NJCAT TECHNOLOGY VERIFICATION

BaySaver Barracuda™ Hydrodynamic Separator

BaySaver Technologies, LLC

September 2017

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1. Description of Technology

The BaySaver Barracuda Hydrodynamic Separator (BaySaver Barracuda) is a manufactured stormwater treatment device that removes suspended solids from stormwater runoff. The device is an insert that can be installed in either a polypropylene plastic pipe or concrete vault, and consists of a cone (vortex separator) and a sump apparatus with protrusions (extending horizontally into the sump area) which are referred to as "teeth".

Stormwater is directed to a cone-shaped (vortex) device inside the unit, which allows denser particles (greater density than the surrounding water) to move to the center of the device where they settle to the bottom. A weir prevents inflowing water from bypassing the vortex separator. Once water has flowed through the vortex and a majority of sediment has settled out into the sump, the effluent water rises to the outlet pipe, which is at virtually the same elevation as the inlet pipe. The "teeth" affixed to the inside walls of the sump reduce the velocity of the water in the vortex flow pattern below the cone and effectively reduce re-suspension of sediment in the sump, allowing the accumulated sediment to be retained within the unit. (**Figure 1**)

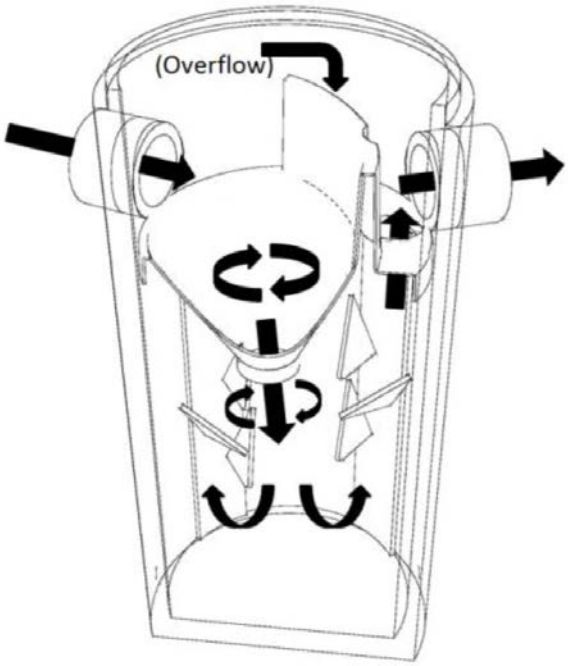

Figure 1 BaySaver Barracuda Flow Path Diagram

2. Laboratory Testing

The BaySaver Barracuda was installed at the Mid-Atlantic Stormwater Research Center (MASWRC, a subsidiary of BaySaver) in Mount Airy, Maryland, to test the removal efficiency of total suspended solids (TSS) and the ability to retain, i.e., inhibit scour, of collected sediment. All testing and data collection procedures including sediment blending, were supervised by Boggs Environmental Consultants, Inc. (BEC), and 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) (NJDEP HDS Protocol). BEC is an independent environmental and engineering consulting company located in Middletown, Maryland. All water quality samples collected during the test program were analyzed by Fredericktowne Labs, which is an independent environmental testing laboratory. All sediment PSD samples were analyzed by ECS Mid-Atlantic, LLC, which is an independent geotechnical and environmental testing facility. Prior to the start of testing, a Quality Assurance Project Plan (QAPP) was submitted to and approved by the New Jersey Corporation for Advanced Technology (NJCAT).

2.1 Test Setup

The test unit was a full-scale commercially available BaySaver Barracuda consisting of a vortex separator, sedimentation sump, and teeth. The unit was measured at approximately 121 inches in height and 48 inches in diameter. Influent and effluent piping to the unit were 12 inches in diameter and at approximately the same inlet/outlet elevations. The total sedimentation area of this unit was 12.57 ft^2.

The test setup is shown in **Figure 2** below. The setup consisted of reservoir tanks, feed basin, pumps, flow control valves, discharge tank, BaySaver Barracuda, flow meter and temperature probe. The maximum water storage capacity of the reservoir tanks was approximately 7,000 ft^3.

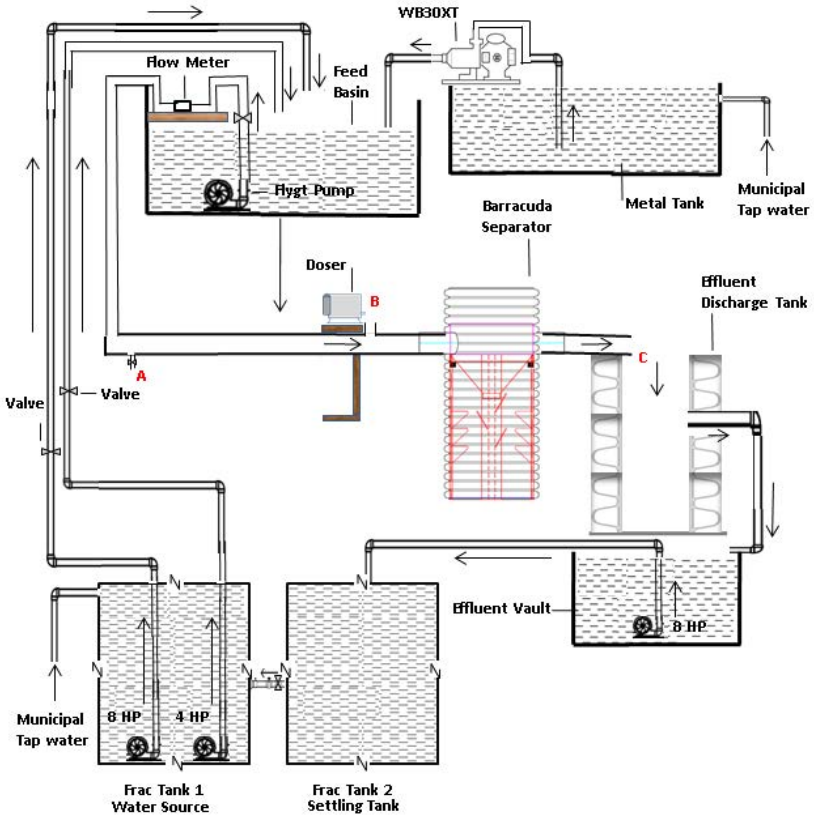

Figure 2 Diagram of the Test Facility for Scour, and 125%, and 100% MTFR Tests

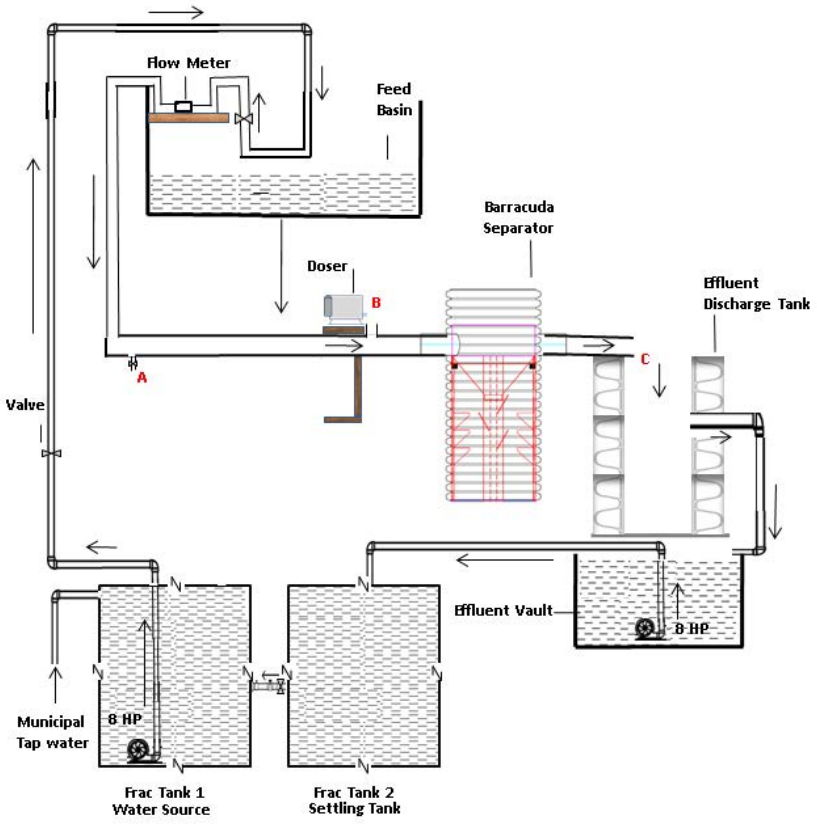

Figure 3 Diagram of the Test Facility for 75%, 50%, and 25% MTFR Tests

The letters **A**, **B**, and **C** indicate the locations where background, influent and effluent samples were collected, respectively.

Reservoir tanks, including two 18,000-gallon Frac Tanks and a 16,000-gallon metal tank, were filled with municipal tap water prior to each test run, and a PVC flow system, various flow control valves, and pumps were used to achieve each flow rate. For the higher flow rate runs (>200% MTFR scour run, 125% MTFR run and 100% MTFR run), water was pumped from the Frac Tanks and metal tank to the feed basin and a Flygt pump (27 hp) pumped water from the feed basin to the influent pipe 18 ft. upstream of the test unit. For the low flow rate runs (75% MTFR, 50% MTFR, and 25% MTFR test runs), a Godwin 8 hp pump pumped water from the Frac Tank to the same flow line as shown in **Figure 3**. Flow rates were controlled using throttling valves located on the discharge side of the pumps. Test sediment was dry fed through a 6-in. port at the crown of the 12-in. inlet pipe at a distance of 5 ft. upstream of the test unit. For all testing, flow rate was measured using a FloCat MFE electromagnetic flow meter and recorded once per minute by a SeaMetrics DL76 data logger. The flow meter was installed approximately 33 feet upstream of the BaySaver Barracuda in a "U" configuration according to manufacturer recommendations to ensure pipe-full condition. For all testing, flow exited the BaySaver Barracuda into the Effluent Discharge Tank. For water conservation purposes during the scour test (>200%) and 125% MTFR removal efficiency test (after clean water from Frac Tank 2 was diverted to Frac Tank 1 for use during the run) the water from the Effluent Discharge Tank was

pumped to Frac Tank 2 and allowed to settle overnight before being used for testing the next day. For all other flow rates, water from the Effluent Discharge Tank was discharged into the sewer.

A HOBO temperature probe and data logger were located in the feed basin for 200%, 125%, and 100% MTFR testing and located in Frac Tank 1 for 75%, 50%, and 25% MTFR testing. Temperature measurements were recorded once per minute during each test run.

Background samples were collected in a 1000-mL bottle from a sampling port (Letter **A**) approximately 12 feet upstream from the sediment injection port. The port was controlled by a 1.5-inch ball valve with a 1.5-inch PVS pipe extending downward 4 ft below the bottom of the inlet pipe and purged several seconds before sample collection.

Effluent water flowed freely into the Effluent Discharge Tank (Letter **C**) at which point effluent samples were grabbed by hand by sweeping a 1000-mL bottle through the flow stream.

Sediment was added to the system via an Acrison volumetric screw auger through the crown of the 12-inch diameter inlet pipe (Letter **B**) approximately 5-feet upstream from the BaySaver Barracuda. Sediment feed samples were collected for an interval timed to the nearest second in 1000-mL plastic containers and then weighed on an analytical balance.

2.2 Test Sediment

Test Sediment for Removal Efficiency Testing

The test sediment used for removal efficiency testing was a blend of high purity commercially available silica sediment. The blend ratio was determined such that the particle size distribution of the blended sediment would meet the specifications outlined in the NJDEP HDS protocol. Prior to the start of testing, a surplus of test sediment was blended in one batch to be used for all five removal efficiency test runs. Six random samples from the batch were collected and composited under the direct supervision of BEC, and then three sub-samples were collected from the composite sample to be sent to ECS Mid-Atlantic, LLC, for PSD analysis using method ASTM D422-63. The PSD test results are summarized below in **Table 1** and **Figure 4**.

Table 1 Particle Size Distribution of Removal Efficiency Test Sediment

Particle Size (um)	Test Blend % Finer by Mass				
	NJDEP Target	Sample A	Sample B	Sample C	Average
1000	100	99.0	100.0	100.0	**99.7**
500	95	93.7	94.4	94.4	**94.2**
250	90	89.7	89.8	89.9	**89.8**
150	75	81.1	81.2	81.0	**81.1**
100	60	63.0	62.8	62.8	**62.9**
75	50	54.6	54.5	54.7	**54.6**
50	45	51.8	52.2	52.5	**52.2**
20	35	37.7	37.6	37.5	**37.6**
8	20	20.5	20.4	20.4	**20.4**
5	10	13.4	13.3	13.4	**13.4**
2	5	4.8	4.7	4.7	**4.7**

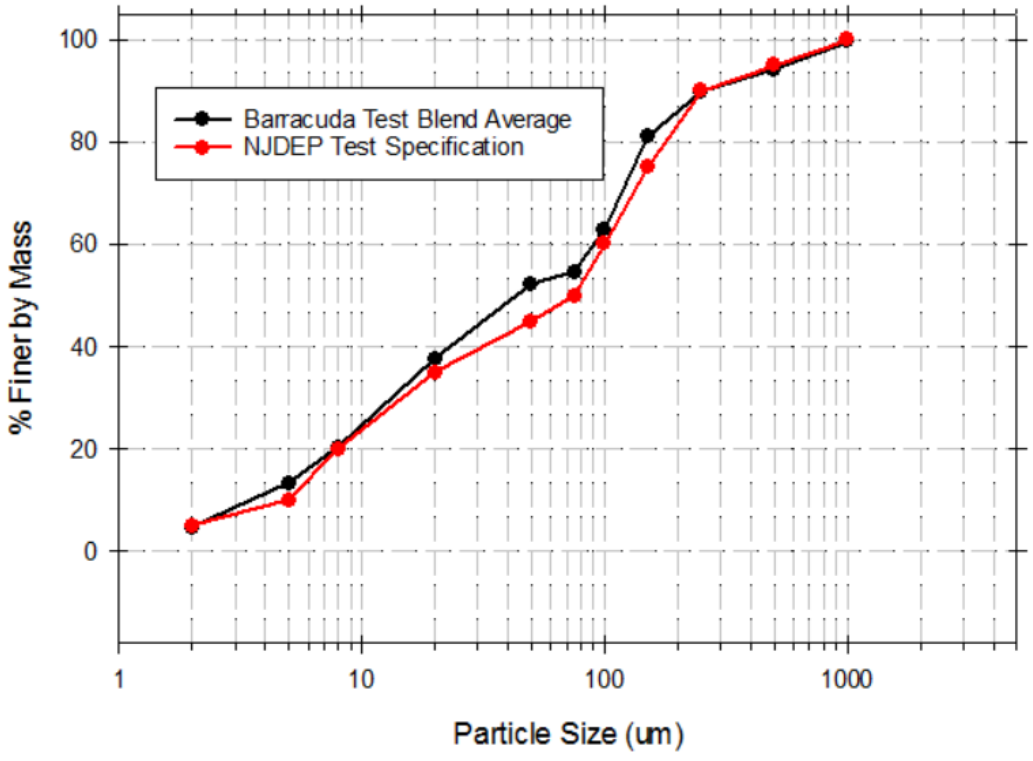

Figure 4 Average Removal Efficiency Test Sediment PSD vs. NJDEP HDS Protocol Specification

The removal efficiency test sediment was verified to be in compliance with the NJDEP HDS Protocol specification. The d_{50} of the sediment was found to be 42 μm and the sediment was finer than that required by the protocol, thus acceptable for use.

Scour Test Sediment

The test sediment used for scour testing was a blend of high purity commercially available silica sediment. The blend ratio was determined such that the particle size distribution of the blended sediment would meet the specifications outlined in the NJDEP HDS protocol. One batch of sediment was blended before the start of testing and six random samples from the batch were collected and composited under the direct supervision of BEC. Three sub-samples were then collected from the composite sample and sent to ECS Mid-Atlantic, LLC, for PSD analysis using method ASTM D422-63. The PSD results for the scour test sediment are summarized below in **Table 2** and **Figure 5**. The scour test sediment was found to be finer than the sediment required by NJDEP HDS Protocol specification and acceptable for use.

Table 2 Particle Size Distribution of Scour Test Sediment

Particle Size (um)	Test Blend % Finer by Mass				
	NJDEP Target	Sample A	Sample B	Sample C	Average
1000	100	99.9	99.9	99.9	**99.9**
500	90	88.6	88.9	88.2	**88.6**
250	55	72.6	72.2	72.8	**72.5**
150	40	55.9	55.3	56.0	**55.7**
100	25	26.0	26.3	26.2	**26.2**
75	10	11.8	11.5	11.8	**11.7**
50	0	5	4.8	4.9	**4.9**

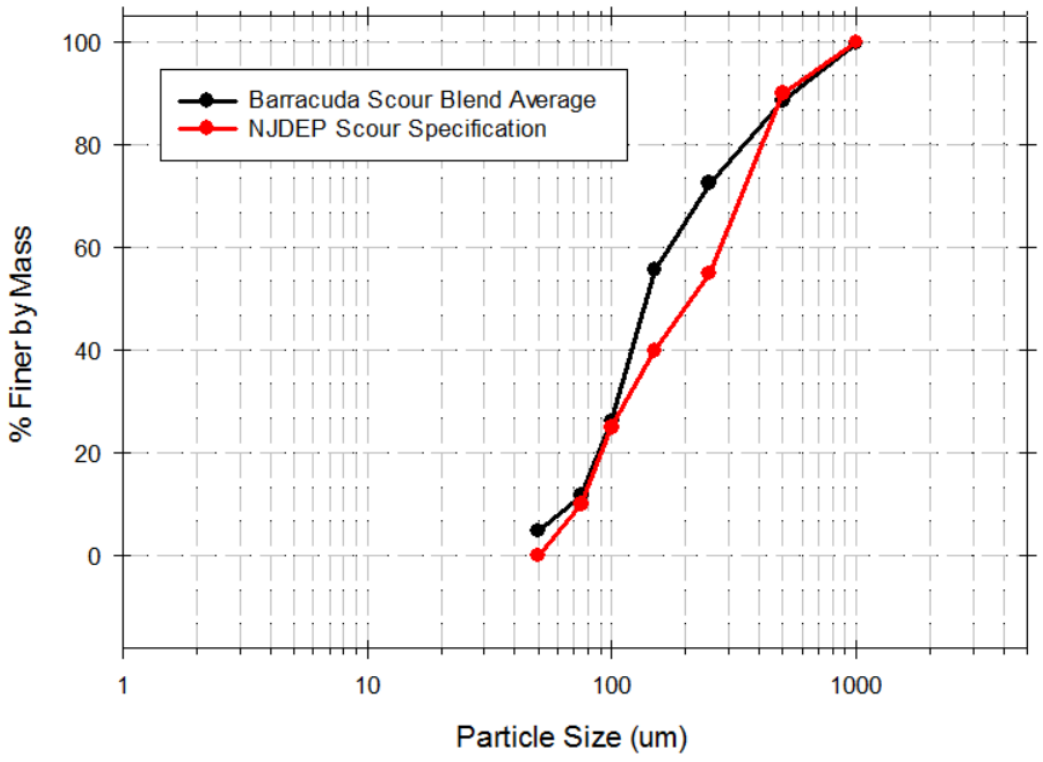

Figure 5 Average Scour Test Sediment PSD vs. NJDEP HDS Protocol Specification

2.3 Removal Efficiency Testing

Removal efficiency testing was conducted in accordance with Section 5 of the NJDEP Laboratory Protocol for HDS MTDs. A false floor was installed in the clean unit at the 50% sediment storage depth of 10-inches above the device floor. Testing was conducted at five flow rates: 25%, 50%, 75%, 100%, and 125% Maximum Treatment Flow Rate (MTFR) (142 gpm – 720 gpm) and at a target influent sediment concentration of 200 mg/L.

Test sediment was introduced to the flow stream via a volumetric screw auger within 10% of the target concentration of 200 mg/L and was sampled six times over the course of each flow rate test. Each sediment sample was collected over an interval timed to the nearest second using a Sportline P176 stopwatch in a 1000 mL plastic container for a sample volume of 100 mL or a collection time of one minute (whichever came first). Sediment feed samples were weighed on a Cole-Parmer Symmetry PR410 analytical balance (under the supervision of BEC).

The first effluent grab sample was collected following a minimum of three MTD detention times after flow rate was established and the first sediment sample was collected. Sequential effluent samples were collected every minute. When sediment feed was interrupted for measurement, the next series of sequential effluent samples were collected after three MTD detention times had

passed. Fifteen effluent samples were collected during each flow test run, and eight background samples were collected with the odd-numbered effluent samples.

2.4 Scour Testing

Before testing began, a false floor was installed 6 inches above the floor of the unit and then pre-loaded with 4 inches of leveled scour test sediment. Measurements were taken by BEC to verify that the final height of the leveled sediment simulated a 50% maximum sediment storage volume. The unit was filled with clear water to the invert of the inlet pipe, and testing began within 96 hours of pre-loading the sediment.

Testing was performed at a flow rate of 1128 gpm (2.51 cfs), slightly greater than two times the MTFR. Target flow rate was achieved within three minutes after commencement of testing, at which time the first background sample was collected. Effluent grab samples were collected every two minutes for a total of fifteen effluent samples. Eight background samples were collected at evenly time spaced intervals throughout the test.

3. Performance Claims

Per the NJDEP verification procedure and based on the laboratory testing conducted for the BaySaver Barracuda S4, the following are the performance claims made by BaySaver Technologies, LLC.

Total Suspended Solids (TSS) Removal Efficiency

For the particle size distribution and weighted calculation method required by the NJDEP HDS Protocol, the BaySaver Barracuda achieved a weighted TSS removal efficiency of at least 50% for an MTFR of 1.25 cfs (561 gpm).

Maximum Treatment Flow Rate (MTFR)

The MTFR for the BaySaver Barracuda S4 model was demonstrated to be 1.25 cfs (561 gpm) with a total sedimentation area of 12.57 ft^2, which corresponds to a surface loading rate of 44.6 gpm/ft^2 of sedimentation area.

Maximum Sediment Storage Depth and Volume

The maximum sediment storage depth is 20 inches which corresponds to 20.94 ft^3 of sediment storage volume for the BaySaver Barracuda S4 model. A sediment storage depth of 10 inches corresponds to 50% full sediment storage capacity (10.47 ft^3).

Effective Treatment and Sedimentation Area

The effective treatment and sedimentation area of the BaySaver Barracuda varies with model size, as it is dependent upon the surface area of the model diameter. The effective treatment and sedimentation area of the BaySaver Barracuda S4 model is 12.57 ft^2.

Detention Time and Volume

The BaySaver Barracuda detention time depends on flow rate and model size. The Barracuda S4 model tested had a detention time of approximately 61 seconds for a flow rate of 1.25 cfs (561 gpm). Detention time is calculated by dividing the treatment chamber wet volume by the MTFR.

On-line Installation

Based on the results of the scour testing, the BaySaver Barracuda qualifies for on-line 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. This information was provided to NJCAT and is available upon request.

4.1 Removal Efficiency Testing

Removal efficiency test runs were completed on the BaySaver Barracuda S4 at flow rates of 25%, 50%, 75%, 100%, and 125% MTFR at a target influent concentration of 200 mg/L in accordance with the NJDEP HDS protocol. The results from the five test runs were used to calculate the overall annualized weighted removal efficiency.

Average flow rate was determined from the data collected from the flow data logger in one-minute intervals. Six sediment feed rate samples were used to calculate the average influent concentration for each run. The samples were required to meet a COV of <0.10, as specified by the NJDEP HDS Protocol. Average influent concentration for each run was calculated by using the total mass of the test sediment added during dosing divided by the volume of water that flowed through the MTD during dosing.

The average effluent concentration was adjusted by subtracting the measured background concentration. All background concentrations were less than the 20 mg/L maximum allowable

concentration specified by the NJDEP HDS Protocol. The removal efficiency for each run was calculated using the following formula:

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

Removal Efficiency Test Results for 25% MTFR

The 25% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 0.31 cfs. A summary of test readings, measurements and calculations is shown in **Table 3** below. **Figure 6** portrays water flow and temperature data and sediment feed results are shown in **Table 4**. Background and effluent sampling measurements are presented in **Table 5**. The BaySaver Barracuda S4 test unit removed 56.6% of the test sediment at a flow rate of 0.32 cfs. QA/QC results for flow rate, feed rate and influent, effluent and background concentrations were within the allowable parameters specified by the protocol as shown below in **Table 6**.

Table 3 Summary of Barracuda S4 25% MTFR

Test Date	Target Flow Rate	Detention Time	Target Sediment Concentration	Target Sediment Feed Rate	Test Duration
	(cfs/gpm)	(sec)	(mg/L)	(mg/min)	(min)
6/22/2017	0.31/139	243	200	106,190	75
Measured Values					
Average Flow Rate	**Average Influent Concentration***	**Maximum Water Temp.**	**Average Adjusted Effluent Concentration**	**Average Removal Efficiency**	**QA/QC Compliance**
(cfs/gpm)	**(mg/L)**	**(°F)**	**(mg/L)**	**(%)**	Yes
0.32/142	191.4	71.5	83.1	56.6	

*Average influent concentration reported was calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test by the total flow volume during the injection of test sediment.

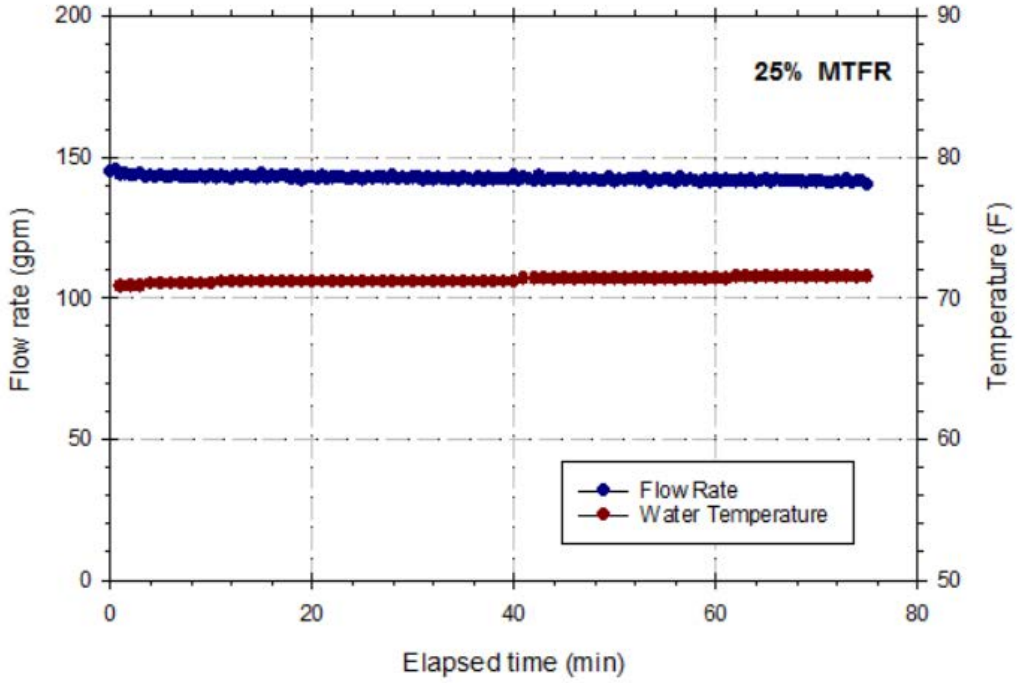

Figure 6 Water Flow and Temperature for 25% MTFR

Table 4 Sediment Feed Summary 25% MTFR

Target Concentration		200 mg/L	Target Feed Rate		106,190 mg/min	
Sample ID	Run Time	Sample Mass	Sample Duration	Feed Rate	Flow rate	Calculated Influent Concentration*
	(min)	(g)	(sec)	(mg/min)	(gpm)	(mg/L)
Sediment 1	0	105.539	60	105,539	144.98	192.31
Sediment 2	15	109.043	60	109,043	143.88	200.21
Sediment 3	30	103.496	60	103,496	142.47	191.91
Sediment 4	45	105.28	60	105,280	142.18	195.61
Sediment 5	60	97.593	60	97,593	142.18	181.33
Sediment 6	75	96.429	60	96,429	140.38	181.46
			Average	102,897	142.68	190.47

*Calculated influent concentrations were calculated using the measured flow rate corresponding to the time sediment sample was collected.

Table 5 Background and Effluent Measurements 25% MTFR

Sample ID	Time	Concentration		
	(min)	(mg/L)		
Background 1	13	1*		
Background 2	15	1*		
Background 3	29	1*		
Background 4	43	1*		
Background 5	45	1*		
Background 6	59	1*		
Background 7	73	1*		
Background 8	75	1*		
Sample #	**Time**	**Effluent Concentration**	**Background Concentration**	**Adjusted Effluent Concentration**
	(min)	**(mg/L)**	**(mg/L)**	**(mg/L)**
1	13	80	1*	79
2	14	89		88
3	15	85	1*	84
4	28	91		90
5	29	77	1*	76
6	30	87		86
7	43	85	1*	84
8	44	84		83
9	45	89	1*	88
10	58	81		80
11	59	82	1*	81
12	60	81		80
13	73	79	1*	78
14	74	96		95
15	75	76	1*	75
Removal Efficiency		**56.6%**	**Average Adjusted Effluent Concentration**	**83.1 mg/L**

*Background concentrations marked with an asterisk were reported by the laboratory as below detection limit (1 mg/L). In these cases, 1 mg/L was used for calculations.

Table 6 QA/QC Results 25% MTFR

Flow Rate (cfs/gpm)				
Run Parameters	Target	Actual	Difference	COV
	0.31/139	0.32/142	+2.2%	0.006
QA/QC Limit			± 10% PASS	0.03 PASS
Sediment Feed Rate (mg/min)				
Run Parameters	Target	Actual	Difference	COV
	106,190	102,897	-3.1%	0.048
QA/QC Limit			± 10% PASS	0.10 PASS
Influent Concentration (mg/L)				
Run Parameters	Target	Actual	Difference	COV
	200	191.4	-4.3%	0.048
QA/QC Limit			± 10% PASS	0.10 PASS
Background Concentration (mg/L)				
Run Parameters	Low	High	Average	Acceptable Threshold
	1	1	1	
QA/QC Limit				<20 mg/L PASS

Removal Efficiency Test Results for 50% MTFR

The 50% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 0.63 cfs. A summary of test readings, measurements and calculations is shown in **Table 7** below. **Figure 7** shows the water flow and temperature data, and sediment feed results are shown in **Table 8**. Background and effluent sampling measurements are presented in **Table 9**. The Barracuda S4 test unit removed 54.1% of the test sediment at a flow rate of 0.61 cfs. QA/QC results for flow rate, feed rate and influent, effluent and background concentrations were within the allowable parameters specified by the protocol as shown below in **Table 10**.

Table 7 Summary of Barracuda S4 50% MTFR

Test Date	Target Flow Rate	Detention Time	Target Sediment Concentration	Target Sediment Feed Rate	Test Duration
	(cfs/gpm)	(sec)	(mg/L)	(mg/min)	(min)
6/19/2017	0.63/281	122	200	212,380	45
Measured Values					
Average Flow Rate	Average Influent Concentration*	Maximum Water Temp.	Average Adjusted Effluent Concentration	Average Removal Efficiency	QA/QC Compliance
(cfs/gpm)	(mg/L)	(°F)	(mg/L)	(%)	Yes
0.61/275	200.0	74.6	91.8	54.1	

*Average influent concentration reported was calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test by the total flow volume during the injection of test sediment.

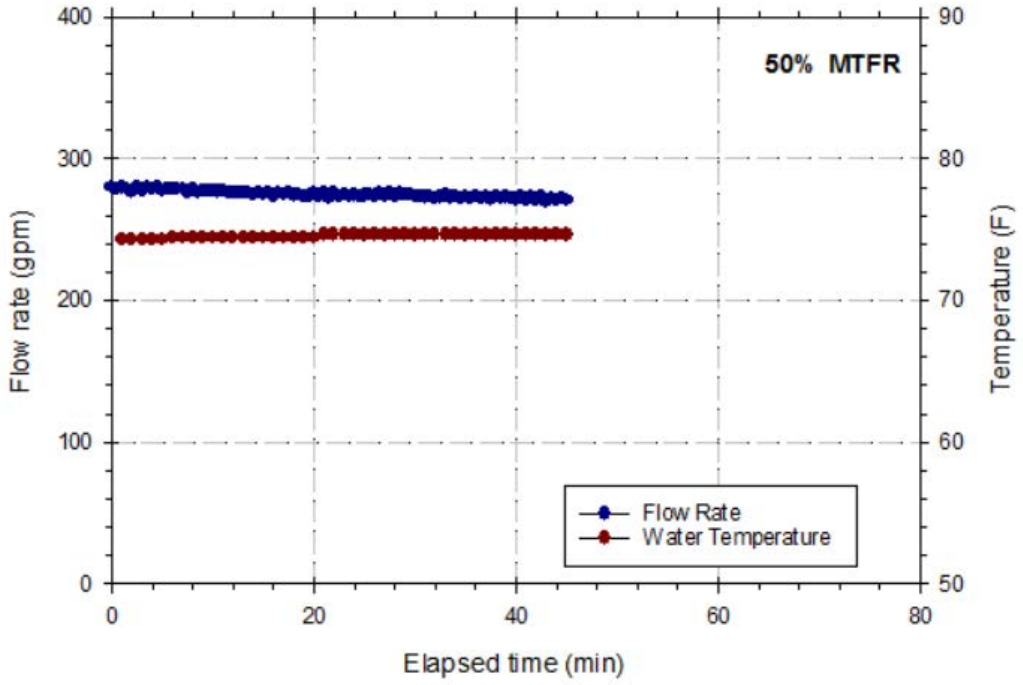

Figure 7 Water Flow and Temperature for 50% MTFR

Table 8 Sediment Feed Summary 50% MTFR

Target Concentration		200 mg/L	Target Feed Rate			212,380 mg/min
Sample ID	Run Time	Sample Mass	Sample Duration	Feed Rate	Flow rate	Calculated Influent Concentration*
	(min)	(g)	(sec)	(mg/min)	(gpm)	(mg/L)
Sediment 1	0	119.888	35	205,522	279.76	194.07
Sediment 2	9	116.814	35	200,253	277.47	190.66
Sediment 3	18	120.320	35	206,263	274.24	198.69
Sediment 4	27	125.003	35	214,291	273.20	207.21
Sediment 5	36	123.988	35	212,551	273.51	205.29
Sediment 6	45	122.843	35	210,588	270.90	205.36
			Average	208,245	274.85	200.21

*Calculated influent concentrations were calculated using the measured flow rate corresponding to the time sediment sample was collected.

Table 9 Background and Effluent Measurements 50% MTFR

Sample ID	Time	Concentration
	(min)	(mg/L)
Background 1	7	1*
Background 2	9	1*
Background 3	17	1*
Background 4	25	1*
Background 5	27	1*
Background 6	35	1*
Background 7	43	1*
Background 8	45	1*

Sample #	Time	Effluent Concentration	Background Concentration	Adjusted Effluent Concentration
	(min)	(mg/L)	(mg/L)	(mg/L)
1	7	88	1*	87
2	8	98		97
3	9	93	1*	92
4	16	77		76
5	17	99	1*	98
6	18	95		94
7	25	95	1*	94
8	26	98		97
9	27	96	1*	95
10	34	98		97
11	35	98	1*	97
12	36	89		88
13	43	96	1*	95
14	44	82		81
15	45	90	1*	89
Removal Efficiency		**54.1%**	**Average Adjusted Effluent Concentration**	**91.8 mg/L**

*Background concentrations marked with an asterisk were reported by the laboratory as below detection limit (1 mg/L). In these cases, 1 mg/L was used for calculations.

Table 10 QA/QC Results 50% MTFR

Flow Rate (cfs/gpm)				
Run Parameters	Target	Actual	Difference	COV
	0.63/281	0.61/275	-2.1%	0.009
QA/QC Limit			± 10% PASS	0.03 PASS
Sediment Feed Rate (mg/min)				
Run Parameters	Target	Actual	Difference	COV
	212,380	208,245	-1.9%	0.025
QA/QC Limit			± 10% PASS	0.10 PASS
Influent Concentration (mg/L)				
Run Parameters	Target	Actual	Difference	COV
	200	200.0	+0.0%	0.025
QA/QC Limit			± 10% PASS	0.10 PASS
Background Concentration (mg/L)				
Run Parameters	Low	High	Average	Acceptable Threshold
	1	1	1	
QA/QC Limit				<20 mg/L PASS

Removal Efficiency Test Results for 75% MTFR

The 75% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 0.94 cfs. A summary of test readings, measurements and calculations is shown in **Table 11** below. **Figure 8** shows the water flow and temperature data, and sediment feed results are shown in **Table 12**. Background and effluent sampling measurements are presented in **Table 13**. The BaySaver Barracuda S4 test unit removed 49.8% of the test sediment at a flow rate of 0.94 cfs. QA/QC results for flow rate, feed rate and influent, effluent and background concentrations were within the allowable parameters specified by the protocol as shown below in **Table 14**.

Table 11 Summary of Barracuda S4 75% MTFR

Test Date	Target Flow Rate	Detention Time	Target Sediment Concentration	Target Sediment Feed Rate	Test Duration
	(cfs/gpm)	(sec)	(mg/L)	(mg/min)	(min)
6/15/2017	0.94/421	81	200	318,730	35
Measured Values					
Average Flow Rate	Average Influent Concentration*	Maximum Water Temp.	Average Adjusted Effluent Concentration	Average Removal Efficiency	QA/QC Compliance
(cfs/gpm)	(mg/L)	(°F)	(mg/L)	(%)	Yes
0.94/419	213.9	70.5	107.3	49.8	

*Average influent concentration reported was calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test by the total flow volume during the injection of test sediment.

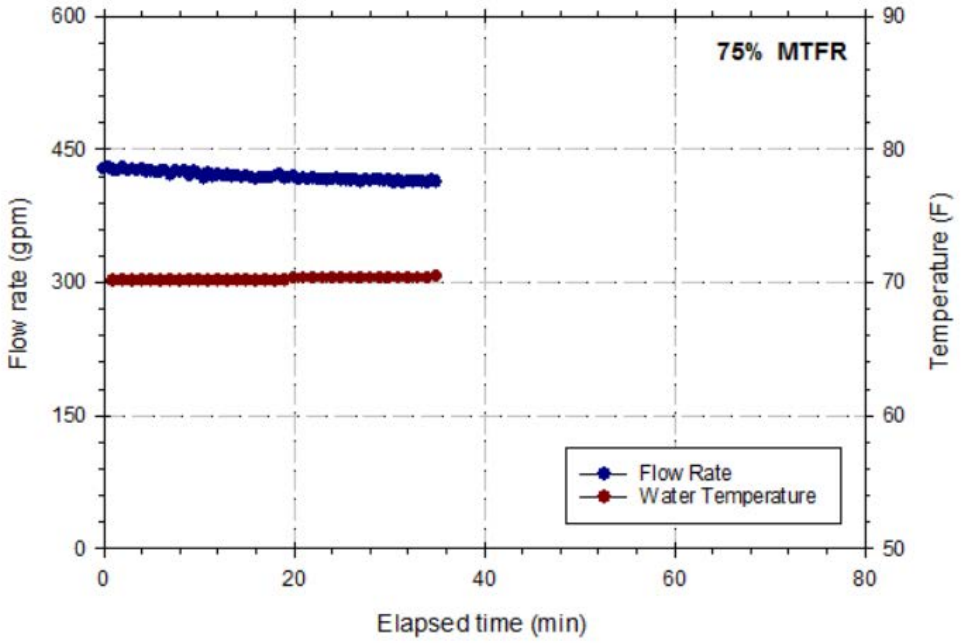

Figure 8 Water Flow and Temperature for 75% MTFR

Table 12 Sediment Feed Summary 75% MTFR

Target Concentration		200 mg/L	Target Feed Rate			318,730 mg/min
Sample ID	Run Time	Sample Mass	Sample Duration	Feed Rate	Flow rate	Calculated Influent Concentration*
	(min)	(g)	(sec)	(mg/min)	(gpm)	(mg/L)
Sediment 1	0	142.987	25	343,169	428.71	211.46
Sediment 2	7	142.154	25	341,170	421.53	213.81
Sediment 3	14	142.365	25	341,676	420.59	214.61
Sediment 4	21	144.156	25	345,974	418.71	218.28
Sediment 5	28	138.538	25	332,491	414.34	211.99
Sediment 6	35	138.021	25	331,250	412.98	211.89
			Average	339,288	419.48	213.67

*Calculated influent concentrations were calculated using the measured flow rate corresponding to the time sediment sample was collected.

Table 13 Background and Effluent Measurements 75% MTFR

Sample ID	Time (min)	Concentration (mg/L)
Background 1	5	4
Background 2	7	1
Background 3	13	1*
Background 4	19	1*
Background 5	21	1*
Background 6	27	1*
Background 7	33	1
Background 8	35	1*

Sample #	Time (min)	Effluent Concentration (mg/L)	Background Concentration (mg/L)	Adjusted Effluent Concentration (mg/L)
1	5	99	4	95
2	6	120		118
3	7	100	1	99
4	12	110		109
5	13	100	1*	99
6	14	110		109
7	19	110	1*	109
8	20	110		109
9	21	110	1*	109
10	26	110		109
11	27	100	1*	99
12	28	110		109
13	33	120	1	119
14	34	100		99
15	35	120	1*	119
Removal Efficiency		**49.8%**	**Average Adjusted Effluent Concentration**	**107.3 mg/L**

*Background concentrations marked with an asterisk were reported by the laboratory as below detection limit (1 mg/L). In these cases, 1 mg/L was used for calculations.

Table 14 QA/QC Results 75% MTFR

Flow Rate (cfs/gpm)				
Run Parameters	Target	Actual	Difference	COV
	0.94/421	0.94/419	-0.5%	0.012
QA/QC Limit			± 10% PASS	0.03 PASS
Sediment Feed Rate (mg/min)				
Run Parameters	Target	Actual	Difference	COV
	318,730	339,288	+6.4%	0.018
QA/QC Limit			± 10% PASS	0.10 PASS
Influent Concentration (mg/L)				
Run Parameters	Target	Actual	Difference	COV
	200	213.9	+6.95%	0.018
QA/QC Limit			± 10% PASS	0.10 PASS
Background Concentration (mg/L)				
Run Parameters	Low	High	Average	Acceptable Threshold
	1	4	1.4	
QA/QC Limit				<20 mg/L PASS

Removal Efficiency Test Results for 100% MTFR

The 100% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 1.25 cfs. A summary of test readings, measurements and calculations is shown in **Table 15** below. **Figure 9** shows the water flow and temperature data, and sediment feed results are shown in **Table 16**. Background and effluent sampling measurements are presented in **Table 17**. The Barracuda S4 test unit removed 48.5% of the test sediment at a flow rate of 1.25 cfs. QA/QC results for flow rate, feed rate and influent and effluent background concentrations were within the allowable parameters specified by the protocol as shown below in **Table 18**.

Table 15 Summary of Barracuda S4 100% MTFR

Test Date	Target Flow Rate	Detention Time	Target Sediment Concentration	Target Sediment Feed Rate	Test Duration
	(cfs/gpm)	(sec)	(mg/L)	(mg/min)	(min)
6/12/2017	1.25/561	61	200	424,750	30
Measured Values					
Average Flow Rate	Average Influent Concentration*	Maximum Water Temp.	Average Adjusted Effluent Concentration	Average Removal Efficiency	QA/QC Compliance
(cfs/gpm)	(mg/L)	(°F)	(mg/L)	(%)	Yes
1.25/559	201.8	72.4	104.0	48.5	

*Average influent concentration reported was calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test by the total flow volume during the injection of test sediment.

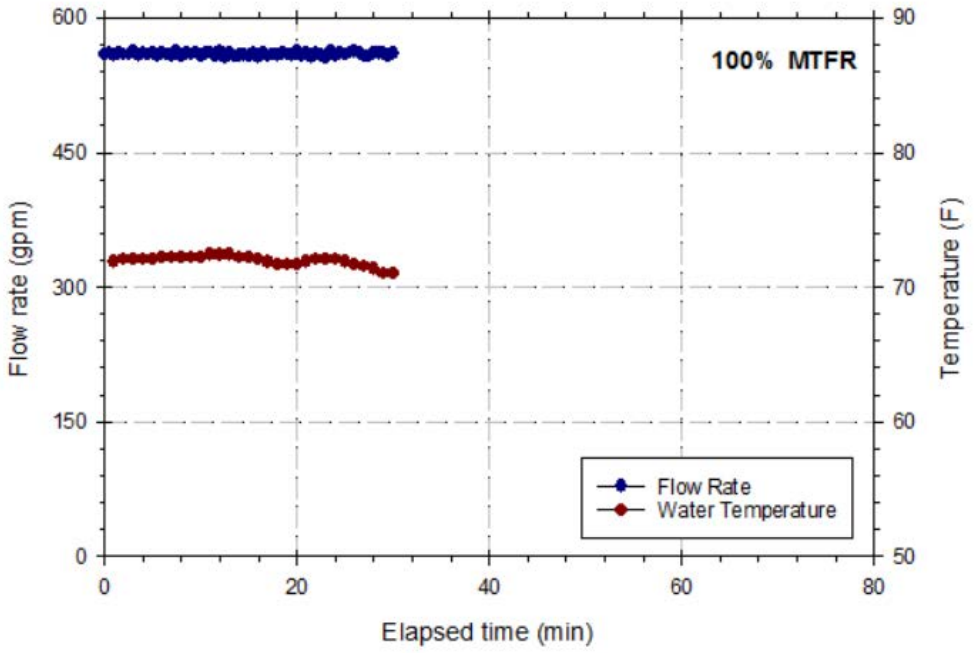

Figure 9 Water Flow and Temperature for 100% MTFR

Table 16 Sediment Feed Summary 100% MTFR

Target Concentration		200 mg/L	Target Feed Rate			424,750 mg/min
Sample ID	Run Time	Sample Mass	Sample Duration	Feed Rate	Flow rate	Calculated Influent Concentration*
	(min)	(g)	(sec)	(mg/min)	(gpm)	(mg/L)
Sediment 1	0	144.997	20	434,991	559.46	205.40
Sediment 2	6	151.714	20	455,142	561.44	214.16
Sediment 3	12	142.895	20	428,685	561.85	201.56
Sediment 4	18	135.247	20	405,741	558.21	192.02
Sediment 5	24	143.448	20	430,344	556.33	204.35
Sediment 6	30	135.835	20	407,505	560.19	192.17
			Average	427,068	559.58	201.61

*Calculated influent concentrations were calculated using the measured flow rate corresponding to the time sediment sample was collected.

Table 17 Background and Effluent Measurements 100% MTFR

Sample ID	Time	Concentration
	(min)	(mg/L)
Background 1	4	1
Background 2	6	1*
Background 3	11	1*
Background 4	16	2
Background 5	18	1
Background 6	23	1
Background 7	28	1
Background 8	30	1

Sample #	Time	Effluent Concentration	Background Concentration	Adjusted Effluent Concentration
	(min)	(mg/L)	(mg/L)	(mg/L)
1	4	110	1	109
2	5	110		109
3	6	110	1*	109
4	10	110		109
5	11	94	1*	93
6	12	96		95
7	16	100	2	98
8	17	120		119
9	18	110	1	109
10	22	120		119
11	23	100	1	99
12	24	110		109
13	28	100	1	99
14	29	91		90
15	30	95	1	94
Removal Efficiency		**48.5%**	**Average Adjusted Effluent Concentration**	**104.0 mg/L**

*Background concentrations marked with an asterisk were reported by the laboratory as below detection limit (1 mg/L). In these cases, 1 mg/L was used for calculations.

Table 18 QA/QC Results 100% MTFR

Flow Rate (cfs/gpm)				
Run Parameters	Target	Actual	Difference	COV
	1.25/561	1.25/559	-0.4%	0.003
QA/QC Limit			± 10% PASS	0.03 PASS
Sediment Feed Rate (mg/min)				
Run Parameters	Target	Actual	Difference	COV
	424,750	427,068	+0.5%	0.043
QA/QC Limit			± 10% PASS	0.10 PASS
Influent Concentration (mg/L)				
Run Parameters	Target	Actual	Difference	COV
	200	201.8	+0.9%	0.043
QA/QC Limit			± 10% PASS	0.10 PASS
Background Concentration (mg/L)				
Run Parameters	Low	High	Average	Acceptable Threshold
	1	2	1.1	
QA/QC Limit				<20 mg/L PASS

Removal Efficiency Test Results for 125% MTFR

The 125% MTFR test was conducted in accordance with the NJDEP HDS Protocol at a target flow rate of 1.56 cfs. A summary of test readings, measurements and calculations is shown in **Table 19** below. **Figure 10** shows the water flow and temperature data, and sediment feed results are shown in **Table 20**. Background and effluent sampling measurements are presented in **Table 21**. The Barracuda S4 test unit removed 43.8% of the test sediment at a flow rate of 1.60 cfs. QA/QC results for flow rate, feed rate and influent, effluent and background concentrations were within the allowable parameters specified by the protocol as shown below in **Table 22**.

Table 19 Summary of Barracuda S4 125% MTFR

Test Date	Target Flow Rate	Detention Time	Target Sediment Concentration	Target Sediment Feed Rate	Test Duration
	(cfs/gpm)	(sec)	(mg/L)	(mg/min)	(min)
6/8/2017	1.56/701	49	200	530,710	25
Measured Values					
Average Flow Rate	Average Influent Concentration*	Maximum Water Temp.	Average Adjusted Effluent Concentration	Average Removal Efficiency	QA/QC Compliance
(cfs/gpm)	(mg/L)	(°F)	(mg/L)	(%)	Yes
1.60/720	188.7	65.3	106.1	43.8	

*Average influent concentration reported was calculated by dividing the entire mass of test sediment injected into the flow stream over the duration of the test by the total flow volume during the injection of test sediment.

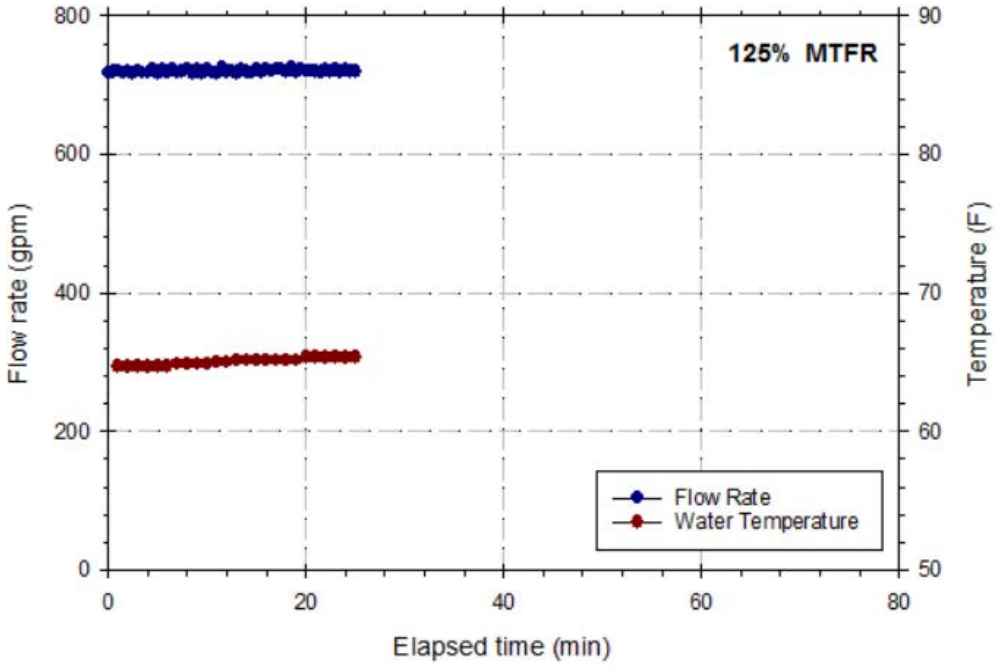

Figure 10 Water Flow and Temperature for 125% MTFR

Table 20 Sediment Feed Summary 125% MTFR

Target Concentration		200 mg/L	Target Feed Rate			530,710 mg/min
Sample ID	Run Time	Sample Mass	Sample Duration	Feed Rate	Flow rate	Calculated Influent Concentration*
	(min)	(g)	(sec)	(mg/min)	(gpm)	(mg/L)
Sediment 1	0	129.382	15	517,528	718.33	190.33
Sediment 2	5	123.383	15	493,532	716.67	181.92
Sediment 3	10	123.833	15	495,332	721.98	181.24
Sediment 4	15	137.213	15	548,852	723.23	200.48
Sediment 5	20	129.834	15	519,336	720.73	190.35
Sediment 6	25	127.839	15	511,356	718.96	187.89
			Average	514,323	719.98	188.70

*Calculated influent concentrations were calculated using the measured flow rate corresponding to the time sediment sample was collected.

Table 21 Background and Effluent Measurements 125% MTFR

Sample ID	Time	Concentration
	(min)	(mg/L)
Background 1	3	1*
Background 2	5	1*
Background 3	9	3
Background 4	13	3
Background 5	15	2
Background 6	19	4
Background 7	23	5
Background 8	25	6

Sample #	Time	Effluent Concentration	Background Concentration	Adjusted Effluent Concentration
	(min)	(mg/L)	(mg/L)	(mg/L)
1	3	110	1*	109
2	4	110		109
3	5	120	1*	119
4	8	120		118
5	9	110	3	107
6	10	120		117
7	13	74	3	71
8	14	110		108
9	15	110	2	108
10	18	77		74
11	19	110	4	106
12	20	95		91
13	23	120	5	115
14	24	140		135
15	25	110	6	104
Removal Efficiency		**43.8%**	**Average Adjusted Effluent Concentration**	**106.1 mg/L**

*Background concentrations marked with an asterisk were reported by the laboratory as below detection limit (1 mg/L). In these cases, 1 mg/L was used for calculations.

Table 22 QA/QC Results 125% MTFR

Flow Rate (cfs/gpm)				
Run Parameters	Target	Actual	Difference	COV
	1.56/701	1.60/720	+2.7%	0.003
QA/QC Limit			± 10% PASS	0.03 PASS
Sediment Feed Rate (mg/min)				
Run Parameters	Target	Actual	Difference	COV
	530,710	514,323	-3.1%	0.039
QA/QC Limit			± 10% PASS	0.10 PASS
Influent Concentration (mg/L)				
Run Parameters	Target	Actual	Difference	COV
	200	188.7	-5.7%	0.039
QA/QC Limit			± 10% PASS	0.10 PASS
Background Concentration (mg/L)				
Run Parameters	Low	High	Average	Acceptable Threshold
	1	6	3.1	
QA/QC Limit				<20 mg/L PASS

Annualized Weighted TSS Removal Efficiency

The annualized weighted TSS removal efficiency has been calculated using the weighting factors provided in the NJDEP HDS protocol. As shown in **Table 23** below, the BaySaver Barracuda S4 achieved a 52.0% annualized weighted TSS removal for an MTFR of 1.25 cfs (561 gpm). This testing demonstrates that the BaySaver Barracuda meets the NJDEP requirement that HDS devices achieve at least a 50% weighted annualized TSS removal efficiency.

Table 23 Annualized Weighted TSS Removal Efficiency for BaySaver Barracuda S4

% MTFR	Removal Efficiency (%)	Annual Weighting Factor	Weighted Removal Efficiency (%)
25	56.6	0.25	14.2
50	54.1	0.3	16.2
75	49.8	0.2	10.0
100	48.5	0.15	7.3
125	43.8	0.1	4.4
Annualized Weighted TSS Removal Efficiency			**52.0%**

4.2 Scour Testing

Scour testing was conducted on the BaySaver Barracuda S4 in accordance with Section 4 of the NJDEP HDS Protocol at a flow rate of 2.51 cfs or 1128 gpm (slightly greater than 200% of the MTFR) to verify that the unit is suitable for on-line installation.

Water flow and temperature data for scour testing is shown in **Figure 11,** and effluent and background concentration results are shown in **Table 24** below. The adjusted effluent concentration was calculated by subtracting the background concentration from the recorded effluent concentration. All background and effluent concentrations were less than or equal to 1 mg/L. The average adjusted effluent concentration was less than 1mg/L when tested at greater than 200% of the MTFR. Based on these results, the BaySaver Barracuda is suitable for on-line installation.

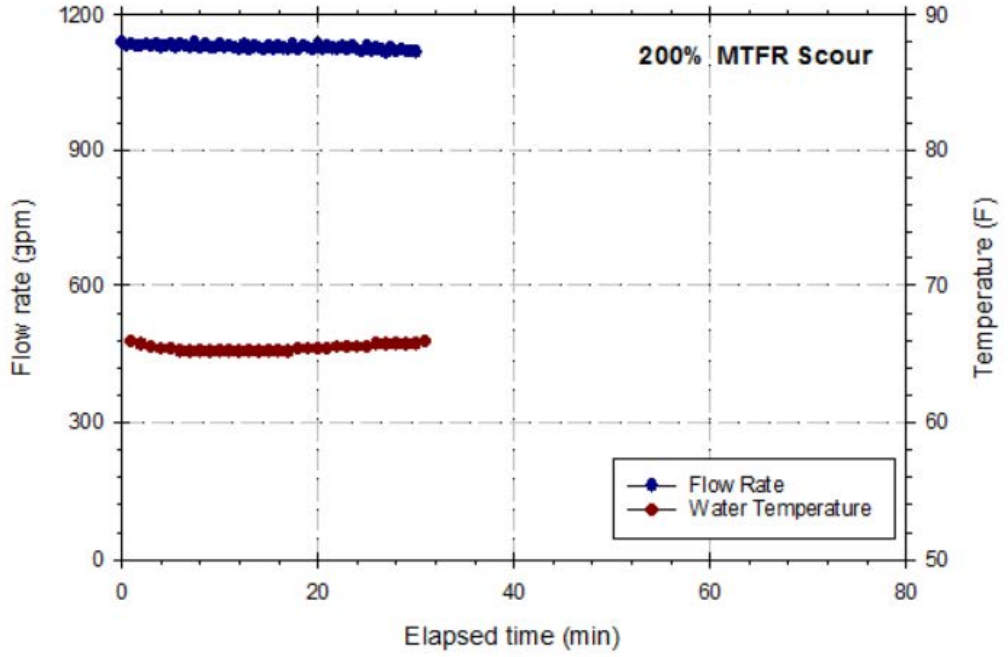

Figure 11 Water Flow and Temperature for >200% MTFR Scour Test

Table 24 Background and Effluent Measurements for Scour Testing

Date	5/30/2017	Average Flow Rate	2.51 cfs/1128 gpm
Maximum Temperature	65.9 °F	Flow Rate COV	0.005
Sample ID	Time (min)	Concentration (mg/L)	
Background 1	0	1*	
Background 2	4.5	1*	
Background 3	9	1*	
Background 4	13.5	1*	
Background 5	18	1*	
Background 6	22.5	1	
Background 7	27	1	
Background 8	30	1	
Sample #	Time (min)	Effluent Concentration (mg/L)	Adjusted Effluent Concentration (mg/L)
1	2	1	<1
2	4	1*	<1
3	6	1	<1
4	8	1	<1
5	10	1	<1
6	12	1	<1
7	14	1	<1
8	16	1*	<1
9	18	1	<1
10	20	1	<1
11	22	1*	<1
12	24	1	<1
13	26	1*	<1
14	28	1	<1
15	30	1*	<1

*Concentrations marked with an asterisk were reported by the laboratory as below detection limit (1 mg/L). In these cases, a value of 1 mg/L was used for calculations.

5. Design Limitations

BaySaver Technologies, LLC, provides engineering support to all clients. Each system is designed and sized according to anticipated flow rate, load rating, and system depth at the installation site. All site and design constraints are discussed during the design and manufacturing process.

Required Soil Characteristics

The BaySaver Barracuda is delivered to the job site to be housed in a pre-cast concrete structure or an ADS polypropylene manhole. During the pre-casting design process, soil characteristics

including corrosiveness, top and lateral loading, and ground water must be addressed. The BaySaver Barracuda can be installed and will function in all soil types. A copy of the geotechnical report along with surface loading requirements, and groundwater situation must be reviewed and verified during the design process (see below for buoyancy situations).

Slope

The BaySaver Barracuda is typically installed on a 0% slope or flat installation grade across the unit (invert in to invert out). In general, it is recommended that the pipe slope into the system not exceed 10%. Slopes in excess of 10% could cause increased velocities which could affect the turbulence into the system. The BaySaver engineering team will evaluate the design prior to specification for application on sites with steep slopes.

Maximum Flow Rate

The maximum treatment flow rate of the BaySaver Barracuda is dependent upon model size and performance specifications. The hydraulic loading rate is 44.6 gpm/ft^2 for all models. BaySaver Engineering staff can assist site design engineers to ensure an appropriate model.

Maintenance Requirements

The lifespan and maintenance needs of the BaySaver Barracuda depend on the sediment load and individual site conditions. The system must be inspected at regular intervals and maintained when necessary to ensure the optimal performance. Detailed requirements can be found in **Section 6**.

Driving Head

Driving head will vary depending on the site specific configuration. Design support is given by BaySaver for each project, and site-specific drawings (cut sheets) will be provided that show pipe inverts, finish surface elevation, and peak treatment and maximum flow rates through the BaySaver Barracuda to ensure no adverse impact on the hydraulic grade-line.

Installation Limitations

BaySaver provides contractors with instructions prior to delivery, and onsite assistance is available from the installation technician during delivery and installations. Pick weights and lifting details are also provided prior to delivery to ensure that the contractor is able to prepare the appropriate equipment on site.

Configurations

The BaySaver Barracuda is available in various configurations and can be installed on- or off-line, although this verification pertains to on-line installations. An internal bypass weir removes the need for any external high-flow diversion structure in the on-line system. When bypass

occurs, flow is routed directly from the treatment chamber to the outlet chamber, thus preventing any scour or loss of captured pollutants. In some cases, inlet/outlet pipes with varying pipe angles can be accommodated. Contact BaySaver for design assistance on this.

Structural Load Limitations

BaySaver Barracudas are typically designed for HS-20 loading. If a depth greater than 15 feet is required from final grade, the manhole structural design must be reviewed by the manufacturer. Contact the BaySaver team if increasing load is expected.

Pre-treatment Requirements

The BaySaver Barracuda has no pre-treatment requirements.

Limitations in Tailwater

Site-specific tailwater conditions will be assessed on each individual project. Tailwater conditions increase the amount of driving head required for optimal system operation. The manufacturer's internal protocols require that these conditions are discussed with the engineer of record and that a solution be implemented to adjust for any design variations caused by tailwater conditions at both treatment and bypass flow rates.

Depth to Seasonal High Water Table

Groundwater conditions do not affect BaySaver Barracuda function and treatment performance. High groundwater may cause buoyancy, and an anti-floatation ballast can be added to the structure to counteract this. If high groundwater is anticipated, the BaySaver engineering team will evaluate the need for anti-buoyance measures and provide the guidance to address the concerns.

6. Maintenance Plans

The BaySaver Barracuda requires periodic maintenance to continue operating at design efficiency. The maintenance process is comprised of the cleaning of the manhole with a vacuum truck. The system needs to be cleaned, when necessary, to ensure optimum performance, typically every 12-18 months. The rate at which the system collects pollutants will depend more upon site activities than the size of the unit. Since storm water solids loads can be variable, it is possible that the maintenance cycle could be more or less than the projected duration for a given O&M cycle.

Inspection

Inspection is the key to effective maintenance, and it is easily performed. BaySaver recommends the BaySaver Barracuda be inspected every six (6) months for the first year and then on an annual basis. Sediment accumulation may be especially variable during the first year after installation as construction disturbances and landscaping stabilizes. Inspections may need to be

performed more often in the winter months in climates where sanding operations may lead to rapid accumulations or in other areas with heavy sediment loading. It is very useful to keep a record of each inspection. NJDEP requires that sediment be removed when the sediment depth reaches 50% of the MTD's maximum sediment storage capacity. The BaySaver Barracuda should be cleaned when inspection reveals that 10 inches or more of sediment is accumulated at the bottom of manhole or when visual inspection shows a large accumulation of debris or oil. This determination of sediment depth can be made by lowering a stadia rod into the manhole until it hits the sediment and measuring the distance from the bottom of the pole to the water line mark on the stadia rod. Note: To avoid underestimating the volume of sediment in the manholes, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile may offer less resistance to the end of the rod than larger particles toward the bottom of the pile. Maintenance frequency can be determined by adhering to the initial sizing frequency given by the initial sizing of the system. Once actual sediment loading on-site is determined, a modified maintenance frequency can be proposed to the site owner. Please contact the ADS/BaySaver Technologies Engineering Department for maintenance cycle estimations or assistance at 1.800.229.7283.

Maintenance Procedures

1. Remove the manhole cover to provide access to the pollutant storage. Pollutants are stored in the sump, below the cone assembly visible from the surface. You'll access this area through the 10" diameter access cylinder.
2. Use a vacuum truck or other similar equipment to remove all water, debris, oils and sediment from both the top cone area and the bottom sump compartment area of the Barracuda unit.
3. Use a high-pressure hose to clean the manhole of all remaining sediment and debris (recommended but optional). Then, use the vacuum truck to remove this water.
4. Fill the cleaned Barracuda unit with water to the invert of the outlet pipe.
5. Replace the manhole cover/close the hatch (if applicable).
6. Dispose of polluted water, oils, sediment and trash at an approved facility.

- Local regulations prohibit the discharge of solid material into the sanitary system. Check with the local sewer authority for authority to discharge the liquid.
- Many places treat the pollutants as leachate. Check with local regulators about disposal requirements. Important: Additional local regulations may apply to the maintenance procedure.

7. Statements

The following signed statements from the manufacturer (BaySaver Technologies, LLC), third-party observer (Boggs Environmental Consultants, Inc.) and NJCAT are required to complete the NJCAT 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.

BAYSAVER TECHNOLOGIES

Date: 07-12-2017

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: Submittal of the laboratory verification report for the Barracuda Separator S4

Dr. Magee,

We are providing this letter as our statement certifying that the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 2013)* has been strictly followed. In addition, we certify that all requirements and criteria were met and exceeded during testing of the BaySaver Barracuda S4 Separator.

If you have any questions, please contact us at your convenience.

Sincerely,

Daniel J. Figola, P.E.
General Manager,
BaySaver Technologies, LLC

Signature: Daniel J Figola Date: 7/12/17

BOGGS ENVIRONMENTAL CONSULTANTS

Middletown, MD & Morgantown, WV

Administrative Office:
200 W Main Street
Middletown, Maryland 21769

Office (301) 694-5687
Fax (301) 694-9799

July 25, 2017

BaySaver Technologies, LLC
1030 Deer Hollow Drive
Mount Airy, MD 21771
(301) 679-0640
dfigola@ads-pipe.com

ATTENTION: Daniel Figola, General Manager

REFERENCE: Third Party Review of Testing Procedures for Baysaver Barracuda S4 Separator at the Mid Atlantic Storm Water Research Center (MASWRC), 1207 Park Ridge Drive, Mount Airy, MD 21771

BOGGS ENVIRONMENTAL CONSULTANTS, INC. (BEC) provided Third Party Review services for the testing of the Baysaver Barracuda S4 Separator, conducted from May 26, 2017, through June 29, 2017, to evaluate if the required testing meets certification standards established by the New Jersey Department of Environmental Protection (NJDEP).

LABORATORY TESTING PROCEDURES & METHODOLOGIES

The following procedures and requirements were followed during the testing of the Baysaver Barracuda S4 Separator.

- NJDEP 2013a. *New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology.* Trenton, NJ. January 25, 2013.
- NJDEP 2013b. *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device.* Trenton, NJ. January 25, 2013.
- BaySaver Technologies, LLC 2017. *Quality Assurance Project Plan for BaySaver Barracuda Separator.* Prepared by BaySaver Technologies. May, 2017.

ONSITE OBSERVATION OF TESTING PROCEDURES

BEC was physically present at MASWRC, at 1207 Park Ridge Drive, in Mount Airy, MD 21771, to observe that the following adhered to the required set forth by the documentation listed above:

- Setup of the testing equipment, including all calibrations;
- Mixing and establishment of sediment blends meeting PSD's specified and approved by NJDEP;
- Establishment of a Procedure Checklist (by BEC), which was used during each run (May 30, 2017 through June 22, 2017) to ensure and document all details of procedures and to personally witness sample collection;
- Mass measurement verification (solid samples), and chain of custody for liquid samples sent to an outside lab;
- Data collection, calculations, and conclusions as reported in BaySaver Technologies, LLC's report entitled, *NJCAT TECHNOLOGY VERIFICATION BaySaver Barracuda™ Hydrodynamic Separator*, July, 2017.

THIRD PARTY VERIFICATION & OPINIONS

Based on observations during the runs and the analysis of all data, BEC verified the following:

- That the testing of the Baysaver Barracuda S4 Separator at the Mid-Atlantic Storm Water Research Center was conducted in accordance with the NJDEP protocols specified above.
- For the particle size distribution and weighted calculation method required by the NJDEP HDS Protocol, the Baysaver Barracuda Separator achieved a weighted TSS removal efficiency of at least 50% for an MTFR of 1.25 cfs (559 gpm).

Should you have any questions, contact our office at your earliest convenience.

Sincerely,
BOGGS ENVIRONMENTAL CONSULTANTS, INC.

William R. Warfel
Principal Environmental Scientist

Robin J. Maliszewskyj
Chemical Engineer

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

July 25, 2017

Shashi Nayak
NJDEP
Division of Water Quality
Bureau of Non-Point Pollution Control
401-02B
PO Box 420
Trenton, NJ 08625-0420

Dear Mr. Nayak,

Based on my review, evaluation and assessment of the testing conducted on the BaySaver Barracuda™ Hydrodynamic Separator (commercial unit model Barracuda S4) at the Mid-Atlantic Storm Water Research Center (MASWRC, a subsidiary of BaySaver), supervised by Boggs Environmental Consultants, Inc.,, the test protocol requirements contained in the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" (NJDEP HDS Protocol) were met or exceeded. Specifically:

Test Sediment Feed

The mean PSD of the test sediments comply with the PSD criteria established by the NJDEP HDS protocol. The BaySaver removal efficiency test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification. The test sediment was shown to be finer than the sediment blend specified by the protocol (<75µ); the test sediment d_{50} was 42 microns. The scour test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification and shown to be finer than specified by the protocol.

Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on the BaySaver Barracuda S4, a 4 ft. diameter commercially available unit, in order to establish the ability of the BaySaver Barracuda to remove the specified test sediment at 25%, 50%, 75%,

100% and 125% of the target MTFR. The BaySaver Barracuda S4 demonstrated 52.0% annualized weighted solids removal as defined in the NJDEP HDS Protocol. The flow rates, feed rates and influent concentration all met the NJDEP HDS test protocol's coefficient of variance requirements and the background concentration for all five test runs never exceeded 20 mg/L (maximum of 6 mg/L).

Scour Testing

In order to demonstrate the ability of the BaySaver Barracuda to be used as an on-line treatment device scour testing was conducted at greater than 200% of MTFR in accordance with the NJDEP HDS Protocol. The average flow rate during the online scour test was 2.51 cfs, which represents 202% of the MTFR (MTFR = 1.25 cfs). Background concentrations were 1 mg/L or non-detect throughout the scour testing, which complies with the 20 mg/L maximum background concentration specified by the test protocol. Unadjusted effluent concentrations ranged from 1 mg/L to non-detect. When adjusted for background concentrations, the effluent concentrations were <1mg/L. These results confirm that the BaySaver Barracuda S4 did not scour at 202% MTFR and meets the criteria for on-line use.

Maintenance Frequency

The predicted maintenance frequency for all BaySaver Barracuda models is essentially 60 months.

Sincerely,

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

8. References

ASTM D422-63. *Standard Test Method for Particle-Size Analysis of Soils.*

ASTM D3977-97. *Standard Test Methods for Determining Concentrations in Water Samples*.

BaySaver Technologies, LLC 2017. *Quality Assurance Project Plan for BaySaver Barracuda Separator.* Prepared by BaySaver Technologies. May 2017.

BaySaver Technologies, LLC 2017. *NJCAT Technology Verification: BayFilter™.* Prepared by BaySaver Technologies. May 2017.

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

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

VERIFICATION APPENDIX

Introduction

- Manufacturer – BaySaver Technologies, LLC, 1030 Deer Hollow Drive, Mt. Airy, MD 21771. Website: http://www.BaySaver.com Phone: 800-229-7283.
- Barracuda MTD – BaySaver Barracuda verified models are shown in **Table A-1** and **Table A-2**.
- TSS Removal Rate – 50%
- On-line installation

Detailed Specification

- NJDEP sizing tables and physical dimensions of the BaySaver Barracuda verified models are attached (**Table A-1** and **Table A-2**).
- New Jersey requires that the peak flow rate of the NJWQ Design Storm event of 1.25 inch in 2 hours shall be used to determine the appropriate size for the MTD. The BaySaver Barracuda S4 model has a maximum treatment flow rate (MTFR) of 1.25 cfs (561 gpm), which corresponds to a surface loading rate of 44.6 gpm/ft^2 of sedimentation area.
- Pick weights and installation procedures vary slightly with model size. Design support is given by BaySaver for each project and pick weights and installation procedures will be provided prior to delivery.
- Maximum recommended sediment depth prior to cleanout is 10 inches for all model sizes.
- Maintenance Guide is at: http://www.ads-pipe.com/pdf/en/Barracuda_Maintenance_07_17.pdf
- Maintenance frequency for the BaySaver Barracuda models is 60 months.
- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the BaySaver Barracuda to be used in series with another hydrodynamic separator to achieve an enhanced TSS removal rate.

Table A-1 MTFRs and Sediment Removal Intervals for BaySaver Barracuda Models

Model[1]	Manhole Diameter[1] (ft)	NJDEP 50% TSS Maximum Treatment Flow Rate (cfs)	Treatment Area (ft^2)	Hydraulic Loading rate (gpm/ft^2)	50% Maximum Sediment Storage[3] (ft^3)	Sediment Removal Interval[2] (months)
Barracuda S3	3	0.70	7.07	44.6	5.89	60
Barracuda S4	4	1.25	12.57	44.6	10.47	60
Barracuda S5	5	1.95	19.63	44.6	16.36	60
Barracuda S6	6	2.80	28.27	44.6	23.56	60
Barracuda S8	8	5.00	50.27	44.6	41.89	60
Barracuda S10	10	7.80	78.54	44.6	65.45	60

Notes:

1. In some areas Barracuda units are available in additional diameters. Units not listed here are sized not to exceed 44.6 gpm/ft^2 of effective treatment during the peak water quality flow.
2. Sediment Removal Interval (months) = (50% HDS MTD Max Sediment Storage Volume * 3.57) / (MTFR * TSS Removal Efficiency) calculated using equation in Appendix B, Part B of the NJDEP HDS Protocol.
3. 50% Sediment Storage Capacity is equal to manhole diameter x 10 inches of sediment depth. Each Barracuda unit has a 20 inches deep sediment sump.

Table A-2 Standard Dimensions for BaySaver Barracuda Models

Model	Manhole Diameter (ft)	NJDEP 50% TSS MTFR (cfs)	Total Chamber Depth (ft)	Treatment Chamber Depth[1] (ft)	Treatment Chamber Wet Volume[4] (ft^3)	Aspect Ratio[2] (Depth/Dia.)	Sediment Sump Depth (in)	Maximum Pipe Diameter (in)
Barracuda S3	3	0.70	4.83	4.00	28.3	1.33	20.0	12.0
Barracuda S4	4	1.25	6.83	6.00	75.4	1.50	20.0	12.0
Barracuda S5	5	1.95	6.83	6.00[3]	117.8	1.20	20.0	18.0
Barracuda S6	6	2.80	6.83	6.00[3]	169.7	1.00	20.0	18.0
Barracuda S8	8	5.00	11.03	10.20	512.7	1.275	20.0	24.0
Barracuda S10	10	7.80	13.59	12.76	1002	1.276	20.0	30.0

Notes:

1. Treatment chamber depth is defined as the total chamber depth minus ½ the sediment storage depth.
2. The aspect ratio is the unit's treatment chamber depth/diameter. The aspect ratio for the tested unit is 1.5. Larger models (>250% MTFR of the tested unit, > 3.125 cfs) must be geometrically proportionate to the tested unit. A variance of 15% is allowable (1.275 to 1.725).
3. For units < 250% MTFR (5 and 6 ft models), the depth must be equal or greater than the depth of the unit treated.
4. Referred to as Treatment Chamber Capacity in the BaySaver Barracuda Maintenance Guide