NJCAT TECHNOLOGY VERIFICATION

StormBrixx® Sediment Filtration Tunnel

ACO Inc.

December 2024

Table of Contents

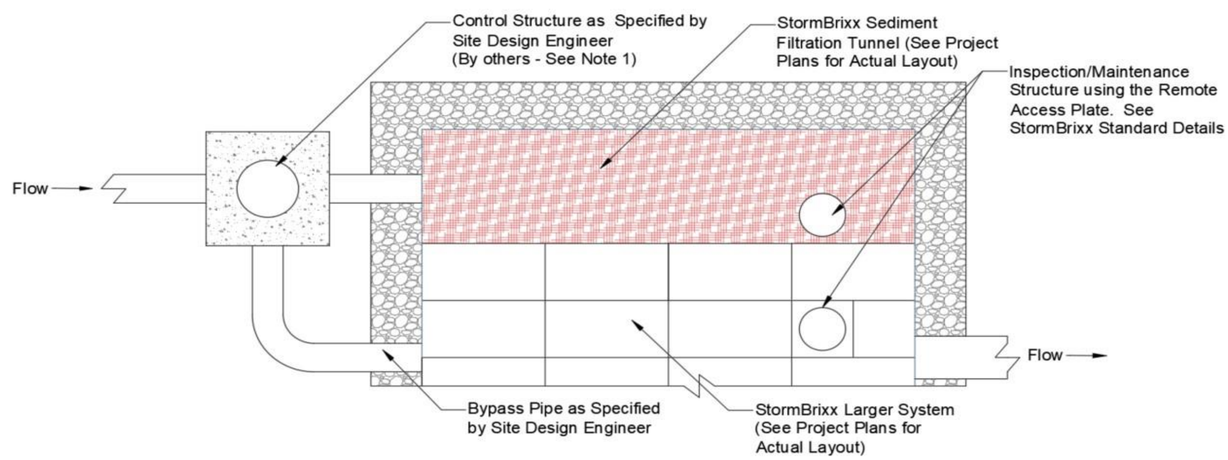
List of Figures

List of Tables

1. Description of Technology

StormBrixx® systems are a type of underground modular storage system. When the patented geocellular thermoplastic units are combined, they form a system that provides high void space (94-97%) stormwater storage for flood mitigation, detention, and infiltration applications. These systems can be outfitted with Sediment Filtration Tunnels to provide treatment of stormwater influent. A Sediment Filtration Tunnel consists of one or more StormBrixx half-modules that are connected to the inflow via a nearby control structure. The control structure directs the treatment flow into the Sediment Filtration Tunnel, with a weir or raised bypass allowing flows greater than the treatment flow rate to bypass the Sediment Filtration Tunnel and discharge into the larger system.

Since this technology fits under the infiltration basin category in the New Jersey Stormwater BMP Manual, it is not eligible for NJDEP MTD certification. The Sediment Filtration Tunnel can be installed at any location within the system, corresponding with the influent connection location and is typically installed along the edge of the system (**Figure 1**).



NOTE 1: Sump below pipe inverts to be specified by Site Design Engineer. Control structures may be installed outside or within the tank footprint depending upon the structure's geometry. Contact ACO for more information.

NOTE 2: Tank Dimensions and Module Orientation Varies based on project-specific layer orientation drawings.

Figure 1 StormBrixx Sediment Filtration Tunnel Example Layout

The Sediment Filtration Tunnel consists of a series of interconnected modules encapsulated with a minimum of a single layer of non-woven geotextile fabric on the exterior sides, top, and bottom. At the interface between the Sediment Filtration Tunnel and the larger system, two layers of non-woven geotextile fabric are installed. This combination provides settling and filtration of stormwater, retains the sediment within the Sediment Filtration Tunnel and provides accessibility for inspection and maintenance. Access points can be added in 2’ by 2’ areas within the tank using the StormBrixx Remote Access Plate or along the exterior of the tank using Remote Access Units. The Remote Access Plate is used when access is desired in the middle of tanks with footprints of at least 6’ by 6’. This minimum footprint allows the plates to be supported on each side. If access is desired in smaller tank sections or along the perimeter of the tank, Remote Access Units are utilized. Both components allow for inspection and cleaning of the Sediment Filtration Tunnel and the larger system. See **Figure 2** for examples of both access types.

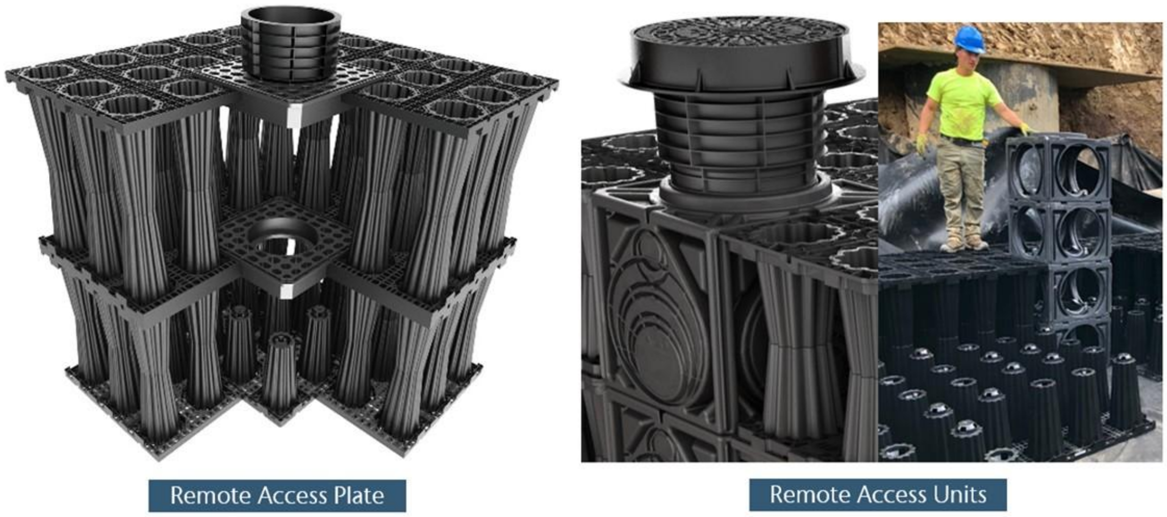


Figure 2 Accessibility for Inspection and Maintenance – Access Configurations

The StormBrixx Sediment Filtration Tunnel is available in three module combinations (600HD, 900SD, and 900SD-300SD) as shown on https://acoswm.com/stormbrixx/. The 900SD module type was selected for this testing at a system height of 1-layer (approximately 36 inches) based on our experience with commonly selected module/system heights for this application.

2. Laboratory Testing

The test program was conducted at the Verdantas Flow Labs LLC, Alden Campus (Verdantas), Holden, Massachusetts, under the direct supervision of Verdantas' senior stormwater engineer, James Mailloux. Verdantas has performed verification testing on numerous 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 ISO/IEC 17025 accredited independent laboratory. Water quality samples collected during the testing process were analyzed in the Verdantas Flow Labs Testing Laboratory.

Laboratory testing was done in accordance with the New Jersey Department of Environmental Protection "Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" January 14, 2022, updated April 25, 2023 (Filtration 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 procedure for obtaining verification of a stormwater MTD from NJCAT (August 4, 2021).

2.1 Test Setup

The test setup included an inlet Sediment Filtration Tunnel of 3 modules and an adjacent Outlet Tank of 3 modules (6 total). Each module measures 4'L x 2'W x 3'H nominally. The modules sit on a 6" base of AASHTO #57 (3/4"-1.5") double-washed angular granite. Each row is wrapped in non-woven geotextile fabric. The perimeter volume and top of the modules are backfilled with the same stone as the base. A 12" influent pipe, set at a 1% slope, is located at the center of the inlet row. The invert of the pipe is located 4" above the base stone. A 12" outlet pipe is located at the center of the outlet row, with the invert located 2" above the base stone. Custom fabric boots are used to seal the influent and effluent pipes to the modules. An external bypass is set at 3.25' above the bottom of the modules. The test unit setup is shown in **Figures 3 and 4**.

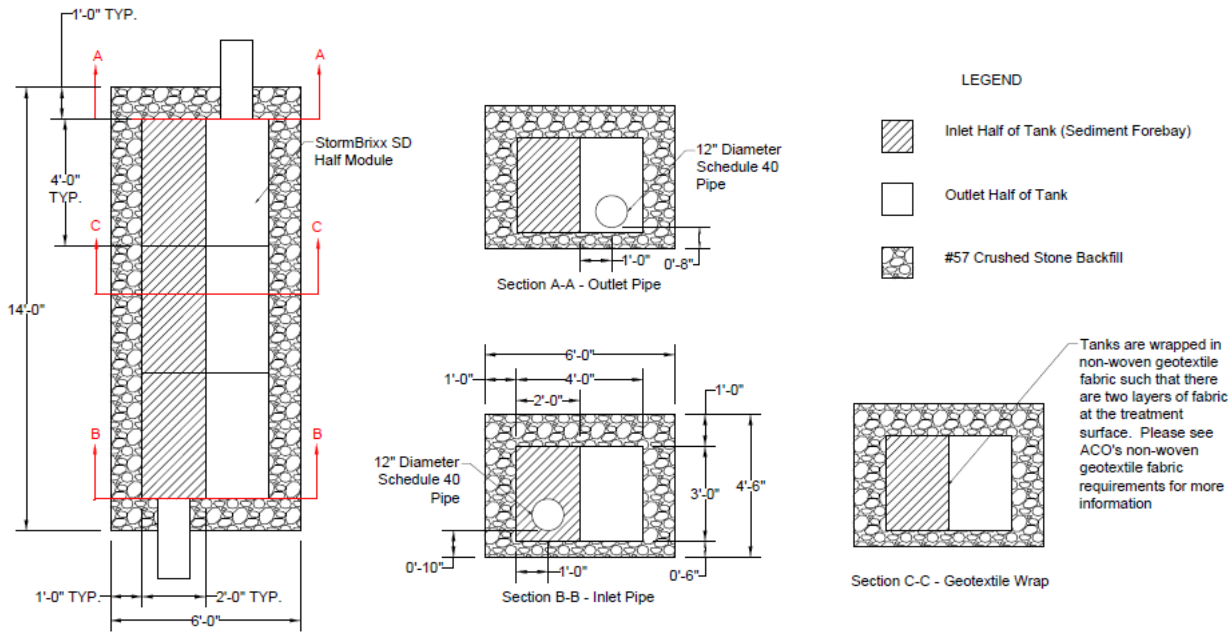


Figure 3 StormBrixx Test Setup Plan and Elevation Views

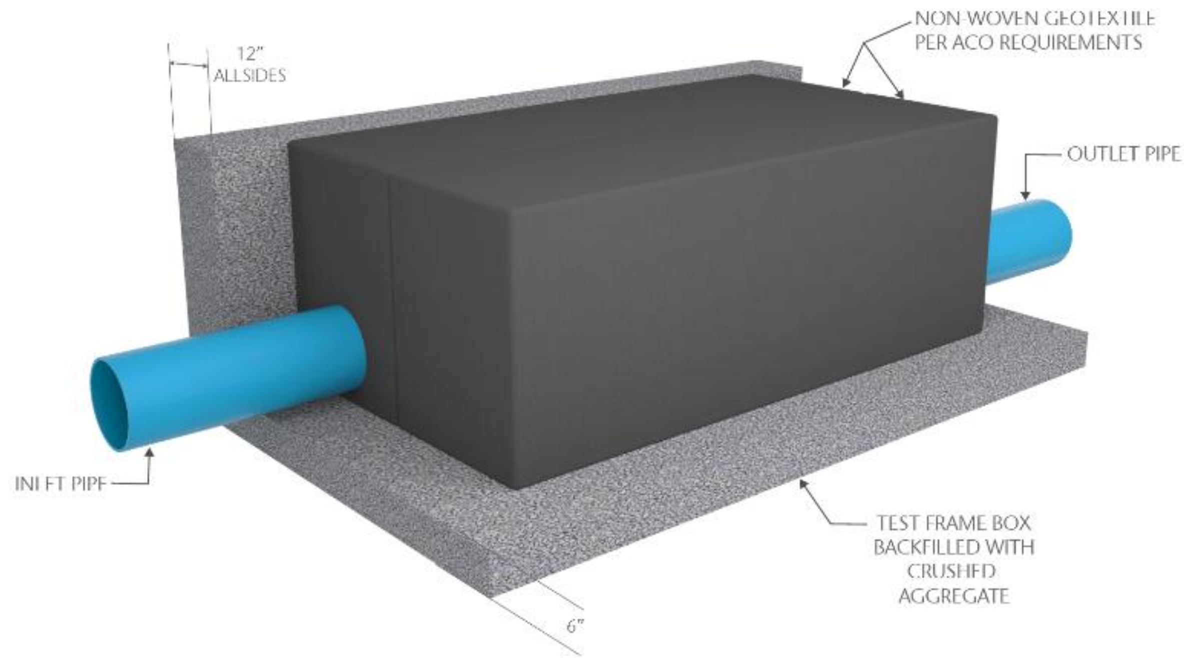


Figure 4 Isometric View of the StormBrixx Test Setup

The StormBrixx test unit was installed in a test loop in the Verdantas Stormwater Testing Facility, shown in **Figure 5**. A water-tight test tank measuring 14'L x 6'W x ~4.5'H was utilized for installing the test unit. The StormBrixx was constructed in the same manner as in the field to meet the specifications of the protocol. All stone used for the test set-up was washed prior to installation. All pipe penetrations were sealed prior to testing. Flow was supplied to the unit with a laboratory pump drawing water from a 45,000-gallon supply sump, which can be heated or cooled to maintain a target temperature of approximately 68° F. The test flow was set and measured using a flow control valve and calibrated 4" orifice-plate flow meter, constructed to ASME guidelines. Flow measurement accuracy is within ±1%. During all test runs, the allowable flow variation was ±10% of the target flow and the coefficient of variance (COV) was ≤0.03.

Flow was conveyed to the test unit by means of a straight 12" diameter smooth-wall PVC influent pipe, with a length of approximately 20 pipe diameters. The pipe was set with a 1% slope. A 6" tee was located 2' 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. A calibrated isokinetic sampler was installed in the upstream vertical riser pipe for collection of the background samples. A 3' long 12" PVC outlet pipe free-discharged the effluent into a channel containing a calibrated V-notch weir and returned to the sump. Filtration of the supply sump flow was performed with an inline filter wall containing 1-micron rated filter bags.

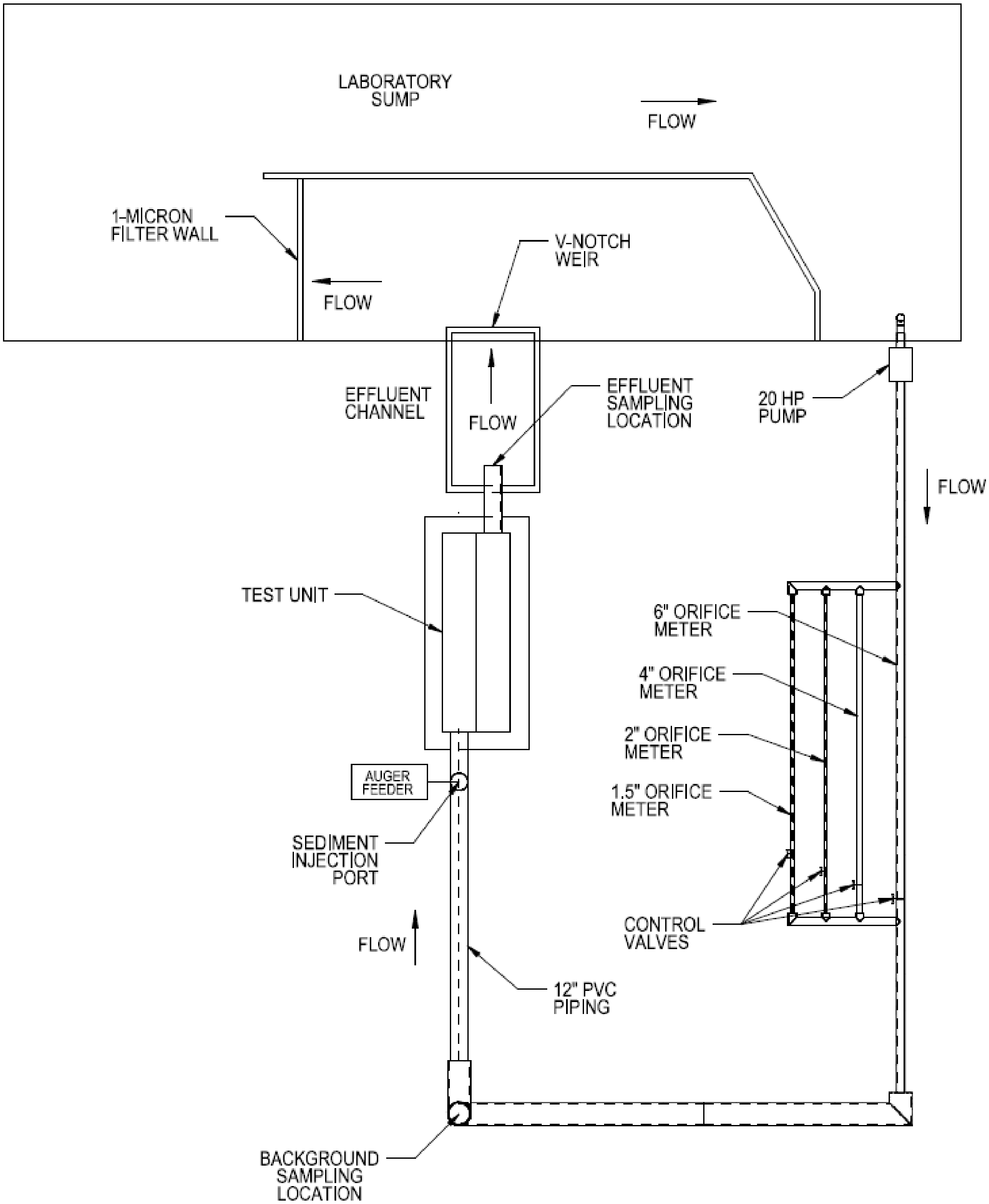


Figure 5 Verdantas Stormwater Test Loop

Photographs of the test setup are shown in **Figure 6** and **Figure 7**. A photograph of the StormBrixx installation is shown in **Figure 8**.

Figure 6 StormBrixx Test Setup

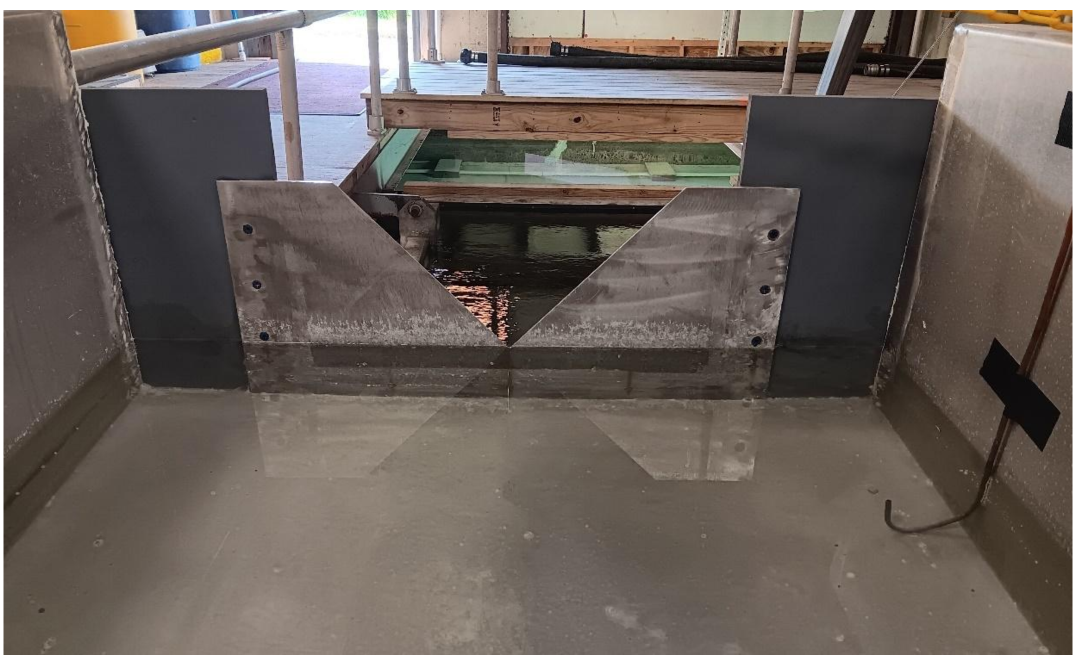


Figure 7 Effluent Channel V-notch Weir

Figure 8 StormBrixx Installation

2.2 Removal Efficiency and Mass Loading Capacity Testing

Sediment removal testing was conducted to determine the removal efficiency, as well as the sediment mass loading capacity. All test runs were conducted with clean water containing a background suspended sediment solids concentration (SSC) of <20 mg/L.

The sediment testing was conducted on an initially clean system at the 100% Maximum Treatment Flow Rate (MTFR) of 216 gpm. A minimum of ten 30-minute test runs were required to be conducted to meet the removal efficiency criterion of a cumulative removal efficiency >80%. The captured sediment was not removed from the system between test runs.

The total mass injected into the system was quantified for each run by subtracting the mass remaining in the feeder and collected for the feed rate calibrations from the recorded starting mass. This value was used in calculating the influent mass/volume concentration. The total mass captured in the system was quantified at the conclusion of the testing. This data is used for determination of the maximum inflow drainage area (acres) per the NJDEP protocol.

From the data collected, the following graphs were produced to show the life cycle performance of the StormBrixx treatment system:

- Driving Head vs. Sediment Mass Loading
- Removal Efficiency vs. Sediment Mass Loading

The test sediment was prepared by Verdantas to meet the PSD gradation of 1-1000 microns in accordance with the distribution shown in column 2 of **Table 1**. The sediment was silica based, with a specific gravity of 2.65. PSD samples of the test sediment were analyzed by GeoTesting Express, an independent certified analytical laboratory using ASTM D6913/ D6913M-17 (2017), "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis" and ASTM D7928-21e1 (2021), "Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis". Additional discussion of the sediment analyses is presented in **Section 4.1**.

Table 1 NJDEP Sediment Particle Size Distribution

Table 1: Test Sediment Particle Size Distribution[1]

Particle Size (Microns)	Target Minimum % Less Than[2]
1,000	100
500	95
250	90
150	75
100	60
75	50
50	45
20	35
8	20
5	10
2	5

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

All sediment testing was conducted using the indirect (sampling) methodology, as per the

NJDEP protocol. Six effluent samples were collected using 2-L beakers and the end-of-pipe grab sampling methodology. The required background samples were collected upstream of the influent pipe using 2-L beakers and a calibrated isokinetic sampler installed in the center of the upstream vertical riser of the inflow piping.

The effluent samples were collected three detention times after the initiation of sediment dosing, as well as after the interruption of dosing for injection measurements. A minimum of three evenly spaced background samples were collected in correspondence with the odd-numbered effluent samples (first, third, fifth). At the termination of the test run, two evenly volume-spaced effluent samples were collected during the drawdown period and used in the removal efficiency calculation. The drawdown volume was calculated by measuring the effluent using a calibrated V-notch weir located at the end of the effluent channel. All effluent and drawdown concentrations were adjusted for background.

The moisture content analysis was conducted by Verdantas, which is ISO 17025 accredited for conducting ASTM D2216 (2019) "Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass".

The target influent sediment concentration was 200 mg/L (±20 mg/L) for all tests. Verification of the injected sediment concentration was achieved by taking a minimum of three timed dry samples from the auger feeder, including one sample at the start of dosing, one sample in the middle of each run, and one sample just prior to the conclusion of dosing. The samples were collected over a duration of one minute. The collected samples were weighed to establish the g/min feed rate for each sample. The sample concentration COV did not exceed 0.10. The influent concentration was calculated using the following two methods:

1. The auger sediment feed rate data was used in conjunction with the corresponding recorded flow data to establish an influent concentration of 200 mg/L (±10%) throughout the test run and demonstrate that the feed rate COV was ≤0.10.

2. The sediment mass in the volumetric screw feeder was quantified at the start and end of each test run and corrected for the three feed calibration samples to determine the mass fed into the test unit. This mass was divided by the total volume of water flowing through the test unit during sediment dosing to determine the mass/volume influent TSS concentration and used in the removal efficiency calculation.

2.3 Scour Testing

ACO decided to not conduct scour testing on a 50% loaded bed at this time. The StormBrixx Sediment Filtration Tunnel will be designated as an offline system.

2.4 Instrumentation and Measuring Techniques

Flow

The inflow to the test unit was measured using a 4" calibrated orifice-plate differential-pressure flow meter. The meter was fabricated per ASME guidelines and calibrated in the Verdantas Flow

Labs Calibration Laboratory prior to the start of testing. The high- and low-pressure lines from the meter were connected to manifolds containing isolation valves. 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 in the Verdantas laboratory prior to testing. All pressure lines and cells were purged of air (bled) prior to the start of each test. The test flow was averaged and recorded every 5 seconds throughout the duration of each test run using an in-house computerized data acquisition program as described in **Section 2.5**. The accuracy of the flow measurement is ±1%. A photograph of the flow meters is shown on **Figure 9.** A photograph of the 20 HP laboratory pump is shown in **Figure 10.**

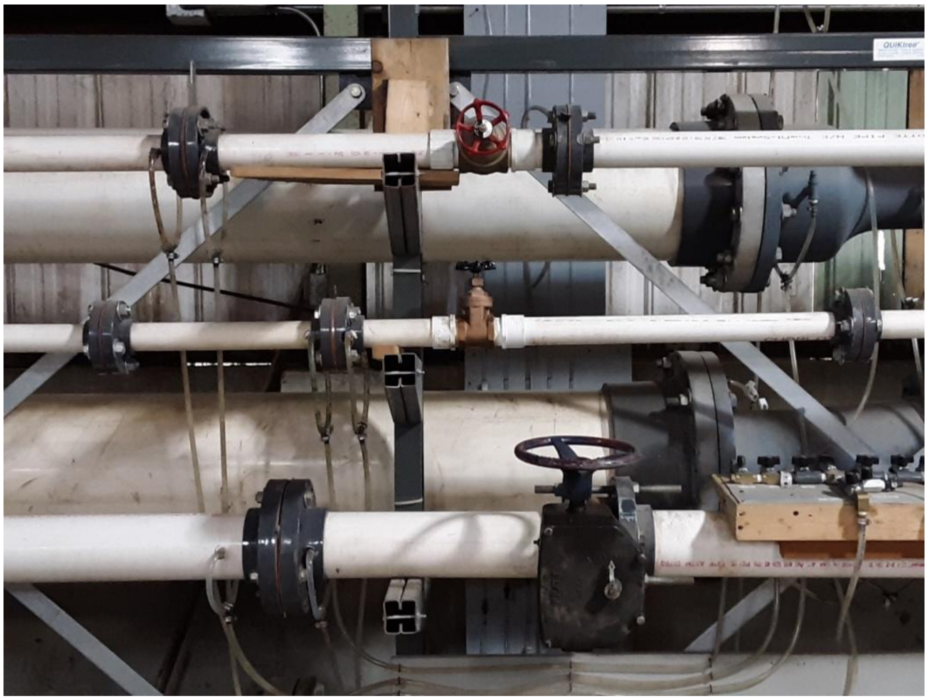


Figure 9 Photograph of Laboratory Flow Meters

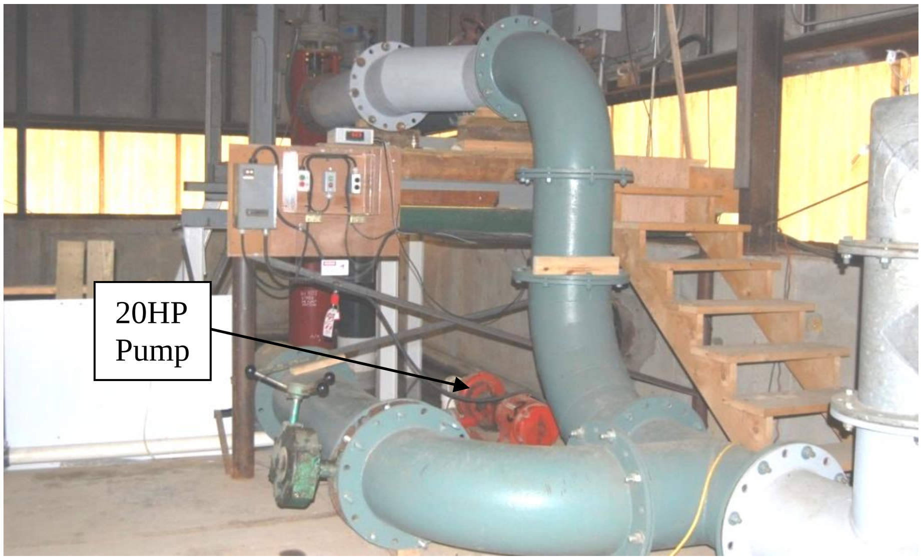


Figure 10 Photograph of 20 HP Laboratory Pump

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 and end of each test, to assure an acceptable testing temperature of $\leq$ 80 degrees F. A mid-test temperature reading was not necessary, as the test loop was a recirculating closed-loop system.

Water Levels

The water level within the treatment row and at the V-notch weir was measured with the use of a Piezometer tap, water manometer and a calibrated pressure transducer. The flow and water elevations were measured and recorded every 5 seconds throughout the duration of each test run, including the drawdown period. The end-of-run water elevation within the treatment unit was recorded just prior to shutting off the flow.

Drawdown Volume

At the termination of the test run, two evenly volume-spaced effluent samples were collected during the drawdown period and used in the removal efficiency calculation. The drawdown volume was calculated by measuring the effluent using a calibrated V-notch weir located at the end of the effluent channel. All effluent and drawdown concentrations were adjusted for background.

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. The auger feed screw, driven with a variable-speed drive, was calibrated with the test sediment prior to testing. The calibration, as well as test verification of the sediment feed was accomplished by collecting timed dry samples of 0.1-liter, up to a maximum of 1-minute, with the use of a NIST traceable digital stopwatch and weighing them on an Ohaus® 2200g x 0.1g, model SPX2201 calibrated digital scale. The allowable Coefficient of Variance (COV) for the injection was ≤0.10.

Sample Collection

Effluent samples were collected in 2-liter containers from the free-discharge at the end of the outlet pipe. Background concentration samples were collected from the center of the vertical pipe upstream of the test unit with the use of a calibrated isokinetic sampler, (**Figure 11)**.

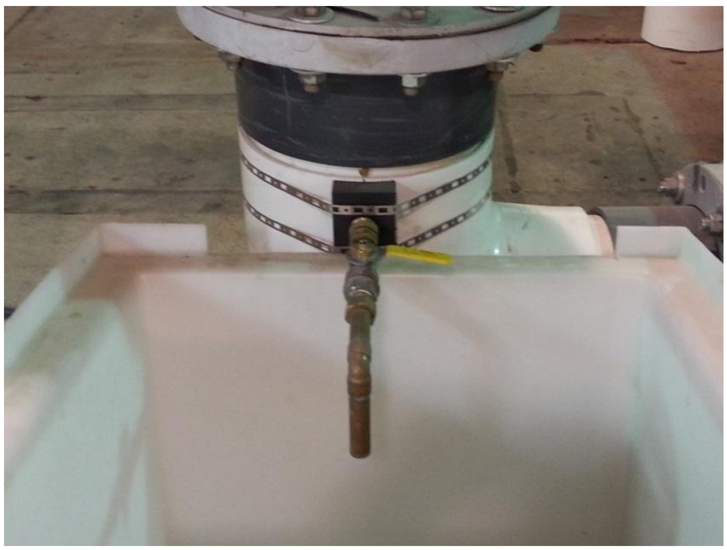


Figure 11 Photograph of the Background Isokinetic Sampler

Sample Concentration Analysis

The suspended solid concentration (SSC) of the effluent and background water samples were analyzed by Verdantas in accordance with Method B, as described in ASTM D 3977-97 (Re-approved 2019), "Standard Test Methods for Determining Sediment Concentration in Water Samples". Verdantas is ISO 17025 accredited for conducting the ASTM D3977 analysis. Verdantas has assigned a Method Detection Limit (MDL) of 1.0 mg/L. To be conservative, all concentrations below the MDL were assigned a value of 0.5 mg/L.

2.5 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 were initialed and dated.

A personal computer running an 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. The Verdantas 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 a user-defined number of significant figures.

Test flow and pressure data were continuously averaged and recorded to file every 5 seconds. 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, and background sample concentrations, flow, pressure, mass, and PSD data. The data were input to the designated spreadsheet for final processing.

2.6 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 the Verdantas 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 collecting each sample. The samples were a minimum of 0.1 liters in size, with a maximum collection time of one minute. The reported overall mass/volume sediment concentrations were adjusted for moisture.

3. Performance Claims

Per the NJDEP verification procedure and based on the laboratory testing conducted for the StormBrixx Sediment Filtration Tunnel (StormBrixx), the following are the performance claims made by ACO, Inc.

Total Suspended Solids (TSS) Removal Efficiency

Based on the laboratory testing conducted, the tested 900SD module type achieved an 82.7% cumulative TSS removal efficiency rounded down to 80% per the NJDEP protocol.

Maximum Treatment Flow Rate (MTFR)

The tested 3-module system has an MTFR of 216 gpm (0.48 cfs) and an effective filtration treatment area (EFTA) of 58.68 ft^2 (hydraulic loading rate = 3.68 gpm/ft^2).

Effective Filtration Treatment Area

The Effective Filtration Treatment Area (EFTA) for the test system is 58.68 ft^2.

Sediment Load Capacity/Mass Load Capture Capacity

Based on laboratory testing results, the test system has a mass loading capacity of 257.2 lbs and a mass loading capture capacity of 212.7 lbs (3.62 lbs/ft^2 of filter area).

Maximum Allowable Inflow Drainage Area

Per the NJDEP filter protocol, to calculate the maximum inflow drainage area, the total sediment load captured mass observed during the test (212.7) is divided by 600 lbs/acre. Thus, the maximum inflow drainage area for the tested system is 0.355 acres.

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 test sediment material used for removal efficiency testing was formulated using 1-1000 micron silica particles in an effort to achieve the sediment particle size distribution (PSD) as called for by NJDEP and illustrated in **Table 1**. The Specific Gravity (SG) of the sediment mixes was 2.65. Commercially-available silica products were provided by AGSCO Corp., a QAS International ISO-9001 certified company, and blended by Verdantas as required. Test batches were prepared in individual 5-gallon buckets, which were used for the removal testing. Four stock buckets with PSD analyses were initially used for testing. Additional sediment was required to complete the removal testing. A large batch was prepared, and 3 random samples were collected for PSD analysis prior to transferring them into individual buckets. All samples were analyzed for PSD in accordance with ASTM D6913 (2017) and ASTM D7928 (2021), by GeoTesting Express, an ISO/IEC 17025 accredited independent laboratory. The average of the bucket samples, as well as the batch samples were used for compliance to the protocol specifications listed in Column 2 of **Table 1**. The median D_{50} of the batch and bucket samples was 61 microns and 74 microns, respectively. The PSD data of the samples are shown in **Table 2** and the corresponding curves are shown on **Figure 12**.

Table 2 PSD Analyses of Verdantas NJDEP 1-1000 Micron Mix

Particle Size µm	Batch Sample 1	Batch Sample 2	Batch Sample 3	Batch Sample Average	Bucket 5	Bucket 6	Bucket 11	Bucket 16	Bucket Average	NJDEP Minimum Allowed Values
1000	100%	100%	99%	100%	99%	99%	99%	99%	99%	98%
500	95%	95%	95%	95%	95%	95%	95%	95%	95%	93%
250	90%	90%	90%	90%	89%	90%	90%	89%	90%	88%
150	74%	74%	75%	74%	74%	76%	75%	75%	75%	73%
100	63%	61%	61%	62%	58%	59%	58%	59%	59%	58%
75	59%	54%	52%	55%	50%	50%	50%	51%	50%	50%
50	44%	45%	45%	45%	44%	44%	44%	44%	44%	43%
20	34%	35%	34%	34%	36%	35%	36%	36%	36%	33%
8	21%	21%	20%	21%	21%	20%	21%	21%	21%	18%
5	13%	13%	13%	13%	13%	12%	14%	13%	13%	8%
2	5%	5%	5%	5%	5%	6%	5%	5%	5%	3%
D_{50}	55	62	66	61	75	73	75	72	74	75

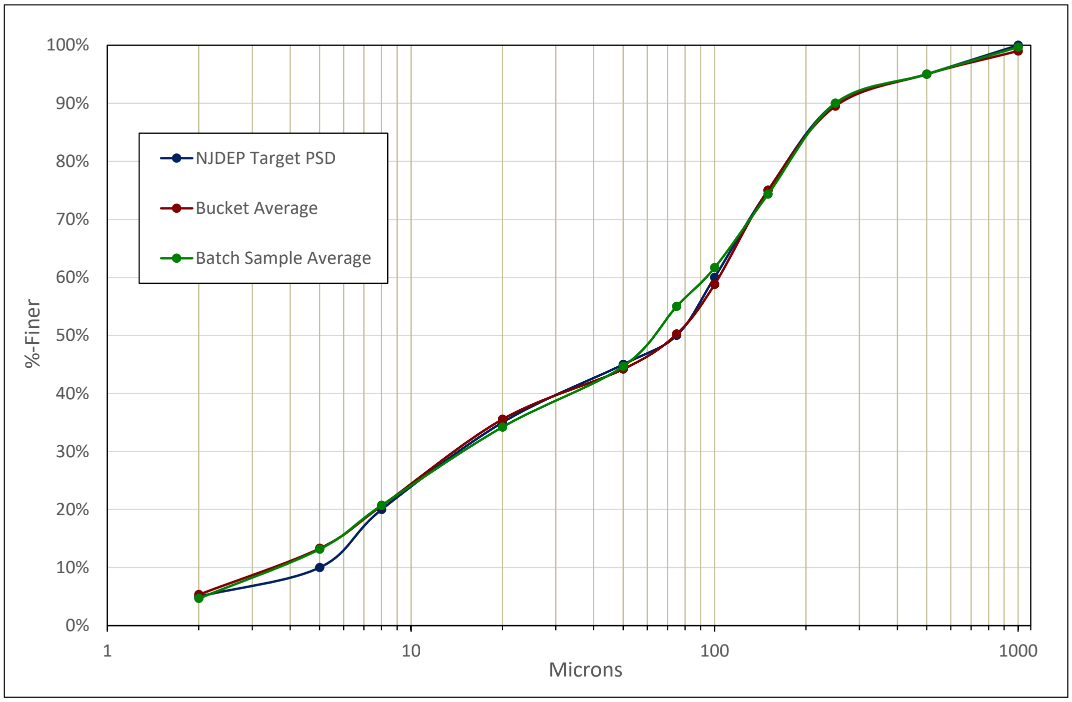


Figure 12 PSD Curves of 1-1000 Micron Test Sediment

4.2 Removal Efficiency and Mass Loading Testing

Testing Summary

Ten removal efficiency tests were conducted at a target flow of 216 gpm. The measured flows ranged from 215.4 gpm to 216.5 gpm. The calculated COV for the test runs ranged from 0.002 to 0.003.The ten removal efficiency runs resulted in a total cumulative average removal efficiency of 83.7%. An additional eight mass loading tests were conducted at 216 gpm. The measured flows ranged from 215.8 gpm to 216.3 gpm. The calculated COV for the eight test runs ranged from 0.002 to 0.003. The maximum recorded temperatures for all tests ranged from 72.4 to 79.1 degrees F. The measured injected influent concentration averages ranged from 192.9 to 207.3 mg/L. The injection COV ranged from 0.009 to 0.056. The calculated mass/volume influent concentrations ranged from 191 to 208 mg/L.

The calculated removal efficiencies from **Equation 1** ranged from 77.0% to 93.0%, with a total cumulative average removal of 82.7% for the 18 test runs. The total cumulative injected and captured mass was 257.2 lbs and 212.7 lbs, respectively. The maximum end-of-run elevation above the stone base layer was 2.547 ft. There was no sediment in the inlet pipe at the conclusion of each test run.

$$Removal\ Efficiency\ (\%) = \frac{\begin{pmatrix} Average\ Influent \\ TSS\ Concentration\ X \\ Total\ Volume \\ of\ Test\ Water \end{pmatrix} - \begin{pmatrix} Adjusted\ Effluent \\ TSS\ Concentration\ X \\ Total\ Volume \\ of\ Effluent\ Water \end{pmatrix} - \begin{pmatrix} Average \\ Drawdown\ Flow \\ TSS\ Concentration\ X \\ Total\ Volume \\ of\ Drawdown\ Water \end{pmatrix}}{\begin{matrix} Average\ Influent\ TSS\ Concentration\ X \\ Total\ Volume\ of\ Test\ Water \end{matrix}} \times 100$$

Equation 1 Equation for Calculating Removal Efficiency

The sampling collection times for the three injected sediment samples, the three background samples, the six effluent samples and the two drawdown samples for each run are shown in **Table 3.** The measured flowrate, flowrate COV, maximum water temperature, end of run water elevation above the base stone, influent sediment concentration and QA/QC compliant (Y/N) are shown in **Table 4.**

The maximum background, adjusted effluent, drawdown and adjusted drawdown concentrations are shown in **Table 5.** Removal efficiency test results are summarized in **Table 6**, and injected mass, mass captured, individual run removal efficiency and cumulative sediment removal efficiency are shown in **Table 7**.

The removal efficiency vs mass loading is shown on **Figure 13.** The recorded driving head at the end of each run vs mass loading is shown on **Figure 14**.

Table 3 Sample Collection Timestamps (minutes)

Run #	Injection 1	Eff 1, BG 1	Eff 2	Eff 3, BG 2	Injection 2	Eff 4	Eff 5, BG 3	Eff 6	Injection 3	DD 1	DD 2
1	1	9	12	15	18	26	29	32	36	39.17	40.75
2	1	9	12	15	18	26	29	32	36	39.17	41.25
3	1	9	12	15	18	26	29	32	36	39.33	42.00
4	1	9	12	15	18	26	29	32	36	39.58	42.83
5	1	9	12	15	18	26	29	32	36	39.92	44.00
6	1	9	12	15	18	26	29	32	36	39.83	44.00
7	1	11	13	15	18	28	30	32	36	39.92	44.33
8	1	11	13	15	18	28	30	32	36	39.92	44.50
9	1	11	13	15	18	28	30	32	36	40.00	44.67
10	1	11	13	15	18	28	30	32	36	40.08	45.25
11	1	11	13	15	18	28	30	32	36	40.17	45.50
12	1	11	13	15	18	28	30	32	36	40.00	44.75
13	1	11	13	15	18	28	30	32	36	40.00	44.50
14	1	11	13	15	18	28	30	32	36	40.08	44.67
15	1	11	13	15	18	28	30	32	36	40.17	45.33
16	1	11	13	15	18	28	30	32	36	40.17	45.50
17	1	15	25	35	40	55	65	75	85	90.25	95.75
18	1	15	25	35	40	55	65	75	85	90.33	95.83

Table 4 Measured Removal Efficiency Test Parameters

Test Run #	Measured Flow		Maximum Water Temperature	End of Run Water El. Above Base stone	Influent Concentration (mg/L)						QA/QC Compliant
	gpm	COV	Deg. F	ft	Sample 1	Sample 2	Sample 3	Average	COV	Mass/Volume	
1	216.1	0.002	77.7	0.927	209.4	190.6	208.6	202.9	0.053	196	Y
2	216.5	0.002	79.1	1.242	203.6	182.8	195.6	194.0	0.054	200	Y
3	215.4	0.002	76.5	1.414	202.3	199.3	182.0	194.5	0.056	198	Y
4	216.2	0.003	76.2	1.550	206.1	195.7	206.9	202.9	0.031	202	Y
5	215.7	0.003	76.5	1.664	203.8	203.9	191.9	199.9	0.035	206	Y
6	215.7	0.003	75.5	1.741	204.9	193.7	188.5	195.7	0.043	193	Y
7	215.8	0.002	76.3	1.843	199.6	204.7	206.1	203.4	0.017	203	Y
8	216.2	0.002	76.4	1.910	199.5	195.2	208.7	201.1	0.034	191	Y
9	215.8	0.002	75.3	1.974	196.0	201.8	199.9	199.2	0.015	199	Y
10	215.7	0.002	74.4	1.989	216.9	205.2	199.7	207.3	0.042	208	Y
11	215.9	0.003	75.2	2.106	208.4	187.5	194.5	196.8	0.054	198	Y
12	216.1	0.003	75.8	2.142	202.6	197.7	207.7	202.7	0.025	202	Y
13	215.8	0.003	76.6	2.178	205.5	194.7	189.5	196.6	0.041	197	Y
14	216.2	0.003	75.7	2.230	200.1	200.0	196.9	199.0	0.009	195	Y
15	216.3	0.003	75.5	2.284	200.5	192.4	194.8	195.9	0.021	197	Y
16	215.8	0.002	74.3	2.329	195.6	199.3	193.7	196.2	0.015	201	Y
17	216.1	0.002	74.1	2.413	203.2	193.2	182.5	192.9	0.054	194	Y
18	216.3	0.002	72.4	2.547	202.5	199.7	195.7	199.3	0.017	195	Y

Table 5 Measured Sample Concentrations

Run #	Max Background	Adjusted Effluent Concentrations (mg/L)							Adjusted Drawdown Concentrations (mg/L)		
	mg/L	E1	E2	E3	E4	E5	E6	**Average**	DD1	DD2	**Average**
1	1.4	44.2	43.5	43.9	50.2	50.0	46.4	**46.4**	31.7	24.4	**28.1**
2	2.1	13.8	11.9	12.9	15.0	13.5	14.3	**13.5**	21.1	15.5	**18.3**
3	1.9	28.3	30.3	30.7	33.3	32.7	32.4	**31.3**	26.7	14.5	**20.6**
4	3.1	34.6	37.5	35.9	43.0	40.9	40.2	**38.7**	24.3	12.4	**18.3**
5	3.7	31.4	32.4	31.8	35.4	37.5	38.1	**34.5**	24.8	12.2	**18.5**
6	3.3	31.9	32.7	33.3	32.7	33.7	35.0	**33.2**	23.8	13.3	**18.6**
7	2.1	34.5	34.4	35.2	34.4	34.9	35.0	**34.7**	29.4	16.5	**22.9**
8	1.2	33.2	34.4	33.3	31.0	33.6	34.4	**33.3**	25.5	14.0	**19.7**
9	1.8	29.7	31.9	32.0	32.9	32.4	33.4	**32.1**	36.6	20.2	**28.4**
10	3.9	36.9	39.5	37.1	39.5	39.6	39.2	**38.6**	37.9	18.5	**28.2**
11	2.2	38.4	37.5	36.6	36.0	36.5	36.6	**36.9**	32.2	15.7	**24.0**
12	5.8	35.0	34.0	34.5	38.6	36.9	38.7	**36.3**	28.9	14.1	**21.5**
13	6.3	30.4	32.3	31.1	34.1	34.3	34.8	**32.9**	27.9	14.0	**21.0**
14	6.3	35.2	37.4	36.5	36.2	34.5	36.8	**36.1**	31.9	17.0	**24.4**
15	3.9	37.1	38.9	37.7	37.0	36.9	37.6	**37.6**	30.4	14.5	**22.4**
16	5.1	36.6	38.6	36.7	39.1	37.7	38.5	**37.9**	33.6	15.9	**24.7**
17	12.6	32.2	32.1	34.8	40.0	40.9	42.1	**37.0**	38.7	20.6	**29.7**
18	14.3	33.4	32.5	37.3	39.6	41.7	43.9	**38.1**	46.2	21.4	**33.8**

Table 6 Removal Efficiency Test Results

Run #	Mass/Volume Influent Concentration	Average Adjusted Effluent Concentration	Average Adjusted Drawdown Concentration	Influent Volume	Effluent Volume	Drawdown Volume	Influent Mass	Effluent Mass	Drawdown Mass
	mg/L	mg/L	mg/L	L	L	L	g	g	g
1	196	46.4	28.1	28208	26431	1777	5541	1225	50
2	200	13.5	18.3	28265	26072	2193	5639	353	40
3	198	31.3	20.6	28134	25498	2636	5560	798	54
4	202	38.7	18.3	28222	25370	2851	5696	981	52
5	206	34.5	18.5	28156	25274	2882	5790	871	53
6	193	33.2	18.6	28154	25128	3026	5424	835	56
7	203	34.7	22.9	28163	25108	3055	5720	872	70
8	191	33.3	19.7	28221	24984	3237	5394	832	64
9	199	32.1	28.4	28164	24807	3357	5596	796	95
10	208	38.6	28.2	28159	24775	3384	5862	957	95
11	198	36.9	24.0	28181	24852	3328	5572	918	80
12	202	36.3	21.5	28205	25008	3198	5685	908	69
13	197	32.9	21.0	28171	24910	3261	5536	818	68
14	195	36.1	24.4	28225	24729	3497	5509	892	85
15	197	37.6	22.4	28237	24596	3641	5574	924	82
16	201	37.9	24.7	28181	24555	3626	5661	930	90
17	194	37.0	29.7	69112	65411	3701	13415	2421	110
18	195	38.1	33.8	69172	65275	3896	13478	2486	132

Table 7 Removal Efficiency Injected and Captured Mass

Run #	Test Duration	Injected Mass	Total Mass Injected	Mass Captured	Total Mass Captured	Removal Efficiency	Cumulative Average
	minutes	lbs	lbs	lbs	lbs	%	%
1	34.5	12.21	12.21	9.40	9.40	**77.0**	**77.0**
2	34.5	12.43	24.64	11.57	20.96	**93.0**	**85.0**
3	34.5	12.26	36.89	10.38	31.34	**84.7**	**84.9**
4	34.5	12.56	49.45	10.28	41.62	**81.9**	**84.1**
5	34.5	12.76	62.22	10.73	52.35	**84.0**	**84.1**
6	34.5	11.96	74.18	9.99	62.34	**83.6**	**84.0**
7	34.5	12.61	86.79	10.53	72.87	**83.5**	**84.0**
8	34.5	11.89	98.68	9.92	82.79	**83.4**	**83.9**
9	34.5	12.34	111.02	10.37	93.16	**84.1**	**83.9**
10	34.5	12.92	123.94	10.60	103.77	**82.0**	**83.7**
11	34.5	12.28	136.22	10.08	113.85	**82.1**	**83.6**
12	34.5	12.53	148.76	10.38	124.23	**82.8**	**83.5**
13	34.5	12.21	160.96	10.25	134.48	**84.0**	**83.5**
14	34.5	12.14	173.11	9.99	144.47	**82.3**	**83.5**
15	34.5	12.29	185.40	10.07	154.54	**82.0**	**83.4**
16	34.5	12.48	197.88	10.23	164.77	**82.0**	**83.3**
17	84.5	29.57	227.45	24.00	188.77	**81.1**	**83.0**
18	84.5	29.71	257.16	23.94	212.71	**80.6**	**82.7**

Note: The increase in run removal efficiency from Run 1 and Run 2 is unexpected. All data were checked and verified.

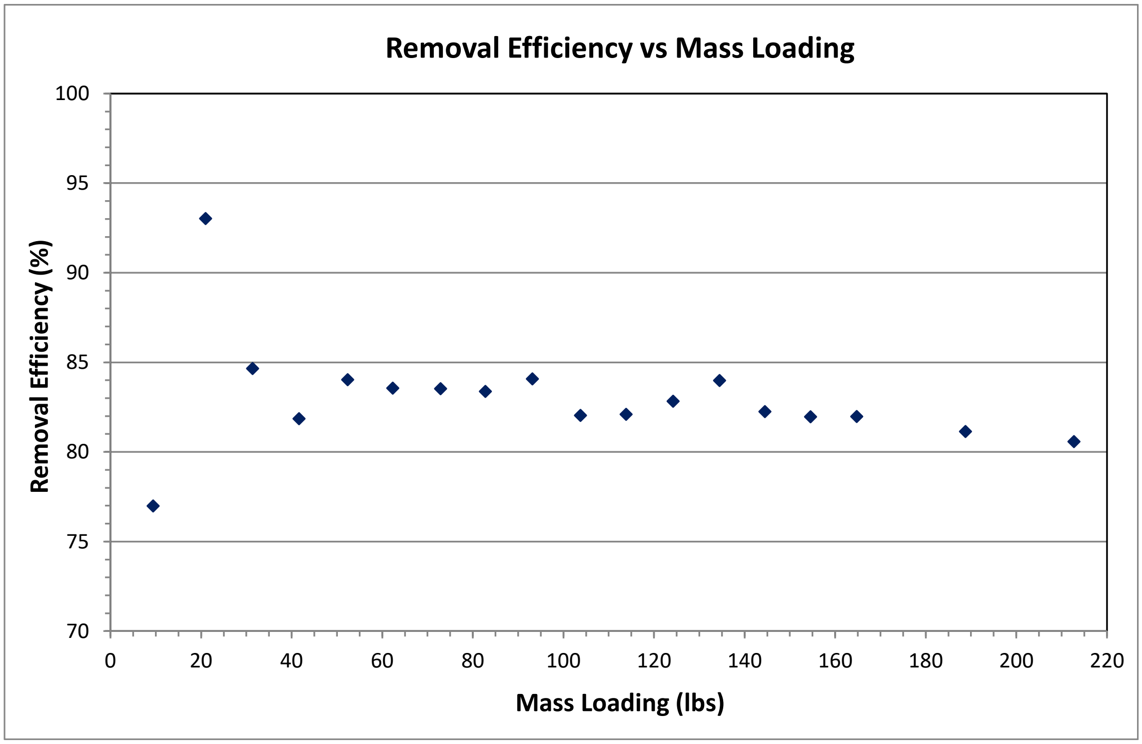


Figure 13 StormBrixx Removal Efficiency vs Mass Loading

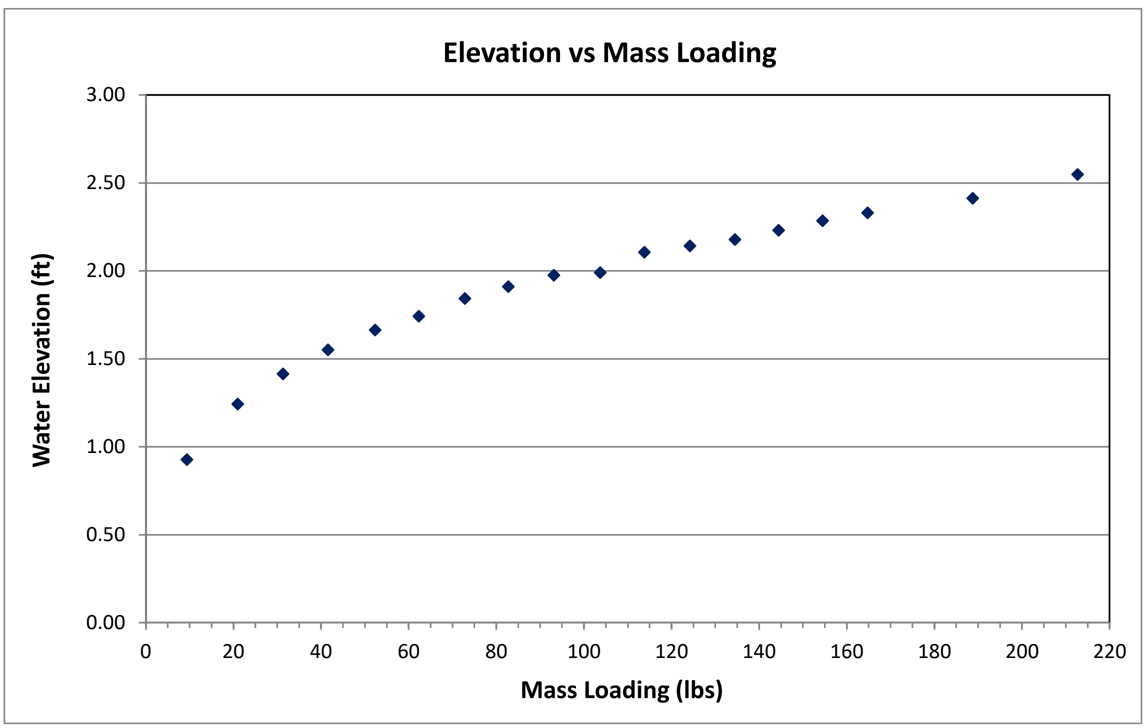


Figure 14 StormBrixx End-of-Run Water Elevations

5. Design Limitations

The engineers at ACO work with site civil engineers and contractors throughout the design, manufacturing, and installation processes to ensure that, once installed, the StormBrixx system functions as designed. Each StormBrixx system will have unique design constraints and limitations; the following limitations should be considered general and not all inclusive.

Required Soil Characteristics

StormBrixx systems must be designed and installed such that the maximum total settlement is less than 1 inch, and the maximum differential settlement is less than 1/4 inch. The project geotechnical and structural engineer should evaluate the subsurface conditions to ensure the design satisfies these requirements. Third-party testing and observation should be conducted on the prepared bearing soils during construction to ensure they are suitable for tank support.

Slope

The StormBrixx system is recommended for installation with a maximum slope of 0.5%. This is controlled by the slope of the underlying bearing soil surface and bedding fill. It is critical that areas of disturbed soil/fill are addressed by the contractor to maintain a level surface. Please contact ACO for questions on site preparation and system slope.

Allowable Head Loss

There is an operational head loss associated with the StormBrixx Sediment Filtration Tunnel. The head loss will increase over time due to the sediment loading to the system. Site-specific treatment flow rates, peak flow rates, pipe diameter, and pipe slopes should be evaluated to ensure there is an appropriate head for the system to function properly. A weir or raised bypass pipe may be included if the designed peak storm flows exceed the treatment flow rate. In these cases, and as demonstrated in the testing, we recommend that the invert of the bypass pipe or the top of the weir be 2.5 feet above the tank invert.

Configurations

The StormBrixx Sediment Filtration Tunnel is integrated into the overall StormBrixx tank footprint. Its modular design provides flexibility to meet project specific design volumes or flow rates. ACO recommends a minimum system height of 2.0 feet to achieve the sediment removal depicted in these test results.

Load Limitations

The StormBrixx system has been designed to require a minimum depth of cover, measured from the top of the unit to the finished grade surface, to achieve HS-20 or HS-25 load rating. Depending on the type of StormBrixx, the minimum cover varies.

Pre-Treatment Requirements

The StormBrixx Sediment Filtration Tunnel does not require additional pre-treatment.

Sediment Load Capacity

Based on laboratory testing results, the StormBrixx Sediment Filtration Tunnel has a mass loading capacity of 3.62 lbs/ft^2 of effective filtration treatment area while operating at a sediment removal efficiency greater than 80% without the water elevation exceeding 2.5 ft. This elevation is noted in the Allowable Head Loss section as the elevation at which peak stormwater events can bypass via overflowing a weir or through a raised bypass pipe.

Depth to Seasonal-High- Water Table

Seasonal high groundwater has the potential to impact driving head and when necessary, the StormBrixx system can be designed with an impermeable liner and watertight outlet so there is no impact. If the seasonal high groundwater table is above the tank invert, structural calculations should be completed to evaluate buoyant vertical forces and additional lateral forces due to groundwater. Designers can contact ACO for technical assistance when trying to meet site-specific requirements.

6. Maintenance

It is important to note that failure to control and remove sediment build-up in stormwater tanks is the largest cause of system failure. The open design of StormBrixx allows the system to be inspected by remote CCTV either through the inlet connection, remote access unit, remote access plate, or inspection points. This allows the system to be inspected for sediment build-up and enables collected sediment to be removed from the infiltration system or flushed through a detention/retention system.

ACO recommends inspections and maintenance be completed at intervals which satisfy the local, state, and federal regulations for underground stormwater storage system. Recommended frequencies and practices may be found in the StormBrixx Maintenance Manual at https://askaco.us/wp-content/uploads/2021/07/SB701-StormBrixx-Maintenance-Manual.pdf

Inspection / Maintenance Steps

Step 1
Locate the access cover on the surface connected to the tank.
Step 2
Once located, safely open the lid and place it out of the way.
Step 3
Perform an inspection of the tank to locate any debris. This can be done visually, with or without an inspection camera.

Step 4
If your tank has standing water in it already, you will need to vacuum and remove that water first before visually inspecting the tank.
Step 5
Use a high pressure jet nozzle or wand to loosen and suspend any solid debris that has built up.
Step 6
A minimum water pressure of 8 PSI is recommended. The maximum pressure depends on the geo-textile fabric chosen. Please check with fabric manufacturer for the max PSI.
Step 7
To ensure correct insertion of a high pressure jet nozzle we recommend using a pipe elbow.
Step 8
Once the water level has reached 3 inches or more, shut the water off and remove the high pressure nozzle.
Step 9
Insert the vacuum hose via the remote access unit or access plate and begin removing the debris that is now suspended in water. Do this until all the water has been removed.
Step 10
Not all water and debris may come out in the first round, repeat steps 5 through 7.
Step 11
Once it appears all debris has been removed, inspect the tank again to make sure everything has been cleared.
Step 12
Once the tank is clear of debris and water, remove all equipment used and place the cover back on the tank. Secure cover accordingly.

Alternatively, a nearby fire hydrant can be used to suspend debris within the StormBrixx system before vacuuming up the water.

7. Statements

The following signed statements from the manufacturer (ACO), independent testing laboratory (Verdantas) and NJCAT are required to complete the NJCAT verification process.

ACO

Dr. Richard Magee, Sc.D., P.E., BCEE
Director – NJCAT c/o Center for Environmental Services
Steven Institute of Technology
One Castle Point on Hudson
Hoboken, NJ 07030

October 15, 2024

RE: Statement of Compliance
StormBrixx Sediment Filtration Tunnel

Dr. Magee:

ACO, Inc. has completed its verification testing for the StormBrixx Sediment Filtration Tunnel module stormwater system in accordance with the "NJDEP Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" (January 14, 2022, updated April 25, 2023). As required, manufacturers shall submit a signed statement confirming that all the procedures and requirements identified in the aforementioned process document have been met. This letter serves as ACO's statement that testing executed by Verdantas in 2024, under the direct supervision of Mr. James Mailloux - Principal Engineer, was conducted in full compliance with all applicable protocol and process documents.

Please feel free to contact me with additional questions or comments.

Sincerely,

Alison K. Frye

Alison K. Frye, PE (OH)
Senior Civil Engineer
ACO, Inc.
825 W. Beechcraft Street
Casa Grande, AZ 85122

verdantas

September 20, 2024

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

Verdantas Flow Labs, LLC is a non-biased independent testing entity which receives compensation for testing services rendered. Verdantas 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 Verdantas and ACO, Incorporated.

Protocol Compliance Statement

Verdantas conducted the performance testing on the ACO. Inc. STORMBRIXX™ Filtration Tunnel treatment system. The Technical Report and all required supporting data documentation has been submitted to NJCAT as required by the protocol.

Testing performed by Verdantas on the ACO STORMBRIXX™ 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 Filtration Manufactured Treatment Device", January 14, 2022, (Updated April 25, 2023).

James T. Mailloux

Senior Consultant
Verdantas Flow Labs, LLC
jmailloux@verdantas.com

(508) 500-6209

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

October 17 , 2024

Ms. Alison Frye, PE
Senior Civil Engineer
ACO, Inc.
825 W. Beechcraft Street
Casa Grande, AZ 85122

Dear Ms. Frye,

Based on my review, evaluation and assessment of the testing on the ACO StormBrixx Sediment Filtration Tunnel conducted at the Verdantas Flow Labs LLC, Alden Campus (Verdantas), Holden, Massachusetts, under the direct supervision of Verdantas' 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 Filtration Manufactured Treatment Device"* (NJDEP Filtration Protocol), dated January 14, 2022 (updated April 25, 2023) were met. Since this technology fits under the infiltration basin category in the New Jersey Stormwater BMP Manual, it is not eligible for NJDEP MTD certification.

Test Sediment Feed -The mean PSD (D_{50}) of the test sediment utilized for removal efficiency testing was < 75 µm as required by the protocol.

Removal Efficiency Testing – The tested 900SD module type achieved an 82.7% cumulative TSS removal efficiency rounded down to 80% per the NJDEP protocol, a hydraulic loading rate of 3.68 gpm/ft^2, and a mass loading capture capacity of 3.62 lbs/ft^2 of filter area.

Scour Testing – ACO decided to not conduct scour testing on a 50% loaded bed at this time. The StormBrixx Sediment Filtration Tunnel will be designated as an offline system.

All other criteria and requirements of the NJDEP HDS Protocol were met. These include flow rate measurements COV <0.03; test sediment influent concentration COV <0.10; test sediment influent concentration within 10% of the targeted value of 200 mg/L; influent background concentrations <20 mg/L; and water temperature <80 ^{o}F.

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. 4.08.

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. 04.09.

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. 4.08.

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 2022. *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device.* Trenton, NJ. January 14, 2022 (Updated April 25, 2023).

VERIFICATION APPENDIX

Introduction

- Manufacturer of StormBrixx Sediment Filtration Tunnels – ACO Inc., 825 W Beechcraft St, Casa Grande, AZ 85122. Phone (866) 953-7687. www.acousa.com.

- MTD: StormBrixx Sediment Filtration Tunnels, see **Table A-1** for StormBrixx module types and sizing.

- TSS Removal Rate: 80%

- StormBrixx Sediment Filtration Tunnels are qualified for offline installation for the New Jersey Water Quality Design Storm (NJWQDS).

Detailed Specification

- StormBrixx module types and sizing (MTFR and maximum drainage area per NJDEP sizing requirements) are attached (**Table A-1**).

- The hydraulic loading rate for the StormBrixx is 3.68 gpm/ft^2 of effective filter treatment area (EFTA).

- The mass loading capacity is 3.62 lbs/EFTA.

- The StormBrixx Maintenance Manual may be found at https://askaco.us/wp-content/uploads/2021/07/SB701-StormBrixx-Maintenance-Manual.pdf

Table A-1 StormBrixx Module Sizing (MTFR and Maximum Allowable Drainage Area)

StormBrixx Sediment Filtration Tunnel Module Type[1]	Surface Loading Rate[2] (gpm/ft^2)	Single Module EFTA[3] (ft^2)	Single Module MTFR[4] (gpm)	Single Module Mass Loading Capacity[5] (lbs)	Single Module Drainage Area[6] (acres)
900SD	3.68	19.56	72.0	70.8	0.118
600HD	3.68	15.69	57.8	56.9	0.095
900SD-300SD	3.68	23.49	85.2	85.2	0.142

Notes:

1. The module type list is for 1-layer systems for 900SD and 600HD.The 900SD-300SD module type consists of 1-layer of 900SD and 1-layer of 300SD for a total height of 48-inches.
2. The surface loading rate is based on the tested StormBrixx with three 900SD modules, which has a total effective filtration treatment area (EFTA) of 19.56 ft2 per module and a total MTFR of 216 gpm.
3. The EFTA was calculated based on the tested StormBrixx setup which equates to one, lengthwise side and the bottom of the 900SD module.
4. The MTFR is calculated using the EFTA of a single module and the surface loading rate of 3.68 gpm/ft^2.
5. Mass loading capacity is based on 3.62 lbs/EFTA.
6. Drainage area is based on the NJDEP Filtration Protocol requirement that assumes an annual sediment loading rate of 600 lbs/acre.