NJCAT TECHNOLOGY VERIFICATION

BioSTORM® Stormwater Treatment System

BioMicrobics, Inc.

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1. Description of Technology

The BioSTORM® Stormwater Treatment System (BioSTORM system) functions as a hydrodynamic separator for Total Suspended Solids (TSS) reduction. The treatment system process uses sediment settling in a uniquely designed treatment module identified as an Interceptor. Welded together plastic corrugated sheets function as the Interceptor (**Figure 1**).

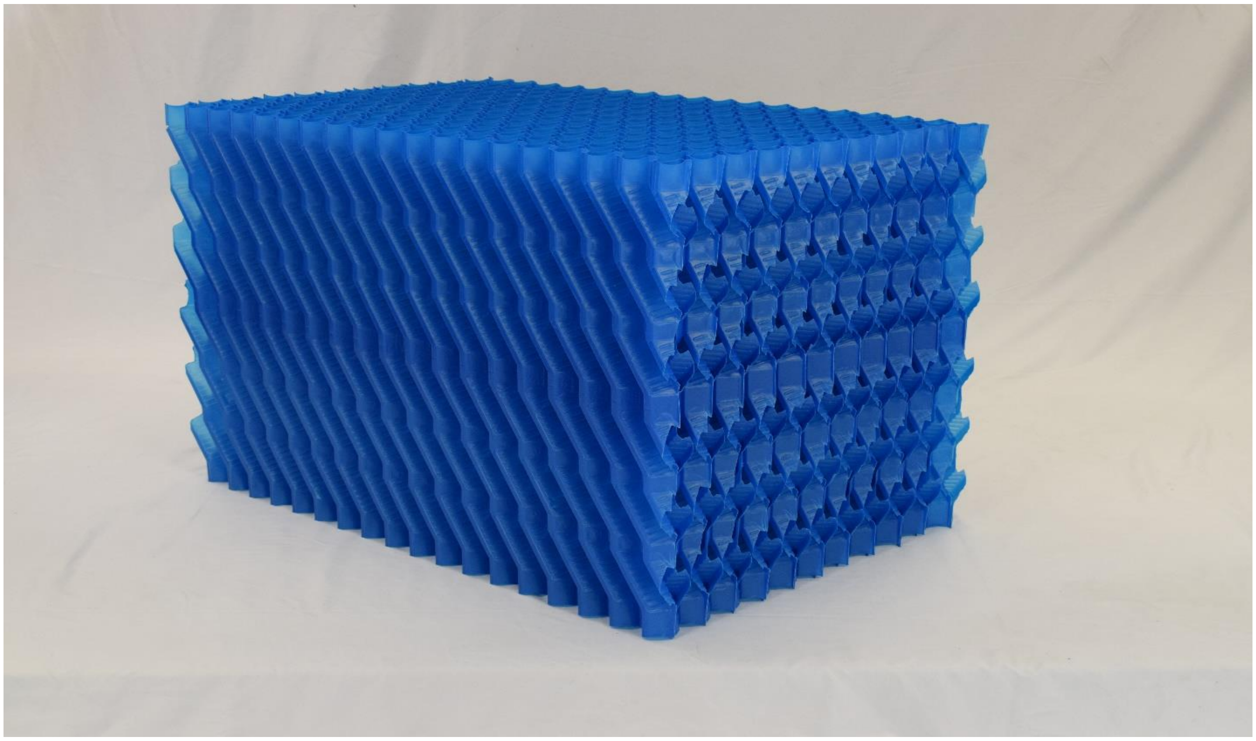

Figure 1 Interceptor Used in the BioSTORM Stormwater Treatment System

Stormwater enters the primary chamber via the inlet pipe. This chamber is designed to support sediment settling and to settle large particles, debris and grit using a StormTEE® screen. **Figure 2** shows the stormwater flow diagram for the BioSTORM system. The secondary chamber receives screened stormwater flow from the primary chamber. This chamber includes the Interceptor installed inside the BioSTORM housing to remove sediments by reducing the hydraulic turbulence and promoting sediment settling. Effluent can only exit through the outlet pipe which is connected to the BioSTORM housing and extends outside of the secondary chamber. Components of the system are installed in the two chambers in which no moving parts and/or electrical requirements are needed. All chambers, piping, and installation are provided by local contractors. BioMicrobics, Inc. (BioMicrobics) provides the non-moving components, including the StormTEE screen and the BioSTORM treatment module (i.e., housing and Interceptor).

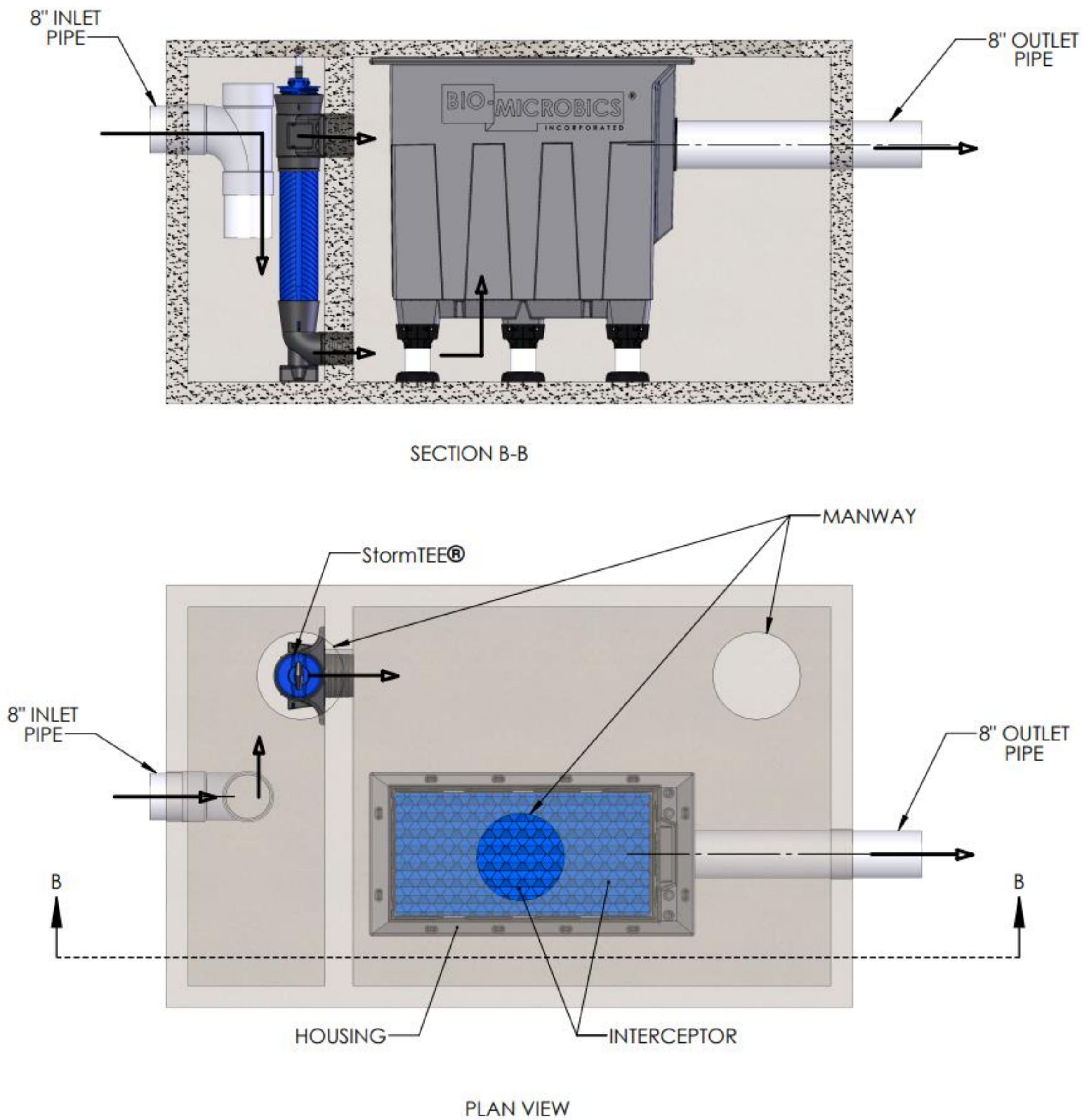

Figure 2 Stormwater Flow Diagram for the BioSTORM 0.5

2. Laboratory Testing

The test program was conducted at the Alden Research Laboratory, LLC (Alden), Holden, Massachusetts, under the direct supervision of Alden's senior stormwater engineer, James Mailloux. Alden has performed verification testing on Hydrodynamic Separator and Filtration Manufactured Treatment Devices (MTDs) for manufacturers under various state and federal testing protocols. Particle size distribution (PSD) analysis was conducted by GeoTesting Express, Inc., Acton, Massachusetts. GeoTesting is an A2LA ISO/IEC 17025 accredited independent laboratory. Water quality samples collected during the testing process were analyzed in Alden's Stormwater Laboratory, which is ISO 17025 accredited.

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 2021, updated April 2023 (NJDEP Hydrodynamic Protocol). 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) as per the NJDEP certification process.

2.1 Test Setup

The test unit, a BioSTORM 0.5 system, is installed in a rectangular vault measuring 5' wide by 6' high by 9.5' long. The vault is separated into two sections: a 24" long by 58" wide primary chamber and an 87" long by 58" wide secondary chamber. Water enters the primary chamber by means of an 8" influent pipe connected to a vertical downward tee. The centerline of the pipe is located 58" above the vault floor and centered on the vault width. In the primary chamber, water is conveyed into a vertical treatment device known as the StormTEE (Model SMT838), which is installed in the dividing wall between the two chambers, at a position 12.5" off the vault sidewall. The StormTEE is constructed from noncorrosive plastic material. It has an 8 inch diameter with 9.5 mm (3/8 inch) slots fixed at 60 degrees to the vertical that are spaced on 25 mm (1 inch) centers. The StormTEE has an imbedded cleaning swab that is used to remove debris and litter off the angled slot surfaces. The cleaning swab is used, as required and according to the maintenance and inspection schedule, without the need to remove the screen from the chamber. Flow entering the StormTEE is conveyed into the secondary chamber by means of two horizontal pipes: a 6" lower pipe and an 8" upper pipe. The centerline of each pipe was located at a height of 6.06" and 44.88", respectively, as shown on **Figure 3**. The StormTEE was raised 3" to allow for the installation of the 50% (6") sump false floor, resulting in centerline heights of 9.06" and 47.88", respectively. The BioSTORM 0.5 stormwater treatment module is a fabricated unit measuring 24.25" wide by 51.5" long by 50.31" high and is raised approximately 14" off the floor with the use of five 4" PVC legs. The centerline of the device is 24" from the vault sidewall, opposite from the StormTEE. The inside of the module contains corrugated angled plastic plates 24"x48"x24" (Interceptor), which provide final stormwater treatment. Water is conveyed through openings in the floor of the BioSTORM treatment module and passes upward through the corrugated angled plates. The treated water is then conveyed into an 8" outlet pipe with a centerline height of 48.75". The influent and effluent pipes have a slope of 1%. A drawing of the BioSTORM 0.5 is shown in **Figure 3**. Treatment system dimensions are shown in **Table 1**. A photograph showing the unit installed in the test loop is shown in **Figure 4.**

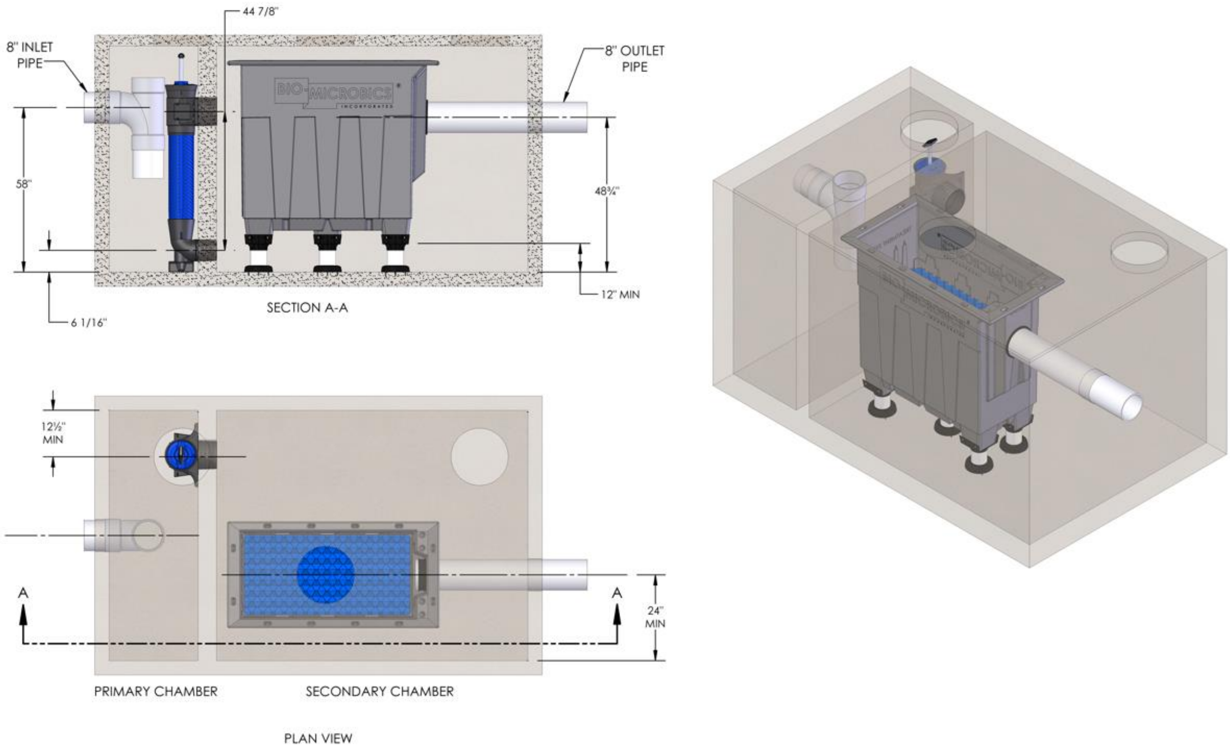

Figure 3 Drawing of the Tested BioSTORM 0.5 Treatment Unit

Table 1 BioSTORM 0.5 Stormwater Treatment System Dimensions

Model	**Primary Chamber (in)**		**Secondary Chamber (in)**		**Interceptor (in)**		
	L	**W**	**L**	**W**	**L**	**W**	**D**
0.5	24	58	87	58	48	24	24

Figure 4 BioSTORM 0.5 Test Unit Installed in Alden Flow Loop

The BioSTORM test unit was installed in the Alden test loop, shown in **Figure 5,** which is set up as a recirculation system. The loop is designed to provide metered flow up to approximately 9 cfs, using calibrated orifice plate and venturi differential-pressure meters. Flow was supplied to the unit using either a 20HP or 50HP laboratory pump (flow dependent), drawing water from a 50,000-gallon supply sump. Thirty (30) ft of straight 8” pipe conveyed the metered flow to the unit. Eight (8) ft of straight 8” effluent piping returned the test flow back to the supply sump as a free discharge. The influent and effluent pipes were set at 1% slopes. An 8” tee was located 2 ft upstream of the test unit for injecting the test sediment into the crown of the influent pipe. Sediment injection was accomplished with the use of a volumetric screw feeder. The mass capture methodology was used for the removal efficiency testing. The end-of-pipe grab sampling methodology was used for the scour test. A calibrated iso-kinetic sampler was installed in the upstream vertical riser pipe for collection of the background samples.

Filtration of the supply sump was performed with an inline filter wall containing 1-micron filter bags.

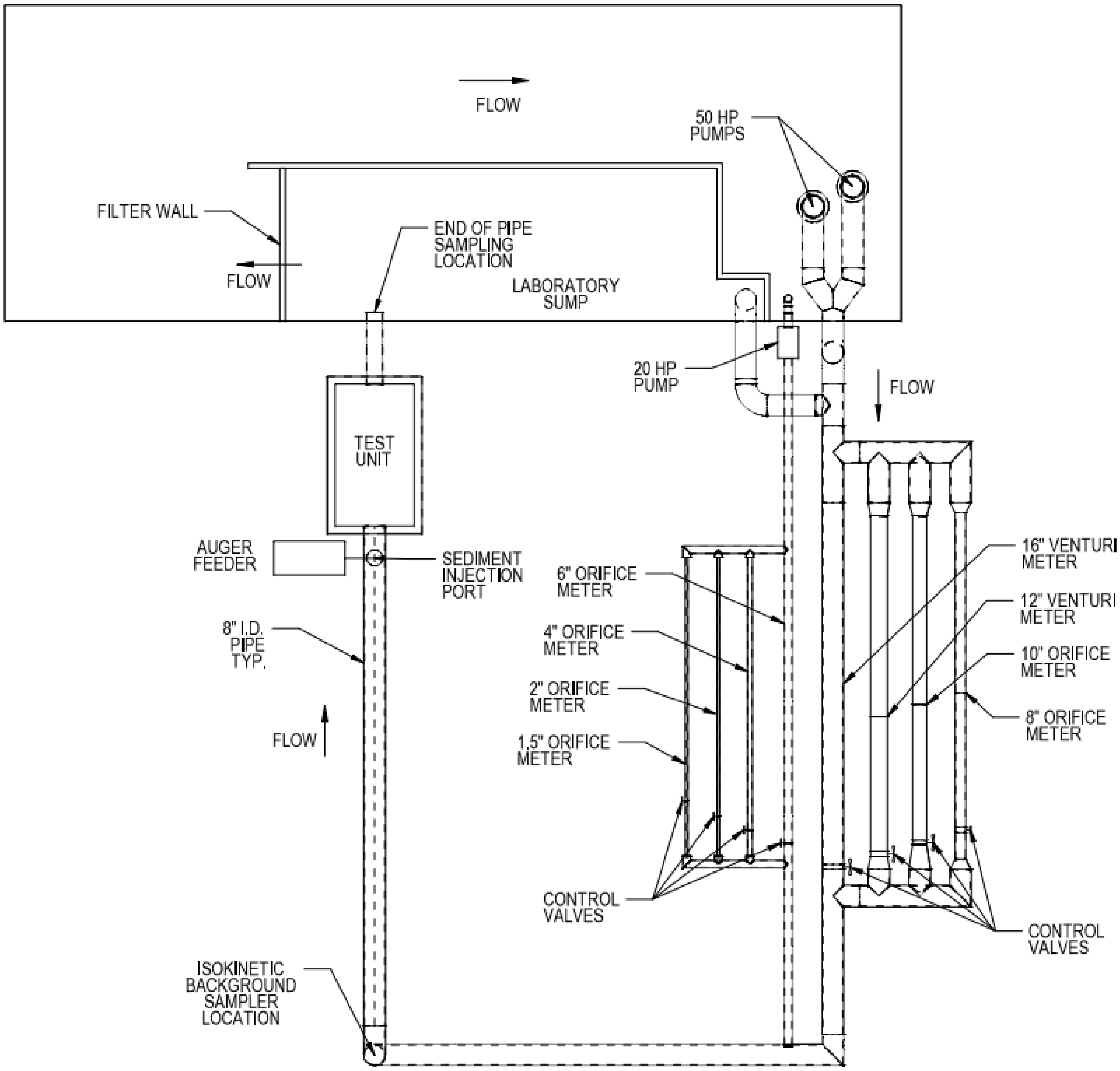

Figure 5 Plan View of Alden Flow Loop

2.2 Hydraulic Testing

The BioSTORM 0.5 was tested with clean water to determine its hydraulic characteristic curves. Flow and water level measurements were recorded at steady-state flow conditions using a computer Data-Acquisition system, which included a data collect program, 0-250" Rosemount Differential Pressure cell, and a Druck 0-2.0 psi Pressure Transducer. Flows were set and measured using calibrated differential-pressure flow meters and control valves. Each test flow was set and operated at steady state for approximately 5 minutes, after which time a minimum of 60 seconds of flow and pressure data were averaged and recorded for each pressure tap location. Water elevations were measured one pipe-diameter upstream and downstream of the test unit, as well as within the primary and secondary chambers.

2.3 Removal Efficiency Testing

Removal testing was conducted on a clean unit utilizing the mass capture testing methodology. A false floor was installed at the 50% collection sump sediment storage depth of 6”. All tests were run with clean water containing a background sediment solids concentration (SSC) of ≤ 20 mg/L.

Seven sediment removal efficiency tests were conducted at flows ranging from 11% to 256% Maximum Treatment Flow Rate (MTFR).

The test sediment was prepared by Alden to meet the PSD gradation of 1-1000 microns (µm) in accordance with the distribution shown in column 2 in **Table 1**. The sediment was silica based, with a specific gravity of 2.65. The target influent sediment concentration was 200 mg/L (±20 mg/L) for all tests. The concentration was verified by collecting a minimum of eight timed dry samples at the injector and correlating the data with the measured flow rate. Each sample volume was a minimum of 0.1 liters. The collection times did not exceed 1 minute for all tests except the 11% MTFR test, which were collected over a duration of 2 minutes to increase accuracy. The allowed Coefficient of Variance (COV) for the measured samples was ≤ 0.10. The reported test concentration was calculated based on the total mass injected during the test and total volume of water introduced during sediment dosing.

A minimum of 25 lbs of test sediment was introduced into the influent pipe for each test, with the exception of the 11% MTFR condition, which was terminated after an 8-hour duration. The moisture content of the test sediment was determined using ASTM D2216 (2019) “Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass”, for each test conducted. Alden is ISO 17025 accredited for conducting the D2216 analysis. The allowed supply water maximum temperature of ≤ 80 degrees F was met for all tests conducted.

A minimum of 8 background samples of the supply water were collected at evenly spaced intervals throughout each test. Samples were collected every hour for any test ≥ 8 hours in duration. Collected samples were analyzed for Suspended Sediment Concentration (SSC) using ASTM D3977-97 (2019) “Standard Test Methods for Determining Sediment Concentration in Water Samples”. Alden is ISO 17025 accredited for conducting the D3977 analysis.

After completion of a selected test, the unit was decanted over a period not exceeding 30 hours. The remaining water and sediment were collected from the treatment unit and dried in designated pre-weighed nonferrous trays in compliance with ASTM D2216 (2019).

Table 2 NJDEP Target Test Sediment Particle Size Distribution

	TSS Removal Test PSD	Scour Test Pre-load PSD
Particle Size (Microns)	Target Minimum % Less Than[2]	Target Minimum % Less Than[3]
1,000	100	100
500	95	90
250	90	55
150	75	40
100	60	25
75	50	10
50	45	0
20	35	0
8	20	0
5	10	0
2	5	0

1. The material shall be hard, firm, and inorganic with a specific gravity of 2.65. The various particle sizes shall be uniformly distributed throughout the material prior to use.
2. 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.
3. This distribution is to be used to pre-load the MTD's sedimentation chamber for off-line and on-line scour testing.

2.4 Scour Testing

A sediment scour test was conducted to evaluate the ability to retain captured material during high flows. Six inches of 50-1000 micron sediment were pre-loaded in the primary and secondary chambers to the 50% capacity level, in accordance with the protocol. All test sediment was evenly distributed and levelled prior to testing as per the protocol.

The unit was filled with clean water (< 20 mg/L sediment concentration) to the dry-weather condition prior to testing. Testing was conducted at a temperature not exceeding 80 degrees F. The test was initiated within 96 hours of filling the unit.

The test was conducted at a minimum of 125% MTFR for offline certification. Testing consisted of conveying the selected target flow through the unit and collecting 15 time-stamped effluent samples (every 2 minutes) for SSC analysis, with the first sample being collected 1 minute after initiating the flow. The target flow was reached within 3 minutes of commencement of the test. A minimum of 8 evenly-spaced time-stamped background samples were collected throughout the test. Flow data was recorded every 3 seconds throughout the test and correlated with the samples. Each effluent grab sample for sediment concentration analysis was collected from the end of the effluent pipe by sweeping a 1 liter wide-mouth bottle through the effluent stream.

2.5 Instrumentation and Measuring Techniques

Flow

The inflow to the test unit was measured using one of five (5) calibrated differential-pressure flow meters (1.5”, 2”, 4”, 6” or, 8”). Each meter was fabricated per ASME guidelines and calibrated in Alden’s Calibration Department, which is ISO 17025 accredited. Flows were set with a control valve and the differential head from the meter was measured using a Rosemount® 0 to 250-inch Differential Pressure cell, also calibrated at Alden. The test flow was averaged and recorded every 3-30 seconds (flow dependent) throughout the duration of the test using an in-house computerized data acquisition program. The accuracy of the flow measurement is ±1%. The allowable Coefficient of Variance (COV) for flow documentation was ≤ 0.03. A photograph of the flow meter array is shown in **Figure 6.**

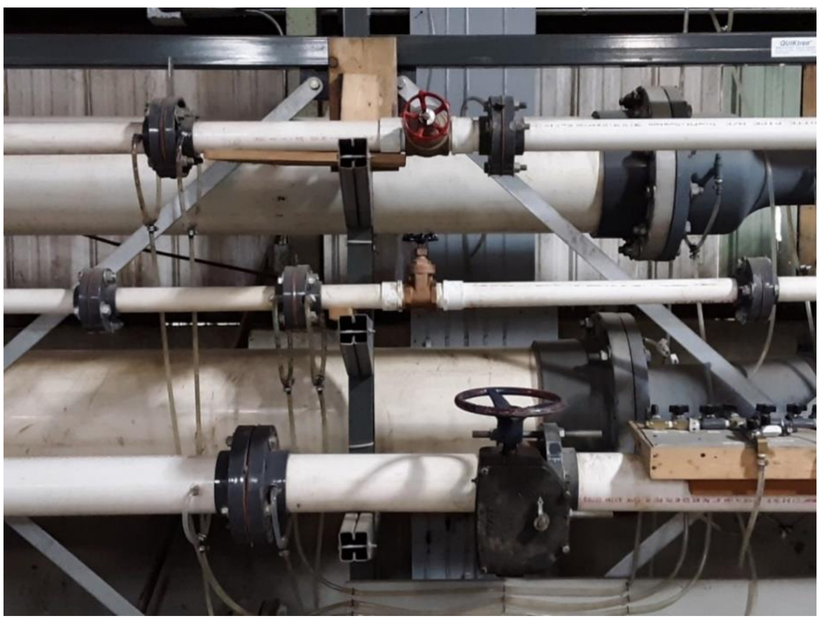

Figure 6 Photograph Showing Laboratory Flow Meters

Temperature

Water temperature measurements within the supply sump were obtained using a calibrated Omega® DP25 temperature probe and readout device. The calibration was performed at the laboratory prior to testing. The temperature measurement was documented at the start, middle and end of each test, to assure a testing temperature of ≤ 80 degrees F per NJDEP protocol requirement.

Pressure Head

Pressure head measurements were recorded at multiple locations using piezometer taps and a Druck, 0 - 2.0 psi pressure transducer, calibrated at Alden prior to testing. Accuracy of the readings is ± 0.001 ft. The cell was installed 2.184 ft below the outlet invert, allowing for elevation readings through the full range of flows. A minimum of 60 seconds of pressure data was averaged and recorded for each pressure tap, under steady-state flow conditions. A photograph of the pressure instrumentation is shown in **Figure 7.**

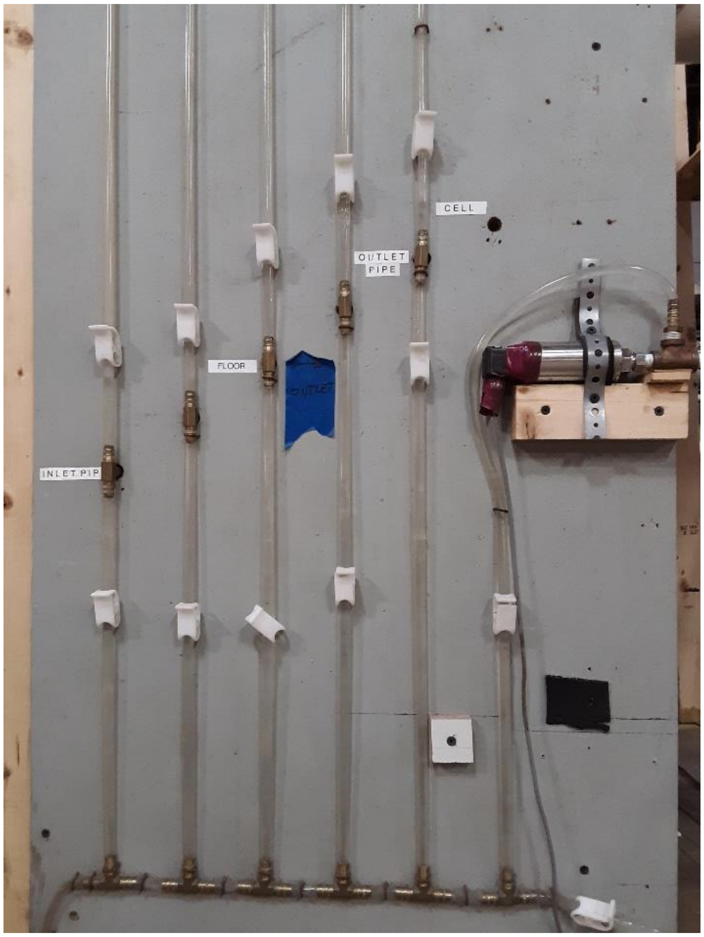

Figure 7 Pressure Measurement Instrumentation

Sediment Injection

The test sediment was injected into the crown of the influent pipe using an Auger Feeders LTD® volumetric screw feeder, model VF-1, shown in **Figure 8**. The feed screws used in testing ranged in size from 0.5” to 1”, depending on the test flow. Each auger screw, driven with a variable-speed drive, was calibrated with the test sediment prior to testing. The pre-test calibration, as well as test verification of the sediment feed was accomplished by collecting 1-minute timed dry samples (2 minutes for 11% MTFR flow) and weighing them on a calibrated Ohaus® 4000g x 0.1g, model SCD-010 digital scale. The allowable COV for sediment feed was ≤ 0.10.

Figure 8 Photograph Showing Variable-Speed Auger Feeder

Sample Collection

Background concentration samples were collected from the center of the vertical riser pipe upstream of the test unit inlet pipe, with the use of a 0.75" diameter isokinetic sampler, shown in **Figure 9**. The sampler was calibrated for each test flow. All scour test effluent grab samples were collected from the free-discharge at the end of the effluent pipe, using 1 L wide-mouth bottles. All collected samples were a minimum of 0.5 L in volume.

Figure 9 Photograph Showing the Background Isokinetic Sampler

Sample Concentration Analysis

Effluent and background concentration samples were analyzed by Alden in accordance with Method B, as described in ASTM Designation: D 3977-97 (Re-approved 2019), “Standard Test Methods for Determining Sediment Concentration in Water Samples”. Alden has assigned a Non-Detection Limit (NDL) of 1.0 mg/L. To be conservative, all concentrations below the NDL were assigned a value of 0.5 mg/L.

Mass Capture Analysis

The mass capture test methodology, in which the injected and captured sediment mass are quantified, was used to determine the sediment removal efficiency for each test flow. The mass of injected sediment was determined by weighing the prepared test batch prior to testing and subtracting the remaining mass in the feeder at the conclusion of the test. All sediment collected for the sediment feed rate concentrations was returned to the feeder prior to the final mass remaining determination. All captured material was collected in designated pre-weighed non-ferrous trays and dried in a Binder® laboratory oven, model ED-400, in accordance with ASTM D2216 (2019) “Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.” Depending on collected mass, each tray was weighed on either an Ohaus® 40000 g x 0.1 g; model SP4001, or Adam® 16 kg x 0.0005 kg; model GBK-35A digital scale. Alden is ISO 17025 accredited for conducting the ASTM D2216 analysis.

2.6 Data Management and Acquisition

A designated Laboratory Records Book was used to document the conditions and pertinent data entries for each test conducted. All entries are initialed and dated.

A personal computer running an Alden in-house Labview® Data Acquisition program was used to record all data related to instrument calibration and testing. A 16-bit National Instruments® NI6212 Analog to Digital board was used to convert the voltage signal from the pressure cells. Alden’s in-house data collection software, by default, collects one-second averages of data collected at a raw rate of 250 Hz. The system allows very long contiguous data collection by continuously writing the collected 1 second averages and their RMS values to disk. The data output from the program is in tab delimited text format with user-defined number of significant figures.

Test flow and pressure data were continuously collected at a frequency of 250 Hz. The flow data was averaged and recorded to file every 3 to 30 seconds, depending on the duration of the test. Steady-state pressure data were averaged and recorded over a duration of 60 seconds for each point. The recorded data files were imported into Excel for further analysis and plotting.

Excel based data sheets were used to record all sediment related data used for quantifying injection rate, effluent (scour) and background sample concentrations, flow, pressure, mass, and PSD data. The data was input to the designated spreadsheet for final processing.

2.7 Quality Assurance and Control

All instruments were calibrated prior to testing and periodically checked throughout the test program. Instrumentation calibrations were provided to NJCAT.

Flow

The flow meters and pressure cells were calibrated in Alden's Calibration Laboratory, which is ISO 17025 accredited. All pressure lines were purged of air prior to initiating each test. A standard water manometer board and Engineers Rule were used to measure the differential pressure and verify the computer measurement of the selected flow meter.

Sediment Injection

The sediment feed (g/min) was verified with the use of a NIST traceable digital stopwatch and a 2200 g x 0.1 g calibrated digital scale. The tare weight of the sample container was recorded prior to collection of each sample. The samples were a minimum of 0.1 liters in size, with a maximum collection time of 1 minute. The reported overall mass/volume sediment concentrations were adjusted for moisture.

3. Performance Claims

The following performance claims for the BioMicrobics BioSTORM 0.5 stormwater treatment system are based on the independent laboratory testing conducted in accordance with the NJDEP testing protocol.

Total Suspended Solids (TSS) Removal Efficiency

The BioSTORM 0.5 system achieved removal efficiencies ranging from 32.4% to 66.0%, using the NJDEP 1-1000 micron sediment PSD. The NJDEP weighted removal efficiency based on an MTFR of 228 gpm, was 56.3%, which meets the 50% TSS removal criterion for Hydrodynamic Separators.

Maximum Treatment Flow Rate (MTFR)

The effective treatment sedimentation area of the tested unit was 44.7 ft^2. The 100% MTFR is 228 gpm, with a corresponding hydraulic loading rate of 5.1 gpm/ft^2.

Maximum Sediment Storage Depth and Volume

The maximum sediment storage depth of the test unit was 12", which equates to a sediment storage volume of 44.7 ft^3. The 50% storage depth was 6", corresponding to a volume of 22.4 ft^3.

Online / Offline Installation

A 125% MTFR offline sediment scour test was performed with the collection sump preloaded to

50% of the sediment storage capacity (6”), using the NJDEP 50-1000 micron sediment PSD. The test resulted in an average adjusted effluent concentration of 9.3 mg/L, which meets the offline installation acceptance criterion.

System Loss

Hydraulic testing was conducted at flows ranging from 25 to 604 gpm. The maximum recorded system energy loss was 2.08 ft at 604 gpm.

4. Supporting Documentation

The NJDEP Procedure (NJDEP, 2021) for obtaining verification of a stormwater manufactured treatment device (MTD) from the New Jersey Corporation for Advanced Technology (NJCAT) requires that “copies of the laboratory test reports, including all collected and measured data; all data from performance evaluation test runs; spreadsheets containing original data from all performance test runs; all pertinent calculations; etc.” be included in this section. This was discussed with NJDEP, and it was agreed that as long as such documentation could be made available by NJCAT upon request 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 Test Sediment PSD Analysis

The sediment particle size distribution (PSD) used for scour and removal efficiency testing was comprised of 50-1000 and 1–1000 micron (respectively) silica particles with a SG of 2.65. The 1-1000 micron sediment batches were prepared by Alden to meet the protocol specifications using commercially-available silica products. A random sample from each test batch was analyzed in accordance with ASTM D6913/D7928, by GeoTesting Express, an A2LA ISO/IEC 17025 accredited independent laboratory. The specified less than (%-finer) values of the sample average were within the 2-percentage point tolerance listed in the protocol. The 50–1000 micron sediment was procured in bulk from AGSCO as certified material. The certification was performed by CTLGroup, an ISO/IEC 17025 accredited independent laboratory, and provided with the material shipment.

Sediment test batches for removal efficiency testing of approximately 30-35 Lbs each were prepared in individual 5 gallon buckets, which were arbitrarily selected for each removal test. A well-mixed sample was collected from each test batch and analyzed for PSD by GeoTesting Express. The average of the samples was used for compliance with the protocol specifications. The PSD data of the samples are shown in **Table 3** and the corresponding curves are shown on **Figure 10.**

Table 3 Removal Efficiency Test Sediment Particle Size Distribution

	Test Sediment Particle Size Distribution									Average	NJCAT Targets	QA / QC Compliant
Particle size	25 gpm	60 gpm	112 gpm	168 gpm	225 gpm	337 gpm	440 gpm	487 gpm	575 gpm			
(micron)	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	
1000	99	99	100	99	99	100	99	99	99	**99**	**100**	Y
500	95	95	96	95	95	96	95	95	95	**95**	**95**	Y
250	89	88	89	88	89	89	89	89	89	**89**	**90**	Y
150	77	77	75	77	77	75	78	80	79	**77**	**75**	Y
100	61	62	64	59	61	63	61	62	61	**61**	**60**	Y
75	52	53	54	50	52	55	52	53	52	**53**	**50**	Y
50	45	46	46	44	45	46	46	46	45	**46**	**45**	Y
20	37	40	35	37	36	34	41	40	36	**38**	**35**	Y
8	22	24	22	22	22	19	26	25	24	**23**	**20**	Y
5	16	17	16	16	17	14	19	18	17	**17**	**10**	Y
2	7	10	7	8	7	8	7	7	8	**8**	**5**	Y
D_{50}	67	65	61	76	66	60	68	65	67	**66**	**75**	Y

The sediment particle size distribution (PSD) used for removal efficiency testing is finer than the NJDEP PSD sediment specifications (**Table 1**) across the entire distribution. The median (D_{50}) of 66 microns was less than the required 75 microns.

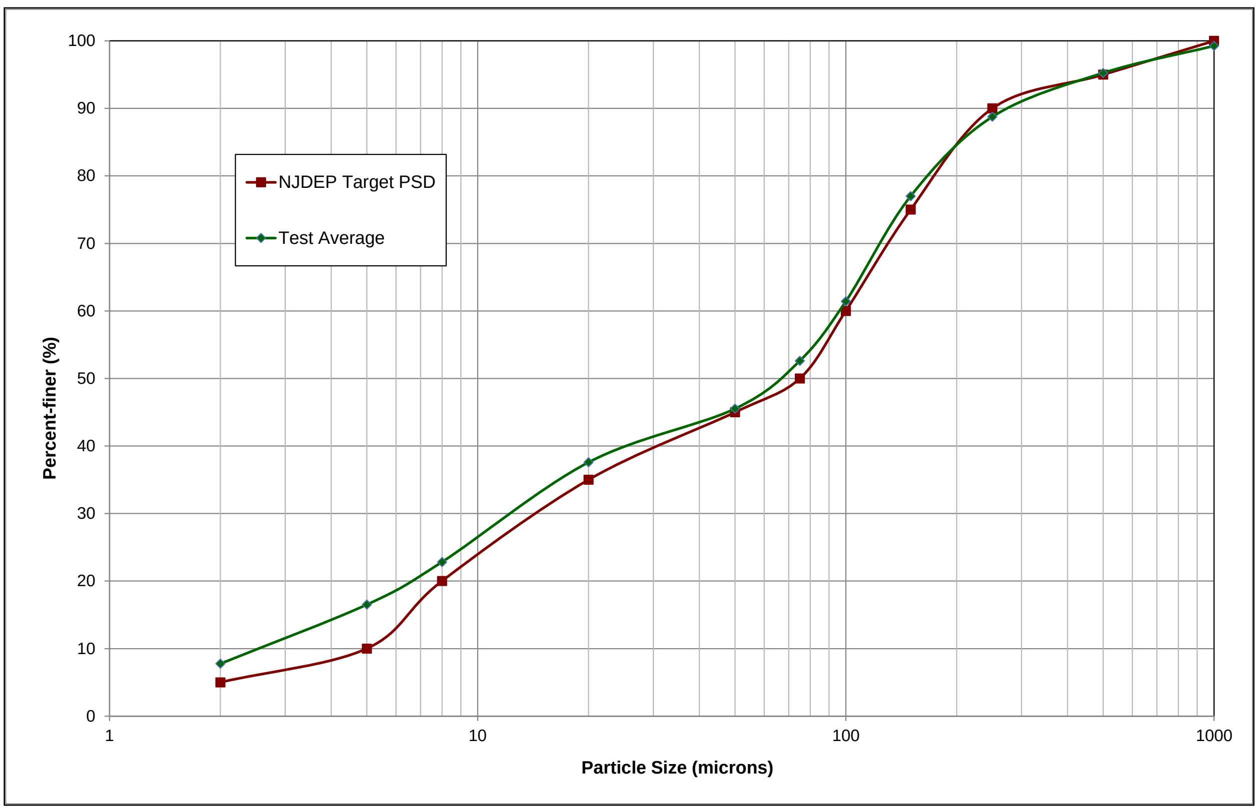

Figure 10 Average Removal Efficiency Test Sediment PSD

4.2 Removal Efficiency Testing

Testing Summary

Removal efficiency tests were conducted at 9 flows ranging from 25 gpm to 575 gpm to allow for the development of the removal efficiency curve and corresponding equation. Three tests were repeated due to equipment issues, which resulted in non-compliance with the protocol.

At the end of each test run, the captured sediment was collected and quantified. For all runs there was zero sediment in the inlet pipe. The removal efficiency was determined by dividing the sediment captured in the BioSTORM 0.5 sump by the injected sediment mass:

$$\%\ \boldsymbol{Removal} = \frac{\boldsymbol{Captured\ Sediment\ Mass}}{\boldsymbol{Injected\ Sediment\ Mass}}\ \boldsymbol{x\ 100}$$

The removal efficiencies of the tested flows ranged from 32.4% to 66.0%. The test data was plotted and a 3rd-order polynomial curve and equation was applied. The R^2 value of the curve equation was 0.965, exceeding the 0.95 criterion. The equation was used to select the 100% MTFR and calculate the NJDEP weighted removals for the 25%, 50%, 75%, 100% and 125% MTFR flows.

The recorded removal efficiency data is shown in **Tables 4 through 6,** and the removal efficiency curve and equation are shown on **Figure 11.** The calculated NJDEP weighted removal efficiency was 56.3% and is shown in **Table 7**.

Table 4 Removal Efficiency Testing Summary

Flow		Removal Efficiency
cfs	gpm	
0.06	25.0	**66.0%**
0.13	60.1	**59.0%**
0.25	112.3	**57.1%**
0.37	168.2	**56.3%**
0.50	225.2	**53.6%**
0.75	336.7	**43.1%**
0.98	439.2	**42.6%**
1.08	486.9	**40.8%**
1.28	574.6	**32.4%**

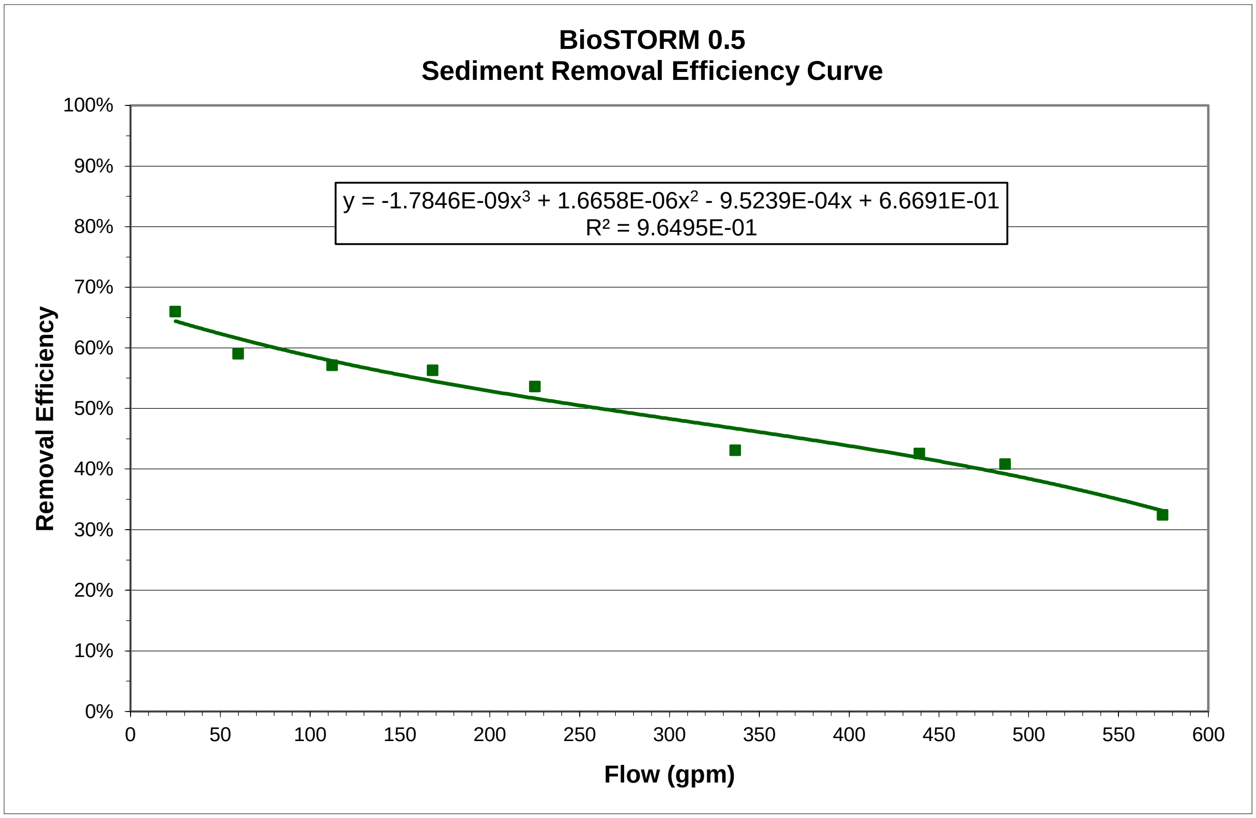

Figure 11 BioSTORM 0.5 Removal Efficiency Curve

Table 5 Injected Sediment Summary

Flow gpm	Target Concentration mg/L	Injector Wts. Concentration mg/L	Injector Measurements COV	Mass/Volume Concentration mg/L	Total Injected Mass Lbs.	QA / QC Compliant
25.0	200	201	0.02	203	17.86	Y
60.1	200	197	0.04	201	27.39	Y
112.3	200	201	0.02	200	26.52	Y
168.2	200	198	0.02	199	28.47	Y
225.2	200	201	0.01	191	28.06	Y
336.7	200	197	0.01	191	26.31	Y
439.2	200	199	0.00	195	30.19	Y
486.9	200	197	0.01	204	28.19	Y
574.6	200	197	0.00	198	27.45	Y

Table 6 Test Flow and Water Temperature Summary

Flow cfs	**Measured Flow** gpm	**Flow Measurement COV**	**Maximum Temperature** Deg. F	**Maximum Background** mg/L	**QA / QC Compliant**
0.06	25.0	0.001	64.7	3.5	Y
0.13	60.1	0.001	66.7	6.6	Y
0.25	112.3	0.001	71.0	12.7	Y
0.37	168.2	0.002	71.0	3.2	Y
0.50	225.2	0.002	73.0	11.3	Y
0.75	336.7	0.003	71.2	16.0	Y
0.98	439.2	0.001	64.6	17.4	Y
1.08	486.9	0.002	64.0	9.8	Y
1.28	574.6	0.001	65.2	11.1	Y

Table 7 Weighted Removal Efficiency

Calculated Weighted Removal Efficiency				
MTFR	**Flow (gpm)**	**Removal**	**Annual Weighting Factor**	**Weighted Removal**
25%	57	61.8%	0.25	15.4%
50%	114	57.7%	0.30	17.3%
75%	171	54.4%	0.20	10.9%
100%	228	51.5%	0.15	7.7%
125%	285	48.9%	0.10	4.9%
			Sum	**56.3%**

11% MTFR (25 gpm)

The test was conducted at 25 gpm over a period of 8.5 hours. The test flow was averaged and recorded every 30 seconds throughout the test. The average recorded test flow was 25.0 gpm, with a COV of 0.001. The maximum recorded temperature for the full test was 64.7 degrees F.

The injection feed rate of 18.9 g/min was verified by collecting timed weight samples from the injector every 30 minutes. The calculated influent injection concentrations for the full test ranged from 195 mg/L to 208 mg/L, with a mean of 201 mg/L and COV of 0.02. The total mass injected into the unit was 17.9 Lbs. The calculated mass/volume concentration for the test was 203 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 12**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.5 to 3.5 mg/L. The background curve is shown on **Figure 13**.

The total mass collected from the unit was 11.8 Lbs, resulting in a removal efficiency of 66.0%.

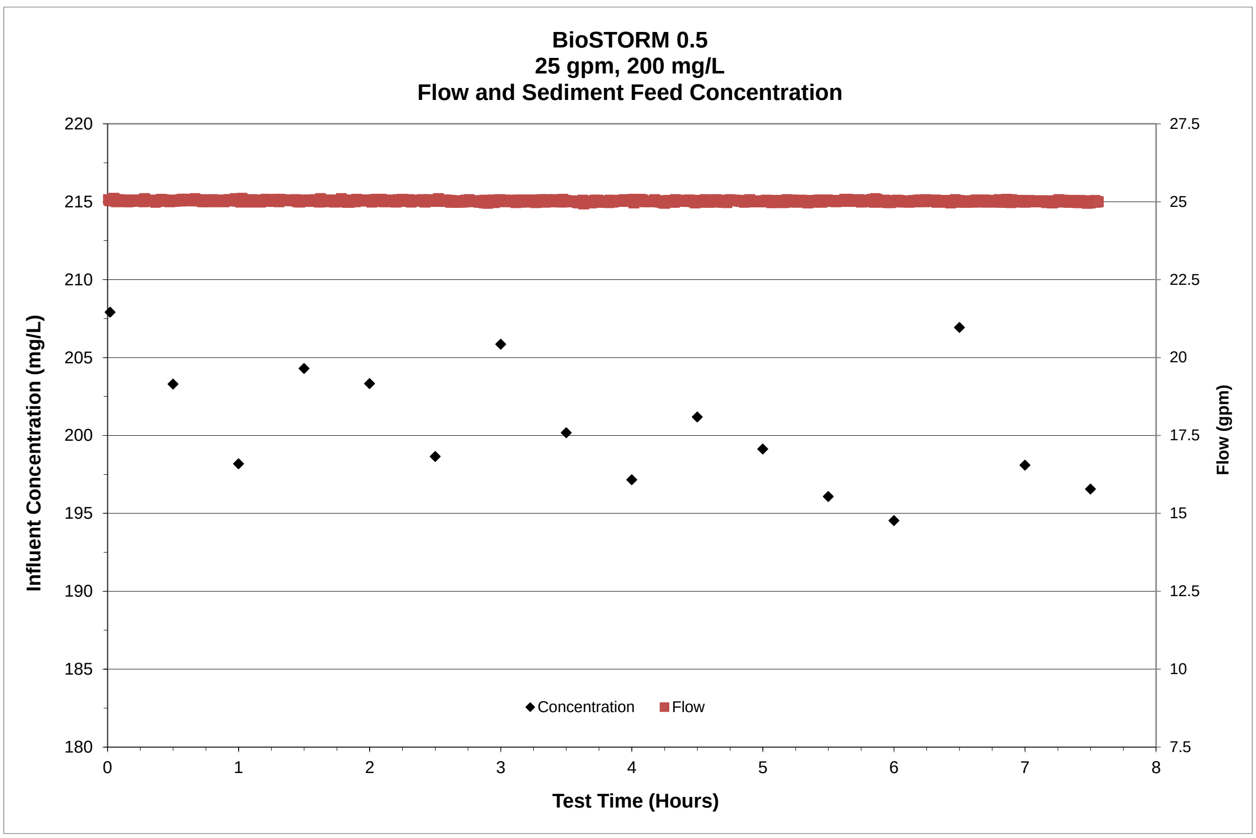

Figure 12 25 gpm Measured Flow and Influent Concentrations

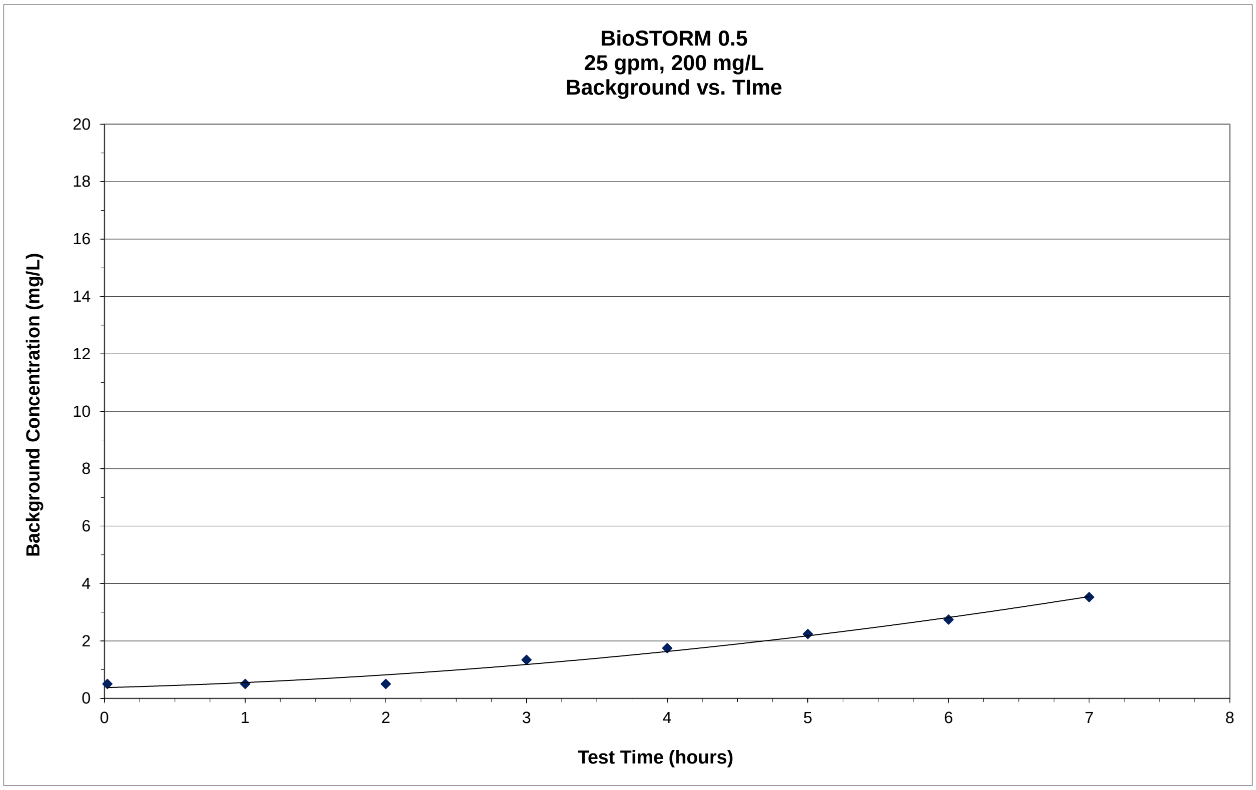

Figure 13 25 gpm Measured Background Concentrations

26% MTFR (60 gpm)

The test was conducted at 60 gpm over a period of approximately 5 hours. The test flow was averaged and recorded every 30 seconds throughout the test. The average recorded test flow was 60.1 gpm, with a COV of 0.001. The maximum recorded temperature for the full test was 66.7 degrees F.

The injection feed rate of 45.4 g/min was verified by collecting timed weight samples from the injector every 20 minutes. The calculated influent injection concentrations for the full test ranged from 183 mg/L to 209 mg/L, with a mean of 197 mg/L and COV of 0.04. The total mass injected into the unit was 27.4 Lbs. The calculated mass/volume concentration for the test was 201 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 14**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 2.2 to 6.6 mg/L. The background curve is shown on **Figure 15**.

The total mass collected from the unit was 16.2 Lbs, resulting in a removal efficiency of 59.0%.

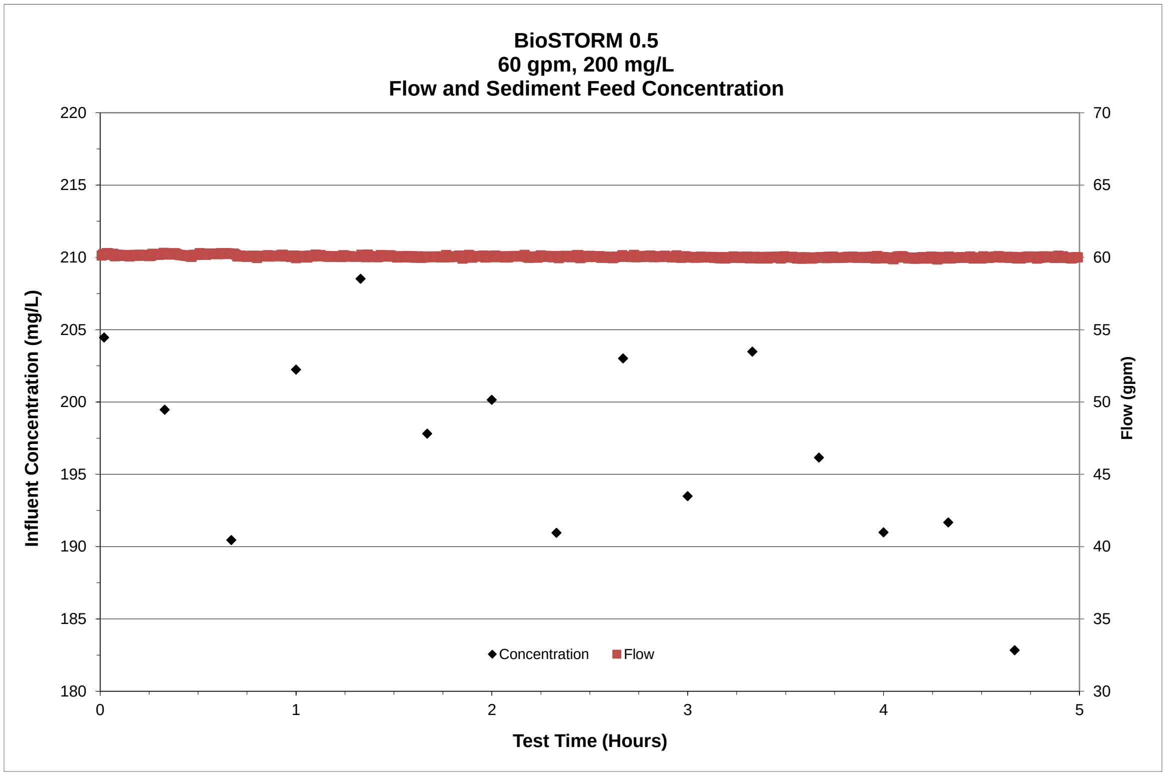

Figure 14 60 gpm Measured Flow and Influent Concentrations

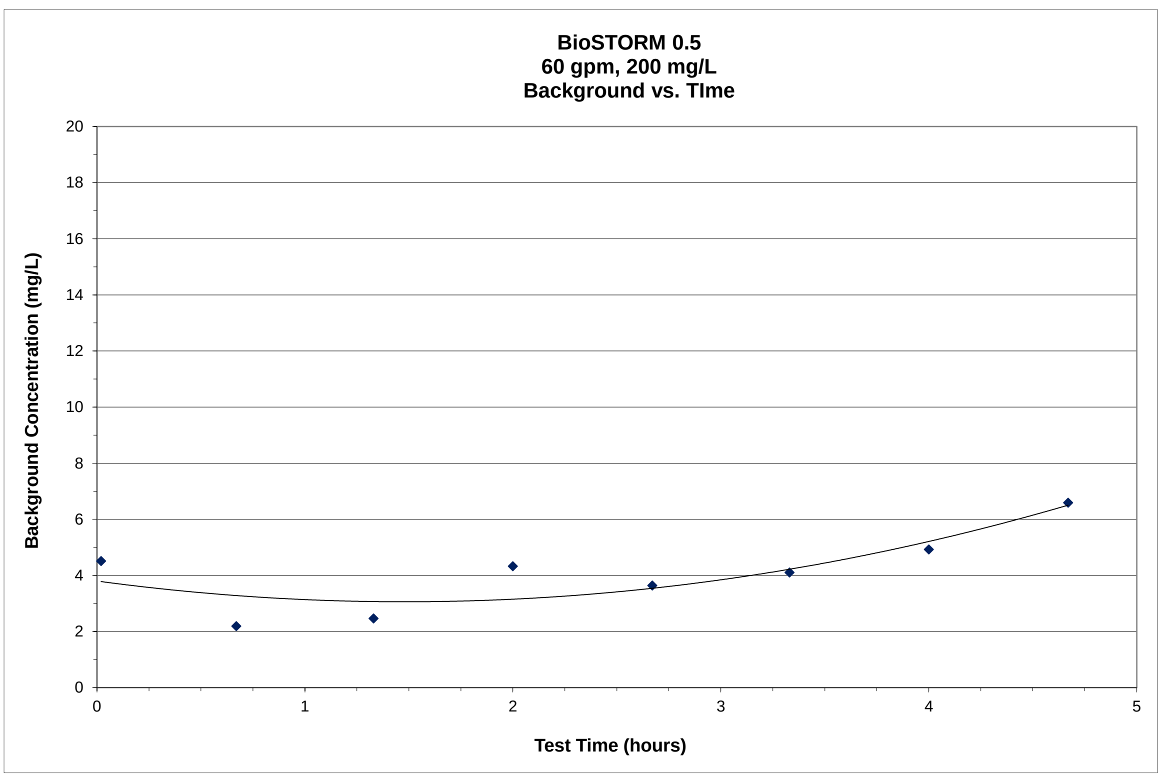

Figure 15 60 gpm Measured Background Concentrations

49% MTFR (112 gpm)

The test was conducted at 112 gpm over a period of approximately 2.7 hours. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 112.3 gpm, with a COV of 0.001. The maximum recorded temperature for the full test was 71.0 degrees F.

The injection feed rate of 84.9 g/min was verified by collecting timed weight samples from the injector every 21 minutes. The calculated influent injection concentrations for the full test ranged from 196 mg/L to 208 mg/L, with a mean of 201 mg/L and COV of 0.02. The total mass injected into the unit was 26.5 Lbs. The calculated mass/volume concentration for the test was 200 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 16**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 1.9 to 12.7 mg/L. The background curve is shown on **Figure 17**.

The total mass collected from the unit was 15.2 Lbs, resulting in a removal efficiency of 57.1%.

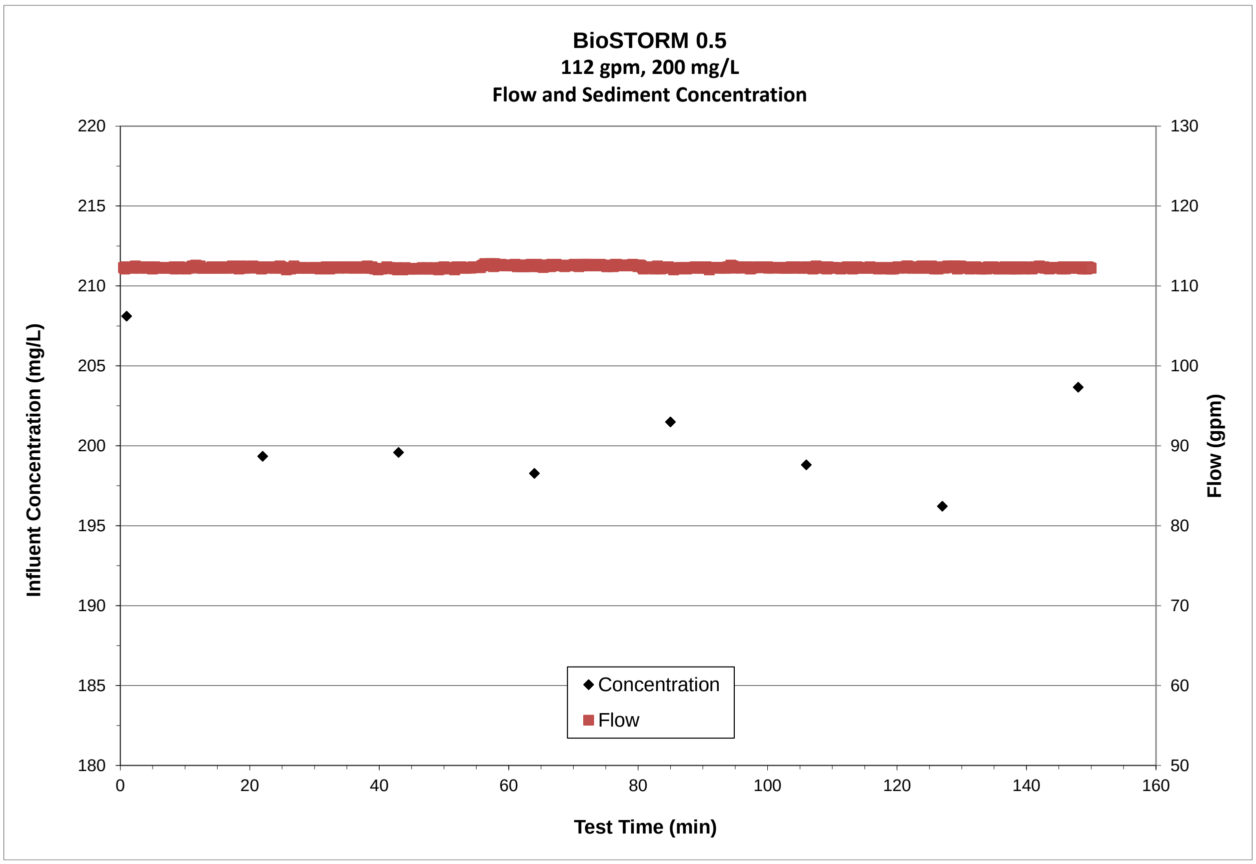

Figure 16 112 gpm Measured Flow and Influent Concentrations

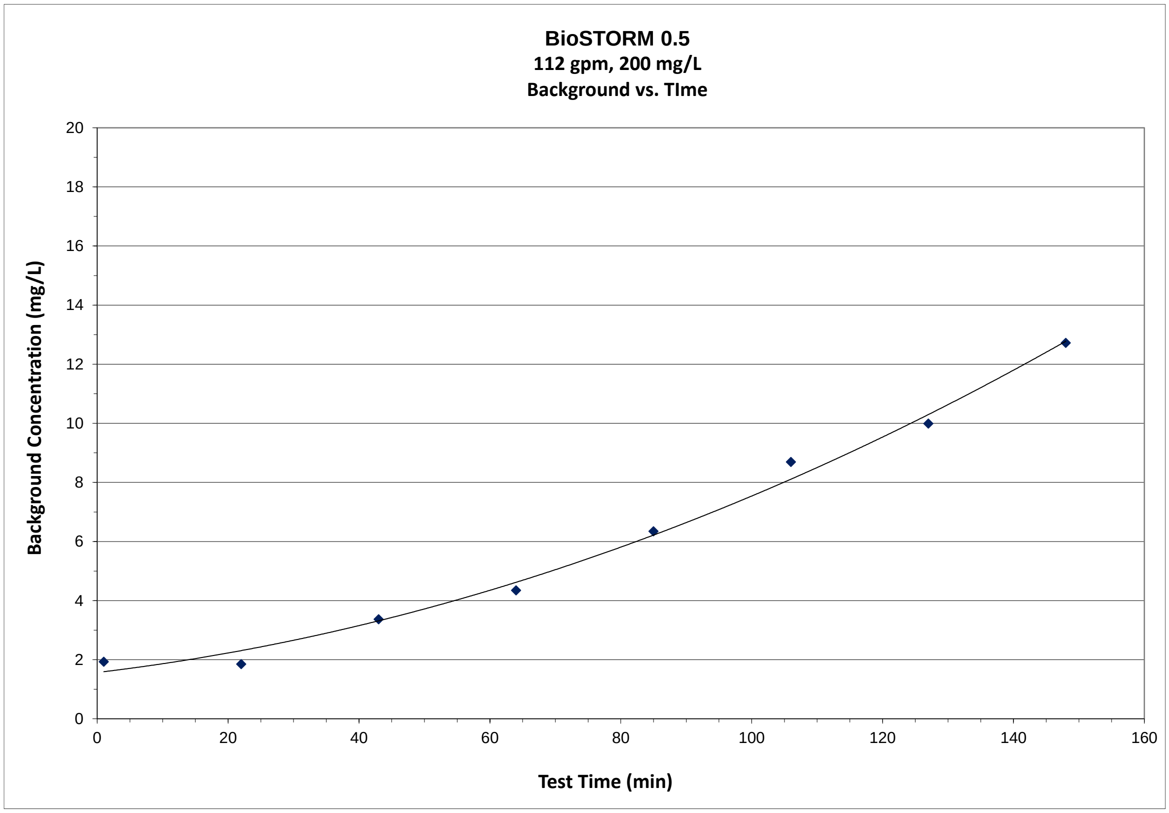

Figure 17 112 gpm Measured Background Concentrations

74% MTFR (168 gpm)

The test was conducted at 168 gpm over a period of approximately 2 hours. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 168.2 gpm, with a COV of 0.002. The maximum recorded temperature for the full test was 71.0 degrees F.

The injection feed rate of 127.4 g/min was verified by collecting timed weight samples from the injector every 15 minutes. The calculated influent injection concentrations for the full test ranged from 192 mg/L to 201 mg/L, with a mean of 198 mg/L and COV of 0.02. The total mass injected into the unit was 28.5 Lbs. The calculated mass/volume concentration for the test was 199 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 18**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.5 to 3.2 mg/L. The background curve is shown on **Figure 19**.

The total mass collected from the unit was 16.0 Lbs, resulting in a removal efficiency of 56.3%.

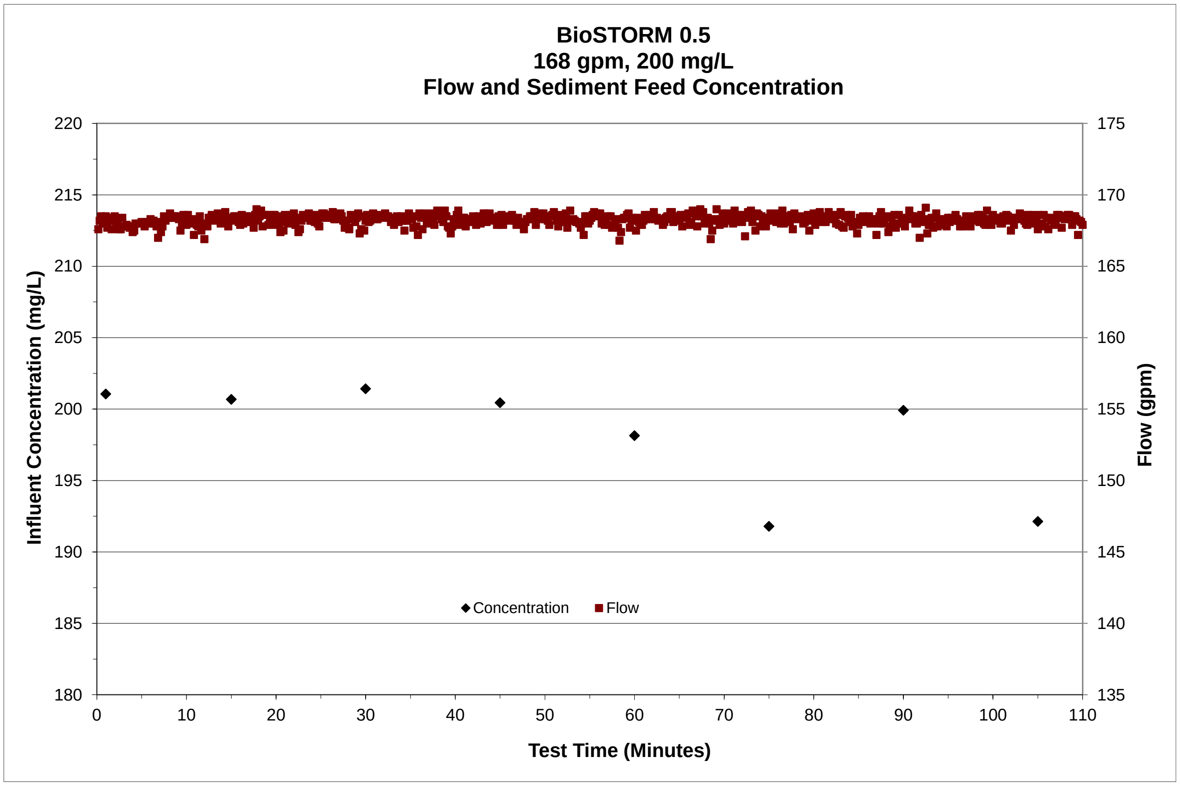

Figure 18 168 gpm Measured Flow and Influent Concentrations

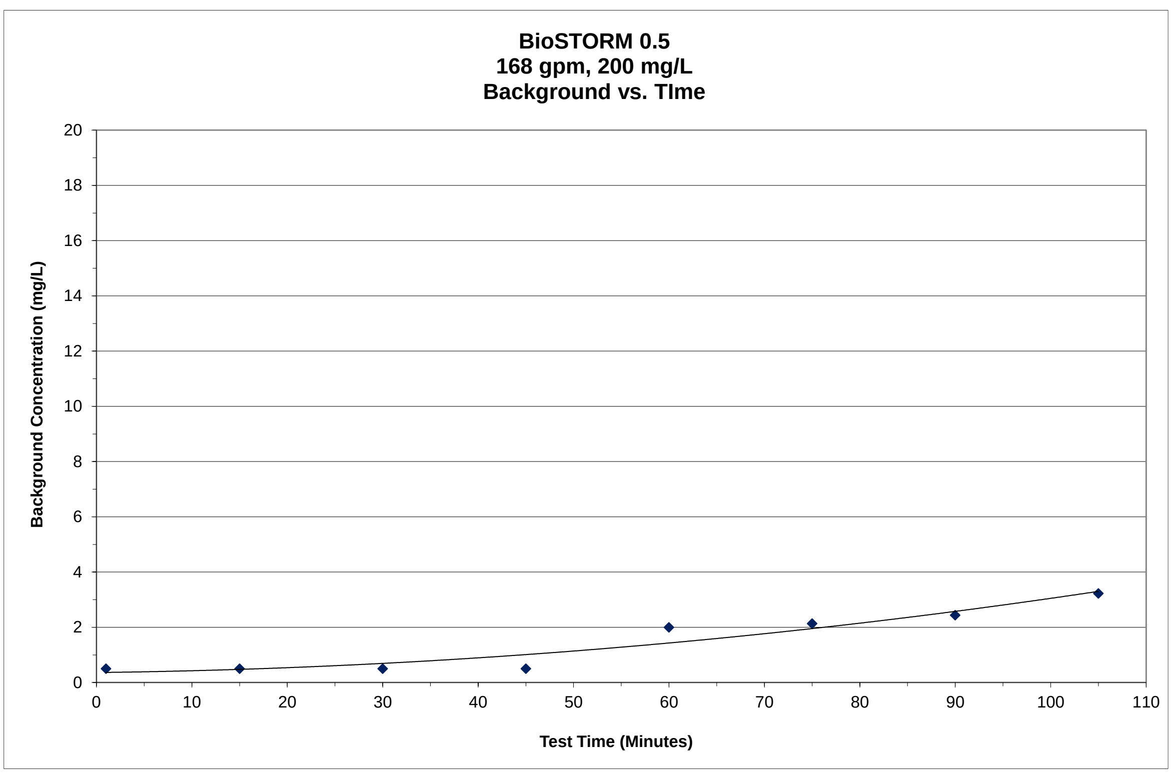

Figure 19 168 gpm Measured Background Concentrations

99% MTFR (225)

The test was conducted at 225 gpm over a period of approximately 90 minutes. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 225.2 gpm, with a COV of 0.002. The maximum recorded temperature for the full test was 73.0 degrees F.

The injection feed rate of 169.9 g/min was verified by collecting timed weight samples from the injector every 12 minutes. The calculated influent injection concentrations for the full test ranged from 196 mg/L to 203 mg/L, with a mean of 201 mg/L and COV of 0.01. The total mass injected into the unit was 28.1 Lbs. The calculated mass/volume concentration for the test was 191 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 20**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.5 to 11.3 mg/L. The background curve is shown on **Figure 21**.

The total mass collected from the unit was 15.1 Lbs, resulting in a removal efficiency of 53.6%.

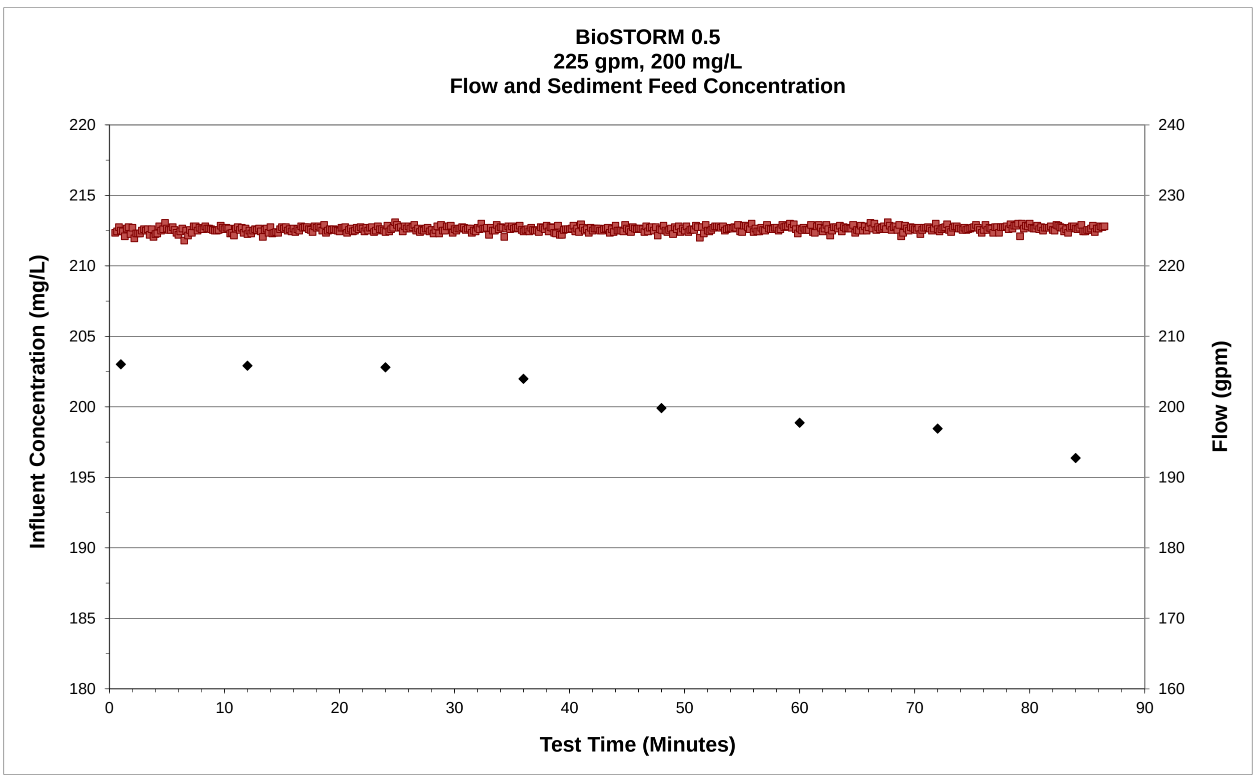

Figure 20 225 gpm Measured Flow and Influent Concentrations

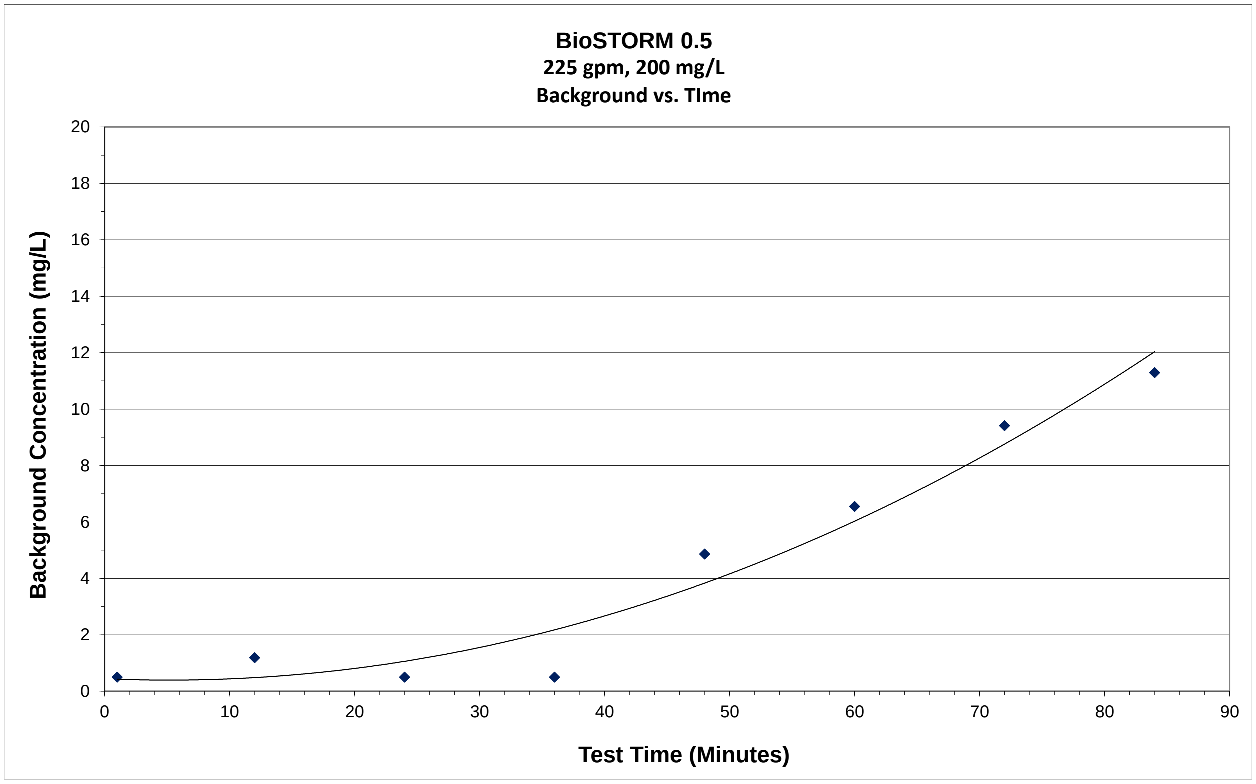

Figure 21 225 gpm Measured Background Concentrations

148% MTFR (337 gpm)

The test was conducted at 337 gpm over a period of approximately 60 minutes. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 336.7 gpm, with a COV of 0.003. The maximum recorded temperature for the full test was 71.2 degrees F.

The injection feed rate of 254.8 g/min was verified by collecting timed weight samples from the injector every 5 minutes. The calculated influent injection concentrations for the full test ranged from 194 mg/L to 201 mg/L, with a mean of 197 mg/L and COV of 0.01. The total mass injected into the unit was 26.3 Lbs. The calculated mass/volume concentration for the test was 191 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 22**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 2.5 to 16.0 mg/L. The background curve is shown on **Figure 23**.

The total mass collected from the unit was 11.3 Lbs, resulting in a removal efficiency of 43.1%.

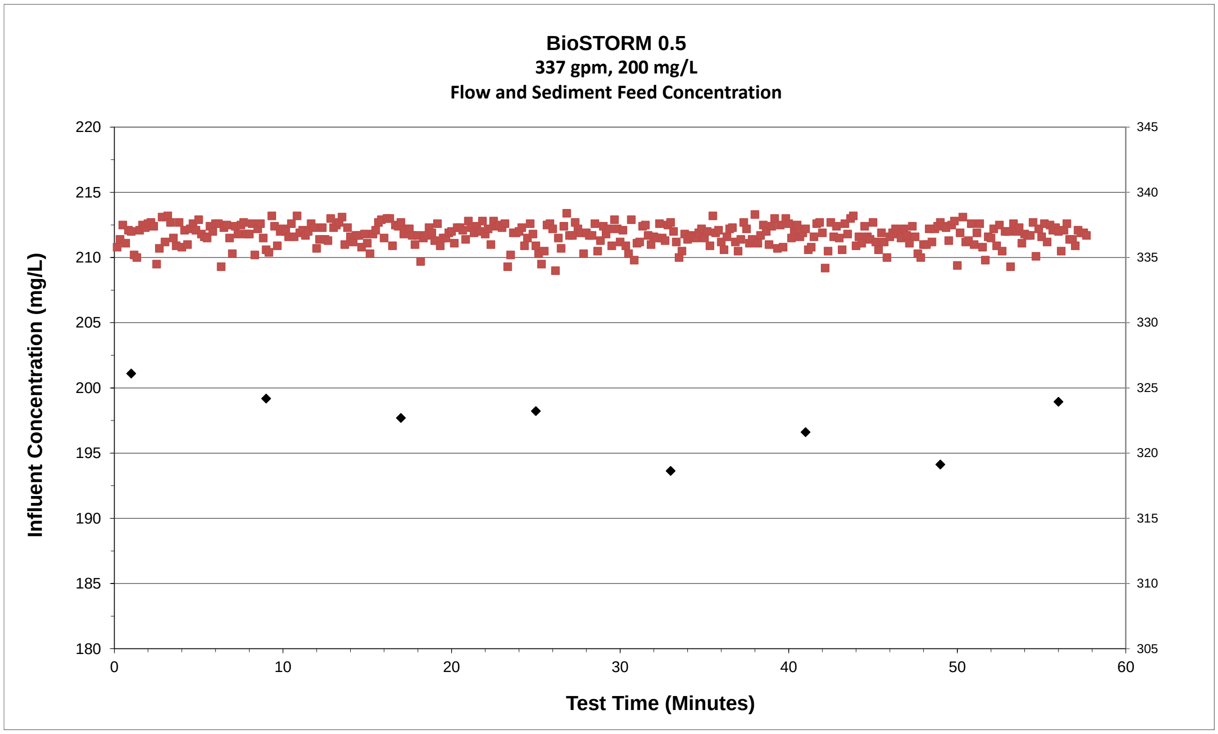

Figure 22 337 gpm Measured Flow and Influent Concentrations

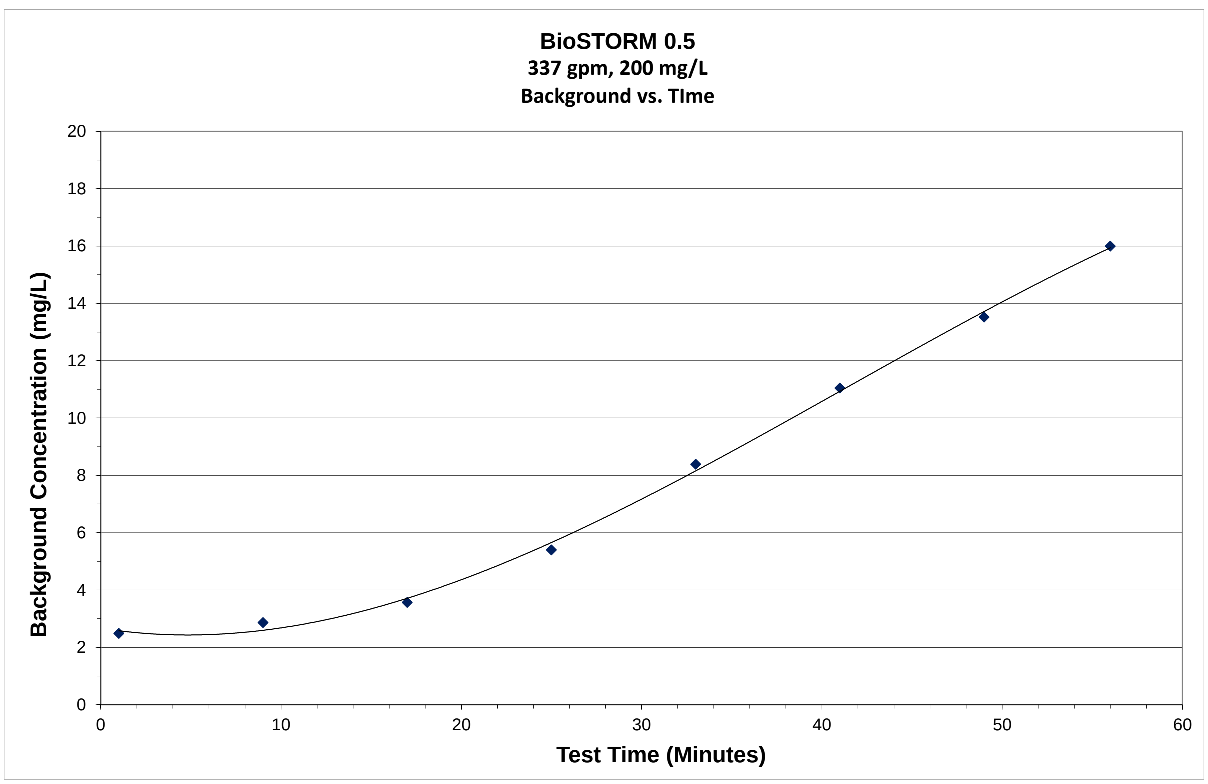

Figure 23 337 gpm Measured Background Concentrations

193% MTFR (440 gpm)

The test was conducted at 440 gpm over a period of 50 minutes. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 439.2 gpm, with a COV of 0.001. The maximum recorded temperature for the full test was 64.6 degrees F.

The injection feed rate of 333.1 g/min was verified by collecting timed weight samples from the injector every 6 minutes. The calculated influent injection concentrations for the full test ranged from 198 mg/L to 201 mg/L, with a mean of 199 mg/L and COV of 0.00. The total mass injected into the unit was 30.2 Lbs. The calculated mass/volume concentration for the test was 195 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 24**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 4.2 to 17.4 mg/L. The background curve is shown on **Figure 25**.

The total mass collected from the unit was 12.9 Lbs, resulting in a removal efficiency of 42.6%.

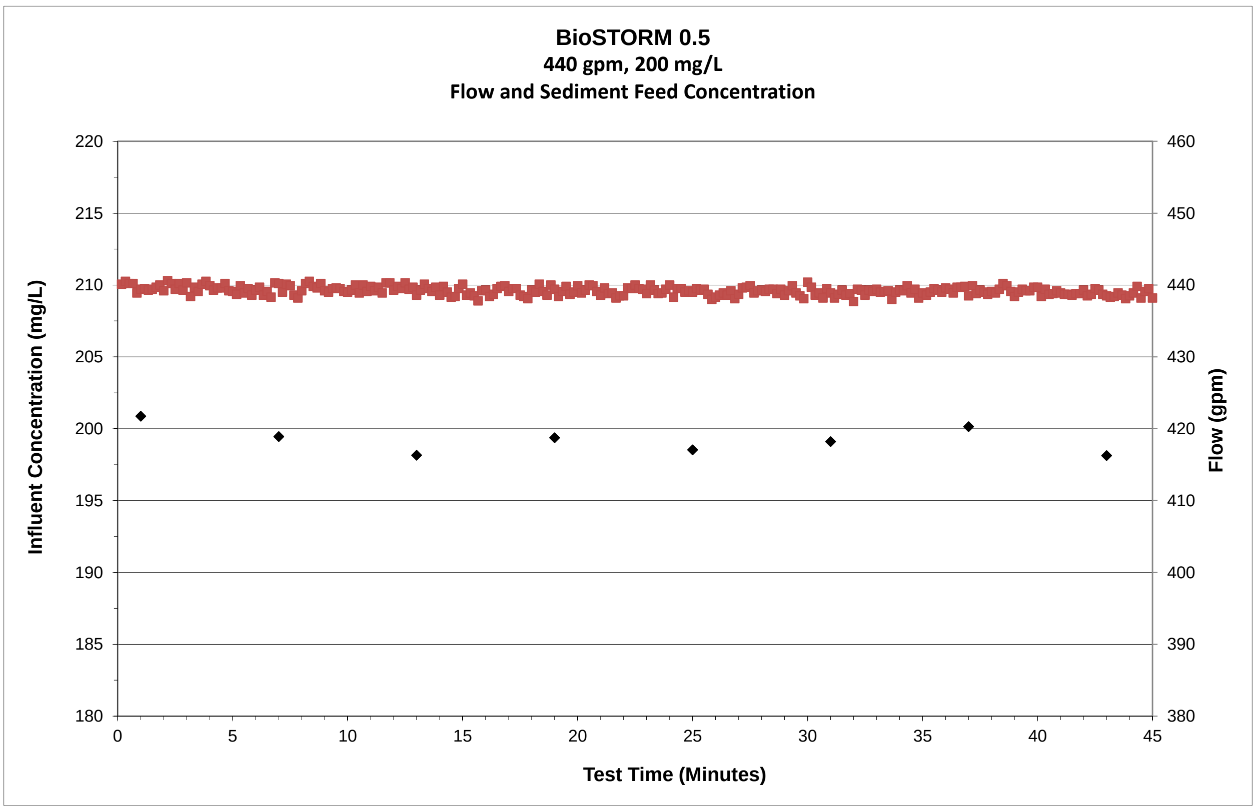

Figure 24 440 gpm Measured Flow and Influent Concentrations

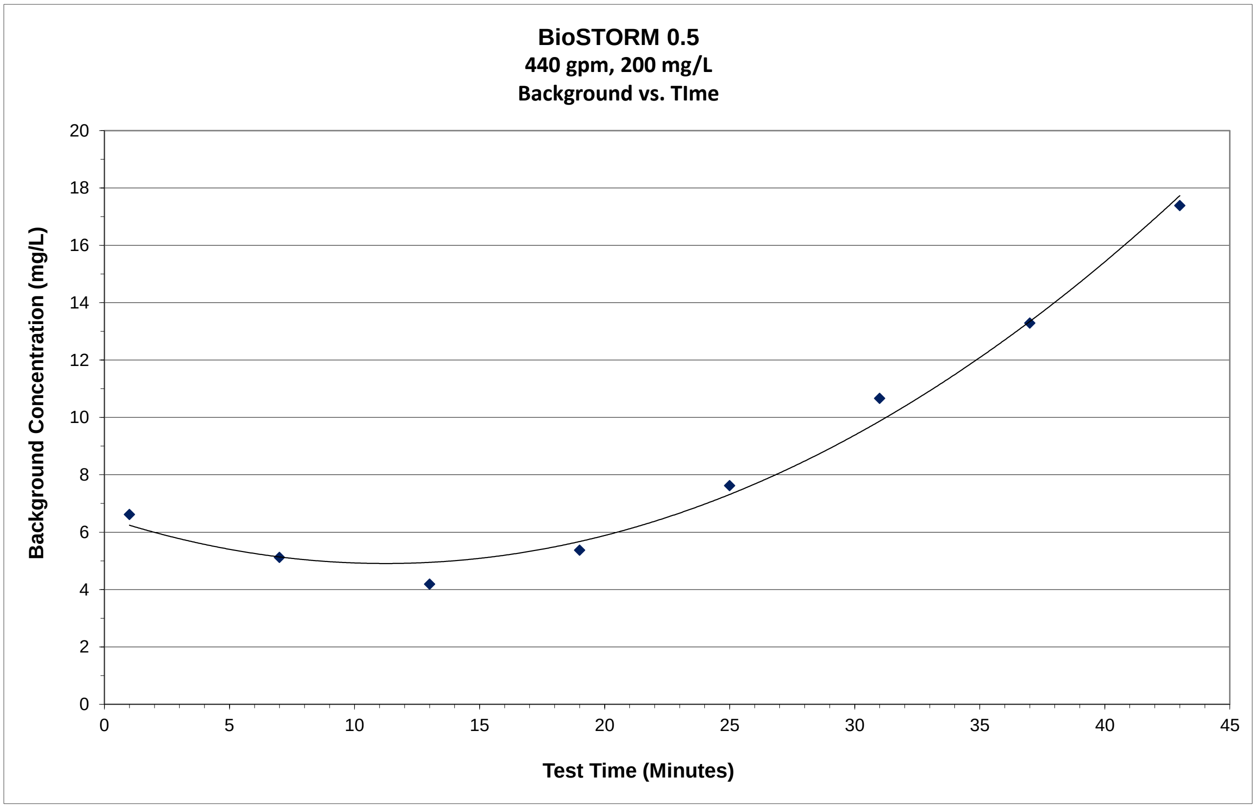

Figure 25 440 gpm Measured Background Concentrations

214% MTFR (487 gpm)

The test was conducted at 487 gpm over a period of approximately 40 minutes. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 486.9 gpm, with a COV of 0.002. The maximum recorded temperature for the full test was 64.0 degrees F.

The injection feed rate of 368.7 g/min was verified by collecting timed weight samples from the injector every 5 minutes. The calculated influent injection concentrations for the full test ranged from 195 mg/L to 201 mg/L, with a mean of 197 mg/L and COV of 0.01. The total mass injected into the unit was 28.2 Lbs. The calculated mass/volume concentration for the test was 204 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 26**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 1.5 to 9.8 mg/L. The background curve is shown on **Figure 27**.

The total mass collected from the unit was 11.5 Lbs, resulting in a removal efficiency of 40.8%.

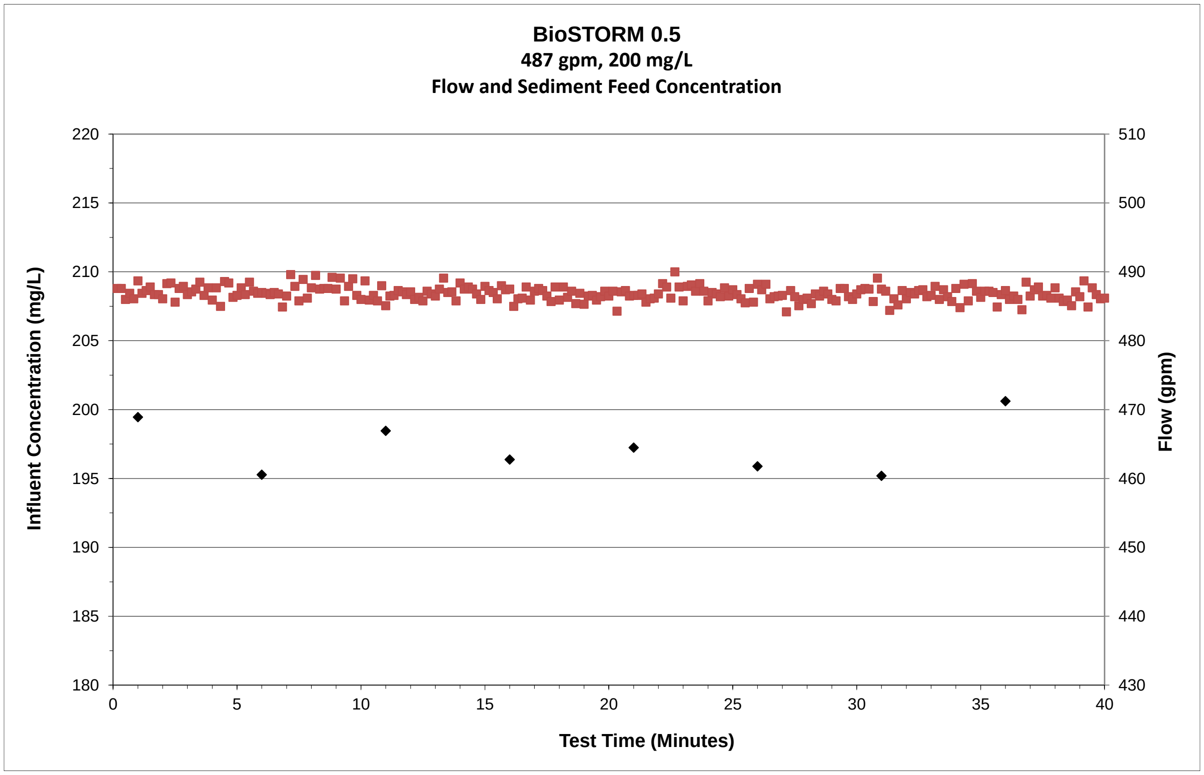

Figure 26 487 gpm Measured Flow and Influent Concentrations

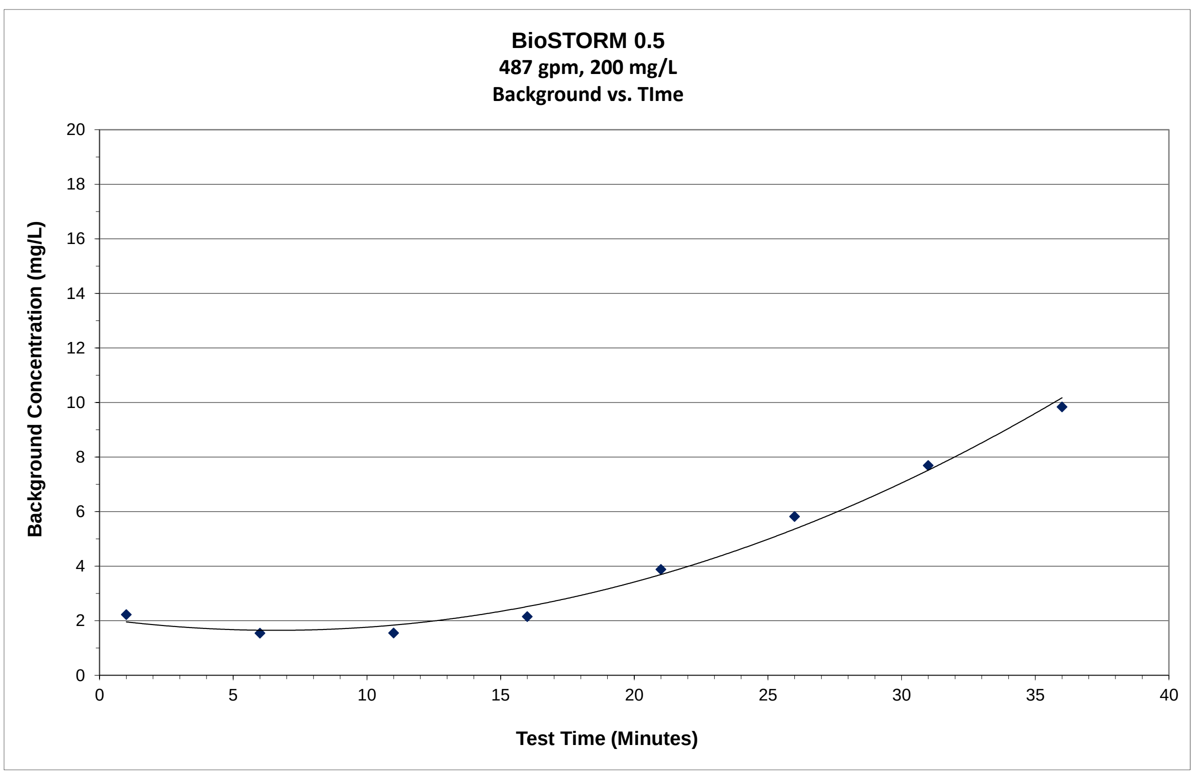

Figure 27 487 gpm Measured Background Concentrations

252% MTFR (575 gpm)

The test was conducted at 575 gpm over a period of approximately 35 minutes. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 574.6 gpm, with a COV of 0.001. The maximum recorded temperature for the full test was 65.2 degrees F.

The injection feed rate of 435.3 g/min was verified by collecting timed weight samples from the injector every 4 minutes. The calculated influent injection concentrations for the full test ranged from 196 mg/L to 198 mg/L, with a mean of 197 mg/L and COV of 0.00. The total mass injected into the unit was 27.5 Lbs. The calculated mass/volume concentration for the test was 198 mg/L. The measured flow and influent concentration data for the complete test are shown on **Figure 28**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 2.2 to 11.1 mg/L. The background curve is shown on **Figure 29**.

The total mass collected from the unit was 8.9 Lbs, resulting in a removal efficiency of 32.4%.

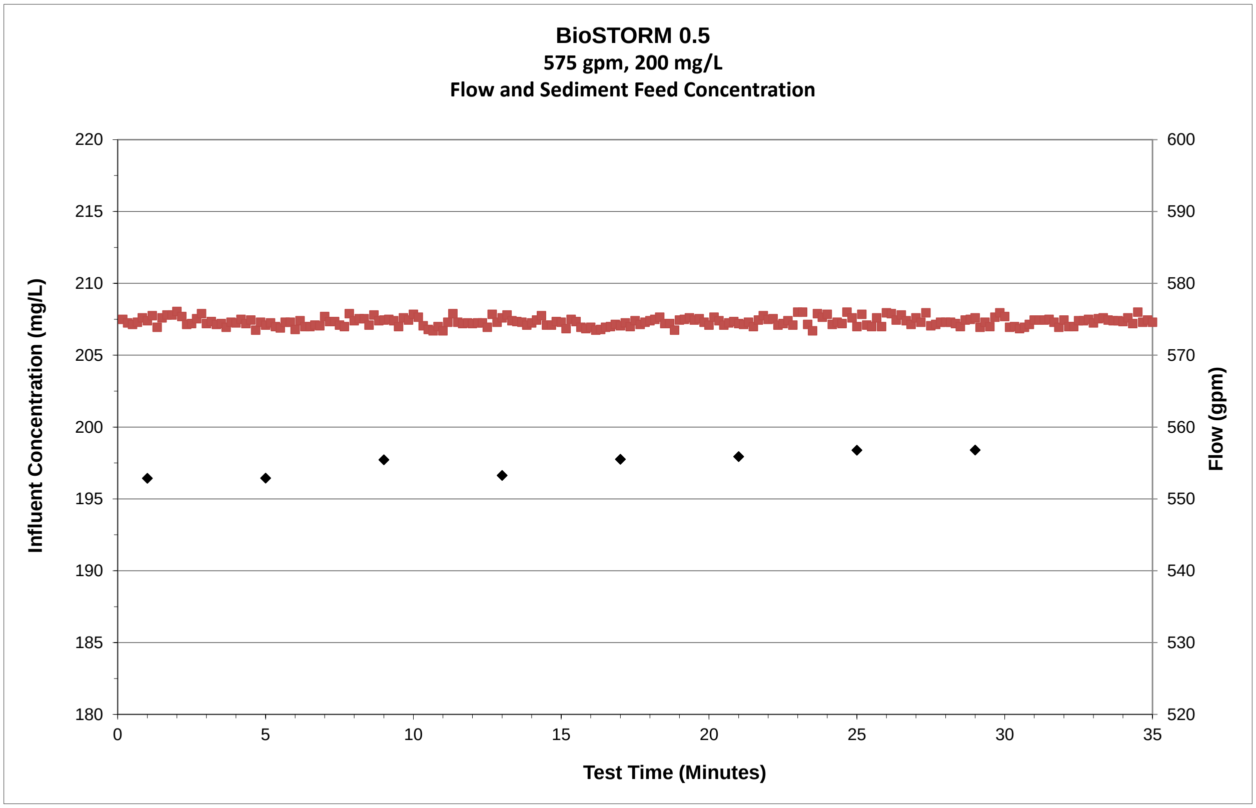

Figure 28 575 gpm Measured Flow and Influent Concentrations

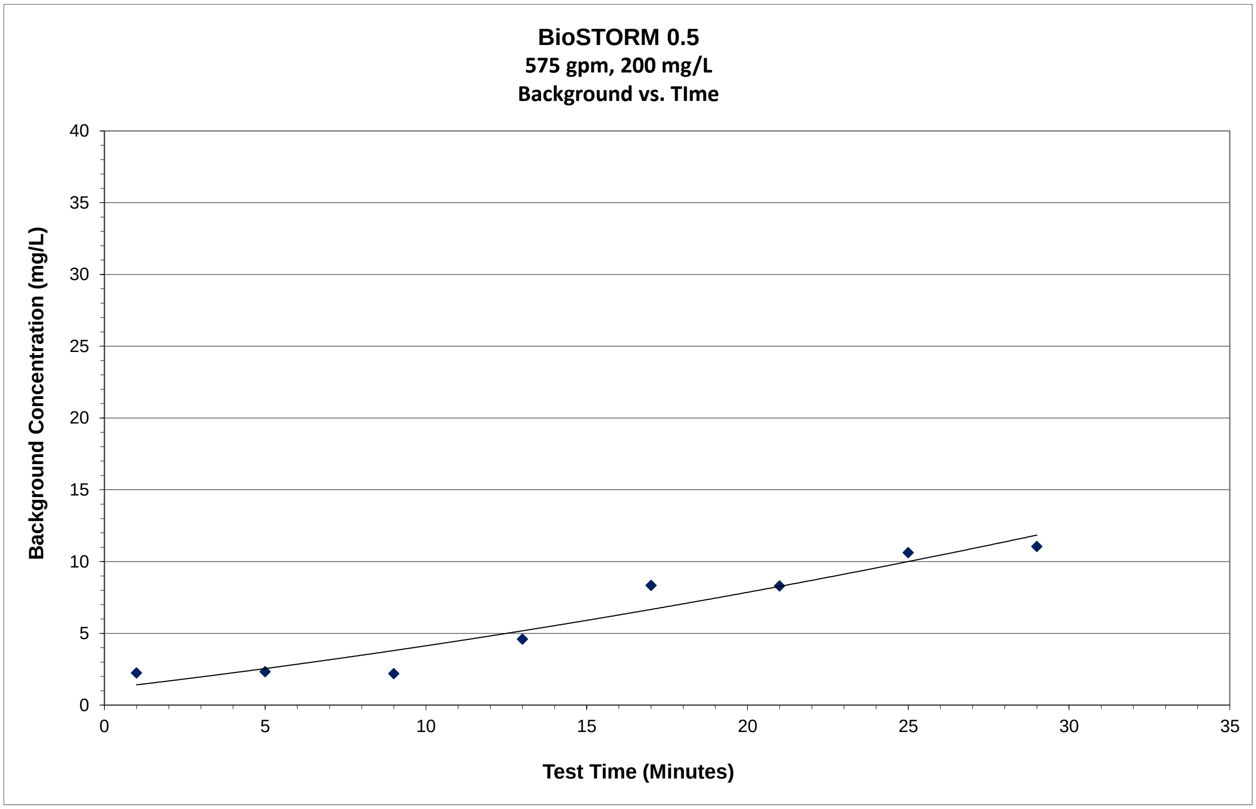

Figure 29 575 gpm Measured Background Concentrations

4.3 Scour Test

The commercially available AGSCO NJDEP 50-1000 sediment mix was utilized for the scour test. Three samples of the batch mix were analyzed in accordance with ASTM D422-63 (2007), by CTLGroup, an ISO/IEC 17025 accredited independent laboratory, and provided with the sediment shipment. The specified less-than (%-finer) values of the sample average were within the specifications listed in column 3 of **Table 1**, as defined by the protocol. The D_{50} of the 3-sample average was 202 microns. The PSD data of the samples are shown in **Table 8** and the corresponding curves, including the initial AGSCO in-house analysis, are shown on **Figure 30**.

Table 8 PSD Analyses of AGSCO NJDEP 50-1000 Batch Mix

Particle size (µm)	NJDEP %-Finer Specifications	Test Sediment Particle Size (%-Finer)			
		Sample 1	Sample 2	Sample 3	Average
1000	100	100	100	100	**100**
500	90	95	95	95	**95**
250	55	58	58	59	**58**
150	40	41	41	42	**41**
100	25	23	23	23	**23**
75	10	10	10	11	**10**
50	0	1	1	1	**1**

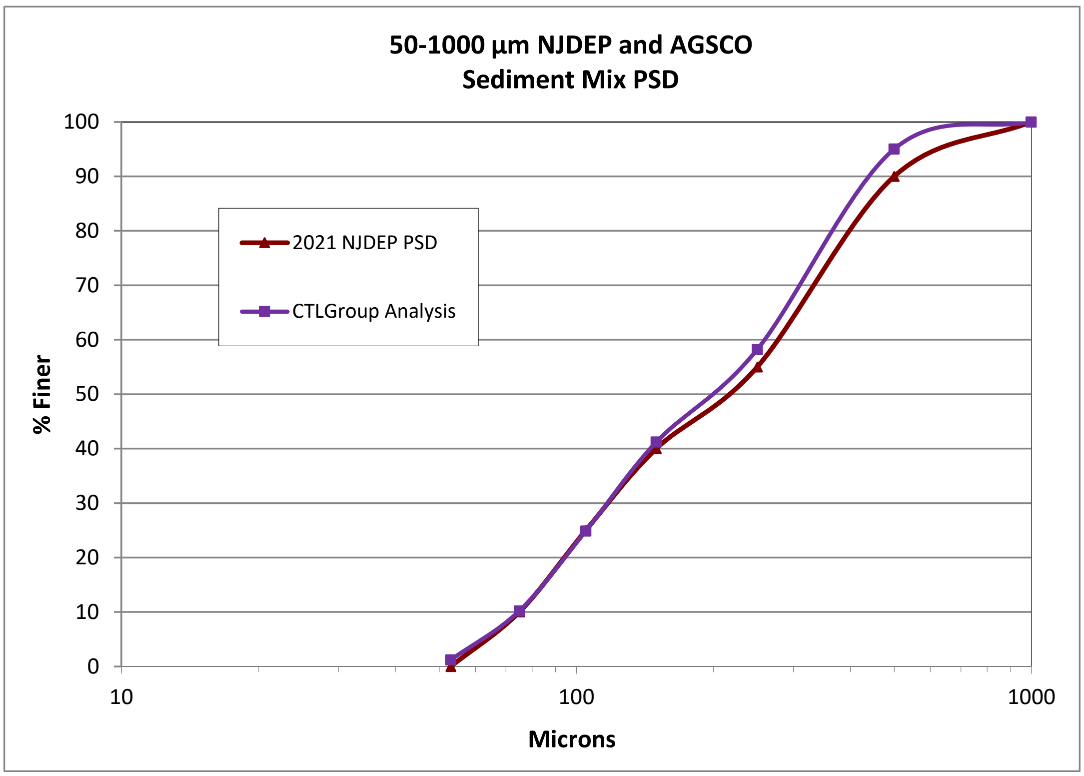

Figure 30 Scour Sediment PSD Curves

The scour test was conducted with the unit pre-loaded as a uniform layer with 6" of sediment to the 50% capacity level. An initial scour test was conducted at 490 gpm, based on an accepted weighted removal efficiency MTFR of 392 gpm. The resulting average effluent concentration exceeded the acceptance limit of 20 mg/L as per the test protocol. The mass that was lost during the test run was calculated and the bed was uniformly replenished accordingly. Based on the results of the first test, it was decided by BioMicrobics to repeat the test based on the original target

MTFR of 225 gpm.

125% MTFR

The test was conducted at 285 gpm, which is equal to 125% MTFR. The flow data was recorded every 3 seconds throughout the test and is shown on **Figure 31.** The target flow was reached within 3 minutes of initiating the test. The average recorded steady-state flow was 285 gpm, with a COV of 0.004. The recorded water temperature was 63.8 degrees F.

Eight background samples were collected throughout the duration of the test. The concentrations ranged from 0.5 to 1.0 mg/L, with an average concentration of 0.55 mg/L.

A total of 15 effluent samples were collected throughout the test. The calculated concentrations, adjusted for background, ranged from 0 to 22.1 mg/L, with an average concentration of 9.3 mg/L. The effluent and background concentration data are shown in **Table 9** and on **Figure 32**.

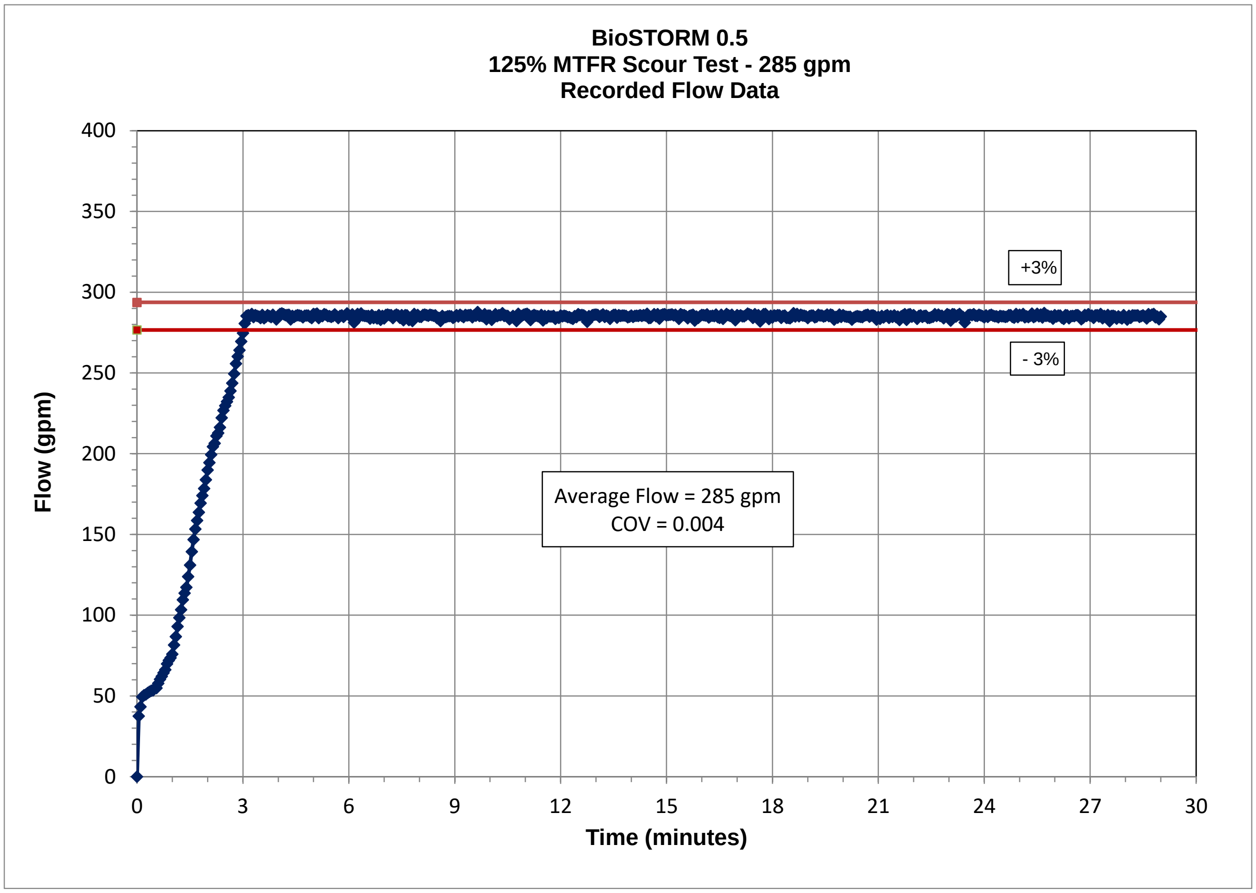

Figure 31 125% MTFR Scour Test Recorded Flow Data

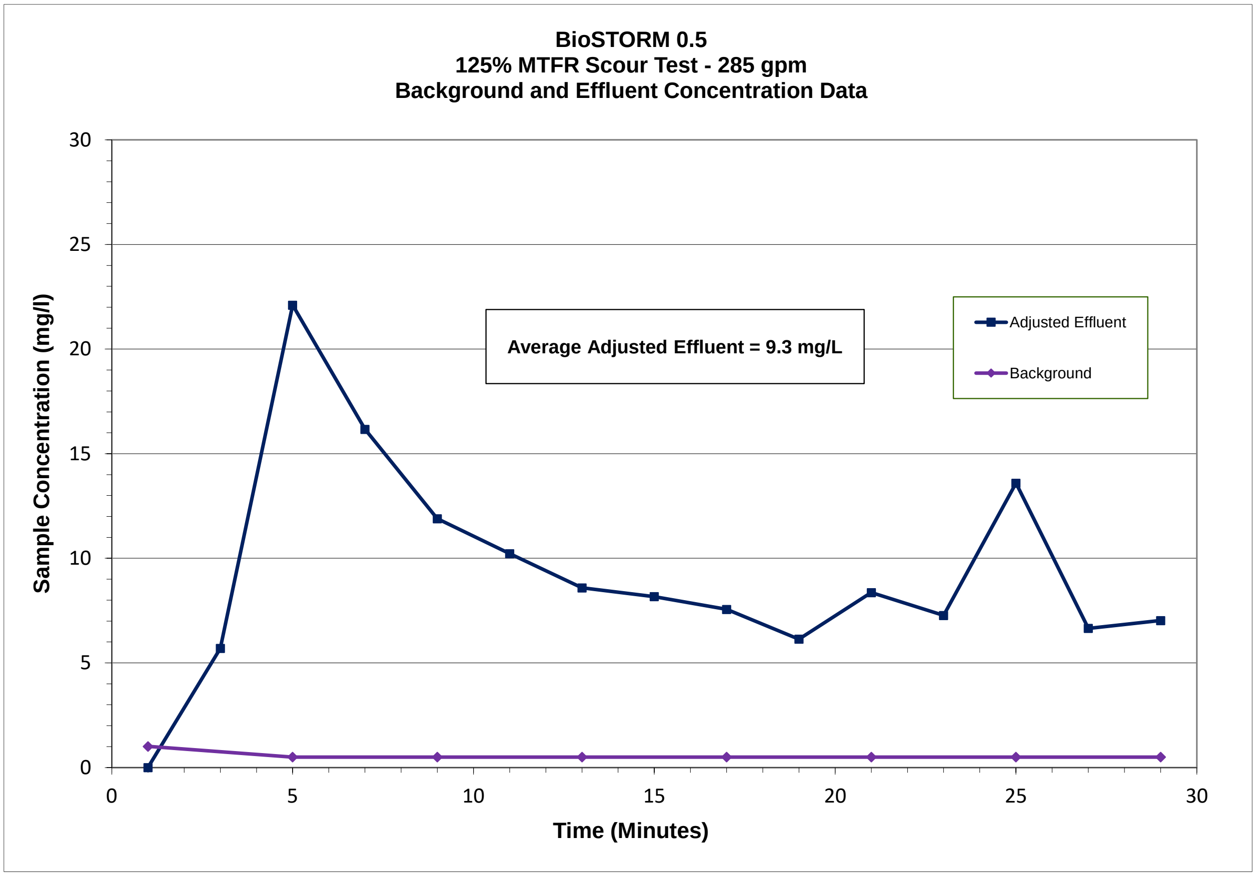

Figure 32 125% MTFR Measured Background and Effluent Concentrations

Table 9 125% MTFR Effluent Concentration Data

Sample ID	Timestamp (minutes)	Effluent Concentration (mg/L)	Background Concentration (mg/L)	Adjusted Effluent Concentration (mg/L)
EFF 1	1	0.50	1.01	0.00
EFF 2	3	6.45	0.76	5.69
EFF 3	5	22.60	0.50	22.10
EFF 4	7	16.67	0.50	16.17
EFF 5	9	12.39	0.50	11.89
EFF 6	11	10.72	0.50	10.22
EFF 7	13	9.09	0.50	8.59
EFF 8	15	8.67	0.50	8.17
EFF 9	17	8.06	0.50	7.56
EFF 10	19	6.64	0.50	6.14
EFF 11	21	8.86	0.50	8.36
EFF 12	23	7.77	0.50	7.27
EFF 13	25	14.09	0.50	13.59
EFF 14	27	7.15	0.50	6.65
EFF 15	29	7.53	0.50	7.03
NDL = 1.0 mg/L	**Average**	**9.81**	**0.55**	**9.30**

4.4 Hydraulics

Piezometer taps were installed in the inlet and outlet pipe inverts, as well as in the primary and secondary chambers, as described in **Section 2.2**. Flow (gpm) and water level (ft) within the system were measured for 10 flows ranging from 25 gpm to 604 gpm. The inflow free discharged into the Primary Chamber for all flows below 300 gpm. A system loss of 0.493 ft was calculated using the Primary Chamber and outlet pipe elevations for flows up to 300 gpm. The inlet pipe elevations, corrected for energy, were used to calculate the system loss at flows above 300 gpm. The maximum calculated system loss was 2.08 ft at 604 gpm. The recorded elevation data and system loss are shown in **Table 10** and on **Figure 33.**

Table 10 Recorded Flow and Elevation Data

Flow gpm	Primary Chamber (B) ft	Outlet El. (D') Corrected for V-head ft	System Loss B-D' ft
0.0			
25.1	3.877	3.846	0.031
50.0	3.966	3.906	0.060
75.1	4.038	3.956	0.082
100.5	4.107	3.998	0.109
151.9	4.249	4.073	0.176
200.1	4.411	4.129	0.282
251.0	4.555	4.193	0.362
300.1	4.739	4.246	0.493
Flow gpm	**Inlet El. (A') Corrected for V-head** ft	**Outlet El. (D') Corrected for V-head** ft	**System Loss** **A'-D'** ft
400.2	5.381	4.367	1.014
604.3	6.798	4.715	2.083

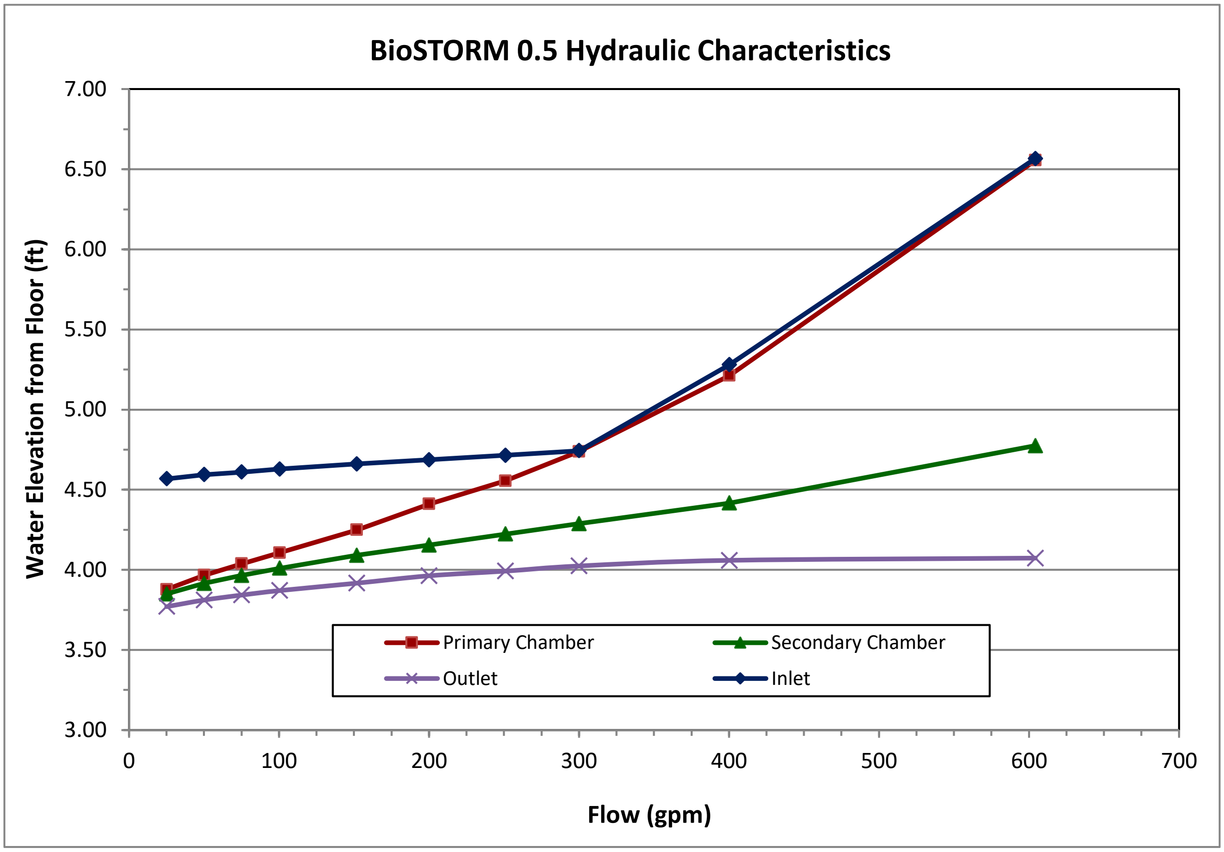

Figure 33 Measured Flow vs Water Elevations

5. Design Limitations

BioMicrobics provides engineering support for the BioSTORM stormwater treatment system to all clients. Each model is designed and sized according to anticipated flow rate, load rating, and installation site constraints and limitations. The design process is discussed to meet site-specific installation requirements. General terms of design parameters and limitations are cited below.

Required Soil Characteristics

The StormTEE screen and BioSTORM system treatment module (i.e., housing and Interceptor) is delivered to the job site ready to be installed in a pre-cast concrete structure, steel tank or fiberglass tank. Soil characteristics including settlement, corrosiveness, top and lateral loading, and groundwater must be addressed. The BioSTORM system can be installed and will function in all soil types.

Slope

Given that both the minimum inlet and outlet pipe elevations are specified for each model size, the site design should consider piping configurations to accommodate the level flow-through piping design. For optimum treatment performance, BioMicrobics recommends a 1% pipe slope into the system and before the invert. Slopes less than 0.5% could cause sediment to accumulate in the bottom of the inflow pipe and affect its hydraulic capacity. In contrast, significantly higher pipe slopes could compromise the system's performance. BioMicrobics recommends contacting our design engineering team when installation of a BioSTORM treatment system requires a drainage line with a slope exceeding 10%. The BioMicrobics team can work with site designers to facilitate an appropriate conveyance configuration.

Maximum Flow Rate

The recommended maximum water quality treatment flow rate is a function of the BioSTORM model. It is recommended to consultant the engineering team at BioMicrobics with regard to high peak flow management practices.

Maintenance Requirements

Maintenance requirements may vary depending on pollutant loading and individual site conditions and the BioSTORM model recommended by BioMicrobics team. It is recommended to inspect the system every six months, importantly, during the first year, to determine loading conditions for each site. These first-year inspections can be used as a baseline to establish inspection and maintenance frequency for subsequent years.

Operational Head

The BioSTORM treatment system is designed with the inlet higher than the outlet. The operational head loss is dependent on the model size used and site-specific conditions. Please refer to **Table 10** and **Figure 33** for additional details. Site specific conditions including flow rates, peak flow rates, pipe diameters, and pipe slopes are evaluated, on a project basis, to ensure an appropriate head for the system to function properly.

Installation Limitations

Pick weights vary with the BioSTORM model and installation procedures may vary slightly with model size. BioMicrobics provides contractors with instructions prior to delivery.

Configurations

The BioSTORM system is designed for offline installations using an external high flow diversion (bypass configuration). BioMicrobics is not responsible for the design of the bypass structure.

Load Limitations

The BioSTORM system can be installed in a pre-cast concrete, steel, or fiberglass structure. The contractor must follow the local structure standards to assure that the design can handle indirect traffic loads with minimal cover. For deeper installations, or installations requiring direct traffic rating or higher, the structure will be designed and modified with potentially thicker tops, bottoms and/or walls to handle the additional loading. Various access hatch options should be available for parkways, indirect traffic, direct traffic and other higher loading requirements such as airports or loading docks.

Pretreatment Requirements

The BioSTORM system has no pre-treatment requirements.

Depth to Seasonal High-Water Table

The BioSTORM system performance is independent of high groundwater conditions. Remediation methods should be employed by the contractor in case high water tables were detected.

Additional Limitations

None.

6. Maintenance

Regular inspections are recommended to ensure that the system is functioning as designed. An Inspection and Maintenance manual can be accessed at: https://biomicrobics.com/wp-content/uploads/2023/08/BioSTORM-IM-Manual-4-AUG-2023.pdf. Please contact your local representative if you have questions regarding the inspection and maintenance of the BioSTORM system. Regular maintenance of the BioSTORM system does not require entry of the underground storm chambers. However, if entry is required, appropriate OSHA and local safety regulations and guidelines should be followed.

Inspection

Inspections should be a part of the standard operating procedure. The required frequency of cleanout depends on site use and other site-specific characteristics and should therefore be determined by inspecting the unit after installation. During the first year of operation, the unit should be inspected at least every six months to determine the rate of sediment and floatable accumulations. More frequent inspections are recommended at sites that would generate heavy solids loads, like parking lots with winter sanding or unpaved maintenance lots. In cases where inspection is performed 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

Inspection should be performed when water conditions are static to avoid interruption during the maintenance duration. Refer to your local and national regulations for any additional inspection requirements and schedules not contained herein. Brief steps of the inspection process are summarized below.

- Perform visual inspection at all manway locations.
- For sediment accumulation, utilize a sediment pole, in both chambers, 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. NJDEP requires sediment removal on or before it reaches 6” (50% of the 12” sump depth).

- Inspect the inlet and outlet pipe openings to ensure that the silt level or any foreign objects are not blocking the pipes.
- It is recommended to visually inspect all pipes and connections for any possible leaks and findings will need to be reported to the contractor.
- Inspect the divergence and conveyance structures. Assure that all piping and connections for the diversion (bypass) configuration are completely sealed.

Maintenance Process

Maintenance should be performed when water conditions are static to avoid interruption during the maintenance duration. Refer to your local and national regulations for any additional maintenance requirements and schedules not contained herein. Brief steps of the maintenance process are summarized below.

- Swab any debris and litter present in the diversion (bypass) configuration.
- Replace and /or cement any broken pipes and connections to prevent leakage in the diversion line.
- Swab debris and litter off the angled slots on the StormTEE by using its built-in plunger.
- Remove floatable debris using a heavy-duty skimmer net or a vacuum-waste pump truck to skim trash floating on the stagnant water surface. Removal of debris and trash does not require entering the chambers. Removal of debris can be performed through the manways. The removed debris should be properly disposed of per local, state, and federal guidelines and regulations.
- Accumulated oil must be removed from the surface using a vacuum-waste pump truck or sump vacuum.
- To remove accumulated sediments off the Interceptor, gently wash off the Interceptor. Note: Using a pressure washer is not recommended on the Interceptor.
- For sediment removal at the system’s floor bed, BioSTORM systems are designed with clear access at both chambers. A vacuum truck, or similar trailer mounted equipment, can be used to remove the sediment, hydrocarbons, and water within the unit. It is recommended to use sewer jetting equipment to force the sediment to the vacuum hose.
- When all pollutants have been removed from the BioSTORM system, the manway lids should be securely installed back in place.
- Proper disposal of the sediment should follow 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.

7. Statements

The following signed statements from the manufacturer (BioMicrobics, Inc.), independent testing laboratory (Alden Research Laboratory) 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.

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July 13th, 2023

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

Re: Verification of BioSTORM® Stormwater Management System to NJDEP Laboratory Testing Protocol for a Hydrodynamic Sedimentation Device

The BioMicrobics Inc. BioStORM® hydrodynamic separator recently completed verification testing in compliance with the NJDEP HDS Laboratory Testing Protocol. As specified by the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology," this letter serves as BioMicrobics Inc. statement that all procedures and requirements identified in the above-cited protocol and process document were met or exceeded. Alden Research Laboratory LLC. was hired by BioMicrobics Inc as an independent third-party testing facility. All BioSTORM®0.5 sediment removal efficiency and scour tests were conducted at the Alden Research Laboratory LLC. in Holden, Massachusetts, under the direct and independent supervision of James Mailloux, Senior Consultant at Alden Research Laboratory LLC. The observer was approved per the Quality Assurance Project Plan dated August 2022. Alden Research Laboratory LLC. was responsible for analyzing all water quality samples and preparing particle size distributions for the sediment removal efficiency and scour testing. Preparation of the verification report and the supporting documentation fulfill the submission requirements of the process document and protocol.

Sincerely,

Amr M. Zaky, PhD.

Associate VP, Research & Advanced Process Technology

June 13, 2023

Dr. Richard Magee, P.E., BCEE
Executive Director
New Jersey Corporation for Advanced Technology
Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030

Conflict of Interest Statement

Alden Research Laboratory (ALDEN) is a non-biased independent testing entity which receives compensation for testing services rendered. ALDEN does not have any vested interest in the products it tests or their affiliated companies. There is no financial, personal, or professional conflict of interest between ALDEN and BioMicrobics, Inc.

Protocol Compliance Statement

Alden performed the verification testing on the BioMicrobics BioStorm®0.5 treatment system. The Technical Report and all required supporting data documentation has been submitted to NJCAT as required by the protocol.

Testing performed by ALDEN on the BioMicrobics BioStorm®0.5 treatment system met or exceeded the requirements as stated in the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device", (January 1, 2021).

James T. Mailloux

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September 14, 2023

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

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing conducted on a BioMicrobics BioSTORM stormwater treatment unit at the Alden Research Laboratory, Inc. (Alden), Holden, Massachusetts, under the direct supervision of Alden's senior stormwater engineer, James Mailloux, the test protocol requirements contained in the *"New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device"* (NJDEP HDS Protocol, January 1, 2021) were met or exceeded consistent with the NJDEP Approval Process. Specifically:

Test Sediment Feed

The mean PSD of the test sediments comply with the PSD criteria established by the NJDEP HDS protocol. The removal efficiency test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification. The test sediment was shown to be slightly finer than the sediment blend specified by the protocol (<75μ); the test sediment d_{50} was 66 microns. The scour test sediment PSD analysis was plotted against the NJDEP scour test PSD specification and shown to meet the protocol specifications.

Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on the BioSTORM 0.5, a commercially available stormwater treatment unit, to establish the ability of the

BioSTORM 0.5 to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the target MTFR. The BioSTORM 0.5 demonstrated an annualized weighted solids removal as defined in the NJDEP HDS Protocol of 56.3%. 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 17.4 mg/L).

Scour Testing

The scour testing was conducted at 285 gpm, which is equal to 125% of the MTFR. The scour test was conducted with the unit preloaded with 6" of sediment to the 50% capacity level. A total of 15 effluent samples were collected throughout the test. The calculated concentrations, adjusted for background, ranged from 0 to 22.1 mg/L, with an average concentration of 9.3 mg/L, qualifying the BioSTORM system for offline installation.

Maintenance Frequency

The predicted maintenance frequency for all BioSTORM models exceeds 25 years.

Sincerely,

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

8. References

ASME (1971), *"Fluid Meters Their Theory and Application- Sixth Edition".*

ASTM (2017), *"Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis",* Annual Book of ASTM Standards, D6913 / D6913M-17, Vol. 4.09

ASTM (2019), *"Standard Test Methods for Determining Sediment Concentration in Water Samples"*, Annual Book of ASTM Standards, D3977-97, Vol. 11.02.

ASTM (2019), *"Standard Test Methods for Determination of Water (Moisture) Content of Soil by Direct Heating"*, Annual Book of ASTM Standards, D2216, Vol. 04.08.

ASTM (2021), *"Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis",* Annual Book of ASTM Standards, D7928-21e1, Vol. 4.09.

NJDEP 2021. *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. August 4, 2021.

NJDEP 2021. *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device.* Trenton, NJ. January 1, 2021 (Updated April 25, 2023).

VERIFICATION APPENDIX

Introduction

- Manufacturer – BioMicrobics Inc., 16002 W 110th St., Lenexa, KS 66219, General Phone: (913) 422-0707, www.biomicrobics.com.
- BioSTORM verified models are shown in **Table A-1** and **Table A-2**.
- TSS Removal Rate – 50%
- Offline installation

Detailed Specification

- NJDEP sizing table and physical dimensions of the BioSTORM 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 BioSTORM 0.5 model has a maximum treatment flow rate (MTFR) of 0.5 cfs (228 gpm), which corresponds to a surface loading rate of 5.1 gpm/ft^2 of sedimentation area.
- Maximum recommended sediment depth prior to cleanout is 6 inches for all model sizes.
- Inspection and Maintenance Manual is at: https://biomicrobics.com/wp-content/uploads/2023/08/BioSTORM-IM-Manual-4-AUG-2023.pdf.
- The maintenance frequency for all the BioSTORM models exceeds 25 years.
- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the BioSTORM 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 BioSTORM Models

Model	Maximum Treatment Flow Rate[1] (cfs)	Treatment Area (ft^2)	Hydraulic Loading Rate (gpm/ft^2)	50% Sediment Storage[3] (ft^3)	Sediment Removal Interval[2] (years)
BioSTORM 0.5	0.5	44.7	5.1	22.4	26.6
BioSTORM 0.75	0.75	66.5	5.1	33.3	26.3
BioSTORM 1.0	1.0	88.1	5.1	44.0	26.1
BioSTORM 1.25	1.25	110.3	5.1	55.1	26.2

1. Based on a verified loading rate of 5.1 gpm/ft^2 for test sediment with a mean particle size of 66 µm and an annualized weighted TSS removal of at least 50% using the methodology in the current NJDEP HDS protocol.
2. Sediment Removal Interval (years) = (50% HDS MTD Max Sediment Storage Volume) / (3.366 * 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 treatment area x 6 inches of sediment depth. Each BioSTORM model has a 12-inch-deep sediment sump.

Table A-2 Standard Dimensions for BioSTORM Models

BioSTORM Model[1]	Primary Chamber (in)			Secondary Chamber (in)			Interceptor (in)			Sediment Sump Depth (in)
	L	W	D[2]	L	W	D[2]	L	W	D	
0.5	24	58	48	87	58	38.75	48	24	24	12
0.75	24	84	48	90	84	38.75	48	36	24	12
1.0	24	84	48	127	84	38.75	51	48	24	12
1.25	24	84	48	165	84	38.75	72	48	24	12

1. All these BioSTORM models are installed with the Model SMT838 StormTEE.
2. Treatment Chamber Depth – the depth from the invert of the influent pipe or the effluent pipe to the chamber floor minus ½ the sediment sump depth.

Table A-3 Treatment Area Ratios for BioSTORM Models

BioSTORM Model	Primary Chamber Area (ft^2)	Secondary Chamber Area (ft^2)	Interceptor Area (ft^2)	ITA/STA	SCA/PCA
0.5	9.7	35.0	8.0	0.218	3.6
0.75	14.0	52.5	12.0	0.220	3.8
1.0	14.0	74.1	17.0	0.239	5.3
1.25	14.0	96.3	24.0	0.278	6.9

ITA – Interceptor Treatment Area

STA – Settling Treatment Area

PCA - Primary Chamber Area

SCA – Secondary Chamber Area