1		
25.33		1	1
26.33			2
27.33	2	2	3
52.67			4
53.67		3	5
54.67	3		6
80.00		4	7
81.00			8
82.00	4	5	9
107.33			10
108.33		6	11
109.33	5		12
134.66		7	13
135.66			14
136.66	6	8	15
137.78	End of Testing		
MTD Detention Time = 8.111 minutes Sediment Sampling Time = 1 minute			

Table 8 Water Flow and Temperature - 25% MTFR STSS-4

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	485	475	-2.1%	0.022	54.9
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

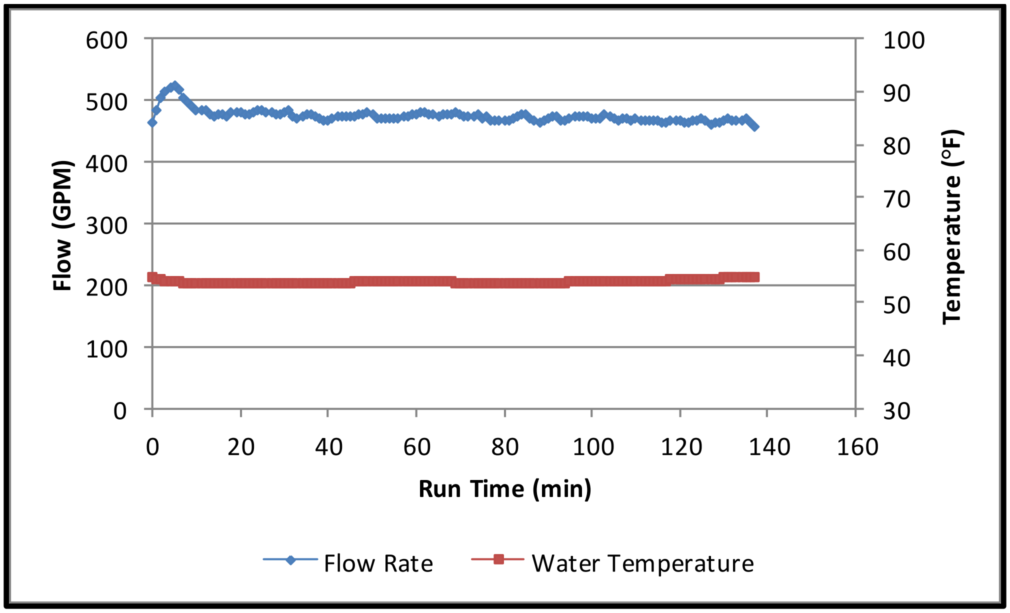

Figure 11 Water Flow and Temperature - 25% MTFR STSS-4

Table 9 Sediment Feed Summary – 25% MTFR STSS-4

Sediment Feed (g) – Sampling Time 1 min		**Sediment Mass Balance**	
1	422.179	Starting Weight of Sediment (lbs.)	300.00
2	372.215		
3	344.136	Recovered Weight of Sediment (lbs.)	189.69
4	354.725		
5	368.734	Mass of Sediment Used (lbs.)	110.31
6	390.696	Volume of Water Through MTD During Dosing (gal)	62,612
Average	375.448		
COV	0.074	Average Influent Sediment Concentration (mg/L)	201.9*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 10 SSC and Removal Efficiency - 25% MTFR STSS-4

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	88.4	88.0	86.8	98.3	100	101	104	103	102	100	97.8	101	105	106	100
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	86.4	86.0	84.8	96.3	98.0	99.0	102	101	100	98.0	95.8	99.0	103	104	98.0
Average Adjusted Effluent Concentration				96.8 mg/L			Removal Efficiency					**52.1%**			

50% MTFR

Table 11 Sampling Schedule - 50% MTFR STSS-4

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
13.17		1	1
14.17			2
15.17	2	2	3
28.33			4
29.33		3	5
30.33	3		6
43.50		4	7
44.50			8
45.50	4	5	9
58.67			10
59.67		6	11
60.67	5		12
73.83		7	13
74.83			14
75.83	6	8	15
76.95	End of Testing		
MTD Detention Time = 4.055 minutes Sediment Sampling Time = 1 minute			

Table 12 Water Flow and Temperature - 50% MTFR STSS-4

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	970	974	+0.4%	0.013	54.0
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

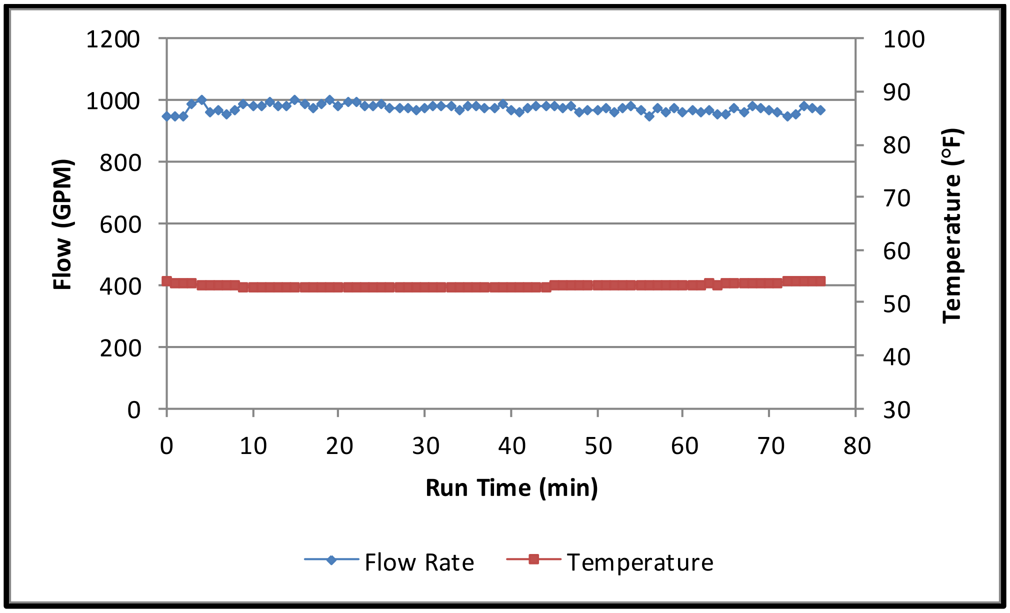

Figure 12 Water Flow and Temperature - 50% MTFR STSS-4

Table 13 Sediment Feed Summary – 50% MTFR STSS-4

Sediment Feed (g) – Sampling Time 1 min		Sediment Mass Balance	
1	839.115	Starting Weight of Sediment (lbs.)	300.00
2	662.805		
3	711.109	Recovered Weight of Sediment (lbs.)	179.69
4	726.493		
5	677.573	Mass of Sediment Used (lbs.)	120.31
6	723.758	Volume of Water Through MTD During Dosing (gal)	69,089
Average	723.476		
COV	0.086	Average Influent Sediment Concentration (mg/L)	192.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 14 SSC and Removal Efficiency - 50% MTFR STSS-4

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	83.8	84.8	83.8	91.5	88.8	94.8	93.8	94.3	94.3	94.0	94.3	97.5	94.8	67.8	89.5
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	81.8	82.8	81.8	89.5	86.8	92.8	91.8	92.3	92.3	92.0	92.3	95.5	92.8	65.8	87.5
Average Adjusted Effluent Concentration						87.9				Removal Efficiency				**54.3%**	

75% MTFR

Table 15 Sampling Schedule - 75% MTFR STSS-4

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
9.11		1	1
10.11			2
11.11	2	2	3
20.22			4
21.22		3	5
22.22	3		6
31.33		4	7
32.33			8
33.33	4	5	9
42.44			10
43.44		6	11
44.44	5		12
53.55		7	13
54.55			14
55.55	6	8	15
56.07	End of Testing		
MTD Detention Time = 2.704 minutes Sediment Sampling Time = 0.5 minutes			

Table 16 Water Flow and Temperature - 75% MTFR STSS-4

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	1455	1509	+3.7%	0.018	58
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

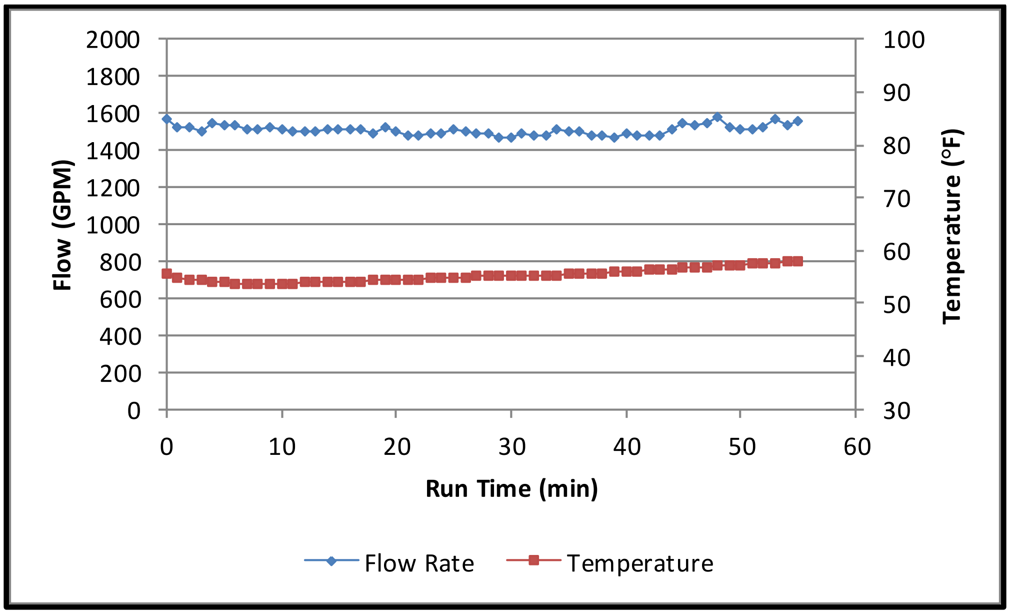

Figure 13 Water Flow and Temperature - 75% MTFR STSS-4

Table 17 Sediment Feed Summary – 75% MTFR STSS-4

Sediment Feed(g) – Sampling Time 0.5 min		Sediment Mass Balance	
1	522.156	Starting Weight of Sediment (lbs.)	300.00
2	541.690		
3	523.642	Recovered Weight of Sediment (lbs.)	171.39
4	510.451		
5	533.598	Mass of Sediment Used (lbs.)	128.61
6	498.222	Volume of Water Through MTD During Dosing (gal)	80,053
Average	521.627		
COV	0.030	Average Influent Sediment Concentration (mg/L)	182.4*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 18 SSC and Removal Efficiency - 75% MTFR STSS-4

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	74.3	76.8	81.3	87.5	85.5	86.3	84.8	88.8	86.5	90.8	84.3	62.5	80.8	84.0	78.3
Background	2.6		5.8		2.0		2.0		2.0		2.0		2.5		2.0
Adjusted Effluent	72.3	72.9	75.5	83.6	83.5	84.3	82.8	86.8	84.5	88.8	82.3	60.3	78.3	81.8	76.3
Average Adjusted Effluent Concentration						79.6 mg/L			Removal Efficiency					**56.4%**	

100% MTFR

Table 19 Sampling Schedule - 100% MTFR STSS-4

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
6.58		1	1
7.58			2
8.58	2	2	3
15.17			4
16.17		3	5
17.17	3		6
23.75		4	7
24.75			8
25.75	4	5	9
32.34			10
33.34		6	11
34.34	5		12
40.92		7	13
41.92			14
42.92	6	8	15
43.42	End of Testing		
MTD Detention Time = 2.028 minutes Sediment Sampling Time = 0.5 minutes			

Table 20 Water Flow and Temperature - 100% MTFR STSS-4

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	1940	1908	-1.6%	0.012	57.2
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

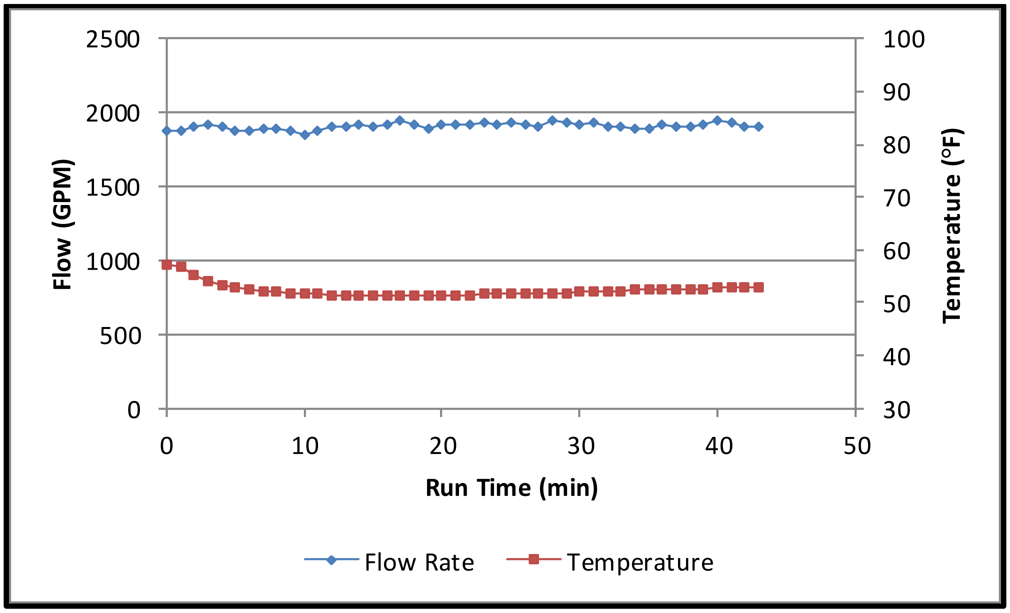

Figure 14 Water Flow and Temperature - 100% MTFR STSS-4

Table 21 Sediment Feed Summary – 100% MTFR STSS-4

Sediment Feed (g) – Sampling Time 0.5 min		Sediment Mass Balance	
1	721.122	Starting Weight of Sediment (lbs.)	300.00
2	763.852		
3	767.382	Recovered Weight of Sediment (lbs.)	160.81
4	751.594		
5	771.685	Mass of Sediment Used (lbs.)	139.19
6	737.996	Volume of Water Through MTD During Dosing (gal)	77,049
Average	752.272		
COV	0.026	Average Influent Sediment Concentration (mg/L)	201.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 22 SSC and Removal Efficiency - 100% MTFR STSS-4

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	88.0	93.8	82.5	94.3	77.3	91.8	89.8	88.5	84.8	98.0	102	86.0	106	92.5	81.8
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	86.0	91.8	80.5	92.3	75.3	89.8	87.8	86.5	82.8	96.0	100	84.0	104	90.5	79.8
Average Adjusted Effluent Concentration				88.5 mg/L			Removal Efficiency						**56.0%**		

125% MTFR

Table 23 Sampling Schedule - 125% MTFR STSS-4

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
5.37		1	1
6.37			2
7.37	2	2	3
12.73			4
13.73		3	5
14.73	3		6
20.10		4	7
21.10			8
22.10	4	5	9
27.46			10
28.46		6	11
29.46	5		12
34.83		7	13
35.83			14
36.83	6	8	15
37.83	End of Testing		
MTD Detention Time = 1.622 minutes Sediment Sampling Time = 0.5 minutes			

Table 24 Water Flow and Temperature - 125% MTFR STSS-4

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	2425	2448	+0.9%	0.012	53.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

During the run, just before the 19-minute mark, the flow meter display froze, displaying a value of zero. The power to the flow meter was cut by unplugging the flow meter display and plugging it back in. After re-initializing, the flow meter was working normally, displaying the correct flow rate. This entire process of restarting the flow meter took less than 1 minute.

The zero reading of the flow meter display was logged by the data logger for the 19-minute mark of the run; however, this reading was obviously incorrect as the reading was due to an electronics error, and not a physical change to the system flow. The flow readings at the 18 and 20 minute marks were 2,451 and 2,444 gpm respectively, a difference of only 0.3%, confirming that there was no actual change in flow. For the purposes of reporting the flow for the 19-minute mark, the average of the flow at 18 and 20 minutes was used **(**see **Figure 15).**

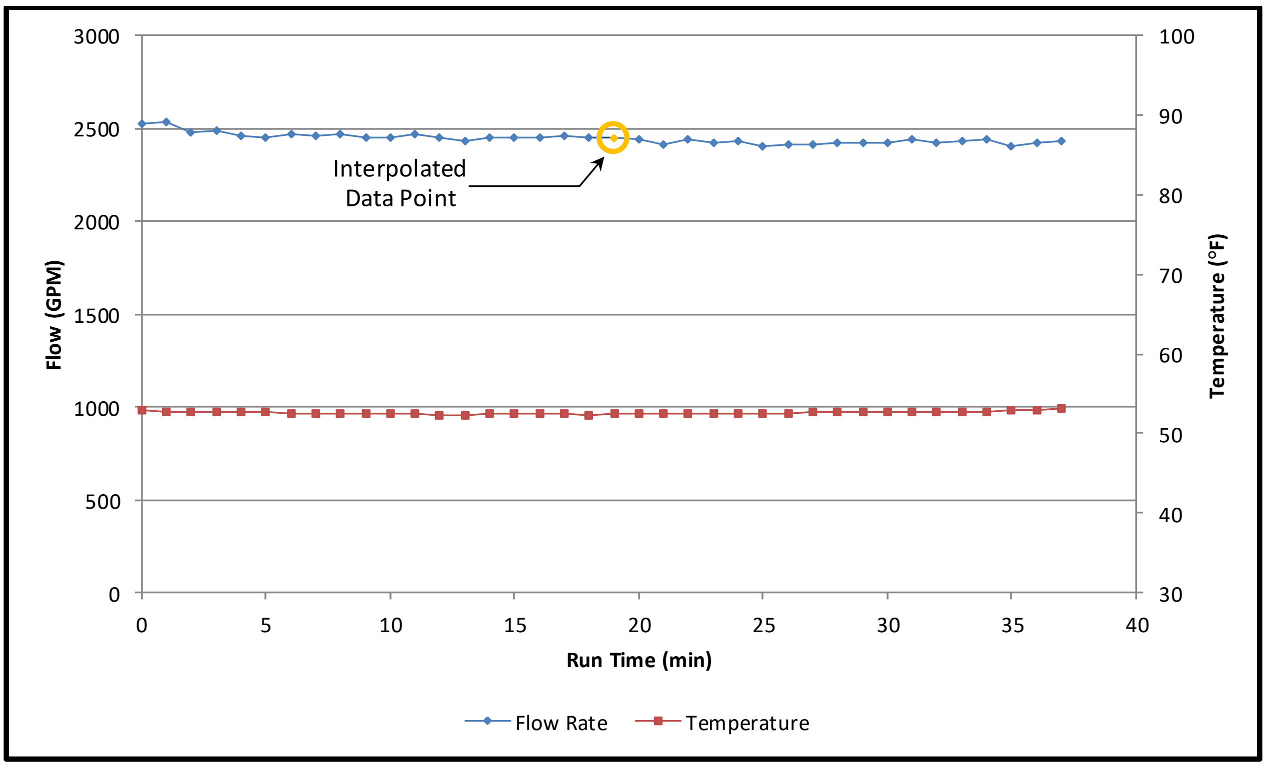

Figure 15 Water Flow and Temperature - 125% MTFR STSS-4

Table 25 Sediment Feed Summary – 125% MTFR STSS-4

Sediment Feed (g) – Sampling Time 0.5 min		Sediment Mass Balance	
1	917.949	Starting Weight of Sediment (lbs.)	300.00
2	894.979		
3	890.201	Recovered Weight of Sediment (lbs.)	155.23
4	854.205		
5	869.684	Mass of Sediment Used (lbs.)	144.77
6	884.004	Volume of Water Through MTD During Dosing (gal)	85,233
Average	885.170		
COV	0.025	Average Influent Sediment Concentration (mg/L)	187.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 26 SSC and Removal Efficiency - 125% MTFR STSS-4

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	78.0	78.4	86.0	93.5	78.0	85.5	82.8	81.0	86.5	93.3	87.0	86.3	89.8	78.5	97.8
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	76.0	76.4	84.0	91.5	76.0	83.5	80.8	79.0	84.5	91.3	85.0	84.3	87.8	76.5	95.8

Average Adjusted Effluent Concentration	83.5 mg/L	Removal Efficiency	**55.4%**

Annualized Weighted Removal Efficiency

The annualized weighted removal efficiency for sediment in stormwater has been calculated using the rainfall weighting factors provided in the NJDEP laboratory test protocol. The STSS-4 annual weighted removal for a MTFR of 1940 gpm is 54.5%, as shown in **Table 27**.

Table 27 Annualized Weighted Removal Efficiency for STSS-4

%MTFR	Removal Efficiency (%)	Annual Weighting Fact	Weighted Removal Efficiency (%)
25	52.1	0.25	13.0
50	54.3	0.30	16.3
75	56.3	0.20	11.3
100	56.0	0.15	8.4
125	55.4	0.10	5.5
Annualized Weighted Removal Efficiency			**54.5%**

STSS – 1 Removal Efficiency

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

25% MTFR

Table 28 Sampling Schedule - 25% MTFR STSS-1

Runtime (min)	Sampling Schedule		
	Sediment Feed	Background	Effluent
0	1		
98.30		1	1
99.30			2
100.30	2	2	3
198.60			4
199.60		3	5
200.60	3		6
298.90		4	7
299.90			8
300.90	4	5	9
399.20			10
400.20		6	11
401.20	5		12
499.50		7	13
500.50			14
501.50	6	8	15
502.50	End of Testing		
MTD Detention Time = 32.433 minutes Sediment Sampling Time = 1 minute			

Table 29 Water Flow and Temperature - 25% MTFR STSS-1

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	121.25	119.29	-1.62	0.011	64.3
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

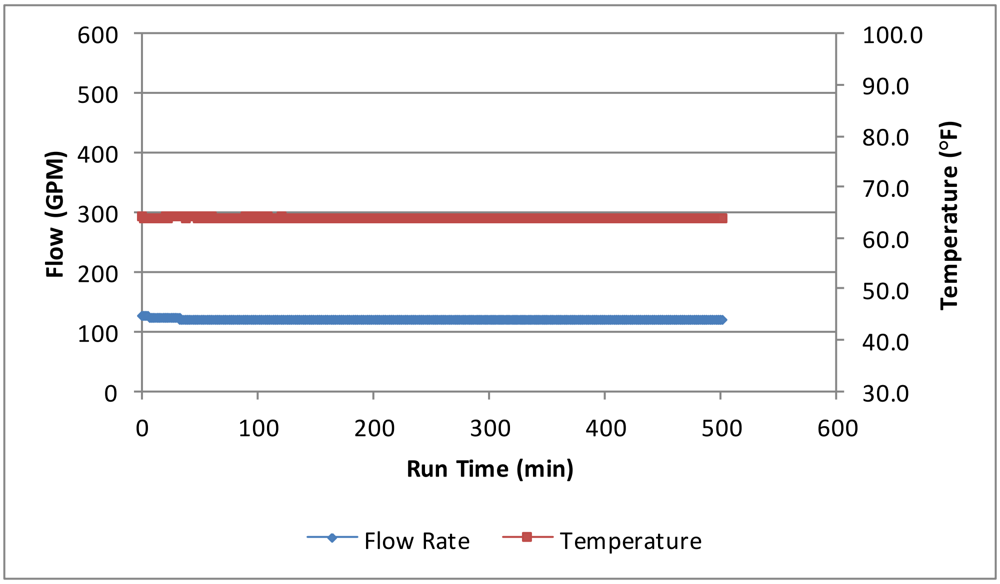

Figure 16 Water Flow and Temperature - 25% MTFR STSS-1

Table 30 Sediment Feed Summary – 25% MTFR STSS-1

Sediment Feed (g) – Sampling Time 1 min		Sediment Mass Balance	
1	95.494	Starting Weight of Sediment (lbs.)	200.06
2	97.591		
3	91.387	Recovered Weight of Sediment (lbs.)	91.87
4	103.444		
5	97.109	Mass of Sediment Used (lbs.)	108.19
6	95.704	Volume of Water Through MTD During Dosing (gal)	59,223
Average	96.788		
COV	0.041	Average Influent Sediment Concentration (mg/L)	216.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 31 SSC and Removal Efficiency - 25% MTFR STSS-1

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	90.0	89.0	90.4	91.2	90.4	90.4	91.6	91.8	92.2	90.0	90.0	81.8	94.2	31.6	79.0
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	88.0	87.0	88.4	89.2	88.4	88.4	89.6	89.8	90.2	88.0	88.0	79.8	92.2	29.6	77.0
Average Adjusted Effluent Concentration				83.6 mg/L			Removal Efficiency						**61.4%**		

50% MTFR

Table 32 Sampling Schedule - 50% MTFR STSS-1

Runtime (min)	**Sampling Schedule**		
	Sediment Feed	**Background**	**Effluent**
0	1		
49.65		1	1
50.65			2
51.65	2	2	3
101.30			4
102.30		3	5
103.30	3		6
152.95		4	7
153.95			8
154.95	4	5	9
204.60			10
205.60		6	11
206.60	5		12
256.25		7	13
257.25			14
258.25	6	8	15
259.25	End of Testing		
MTD Detention Time = 16.217 minutes Sediment Sampling Time = 1 minute			

Table 33 Water Flow and Temperature - 50% MTFR STSS-1

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	242.5	243.1	0.25	0.017	67.0
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

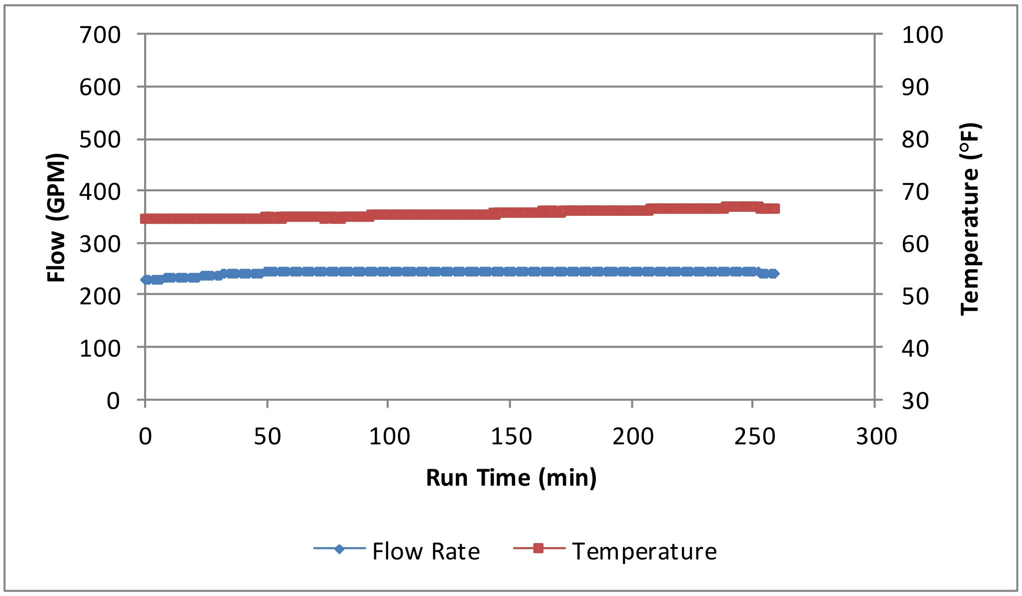

Figure 17 Water Flow and Temperature - 50% MTFR STSS-1

Table 34 Sediment Feed Summary – 50% MTFR STSS-1

Sediment Feed (g) – Sampling Time 1 min		Sediment Mass Balance	
1	201.450	Starting Weight of Sediment (lbs.)	200.00
2	192.171		
3	199.959	Recovered Weight of Sediment (lbs.)	92.39
4	191.570		
5	201.472	Mass of Sediment Used (lbs.)	107.61
6	189.995	Volume of Water Through MTD During Dosing (gal)	61,562
Average	196.103		
COV	0.028	Average Influent Sediment Concentration (mg/L)	204.4*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 35 SSC and Removal Efficiency - 50% MTFR STSS-1

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	85.2	90.4	89.2	92.2	91.6	93.8	97.4	94.2	96.2	92.8	90.4	89.4	96.4	84.2	95.4
Background	3.6		3.2		2		2		2		2		2		2
Adjusted Effluent	81.6	87.0	86.0	89.6	89.6	91.8	95.4	92.2	94.2	90.8	88.4	87.4	94.4	82.2	93.4
Average Adjusted Effluent Concentration				89.6 mg/L			Removal Efficiency						**56.2%**		

75% MTFR

Table 36 Sampling Schedule - 75% MTFR STSS-1

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
33.43		1	1
34.43			2
35.43	2	2	3
68.87			4
69.87		3	5
70.87	3		6
104.30		4	7
105.30			8
106.30	4	5	9
139.73			10
140.73		6	11
141.73	5		12
175.17		7	13
176.17			14
177.17	6	8	15
178.17	End of Testing		
MTD Detention Time = 10.811 minutes Sediment Sampling Time = 1 minute			

Table 37 Water Flow and Temperature - 75% MTFR STSS-1

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	363.8	352.5	-3.12	0.024	68.6
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

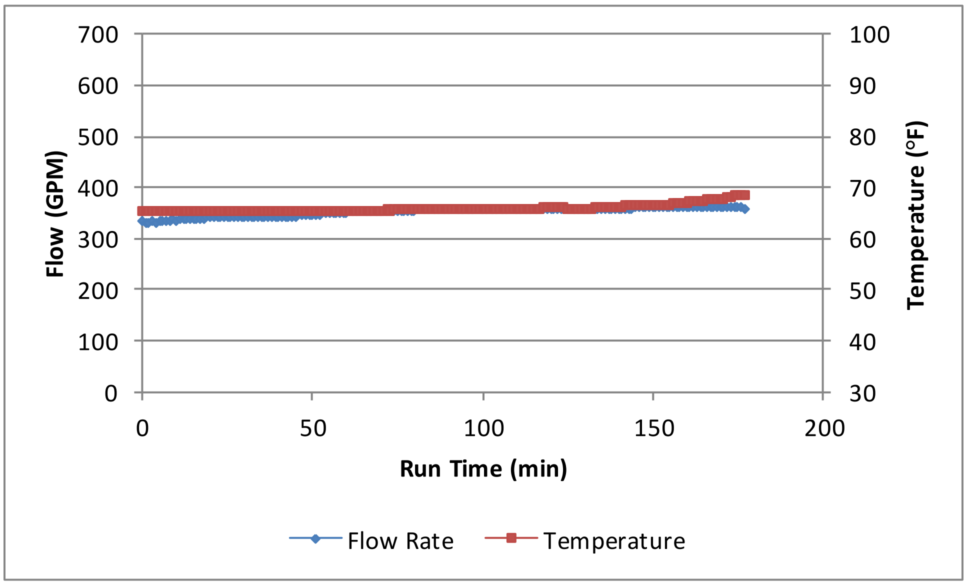

Figure 18 Water Flow and Temperature - 75% MTFR STSS-1

Table 38 Sediment Feed Summary – 75% MTFR STSS-1

Sediment Feed(g) – Sampling Time 1 min		Sediment Mass Balance	
1	298.917	Starting Weight of Sediment (lbs.)	200.00
2	289.077		
3	284.717	Recovered Weight of Sediment (lbs.)	91.52
4	278.398		
5	270.664	Mass of Sediment Used (lbs.)	108.48
6	277.269	Volume of Water Through MTD During Dosing (gal)	60,857
Average	283.174		
COV	0.035	Average Influent Sediment Concentration (mg/L)	206.2*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 39 SSC and Removal Efficiency - 75% MTFR STSS-1

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	95.6	90.6	92.0	71.2	84.8	86.0	90.8	63.6	97.0	88.0	80.4	64.6	91.8	74.0	74.4
Background	5.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	90.6	87.1	90.0	69.2	82.8	84.0	88.8	61.6	95.0	86.0	78.4	62.6	89.8	72.0	72.4
Average Adjusted Effluent Concentration				80.7 mg/L			Removal Efficiency						**60.9 %**		

100% MTFR

Table 40 Sampling Schedule - 100% MTFR STSS-1

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
25.33		1	1
26.33			2
27.33	2	2	3
52.65			4
53.65		3	5
54.65	3		6
79.98		4	7
80.98			8
81.98	4	5	9
107.30			10
108.30		6	11
109.30	5		12
134.63		7	13
135.63			14
136.63	6	8	15
137.63	End of Testing		
MTD Detention Time = 8.111 minutes Sediment Sampling Time = 1 minute			

Table 41 Water Flow and Temperature - 100% MTFR STSS-1

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	485.0	480.9	-0.837	0.012	75.4
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

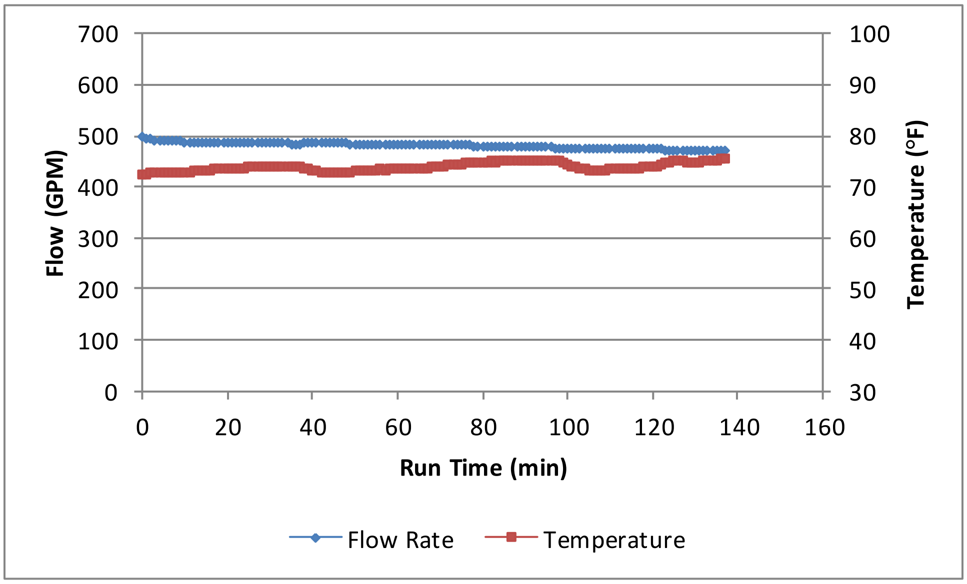

Figure 19 Water Flow and Temperature - 100% MTFR STSS-1

Table 42 Sediment Feed Summary – 100% MTFR STSS-1

Sediment Feed (g) – Sampling Time 1 min		Sediment Mass Balance	
1	377.391	Starting Weight of Sediment (lbs.)	225.00
2	366.289		
3	339.324	Recovered Weight of Sediment (lbs.)	119.10
4	332.231		
5	354.156	Mass of Sediment Used (lbs.)	105.9
6	345.130	Volume of Water Through MTD During Dosing (gal)	63,293
Average	352.420		
COV	0.048	Average Influent Sediment Concentration (mg/L)	191.7*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 43 SSC and Removal Efficiency - 100% MTFR STSS-1

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	85.6	71.4	86.6	72.0	84.2	89.6	91.2	91.2	93.4	93.8	95.0	94.4	96.4	99.2	99.2
Background	4.0		4.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	81.6	67.4	82.6	69.0	82.2	87.6	89.2	89.2	91.4	91.8	93.0	92.4	94.4	97.2	97.2
Average Adjusted Effluent Concentration				87.1 mg/L			Removal Efficiency						**54.6%**		

125% MTFR

Table 44 Sampling Schedule - 125% MTFR STSS-1

Runtime (min)	**Sampling Schedule**		
	Sediment Feed	**Background**	**Effluent**
0	1		
20.46		1	1
21.46			2
22.46	2	2	3
42.92			4
43.92		3	5
44.92	3		6
65.38		4	7
66.38			8
67.38	4	5	9
87.84			10
88.84		6	11
89.94	5		12
110.30		7	13
111.30			14
112.30	6	8	15
113.30	End of Testing		
MTD Detention Time = 6.487 minutes Sediment Sampling Time = 1 minute			

Table 45 Water Flow and Temperature - 125% MTFR STSS-1

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	606.3	590.7	-2.56	0.006	70.9
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

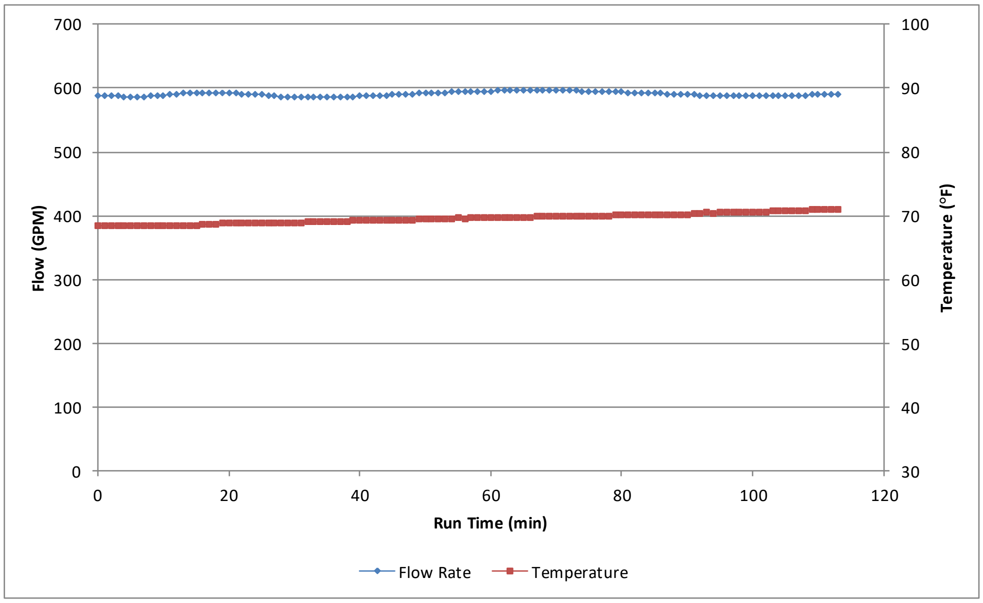

Figure 20 Water Flow and Temperature - 125% MTFR STSS-1

Table 46 Sediment Feed Summary – 125% MTFR STSS-1

Sediment Feed (g) – Sampling Time 0.5 min		Sediment Mass Balance	
1	466.789	Starting Weight of Sediment (lbs.)	200.00
2	458.106		
3	451.155	Recovered Weight of Sediment (lbs.)	86.53
4	463.463		
5	461.581	Mass of Sediment Used (lbs.)	113.47
6	486.450	Volume of Water Through MTD During Dosing (gal)	63,387
Average	464.591		
COV	0.026	Average Influent Sediment Concentration (mg/L)	202.9*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 47 SSC and Removal Efficiency - 125% MTFR STSS-1

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	88.0	90.2	101	92.2	85.4	95.8	95.2	99.0	99.6	104	98.6	97.2	88.6	97.4	98.2
Background	6.0		2		2		2		2		2		2		2
Adjusted Effluent	82.0	86.2	99.0	90.2	83.4	93.8	93.2	97.0	97.6	102	96.6	95.2	86.6	95.4	96.2
Average Adjusted Effluent Concentration				93.0 mg/L			Removal Efficiency						**54.2%**		

Annualized Weighted Removal Efficiency

The annualized weighted removal efficiency for sediment in stormwater has been calculated using the rainfall weighting factors provided in the NJDEP laboratory test protocol. The STSS-1 annual weighted removal for a MTFR of 485 gpm is 58.1%, as shown in **Table 48.**

Table 48 Annualized Weighted Removal Efficiency for STSS-1

%MTFR	Removal Efficiency (%)	Annual Weighting Fact	Weighted Removal Efficiency (%)
25	61.4	0.25	15.4
50	56.2	0.30	16.9
75	60.9	0.20	12.2
100	54.6	0.15	8.2
125	54.2	0.10	5.4
Annualized Weighted Removal Efficiency			**58.1%**

Since the annualized weighted removal efficiency of the STSS-1 is within five percentage points of the STSS-4 weighted removal efficiency as required by the NJDEP Protocol, an alternative scaling methodology, based on deductive reasoning, is considered valid. The alternative scaling methodology, attributes 58.1% sediment removal efficiency to plate 1, and 53.3% to subsequent perforated-opening/plate additions. For the STSS-4 this results in the sediment removal efficiency of 54.5% {54.5 = ¼ (58.1) + ¾ (53.3)}. One can then readily calculate the anticipated removal efficiency for other STSS models (STSS-11 = 53.7%; STSS-18 = 53.6%).

4.2 Scour Testing

Scour testing was conducted in accordance with Section 4 of the NJDEP Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation MTD. Testing was conducted at a target flow rates of 1,050 (STSS-1) and 4,200 (STSS-4) gpm, over 200% of the maximum treatment flow rate (MTFR).

Scour testing began by increasing the flow rate to the target flow within a 5-minute period. Effluent and background samples were taken from the same locations as for the removal efficiency testing, starting less than 5 minutes after flow was initiated. The sampling frequency is summarized in **Table 49**.

Table 49 Scour Test Sampling Frequency

Sample/ Measurement Taken	Run Time (min.)														
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**
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

Note: The Run time of 0 minutes is the time the 1st set of samples was taken, following the flow equilibration period.

Table 50 Water Flow and Temperature – STSS-1 and STSS-4 Scour Tests

Scour Test	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
STSS-1	1,050	1,151	9.6	0.004	71.6
STSS-4	4,200	4,182	-0.4%	0.017	57.6
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

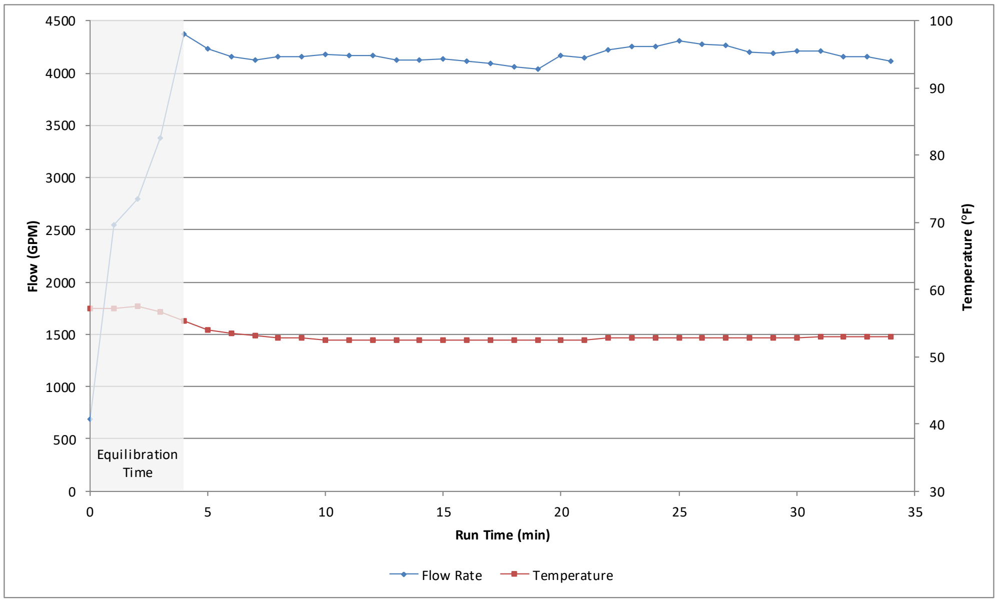

Figure 21 Water Flow and Temperature for STSS-4 Scour Test

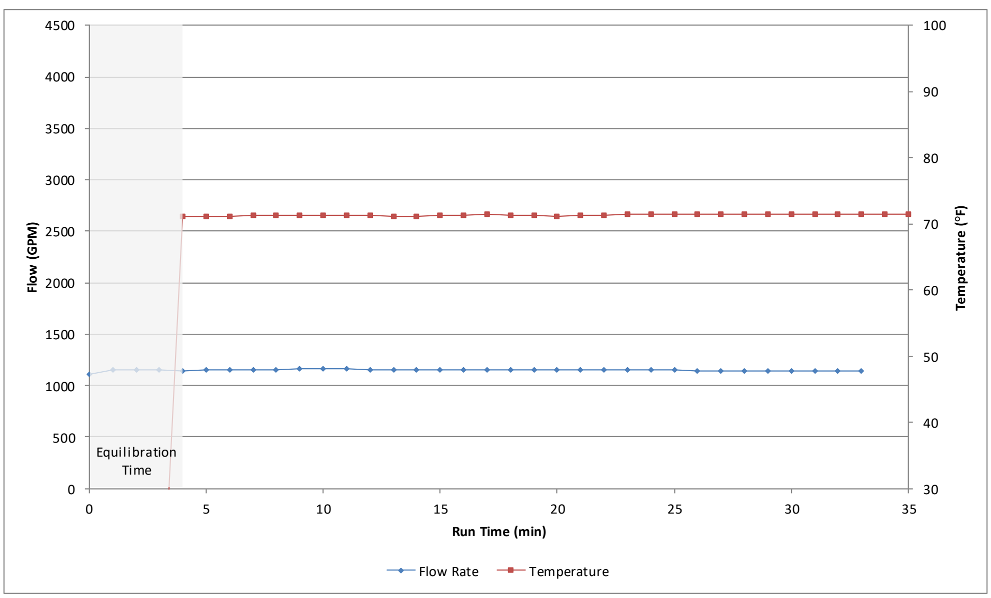

Figure 22 Water Flow and Temperature for STSS-1 Scour Test

The effluent and background SSC results are reported in **Table 51** and **Table 52**. The adjusted effluent concentration was calculated as:

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

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 7.0 mg/L for the STSS-4 and 12.1 mg/L for the STSS-1; therefore, when operated at 200% of the MTFR, the StormTrap SiteSaver meets the criteria for online use.

Table 51 Suspended Sediment Concentrations for STSS-4 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	13.3	13.5	12.0	12.5	8.50	10.3	9.60	11.0	9.50	8.50	7.50	8.50	8.00	7.80	6.00
Background	3.5		2.4		2.5		3.0		2.75		2.75		2.5		3.0
Adjusted Effluent	9.8	10.6	9.6	10.1	6.0	7.6	6.6	8.1	6.8	5.8	4.8	5.9	5.5	5.0	3.0
Average Adjusted Effluent Concentration	**7.0 mg/L**														

Table 52 Suspended Sediment Concentrations for STSS-1 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	38.4	27.8	23.0	18.6	15.4	11.6	11.6	9.6	8.2	8.0	8.4	8.2	7.8	6.8	7.6
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	36.4	25.8	21.0	16.6	13.4	9.6	9.6	7.6	6.2	6.0	6.4	6.2	5.8	4.8	5.6
Average Adjusted Effluent Concentration	**12.1 mg/L**														

5. Design Limitations

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

Soil Characteristics

StormTrap specifies that stone backfill be used. SiteSaver modules are typically placed on a level, 6” foundation of ¾” aggregate extending 2’-0” past the outside of the system in accordance with ASTM C891 “Standard practice for installation of underground precast utility structures”. Native soils can be used as backfill provided that StormTrap engineers review the soil characteristics prior to installation to confirm that the native material conforms to the backfill specifications.

Slope of Drainage Pipe

There are no specific drainage pipe slope limitations provided that both the inlet and outlet pipe elevations are identical. When utilizing a netting bag to contain floating debris, it is recommended that the inflow velocity be below 7 ft/sec. If the inflow velocity exceeds 7 ft/sec contact StormTrap for design options to accommodate the larger inflow velocity.

Maximum Treatment Flow Rate

The maximum treatment flow rate (MTFR) for StormTrap SiteSaver models is based upon the quantity of plates utilized. Each plate can accommodate 1.08 cfs (485 gpm) per plate based upon the tested particle size therefore; the MTFR of an STSS-1 is 1.08 cfs (485 gpm) and 4.32 cfs (1940 gpm) for the STSS-4. StormTrap engineers can assist with site design engineers to ensure an appropriate design.

Maintenance Requirements

SiteSaver systems should be inspected and maintained following the recommendations and guidelines included in the current SiteSaver® Manufacturer’s Instruction Manual at: http://stormtrap.com/products/sitesaver/sitesaver-maintenance-manual/

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

Driving Head

The SiteSaver does not require a certain driving head to operate effectively.

Installation Limitations

StormTrap will provide contractors with specific pick weights prior to delivery.

Configurations

It is recommended that the SiteSaver be installed inline. StormTrap advises draining multiple inlets to the SiteSaver. This method shifts maintenance from multiple inlets to maintenance at a single point in order to ease site maintenance and reduce maintenance frequencies.

Structural Load Limitations

Standard SiteSaver modules are designed for HS-20 loading. Contact StormTrap if design loadings are anticipated to exceed HS-20.

Pre-treatment Requirements

The SiteSaver has no pre-treatment requirements.

Depth to Seasonal High-Water Table

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

6. Maintenance Plans

Regular inspections are recommended to ensure that the system is functioning as designed. Please contact your Authorized SiteSaver Representative if you have questions regarding the inspection and maintenance of the SiteSaver system. SiteSaver does not require entry into the system for maintenance; however, it is prudent to note that prior to entry into any underground storm sewer or underground structure, appropriate OSHA and local safety regulations and guidelines should be followed.

Inspection Scheduling

SiteSaver systems are recommended for inspection whenever the upstream and downstream catch basins and stormwater pipes of the stormwater collection system are inspected or maintained. This will economize the cost of the inspection if it is done at the same time. If inspected on an annual basis, the inspection should be conducted before the stormwater season begins to ensure that the system is functioning properly for the upcoming storm season.

Inspection Process

Inspections should be done such that enough time has lapsed since the most recent rain event to allow for a static water condition. Visually inspect the system at all manhole locations. For debris accumulation, visually inspect the netting component (if utilized) to determine bag capacity. For sediment accumulation, utilize a sediment pole to measure and document the amount of sediment accumulation. To determine the amount of sediment in the system first insert the pole to the top of the sediment layer and record the depth. Then, insert the pole to the bottom of the system and record the depth. The difference in the two measurements corresponds to the amount of sediment in the system. Eight-inches of sediment accumulation corresponds to the maximum sediment storage capacity. NJDEP requires sediment removal on or before it reaches a maximum depth of 4-inches (50% of the MTD's maximum storage depth). Finally, inspect the inlet pipe opening to ensure that the silt level or any foreign objects are not blocking the pipe.

Maintenance Process

Maintenance should be done such that enough time has lapsed since the most recent rain event to allow for a static water condition for the duration of the maintenance process. For floatable debris removal, remove the netting bag by lifting the bag by the netting frame moving it upwards along the netting support frame. Once the netting component is fully removed from the system, it should be properly disposed of per local, state, and federal guidelines and regulations. Typically, the netting component can be disposed of in a common dumpster receptacle. For sediment removal, the SiteSaver is designed with clear access at both the inlet and outlet. A vacuum truck, or similar trailer mounted equipment, can be used to remove the sediment, hydrocarbons, and water within the unit. For more effective removal it is recommended to use sewer jetting equipment or a spray lance to force the sediment to the vacuum hose. When the floor is sufficiently cleaned, fill the system back to its normal water elevation (to the pipe inverts) Finally, install a new net assembly by sliding the netting frame down the support frame and ensure the netting lays over the plate assembly. Secure the access openings and properly dispose of the sediment per local, state, and federal guidelines and regulations.

Proof of inspections and maintenance is the responsibility of the owner. All inspection reports and data should be kept on site or at a location where they will be accessible for years in the future. Some municipalities require these inspection and cleaning reports to be forwarded to the proper governmental permitting agency on an annual basis. Refer to your local and national regulations for any additional maintenance requirements and schedules not contained herein. Inspections should be a part of the standard operating procedure.

7. Statements

The following attached pages are signed statements from the manufacturer (StormTrap), the independent observer (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.

October 8, 2018

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

Subject: Submittal of laboratory verification report for SiteSaver STSS-4 & STSS-1

Dear Dr. Magee,

StormTrap Inc. certifies that the protocol requirements of "New Jersey Deparment of Environment Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device", dated January 25, 2013, were met or exceeded.

Sincerely,

StormTrap Inc.

Dan Fajman

General Manager – Water Quality

PHONE 815 941 4663
FAX 331 318 5347
WEB www.stormtrap.com
EMAIL info@stormtrap.com
1287 Windham Parkway
Romeoville, Illinois 60446

Good Harbour Laboratories

September 11, 2018

Dr. Greg Williams, Managing Director
Good Harbour Laboratories Ltd.
2596 Dunwin Dr.
Mississauga, ON L5L 1J5

Dr. Richard Magee
Executive Director
New Jersey Corporation for Advancement of Technology

RE: Third party observation of testing of the StormTrap (formerly FreshCreek Technologies) STSS-4 and STSS-1 according to the **New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device (January 25, 2013)**

Dear Dr. Magee,

This purpose of this letter is to confirm that Good Harbour Laboratories staff, specifically Joe Costa, De Wu Zhang or I, witnessed all of the STSS-4 and STSS-1 testing that is included in the report **NJCAT TECHNOLOGY VERIFICATION StormTrap SiteSaver® Hydrodynamic Separator, StormTrap LLC (September 2018)**. Testing was conducted at the client's facility in Morris, Illinois from October 2016 to August 2018. Although the test set up changed slightly over the course of the testing program, I can attest that all the testing was done in accordance with the above referenced protocol, as required by the **Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology, for use in accordance with the Stormwater Management Rules N.J.A.C. 7:8 (January 25, 2013).**

Prior to each round of testing we confirmed that the instrumentation being used was calibrated and we witnessed the blending of sediment delivered from Agsco directly to StormTrap. All sediment was sealed and unsealed under supervision. GHL staff also took physical measurements and pictures of the test set up.

During the testing we witnessed the sampling during every run and verified all mass measurements. We also verified all sample bottle labels and confirmed the chains of custody for all analyzed samples.

Good Harbour Laboratories

After the testing I reviewed all of the data, calculations and conclusions contained in the report. I can confirm that the report accurately represents what we observed. Furthermore, GHL has retained copies of the background data, field notes, analytical reports and calibration certificates, as well as the calculations, in an independent and secure location on the GHL server. This supporting information is available to you upon request.

Sincerely,

Greg Williams

Greg Williams, Ph.D., P.Eng.

CC: Dan Fajman, StormTrap LLC

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A: 2596 Dunwin Drive, Mississauga, ON L5L 1J5
www.goodharbourlabs.com

Good Harbour Laboratories

September 11, 2018

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

Re: Performance Verification of the StormTrap SiteSaver STSS-4 & STSS-1

Dear Dr. Magee,

Good Harbour Laboratories was contracted by StormTrap LLC to witness the performance testing of their STSS-4 and STSS-1 hydrodynamic separators in accordance with New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January, 2013).

Good Harbour Laboratories (GHL), a wholly owned subsidiary of Monteco Ltd., is an independent hydraulic test facility located in Mississauga, Ontario, Canada. 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 and Monteco, confirm:

-that I do not have any conflict of interest in connection to the contracted testing. Potential conflict of interest may arise in particular as a result of economic interests, political or national affinities, family or emotional ties, or any other relevant connection or shared interest;

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

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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 award of the contract.

Sincerely, Date

Greg Williams Sep. 11/18

Dr. Greg Williams, P.Eng.
Managing Director
Good Harbour Laboratories

CC: Dan Fajman, StormTrap LLC

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Center for Environmental Systems

Stevens Institute of Technology

One Castle Point

Hoboken, NJ 07030-0000

October 04, 2018

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 two full-scale, commercially available StormTrap SiteSaver hydrodynamic separators at StormTrap facility in Morris, IL, with Good Harbour Laboratories providing independent third-part oversight, 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 Filter Protocol, January 2013) were met consistent with the NJDEP Approval Process. Specifically:

Test Units

The two full-scale commercially available test units had an MTFR difference of 400% satisfying an MTFR difference of at least 250% to validate an alternative scaling methodology.

Test Sediment Feed

The test sediment used for the removal efficiency testing was a custom blend of commercially available silica sediments. The sediment was blended by StormTrap in multiple batches using a cement mixer. The particle size distribution was independently verified by Interra in Bolingbrook, IL certifying that the supplied silica meets the specification within tolerance as described in Section 5B of the NJDEP protocol and was acceptable for use. The d_{50} of the sediment was <50 µm, significantly less than the NJDEP specification of <75 µm.

Scour Test Sediment

The test sediment used for the scour study was supplied by AGSCO Corporation and sent to Interre for particle size distribution analysis. The scour test sediment was finer than required by the NJDEP test protocol and therefore acceptable for use.

Removal Efficiency Testing

The weighted sediment removal efficiency of the STSS-1 (MTFR 485 gpm) was 58.1%, while the weighted sediment removal efficiency of the STSS-4 (MTFR 1940 gpm) was 54.5%. Since the removal efficiencies were within five percent, an alternative scaling methodology based on deductive reasoning (algebraic extrapolation) was validated.

Scour Testing

Scour testing of the STSS-1 at 1,050 gpm (216% MTFR) resulted in an average effluent concentration of 12.1 mg/L and for the STSS-4 at 4182 gpm (216% MTFR) an average effluent concentration of 7.0 mg/L, qualifying the StormTrap SiteSaver for online installation.

Sincerely,

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

8. References

1. NJDEP 2013. New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology. January 25, 2013.

2. 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.

VERIFICATION APPENDIX

Introduction

- Manufacturer: StormTrap, Inc., 1287 Windham Parkway, Romeoville, Illinois, 60446. *General Phone: (815) 941-4549*. Website: www.stormtrap.com.

- MTD: StormTrap SiteSaver®. Verified SiteSaver® models are shown in **Table A-1**.

- TSS Removal Rate: 50%

- Offline or Online installation

Detailed Specification

- NJDEP sizing tables attached as **Table A-1**

- StormTrap provides contractors with project-specific unit pick weights and installation instructions as warranted prior to delivery.

- Maximum recommended sediment depth prior to cleanout is 4 inches.

- Maintenance frequency varies between models and is shown in **Table A-1**.

- A SiteSaver® Maintenance Instruction Manual is available at: http://stormtrap.com/products/sitesaver/sitesaver-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 SiteSaver® to be used in series with another hydrodynamic separator to achieve an enhanced TSS removal rate.

Table A-1 MTFRs and Required Sediment Removal Intervals for StormTrap SiteSaver® Models			
StormTrap SiteSaver Models[1]	**Number of Inclined Plates**	**NJDEP TSS MTFR[2] (cfs)**	**Required Sediment Removal Interval (months)[3]**
STSS-1	**1**	**1.08**	**186**
STSS-2	**2**	**2.16**	**93**
STSS-3	**3**	**3.24**	**62**
STSS-4	**4**	**4.32**	**47**
STSS-5	**5**	**5.40**	**37**
STSS-6	**6**	**6.48**	**31**
STSS-7	**7**	**7.56**	**27**
STSS-8	**8**	**8.64**	**23**
STSS-9	**9**	**9.72**	**21**
STSS-10	**10**	**10.80**	**19**
STSS-11	**11**	**11.88**	**17**
STSS-12	**12**	**12.96**	**16**
STSS-13	**13**	**14.04**	**14**
STSS-14	**14**	**15.12**	**13**
STSS-15	**15**	**16.20**	**12**
STSS-16	**16**	**17.28**	**12**
STSS-17	**17**	**18.36**	**11**
STSS-18	**18**	**19.44**	**10**

[1]Physical exterior (6.83’W x 15’L) and interior (6’W x 14’L) dimensions are the same for all StormTrap SiteSaver models.

[2]Based on 1.08 cfs per inclined plate.

[3] Sediment removal intervals calculated using the equation specified in Appendix A, Section B of the NJDEP HDS protocol.