NJCAT TECHNOLOGY VERIFICATION

EcoPure BioFilter™

Advanced Drainage Systems, Inc.

June 2020

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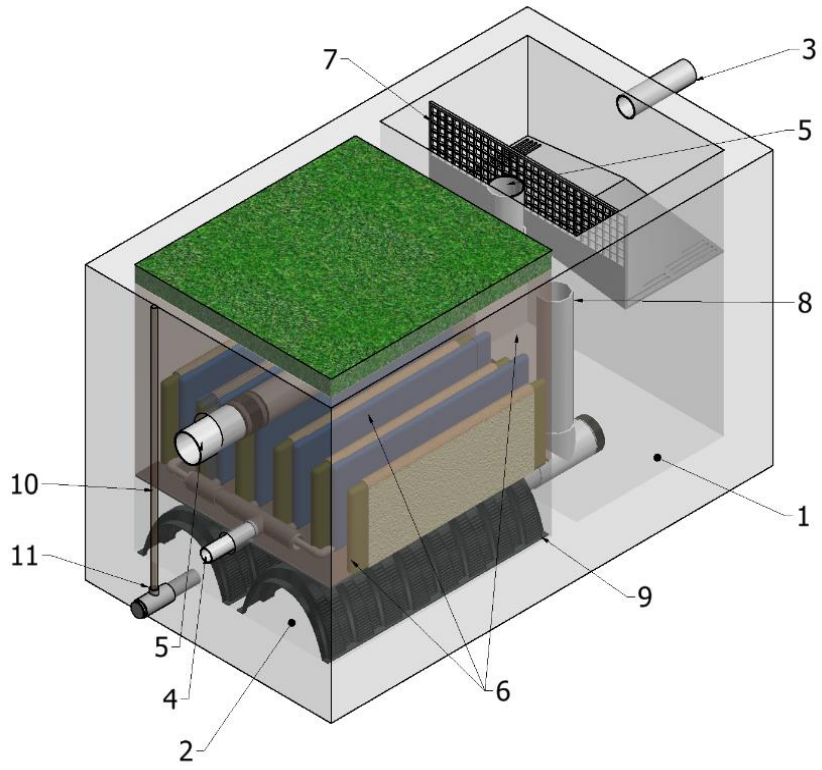
1. Description of Technology

The EcoPure BioFilter™ Filtration System (EcoPure BioFilter™), shown in **Figure 1**, is a stormwater quality manufactured treatment device (MTD) with engineered biofiltration media designed for removing traditional stormwater pollutants of concern. The EcoPure BioFilter™ unit allows for a high treatment flowrate with a smaller footprint than conventional bioretention and filtration (e.g., sand filter) systems.

For this testing, the EcoPure BioFilter™ removes solid "sediment" pollutants from water by three mechanisms: 1) screening, 2) gravitational settling and 3) filtration. The first cell of the EcoPure BioFilter™ allows for gravity-driven settling of coarse particles of sediment, prior to introduction of water to the second cell, which removes sediment and particulate bound pollutants through filtration. For this testing, the filtration occurs when particulates become trapped within the EcoPure BioFilter™ bioretention filter media.



1	Pretreatment Gravitational and Trash-removal Cell
2	Biofiltration Cell
3	Pipe or Surface Influent
4	Effluent Pipe
5	High-flow Bypass
6	Internal Manifold and Bioretention Planting Media Layer
7	Trash Screen
8	Riser Pipes (two symmetrical pipes; one visible here)
9	Infiltrator® Chambers
10	Gravel Layer
11	Standpipe for Measuring Hydrostatic Head

Figure 1 The EcoPure BioFilter™

The EcoPure BioFilter™, shown in three dimensions in **Figure 1**, is assembled inside a 4' x 8' concrete vault and consists of a pretreatment gravitational settling (**Item 1**), and a biofiltration cell (**Item 2**). The structure contains the influent pipe (**Item 3**) (which could be a curb, gutter, grated inlet, or straight-in pipe), an effluent pipe (**Item 4**), a high-flow bypass pipe (**Item 5**), and an internal manifold and bioretention media layer (**Item 6**) that delivers treated water to the outlet of the EcoPure BioFilter™. For this testing, the upper bioretention media layer did not include plants.

The flow path for the EcoPure BioFilter™ is shown in **Figure 2a**. Stormwater runoff enters the concrete structure via an influent pipe or surface inlet (**Item 3**) and begins to fill the first cell of the structure (**Item 1**), which is 3' x 4' and contains a trash/debris screen (**Item 7**) for removal of large solid materials and disbursement of the influent water such that influent turbulence is reduced. Larger sediment debris is collected, and the coarse sediment particles in the influent settle out in this first cell. When the water surface elevation in the pretreatment cell reaches the level of the top of the "riser" pipes, the water exits via two 6"-diameter riser pipes (**Item 8**; two symmetrical pipes; one visible in **Figure 1**) and flows into the bottom of the second cell. (The first cell also includes a third riser pipe at a higher elevation, which serves as the inlet to the internal high-flow bypass (**Item 5**), which is constructed of a solid-wall pipe.). Water then flows to the second cell (**Item 2**) and through the filtration bioretention media, driven by hydrostatic head. In the second cell, the water fills from the bottom through Infiltrator® chambers (**Item 9**) and a gravel layer (**Item 10**), is distributed through multiple manifold inlets, then flows horizontally and vertically through the bioretention media bed, where pollutants are removed, and then flows downward through multiple manifold outlets, and out through the effluent pipe (**Item 4**). The standpipe (**Item 12**), used to measure hydrostatic head during testing, is part of the tested unit only.

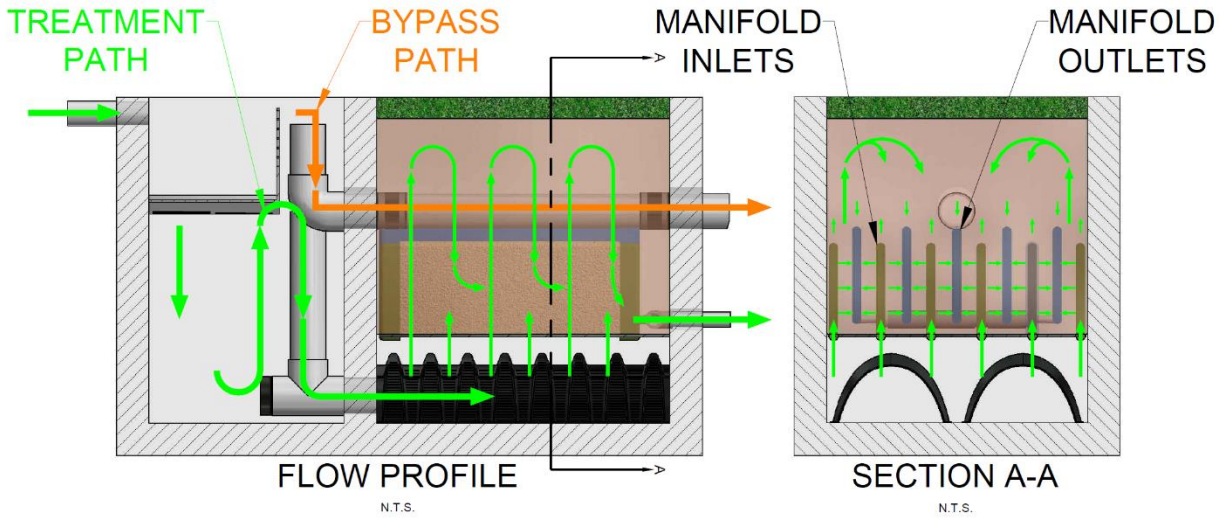


Figure 2a Flow Path of the EcoPure BioFilter™

Figure 2b provides section dimensions for the NJCAT "tested" EcoPure BioFilter™ Unit. The 4' x 8' EcoPure BioFilter™ has 60 square feet of effective filtration treatment area (See page 24 for calculation details.). This is calculated from the surface area of the manifold outlet piping installed

in the filter bed through which the effluent filtered water flows. The maximum treatment flow rate (MTFR) is 60 gpm for this tested unit. The effective filtration area is based on the square footage of the exiting manifold. Separation between inlet and outlet manifolds is approximately 3". Complete details of the design, operation, and maintenance of the EcoPure BioFilter™ are available in the EcoPure BioFilter™ Technical and Design Manual, available electronically at https://baysaver.com/resources/.

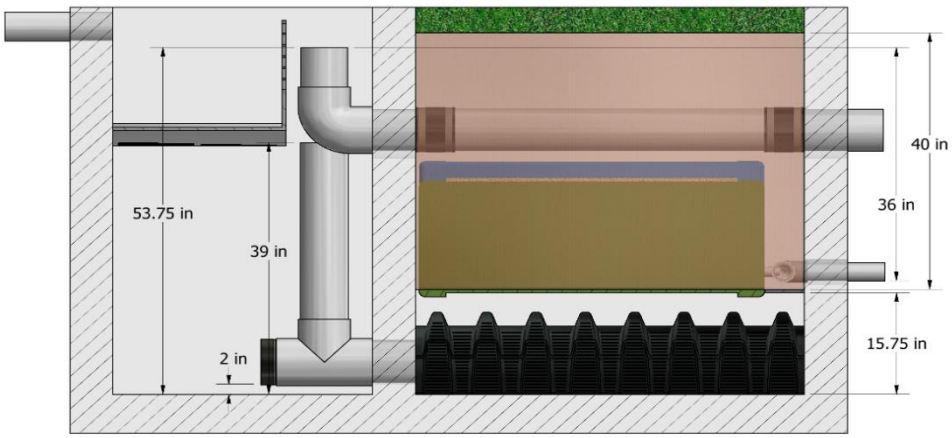


Figure 2b Key Dimensions of the EcoPure BioFilter™

2. Laboratory Testing

Beginning in December 2019, one EcoPure BioFilter™ 4' x 8' commercial size unit was installed at the BaySaver Laboratory in Mount Airy, Maryland, to evaluate the performance of the EcoPure BioFilter™ on Total Suspended Solids (TSS) removal. Boggs Environmental Consultants (BEC) provided third-party review and oversight of all testing and data collection 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 2013)*. All sediment concentration samples were analyzed by Fredericktowne Labs (FTL) using ASTM D3977-97 (re-approval 2007). All sediment particle size distribution (PSD) analysis was performed by Environmental Consulting Services (ECS), using the methodology of ASTM D422-63. Prior to the start of testing, a Quality Assurance Project Plan (QAPP), revision dated December 3, 2019, was submitted and approved by the New Jersey Corporation for Advanced Technology (NJCAT).

2.1 Test Setup

The testing system, shown in **Figure 3**, consisted of source tanks, feed pump, flow control valve, flow meter in a vertical up-flow configuration, background sample port, screw-auger sediment doser, and an EcoPure BioFilter™.

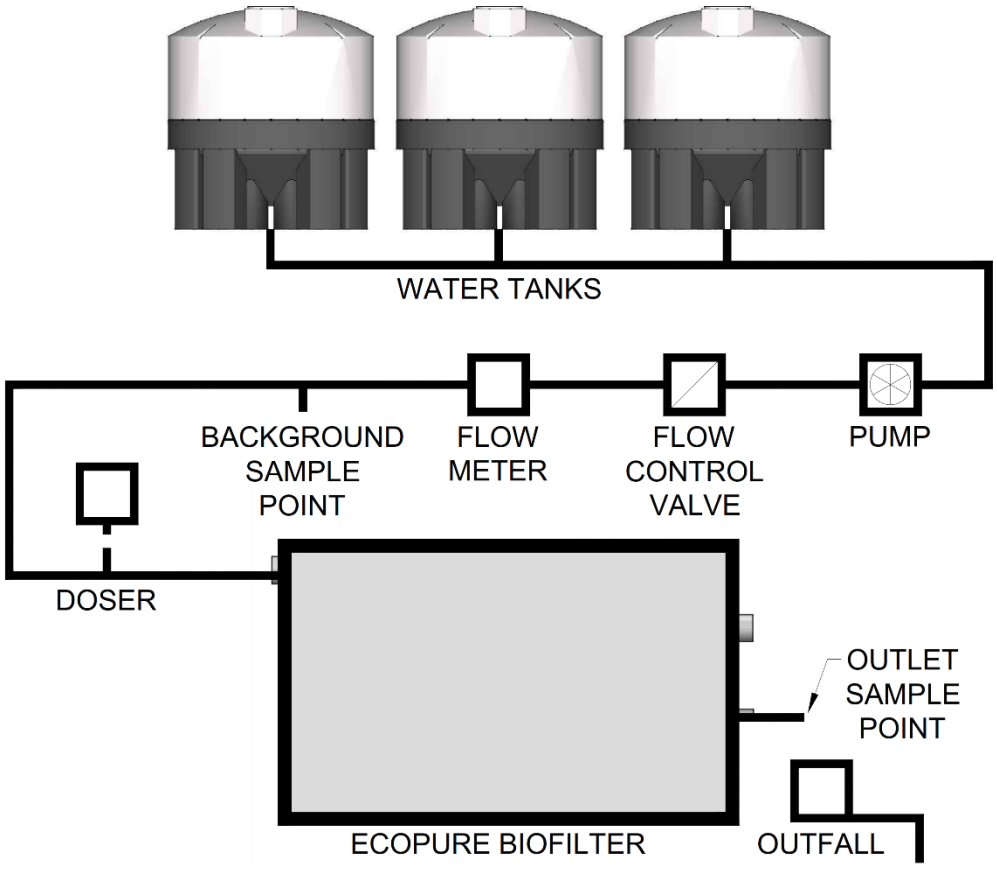


Figure 3 Schematic of the EcoPure BioFilter™ Test Configuration

Testing Procedure

The water source was potable water from the Town of Mount Airy, MD, Water and Sewer Department, obtained from an onsite tap. Municipal tap water was used to fill the source tanks, and then pumped to the system. Flow rate was controlled to the target of 60 gpm by a flow control valve. A calibrated inline flow meter (Seametrics IMAG4700P) measured and recorded the flow rate at one-minute intervals (pictured in **Figure 4**). Approximately four feet upstream of the system inlet, sediment was introduced to the feed stream via a dosing port (pictured in **Figure 5**); dosing rate was controlled by a screw-auger Velodyne Barracuda 500A volumetric feeder with a ½ HP variable speed motor. The dosing rate was set to deliver an amount of sediment that, when mixed with the water from the source tank, would produce influent water with a target test sediment concentration of 200 mg/L.

Figures 4 and 5 Photographs of Flow Meter and Sediment Delivery Port

Flow entered the concrete structure via the influent pipe and began to fill the first cell. Once the water level reached the top of the riser pipes (**Item 8**; two symmetrical pipes; only one is visible in **Figure 1**) in the first cell, water began to flow to the second cell and flowed through the filtration bio-media, driven by hydrostatic head. A standpipe (**Item 11**) indicated the water head level. The treated water exited via a pipe near the bottom of the EcoPure BioFilter™ bioretention media bed.

Test Unit and Scaling Explanation

The EcoPure BioFilter™ model tested contains the same depth of media, composition of media, and gradation of media as all commercial models. The only major difference in the EcoPure BioFilter™ model tested is that no established plant life was included on top of the biofiltration cell. The effective filtration treatment area loading rate is 1.0 gpm/ft^2, and the ratio of effective sedimentation treatment area to effective filtration treatment area is 0.5. The ratio of wet volume to effective filtration treatment area is 0.94 ft. Given these data, we can effectively scale the test results for all commercial systems.

Sample Collection

The grab sampling method was used for all sample collection by sweeping a wide-mouth 1-L plastic bottle through an open flowing stream, to ensure the full cross section of the flow was sampled. The start time for each run was recorded.

The sampling schedule is provided in **Table 1**. The detention time for the EcoPure BioFilter™ is 7 minutes. To comply with the NJDEP Filter Protocol, after initiating and stabilizing the MTFR flow rate and beginning sediment feed, effluent sampling did not begin until the filtration MTD had been in operation for a minimum of three detention times.

Background water samples were collected upstream of the doser (**Figures 3 and 6**) in correspondence with the odd-numbered effluent samples (i.e., Samples E1, E3, E5 at t = 27, 57, 87 minutes).

Figure 6 Photograph of Background Sampling Port

Two evenly-volume-spaced drawdown samples, DDA and DDB, were taken after the flow and sediment feed to the unit had been stopped.

Sediment sample rates were measured using a stopwatch, once at the very beginning of the run and twice more during the run. The duration of each run was 89 minutes.

Table 1 Sampling Schedule for the EcoPure BioFilter™ Tests

Time (min)	Sample(s)	Time (min)	Sample(s)
0	S1	59	S3
27	E1, BG1	87	E5, BG5
28	E2	88	E6
29	S2	89	Stop Flow
57	E3, BG3	N/A	DDA
58	E4	N/A	DDB

NOTE: S = sediment rate; E = effluent; BG = background; DD = drawdown

A Chain of Custody (COC) form was used for each test run to record sampling date and time for externally analyzed samples. Copies of these forms were maintained by the BaySaver Laboratory and FTL. Sample bottles were labeled to identify the test run number and sample type (e.g., background, effluent), corresponding to the sample identification on the COC form. BEC was present and witnessed labeling, completion of COC forms, and packaging of samples for delivery to the external laboratory (FTL). Each person taking or relinquishing possession of the samples was required to sign a COC form before samples changed hands.

Other Instrumentation and Measurement

Water temperature was recorded every minute by a HOBO data logger placed in the first cell of the EcoPure BioFilter™. The water level in the second cell of the EcoPure BioFilter™ was recorded every 5 minutes by visual observation of an externally-mounted manometer (standpipe); readings were performed by BEC personnel. Run times and sampling times were measured using a digital timer and a stopwatch, respectively.

2.2 Test Sediment

The test sediment had the particle size distribution (PSD) presented in **Figure 7**. The test sediment blend was custom-blended using various commercially available silica sands, the blend ratio of which was determined such that the size distribution of the resulting blended sediment would meet the specification for the NJDEP Filter Protocol. The test sediment was batched, labeled, and stored in covered bins for the duration of this project. Under the supervision of BEC, twenty-four subsamples, taken from various locations within the test sediment containers, were composited. From the composite, three random samples were taken for analysis, which was performed by ECS, using the methodology of ASTM method D422-63.

The PSD test results are also summarized in **Table 2**. ECS results showed that 19-20% of the test sediments were less than 8 microns (µm) and 89-90% of the test sediments were less than 250 µm. The median size particles d_{50} values (approximately 61 µm) also indicated that there was no significant difference between the NJDEP target gradation and the ECS-analyzed gradation of the test sediment. Thus, the blended test sediment was found to meet the NJDEP particle size

specification and was acceptable for use. ECS also analyzed the sediment samples for moisture. The average moisture content was less than 0.1%.

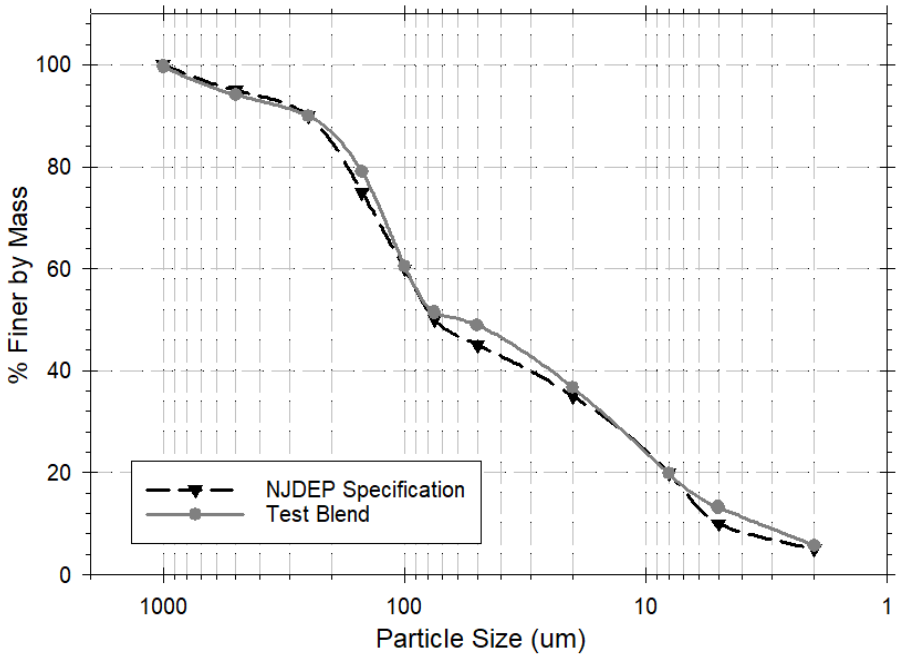


Figure 7 Average Particle Size Distribution of Test Sediment Analyzed by ECS

Table 2 Particle Size Distribution of Test Sediment as Analyzed by ECS

Particle Size (µm)	Test Blend % Finer by Mass Analyzed by ECS				
	NJ Blend A	NJ Blend B	NJ Blend C	Average	NJDEP Specification (minimum % passing)
1000	99.6	99.6	99.5	99.6	98
500	94.3	94.2	93.9	94.1	93
250	90.2	90.1	89.6	90.0	88
150	79.3	79.2	78.5	79.0	73
100	59.9	61.1	60.6	60.5	58
75	50.7	52.4	51.0	51.4	50
50	48.2	50.3	48.3	48.9	43
20	36.4	36.6	36.6	36.6	33
8	19.6	20.0	19.7	19.8	18
5	13.2	13.3	13.2	13.2	8
2	5.8	5.5	5.8	5.7	3

2.3 Sediment Removal Efficiency Testing

Sediment removal efficiency testing adhered to the guidelines set forth in Section 5 of the NJDEP Laboratory Protocol for Filtration MTDs. The target flow rate through the system was 60 gpm, with a target sediment concentration of 200 mg/L. All samples were collected in clean, 1-L wide-mouth bottles. Three background samples were taken at 27, 57 and 87 minutes after the test began to ensure the tap water source met the sediment concentration requirement. According to the NJDEP Filter Protocol, these background concentrations cannot exceed a TSS of 20 mg/L.

The test sediment screw-auger feeder (doser) introduced the test sediment into the feed water stream to achieve the target influent TSS concentration of 200 mg/L. According to the NJDEP Filter Protocol, this influent concentration must stay within 10% of target, allowing for a 180 mg/L to 220 mg/L influent concentration. The feeder was calibrated prior to each run. In order to confirm sediment feed rates during the test, in accordance with the NJDEP Filter Protocol, three samples of the test sediment were collected from the injection point (**Figure 3**, "Doser") into a clean one-liter container for verification of sediment feed rate, over an interval timed to the nearest second, with a minimum volume of 0.1 liter or a collection interval not exceeding one minute (whichever came first). The time was kept with a stopwatch. The samples were weighed to the nearest milligram in the BaySaver Laboratory under the observation of BEC. The sediment feed rate coefficient of variance (COV) for the test sediment samples did not exceed 0.10. The mass from the sediment feed rate measurement samples was subtracted from the total mass introduced to the system when removal efficiency was calculated.

Effluent sampling was performed by the grab sampling method during each run, according to the schedule in **Table 1**. When the test sediment feed was interrupted for test sediment measurements, the next effluent samples were collected after at least three detention times had elapsed. During the drawdown period, two evenly-volume-spaced effluent samples were collected after flow and sediment feed had stopped. All sediment concentration samples were analyzed by Fredericktowne Labs (FTL) using the ASTM D3977-97 (re-approval 2007) "Standard Test Methods for Determining Sediment Concentrations in Water Samples."

2.4 Sediment Mass Loading Capacity Testing

The sediment mass loading capacity testing occurred as a continuation of the removal efficiency testing, with the target for influent concentration remaining at 200 mg/L, and all aspects of testing procedures kept the same to ensure consistency throughout. The sediment mass loading capacity of the EcoPure BioFilter™ was defined as the cumulative mass loading of the unit at the end of the test run during which the maximum driving head was reached while operating at 54 gpm (90% of MTFR). In this testing program, the EcoPure BioFilter™ reached maximum driving head (36 inches) at 60 gpm (100% of MTFR) during Run 21. The feed flow rate was then reduced to 54 gpm (90% of MTFR), and testing continued until the maximum driving head was reached once again (Run 26).

2.5 Scour Testing

Scour testing was performed to demonstrate that the EcoPure BioFilter™ can be located on-line. The test was performed at an average feed flow rate of 111.2 gpm (185% of the MTFR), the maximum flow rate that could be delivered by the test setup. In accordance with the NJDEP Filter Protocol, the average effluent concentration during the scour run must be less than 20 mg/L above the background concentration.

Scour testing was performed on the same EcoPure BioFilter™ used for removal efficiency and mass loading capacity testing, after all that testing was complete. Thus, the scour test took place on a unit that had already been pre-loaded with 100% of the manufacturer's recommended maximum sediment storage volume (determined by mass loading capacity testing, **Sections 2.4 and 5.5**).

The scour testing commenced by gradually introducing and increasing clear water into the test unit until the flow rate stabilized at 111 gpm (five minutes). Effluent samples were collected utilizing the Effluent Grab Sampling Method every two minutes afterward. Fifteen effluent samples were collected in clean, 1-L bottles. Flow rate was recorded every minute.

Eight background samples were collected at the same time as the odd-numbered effluent samples (first, third, fifth, etc.). All samples collected (background and effluent) were analyzed by FTL for TSS according to ASTM D3977-97 (re-approval 2007) "Standard Test Methods for Determining Sediment Concentrations in Water Samples." In accordance with the NJDEP Filter Protocol, all background concentrations must be less than 20 mg/L.

All effluent sample results from the scour test run were adjusted by subtracting the background concentration from the recorded effluent sample concentration.

3. Performance Claims

Per the NJDEP verification procedure and based on the laboratory testing conducted for the EcoPure BioFilter™ model tested (4' x 8'), the following are the performance claims made by Advanced Drainage Systems, Inc.

Total Suspended Solids (TSS) Removal Efficiency

Based on the laboratory testing conducted, the EcoPure BioFilter™ achieved 88.0% cumulative TSS removal efficiency.

Maximum Treatment Flow Rate (MTFR)

The EcoPure BioFilter™ model tested (4' x 8') has an MTFR of 0.13 cfs (60 gpm) and an effective filtration treatment area (EFTA) of 60 ft^2 (loading rate = 1.0 gpm/ft^2).

Detention Time and Volume

The EcoPure BioFilter™ model tested (4' x 8') wet volume is 56 ft^3, and the detention time is about 7 minutes at the test flow rate of 60 gpm.

Effective Sedimentation Treatment Area

The Effective Sedimentation Treatment Area (ESTA) increases as the size of the EcoPure BioFilter™ increases, with a larger system having a higher ESTA. Under test conditions with a single 4' x 8' unit, the ESTA is 30 ft^2 and the ratio ESTA/EFTA is 0.5.

Sediment Load Capacity/Mass Load Capture Capacity

Based on laboratory testing results, the EcoPure BioFilter™ model tested (4' x 8') has a mass loading capacity of 221lbs and a mass loading capture capacity of 194.5 lbs.

Maximum Allowable Inflow Drainage Are

Laboratory testing results show that 221lbs of sediment can be loaded into a 4ft x 8ft EcoPure BioFilter™ with internal bypass, while achieving a cumulative sediment mass removal efficiency of 88.0% (mass loading capture capacity = 194.5 lbs). Per the NJDEP Filter Protocol, to calculate the maximum inflow drainage area, the total sediment load captured mass observed during the test (194.5 lbs) is divided by 600 lb./acre. Thus, the maximum inflow drainage area is 0.324 acres.

4. Supporting Documentation

The Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from NJCAT states that copies of the laboratory test reports, all data from performance evaluation test runs, original data, pertinent calculations, and documentation of any maintenance activities that occur during the testing process are to be included in this section. This information has been made available to NJCAT and is available upon request.

5. Testing Results

A total of 26 removal efficiency test runs were completed in accordance with the NJDEP filter protocol. The target flow rate and influent sediment concentration were 60 gpm and 200 mg/L, respectively. The results from all 26 runs were used to calculate the overall cumulative removal efficiency of the EcoPure BioFilter™.

5.1 Flow Rate

Flow rate was recorded by a Seametrics IMAG4700P Flow Meter every minute during each run. For each run, the flow rate was maintained within 10% of the target flow rate (54 - 66 gpm at 100% MTFR, and 48.6 – 59.4 gpm at 90% MTFR). The average flow rate for the first 21 runs (100% MTFR) was 59.5 gpm. The average flow rate for Runs 22 through 26 (90% of MTFR) was 53.3 gpm. The flow data with coefficient of variation (COV) values for all 26 runs are summarized in **Table 3**.

5.2 Water Temperature

Temperatures were recorded every minute by a HOBO water level logger (U20L-04). On average for all 26 runs, the water temperature during testing was 55.5 degrees Fahrenheit, with a maximum of 59.5 degrees Fahrenheit, meeting the NJDEP Filter Protocol requirement to be no greater than 80 degrees Fahrenheit. Data are summarized in **Table 3**.

Table 3 Flow Rate and Temperature Summary for All Runs

Run #	Max Flow (gpm)	Min Flow (gpm)	Average Flow (gpm)	Flow COV	Flow Compliance (COV ≤ 0.1)	Maximum Temperature (Fahrenheit)	NJDEP Temperature Compliance (≤ 80 F)
1	62.13	58.40	61.10	0.0120	Y	56	Y
2	62.40	60.53	61.15	0.0067	Y	55	Y
3	60.27	58.93	59.34	0.0046	Y	55	Y
4	60.27	58.67	59.14	0.0061	Y	56	Y
5	60.27	58.67	59.24	0.0051	Y	56	Y
6	60.53	58.93	59.51	0.0038	Y	57	Y
7	60.00	59.20	59.50	0.0026	Y	58	Y
8	60.27	58.93	59.55	0.0036	Y	57	Y
9	60.27	58.93	59.49	0.0036	Y	56	Y
10	60.25	58.91	59.43	0.0041	Y	56	Y
11	60.53	58.67	59.46	0.0042	Y	60	Y
12	60.00	57.87	59.38	0.0046	Y	58	Y
13	60.00	58.67	59.37	0.0036	Y	58	Y
14	60.00	58.93	59.36	0.0032	Y	58	Y
15	60.00	58.93	59.38	0.0029	Y	58	Y
16	60.00	58.93	59.44	0.0035	Y	56	Y
17	60.25	59.18	59.49	0.0033	Y	56	Y
18	60.53	59.20	59.57	0.0035	Y	58	Y
19	60.27	58.67	59.35	0.0043	Y	57	Y
20	60.00	58.67	59.31	0.0034	Y	57	Y
21	59.20	58.13	58.64	0.0039	Y	57	Y
22	54.13	53.07	53.56	0.0027	Y	57	Y
23	54.12	52.78	53.43	0.0040	Y	56	Y
24	53.87	52.80	53.09	0.0044	Y	55	Y
25	54.93	52.80	53.23	0.0062	Y	56	Y
26	53.87	52.80	53.22	0.0047	Y	56	Y

5.3 Head

The head level in the second cell bioretention filter media of the EcoPure BioFilter™ was recorded to the nearest 1/8 inch (0.125 in) every five minutes by BEC personnel, through visual observation of an externally-mounted manometer (standpipe). With each run, the head during the run increased slightly over that of the previous run, until reaching the maximum (36 inches) in Run 21. Beginning with Run 22, the flow rate was reduced to 90% MTFR (54 gpm), and the maximum head decreased by about 3 inches from Run 21 to Run 22. The head then progressively increased again with each successive run, until once again reaching the maximum during Run 26. Maximum head for each run is summarized in **Table 4**.

Table 4 Maximum Head (inches) for All Runs

Run #	Maximum Head (inches)	Run #	Maximum Head (inches)
1	25.125	14	32.375
2	27.0	15	32.875
3	27.375	16	33.5
4	27.875	17	34.0
5	28.625	18	34.125
6	28.875	19	35.0
7	29.75	20	35.375
8	30.0	21	35.875
9	30.375	22	32.5
10	30.875	23	33.25
11	30.5	24	33.5
12	31.5	25	35.625
13	31.625	26	36.25

Note: Per the requirements of the NJ Filter Protocol, the head measurements for this testing were made using a yard stick, read to the nearest 1/8 inch (0.125 in).

5.4 Sediment Concentration and Removal Efficiency

Background TSS

Municipal tap water was used as the water source during testing. Overall, the average background TSS concentration was 0.9 mg/L, which is far below the 20 mg/L NJDEP Protocol limit. Background TSS concentrations for each run are provided in **Table 5**. The average background TSS concentration for each run was subtracted from effluent and drawdown TSS concentrations to provide adjusted figures, per the protocol.

Table 5 Background TSS Concentrations

Run #	Background TSS (mg/L)	NJDEP Background TSS Compliance (≤ 20 mg/L)	Run #	Background TSS (mg/L)	NJDEP Background TSS Compliance (≤ 20 mg/L)
1	0.8	Y	14	0.5	Y
2	0.5	Y	15	0.5	Y
3	0.5	Y	16	0.5	Y
4	0.5	Y	17	0.5	Y
5	0.7	Y	18	0.5	Y
6	0.5	Y	19	0.5	Y
7	0.5	Y	20	0.5	Y
8	0.5	Y	21	0.7	Y
9	0.5	Y	22	0.5	Y
10	0.5	Y	23	0.5	Y
11	0.5	Y	24	0.7	Y
12	0.5	Y	25	1.5	Y
13	0.5	Y	26	8.7	Y
MEAN Background TSS (mg/L)				0.9	Y

Sediment Dosing Rate and Influent TSS

Influent TSS concentration was calculated by dividing the total mass of sediment added during a given run by the total volume of water flowing through the MTD during the addition of test sediment during that run. The volume of water flowing through the device during the run was calculated by multiplying the average feed flow rate by the time of sediment addition only. The average influent TSS was 201 mg/L, with individual run averages ranging from 187 to 214 mg/L. All values are within the target range of 200 ± 20 mg/L. **Tables 6, 7 and 8** provide the measured sediment feed rates for each run, and the resulting calculated influent TSS concentration. In these tables, NJDEP Protocol compliance is defined as a TSS concentration in the range 180 – 200 mg/L and COV ≤ 0.1.

Table 6 Sediment Rate Measurements for Runs 1-10

Run	Run Time (min)	Sediment Weight (g)	Duration (s)	Sediment Feed Rate (g/min)	Influent Water Flow Rate (gpm)	Influent TSS Conc. (mg/L)	NJDEP Compliance
1	0	47.602	60	47.6	61.1	199.6	Y
	29	44.047	60	44.0			
	59	46.773	60	46.8			
	COV			0.0403			
2	0	45.301	60	45.3	61.1	193.4	Y
	29	42.010	60	42.0			
	59	46.955	60	47.0			
	COV			0.0563			
3	0	45.051	60	45.1	59.3	200.3	Y
	29	42.730	60	42.7			
	59	47.156	60	47.2			
	COV			0.0492			
4	0	47.747	60	47.7	59.1	207.9	Y
	29	44.635	60	44.6			
	59	47.176	60	47.2			
	COV			0.0356			
5	0	47.658	60	47.7	59.2	213.8	Y
	29	47.085	60	47.1			
	59	49.082	60	49.1			
	COV			0.0214			
6	0	43.009	60	43.0	59.5	202.2	Y
	29	47.507	60	47.5			
	59	46.205	60	46.2			
	COV			0.0508			
7	0	47.386	60	47.4	59.5	211.3	Y
	29	48.429	60	48.4			
	59	46.949	60	46.9			
	COV			0.0160			
8	0	44.529	60	44.5	59.5	195.8	Y
	29	43.962	60	44.0			
	59	43.866	60	43.9			
	COV			0.0081			
9	0	43.898	60	43.9	59.5	203.8	Y
	29	45.691	60	45.7			
	59	48.147	60	48.1			
	COV			0.0465			
10	0	44.429	60	44.4	59.4	200.4	Y
	29	45.413	60	45.4			
	59	45.414	60	45.4			
	COV			0.0126			

Table 7 Sediment Rate Measurements for Runs 11-20

Run	Run Time (min)	Sediment Weight (g)	Duration (s)	Sediment Feed Rate (g/min)	Influent Water Flow Rate (gpm)	Influent TSS Conc. (mg/L)	NJDEP Compliance
11	0	44.174	60	44.2	59.5	200.2	Y
	29	44.676	60	44.7			
	59	46.345	60	46.3			
	COV			0.0252			
12	0	46.507	60	46.5	59.4	207.7	Y
	29	45.916	60	45.9			
	59	47.662	60	47.7			
	COV			0.0190			
13	0	44.704	60	44.7	59.4	195.2	Y
	29	43.830	60	43.8			
	59	43.038	60	43.0			
	COV			0.0190			
14	0	45.266	60	45.3	59.4	196.8	Y
	29	43.566	60	43.6			
	59	43.776	60	43.8			
	COV			0.0210			
15	0	44.085	60	44.1	59.4	187.5	Y
	29	41.147	60	41.1			
	59	41.128	60	41.1			
	COV			0.0404			
16	0	44.016	60	44.0	59.4	199.8	Y
	29	46.156	60	46.2			
	59	44.698	60	44.7			
	COV			0.0243			
17	0	43.407	60	43.4	59.5	197.1	Y
	29	45.096	60	45.1			
	59	44.707	60	44.7			
	COV			0.0199			
18	0	47.519	60	47.5	59.6	205.8	Y
	29	46.684	60	46.7			
	59	45.000	60	45.0			
	COV			0.0276			
19	0	45.828	60	45.8	59.4	198.9	Y
	29	45.245	60	45.2			
	59	42.913	60	42.9			
	COV			0.0345			
20	0	44.048	60	44.0	59.3	204.4	Y
	29	44.748	60	44.7			
	59	48.952	60	49.0			
	COV			0.0578			

Table 8 Sediment Rate Measurements for Runs 21-26

Run	Run Time (min)	Sediment Weight (g)	Duration (s)	Sediment Feed Rate (g/min)	Influent Water Flow Rate (gpm)	Influent TSS Conc. (mg/L)	NJDEP Compliance
21	0	42.850	60	42.9	58.6	200.5	Y
	29	47.068	60	47.1			
	59	43.690	60	43.7			
	COV			0.0501			
22	0	41.079	60	41.1	53.6	202.1	Y
	29	41.766	60	41.8			
	59	40.052	60	40.1			
	COV			0.0211			
23	0	38.658	60	38.7	53.4	193.4	Y
	29	40.431	60	40.4			
	59	38.251	60	38.3			
	COV			0.0296			
24	0	40.129	60	40.1	53.1	186.5	Y
	29	34.942	60	34.9			
	59	37.295	60	37.3			
	COV			0.0693			
25	0	42.748	60	42.7	53.2	209.9	Y
	29	42.884	60	42.9			
	59	41.272	60	41.3			
	COV			0.0211			
26	0	40.369	60	40.4	54.0	203.8	Y
	29	40.138	60	40.1			
	59	42.716	60	42.7			
	COV			0.0347			

Effluent TSS

During each run, grab samples were taken of the effluent according to the schedule in **Table 1**, and all TSS analysis was conducted by Fredericktowne Labs. For each run, the average effluent concentration was adjusted by subtracting the average background TSS concentration. The average adjusted effluent TSS concentration during testing was 24 mg/L, with individual run averages ranging from 21 to 30 mg/L. Adjusted effluent TSS concentrations for each run are given in **Table 10**.

Drawdown TSS

According to the NJDEP Filter Protocol, the amount of sediment that leaves the filter during the drawdown period must be accounted for and documented. For each run, two evenly-volume-spaced grab samples were taken of the effluent during drawdown, and all TSS analysis was conducted by Fredericktowne Labs. For each run, the average drawdown concentration was adjusted by subtracting the average background TSS concentration. The average adjusted drawdown TSS was 25 mg/L, with individual run averages ranging from 17 to 56 mg/L. In order

to estimate the volume of water during drawdown, under observation by BEC, the unit was filled prior to all testing with clean water and the drawdown volume as a function of time was measured using the timed bucket method. Total drawdown volume was estimated at 117.5 gal at an operating head of 24 inches. This volume was used to determine the void fraction of the media bed, which was then used to calculate the drawdown volume for incremental head levels above 24 inches. Adjusted average drawdown TSS concentrations and drawdown losses are given in **Table 9**.

Table 9 Removal Efficiency Drawdown Losses

Run #	Head Level at End of Run (in)	Drawdown Volume (gal)	Average Adjusted Drawdown TSS Conc. (mg/L)	Total Sediment Lost During Drawdown (g)
1	25.125	121.7	38.0	17.5
2	27.0	128.8	41.5	20.2
3	27.25	129.7	38.0	18.7
4	27.875	132.1	56.0	28.0
5	28.625	134.9	32.5	16.6
6	28.75	135.4	28.5	14.6
7	29.75	139.1	24.0	12.6
8	29.875	139.6	19.0	10.0
9	30.375	141.5	22.0	11.8
10	30.75	142.9	21.0	11.4
11	30.5	141.9	19.5	10.5
12	31.5	145.7	19.5	10.8
13	31.5	145.7	17.5	9.7
14	32.25	148.5	20.0	11.2
15	32.875	150.9	19.5	11.1
16	33.375	152.8	24.5	14.2
17	33.875	154.6	22.5	13.2
18	34.125	155.6	22.5	13.3
19	35.0	158.9	22.5	13.5
20	35.25	159.8	24.0	14.5
21	35.875	162.2	23.0	14.1
22	32.5	149.5	18.0	10.2
23	33.25	152.3	18.5	10.7
24	33.5	153.2	18.5	10.7
25	35.5	160.7	20.5	12.5
26	36.25	163.6	29.0	18.0

Removal Efficiency Calculation

Removal efficiency was calculated using the following equation from the NJDEP Filter Protocol:

$$\text{Removal Efficiency (\%)} = \frac{\left(\begin{array}{c}\text{Average Influent}\\ \text{TSS Concentration x}\\ \text{Total Volume}\\ \text{of Test Water}\end{array}\right) - \left(\begin{array}{c}\text{Adjusted Eflluent}\\ \text{TSS Concentration x}\\ \text{Total Volume}\\ \text{of Effluent Water}\end{array}\right) - \left(\begin{array}{c}\text{Average}\\ \text{Drawdown Flow}\\ \text{TSS Concentration x}\\ \text{Total Volume}\\ \text{of Drawdown Water}\end{array}\right)}{\text{Average Effluent TSS Concentration x Total Volume of Test Water}} \text{ x } 100$$

For each run, sediment concentrations of background, influent, effluent, and drawdown, as well as calculated removal efficiency, are summarized in **Table 10**. As shown in this summary table, the EcoPure BioFilter™ demonstrated a cumulative sediment removal efficiency of 88.0% over the course of 26 test runs. No removal efficiencies below 80% were experienced.

Table 10 Removal Efficiency Results

Run #	Average Influent TSS (mg/L)	Influent Water Volume (gal)	Adjusted Average Effluent TSS (mg/L)	Effluent Water Volume (gal)	Adjusted Average Drain Down TSS (mg/L)	Drain Down Water Volume (gal)	Single Run Removal Efficiency (%)	Mass of Captured Sediment (g)	Cumulative Removal Efficiency (%)
1	200	5316	21	5194	37	122	89.1	3579	89.1
2	193	5320	23	5191	41	129	88.0	3429	88.6
3	200	5162	22	5032	38	130	88.7	3473	88.6
4	208	5145	24	5013	56	132	88.1	3568	88.5
5	214	5154	24	5019	32	135	88.5	3692	88.5
6	202	5177	24	5042	28	135	87.9	3484	88.4
7	211	5177	26	5038	24	139	88.0	3641	88.4
8	196	5180	24	5041	19	140	87.7	3368	88.3
9	204	5175	26	5034	22	141	87.5	3492	88.2
10	200	5170	26	5027	21	143	87.2	3419	88.1
11	200	5173	24	5031	19	142	88.3	3462	88.1
12	208	5166	25	5021	19	146	87.9	3570	88.1
13	195	5165	23	5020	17	146	88.4	3373	88.1
14	197	5164	24	5016	20	149	87.9	3380	88.1
15	187	5166	22	5016	19	151	88.5	3244	88.1
16	200	5171	30	5018	24	153	85.3	3336	87.9
17	197	5176	26	5021	22	155	87.0	3361	87.9
18	206	5182	27	5027	22	156	87.0	3514	87.8
19	199	5164	26	5005	22	159	87.2	3390	87.8
20	204	5160	26	5000	24	160	87.2	3480	87.8
21	201	5102	24	4940	22	162	88.2	3417	87.8
22	202	4660	21	4510	18	149	89.6	3193	87.9
23	193	4649	23	4496	18	152	88.4	3009	87.9
24	187	4619	22	4466	18	153	88.2	2876	87.9
25	210	4631	23	4471	19	161	89.3	3288	88.0
26	204	4630	21	4467	20	164	89.6	3202	88.0
Ave.	200.7	5075	24	4929	24.5	146	88.0	3394	N/A
Cumulative Mass Removed (g)								88242	
Cumulative Mass Removed (lbs)								194.5	
Total Mass Loaded (lbs)								221.0	
Cumulative Removal Efficiency (%)								88	

5.5 Sediment Mass Loading

Sediment mass loading for each run was approximately 8.69 lbs on average for Runs 1-21, and 7.71 lbs for Runs 22-26 (lower for these runs, due to reduced flow rate and a desire to keep the influent TSS concentration at 200 mg/L). These data are summarized in **Table 11**.

Table 11 Sediment Mass Loading Summary

Run #	Sediment Loading (lbs)	Cumulative Sediment Loading (lbs)	Run #	Sediment Loading (lbs)	Cumulative Sediment Loading (lbs)
1	8.85	8.9	14	8.48	122.4
2	8.59	17.4	15	8.08	130.5
3	8.63	26.1	16	8.62	139.2
4	8.93	35.0	17	8.51	147.7
5	9.19	44.2	18	8.90	156.6
6	8.74	52.9	19	8.57	165.1
7	9.13	62.0	20	8.80	173.9
8	8.46	70.5	21	8.54	182.5
9	8.80	79.3	22	7.86	190.3
10	8.65	88.0	23	7.50	197.8
11	8.64	96.6	24	7.19	205.0
12	8.96	105.6	25	8.11	213.1
13	8.41	114.0	26	7.88	221.0

Sediment mass loading was calculated from the summation of the total sediment mass added during dosing in each run.

Overall, a total of 221 lbs of sediment was loaded into the EcoPure BioFilter™ over the course of the 26 runs. Total captured mass over the 26 runs was 194.5 lbs **(Table 10).**

The relationship between removal efficiency and sediment mass loading is shown in **Figure 8**. The relationship between driving head and sediment mass loading is shown in **Figure 9**.

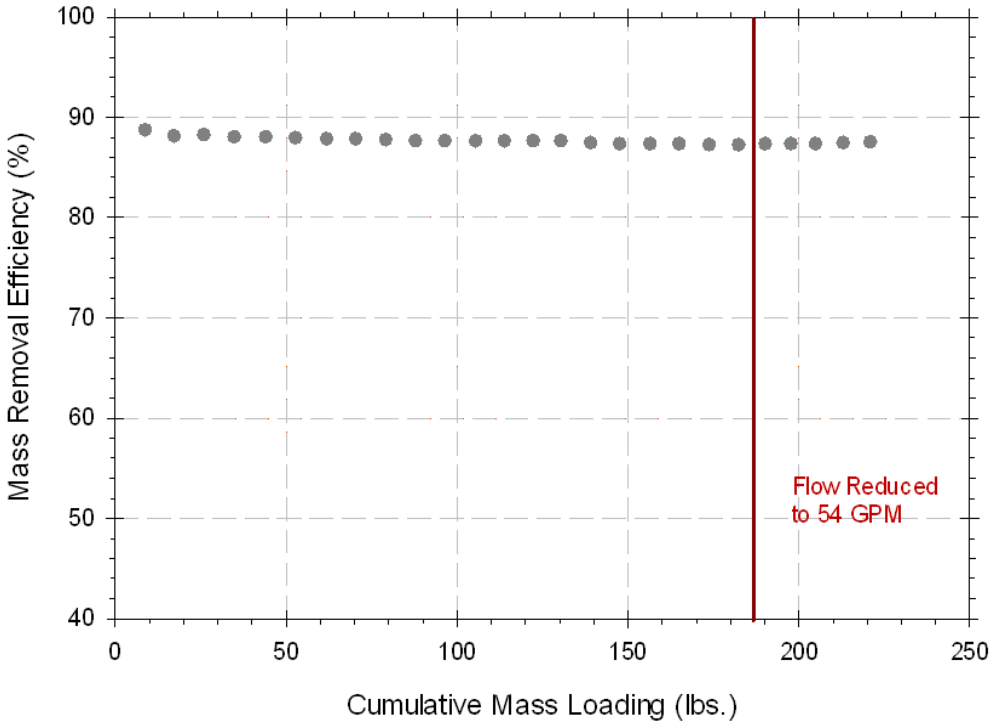


Figure 8 Removal Efficiency vs. Sediment Mass Loading

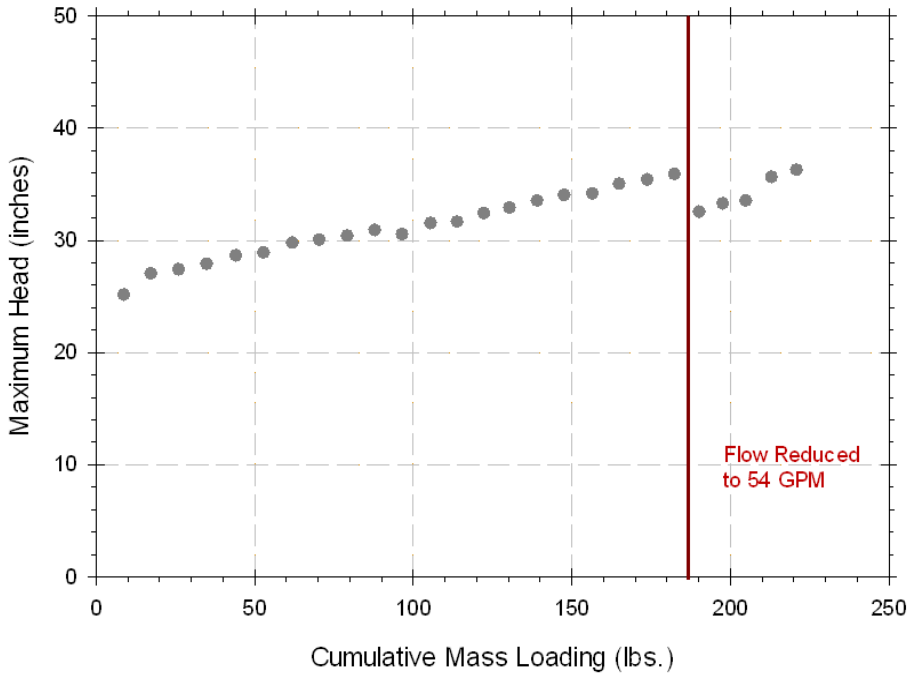


Figure 9 Driving Head vs. Sediment Mass Loading

5.6 Scour

The scour test took place on a unit that had been pre-loaded with 100% of the manufacturer's recommended maximum sediment storage volume (which occurred during removal efficiency and sediment mass capacity testing). Scour testing was conducted in accordance with Section 4 of the NJDEP Filter Protocol, except for loading, which was done as part of the mass removal efficiency and sediment mass loading testing described above. The target scour testing flow rate was achieved 5 minutes after initiating flow to the system; effluent sampling began 2 minutes after that, and background samples were taken with odd-numbered effluent samples, according to the schedule shown in **Table 12**.

Table 12 Scour Run Sampling Schedule

Sample	Run Time (min)															
	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Effluent		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Background		X		X		X		X		X		X		X		X

Note: The Run Time of 0 minutes was the time at which the target flow rate was achieved.

The flow rate during the scour run averaged 111.2 gpm (185% of MTFR), with a COV of 0.003, which is in compliance with the NJDEP Filter Protocol. The maximum temperature during the scour run was 56.8 degrees Fahrenheit, which is also in compliance with the NJDEP Filter Protocol.

Scour test TSS results are presented in **Table 13**. The maximum background TSS concentration was 2 mg/L, which is far below the maximum of 20 mg/L allowed by the NJDEP Filter Protocol. Each effluent TSS concentration was adjusted by subtracting the background concentration. For samples that did not have a corresponding background sample, the background TSS concentration was interpolated from the previous and subsequent background samples' TSS concentration. The average adjusted TSS concentration of the effluent is 2 mg/L. As this value is below the NJDEP-Protocol-specified limit of 20 mg/L, the EcoPure BioFilter™ met the requirement for on-line use.

Table 13 Scour Run TSS Results

	Scour Test TSS Concentrations (mg/L)														
Sample #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Effluent	16	6	6	3	3	2	4	2	2	2	2	2	1	1	1
Background	2		2		2		1		2		1		1		1
Adjusted Effluent	14	4	4	1	1	0.5	3	0.5	0	0.5	1	1	0	0	0
Average Adjusted Effluent Concentration (mg/L)							2.0								

6. Design Limitations

Maximum Flow Rate

The 4' x 8' EcoPure BioFilter™ tested has an MTFR of 0.13 cfs (60 gpm) and an effective filtration treatment area (EFTA) of 60 ft^2 (loading rate = 1.0 gpm/ft^2). The EFTA is calculated by the surface area of the exiting manifold. The exiting manifold consists of five (5) double sided perforated HDPE flat panel pipes that are 4 feet long and 18" in height. EFTA = 5 panels x 2 sides x 4 ft in length x 1.5 ft in height = 60 ft^2. Commercial units only vary in the length of the manifold systems, i.e., a 4 x16 unit has 120 ft^2 of exiting manifold area. The loading rate of 1.0 gpm/ ft^2 is constant.

Slope

The EcoPure BioFilter™ is recommended for installation with little-to-no slope to ensure proper, consistent operation. Steep slopes should be reviewed by ADS/BaySaver Engineering support.

Allowable Head Loss

There is an operational head loss associated with the EcoPure BioFilter™. The head loss will increase over time due to the sediment loading to the system. When configured with an internal bypass, a design head loss of 36 inches should be used. Site-specific treatment flow rates, peak flow rates, pipe diameter, and pipe slopes should be evaluated to ensure there is appropriate head for the system to function properly.

Sediment Load Capture Capacity

Based on laboratory testing results, the EcoPure BioFilter™ model tested has a mass loading capacity of 221 lbs while operating at a sediment removal efficiency of 88.0%; the total sediment load captured by the tested EcoPure BioFilter™ is 194.5 lbs, which is the governing value for calculating allowable drainage area.

Pre-treatment Requirements

The EcoPure BioFilter™ does not require additional pretreatment.

Configurations

The EcoPure BioFilter™ is available in multiple configurations, with curb, gutter, grated inlet, or straight-in pipe inlets. The EcoPure BioFilter™ can be installed above (i.e., planter box), or at grade with a planting bed to allow maximum design flexibility.

Structure Load Limitations

The EcoPure BioFilter™ is typically located adjacent to a roadway and therefore, the precast vault or structure is designed to handle H-20 traffic loads. For deeper installations or installations requiring a greater load capacity, the system will be designed and manufactured to meet those

requirements. ADS/BaySaver provides full-service technical design support throughout the life of a project and can help ensure the system is designed for the appropriate structural load requirements.

7. Maintenance Plan

*General Inspect*ion

The ADS inspection process for the EcoPure BioFilter™ is detailed in the Operation and Maintenance Guidelines and is available electronically at https://baysaver.com/resources/, under the EcoPure BioFilter™ information section. It is also provided to the owner at the time of installation and detailed in this report.

ADS recommends inspecting the EcoPure BioFilter™ quarterly for the first year of service, and after every significant storm event occurring during the first six months. The definition of a significant storm event will vary depending on the geographic area, but if the event is greater than 1 inch of intensity within an hour or 3 inches within a 24-hour period, the system should be inspected. After the first year, systems should be inspected at least bi-annually and ideally before the spring or rainy season and after the summer season, or prior to fall or winter seasons. It is recommended that some general "good housekeeping" maintenance be performed at the beginning of the rainy or spring season every year.

For maintenance needs related to the top plant section of the EcoPure BioFilter™ the process follows the practices used for handling standard bioretention systems (i.e., general landscaping, cover management, and replacement planting of surface plants). Additional maintenance involving removing some of the captured sediment is not possible in many bioretention systems (both generic and proprietary) in that once sediment introduced and lost into the media of those systems, it cannot be readily extracted. For the EcoPure BioFilter™ design, a sizable amount of collected sediment can be removed from the pretreatment cell and the bottom cavity of the bioretention cell before it enters into the bioretention media matrix. This ability assists in "adding" to the longevity of the EcoPure BioFilter™ bioretention soil media. This is explained in greater detail below in the General Inspection and Maintenance Procedure section (see the 5th and 6th paragraphs).

Inspection and General Maintenance Equipment

The following is a list of equipment recommended for inspection and general maintenance:

- Personal Protection Equipment - (pants, steel-toed shoes, safety glasses, gloves, safety vest, hard hat, etc.)
- Manhole Hook
- Traffic Cones and Signage
- Stadia Rod and Tape Measure
- Inspection Operation & Maintenance Log (provided in the O&M Manual) or other recording method
- Flashlight

- Trash Removal "Net" Device
- Shovel, rake, broom, and trash receptacle
- Vactor Truck (if more extensive maintenance is required)
- Light Duty Construction Equipment (if media replacement is required)

General Inspection and Maintenance Procedure

Routine inspection will ensure that the system is performing at optimal conditions and that the risk of flooding is low. EcoPure BioFilter^{TM} inspection involves a visual inspection of the plant surface area, structure inlet, pretreatment cell, and clean-out ports. This can all be done at the surface and requires no confined-space entry into the EcoPure BioFilter^{TM} cell. An Inspection O&M log should be used, and dates and weather conditions should be noted.

If the EcoPure BioFilter^{TM} is located in a traffic area (i.e., roadway or automobile travel way), and inspection is not possible without entering the vehicular area, safety measures should be employed -- safety cones set up, etc. -- prior to performing the inspection and maintenance.

A visual inspection of the general appearance of the EcoPure BioFilter^{TM} should be performed, and notes should be taken detailing the condition of the surface plant life, invasive species intrusion, erosion in the planting area and any signs of standing water or disturbed or "shifted" surface soil bed area. This general system condition should be noted in the inspection/maintenance log.

If the plant life and surface media show signs of distress, general landscaping O&M should be performed, i.e., raking, weeding (removal of invasive plants), and general planting replacement to maximize the cover area in the planting bed/media treatment cell. If signs of excessively high water levels (i.e., damp wet conditions still visible in the top planting area) are seen in the media treatment cell and the last rain event was greater than 24 hours prior, further inspection should be performed to ensure the effluent pipe is not blocked. All blocked pipes should be cleared and cleaned. Inspecting the bypass piping in the pretreatment cell is also advised to see if the system is going into bypass during recent storms (i.e., signs of debris in bypass piping). If the inspection results in the conclusion that the media is compromised or has reached its service life, total replacement of the media treatment cell is recommended. ADS should be contacted for material specifications and replacement parts. Media cell replacement will involve utilizing small construction excavation equipment.

For inspection of the pretreatment cell, the manhole cover should be safely removed (i.e., using a manhole hook). A visual inspection of the condition of the surface concrete and any inlet grates should be noted. If grates are missing or inlets are damaged, contact ADS for recommendation of repair. The suspended trash grate area should be relatively clear of debris. If excessive debris is observed, a trash capture net should be employed, and debris removed. Next, a stadia rod should be sent down to the bottom of the pretreatment cell and the level of debris should be recorded in the maintenance log. When the debris in the sump reaches 10 inches in average depth, a vactor truck should be used to remove the accumulated sump debris. Employing a vactor track for

cleaning the pretreatment cell follows the typical guidelines used for cleaning hydrodynamic stormwater devices.

For inspection and cleaning of the chamber section of the EcoPure BioFilter™ (open cavity under the media cell), it is generally recommended that if the 10-inch sediment mark has been reached in the pretreatment cell, the owner should backwash the chamber section of the media cell. With the pretreatment cell cleaned and dewatered, the cleanout risers should be exercised and low-pressure water (60-80 psi) should be introduced to force and move sediment within the chamber cavities into the pretreatment cell (the riser tees have a removable cap to facilitate a "bottom" exit at the floor of the first cell). See the O&M guide for details of backflushing this unit. Once it is deemed that most of the sump sediment from the media cell has been backflushed, clean water flow should cease. The pretreatment cell should be vacuumed dry (during this backflushing procedure), the trash rack reinstalled/repositioned, and the manhole cover replaced. The backflushing process may require confined-space entry, and all rules and precautions should be adhered to, based on OSHA requirements and the practices and procedures in place for the entity performing the work.

Disposal of material from the pretreatment cell, trash debris rack, and chamber cavity should be in accordance with the local municipality's requirements. Typically, traditional municipal landfills can be used for disposal of solids and trash obtained from servicing the EcoPure BioFilter™. The same disposal methods should be used if the media cell is replaced. Call ADS at 1-800-821-6710 for further information.

8. Statements

The attached pages include signed statements from the manufacturer (Advanced Drainage Systems, Inc.), the supervising third-party observer (Boggs Environmental Consultants, Inc.), and NJCAT. These statements are included as a requirement for the verification process.

THE MOST ADVANCED NAME IN WATER MANAGEMENT SOLUTIONS™

ADS

March 18, 2020

Dr. Richard S. Magee, Sc.D., P.E., BCEE
NJCAT
Center for Environmental Systems
Stevens Institute of Technology
Castle Point on Hudson
Hoboken, NJ 07030-0000

Advanced Drainage Systems is pleased to provide this letter as our statement certifying that the protocol, "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" (NJDEP Filter Protocol, January25, 2013),was strictly followed while testing our EcoPure BioFilter™ system. The testing was performed at the BaySaver Laboratory, located in Mount Airy, MD. All data pertaining to the EcoPure BioFilter™ NJDEP Protocol test is included in the Verification Report.

Sincerely,

Daniel J Figola

Daniel J Figola, PE

Director of Sustainability Development
Advanced Drainage Systems, Inc.

BOGGS ENVIRONMENTAL CONSULTANTS

Middletown, MD & Morgantown, WV

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April 6, 2020

BaySaver Technologies, LLC
Advanced Drainage Systems, Inc.
1030 Deer Hollow Drive
Mount Airy, MD 21771
dfigola@ads-pipe.com

ATTENTION Daniel Figola
Director of Sustainability Development
Advanced Drainage Systems, Inc.

REFERENCE: Third Party Review of Testing Procedures of the EcoPure Biofilter™ at the BaySaver Laboratory
1207 Park Ridge Drive
Mount Airy, MD 21771

BOGGS ENVIRONMENTAL CONSULTANTS, INC. (BEC) provided Third Party Review services for the testing of the EcoPure Biofilter™ to evaluate if the required testing meets certification standards established by the New Jersey Department of Environmental Protection (NJDEP).

LABORATORY TESTING PROCEDURES & METHODOLOGIES

The following two procedures and testing requirements were followed during the testing process of the EcoPure Biofilter™:

- *New Jersey Department of Environmental Protection, Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device, dated January 25, 2013.*
- *QAPP for EcoPure Biofilter™, New Jersey Department of Environmental Protection Testing,* prepared by BaySaver Technologies LLC (a subsidiary of Advanced Drainage Systems, Inc,), Prepared November 14, 2019, Revised December 3, 2019.

ONSITE THIRD-PARTY OBSERVATION OF TESTING PROCEDURES

BEC was present at the BaySaver Laboratory, at 1207 Park Ridge Drive, in Mount Airy, MD 21771, to observe the following:

- The mixing and establishment of a sediment blend that included manufactured sands that when delivered to the feed water would result in influent Total Suspended Solids (TSS) concentrations within the established range of approximately 200 mg/L and a particle size distribution specified and approved by NJDEP;
- BEC assisted in the establishment of a Procedure Checklist to be used on each run to verify and document the following: Verify that pumps and measurement devices are turned on and functioning; Verification that the correct measurements of dry sediments are added to the doser and feed stream; Document that, background effluent, and duplicate samples are collected at established intervals during the run; and, Recording of periodic flow rates and head measurements during each run;
- Observation of Runs 1 through 26 from December 9, 2019 to January 24, 2020 and verified that that sediment, background, effluent samples were collected during each 89-minute run, and that drawdown samples were collected after the end of each run. BEC also observed the Scour Run on January 28, 2020.
- After sampling was completed for each run, BEC was present for the downloading of flow data as well as sediment feed rates to verify that calculated sediment feed rates met NJDEP protocols for testing. BEC also verified that that sample containers were properly labeled and chain of custodies were filled and were boxed and sealed for delivery to Fredericktowne Labs for analysis of Total Suspended Solids (TSS).

THIRD-PARTY VERIFICATION & OPINIONS

Based on observations during the runs and the reported TSS analytical results, BEC verified the following:

- That the testing of the EcoPure Biofilter™ at the BaySaver Laboratory was conducted in accordance with the *New Jersey Department of Environmental Protection, Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device, dated January 25, 2013* and procedures established in Advanced Drainage Systems, Inc.'s *QAPP for EcoPure Biofilter™, New Jersey Department of Environmental Protection Testing*, prepared by BaySaver Technologies LLC (a subsidiary of Advanced Drainage Systems), Prepared November 14, 2019, Revised December 3, 2019.
- The report titled *NJCAT Technology Verification, of EcoPure Biofilter™*, prepared by Advanced Drainage Systems, Inc., dated April 2020, used applicable NJCAT protocol and accurately reflects the testing observed by BEC.

BEC has no financial conflict of interest, as defined in the *Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation of Advanced Technology* (NJEP 2013).

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

Sincerely,
BOGGS ENVIRONMENTAL CONSULTANTS, INC.

William R. Warfel
Principal Environmental Scientist

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

April1, 2020

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

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing conducted on the Advanced Drainage Systems EcoPure BioFilter™ (4' x 8' commercial system) at the BaySaver Laboratory (BaySaver Technologies, LLC is a subsidiary of Advanced Drainage Systems, Inc.), under the independent third-party oversight of Boggs Environmental Consultants (BEC), Inc., 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 Filter Protocol, January 2013) were met or exceeded. Specifically:

Test Sediment Feed

The test blend was custom-blended using various commercially available silica sands under the oversight of BEC. The particle size distribution was independently analyzed by Environmental Consulting Services (ECS), using the methodology of ASTM method D422-63.The blended silica met the specification within tolerance as described in Section 5B of the NJDEP filter protocol and was acceptable for use.

Removal Efficiency Testing

Twenty-six (26) removal efficiency testing runs were completed in accordance with the NJDEP filter protocol. Twenty-one (21) of the 26 test runs were conducted at the target flow rate of 60

gpm and an influent sediment concentration of 200 mg/L. Maximum driving head of 36" was reached at Test Run 21 and the flow rate was reduced to 90% of the MTFR (54 gpm) for Test Runs 22-26 per the filter protocol. The EcoPure BioFilter™ demonstrated an average sediment removal efficiency on a cumulative mass basis of 88.0% over the course of the 26 test runs.

Sediment Mass Loading Capacity

Mass loading capacity testing was conducted concurrently with removal efficiency testing. The 4' x 8' EcoPure BioFilter™ has a mass loading capture capacity of 194.5 lbs (3.24 lbs/ft^2 of filtration area).

No maintenance was performed on the test system during the entire testing program.

Scour Testing

The 4' x 8'EcoPure BioFilter™ at 100% mass loading/capture capacity demonstrated minimal scour (2.0 mg/L adjusted effluent sediment concentration) at 111.2 gpm (185% of MTFR) qualifying it for on-line installation up to this flow rate.

Sincerely,

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

VERIFICATION APPENDIX

Introduction

- Manufacturer – Advanced Drainage Systems, Inc, 4640 Trueman Blvd, Hilliard, OH 43026 Website: https://www.ads-pipe.com Phone: 800-229-7283.
- MTD - EcoPure BioFilter™ verified models are shown in **Table A-1. In the bio-media bed**
- TSS Removal Rate – 80%
- On-line installation up to 185% MTFR

Detailed Specification

- NJDEP sizing tables and physical dimensions of EcoPure BioFilter™ verified models are attached (**Table A-1**). These sizing tables are valid for NJ following NJDEP Water Quality Design Storm Event of 1.25" in 2 hours (NJAC 7:8-5.5(a)).
- Maximum inflow drainage area
    - The maximum inflow drainage area is governed by the maximum treatment flow rate of each model as presented in **Table A-1.**
- Driving head will vary for a given EcoPure BioFilter™ model based on the site-specific configuration. The maximum head available until bypass is 36", but the minimum head varies depending on the flow rate through the unit and the cumulative mass captured in the biofiltration cell over time. Design support is given by BaySaver for each project, and site-specific drawings (cut sheets) will be provided that show pipe inverts, finish surface elevation, and peak treatment and maximum flow rates through the unit.
- The drawdown flow exits via an effluent pipe at the bottom of the filter bed. A clean filter draws down in approximately 20 minutes. The pretreatment cell of the EcoPure BioFilter™ remains full of water after drawdown.
- See Advanced Drainage Systems EcoPure BioFilter™ Design Manual I & M Section for inspection and maintenance procedures at https://baysaver.com/resources/.

Table A-1 EcoPure BioFilter™ Model Sizes and New Jersey Treatment Capacities

Overall Unit (ft)	Pre-treatment Cell (ft)	Filter Bed (ft)	Effective Filtration Treatment Area (EFTA) (ft^2)[1]	Effective Sedimentation Treatment Area (ESTA) (ft^2)	ESTA/EFTA	Wet Volume (WV) (ft^3)	WV/EFTA	MTFR (cfs)[2]	Mass Capture Capacity (lbs)	Drainage Area (acres)[3]
4 x 8	4 x 3	4 x 4.5	60	30	0.50	56	0.94	0.134	194.5	0.324
4 x 10	4 x 4	4 x 5.5	75	38	0.51	73	0.97	0.167	242.4	0.404
4 x 12	4 x 5	4 x 6.5	90	46	0.51	90	1.00	0.201	291.8	0.486
4 x 14	4 x 6	4 x 7.5	105	54	0.51	106	1.01	0.234	339.6	0.566
4 x 16	4 x 7	4 x 8.5	120	62	0.52	123	1.03	0.268	389.0	0.648
8 x 12	8 x 5	8 x 6.5	180	92	0.51	179	0.99	0.401	583.5	0.973
8 x 16	8 x 7	8 x 8.5	240	124	0.52	246	1.02	0.535	778.0	1.297
8 x 20	8 x 8.5	8 x 11	315	156	0.50	304	0.96	0.702	1021.1	1.702
8 x 24	8 x 10.5	8 x 13	375	188	0.50	371	0.99	0.836	1215.6	2.026

1. Effective Filtration Treatment Area (EFTA) is defined as the surface area of the ADS AdvanEDGE pipe that is available for flow from the bioretention filter media layer.
2. Based on 1 gpm/ft^2 of effective filtration treatment area.
3. Drainage Area is based on Mass Capture Capacity (194.5/60 = 3.24 lbs/ft^2 of filtration area) and the equation in the NJDEP Filter Protocol wherein drainage area is calculated by dividing the pounds of mass captured by 600 lbs/acre.