NJCAT TECHNOLOGY VERIFICATION

Filterra® HC (High Capacity) Bioretention System

Contech Engineered Solutions

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1. DESCRIPTION OF TECHNOLOGY

The Filterra® HC (High Capacity) Bioretention System (Filterra HC) is an engineered, bioretention system (**Figure 1**). It is typically installed as a standalone, pre-constructed unit (or contractor provided vessel/basin, i.e., Filterra HC Bioscape) designed to treat contaminated runoff in the urban landscape. The Filterra HC utilizes the same engineered biofiltration soil media as the previously certified Filterra configuration, but the Filterra HC was tested with an 18” deep media layer vs the 21” deep media tested previously and the Filterra HC was tested at 300 in/hr MTFR vs 140 in/hr MTFR for the previous Filterra certification. The “HC” designation is being added to distinguish this configuration from the one previous certified in 2014.

Filterra HC is similar in concept to traditional bioretention systems in its function and applications, however its high flow engineered biofiltration soil media allows for a reduction in footprint. Filterra HC provides an effective Low Impact Development (LID) solution for tight, highly developed sites such as urban development projects, commercial parking lots, residential streets, and streetscapes.

Stormwater enters the Filterra HC through a pipe, curb inlet, or sheet flow and then ponds over the pretreatment mulch layer, which captures heavier sediment and debris. The media (**Figure 2**) provides finer level treatment. Once the stormwater runoff flows down through the media it continues into an underdrain system where the treated water is discharged. Where feasible, the Filterra HC can also be configured to infiltrate runoff into the native soils. Higher flows in excess of the water quality event bypass the Filterra HC via upstream flow control or a downstream inlet structure, curb cut or other appropriate relief.

The Filterra HC is available in a variety of precast configurations, and can also be configured as a Filterra HC Bioscape, an open top configuration which can be installed directly into an excavated basin, for better aesthetics and effective infiltration into the soil when native soils allow. Both precast and Bioscape configurations are identical in form and function with the exception of the use of a vault in precast systems. Filterra HC can be configured in many ways to enhance site aesthetics, integrate with other LID practices, or increase runoff reduction through infiltration below or downstream of the system.

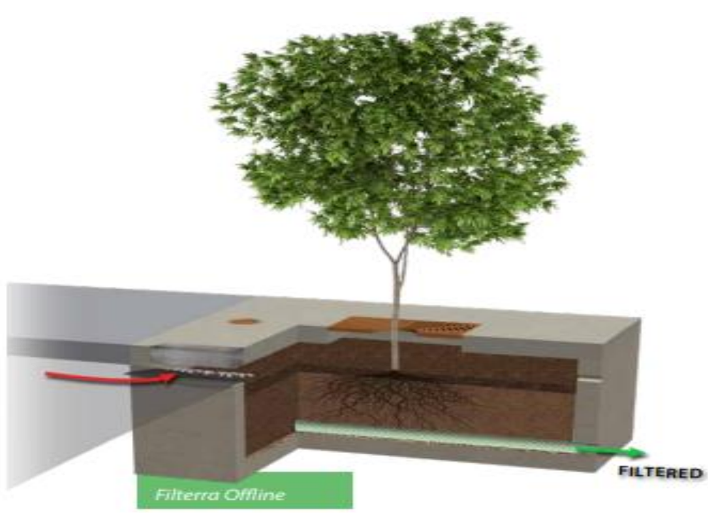

Figure 1: Typical Filterra HC Configuration

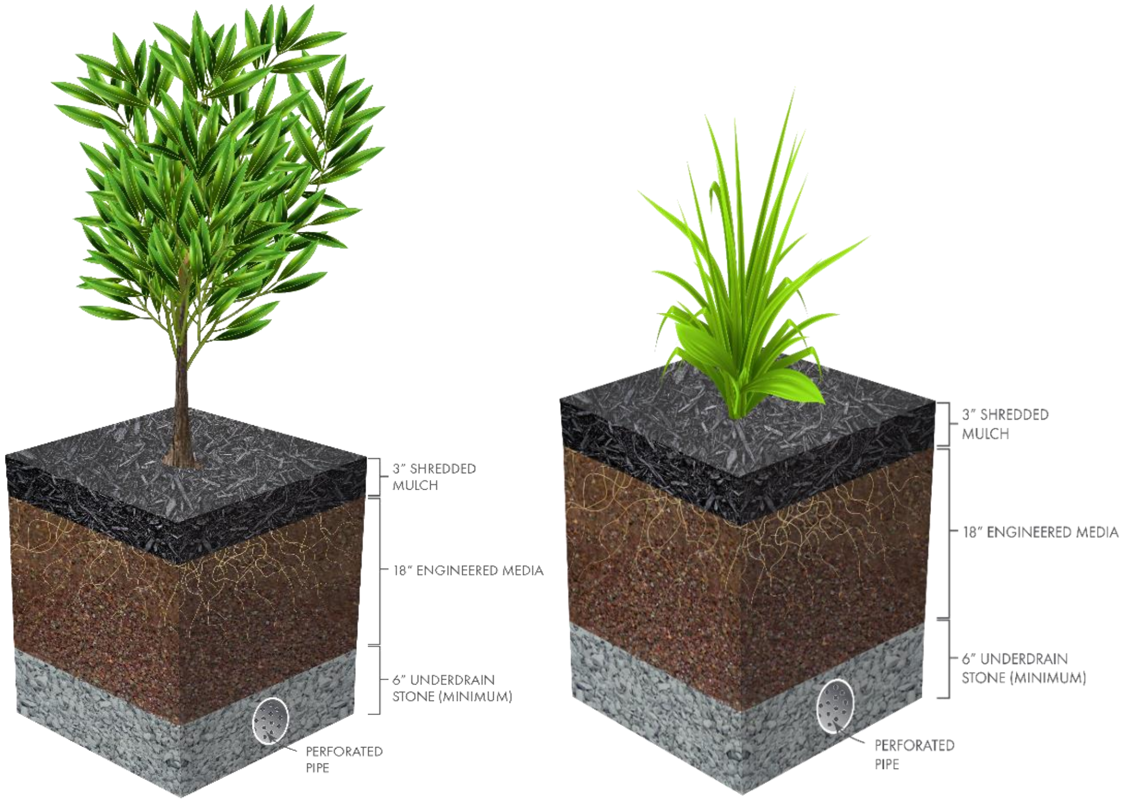

Figure 2: Internal Filterra HC Components (Replicated to show differing plant options)

2. LABORATORY TESTING

All testing disclosed in this report was performed in accordance with the New Jersey Department of Environmental Protection (NJDEP) Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device (NJDEP Protocol) dated January 25, 2013.

All removal efficiency and sediment mass loading capacity testing for this project was carried out at Contech's Ashland, Virginia laboratory beginning in July 2020. Independent third-party observation for all testing was provided by Don Rissmeyer, P.E. from A. Morton Thomas and Associates, Inc. in Richmond, VA. Don Rissmeyer has an extensive background in stormwater, and no conflict of interest that would disqualify him from serving as an independent third-party observer during this testing process.

Test sediment blended for compliance with the NJDEP particle size distribution (PSD) requirements was provided by Good Harbour Laboratories in Mississauga, ON. Prior to testing, samples for PSD analysis were sent to Apex Laboratories in Tigard, OR, an independent analytical laboratory, for processing according to ASTM D422 Standard Test Method for Particle-Size Analysis of Soils to confirm it met the specification in accordance with the NJDEP Protocol. Test sediment samples for moisture content were also analyzed by Apex Laboratories in Tigard, OR according to ASTM D2216 Standard Test Methods for Laboratory Determination of Water

(Moisture) Content of Soil and Rock by Mass. Samples for suspended solids concentration (SSC) analysis were sent to Analytics Laboratory in Ashland, VA, an independent analytical laboratory, for processing according to ASTM D3977 Standard Test Methods for Determining Sediment Concentration in Water Samples.

2.1. TEST UNIT

Laboratory testing was completed on a full-scale, commercially available Filterra HC Unit deployed in an Offline - Pipe configuration (**Figure 3**). A piped inlet was used to deliver influent to the test unit during testing. The Filterra HC components as shown in **Figure 2** were housed in a 4 ft long, 4 ft wide and 3.4 ft (41in.) tall aluminum test box. The bottom of the Filterra HC system contained an underdrain system consisting of a perforated 6 in. diameter PVC pipe surrounded by ¾ in. stone, which is connected to a clean out via a 90-degree elbow. Above the underdrain system lies 18 in. of engineered Filterra media, and over top of the media is 3 in. of shredded mulch. Dissipation stone consisting of 3-6 inch diameter washed stones or cobbles (**Figure 5**) over tops the mulch surrounding the inlet. The test box has a depth of 31 in. from floor to inlet pipe invert. The inlet pipe invert is 7 in. above the media surface (4 inches above the mulch layer), representing a typical inlet invert elevation between 3 in. and 9 in. above the media surface, 9 inches representing the maximum available driving head (ponding depth). The effective treatment area is 16 ft^2. The approximate operation volume of 21.5 ft^3 was used to calculate the detention time.

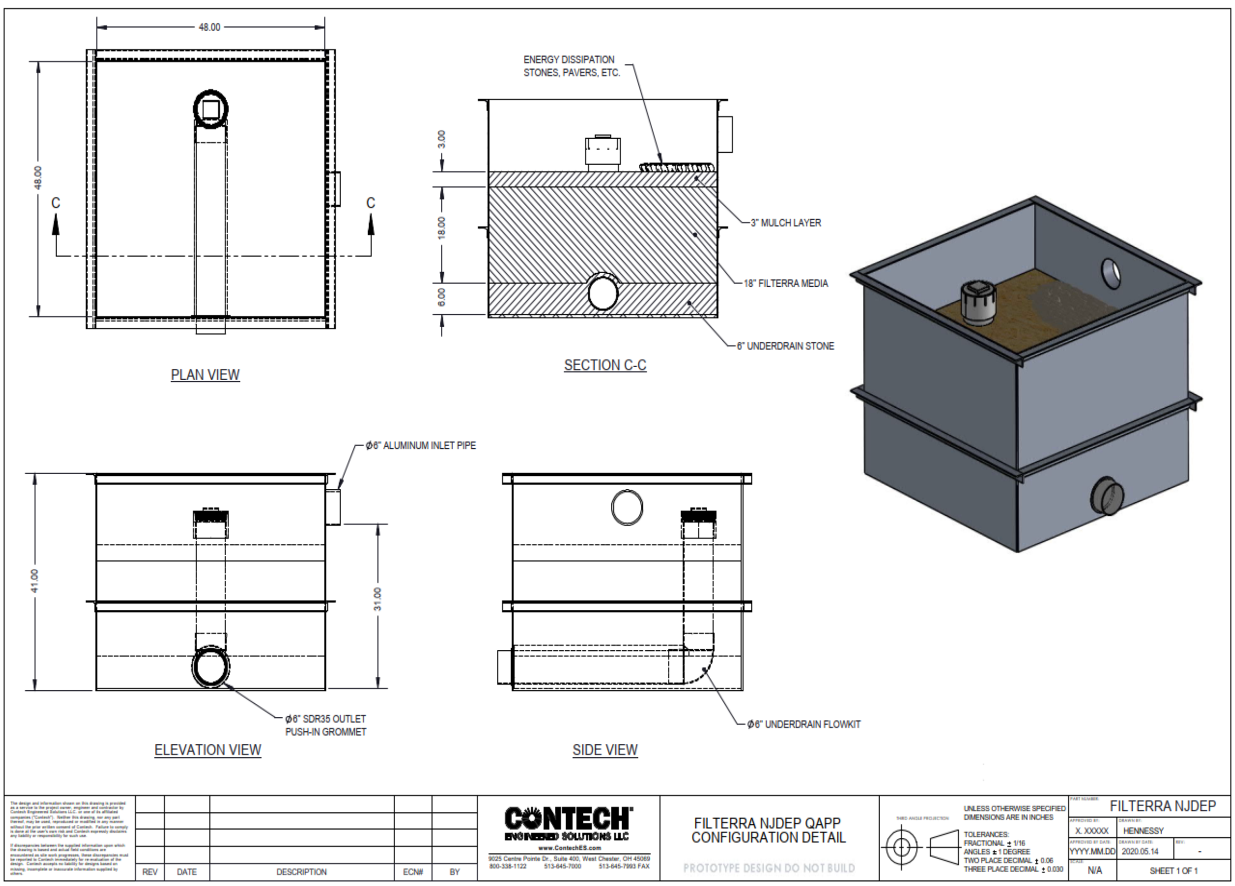

Figure 3: Filterra HC Offline – Pipe Test Box Detail

2.2. TEST SETUP

The Filterra HC was tested on a recirculating test loop (**Figure 4**). The test box was raised off the floor by a test platform to allow discharge to be collected in the 300 gal effluent tank (**Figure 6**). During removal efficiency and sediment mass loading capacity tests, clean and filtered tap water was drawn from a 2,500 gal source water tank using a 3/4 HP, submersible pump (Pump 1, **Figure 4**), and delivered to the test box through 6 in. PVC piping. Flow from Pump 1 was controlled manually with a 2 in. globe valve and measured by a factory-calibrated Seametrics EX810 electromagnetic flowmeter and logged at a minimum of 1 min intervals. The logged flow data was used to determine test water volume and to verify that each trial was conducted at the target flow rate.

Influent water then traveled into 6 in. influent piping where background SSC samples were taken from a 3/4 in. PVC pipe sampling port at the bottom of the influent pipe, upstream of the sediment injection point. Influent water was then dosed with sediment at the crown of the pipe from an Acrison 105X volumetric sediment feeder upstream of the test box, located 17.75 in. upstream of the test box. The sediment feeder was stationed on an Ohaus Defender 5000 scale with digital output for determining sediment mass before and after each test. Influent water entered the test box via the 6 in. influent piping where water surface level (WSL) was measured and logged at 10 sec intervals by a calibrated Krohne OptiSound VU31 ultrasonic level sensor. The level sensor was installed in a perforated standpipe positioned on top of the media surface and connected to a Lascar Electronics EL-USB-4 Data Logger. There is minimal driving head required in a clean Filterra HC system and it increases as media occlusion begins to occur. Water was treated by the Filterra HC and exited the system via the underdrain system. Water exited the effluent pipe in a free-fall stream (end of green pipe **Figure 7**), where effluent SSC grab samples were taken by making a single sweeping pass through the cross section of the effluent stream before it entered a 300-gal effluent tank equipped with a submersible pump (**Figure 4** and **Figure 6**). Note. White pipe shown in **Figure 7** was used to transfer drawdown volume not sampled into an isolated tank.

Effluent water was transferred to the source water tank to maintain water balance in the source water tank. Effluent water was pumped through a cartridge filter housing using a 3/4 HP, submersible pump (Pump 2, **Figure 4**). The filtered effluent was discharged into the source water tank for re-use. When necessary, clean water was brought into the source water tank for dilution. Flocculants were not used to reduce background SSC at any time. Influent water temperature was monitored with an Extech PH100 meter and did not exceed 80 degrees Fahrenheit.

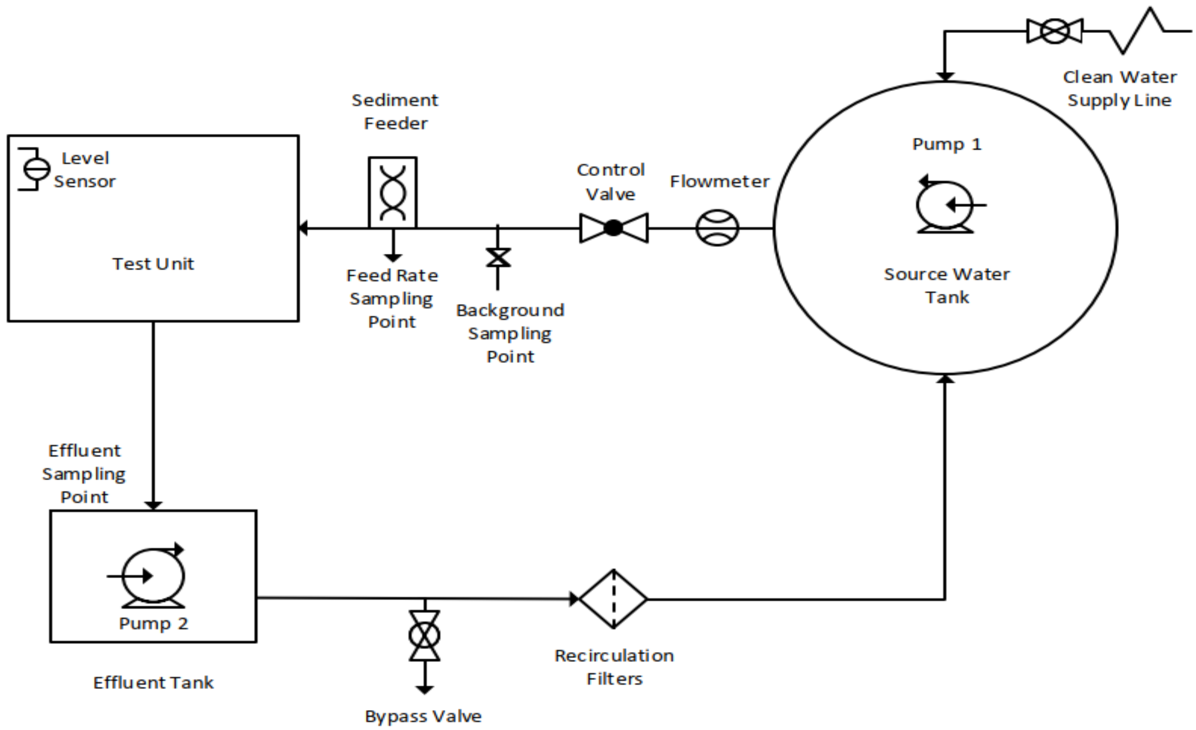

Figure 4: Lab Setup for Removal Efficiency and Sediment Mass Determination

Figure 5: Photo of the Filterra HC Test Unit and Upstream Test Loop in Operation

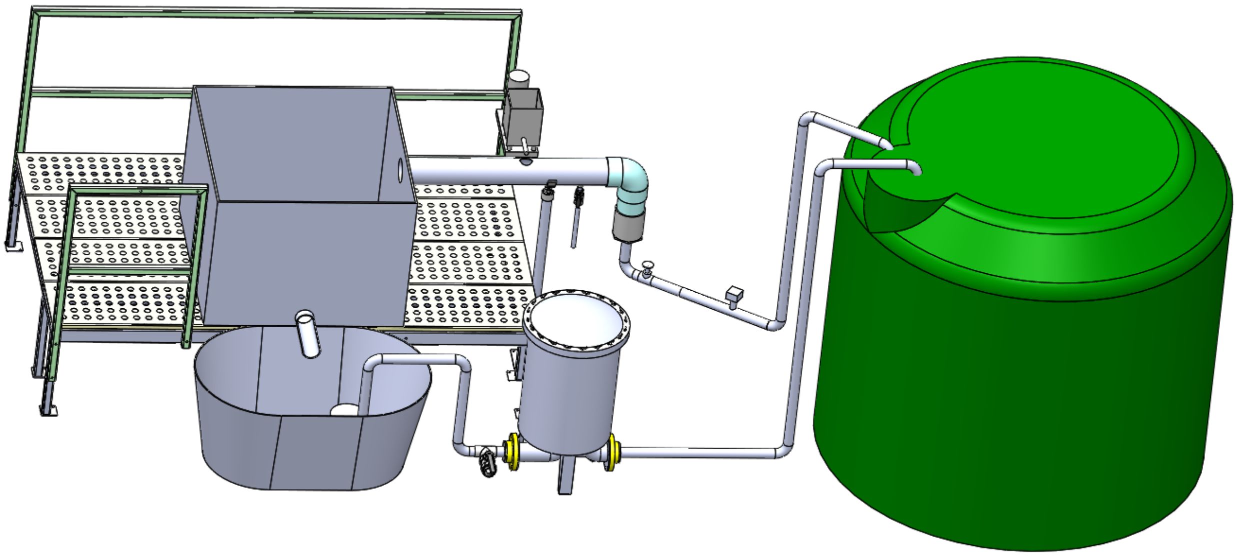

Figure 6: Laboratory Layout - Sampling and Control Locations

Figure 7: Photo of Test Loop Downstream of the Test Unit

2.3. Test Sediment

The sediment used for removal efficiency tests was a silica blend with a specific gravity of 2.65, previously blended and provided by Good Harbour Laboratories in Mississauga, ON. Test sediment PSD samples were collected under third-party observation and then analyzed by Apex Laboratories in Tigard, OR prior to testing. The test sediment was stored in covered barrels for the duration of this project. Sediment was sampled by taking 6 subsamples per drum of delivered sediment, which was then composited. From the composite, three samples were taken for PSD and moisture content analysis. The average PSD was used to determine compliance with the target PSD as outlined in Table 1 of the NJDEP Protocol. The average sediment moisture content was used in feed rate calculations (**Equation 1**) and influent mass calculations (**Equation 2**).

2.4. Removal Efficiency And Sediment Mass Loading Capacity Testing Procedure

Removal efficiency testing followed the effluent grab sampling test method outlined in Section 5 of the NJDEP Protocol. Testing was performed at a 300 in/hr. infiltration rate which is representative of a 49.87 gpm maximum treatment flow rate (MTFR) or 3.12 gpm/ft^2 for a 4 ft by 4 ft Filterra HC system.

For each trial, testing commenced once the flow rate was stabilized at the target value. The flow rate was held steady during the test at ±10% of the target value with a coefficient of variation (COV) less than the allowed 0.03. Water temperature remained below 80 °F during all testing. WSL was measured at the media surface to confirm driving head was below the 9 in. maximum design head above the media surface.

Sediment was injected at a known rate to produce a target average influent SSC concentration of 200 mg/L (± 10%) and 400 mg/L (± 10%) for removal efficiency and sediment mass capacity testing, respectively, with a COV of less than the allowed 0.10. Feed rates were determined by sampling the injection stream at three, evenly spaced intervals throughout each test. Samples were collected in clean beakers. Each sample was timed to the nearest 0.01 second with a Thomas Scientific 1235C26 traceable stopwatch and was a minimum of 0.1 L or collected for 1 minute, whichever came first. The samples were weighed (in-house), under the direct observation of the third-party observer, to the nearest mg on a calibrated Ohaus Scout SPX223 balance and feed rate was calculated using **Equation 1**. The total influent mass per test run was determined by measuring the sediment mass (to the nearest 0.01 kg) in the feeder before and after testing on a calibrated Ohaus Defender TD52XW, subtracting the mass collected for feed rate samples, and correcting for moisture content (**Equation 2**). Average influent SSC was calculated by dividing the influent mass by the volume of water sent to the test unit during sediment injection using **Equation 3**.

$$Feed\ Rate\ \left({}^{mg}/_{min}\right) = \frac{Mass_{sample+bottle}(g) - Mass_{bottle}(g)}{Time_{collection}(s) \times \left(\frac{min}{60\ s}\right)} \times \left(\frac{1E3\ mg}{g}\right) \times (1 - Sediment\ Moisture\ Content)$$

(**Equation 1**)

$$Influent\ Mass\ (mg) = (1 - Sediment\ Moisture\ Content)\ \times\ \left[Mass_{pre\cdot test}\,(kg) - Mass_{post\cdot test}(kg)\right] \times \left(\frac{1E6\ mg}{kg}\right) - \sum Mass_{feed\ rate\ samples}(mg)$$

(**Equation 2**)

$$Average\ Influent\ SSC\ \left({}^{mg}/_{L}\right) = \frac{Influent\ Mass\ (mg)}{Average\ Flow\ Rate\ \left({}^{gal}/_{min}\right) \times \left(\frac{3.78541\ L}{gal}\right) \times Time_{sediment\ injection}(min)}$$

(**Equation 3**)

Five effluent grab samples were collected during each test run. When the sediment stream was interrupted for feed rate sampling, effluent sampling began after a minimum of three detention times passed. Each sample volume was a minimum of 0.5 L. Samples were collected in clean, 1 L bottles by sweeping the bottle through the cross-section of the free-discharge effluent stream in a single pass.

Five background SSC samples were taken upstream of the test sediment feed injection point at paired sampling times with effluent SSC samples during each test run. Each sample was a minimum of 0.5 L and collected in a clean, 1 L bottle from the background sampling port. Samples were collected after the port valve was opened and the line was flushed for a minimum of 3 seconds. Average background concentration did not exceed 20 mg/L during any test. Paired background SSC was used to adjust effluent SSC and the adjusted effluent SSC values were averaged (**Equation 4**) and used to calculate effluent mass (**Equation 5**).

$$Average\ Adjusted\ Effluent\ SSC\ \left({}^{mg}/_{L}\right) = \frac{1}{5}\sum_{i=1}^{5}\left[Effluent\ SSC\left({}^{mg}/_{L}\right) - Background\ SSC\ \left({}^{mg}/_{L}\right)\right]_i$$

(**Equation 4**)

$$Effluent\ Mass\ (\mathrm{mg}) = Average\ Adjusted\ Effluent\ SSC\ \left({}^{mg}/_{L}\right) \times\ Average\ Flow\ Rate\ \left({}^{gal}/_{min}\right) \times \frac{3.78541\ L}{gal} \times Time_{sediment\ injection}(min)$$

(**Equation 5**)

Two evenly spaced volume paced drawdown samples were collected at 1/3 and 2/3 of the drawdown volume during the period after flow was suspended at the end of each test run. Appropriate drawdown sample times were established prior to the initial removal efficiency test run using the collected clean water operation draindown volume. This data was then applied to the initial test run. The evenly spaced drawdown sampling times were shifted throughout testing to accommodate any changes in drain volume as a result of sediment loading in the system over time. Any remaining water volume left in the test box after drawdown was not measured or included in calculations. Drawdown flow mass was calculated using Equation 6.

$$Drawdown\ Flow\ Mass\ (\mathrm{mg}) = \left(Average\ Drawdown\ Flow\ SSC\ \left({}^{mg}/_{L}\right) - Average\ \mathrm{Background\ SSC}\ \left({}^{\mathrm{mg}}/_{\mathrm{L}}\right)\right)\ x\ Drawdown\ Flow\ Volume\ (L)$$

(Equation 6)

Removal efficiency at the MTFR for each test run was calculated using **Equation 7**. Note the numerator is the mass captured during the run.

$$Removal\ Efficiency\ (\%) = \frac{(Influent\ Mass\ (mg) - Effluent\ Mass\ (mg) - Drawdown\ Flow\ Mass\ (mg))}{Influent\ Mass\ (mg)} \times 100$$

(Equation 7)

Cumulative removal efficiency at the MTFR was calculated using **Equation 8**.

$$Cumulative\ Removal\ Efficiency\ (\%) = \frac{\sum Influent\ Mass\ \ (mg) - \sum Effluent\ Mass\ (mg) - \sum Drawdown\ Flow\ Mass\ (mg)}{\sum Influent\ Mass\ (mg)} \times 100$$

(Equation 8)

Cumulative mass loaded at the MTFR was calculated using **Equation 9**.

$$Cumulative\ Mass\ Load\ (lb) = \frac{\sum Influent\ Mass\ \ (mg)}{\frac{453{,}592\ mg}{lb}}$$

(Equation 9)

Cumulative mass load captured at the MTFR was calculated using **Equation 10**.

$$Cumulative\ Mass\ Load\ Capacity\ (lb) = \frac{\sum Influent\ Mass\ \ (mg) - \sum Effluent\ Mass\ \ (mg) - \sum Drawdown\ Flow\ Mass\ (mg)}{\frac{453{,}592\ mg}{lb}}$$

(Equation 10)

Infiltration rate (gpm) for the 4x4ft test unit was determined using **Equation 11**.

Test Unit Infiltration Rae (gpm) = 300(in/hr) x 4(ft) x 4(ft) x 1 (ft)/12 (in) x 7.48 (gal/ft^3) x 1 (hr)/ 60 (min)

(Equation 11)

3. Performance Claims

The following performance claims are specific to the 4 ft x 4 ft Filterra HC, the unit size tested following the NJDEP Protocol. Additional information for all available models is provided in **Table A-1**.

Verified Total Suspended Solids Removal Rates

The Filterra HC exceeded the NJDEP required total suspended solids (TSS) removal rate of 80% at an MTFR of 49.9 gpm. The removal rate of 86.2% was determined according to the procedure and calculations described in the NJDEP Protocol and rounded down to 80% per Section C in the Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology (Verification Procedure) dated January 25, 2013.

Maximum Treatment Flow Rate

The 4 ft x 4 ft Filterra HC MTFR was determined to be 300 inches/hr. or 49.9 gpm. The corresponding hydraulic loading rate is 3.12 gpm/ft^2 of effective filtration treatment area.

Effective Filtration Treatment Area

The effective filtration treatment area and sedimentation area is 16 ft^2 on the 4 ft x 4 ft Filterra HC.

Sediment Mass Load Capacity

The 4 ft x 4 ft Filterra HC unit tested has a mass load capacity of 294.5 lbs and mass load capture capacity of 241.5 lbs, or 15.1 lbs/ft^2 of effective filtration treatment area.

MAXIMUM ALLOWABLE INFLOW DRAINAGE AREA

The 4 ft x 4 ft Filterra HC can treat 0.40 acres based on a sediment mass capture capacity of 241.5 lbs.

DETENTION TIME AND VOLUME

The operational wet volume of 21.5 ft^3 for a 4 ft x 4 ft Filterra HC produces a detention time of 3.2 minutes at 49.9 gpm.

4. SUPPORTING DOCUMENTATION

The NJDEP Verification Procedure, Section 5.D 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 the New Jersey Corporation for Advanced Technology (NJCAT) upon request that it would not be prudent or necessary to include all this information in this verification report.

4.1. TEST SEDIMENT PSD

The average removal efficiency test sediment PSD and NJDEP specification are presented in **Table 1** and **Figure 8.** For a clear comparison, the percent finer values were interpolated to match the particle diameters listed in Table 1 of the NJDEP Protocol. The test sediment distribution was finer than the specification, with a d50 particle size of 69 µm. The moisture content was determined to be less than the detection limit of 1%, so half the detection limit was used for sediment mass calculations.

Table 1: Test Sediment PSD

Particle Diameter (µm)	Percent Finer by Mass (%)					
	NJDEP Specification	NJDEP Minimum Allowable	Test Sample 1	Test Sample 2	Test Sample 3	Test Sediment Average
1000	100	98	100	100	100	100
500	95	93	97	97	97	97
250	90	88	89	90	90	90
150	75	73	78	78	79	78
100	60	58	58	59	59	59
75	50	50	51	51	51	51
50	45	43	47	47	47	47
20	35	33	41	37	38	39
8	20	18	26	22	23	24
5	10	8	16	14	14	15
2	5	3	7	6	6	6
d50 (µm)	< 75	-	71	68	67	69

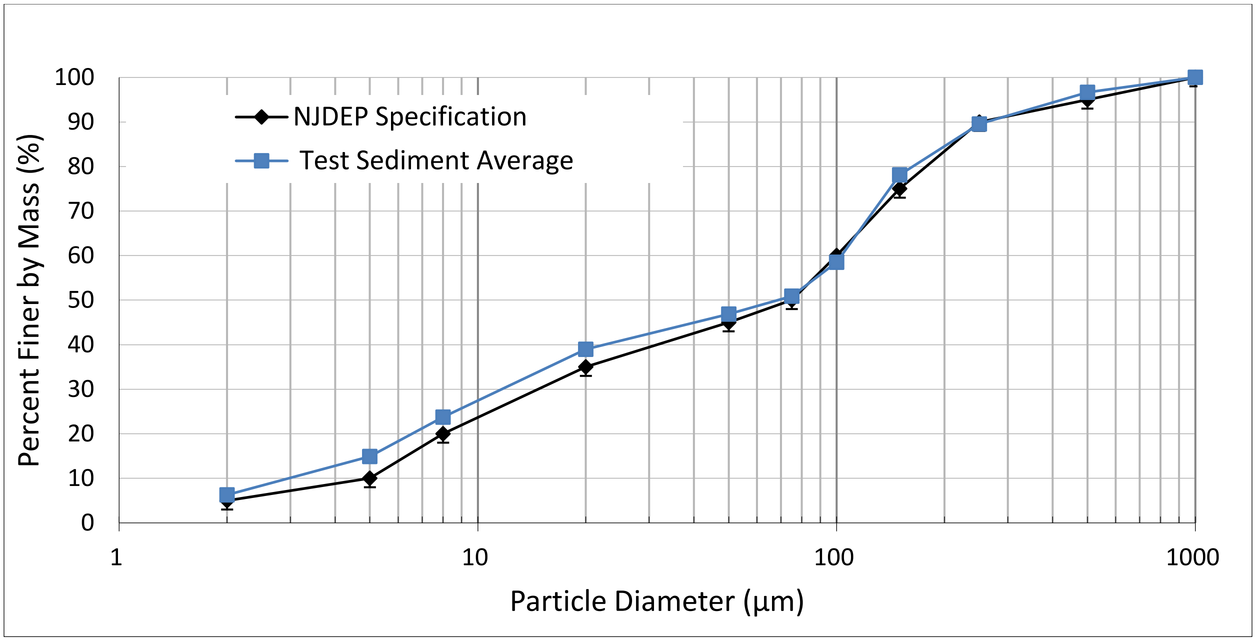

Figure 8: Test Sediment Average PSD

4.2. QA/QC RESULTS

A total of 15 removal efficiency test runs and 21 additional sediment mass loading capacity test runs were performed in accordance with the NJDEP Protocol. The target influent concentration was increased to 400 mg/L for the additional sediment mass loading capacity test runs. All tests met the NJDEP Protocol requirements and QA/QC parameters. **Table 2a, Table 2b and Table 2c** summarize flow rate, water temperature, feed rate, background, and sample volume QA/QC results.

Table 2a: Summary Removal Efficiency Flow and Temperature QA/QC Results

FLOW RATE AND WATER TEMPERATURE					
Test ID	QAQC PASS/FAIL	Target Inflow Rate (gpm)	Average Inflow Rate (gpm) (± 10%)	Inflow Rate COV (≤ 0.03)	Maximum Water Temperature (°F) (≤ 80 °F)
RE-T1	PASS	49.9	50.4	0.015	79.8
RE-T2	PASS	49.9	50.6	0.004	77.8
RE-T3	PASS	49.9	49.8	0.003	77.6
RE-T4	PASS	49.9	50.1	0.004	78.1
RE-T5	PASS	49.9	49.8	0.004	78.2
RE-T6	PASS	49.9	49.8	0.004	78.7
RE-T7	PASS	49.9	50.0	0.004	75.2
RE-T8	PASS	49.9	50.1	0.004	75.2
RE-T9	PASS	49.9	49.9	0.003	75.8
RE-T10	PASS	49.9	50.0	0.004	75.1
RE-T11	PASS	49.9	50.1	0.004	75.1
RE-T12	PASS	49.9	49.9	0.004	75.3
RE-T13	PASS	49.9	50.1	0.006	76.9
RE-T14	PASS	49.9	49.8	0.004	76.7
RE-T15	PASS	49.9	49.8	0.004	76.6

Table 2b: Summary Sediment Mass Loading Capacity Flow and Temperature QA/QC Results

FLOW RATE AND WATER TEMPERATURE					
Test ID	**QAQC PASS/FAIL**	**Target Inflow Rate (gpm)**	**Average Inflow Rate (gpm)** (± 10%)	**Inflow Rate COV** (≤ 0.03)	**Maximum Water Temperature (°F)** (≤ 80 °F)
SML-T1	PASS	49.9	49.9	0.004	76.2
SML-T2	PASS	49.9	49.9	0.004	75.0
SML-T3	PASS	49.9	49.9	0.004	76.2
SML-T4	PASS	49.9	49.9	0.004	74.5
SML-T5	PASS	49.9	49.8	0.004	77.1
SML-T6	PASS	49.9	49.8	0.003	77.6
SML-T7	PASS	49.9	49.8	0.006	75.2
SML-T8	PASS	49.9	49.8	0.004	75.7
SML-T9	PASS	49.9	49.9	0.004	75.8
SML-T10	PASS	49.9	49.9	0.004	75.7
SML-T11	PASS	49.9	49.7	0.004	76.0
SML-T12	PASS	49.9	50.0	0.004	74.9
SML-T13	PASS	49.9	49.9	0.005	75.6
SML-T14	PASS	49.9	50.1	0.004	74.2
SML-T15	PASS	49.9	49.8	0.004	75.9
SML-T16	PASS	49.9	49.9	0.004	74.1
SML-T17	PASS	49.9	50.0	0.004	76.2
SML-T18	PASS	49.9	50.0	0.011	76.5
SML-T19	PASS	49.9	50.1	0.010	77.7
SML-T20	PASS	49.9	50.0	0.010	75.1
SML-T21	PASS	49.9	50.1	0.006	76.3

Table 2c: Summary Feed Rate and Concentration QA/QC Results

INFLUENT AND BACKGROUND CONCENTRATION									
Test ID	QAQC PASS/FAIL	Target Influent SSC (mg/L)	Average Influent SSC (mg/L) (± 10%)	Moisture Corrected Feed Rate (g/min)			Feed Rate COV (≤ 0.10)	Average Background SSC (≤ 20 mg/L)	Minimum SSC Sample Volume (mL) (> 500 mL)
RE-T1	PASS	200	194	38.087	35.844	37.387	0.03	5.3	683
RE-T2	PASS	200	191	34.686	37.624	37.278	0.04	4.0	650
RE-T3	PASS	200	183	34.337	34.957	34.181	0.01	4.2	645
RE-T4	PASS	200	202	40.893	36.960	37.205	0.06	3.2	647
RE-T5	PASS	200	198	36.895	38.494	36.492	0.03	2.8	580
RE-T6	PASS	200	208	38.425	38.474	40.754	0.03	2.5	547
RE-T7	PASS	200	199	39.679	36.458	37.099	0.05	2.4	624
RE-T8	PASS	200	203	36.720	38.520	40.528	0.05	2.6	575
RE-T9	PASS	200	209	39.529	41.007	37.974	0.04	2.6	630
RE-T10	PASS	200	206	40.837	37.031	39.095	0.05	2.2	552
RE-T11	PASS	200	195	36.570	38.845	35.425	0.05	2.5	662
RE-T12	PASS	200	199	39.424	37.905	35.570	0.05	2.4	681
RE-T13	PASS	200	206	39.041	40.367	37.496	0.04	3.7	865
RE-T14	PASS	200	204	38.934	39.842	36.978	0.04	3.0	847
RE-T15	PASS	200	201	38.860	37.643	37.293	0.02	2.7	848
SML-T1	PASS	400	397	77.282	75.035	72.241	0.03	3.2	716
SML-T2	PASS	400	386	75.768	70.829	72.513	0.03	4.2	727
SML-T3	PASS	400	407	77.289	77.793	75.519	0.02	4.9	781
SML-T4	PASS	400	385	73.807	73.653	70.853	0.02	6.1	801
SML-T5	PASS	400	397	75.413	77.306	71.633	0.04	5.8	755
SML-T6	PASS	400	395	78.085	70.409	74.934	0.05	6.6	716
SML-T7	PASS	400	388	74.622	71.278	73.567	0.02	7.2	837
SML-T8	PASS	400	392	76.523	71.872	73.094	0.03	8.4	680
SML-T9	PASS	400	377	74.077	69.198	70.442	0.04	8.5	757
SML-T10	PASS	400	383	70.376	74.877	71.805	0.03	9.3	682
SML-T11	PASS	400	385	73.246	72.541	71.614	0.01	9.7	697
SML-T12	PASS	400	404	80.392	74.565	74.085	0.05	9.6	619
SML-T13	PASS	400	399	74.749	78.542	73.145	0.04	11.0	793
SML-T14	PASS	400	399	78.096	75.288	73.565	0.03	11.4	701
SML-T15	PASS	400	417	75.338	81.469	78.834	0.04	11.6	763
SML-T16	PASS	400	404	75.002	77.629	76.254	0.02	10.7	725
SML-T17	PASS	400	396	77.417	77.757	69.755	0.06	12.2	772
SML-T18	PASS	400	407	79.185	76.226	75.700	0.02	11.4	786
SML-T19	PASS	400	408	80.198	78.249	73.827	0.04	11.3	817
SML-T20	PASS	400	407	79.995	74.912	75.859	0.04	14.0	698
SML-T21	PASS	400	404	76.414	76.532	76.975	0.00	15.6	715

4.3. REMOVAL EFFICIENCY TESTING

Sediment feed rate, background, effluent and drawdown samples were collected via grab sampling for the 15 removal efficiency tests. An example of the removal efficiency sampling schedule is presented in **Table 3**.

Table 3: Example Removal Efficiency Sampling Schedule

Sample Time (hh:mm:ss)	Feed Rate Sample	Effluent Sample	Background Sample
00:00:00	1		
00:12:00		1	
00:12:04			1
00:14:00		2	
00:14:04			2
00:16:00	2		
00:28:00		3	
00:28:04			3
00:30:00		4	
00:30:04			4
00:32:00		5	
00:32:04			5
00:32:30	3		
1/3 Drawdown Volume		6	
2/3 Drawdown Volume		7	

The Filterra HC achieved a cumulative removal efficiency of 86.2% for trials 1 through 15 at an MTFR of 300 inches/hour. The removal efficiency results are summarized in **Table 4**. Individual effluent and background concentrations are presented for removal efficiency trials 1 through 15. All test runs met the NJDEP Protocol requirements and QA/QC parameters (**Table 2**).

Table 4: Summary of Removal Efficiency Results

REMOVAL EFFICIENCY PERFORMANCE SUMMARY												
Test ID	Average Flow Rate (gpm)	Test Water Volume (L)	Moisture Corrected Sediment Mass Injected kg (lb)	Influent TSS based on Mass Injected (mg/L)	Average Adjusted Effluent TSS (mg/L)	Effluent Mass kg (lb)	Average Adjusted Drawdown TSS (mg/L)	Drawdown Volume (L)	Drawdown Mass kg (lb)	Cumulative Mass Captured kg (lb)	Removal Efficiency (%)	Cumulative Removal Efficiency (%)
RE-T1	50.4	5,821	1.21 (2.67)	208	20	0.11 (0.25)	48	185	0.01 (0.02)	1.09 (2.40)	89.9	89.9
RE-T2	50.6	5,836	1.06 (2.35)	182	21	0.12 (0.27)	51	189	0.01 (0.02)	2.02 (4.46)	87.6	88.8
RE-T3	49.8	5,750	1.09 (2.40)	190	23	0.13 (0.29)	49	201	0.01 (0.02)	2.97 (6.55)	87.0	88.2
RE-T4	50.1	5,783	1.18 (2.60)	204	29	0.17 (0.37)	63	174	0.01 (0.02)	3.97 (8.75)	84.7	87.3
RE-T5	49.8	5,758	1.18 (2.61)	205	27	0.15 (0.34)	58	193	0.01 (0.02)	4.99 (10.99)	86.1	87.1
RE-T6	49.8	5,759	1.19 (2.62)	206	25	0.15 (0.32)	58	208	0.01 (0.03)	6.01 (13.26)	86.6	87.0
RE-T7	50.0	5,779	1.16 (2.56)	201	25	0.14 (0.32)	73	185	0.01 (0.03)	7.02 (15.47)	86.4	86.9
RE-T8	50.1	5,790	1.21 (2.67)	209	26	0.15 (0.33)	66	208	0.01 (0.03)	8.07 (17.78)	86.6	86.9
RE-T9	49.9	5,772	1.22 (2.68)	211	26	0.15 (0.32)	61	216	0.01 (0.03)	9.12 (20.11)	86.8	86.9
RE-T10	50.0	5,773	1.20 (2.64)	207	25	0.14 (0.32)	78	193	0.02 (0.03)	10.16 (22.40)	86.7	86.8
RE-T11	50.1	5,789	1.13 (2.50)	196	24	0.14 (0.31)	55	216	0.01 (0.03)	11.14 (24.56)	86.6	86.8
RE-T12	49.9	5,766	1.14 (2.52)	198	26	0.15 (0.33)	60	220	0.01 (0.03)	12.12 (26.72)	85.6	86.7
RE-T13	50.1	5,787	1.17 (2.57)	202	33	0.19 (0.42)	93	182	0.02 (0.04)	13.08 (28.84)	82.3	86.4
RE-T14	49.8	5,761	1.15 (2.53)	199	29	0.17 (0.37)	64	212	0.01 (0.03)	14.05 (30.97)	84.3	86.2
RE-T15	49.8	5,758	1.11 (2.45)	193	26	0.15 (0.34)	64	220	0.01 (0.03)	14.99 (33.06)	85.0	86.2

Table 5: Removal Efficiency SSC Data

Test ID	SUSPENDED SEDIMENT CONCENTRATION (mg/L)						Average
RE-T1	Background	1.0	9.3	6.6	4.8	5.0	5.3
	Effluent	19.7	26.9	27.5	26.0	24.1	24.8
RE-T2	Background	3.7	4.2	4.3	3.7	4.0	4.0
	Effluent	22.9	26.3	23.8	27.4	24.0	24.9
RE-T3	Background	4.2	4.3	4.2	4.4	4.1	4.2
	Effluent	32.2	21.6	28.2	24.2	30.2	27.3
RE-T4	Background	3.5	3.3	2.7	3.2	3.4	3.2
	Effluent	33.7	29.6	28.3	35.8	35.2	32.5
RE-T5	Background	2.9	2.7	2.6	2.9	2.8	2.8
	Effluent	27.5	26.6	29.0	29.1	35.0	29.4
RE-T6	Background	2.2	2.6	2.7	2.5	2.6	2.5
	Effluent	23.8	27.3	29.1	28.6	31.2	28.0
RE-T7	Background	2.2	2.3	2.3	2.5	2.6	2.4
	Effluent	27.4	26.5	24.3	27.3	31.2	27.3
RE-T8	Background	2.7	2.5	2.5	2.3	2.8	2.6
	Effluent	27.6	29.2	28.4	25.7	30.3	28.2
RE-T9	Background	2.5	2.6	2.7	2.7	2.4	2.6
	Effluent	26.1	28.1	27.2	30.4	28.6	28.1
RE-T10	Background	2.2	2.3	2.0	2.3	2.1	2.2
	Effluent	29.9	25.2	26.4	27.0	27.6	27.2
RE-T11	Background	2.0	2.8	2.6	2.7	2.4	2.5
	Effluent	21.6	28.3	27.8	29.8	25.9	26.7
RE-T12	Background	2.3	2.8	2.2	2.5	2.4	2.4
	Effluent	27.6	28.2	27.6	29.6	30.7	28.7
RE-T13	Background	4.7	4.0	3.0	3.5	3.2	3.7
	Effluent	36.9	36.7	39.1	38.2	31.2	36.4
RE-T14	Background	3.6	3.0	2.7	2.8	2.8	3.0
	Effluent	31.3	34.6	30.9	32.0	30.7	31.9
RE-T15	Background	2.7	3.4	2.5	2.6	2.3	2.7
	Effluent	33.7	29.6	28.8	25.0	28.5	29.1

4.4 Sediment Mass Loading Capacity Testing

After completion of the 15 removal efficiency test runs, sediment feed rate, background, effluent and drawdown samples were collected via grab sampling for 21 additional sediment mass loading capacity tests during which the target influent concentration was increased to 400 mg/L. An example of the sediment mass loading capacity sampling schedule is presented in **Table 6.**

Table 6: Example Sediment Mass Loading Capacity Sampling Schedule

Sample Time (hh:mm:ss)	Feed Rate Sample	Effluent Sample	Background Sample
0:00:00	1		
0:15:00		1	
0:15:04			1
0:30:00		2	
0:30:04			2
0:45:00		3	
0:45:04			3
0:46:00	2		
1:00:00		4	
1:00:04			4
1:15:00		5	
1:15:04			5
1:15:30	3		
1/3 Drawdown Volume		6	
2/3 Drawdown Volume		7	

The Filterra HC achieved a cumulative mass removal efficiency of 82.0% for a total of 36 trials including 15 removal efficiency trials and 21 sediment mass loading capacity trials at an MTFR of 300 inches/hour. The sediment mass loading capacity results are summarized in **Table 7**. Individual effluent and background concentrations are presented in **Table 8** for sediment mass loading capacity trials 1 through 21. All test runs met the NJDEP Protocol requirements and QA/QC parameters (**Table 2**). **Figure 9** illustrates the correlation between sediment mass load captured and cumulative removal efficiency. Testing was suspended after test 36 (test 21 of the sediment mass loading capacity testing) since individual test removal efficiencies began to drop below 80%, and all applicable requirements of the protocol had been met. While the system had not reached a failure point as defined by the protocol, it was concluded that there was little value in completing additional test runs.

Table 7: Summary of Sediment Mass Loading Capacity Results

SEDIMENT MASS LOAD CAPACITY PERFORMANCE SUMMARY												
Test ID	Average Flow Rate (gpm)	Test Water Volume (L)	Moisture Corrected Sediment Mass Injected kg (lb)	Influent TSS based on Mass Injected (mg/L)	Average Adjusted Effluent TSS (mg/L)	Effluent Mass kg (lb)	Average Adjusted Drawdown TSS (mg/L)	Drawdown Volume (L)	Drawdown Mass kg (lb)	Cumulative Mass Captured kg (lb)	Removal Efficiency (%)	Cumulative Removal Efficiency (%)
SML-T1	49.9	13,878	5.50 (12.12)	396	63	0.87 (1.91)	183	201	0.04 (0.08)	19.59 (43.18)	83.5	85.5
SML-T2	49.9	13,895	5.47 (12.07)	394	60	0.83 (1.84)	222	189	0.04 (0.09)	24.19 (53.32)	84.0	85.2
SML-T3	49.9	13,878	5.55 (12.24)	400	66	0.92 (2.03)	167	208	0.03 (0.08)	28.79 (63.46)	82.8	84.8
SML-T4	49.9	13892	5.50 (12.14)	396	64	0.88 (1.95)	238	201	0.05 (0.11)	33.36 (73.54)	83.1	84.6
SML-T5	49.8	13858	5.53 (12.19)	399	64	0.89 (1.95)	239	201	0.05 (0.11)	37.96 (83.68)	83.1	84.4
SML-T6	49.8	13858	5.31 (11.71)	383	61	0.84 (1.86)	241	201	0.05 (0.11)	42.38 (93.42)	83.2	84.3
SML-T7	49.8	13861	5.36 (11.81)	386	67	0.93 (2.04)	123	204	0.03 (0.06)	46.78 (103.14)	82.3	84.1
SML-T8	49.8	13865	5.34 (11.78)	385	66	0.92 (2.03)	223	208	0.05 (0.10)	51.16 (112.79)	81.9	83.9
SML-T9	49.9	13884	5.32 (11.73)	383	60	0.84 (1.84)	252	204	0.05 (0.11)	55.59 (112.56)	83.3	83.9
SML-T10	49.9	13878	5.38 (11.85)	387	68	0.95 (2.09)	257	208	0.05 (0.12)	59.97 (132.21)	81.4	83.7
SML-T11	49.7	13844	5.39 (11.88)	389	66	0.91 (2.02)	261	204	0.05 (0.12)	64.39 (141.95)	82.0	83.6
SML-T12	50.0	13909	5.49 (12.11)	395	70	0.97 (2.14)	249	193	0.05 (0.11)	68.86 (151.81)	81.4	83.4
SML-T13	49.9	13898	5.55 (12.23)	399	67	0.93 (2.05)	260	208	0.05 (0.12)	73.42 (161.87)	82.2	83.3
SML-T14	50.1	13953	5.67 (12.49)	406	76	1.06 (2.34)	281	204	0.06 (0.13)	77.97 (171.89)	80.2	83.2
SML-T15	49.8	13849	5.74 (12.65)	414	81	1.12 (2.47)	269	216	0.06 (0.13)	82.53 (181.94)	79.5	82.9
SML-T16	49.9	13890	5.71 (12.60)	411	78	1.09 (2.40)	300	212	0.06 (0.14)	87.09 (192.00)	79.9	82.8
SML-T17	50.0	13914	5.56 (12.25)	399	73	1.01 (2.23)	238	216	0.05 (0.11)	91.59 (201.92)	80.9	82.7
SML-T18	50.0	13928	5.77 (12.72)	414	84	1.17 (2.58)	266	216	0.06 (0.13)	96.13 (211.94)	78.7	82.5
SML-T19	50.1	13938	5.69 (12.55)	408	85	1.18 (2.61)	292	208	0.06 (0.13)	100.58 (221.74)	78.2	82.3
SML-T20	50.0	13904	5.64 (12.44)	406	81	1.13 (2.48)	301	208	0.06 (0.14)	105.03 (231.56)	78.9	82.1
SML-T21	50.1	13941	5.68 (12.53)	408	81	1.13 (2.48)	306	208	0.06 (0.14)	109.52 (241.46)	79.0	82.0

Table 8: Sediment Mass Loading Capacity SSC Data

Test ID	SUSPENDED SEDIMENT CONCENTRATION (mg/L)						Average
	Sample Number	1	2	3	4	5	
SML-T1	Background	2.5	2.9	3.4	3.4	4.0	3.2
	Effluent	61.1	65.2	66.8	65.0	70.8	65.8
SML-T2	Background	3.9	3.6	4.0	4.7	4.7	4.2
	Effluent	58.9	41.3	72.9	73.0	74.4	64.1
SML-T3	Background	5.0	5.2	5.0	5.5	3.9	4.9
	Effluent	68.1	69.4	71.8	73.1	73.5	71.2
SML-T4	Background	5.2	6.3	6.2	6.2	6.6	6.1
	Effluent	69.8	54.6	75.9	75.0	73.5	69.8
SML-T5	Background	4.3	5.4	6.2	6.3	7.0	5.8
	Effluent	63.4	69.9	69.9	72.4	73.0	69.7
SML-T6	Background	5.6	6.6	7.0	7.2	6.8	6.6
	Effluent	70.3	68.3	66.9	72.5	58.8	67.4
SML-T7	Background	5.8	6.7	7.2	7.8	8.4	7.2
	Effluent	69.8	76.5	74.3	75.9	73.1	73.9
SML-T8	Background	8.5	8.4	8.0	8.1	8.8	8.4
	Effluent	76.5	74.2	73.1	71.9	77.7	74.7
SML-T9	Background	8.1	8.0	8.8	8.8	8.9	8.5
	Effluent	75.0	74.8	71.8	48.7	73.3	68.7
SML-T10	Background	8.6	9.0	9.5	9.9	9.7	9.3
	Effluent	74.4	74.2	80.9	79.2	79.4	77.6
SML-T11	Background	9.2	9.5	9.9	9.6	10.1	9.7
	Effluent	78.5	78.9	78.0	81.5	61.6	75.7
SML-T12	Background	9.0	9.8	10.0	9.8	9.2	9.6
	Effluent	78.6	80.3	64.1	83.1	91.1	79.4
SML-T13	Background	9.8	11.8	11.2	11.0	11.1	11.0
	Effluent	81.8	58.0	72.7	86.4	91.0	78.0
SML-T14	Background	11.3	11.3	11.8	11.3	11.3	11.4
	Effluent	79.3	86.4	88.6	91.8	91.9	87.6
SML-T15	Background	10.6	11.3	11.8	11.9	12.6	11.6
	Effluent	83.7	91.6	93.2	93.2	101.0	92.5
SML-T16	Background	8.2	8.3	11.6	12.1	13.2	10.7
	Effluent	76.1	92.7	93.1	85.2	97.6	88.9
SML-T17	Background	11.2	11.9	11.2	12.9	13.6	12.2
	Effluent	92.4	70.1	74.7	93.4	93.0	84.7
SML-T18	Background	9.1	11.6	11.5	11.8	12.9	11.4
	Effluent	94.4	89.2	92.0	102.0	98.9	95.3
SML-T19	Background	8.4	10.2	12.0	12.7	13.4	11.3
	Effluent	93.4	88.1	96.5	98.8	104.0	96.2
SML-T20	Background	11.7	12.8	13.4	13.9	15.4	13.4
	Effluent	67.8	102.0	96.3	103.0	103.0	94.4
SML-T21	Background	15.0	15.4	15.1	15.3	16.2	15.4
	Effluent	98.4	74.8	103.0	101.0	104.0	96.2

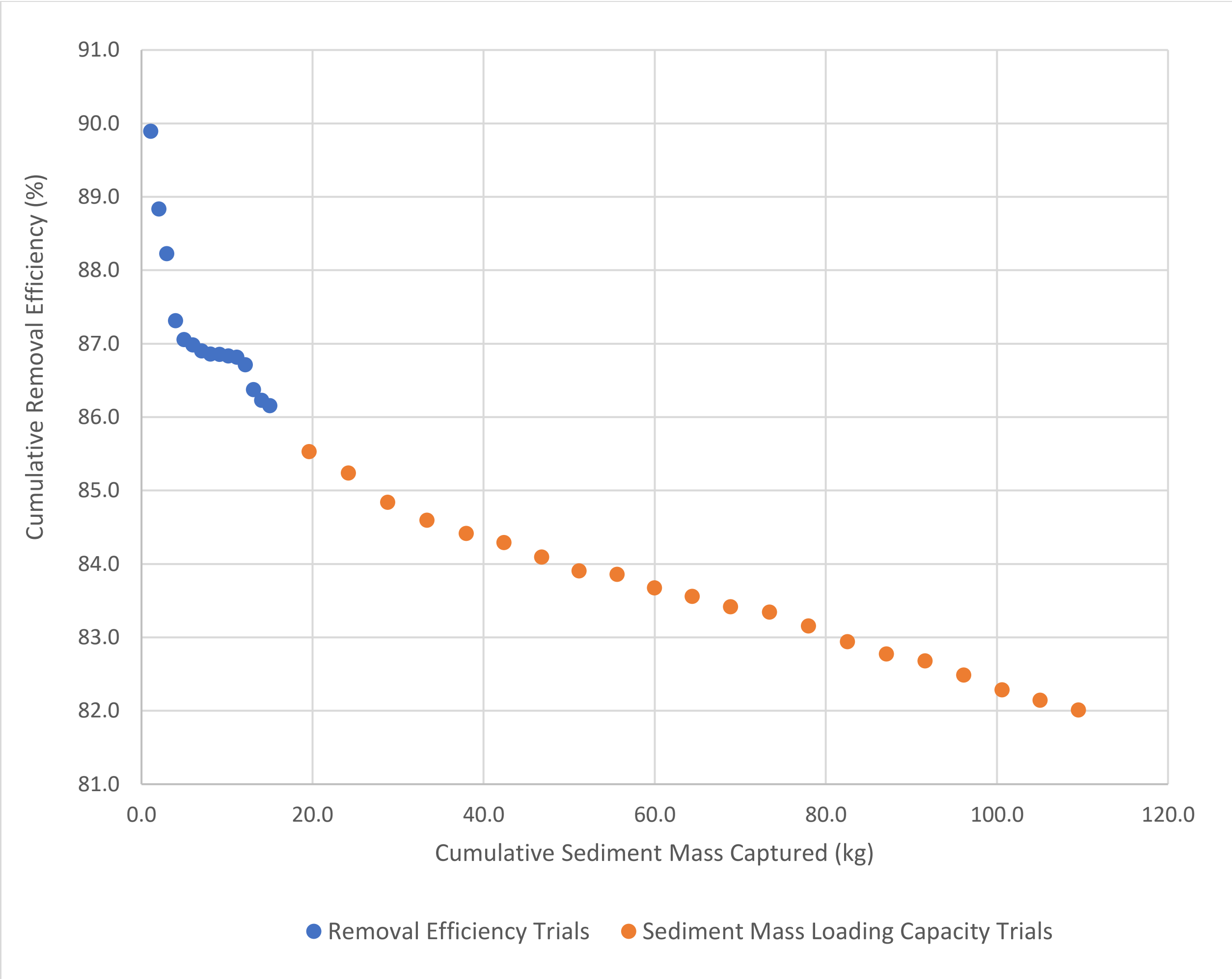

Figure 9: Cumulative Mass Removal Efficiency vs. Sediment Mass Captured

4.5 WATER SURFACE LEVEL

The effect of cumulative mass load captured on the water surface level measured from the surface of the media is presented in **Table 9** and **Figure 10**. Testing ceased well before the maximum available driving head of 9 inches was reached. A maximum of 2.075 in. of water surface level was observed above the media during testing.

Table 9: Water Surface Level vs. Cumulative Mass Captured

WATER SURFACE LEVEL			
Test ID	Maximum WSL (in)	Cumulative Mass Captured (kg)	Cumulative Mass Captured (lb)
RE-T1	0.075	1.1	2.4
RE-T2	0.075	2.0	4.5
RE-T3	0.075	3.0	6.5
RE-T4	0.075	4.0	8.7
RE-T5	0.075	5.0	11.0
RE-T6	0.100	6.0	13.3
RE-T7	0.100	7.0	15.5
RE-T8	0.100	8.1	17.8
RE-T9	0.100	9.1	20.1
RE-T10	0.100	10.2	22.4
RE-T11	0.100	11.1	24.6
RE-T12	0.075	12.1	26.7
RE-T13	0.075	13.1	28.8
RE-T14	0.075	14.0	31.0
RE-T15	0.075	15.0	33.1
SML-T1	0.100	19.6	43.2
SML-T2	0.075	24.2	53.3
SML-T3	0.075	28.8	63.5
SML-T4	0.125	33.4	73.5
SML-T5	0.100	38.0	83.7
SML-T6	0.125	42.4	93.4
SML-T7	0.050	46.8	103.1
SML-T8	0.025	51.2	112.8
SML-T9	0.025	55.6	122.6
SML-T10	0.025	60.0	132.2
SML-T11	0.125	64.4	141.9
SML-T12	0.175	68.9	151.8
SML-T13	0.250	73.4	161.9
SML-T14	0.325	78.0	171.9
SML-T15	0.750	82.5	181.9
SML-T16	0.100	87.1	192.0
SML-T17	0.950	91.6	201.9
SML-T18	1.025	96.1	211.9
SML-T19	2.075	100.6	221.7
SML-T20	1.375	105.0	231.6
SML-T21	1.975	109.5	241.5

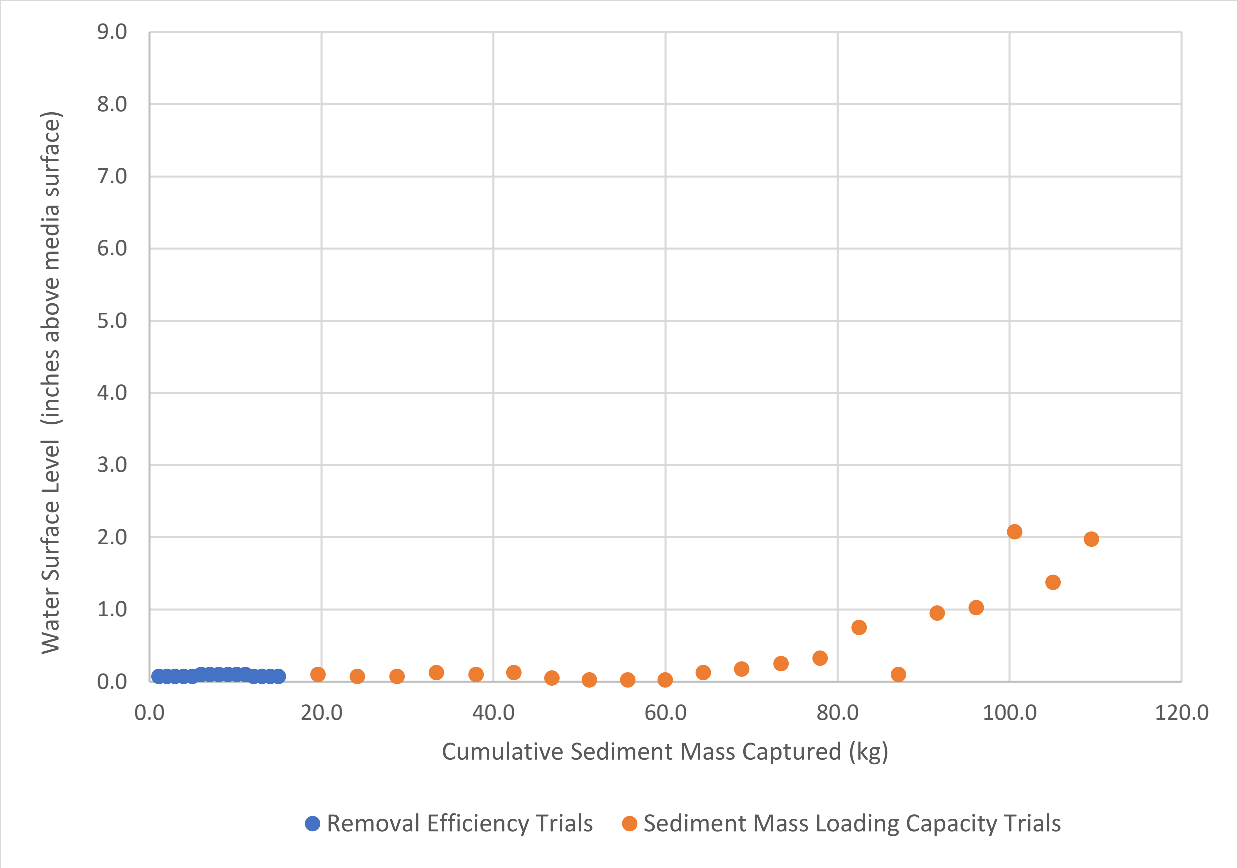

Figure 10: Sediment Mass Load Captured vs. Water Surface Level

5. Design Limitations

Contech's engineering staff typically works with the site design engineer to ensure all potential constraints are addressed during the specification process and that the Filterra HC system will function as intended. Each installation will have unique limitations or requirements; the following limitations should be considered general and are not all inclusive.

Required Soil Characteristics

The functionality of the precast Filterra HC system is not affected by existing soil conditions at the installed location and as such the unit can be installed in all soil types. Filterra HC Bioscape can be installed directly into an excavated basin, providing infiltration when native soils allow. In instances when native soils only allow for partial infiltration of the water quality storm Contech's engineering team should be contacted to ensure proper design. If native soils do not allow infiltration, Filterra HC Bioscape may still be used for aesthetic purposes, but no credit will be taken for any infiltration. Site stabilization should occur prior to unit activation to limit construction site sediment loading in the influent water.

Slope

The top slab can typically be installed at curb grade. It is generally not advisable to install the Filterra HC unit with steep curb slopes. When the Filterra HC is being considered with steep slopes, Contech recommends contacting their engineering staff to evaluate the design prior to specification.

Flow Rate

The hydraulic loading rate of the Filterra HC is 3.12 gpm/ft^2 of effective filtration treatment area, equivalent to 300 inches/hour.

Maintenance Requirements

Filterra HC includes a 1-year maintenance plan with each unit purchased which includes mulch replacement, debris removal and pruning of vegetation up to twice during the first year after activation. The Filterra HC system must be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants depends heavily on specific site activities within the contributing drainage area. See Section 6 for a more detailed discussion of maintenance and inspection requirements.

Driving Head

The maximum available driving head for a given Filterra HC system is 9 inches above the media surface. The total distance from the bottom of the Filterra HC media layer to the maximum head elevation 9 inches above the media layer is 27 inches. The maximum driving head reached during this testing was 2.08 inches above the media layer.

Installation Limitations

Prior to installation, Contech provides contractors detailed installation instructions and is also available to consult onsite during installation. The Filterra HC system is delivered fully assembled. Pick weights for Filterra HC are provided prior to delivery so that the contractor can secure proper equipment for lifting Filterra HC units into place. The Filterra HC system cannot be activated until site construction is complete. Note that plants should be installed at the time of activation.

Configurations

Filterra HC can accept flow through a pipe, curb inlet or grated inlet. Filterra HC units can be installed offline or utilize a peak diversion configuration to convey flows around the effective treatment area without the need for an external bypass structure. The Filterra HC is available in a variety of precast configurations, and can also be configured as a Filterra HC Bioscape, an open top configuration which can be installed directly into an excavated basin for better aesthetics and effective infiltration into the soil when native soils allow. Both precast and Bioscape configurations are identical in form and function with the exception of the use of a vault in precast systems. Filterra HC can be configured in many ways to enhance site aesthetics, integrate with other LID practices, or increase runoff reduction through infiltration below or downstream of the system.

Load Limitations

Filterra HC systems are designed to support the loading necessary for the particular application and configuration of the system. This can vary depending on whether the system is partially below a traffic area where it would be designed for HS-20 loading or if the unit is in a pedestrian area where it would be designed to support smaller vehicle loads with an HS-20 surcharge. Systems can be designed to meet site specific requirements as well. Contech provides technical design support on all projects and can help to ensure the system is designed for the appropriate structural load requirements.

PRETREATMENT REQUIREMENTS

There are no pre-treatment requirements for the Filterra HC system.

LIMITATIONS ON TAILWATER

It is typically recommended that the outlet pipe of the Filterra HC system be at an elevation greater than the tailwater created by the receiving body or structure to not allow for water to backup into the system. However, in cases where tailwater is above the invert of the outlet pipe, site specific design conditions can be addressed as part of the design process.

DEPTH TO SEASONAL HIGH-WATER TABLE

Filterra HC unit performance is not typically impacted by high groundwater. Depth of the seasonal high water table is not an issue with the Filterra HC as it includes a precast concrete vault with a solid floor and the weight of the Filterra HC (fully loaded with media and under-drain stone) will weigh more than the water it will displace. If high groundwater is expected, Contech's engineering staff can evaluate whether anti-buoyancy measures are required during the design process. For Filterra HC Bioscape applications without a precast vault, site specific considerations can be addressed as part of the design process which could include utilizing a liner or vault to prevent groundwater intrusion.

6. MAINTENANCE PLAN

. Routine maintenance is included by the manufacturer on all Filterra HC systems for the first year after activation. This includes a maximum of 2 visits to remove debris, replace pretreatment mulch, and prune the vegetation. More information is provided in the Filterra HC Bioretention Systems Owner's Manual available at:

https://www.conteches.com/Portals/0/Documents/Maintenance%20Guides/Filterra%20HC%20OM%20Packet.pdf

Routine maintenance outside of the included first year, can be provided by certified maintenance providers listed on the Contech website. Training can also be provided to other stormwater maintenance or landscape providers.

Simple maintenance of the Filterra HC is required to continue effective pollutant removal from stormwater runoff before discharge into downstream waters. This procedure will also extend the longevity of the living biofilter system. The unit will accumulate pollutants within the mulch and media layers but is also subjected to other materials entering the inlet. This may include trash, silt and leaves etc. which will be contained above the mulch layer. Too much silt may inhibit Filterra HC's flow rate, which is the reason for site stabilization before activation. Regular replacement of the mulch stops accumulation of such sediment.

Frequency

Routine maintenance visits should be scheduled seasonally; the spring visit aims to clean up after winter loads including salts and sands, while the fall visit helps the system by removing excessive leaf litter. Site conditions, climate and land use can affect maintenance frequency, e.g., some fast food restaurants require more frequent trash removal. Contributing drainage areas which are subject to new development, wherein the recommended erosion and sediment control measures have not been implemented, may require additional maintenance visits. Typically, 1-2 routine maintenance visits are required annually. Over time, site specific conditions or abnormal occurrences such as spills may necessitate the full replacement of the media bed similar to other biofiltration systems.

Maintenance Visit Summary

Each routine maintenance visit consists of the following simple tasks (detailed instructions are provided in the link above).

1. Inspection of Filterra HC and surrounding area

2. Setting aside of tree grate and erosion control stones

3. Removal of debris, trash, and mulch

4. Mulch replacement

5. Plant health evaluation and pruning or replacement as necessary

6. Clean area around Filterra HC

7. Complete paperwork

Maintenance Tools, Safety Equipment and Supplies

Ideal tools include camera, bucket, shovel, broom, pruners, hoe/rake, and tape measure. Appropriate Personal Protective Equipment (PPE) should be used in accordance with local or company procedures. This may include impervious gloves where the type of trash is unknown, high visibility clothing and barricades when working in close proximity to traffic and also safety hats and shoes. A T-Bar or crowbar should be used for moving the tree grates (up to 170 lbs ea.). Most visits require minor trash removal and a full replacement of mulch. Mulch should be a double shredded, hardwood variety. Some visits may require additional Filterra engineered soil media available from Contech.

7. STATEMENTS

The following signed statements from the manufacturer (Contech Engineered Solutions, LLC), third-party observer (Don Rissmeyer) and NJCAT are required to complete the verification process.

CONTECH®
ENGINEERED SOLUTIONS

Contech Engineered Solutions LLC
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9/28/2020

Dr. Richard Magee
Executive Director
New Jersey Corporation for Advanced Technology
c/o Center for Environmental Systems
Stevens Institute of Technology
One Castle Point on Hudson
Hoboken, NJ 07030

RE: Verification of the Filterra HC Bioretention System

Dr. Richard Magee,

This correspondence is being sent to you in accordance with the "*Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology"* dated January 25, 2013. Specifically, the process document requires that manufacturers submit a signed statement confirming that all of the procedures and requirements identified in the aforementioned process document and the *"New Jersey Department of Environmental Protection (NJDEP) Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device"* dated January 25, 2013 have been met. We believe that the testing executed in Contech's laboratory in Ashland, VA on the Filterra® HC Bioretention System during the summer of 2020 under the direct supervision of Don Rissmeyer, PE, CFM from A. Morton Thomas and Associates Inc. was conducted in full compliance with all applicable protocol and process criteria. Additionally, we believe that all the required documentation of the testing and resulting performance calculations has been provided within the submittal accompanying this correspondence.

Please do not hesitate to contact me with any additional questions related to this matter.

Respectfully,

Derek M. Berg
Director - Stormwater Regulatory Management - East
Contech Engineered Solutions LLC
71 US Route 1, Suite F | Scarborough, ME 04074
T: 207.885.6174 F: 207.885.9825
DBerg@conteches.com
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February 25, 2020

Mindy Hills, CPSWQ
Project Manager – R&D
Contech Engineered Solutions LLC
10408 Lakeridge Pkwy, Suite 600
Ashland, Virginia 23005
mhills@conteches.com

Re: Potential Conflicts of Interest Statement for Third Party Observer
AMT Project 19-0957.001

To Whom it May Concern,

Per the criteria described in the "*Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology*", dated January 25, 2013, this letter discloses that we have no conflicts of interest in serving as the designated third party observer for Contech Engineered Solutions, LLC on this manufactured treatment device (MTD) testing. Reasons are noted as follows:

- Designated staff persons at AMT have no previous or current personal, professional, or financial relationships with Contech Engineered Solutions, LLC, except for a consulting agreement for the pending role as third party observer for this planned testing.
- AMT has provided professional services as an engineering consultant or independent third party to other manufacturers of stormwater products over the years, with no history of conflicts of interest or ethical problems in our services provided. Previous and current contracts have included services to: Filterra Bioretention Systems, SWM PAVE through Eagle Bay USA, Midwest Building & Block Company, and ACF Environmental. Our limited work for each client was protected through non-disclosure agreements and is independent of the planned third-party observer services for Contech Engineered Solutions, LLC.
- We do not have any existing or prior ownership stake in the manufacturer, we have not received any commissions for selling or helping to sell MTD's for any clients, we do not have licensing agreements with any manufacturer or any similar types of arrangements.

Additional information about the AMT team's qualifications to supervise and provide third party observation is summarized in the enclosed one-page resumes that generally describes similar consulting services to the extent allowed by our non-disclosure agreements. AMT requests that NJCAT confirm that if no conflict of interest exists as a result of this disclosure statement and advise if any additional information is necessary for your decision, prior to AMT participating in the planned testing as a third-party observer.

Thank you for your consideration.

Sincerely,
A. Morton Thomas and Associates, Inc.

Don Rissmeyer, PE, CFM (VA 026104)
Associate

October 6, 2020

Mindy Hills, CPSWQ
Project Manager – Research & Development Team
Contech Engineered Solutions LLC
Ashland Virginia Laboratory
mhills@conteches.com

Re: Third-Party Observation of NJCAT Testing for the Filterra Bioretention System
AMT Project 19-0957.001

To Whom it May Concern,

Based on my direct observations for all of the equipment calibration and performance testing conducted by Contech Engineering Solutions LLC, all of the requirements of the approved Quality Assurance Project Plan for NJCAT testing of the Filterra Bioretention System have been met or exceeded. My signature as third-party observer in this letter is to also establish that the verification report reflects the testing observed.

Also, as described in the AMT letter dated February 25, 2020 as part of the previously approved Quality Assurance Project Plan, AMT has no conflicts of interest that would bias our independent third-party observation of this testing for the Filterra Bioretention System.

Please let me know if I can provide any additional information.

Sincerely,
A. Morton Thomas and Associates, Inc.

Don Rissmeyer, PE, CFM (VA 026104)
Associate

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

October 10, 2020

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

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing conducted on a full-scale, commercially available Contech Filterra® HC Bioretention System, and observed by Donald Rissmeyer, P.E., A. Morton Thomas and Associates, Inc., Richmond, VA, the test protocol requirements contained in the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" (NJDEP Filtration Protocol, January 2013) were met or exceeded. Specifically:

Test Sediment Feed

The mean PSD of the Filterra HC test sediment complied with the PSD criteria established by the NJDEP HDS protocol. The Contech Filterra HC removal efficiency test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification. The test sediment was shown to be finer than the sediment blend specified by the protocol (<75µm); the test sediment d_{50} was approximately 69 microns.

Removal Efficiency (RE) Testing

Thirty-six (36) removal efficiency test runs were completed in accordance with the NJDEP test protocol. Fifteen (15) of the 36 test runs were conducted during removal efficiency testing and 21 tests were conducted during mass loading testing. The target flow rate and influent sediment concentration were 49.9 gpm and 200 mg/L for the removal efficiency testing. The Filterra HC achieved a cumulative removal efficiency of 86.2% for trials 1 through 15 at the MTFR of 49.9 gpm (300 inches/hour).

Sediment Mass Loading Capacity

Mass loading capacity testing was conducted as a continuation of removal efficiency testing. Mass loading test runs were conducted using identical testing procedures and flow rate target as those used in the RE runs; the only change was to increase the target influent concentration to 400 mg/L. Testing concluded after 21 mass loading test runs. The Filterra HC achieved a cumulative mass removal efficiency of 82% over the 36 trials.

The total influent mass loaded through Run 36 was 294.5 lbs and the total mass captured by the Filterra HC was 241.5 lbs. This is equivalent to a sediment mass loading capacity of 15.1 lbs/ft^2 of effective filtration treatment area.

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

Scour Testing

The Contech Filterra HC Bioretention System is designed for offline installation. Consequently, scour testing is not required.

Sincerely,

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

VERIFICATION APPENDIX

INTRODUCTION

- Contech Engineered Solutions is the manufacturer of the Filterra® HC Bioretention System MTD.

  Contech Engineered Solutions
  9025 Centre Point Drive
  West Chester, OH 45069
  Phone: (513) 645-7000
  Fax: (513) 645-7993
  www.ContechES.com

- MTD: Contech Filterra® HC Bioretention System. Verified Contech Filterra models are shown in **Table A-1**

- TSS removal rate: 80%.

- The Filterra HC Bioretention System MTD qualifies for offline installation for the New Jersey Water Quality Design Storm (NJWQDS).

DETAILED SPECIFICATION

- NJDEP sizing table for the Filterra HC Bioretention System is attached (**Table A-1**).

- New Jersey requires that the peak flow rate of the NJWQDS event of 1.25 inch in 2 hours shall be used to determine the appropriate size for the MTD. The Filterra HC Bioretention System has a maximum treated flow (MTFR) of 300 inches per hour, which corresponds to a surface loading rate of 3.12 gpm/ft^2 of effective filtration treatment area.

- Prior to installation, Contech provides contractors detailed installation and assembly instructions and is also available to consult onsite during installation.

- Maximum available driving head is 9 inches above the media surface. The maximum available driving head represents 27 inches above the bottom of the media layer. The maximum driving head required during testing was 2.08 inches above the media surface.

- See Filterra HC Bioretention System Owner's Manual for detailed maintenance information:
  https://www.conteches.com/Portals/0/Documents/Maintenance%20Guides/Filterra%20HC%20OM%20Packet.pdf

- The Filterra HC Bioretention System cannot be used in series with another MTD or a media filter (such as a sand filter) to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.

Table A-1. Filterra HC MTFRs and Maximum Allowable Drainage Area

	Available Filterra® Media Bay Sizes (feet)	Effective Filtration Treatment Area (ft^2)	Treatment Flow Rate (cfs)	Maximum Allowable Drainage Area (ac)	Minimum Underdrain / Outlet Pipe Size
Standard Configuration Filterra and Filterra Biosape Vaults	4x4	16	0.111	0.40	6" SDR-35 PVC
	4x6 or 6x4	24	0.167	0.60	6" SDR-35 PVC
	4.5x7.83 or 7.83x4.5 (Nominal 4x8/8x4)	35.24	0.245	0.89	6" SDR-35 PVC
	6x6	36	0.250	0.91	6" SDR-35 PVC
	6x8 or 8x6	48	0.333	1.21	6" SDR-35 PVC
	6x10 or 10x6	60	0.417	1.51	6" SDR-35 PVC
	6x12 or 12x6	72	0.500	1.81	6" SDR-35 PVC
	7x13 or 13x7	91	0.632	2.29	6" SDR-35 PVC
	14x8	112	0.778	2.82	6" SDR-35 PVC
	16x8	128	0.889	3.22	6" SDR-35 PVC
	18x8	144	1.000	3.62	6" SDR-35 PVC
	20x8	160	1.111	4.03	6" SDR-35 PVC
	22x8	176	1.222	4.43	6" SDR-35 PVC
Peak Diversion Filterra Vaults	4x4	16	0.111	0.40	6" SDR-35 PVC
	4.5x5.83 (Nominal 4x6)	26.24	0.182	0.66	6" SDR-35 PVC
	6x4	24	0.167	0.60	6" SDR-35 PVC
	6x6	36	0.250	0.91	6" SDR-35 PVC
	6x8	48	0.333	1.21	6" SDR-35 PVC
	6x10 or 10x6	60	0.417	1.51	6" SDR-35 PVC
	7x10	70	0.486	1.76	6" SDR-35 PVC
	8x10.5	84	0.583	2.11	6" SDR-35 PVC
	8x12.5	100	0.694	2.52	6" SDR-35 PVC
	Custom and/or Filterra Bioscape	Media Area in ft^2	0.00694 * (Media Area in ft^2)	0.0252 * (Media Area in ft^2)	6" SDR-35 PVC